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Clinician's Pocket Reference Interval

NINTH EDITION

Clinician's Pocket Reference

Leonard G. Gomella
Steven A. Haist

9th
EDITION

CLINICIAN'S POCKET REFERENCE

EDITED BY

LEONARD G. GOMELLA, MD, FACS

The Bernard W. Godwin, Jr., Associate Professor
Department of Urology
Jefferson Medical College
Thomas Jefferson University
Philadelphia, Pennsylvania

WITH

Steven A. Haist, MD, MS, FACP

Professor of Medicine
Division of General Internal Medicine
Department of Internal Medicine
University of Kentucky Medical Center
Lexington, Kentucky

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University of Kentucky College of Medicine
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To Tricia, Mom, Dad, Leonard, Patrick, Andrew, Michael and Aunt Lucy

"We don't drive the trucks, we only load them."

Nick Pavona, MD
UKMC Class of 1980

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CONSULTING EDITORS

MARIANNE BILLETER, PharmD, BCPS

Associate Professor of Pharmacy Practice, Division of Distance Education, Bernard J. Dunn School of Pharmacy, Shenandoah University, Winchester, Virginia

TRICIA L. GOMELLA, MD

Part-Time Clinical Assistant Professor of Pediatrics, Johns Hopkins University School of Medicine, Baltimore, Maryland

IRA HOROWITZ, MD

Professor of Gynecology and Obstetrics and Oncology, Director of Gynecologic Oncology, Emory University, Atlanta, Georgia

ALAN T. LEFOR, MD, MPH, FACS

Director, Division of Surgical Oncology, Director, Surgical Education and Academic Affairs, Department of Surgery, Cedars-Sinai Medical Center, Los Angeles, California; Associate Professor of Clinical Surgery, Department of Surgery, University of California, Los Angeles, Los Angeles, California

JOHN A. MORRIS, MD

Director, Division of Trauma, Department of Surgery, Vanderbilt University Medical Center, Nashville, Tennessee

CONTRIBUTORS

Aimee G. Adams, PharmD

Director, Primary Care Pharmacy Practice Residency, University of Kentucky Medical Center; Assistant Professor College of Pharmacy and Department of Medicine, University of Kentucky, Lexington, Kentucky

Marianne Billeter, PharmD, BCPS

Associate Professor of Pharmacy Practice, Division of Distance Education, Bernard J. Dunn School of Pharmacy, Shenandoah University, Winchester, Virginia

Pasquale Casale, MD

Chief Resident, Department of Urology, Thomas Jefferson University, Philadelphia, Pennsylvania

Murray Cohen, MD

Clinical Associate Professor of Surgery, Director, Division of Trauma/Critical Care, Department of Surgery, Jefferson Medical College, Philadelphia, Pennsylvania

Marisa Davis

Doctor of Pharmacy Candidate, Bernard J. Dunn School of Pharmacy, Shenandoah University, Winchester, Virginia

Neil M. Davis, PharmD, FASHP

Professor Emeritus of Pharmacy, Temple University, Philadelphia, Pennsylvania; Director, Safe Medication Practice Consulting, Inc., Huntingdon Valley, Pennsylvania

Ehab A. El Gabry, MD

Fellow, Department of Urology, Thomas Jefferson University, Philadelphia, Pennsylvania

Sue Fosson, MA

Former Associate Dean for Student Affairs, University of Kentucky College of Medicine, Lexington, Kentucky

Leonard G. Gomella, MD, FACS

The Bernard W. Godwin, Jr., Associate Professor, Department of Urology, Jefferson Medical College, Thomas Jefferson University, Philadelphia, Pennsylvania

Steven A. Haist, MD, MS, FACP

Professor of Medicine, Division of General Internal Medicine, Department of Internal Medicine, University of Kentucky Medical Center, Lexington, Kentucky

Sara Maria Haverty, MD

Senior Resident, Department of Obstetrics and Gynecology, Thomas Jefferson University, Philadelphia, Pennsylvania

Mohamed Ismail, MD

Senior Resident, Department of Urology, Thomas Jefferson University, Philadelphia, Pennsylvania

Gregory C. Kane, MD

Clinical Associate Professor of Medicine, Program Director, Internal Medicine Residency, Jefferson Medical College, Philadelphia, Pennsylvania

Matthew J. Killion, MD

Assistant Professor of Medicine, Jefferson Medical College, Philadelphia, Pennsylvania

Alan T. Lefor, MD, MPH, FACS

Director, Division of Surgical Oncology, Director, Surgical Education and Academic Affairs, Department of Surgery, Cedars-Sinai Medical Center, Los Angeles, California; Associate Professor of Clinical Surgery, Department of Surgery, University of California, Los Angeles, Los Angeles, California

Layla F. Makary, MD, MSC, PhD

Lecturer, Department of Anesthesia, Cairo University, Clinical Fellow, Department of Anesthesia, Cleveland Clinic Foundation, Cleveland, Ohio

John Moore, MD

Clinical Associate Professor, Department of Surgery, Division of Plastic Surgery, Jefferson Medical College, Philadelphia, Pennsylvania

Nick A. Pavona, MD

Associate Professor, Department of Surgery, Division of Urology, Benjamin Franklin University Medical Center, Chadds Ford, Pennsylvania

Roger J. Pomerantz, MD, FACP

Professor of Medicine, Biochemistry and Molecular Pharmacology, Division of Infectious Diseases and Center for Human Virology, Jefferson Medical College, Thomas Jefferson University, Philadelphia, Pennsylvania

Ganesh Raj, MD, PhD

Senior Resident, Division of Urology, Department of Surgery, Duke University Medical Center, Durham, North Carolina

Steven Rosensweig, MD

Director, Jefferson Center for Integrative Medicine, Jefferson Medical College, Philadelphia, Pennsylvania

Paul J. Schenarts, MD

Instructor in Surgery, Section of Surgical Sciences, Vanderbilt University, Nashville, Tennessee

Francis G. Serio, DMD, MS

Associate Professor and Chairman, Department of Periodontics, University of Mississippi School of Dentistry, Jackson, Mississippi

Kelly Smith, PharmD

Clinical Associate Professor, Division of Pharmacy Practice & Science, University of Kentucky College of Pharmacy; Director, Pharmacy Practice Residency, University of Kentucky Medical Center, Lexington, Kentucky

PREFACE

The *Clinician's Pocket Reference* is based on a University of Kentucky house manual entitled *So You Want to Be a Scut Monkey: Medical Student's and House Officer's Clinical Handbook.* The Scut Monkey Program at the University of Kentucky College of Medicine began in the summer of 1978 and was developed by members of the Class of 1980 to help ease the often frustrating transition from the preclinical to the clinical years of medical school. From detailed surveys at the University of Kentucky College of Medicine and 44 other medical schools, a list of essential information and skills that third-year students should be familiar with at the start of their clinical years was developed. The Scut Monkey Program was developed around this core of material and consisted of reference manuals and a series of workshops conducted at the start of the third year. Presented originally as a pilot program for the University of Kentucky College of Medicine Class of 1981, the program has been incorporated into the third-year curriculum. It is the responsibility of each new fourth-year class to orient the new third-year students. The basis of the program's success is the fact that it was developed and taught by students for other students. This method has allowed us to maintain perspective on those areas that are critical not only for learning while on the wards but also for delivering effective patient care. Information on the Scut Monkey Orientation Program is available from Todd Cheever, MD, Associate Dean for Academic Affairs at the University of Kentucky College of Medicine.

Through the last eight editions, the book has undergone expansion and careful revisions as the practice of medicine and the educational needs of students have changed. Although the book's original mission, providing new clinical clerks with essential patient care information in an easy-to-use format, remains unchanged, our readership has expanded. Residents, practicing physicians, and allied health professionals all use the *Clinician's Pocket Reference* as a "manual of manuals." Even individuals considering careers in medicine have used the book in their decision-making process. An attempt is made to cover the most frequently asked basic management questions that are normally found in many different sources, such as procedure manuals, laboratory manuals, drug references, and critical care manuals, to name a few. It is not meant as a substitute for specialty-specific reference manuals. The core of information presented is a foundation for new medical students as they move through training to more advanced medical studies.

The book is designed to represent a cross section of medical practices around the country. The *Clinician's Pocket Reference* has been translated into six different languages with electronic media versions in development. I was honored to have been asked to grant permission to Warner Brothers, the producers of the TV show "ER," to have the eighth edition of the Scut Monkey book as one of the books used on their series.

I would like to express special thanks to my wife and my family for their long-term support of the Scut Monkey project. Linda Davoli, our extraordinary copy editor, had an exceptional eye for detail in helping create this final work. Janet Foltin, Harriet Lebowitz, Lester

Sheinis, and the team at McGraw-Hill were instrumental in moving the book forward and in giving the ninth edition a fresh, new two-color format. They are also responsible for helping reach our long-term goal of the new companion manual, the *Clinician's Pocket Drug Reference*. A special thanks to my assistant Conchita Ballard, who always kept things organized and flowing smoothly. I am indebted to all of the past contributors and readers who have helped to keep the Scut Monkey book as a useful reference for students and residents worldwide. The original coeditors of this work, G. Richard Braen, MD, and Michael J. Olding, MD, are acknowledged for their early contributions.

Your comments and suggestions for improvement are always welcomed by me personally, since revisions to the book would not be possible if it were not for the ongoing interest of our readers. I hope this book will not only help you learn some of the basics of the art and science of medicine but also allow you to care for your patients in the best way possible.

Leonard G. Gomella, MD
Philadelphia, Pennsylvania
Leonard.Gomella@mail.tju.edu

ABBREVIATIONS

The following are common abbreviations used in medical records and in this edition

÷: divided dose
↓: decrease(d), reduce, downward
×: times for multiplication sign
↑: increase(d), upward (as in titrate upward)
/: per
±: with or without
+: with
<: less than, younger than
>: more than, older than
≅: approximately equal to
AAA: abdominal aortic aneurysm
$AaDo_2$: difference in partial pressures of oxygen in mixed alveolar gas and mixed arterial blood
A-a gradient: alveolar-to-arterial gradient
AAI: ankle-arm index
AAS: acute abdominal series
AB: antibody, abortion, antibiotic
A&B: apnea and bradycardia
ABD: abdomen
ABG: arterial blood gas
A/B index: ankle-brachial index
ABMT: autologous bone marrow transplantation
ac: before eating (*ante cibum*), assist-controlled
ACCP: American College of Chest Physicians
ACE: angiotensin-converting enzyme
Ach-ase: acetylcholinesterase
ACLS: Advanced Cardiac Life Support
ACS: acute coronary syndrome, American Cancer Society, American College of Surgeons
ACTH: adrenocorticotropic hormone
A.D.C. VAAN DIML: mnemonic for *A*dmit, *Di*agnosis, *C*ondition, *V*itals, *A*ctivity, *A*llergies, *N*ursing procedures, *D*iet, *I*ns and outs, *M*edications, *L*abs
A.D.C. VAN DISSEL: mnemonic for *A*dmit, *Di*agnosis, *C*ondition, *V*itals, *A*ctivity, *N*ursing procedures, *D*iet, *I*ns and outs, *S*pecific drugs, *S*ymptomatic drugs, *E*xtras, *L*abs
ADH: antidiuretic hormone
ADHD: attention-deficit hyperactivity disorder
ad lib: as much as needed (*ad libitum*)
AEIOU TIPS: mnemonic for *A*lcohol, *E*ncephalopathy, *I*nsulin, *O*piates, *U*remia, *T*rauma, *I*nfection, *P*sychiatric, *S*yncope (diagnosis of coma)
AF: afebrile, aortofemoral, atrial fibrillation
AFB: acid-fast bacilli
AFP: alpha-fetoprotein
A/G: albumin/globulin ratio
AHA: American Heart Association
AHF: antihemophilic factor
AI: aortic insufficiency
AIDS: acquired immunodeficiency syndrome
AJCC: American Joint Committee on Cancer
AKA: above-the-knee amputation
ALAT: alanine aminotransferase
ALL: acute lymphocytic leukemia
ALS: amyotrophic lateral sclerosis
ALT: alanine aminotransferase
AM: morning
amb: ambulate
AMI: acute myocardial infarction
AML: acute myelocytic leukemia, acute myelogenous leukemia
AMMoL: acute monocytic leukemia
amp: ampule
AMP: adenosine monophosphate
ANA: antinuclear antibody

ANC: absolute neutrophil count
ANCA: antineutrophil cytoplasmic antibody
ANLL: acute nonlymphoblastic leukemia
ANS: autonomic nervous system
AOB: alcohol on breath
AODM: adult-onset diabetes mellitus
AP: anteroposterior, abdominal-perineal
APAP: acetaminophen
APL: acute promyelocytic leukemia
aPPT: activated partial thromboplastin time
APSAC: anisoylated plasminogen streptokinase activator complex
APUD: amine precursor uptake (and) decarboxylation
Ara-C: cytarabine
ARD: antibiotic removal device
ARDS: adult respiratory distress syndrome
ARF: acute renal failure
AS: aortic stenosis
ASA: American Society of Anesthesiologists
ASAP: as soon as possible
ASAT: aspartate aminotransferase
ASCVD: atherosclerotic cardiovascular disease
ASD: atrial septal defect
ASHD: atherosclerotic heart disease
ASO: antistreptolysin O
AST: aspartate aminotransferase
ATG: antithymocyte globulin
ATN: acute tubular necrosis
ATP: adenosine triphosphate
AUC: area under the curve
AV: atrioventricular
A-V: arteriovenous
A-Vo_2: arteriovenous oxygen
B I&II: Billroth I and II
BACOD: bleomycin, doxorubicin (Adriamycin), cyclophosphamide, vincristine (Oncovin), dexamethasone
BACOP: bleomycin, doxorubicin (Adriamycin), cyclophosphamide, vincristine (Oncovin), prednisone
BBB: bundle branch block
BC: bone conduction
BCAA: branched-chain amino acid
BCG: bacille Calmette-Guérin
BE: barium enema
BEE: basal energy expenditure
bid: twice a day (*bis in die*)
bili: bilirubin
BKA: below-the-knee amputation
BM: bone marrow, bowel movement
BMR: basal metabolic rate
BMT: bone marrow transplantation
BOM: bilateral otitis media
BP: blood pressure
BPH: benign prostatic hypertrophy
bpm: beats per minute
BR: bed rest
BRBPR: bright red blood per rectum
BRP: bathroom privileges
bs, BS: bowel sounds, breath sounds
BSA: body surface area
BS&O: bilateral salpingo-oophorectomy
BUN: blood urea nitrogen
BW: body weight
Bx: biopsy
c: with (*c*um)
Ca: calcium
CA: cancer
CAA: crystalline amino acid
CABG: coronary artery bypass graft
CAD: coronary artery disease
CAF: cyclophosphamide, doxorubicin (Adriamycin), 5-fluorouracil
CALGB: Cancer and Leukemia Group B
cAMP: cyclic adenosine monophosphate
Cao_2: arterial oxygen content
caps: capsule(s)
CAT: computed axial tomography
CBC: complete blood count
CBG: capillary blood gas
CC: chief complaint
CCI: corrected count increment (platelets)
CCO: continuous cardiac output
Cco_2: capillary oxygen content
CCU: clean-catch urine, cardiac care unit
CCV: critical closing volume
CD: continuous dose
CDC: Centers for Disease Control and Prevention
CEA: carcinoembryonic antigen
CEP/CIEP: counterimmunoelectrophoresis
CF: cystic fibrosis
CFU: colony-forming unit(s)
CGL: chronic granulocytic leukemia

CH_{50}: (total serum) hemolytic complement
CHD: coronary heart disease
CHF: congestive heart failure
CHO: carbohydrate
CHOP: cyclophosphamide, doxorubicin, vincristine (Oncovin), prednisone
CI: cardiac index
CIE: counterimmunoelectrophoresis
CIS: carcinoma in situ
CK: creatine phosphokinase
CKI: cyclin-dependent kinase inhibitor
CK-MB: isoenzyme of creatine kinase with muscle and brain subunits
Cl: chlorine
CLL: chronic lymphocytic leukemia
cm: centimeter
CML: chronic myelogenous leukemia
CMV: cytomegalovirus
CN: cranial nerve
CNS: central nervous system
CO: cardiac output
C/O: complaining of
COAD: chronic obstructive airway disease
COLD: chronic obstructive lung disease
COMT: catechol-*O*-methyltransferase
conc: concentrate
cont inf: continuous infusion
COPD: chronic obstructive pulmonary disease
COX-2: cyclooxygenase-2
CP: chest pain, cerebral palsy
CPAP: continuous positive airway pressure
CPK: creatinine phosphokinase
CPP: central precocious puberty
CPR: cardiopulmonary resuscitation
CR: controlled release
CrCl: creatine clearance
CREST: calcinosis cutis, Raynaud's disease, esophageal dysmotility, syndactyly, telangiectasia
CRF: chronic renal failure
CRH: corticotropin-releasing hormone
CRP: C-reactive protein
C&S: culture and sensitivity
CSF: cerebrospinal fluid, colony-stimulating factor
C-spine: cervical spine
CT: computed tomography
CVA: cerebrovascular accident, costovertebral angle
CVAT: costovertebral angle tenderness
CVH: common variable hypogammaglobulinemia
Cvo_2: oxygen content of mixed venous blood
CVP: central venous pressure
CXR: chest x-ray
d: day
D_5LR: 5% dextrose in lactated Ringer's solution
D_5W: 5% dextrose in water
DAG: diacylglycerol
DAP: diastolic pulmonary artery pressure
DAT: diet as tolerated
DAW: dispense as written
DC: discontinue, discharge, direct current
D&C: dilation and curettage
ddI: dideoxyinosine
DDx: differential diagnosis
DEA: United States Drug Enforcement Administration
DES: diethylstilbestrol
DEXA: dual-energy x-ray absorptiometer
DHEA: dehydroepiandrosterone
DHEAS: dehydroepiandrosterone sulfate
DI: diabetes insipidus
DIC: disseminated intravascular coagulation
DIP: distal interphalangeal joint
DIT: diiodotyrosine
DJD: degenerative joint disease
DKA: diabetic ketoacidosis
dL: deciliter
DM: diabetes mellitus
DMSA: dimercaptosuccinic acid
DNA: deoxyribonucleic acid
DNP: deoxyribonucleic protein
DNR: do not resuscitate
DOA: dead on arrival
DOCA: deoxycorticosterone acetate
DOE: dyspnea on exertion
DOPA: dihydroxyphenylalanine
DP: dorsalis pedis
2,3-DPG: 2,3-diphosphoglycerate
DPL: diagnostic peritoneal lavage
DPT: diphtheria, pertussis, tetanus
DR: delayed release
DRG: diagnosis-related group
DS: double strength
DSA: digital subtraction angiography
DTPA: diethylenetriamine-pentaacetic acid

DTR: deep tendon reflex
DVT: deep venous thrombosis
Dx: diagnosis
EAA: essential amino acid
EBL: estimated blood loss
EBV: Epstein–Barr virus
EC: enteric-coated
ECG: electrocardiogram
ECOG: Eastern Cooperative Oncology Group
ECT: electroconvulsive therapy
EDC: estimated date of confinement
EDTA: ethylenediamine tetraacetic acid
EDVI: end-diastolic volume index
EFAD: essential fatty acid deficiency
ELISA: enzyme-linked immunosorbent assay
EMD: electromechanical dissociation
EMG: electromyelogram
EMS: emergency medical system, eosinophilia-myalgia syndrome
EMV: eyes, motor, verbal response (Glasgow Coma Scale)
ENA: extractable nuclear antigen
ENT: ear, nose, and throat
eod: every other day
EOM: extraocular muscle
EPO: erythropoietin
EPSP: excitatory postsynaptic potential
ER: endoplasmic reticulum, Emergency Room, extended release
ERCP: endoscopic retrograde cholangiopancreatography
ERV: expiratory reserve volume
ESR: erythrocyte sedimentation rate
ESRD: end-stage renal disease
ET: endotracheal
ETOH: ethanol
ETT: endotracheal tube
EUA: examination under anesthesia
ExU: excretory urogram
Fab: antigen-binding fragment
FANA: fluorescent antinuclear antibody
FBS: fasting blood sugar
Fe: iron
FEV_1: forced expiratory volume in 1 s
FFP: fresh frozen plasma
FHR: fetal heart rate
FIGO: Fédération Internationale de Gynécologie et d'Obstétrique
FiO_2: fraction of inspired oxygen
FRC: functional residual capacity
FSH: follicle-stimulating hormone
FSP: fibrin split product
ft: foot
FTA-ABS: fluorescent treponemal antibody-absorbed
FTT: failure to thrive
FU: follow-up
5-FU: fluorouracil
FUO: fever of unknown origin
FVC: forced vital capacity
Fx: fracture
g: gram
G: gravida
GABA: gamma-aminobutyric acid
GAD: glutamic acid decarboxylase
GC: gonorrhea (gonococcus)
G-CSF: granulocyte colony-stimulating factor
GDP: guanosine diphosphate
GERD: gastroesophageal reflux disease
GETT: general by endotracheal tube (anesthesia)
GFR: glomerular filtration rate
GGT: gamma-glutamyltransferase
GH: growth hormone
GHIH: growth hormone-inhibiting hormone
GI: gastrointestinal
GM-CSF: granulocyte-macrophage colony-stimulating factor
GNID: gram-negative intracellular diplococci
GnRH: gonadotropin-releasing hormone
GOG: Gynecologic Oncology Group
G6PD: glucose-6-phosphate dehydrogenase
gr: grain
GSW: gunshot wound
gt, gtt: drop, drops (*gutta*)
GTP: guanosine triphosphate
GTT: glucose tolerance test
GU: genitourinary
GVHD: graft-versus-host disease
GXT: graded exercise tolerance (cardiac stress test)
HA: headache
HAA: hepatitis B surface antigen (hepatitis-associated antigen)

HAV: hepatitis A virus
HBcAg: hepatitis B core antigen
HBeAg: hepatitis B e antigen
HBP: high blood pressure
HBsAg: hepatitis B surface antigen
HBV: hepatitis B virus
HCG: human chorionic gonadotropin
HCL: hairy cell leukemia
HCT: hematocrit
HCTZ: hydrochlorothiazide
HDL: high-density lipoprotein
HEENT: head, eyes, ears, nose, and throat
HFV: high-frequency ventilation
Hgb: hemoglobin
[Hgb]: hemoglobin concentration
H/H: hemoglobin/hematocrit, Henderson–Hasselbalch equation
HIAA: 5-hydroxyindoleacetic acid
HIDA: hepatic 2,6-dimethyliminodiacetic acid
HIV: human immunodeficiency virus
HJR: hepatojugular reflex
HLA: histocompatibility locus antigen
HO: history of
HOB: head of bed
H&P: history and physical examination
hpf: high-power field
HPI: history of the present illness
HPLC: high-pressure liquid chromatography
HPV: human papilloma virus
HR: heart rate
hs: at bedtime (*hora somni*)
HSG: hysterosalpingogram
HSM: hepatosplenomegaly
HSV: herpes simplex virus
5-HT$_3$: 5-hydroxytryptamine
HTLV-III: human T-lymphotropic virus, type III (AIDS agent, HIV)
HTN: hypertension
Hx: history
IC: inspiratory capacity
ICN: Intensive Care Nursery
ICS: intercostal space
ICSH: interstitial cell-stimulating hormone
ICU: intensive care unit
ID: identification, infectious disease
I&D: incision and drainage
IDDM: insulin-dependent diabetes mellitus
Ig: immunoglobulin
IgG1{k}: immunoglobulin G1 kappa
IHSS: idiopathic hypertrophic subaortic stenosis
IL: interleukin
IM: intramuscular
IMV: intermittent mandatory ventilation
in.: inch
INF: intravenous nutritional fluid
INH: isoniazid
inhal: inhalation
inj: injection
INR: international normalized ratio
I&O: intake and output
IP$_3$: inositol triphosphate
IPPB: intermittent positive pressure breathing
IPSP: inhibitory postsynaptic potential
iPTH: parathyroid hormone by radioimmunoassay
IR: inversion recovery
IRBBB: incomplete right bundle branch block
IRDM: insulin-resistant diabetes mellitus
IRV: inspiratory reserve volume
ISA: intrinsic sympathomimetic activity
IT: intrathecal
ITP: idiopathic thrombocytopenic purpura
IV: intravenous
IVC: intravenous cholangiogram
IVP: intravenous pyelogram
JODM: juvenile-onset diabetes mellitus
JVD: jugular venous distention
K: potassium
katal: unit of enzyme activity
kg: kilogram
KOR: keep open rate
17-KSG: 17-ketogenic steroids
KUB: kidneys, ureters, bladder
KVO: keep vein open
L: left, liter
LAD: left axis deviation, left anterior descending
LAE: left atrial enlargement
LAHB: left anterior hemiblock
LAP: left atrial pressure, leukocyte alkaline phosphatase
LBBB: left bundle branch block
LDH: lactate dehydrogenase
LDL: low-density lipoprotein

LE: lupus erythematosus
LH: luteinizing hormone
LHRH: luteinizing hormone releasing hormone
LIH: left inguinal hernia
liq: liquid
LLL: left lower lobe
LLSB: left lower sternal border
LMP: last menstrual period
LNMP: last normal menstrual period
LOC: loss of consciousness, level of consciousness
LP: lumbar puncture
lpf: low-power field
LPN: licensed practical nurse
LSB: left sternal border
LSD: lysergic acid diethylamide
LUL: left upper lobe
LUQ: left upper quadrant
LV: left ventricle
LVD: left ventricular dysfunction
LVEDP: left ventricular end-diastolic pressure
LVH: left ventricular hypertrophy
m: meter
MAC: *Mycobacterium avium* complex
MACE: methotrexate, doxorubicin (Adriamycin), cyclophosphamide, epipodophyllotoxin
MAG3: mercaptoacetyltriglycine
MAMC: midarm muscle circumference
MAO: monoamine oxidase
MAOI: monoamine oxidase inhibitor
MAP: mean arterial pressure
MAST: military/medical antishock trousers
MAT: multifocal atrial tachycardia
max: maximum
MBC: minimum bactericidal concentration
MBT: maternal blood type
MCH: mean cell hemoglobin
MCHC: mean cell hemoglobin concentration
MCT: medium-chain triglycerides
MCTD: mixed connective tissue disease
MCV: mean cell volume
MEN: multiple endocrine neoplasia
meq: milliequivalent
MESNA: 2-mercaptoethane sulfonate sodium
met-dose: metered-dose
mg: milligram
Mg: magnesium
MHA-TP: microhemagglutination-*Treponema pallidum*
MHC: major histocompatibility complex
MI: myocardial infarction, mitral insufficiency
MIBG: metaiodobenzyl-guanidine
MIC: minimum inhibitory concentration
min: minute, minimum
MIT: monoiodotyrosine
mL: milliliter
MLE: midline episiotomy
mm: millimeter
MMEF: maximal midexpiratory flow
mm Hg: millimeters of mercury
mmol: millimole
MMR: measles, mumps, rubella
mo: month
mol: mole
MOPP: mechlorethamine, vincristine (Oncovin), procarbazine, prednisone
6-MP: mercaptopurine
MPF: M phase-promoting factor
MPGN: membrane-proliferative glomerulonephritis
MPTP: analog of meperidine (used by drug addicts)
MRI: magnetic resonance imaging
mRNA: messenger ribonucleic acid
MRS: magnetic resonance spectroscopy
MRSA: methicillin-resistant *Staphylococcus aureus*
MS: mitral stenosis, morphine sulfate, multiple sclerosis
MSBOS: maximal surgical blood order schedule
MSH: melanocyte-stimulating hormone
MTT: monotetrazolium
MTX: methotrexate
MUGA: multigated (image) acquisition (analysis)
μm: micrometer
MVA: motor vehicle accident
MVI: multivitamin injection
MVV: maximum voluntary ventilation
MyG: myasthenia gravis
Na: sodium
NAACP: mnemonic for *N*eoplasm, *A*llergy, *A*ddison's disease, *C*ollagen-vascular

disease, *P*arasites (causes of eosinophilia)
NAD: no active disease
Na^+/K^+-ATPase: sodium/potassium adenosine triphosphate
NAPA: *N*-acetylated procainamide, *N*-acetylparaaminophenol
NAS: no added sodium
NAVEL: mnemonic for *N*erve, *A*rtery, *V*ein, *E*mpty space, *L*ymphatic
NCV: nerve conduction velocity
NE: norepinephrine
neb: nebulizer
NED: no evidence of recurrent disease
ng: nanogram
NG: nasogastric
NIDDM: non-insulin-dependent diabetes mellitus
NK: natural killer
NKA: no known allergies
NKDA: no known drug allergy
nmol: nanomole
NMR: nuclear magnetic resonance
NPC: nuclear pore complex
NPO: nothing by mouth (*nil per os*)
NRM: no regular medicines
NS: normal saline
NSAID: nonsteroidal antiinflammatory drug
NSILA: nonsuppressible insulin-like activity
NSR: normal sinus rhythm
NT: nasotracheal
NTG: nitroglycerin
OB: obstetrics
OCD: obsessive-compulsive disorder
OCG: oral cholecystogram
7-OCHS: 17-hydroxycorticosteroids
OD: overdose, right eye (*oculus dexter*)
oint: ointment
OM: otitis media
OOB: out of bed
ophth: ophthalmic
OPV: oral polio vaccine
OR: operating room
OS: opening snap, left eye (*oculus sinister*)
OTC: over-the-counter (medications)
OU: both eyes
***p*:** para
PA: posteroanterior, pulmonary artery
PAC: premature atrial contraction
PAD: diastolic pulmonary artery pressure
PAF: paroxysmal atrial fibrillation
PAL: periarterial lymphatic (sheath)
Pao_2: peripheral arterial oxygen content
PAo_2: alveolar oxygen
PAOP: pulmonary artery occlusion pressure
PAP: pulmonary artery pressure, prostatic acid phosphatase
PAS: systolic pulmonary artery pressure
PASG: pneumatic antishock garment
PAT: paroxysmal atrial tachycardia
PBM: pharmacy benefit manager
pc: after eating (*post cibum*)
PCA: patient-controlled analgesia
PCI: percutaneous coronary intervention
PCKD: polycystic kidney disease
PCN: percutaneous nephrostomy
pCO_2: partial pressure of carbon dioxide
PCP: *Pneumocystis carinii* pneumonia, phencyclidine
PCR: polymerase chain reaction
PCWP: pulmonary capillary wedge pressure
PDA: patent ductus arteriosus
PDGF: platelet-derived growth factor
***PDR*:** *Physicians' Desk Reference*
PDS: polydioxanone
PE: pulmonary embolus, physical examination, pleural effusion
PEA: pulseless electrical activity
PEEP: positive end-expiratory pressure
PEG: polyethylene glycol, percutaneous gastrostomy
PERRLA: pupils equal, round, reactive to light and accommodation
PERRLADC: pupils equal, round, reactive to light and accommodation directly and consensually
PET: positron emission tomography
PFT: pulmonary function test
pg: picogram
PGE_1: prostaglandin E_1
PI: pulmonic insufficiency (disease)
PICC: peripherally inserted central catheter
PID: pelvic inflammatory disease
PIE: pulmonary infiltrates with eosinophilia

PIH: prolactin-inhibiting hormone
PKU: phenylketonuria
PMDD: premenstrual dysphoric disorder
PMH: past medical history
PMI: point of maximal impulse
PMNL: polymorphonuclear leukocyte (neutrophil)
PND: paroxysmal nocturnal dyspnea
PNS: peripheral nervous system
PO: by mouth (*per os*)
pO_2: partial pressure of oxygen
POD: postoperative day
postop: postoperative, after surgery
PP: pulsus paradoxus, postprandial
PPD: purified protein derivative
P&PD: percussion and postural drainage
PPN: partial parenteral nutrition
PR: by rectum
PRA: plasma renin activity
PRBC: packed red blood cells
preop: preoperative, before surgery
PRG: pregnancy
PRK: photorefractive keratectomy
PRN: as often as needed (*pro re nata*)
PS: pulmonic stenosis, partial saturation
PSA: prostate-specific antigen
PSV: pressure support ventilation
PSVT: paroxysmal supraventricular tachycardia
Pt: patient
PT: prothrombin time, physical therapy, posterior tibial
PTCA: percutaneous transluminal coronary angioplasty
PTH: parathyroid hormone
PTHC: percutaneous transhepatic cholangiogram
PTT: partial thromboplastin time
PTU: propylthiouracil
PUD: peptic ulcer disease
PVC: premature ventricular contraction
PVD: peripheral vascular disease
PVR: peripheral vascular resistance
PWP: pulmonary wedge pressure
PZI: protamine zinc insulin
q: every (*quaque*)
Q: mathematical symbol for flow
qd: every day
qh: every hour
q{_}h: every {_} hours
qhs: every hour of sleep
qid: four times a day (*quater in die*)
QNS: quantity not sufficient
qod: every other day
Qs: volume of blood (portion of cardiac output) shunted past nonventilated alveoli
Qs/Qt: shunt fraction
Qt: total cardiac output
R: right
RA: rheumatoid arthritis, right atrium
RAD: right axis deviation
RAE: right atrial enlargement
RAP: right atrial pressure
RBBB: right bundle branch block
RBC: red blood cell (erythrocyte)
RBP: retinol-binding protein
RCC: renal cell carcinoma
RDA: recommended dietary allowance
RDS: respiratory distress syndrome (of newborn)
RDW: red cell distribution width
REF: right ventricular ejection fraction
REM: rapid eye movement
RER: rough endoplasmic reticulum
%RH: percentage of relative humidity
RIA: radioimmunoassay
RIH: right inguinal hernia
RIND: reversible ischemic neurologic deficit
RL: Ringer's lactate
RLL: right lower lobe
RLQ: right lower quadrant
RME: resting metabolic expenditure
RML: right middle lobe
RMSF: Rocky Mountain spotted fever
RNA: ribonucleic acid
RNase: ribonuclease
R/O: rule out
ROM: range of motion
ROS: review of systems
RPG: retrograde pyelogram
RPR: rapid plasma reagin
rRNA: ribosomal ribonucleic acid
RRR: regular rate and rhythm
RSV: respiratory syncytial virus
RT: rubella titer, respiratory therapy, radiation therapy
RTA: renal tubular acidosis
RTC: return to clinic
RTOG: Radiation Therapy Oncology Group

RU: resin uptake
RUG: retrograde urethrogram
RUL: right upper lobe
RUQ: right upper quadrant
RV: residual volume
RVEDVI: right ventricular end-diastolic volume index
RVH: right ventricular hypertrophy
Rx: treatment
s: without (*sine*), second
SA: sinoatrial
S&A: sugar and acetone
SAA: synthetic amino acid
Sao_2: arterial oxygen saturation
SBE: subacute bacterial endocarditis
SBFT: small bowel follow-through
SBS: short bowel syndrome
SCr: serum creatinine
segs: segmented cells
SEM: systolic ejection murmur
SER: smooth endoplasmic reticulum
SG: Swan–Ganz
SGA: small for gestational age
SGGT: serum gamma-glutamyl transpeptidase
SGOT: serum glutamic-oxaloacetic transaminase
SGPT: serum glutamic-pyruvic transaminase
SI: Système International (see page 55)
SIADH: syndrome of inappropriate antidiuretic hormone
sig: write on label (*signa*)
SIMV: synchronous intermittent mandatory ventilation
SIRS: systemic inflammatory response syndrome
SKSD: streptokinase-streptodornase
SL: sublingual
SLE: systemic lupus erythematosus
SMA: sequential multiple analysis
SMO: slips made out
SMX: sulfamethoxazole
SOAP: mnemonic for *S*ubjective, *O*bjective, *A*ssessment, *P*lan
SOB: shortness of breath
SOC: signed on chart
soln: solution
SPAG: small-particle aerosol generator
SPECT: single-photon emission computed tomography
SQ: subcutaneous
SR: sustained release
SRP: single recognition particle
SRS-A: slow-reacting substance of anaphylaxis
SSKI: saturated solution of potassium iodide
SSRI: selective serotonin reuptake inhibitor
stat: immediately (*statim*)
STD: sexually transmitted disease
supp: suppository
susp: suspension
SVD: spontaneous vaginal delivery
Svo_2: mixed venous blood oxygen saturation
SVR: systemic vascular resistance
SVT: supraventricular tachycardia
SWOG: Southwest Oncology Group
Sx: symptoms
$\dot{T}$: one, **$\dot{T}\dot{T}$**: two, etc.
T_3: triiodothyronine
T_3 RU: triiodothyronine resin uptake
T_4: thyroxine
tabs: tablet(s)
TAH: total abdominal hysterectomy
TB: tuberculosis
TBG: thyroxine-binding globulin, total blood gas
TBLC: term birth, living child
T&C: type and cross-match
TC&DB: turn, cough, and deep breathe
TCF: triceps skin fold
TCP: transcutaneous pacer
Td: tetanus-diphtheria toxoid
TD: transdermal
TFT: thyroid function test
6-TG: 6-thioguanine
T&H: type and hold
TIA: transient ischemic attack
TIBC: total iron-binding capacity
tid: three times a day (*ter in die*)
TIG: tetanus immune globulin
TKO: to keep open
TLC: total lung capacity
TMJ: temporal mandibular joint
TMP: trimethoprim
TMP-SMX: trimethoprim-sulfamethoxazole
TNFα: tumor necrosis factor alpha

TNM: tumor-nodes-metastases
TNTC: too numerous to count
TO: telephone order
TOPV: trivalent oral polio vaccine
TORCH: toxoplasma, rubella, cytomegalovirus, herpes virus (*O* = other [syphilis])
TPA: tissue plasminogen activator
TPN: total peripheral resistance, total parenteral nutrition
TRH: thyrotropin-releasing hormone
TSH: thyroid-stimulating hormone
TT: thrombin time
TTP: thrombotic thrombocytopenic purpura
TU: tuberculin units
TUR: transurethral resection
TURBT: TUR bladder tumors
TURP: TUR prostate
TV: tidal volume
TVH: total vaginal hysterectomy
Tx: treatment, transplant, transfer
type 2 DM: noninsulin-dependent diabetes mellitus, type 2 diabetes mellitus
UA: urinalysis
UAC: uric acid
ud: as directed (*ut dictum*)
UDS: urodynamic studies
UGI: upper gastrointestinal
UPEP: urine protein electrophoresis
URI: upper respiratory infection
US: ultrasonography
USP: United States Pharmacopeia
UTI: urinary infection
UUN: urinary urea nitrogen
V: volt
VAMP: vincristine, doxorubicin (Adriamycin), methylprednisolone
VC: vital capacity
VCUG: voiding cystourethrogram
VDRL: Venereal Disease Research Laboratory
VF: ventricular fibrillation
VLDL: very low density lipoprotein
VMA: vanillylmandelic acid
VO: voice order
VP-16: etoposide
$\dot{V}/\dot{Q}$: ventilation-perfusion
VSS: vital signs stable
VT: ventricular tachycardia
W: watt
WB: whole blood
WBC: white blood cell, white blood cell count
WD: well developed
WF: white female
wk: week
WM: white male
WN: well nourished
wnl, WNL: within normal limits
WPW: Wolff-Parkinson-White
XRT: x-ray therapy
y: year
YO: years old
ZE: Zollinger–Ellison

"SO YOU WANT TO BE A SCUT MONKEY": AN INTRODUCTION TO CLINICAL MEDICINE*

The transition from the preclinical years to the clinical years of medical school is often a difficult one. Understanding the new responsibilities and a set of ground rules can ease this transition. What follows is a brief introduction to clinical medicine for the new clinical clerk.

THE HIERARCHY

Most services can be expected to have at least one of each of the following physicians on the team.

The Intern

In some programs, the intern is known euphemistically as the first-year resident. This person has the day-to-day responsibilities of patient care. This duty, combined with a total lack of seniority, usually serves to keep the intern in the hospital more than the other members of the team and may limit his or her teaching of medical students. Any question concerning details in the evaluation of the patient, for example, whether Mrs. Pavona gets a complete blood count this morning or this evening, is usually referred first to the intern.

The Resident

The resident is a member of the house staff who has completed at least 1 year of postgraduate medical education. The most senior resident is typically in charge of the overall conduct of the service and is the person you might ask a question such as "What might cause Mrs. Pavona's white blood cell count to be 142,000?" You might also ask your resident for an appropriate reference on the subject or perhaps to arrange a brief conference on the topic for everyone on the service. A surgical service typically has a chief resident, a doctor in the last year of residency who usually runs the service. On medical services the chief resident is

* Adapted, with permission, from Epstein A, Frye T (eds.): *So You Want to Be a Toad.* College of Medicine, Ohio State University, Columbus, OH.

usually an appointee of the chairman of medicine and primarily has administrative responsibilities with limited ward duties.

The Attending Physician

The attending physician is also called simply "The Attending," and on nonsurgical services, "the attending." This physician has completed postgraduate education and is now a member of the teaching faculty. The attending is morally and legally responsible for the care of all patients whose charts are marked with the attending's name. All major therapeutic decisions made about the care of these patients are ultimately passed by the attending. In addition, this person is responsible for teaching and evaluating house staff and medical students. This is the member of the team you might ask, "Why are we treating Mrs. Pavona with busulfan?"

The Fellow

Fellows are physicians who have completed their postgraduate education and elected to do extra study in one special field, such as, nephrology, high-risk obstetrics, or surgical oncology. They may or may not be active members of the team and may not be obligated to teach medical students, but usually they are happy to answer any questions you may ask. You might ask this person to help you read Mrs. Pavona's bone marrow smear.

TEAMWORK

The medical student, in addition to being a member of the medical team, must interact with members of the professional team of nurses, dietitians, pharmacists, social workers, and all others who provide direct care for the patient. Good working relations with this group of professionals can make your work go more smoothly; bad relations with them can make your rotation miserable.

Nurses are generally good-tempered, but overburdened. Like most human beings, they respond very favorably to polite treatment. Leaving a mess in a patient's room after the performance of a floor procedure, standing by idly while a 98-lb licensed practical nurse struggles to move a 350-lb patient onto the chair scale, and obviously listening to three ringing telephones while room call lights flash are acts guaranteed not to please. Do not let anyone talk you into being an acting nurse's aide or ward secretary, but try to help when you can.

You will occasionally meet a staff member who is having a bad day, and you will be able to do little about it. Returning hostility is unwarranted at these times, and it is best to avoid confrontations except when necessary for the care of the patient.

When faced with ordering a diet for your first sick patient, you will no doubt be confronted with the inadequacy of your education in nutrition. Fortunately for your patient, dietitians are available. Never hesitate to call one.

In matters concerning drug interactions, side effects, individualization of dosages, alteration of drug dosages in disease, and equivalence of different brands of the same drug, it never hurts to call the pharmacist. Most medical centers have a pharmacy resident who follows every patient on a floor or service and who will gladly answer any questions you have on medications. The pharmacist or pharmacy resident can very often provide pertinent articles on a requested subject.

YOUR HEALTH AND A WORD ON "AGGRESSIVENESS"

In your months of curing disease both day and night, it becomes easy to ignore your own right to keep yourself healthy. There are numerous bad examples of medical and surgical interns who sleep 3 hours a night and get most of their meals from vending machines. Do not let anyone talk you into believing that you are not entitled to decent meals and sleep. If you offer yourself as a sacrifice, it will be a rare rotation on which you will not become one.

You may have the misfortune someday of reading an evaluation that says a student was not "aggressive enough." This is an enigmatic notion to everyone. Does it mean that the student refused to attempt to start an intravenous line after eight previous failures? Does it mean that the student was not consistently the first to shout out the answer over the mumblings of fellow students on rounds? Whatever constitutes "aggressiveness" must be a dubious virtue at best.

A more appropriate virtue might be **assertiveness in obtaining your education.** Ask **good** questions, have the house staff show you procedures and review your chartwork, read about your patient's illness, review the surgery basics before going to the OR, participate actively in your patient's care, and take an interest in other patients on the service. This approach avoids the need for victimizing your patients and comrades that the definition of *aggression* suggests.

ROUNDS

Rounds are meetings of all members of the service for discussing the care of the patient. These occur daily and are of three kinds.

Morning Rounds

Also known as "work rounds," these take place anywhere from 6:30 to 9:00 AM on most services and are attended by residents, interns, and students. This is the time for discussing what happened to the patient during the night, the progress of the patient's evaluation or therapy or both, the laboratory and radiologic tests to be ordered for the patient, and, last but not least, talking with and evaluating the patient. Know about your patient's most recent laboratory reports and progress—this is a chance for you to look good.

Ideally, differences of opinion and any glaring omissions in patient care are politely discussed and resolved here. Writing new orders, filling out consultations, and making any necessary telephone calls are best done right after morning rounds.

Attending Rounds

These vary greatly depending on the service and on the nature of the attending physician. The same people who gathered for morning rounds will be here, with the addition of the attending. At this meeting, the patients are often seen again (especially on the surgical services); significant new laboratory, radiographic, and physical findings are described (often by the student caring for the patient); and new patients are formally presented to the attending (again, often by the medical student).

The most important priority for the student on attending rounds is to **know the patient.** Be prepared to concisely tell the attending what has happened to the patient. Also be ready to give a brief presentation on the patient's illness, especially if it is unusual. The attending will probably not be interested in minor details that do not affect therapeutic decisions. Additionally, the attending will probably not wish to hear a litany of normal laboratory values, only the pertinent ones, such as, Mrs. Pavona's platelets are still 350,000/μL in spite of her bone marrow disease. You do not have to tell everything you know on rounds, but you must be prepared to do so.

Open disputes among house staff and students are bad form on attending rounds. For this reason, the unwritten rule is that any differences of opinion not previously discussed shall not be initially raised in the presence of the attending.

Check-out or Evening Rounds

Formal evening rounds on which the patients are seen by the entire team a second time are typically done only on surgical services and pediatrics. Other services, such as, medicine, often will have check-out with the resident on call for the service that evening (sometimes

called "card rounds"). Expect to convene sometime between 3:00 and 7:00 PM on most days. All new data are presented by the person who collected them (usually the student). Orders are again written, laboratory work desired for early the next day is requested, and those unfortunates on call compile a "scut list" of work to be done that night and a list of patients who need close supervision.

BEDSIDE ROUNDS

Basically, these are the same as any other rounds except that tact is at a premium. The first consideration at the bedside must be for the patient. If no one else on the team says "Good morning" and asks how the patient is feeling, do it yourself; this is not a presumptuous act on your part. Keep this encounter brief and then explain that you will be talking about the patient for a while. If handled in this fashion, the patient will often feel flattered by the attention and will listen to you with interest.

Certain points in a hallway presentation are omitted in the patient's room. The patient's race and sex are usually apparent to all and do not warrant inclusion in your first sentence. The patient must *never* be called by the name of the disease, eg, Mrs. Pavona is not "a 45-year-old CML (chronic myelogenous leukemia)" but "a 45-year-old *with* CML." The patient's general appearance need not be reiterated. Descriptions of evidence of disease must not be prefaced by words such as *outstanding* or *beautiful*. Mrs. Pavona's massive spleen is not beautiful to her, and it should not be to the physician or student either.

At the bedside, keep both feet on the floor. A foot up on a bed or chair conveys impatience and disinterest to the patient and other members of the team. It is poor form to carry beverages or food into the patient's room.

Although you will probably never be asked to examine a patient during bedside rounds, it is still worthwhile to know how to do so considerately. Bedside examinations are often done by the attending at the time of the initial presentation or by one member of a surgical service on postoperative rounds. First, warn the patient that you are about to examine the wound or affected part. Ask the patient to uncover whatever needs to be exposed rather than boldly removing the patient's clothes yourself. If the patient is unable to do so alone, you may do it, but remember to explain what you are doing. Remove only as much clothing as is necessary and then promptly cover the patient again. In a ward room, remember to pull the curtain.

Bedside rounds in the intensive care unit call for as much consideration as they do in any other room. That still, naked soul on the bed might not be as "out of it" as the resident (or anyone else) might believe and may be hearing every word you say. Again, exercise discretion in discussing the patient's illness, plan, prognosis, and personal character as it relates to the disease.

Remember that the patient information you are entrusted with as a health care provider is confidential. There is a time and place to discuss this sensitive information and public areas such as elevators or cafeterias are not the appropriate location for these discussions.

READING

Time for reading is at a premium on many services, and it is therefore important to use that time effectively. Unless you can remember everything you learned in the first 20 months of medical school, you will probably want to review the basic facts about the disease that brought your patient into the hospital. These facts are most often found in the same core texts that got you through the preclinical years. Unless specifically directed to do so, avoid the temptation to sit down with MEDLINE/*Index Medicus* to find all the latest articles on a disease you have not read about for the last 7 months; you do not have the time.

The appropriate time to head for the MEDLINE/*Index Medicus* is when a therapeutic dilemma arises and only the most recent literature will adequately advise the team. You may wish to obtain some direction from the attending, the fellow, or the resident before plunging into

the library on your only Friday night off call this month. Ask the residents or fellow students for the pocket manuals or PDA downloads that they found most useful for a given rotation.

THE WRITTEN HISTORY AND PHYSICAL

Much has been written on how to obtain a useful medical history and perform a thorough physical examination, and there is little to add to it. Three things worth emphasizing are your own physical findings, your impression, and your own differential diagnosis.

Trust and record your own physical findings, even if other examiners have written things different from those you found. You just may be right, and, if not, you have learned something from it. Avoid the temptation to copy another examiner's findings as your own when you are unable to do the examination yourself. Still, it would be an unusually cruel resident who would make you give Mrs. Pavona her fourth rectal examination of the day, and in this circumstance you may write "rectal per resident." *Do not do this routinely just to avoid performing a complete physical examination. Check with the resident first.*

Although not always emphasized in physical diagnosis, your clinical impression is probably the most important part of your write-up. Reasoned interpretation of the medical history and physical examination is what separates physicians from the computers touted by the tabloids as their successors. Judgment is learned only by boldly stating your case, even if you are wrong more often than not.

The differential diagnosis, that is, your impression, should include only those entities that you consider when evaluating your patient. Avoid including every possible cause of your patient's ailments. List only those that you are seriously considering, and include in your plan what you intend to do to exclude each one. Save the exhaustive list for the time your attending asks for all the causes of a symptom, syndrome, or abnormal laboratory value.

THE PRESENTATION

The object of the presentation is to *briefly* and *concisely* (usually in a few minutes) describe your patient's reason for being in the hospital to all members of the team who do not know the patient and the story. Unlike the write-up, which contains all the data you obtained, the presentation may include only the pertinent positive and negative evidence of a disease and its course in the patient. It is hard to get a feel for what is pertinent until you have seen and done a few presentations yourself.

Practice is important. Try never to read from your write-up, as this often produces dull and lengthy presentations. Most attendings will allow you to carry note cards, but this method can also lead to trouble unless content is carefully edited. Presentations are given in the same order as a write-up: identification, chief complaint, history of the present illness, past medical history, family history, psychosocial history, review of systems, physical examination, laboratory and x-ray data, clinical impression, and plan. Only pertinent positives and negatives from the review of systems should be given. These and truly relevant items from other parts of the interview often can be added to the history of the present illness. Finally, the length and content of the presentation vary greatly according to the wishes of the attending and the resident, but you will learn quickly what they do and do not want.

RESPONSIBILITY

Your responsibilities as a student should be clearly defined on the first day of a rotation by either the attending or the resident. Ideally, this enumeration of your duties should also include a list of what you might expect concerning teaching, floor skills, presentations, and all the other things you are paying many thousand dollars a year to learn.

On some services, you may feel like a glorified unit secretary (clinical rotations are called "clerkships" for good reason!), and you will not be far from wrong. This is *not* what you are going into hock for. The scut work should be divided among the house staff.

You will frequently be expected to call for a certain piece of laboratory data or to go review an x-ray with the radiologist. You may then mutter under your breath, "Why waste my time? The report will be on the chart in a day or two!" You will feel less annoyed in this situation if you consider that every piece of data ordered is vital to the care of your patient.

Outpatient clinic experiences are incorporated into many rotations today. The same basic rules and skill set necessary for inpatient care can be easily transferred to the outpatient setting.

The student's responsibility may be summarized in three words: **know your patient.** The whole service relies to a great extent on a well-informed presentation by the student. The better informed you are, the more time left for education and the better your evaluation will be. A major part of becoming a physician is learning responsibility.

ORDERS

Orders are the physician's instructions to the nursing and other members of the professional staff on the care of the patient. These may include the frequency of vital signs, medications, respiratory care, laboratory and x-ray studies, and nearly anything else that you can imagine.

There are many formats for writing concise admission, transfer, and postoperative orders. Some rotations may have a precisely fixed set of routine orders, but others will leave you and the intern to your own devices. It is important in each case to avoid omitting instructions critical to the care of the patient. Although you will be confronted with a variety of lists and mnemonics, ultimately it is helpful to devise your own system and commit it to memory. Why memorize? Because when you are an intern and it is 3:30 AM, you may overlook something if you try to think it out. One system for writing admission or transfer orders uses the mnemonic "A.D.C. Vaan Diml" and is discussed in Chapter 2.

The word *stat* is the abbreviation for the Latin word *statim,* which means "immediately." When added to any order, it puts the requested study in front of all the routine work waiting to be done. Ideally, this order is reserved for the truly urgent situation, but in practice it is often inappropriately used. Most of the blame for this situation rests with physicians who either fail to plan ahead or order stat lab results when routine studies would do.

Student orders usually require a co-signature from a physician, although at some institutions students are allowed to order routine laboratory studies. Do not ask a nurse or pharmacist to act on an unsigned student order; it is **illegal** for them to do so.

The intern is usually responsible for most orders. The amount of interest shown by the resident and the attending varies greatly, but ideally you will review the orders on routinely admitted patients with the intern. Have the intern show you how to write some orders on a few patients, then take the initiative and write the orders yourself and review them with the intern.

THE DAY

The events of the day and the effective use of time are two of the most distressing enigmas encountered in making the transition from preclinical to clinical education. For example, there are no typical days on surgical services, as the operating room schedule prohibits making rounds at a regularly scheduled time every day. The following are suggestions that will help on any service.

1. Schedule special studies early in the day. The free time after work rounds is usually ideal for this. Also, call consultants early in the morning. Often, they can see your patient on the same day or at least early the next day.
2. Try to take care of all your business in the radiology department in one trip unless a given problem requires viewing a film promptly. *Do not* make as many separate trips as you have patients.
3. Make a point of knowing when certain services become unavailable, for example, electrocardiograms, contrast-study scheduling, and blood drawing. Be sure to get these procedures done while it is still possible to do so.
4. Make a daily work or "scut"* list, and write down laboratory results as soon as you obtain them. Few people can keep all the daily data in their heads without making errors.
5. Try to arrange your travels around the hospital efficiently. If you have patients to see on four different floors, try to take care of all their needs, such as, drawing blood, removing sutures, writing progress notes, and calling for consultations, in one trip.
6. Strive to work thoroughly but quickly. If you do not try to get work done early, you never will (this is not to say that you will succeed even if you do try). There is no sin in leaving at 5:00 PM or earlier if your obligations are *completed* and the supervising resident has dismissed you.

A PARTING SHOT

The clinical years are when all the years of premed study in college and the first two years of medical school suddenly come together. Trying to tell you adequately about being a clinical clerk is similar to trying to make someone into a swimmer on dry land.

The terms to describe new clinical clerks may vary at different medical centers ("scut monkey," "scut boy," "scut dog," "torpedoes"). These euphemistic expressions describing the new clinical clerk acknowledge that the transition, a sort of rite of passage, into the next phase of physician training has occurred. It is hoped that this "So You Want to Be a Scut Monkey" introduction and the information contained in this book will give you a good start as you enter the "hands on" phase of becoming a successful and respected physician.

* Although the origin of the word *scut* is obscure, it probably represents an acronym for "some common unfinished task" or "some clinically useful training."

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1 HISTORY AND PHYSICAL EXAMINATION

HISTORY AND PHYSICAL EXAMINATION

An example of a complete H&P write-up can be found on page 28. The details provided and length of the written H&P can vary with the particular problem and with the service to which the patient is admitted.

History

Identification: Name, age, sex, referring physician, and the informant (eg, patient, relative, old chart) and the informant's reliability.

Chief Complaint: State, in patient's own words, the current problem.

History of the Present Illness (HPI): Defines the present illness by quality; quantity; setting; anatomic location and radiation; time course, including when it began; whether the complaint is progressing, regressing, or steady; of constant or intermittent frequency; and aggravating, alleviating, and associated factors. The information should be in chronologic order, including diagnostic tests done prior to admission. Related history, including previous treatment for the problem, risk factors, and pertinent negatives should be included. Any other significant ongoing problems should be included in the HPI in a separate section or paragraph. For instance, if a patient with poorly controlled diabetes mellitus comes to the emergency room because of chest pain, the HPI would first include information regarding the chest pain followed by a detailed history of the diabetes mellitus. If the diabetes mellitus was well controlled or diet-controlled, the history of the diabetes mellitus is placed in the past medical history.

Past Medical History (PMH): Current medications, including OTC medications, vitamins, and herbals; allergies (drugs and other—include how allergies are manifested); surgeries; hospitalizations; blood transfusions, include when and how many units and the type of blood product; trauma; stable current and past medical problems unrelated to the HPI. Specific illnesses to inquire about include diabetes mellitus, hypertension, MI, stroke, peptic ulcer disease, asthma, emphysema, thyroid and kidney disease, bleeding disorders, cancer,

TB, hepatitis, and STDs. Also inquire about routine health maintenance. This category depends on the age and sex of the patient but could include last Pap smear and pelvic exam, breast exam, whether the patient does self breast examination, date of last mammogram, diphtheria/tetanus immunization, pneumococcal and flu vaccine, stool samples for hemoccult, sigmoidoscopy, cholesterol, HDL cholesterol, and use of seat belts. **Pediatric patients:** Include prenatal and birth history, feedings, food intolerance, and immunization history.

Family History: Age, status (alive, dead) of blood relatives and medical problems for any blood relatives (inquiry about cancer, especially breast, colon, and prostate; TB, asthma; MI; HTN; thyroid disease; kidney disease; peptic ulcer disease; diabetes mellitus; bleeding disorders; glaucoma, and macular degeneration). Can be written out or use family tree.

Psychosocial (Social) History: Stressors (financial, significant relationships, work or school, health) and support (family, friends, significant other, clergy); life-style risk factors, (alcohol, drugs, tobacco, and caffeine use; diet; and exposure to environmental agents; and sexual practices); patient profile (may include marital status and children; present and past employment; financial support and insurance; education; religion; hobbies; beliefs; living conditions); for veterans, include military service history. **Pediatric patients:** Include grade in school, sleep, and play habits.

Review of Systems (ROS)

General. Weight loss, weight gain, fatigue, weakness, appetite, fever, chills, night sweats

Skin. Rashes, pruritus, bruising, dryness, skin cancer or other lesions

Head. Trauma, headache, tenderness, dizziness, syncope

Eyes. Vision, changes in the visual field, glasses, last prescription change, photophobia, blurring, diplopia, spots or floaters, inflammation, discharge, dry eyes, excessive tearing, history of cataracts or glaucoma

Ears. Hearing changes, tinnitus, pain, discharge, vertigo, history of ear infections

Nose. Sinus problems, epistaxis, obstruction, polyps, changes in or loss of sense of smell

Throat. Bleeding gums; dental history (last checkup, etc); ulcerations or other lesions on tongue, gums, buccal mucosa

Respiratory. Chest pain; dyspnea; cough; amount and color of sputum; hemoptysis; history of pneumonia, influenza, pneumococcal vaccinations, or positive PPD

Cardiovascular. Chest pain, orthopnea, dyspnea on exertion, paroxysmal nocturnal dyspnea, murmurs, claudication, peripheral edema, palpitations

Gastrointestinal. Dysphagia, heartburn, nausea, vomiting, hematemesis, indigestion, abdominal pain, diarrhea, constipation, melena (hematochezia), hemorrhoids, change in stool shape and color, jaundice, fatty food intolerance

Gynecologic. Gravida/para/abortions; age at menarche; last menstrual period (frequency, duration, flow); dysmenorrhea; spotting; menopause; contraception; sexual history, including history of venereal disease, frequency of intercourse, number of partners, sexual orientation and satisfaction, and dyspareunia

Genitourinary. Frequency, urgency, hesitancy; dysuria; hematuria; polyuria; nocturia; incontinence; venereal disease; discharge; sterility; impotence; polyuria; polydipsia; change in urinary stream; and sexual history, including frequency of intercourse, number of partners, sexual orientation and satisfaction, and history of venereal disease

Endocrine. Polyuria, polydipsia, polyphagia, temperature intolerance, glycosuria, hormone therapy, changes in hair or skin texture

Musculoskeletal. Arthralgias, arthritis, trauma, joint swelling, redness, tenderness, limitations in ROM, back pain, musculoskeletal trauma, gout

Peripheral Vascular. Varicose veins, intermittent claudication, history of thrombophlebitis
Hematology. Anemia, bleeding tendency, easy bruising, lymphadenopathy
Neuropsychiatric. Syncope; seizures; weakness; coordination problems; alterations in sensations, memory, mood, sleep pattern; emotional disturbances; drug and alcohol problems

Physical Examination

General: Mood, stage of development, race, and sex. State if patient is in any distress or is assuming an unusual position, such as, sitting up leaning forward (position often seen in patients with acute exacerbation of COPD or pericarditis)

Vital Signs: Temperature (note if oral, rectal, axillary), pulse, respirations, blood pressure (may include right arm, left arm, lying, sitting, standing), height, weight. Blood pressure and heart rate supine and after standing 1 min should always be included if volume depletion is suspected, such as in GI bleeding, diarrhea, dizziness, or syncope.

Skin: Rashes, eruptions, scars, tattoos, moles, hair pattern (See page 20 for definitions of dermatologic lesions.)

Lymph Nodes: Location (head and neck, supraclavicular, epitrochlear, axillary, inguinal), size, tenderness, motility, consistency

Head, Eyes, Ears, Nose, and Throat (HEENT)

Head. Size and shape, tenderness, trauma, bruits. **Pediatric patients:** Fontanels, suture lines

Eyes. Conjunctiva; sclera; lids; position of eyes in orbits; pupil size, shape, reactivity; extraocular muscle movements; visual acuity (eg, 20/20); visual fields; fundi (disc color, size, margins, cupping, spontaneous venous pulsations, hemorrhages, exudates, A-V ratio, nicking)

Ears. Test hearing, tenderness, discharge, external canal, tympanic membrane (intact, dull or shiny, bulging, motility, fluid or blood, injected)

Nose. Symmetry; palpate over frontal, maxillary, and ethmoid sinuses; inspect for obstruction, lesions, exudate, inflammation. **Pediatric patients:** Nasal flaring, grunting

Throat. Lips, teeth, gums, tongue, pharynx (lesions, erythema, exudate, tonsillar size, presence of crypts)

Neck: ROM, tenderness, JVD, lymph nodes, thyroid examination, location of larynx, carotid bruits, HJR. JVD should be reported in relationship to the number of centimeters above or below the sternal angle, such as "1 cm above the sternal angle," rather than "no JVD."

Chest: Configuration and symmetry of movement with respiration; intercostal retractions; palpation for tenderness, fremitus, and chest wall expansion; percussion (include diaphragmatic excursion); breath sounds; adventitious sounds (rales, rhonchi, wheezes, rubs). If indicated: vocal fremitus, whispered pectoriloquy, egophony (found with consolidation)

Heart: Rate, inspection, and palpation of precordium for point of maximal impulse and thrill; auscultation at the apex, LLSB, and right and left second intercostal spaces with diaphragm and apex and LLSB with bell. Heart murmurs are reviewed on pages 16 to 18.

Breast: Inspection for nipple discharge, inversion, excoriations and fissures, and skin dimpling or flattening of the contour; palpation for masses, tenderness; gynecomastia in males

Abdomen: Note shape (scaphoid, flat, distended, obese); examine for scars; auscultate for bowel sounds and bruits; percussion for tympani and masses; measure liver size (span in midclavicular line); note costovertebral angle tenderness; palpate for tenderness (if present, check for rebound tenderness), note hepatomegaly, splenomegaly; guarding, inguinal adenopathy

Male Genitalia: Inspect for penile lesions, scrotal swelling, testicles (size, tenderness, masses, varicocele), and hernia, and observe for transillumination of testicular masses

Pelvic: See Chapter 13, page 289.

Rectal: Inspect and palpate for hemorrhoids, fissures, skin tags, sphincter tone, masses, prostate (size [grade from small 1+ to massively enlarged 4+], note any nodules, tenderness); note presence or absence of stool; test stool for occult blood

Musculoskeletal: Note amputations, deformities, visible joint swelling, and ROM; also palpate joints for swelling, tenderness, and warmth

Peripheral Vascular: Note hair pattern; color change of skin; varicosities; cyanosis; clubbing; palpation of radial, ulnar, brachial, femoral, popliteal, posterior tibial, dorsalis pedis pulses; simultaneous radial pulses; calf tenderness; Homans's sign; edema; auscultate for femoral bruits

Neurologic

Mental Status Examination. (If appropriate, see sections "Psychiatric History and Physical," and "Psychiatric Mental Status Examination," page 13.)

Cranial Nerves. There are 12 cranial nerves, the functions of which are as follows:

- **I** Olfactory—Smell
- **II** Optic—Vision, visual fields, and fundi; afferent limb of pupillary response
- **III, IV, VI** Oculomotor, trochlear, abducens—Efferent limb pupillary response, ptosis, volitional eye movements, pursuit eye movements
- **V** Trigeminal—Corneal reflex (afferent), facial sensation, masseter and temporalis muscle tested by biting down
- **VII** Facial—Raise eyebrows, close eyes tight, show teeth, smile, or whistle, corneal reflex (efferent)
- **VIII** Acoustic—Test hearing by watch tick, finger rub, Weber–Rinne test (see also page 27) to be done if hearing loss noted on history or by gross testing. (Air conduction lasts longer than bone conduction in a normal person.)
- **IX, X** Glossopharyngeal and vagus—Palate moves in midline; gag; speech
- **XI** Spinal accessory—Shoulder shrug, push head against resistance.
- **XII** Hypoglossal—Stick out tongue. Strength can be tested by having the patient press tongue against the buccal mucosa on each side and the examiner can press a finger against the patient's cheek. Also look for fasciculations.

Motor. Strength should be tested in upper and lower extremities proximally and distally. (Grading system: 5 active motion against full resistance; 4 active motion against some resistance; 3 active motion against gravity; 2 active motion with gravity eliminated; 1 barely detectable motion; 0 no motion or muscular contraction detected)

Cerebellum. Romberg's test (see page 27)—heel to shin (should not be with assistance from gravity), finger to nose, heel and toe walking, rapid alternating movements upper and lower extremities

Sensory. Pain (sharp) or temperature distal and proximal upper and lower extremities, vibration using either a 128- or 256-Hz tuning fork or position sense distally upper and lower extremities, and stereognosis or graphesthesia. Identify any deficit using the dermatome and cutaneous innervation diagrams (see Figure 1–3).

Reflexes. Brachioradialis and biceps C5–6, triceps C7–8, abdominal (upper T8–10, lower T10–12), quadriceps (knee) L3–4–5, ankle S1–2, (Grading system: 4+ Hyperactive with clonus; 3+ brisker than usual; 2+ normal or average; 1+ decreased or less than normal; 0 absent). Check for pathologic reflexes: Babinski's sign, Hoffmann's sign, snout, others (see pages 21 to 27). **Pediatric patients:** Moro's reflex (startle) and suck reflexes

Database

Laboratory tests, x-rays ordered as indicated by the history and physical

Problem List

(See example page 31.) Should include entry date of problem, date of problem onset, problem number. (With initial problem list, the more severe problems are numbered first. After the initial list is generated, problems are added chronologically.) List problem by status: active or inactive.

Assessment (Impression)

A discussion and evaluation of the current problems with a differential diagnosis.

Plan: Additional laboratory tests, medical treatment, consults, etc.
Note: The history and physical examination should be legibly signed and your title noted. Each entry should be dated and timed.

PSYCHIATRIC HISTORY AND PHYSICAL

The elements of the psychiatric history and physical are identical to those of the basic history and physical outlined earlier. The main difference involves attention to the past psychiatric history and more detailed mental status examination as described in the following section.

Psychiatric Mental Status Examination

The following factors are evaluated as part of the psychiatric status examination.

- **Appearance:** Gestures, mannerisms, and so on
- **Speech:** Coherence, flight of ideas, and so on
- **Mood and Affect:** Depression, elation, anger, and so on
- **Thought Process:** Blocking, evasion, and so on
- **Thought Content:** Worries, hypochondriasis, lack of self-confidence, delusions, hallucinations, and so on
- **Motor Activity:** Slow, rapid, purposeful, and so on
- **Cognitive Functions:**
  Attention and concentration
  Memory (immediate, recent, and remote recall)
  Calculations
  Abstractions
  Judgment

Mini Mental Status Examination

A thorough mental status exam should be done on every geriatric patient, every patient with AIDS, and any patient suspected of having dementia. The mini mental status exam is a simple, practical test that takes only a few minutes and can be followed over time. It may show progression, improvement, or no changes in the underlying process. The mini mental status exam developed by Folstein, Folstein, and McHugh is discussed in detail in the *Journal of Psychiatric Research,* 1975, Vol. 12, pages 189–198. The test is divided into two sections: one assessing orientation, memory, and attention and the other testing the patient's ability to

write a sentence and to copy a diagram (usually two intersecting pentagons whose intersect forms a four-sided figure. Table 1–1 is the "Mini Mental State" Examination as outlined by Folstein and associates.

HEART MURMURS AND EXTRA HEART SOUNDS

Table 1–2 and Figure 1–1 describe the various types of heart murmurs and extra heart sounds.

BLOOD PRESSURE GUIDELINES

There is a clear association between hypertension and coronary artery and cerebrovascular disease.

Hypertension is defined as systolic BP >140 mm Hg or a diastolic BP >90 mm Hg in adults. Measure the BP after 5 min of rest with patient seated and arm at heart level. Use the bell of the stethoscope, the last sounds heard are the Korotkoff sounds, which are low-pitched. Take the average of two readings separated by 2 min. Elevated readings on three separate days should be obtained prior to diagnosing hypertension. Classification and follow-up recommendations for adults are shown in Table 1–3.

In children from age 1 to 10 years, systolic blood pressure can be calculated as follows:

Lower limits (5th percentile): 70 mm Hg + (child's age in years × 2)
Typical (50th percentile): 90 mm Hg + (child's age in years × 2)

DENTAL EXAMINATION

The dental examination is an often overlooked part of the history and physical. Many times, the patient may have some intraoral problem that is contributing to the overall medical condition (ie, the inability to eat due to a toothache, abscess, or ill-fitting denture in a poorly controlled diabetic) for which a dental consult may be necessary. Loose dentures can compromise the ability to manually maintain an open airway. In addition, in an emergency situation when intubation is necessary, complications may occur if the clinician is unfamiliar with the oral structures.

The patient may be able to give some dental history, including recent toothaches, abscesses, and loose teeth or dentures. Be sure to ask if the patient is wearing a removable partial denture (partial plate), which should be removed before intubation. As lost dentures are a chief dental complaint of hospitalized patients, care must be taken not to misplace the removed prosthesis.

A brief dental examination may be performed with gloved hand, two tongue blades, and a flashlight. Look for any obvious inflammation, erythema, edema, or ulceration of the gingiva (gums) and oral mucosa. Gently tap on any natural teeth to test for sensitivity. Place each tooth between two tongue blades and push gently to check for looseness. This is especially important for the maxillary anterior teeth, which serve as the fulcrum for the laryngoscope blade. Any abnormal dental findings should be noted and the appropriate consults obtained. Many diseases, including AIDS, STDs, pemphigus, pemphigoid, allergies, uncontrolled diabetes, leukemia, and others, may first manifest themselves in the mouth.

Hospitalized patients often have difficulty cleaning their teeth or dentures. This care should be added to the daily orders if indicated. Patients who will be receiving head and neck radiation must be examined and treated for any tooth extractions or dental infections before the initiation of the radiation therapy. Extractions after radiation to the maxilla and particularly the mandible may lead to osteoradionecrosis, a condition that may be impossible to control.

(*text continues on page 17*)

TABLE 1–1
The Mini Mental State Examination

Patient _____
Examiner _____
Date _____

"Mini Mental State"

Maximum Score	Score	
		Orientation
5		What is the (year) (season) (date) (day) (month)?
5		Where are we? (state) (county) (town) (hospital) (floor)
		Registration
3		Name 3 objects: 1 second to say each. Then ask the patient all 3 after you have said them. Give 1 point for each correct answer. Then repeat until he learns all 3. Count trials and record. Trials _____
		Attention and Calculation
5		Serial 7's: One point for each correct. Stop after 5 answers. Alternatively, spell "world" backward.
		Recall
3		Ask for the 3 objects repeated above. Give 1 point for each correct answer.
		Language
9		Point to a pencil, and watch and ask the patient to name it. (2 points) Repeat the following: "No if's, and's, or but's." (1 point) Follow a 3-stage command: "Take a paper in your right hand, fold it in half, and put it on the floor." (3 points) Read and obey the following: Close your eyes (1 point) Write a sentence (1 point) Copy design (1 point)

_____ Total Score

Assess level of consciousness along the following continuum

Alert Drowsy Stupor Coma

Source: Based on data from Folstein, Folstein, and McHugh: *J Psychiatr Res* 1975; **12:**189–198, 1975.

TABLE 1–2
Heart Murmurs and Extra Heart Sounds*

Type†	Description
A. Aortic stenosis (AS)	Heard best at second intercostal space. Systolic (medium-pitched) crescendo–decrescendo murmur with radiation to the carotid arteries. A_2 decreased, ejection click and S_4 often heard at apex. Paradoxical splitting of S_2. Narrow pulse pressure and delayed carotid upstroke and left ventricular hypertrophy (LVH) with lift at apex.
B. Aortic insufficiency (AI)	Heard best at left lower sternal border third and fourth interspace with patient sitting up, leaning forward and fully exhaled. Diastolic (high-pitched) decrescendo murmur. Often with LVH. Widened pulse pressure, bisferious pulse, Traube's sign, Quincke's sign, and Corrigan's pulse may be seen with chronic aortic insufficiency. S_3 and pulsus alternans often present with acute aortic insufficiency.
C. Pulmonic stenosis (PS)	Heard best at left second intercostal space. Systolic crescendo–decrescendo murmur. Louder with inspiration. Click often present. P_2 delayed and soft if severe. Right ventricular hypertrophy (RVH) with parasternal lift.
D. Pulmonic insufficiency (PI)	Heard best at left second intercostal space. Diastolic decrescendo or crescendo–decrescendo murmur. Louder with inspiration. RVH usually present.
E. Mitral stenosis (MS)	Localized at the apex. Diastolic (low-pitched rumbling sound) murmur heard best with the bell in the left lateral decubitus position. With increased or decreased S_1. Opening snap (OS) heard best at apex with diaphragm. Increased P_2, right-sided S_4, left-sided S_3 often present. RVH with parasternal lift may be present.
F. Mitral insufficiency (MI)	Heard best at apex. Holosystolic (high-pitched) murmur with radiation to axilla. Soft S_1, may be masked by murmur. S_3 and LVH often present. Midsystolic click suggests mitral valve prolapse.
G. Tricuspid insufficiency (TI)	Heard best at left lower sternal border. Holosystolic (high-pitched) murmur. Increases with inspiration. Right-sided S_3 often present. Large V wave in jugular venous pulsations.

(*continued*)

TABLE 1–2 (Continued)

Type†	Description
H. Atrial septal defect (ASD)	Heard best at left upper sternal border. Systolic (medium-pitched) murmur. Fixed splitting of S_2 and RVH, often with left- and right-sided S_4.
I. Ventricular septal defect (VSD)	Heard best at left lower sternal border. Harsh holosystolic (high-pitched) murmur with midsystolic peak. S_1 and S_2 may be soft.
J. Patent ductus arteriosus (PDA)	Heard best at left first and second intercostal space. Continuous, machinery (medium-pitched) murmur. Increased P_2 and ejection click may be present.
K. Third heard sound (S_3)	Early diastolic sound caused by rapid ventricular filling. Heard best with bell. Left-sided S_3 heard at apex, right-sided S_3 heard at left lower sternal border. Left-sided S_3 seen normally in young people, also pregnancy, thyrotoxicosis, mitral regurgitation, and congestive heart failure.
L. Fourth heart sound (S_4)	Late diastolic sound caused by a noncompliant ventricle. Heard best with bell. Left-sided S_4 heard at apex, right-sided S_4 heard at left lower sternal border. Left-sided S_4 seen with hypertension, aortic stenosis, and myocardial infarction. Right-sided S_4 seen with pulmonic stenosis and pulmonary hypertension.

*Refer to Figure 1–1 for graphic representations of murmurs.
†Capital letters preceding type of murmur refer to graphs in Figure 1–1.

Eruption of Teeth

The eruption of teeth may be of great concern to new parents. Often, parents think something is developmentally wrong with their child if teeth have not appeared by a certain age. The timing of tooth eruption varies tremendously. Factors contributing to this variation include family history, ethnic background, vitality during fetal development, position of teeth in the arch, size and shape of the dental arch itself, and, in the case of the eruption of permanent teeth, when the primary tooth was lost. Radiographs of the maxilla and mandible can determine whether or not the teeth are present. Figure 1–2 serves as a guide to the chronology of tooth eruption. Remember that variations may be greater than 1 year in some cases.

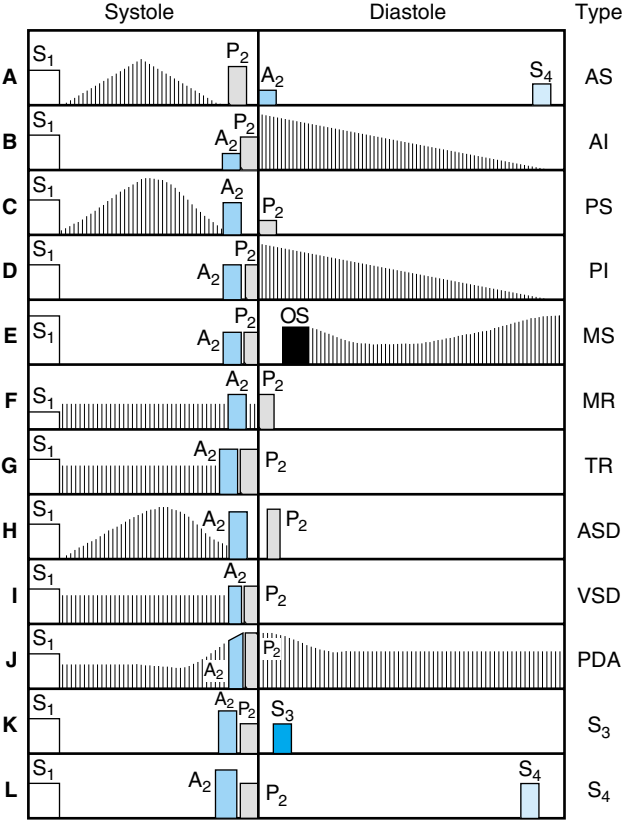


FIGURE 1–1 Graphic representation of common heart murmurs. See Table 1–2 for abbreviations and descriptions of murmurs.

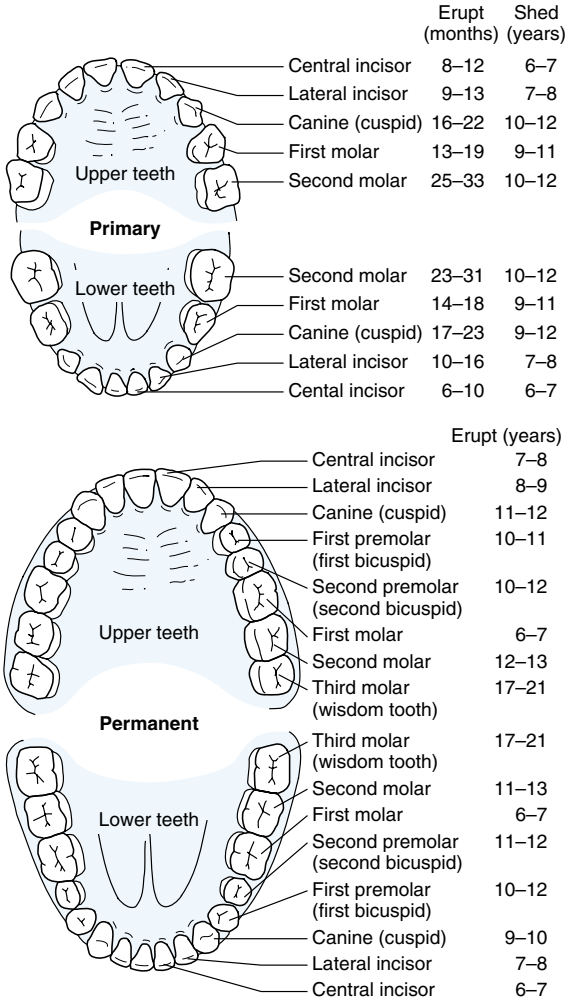


FIGURE 1–2 Dentition development sequences. The age when teeth are shed and erupt varies widely. (Based on data from: McDonald RE and Avery DR [eds]: *Dentistry for the Child and Adolescent,* Mosby, St. Louis, 1994. Used with permission.)

TABLE 1–3 Guidelines for Blood Pressure Management in Adults

CLASSIFICATION SYSTEM

Category	Systolic (mm Hg)	Diastolic (mm Hg)
Desired	<120	<80
Normal	<130	<85
High normal	130–139	85–89
Hypertension		
Stage 1	140–159	90–99
Stage 2	160–179	100–109
Stage 3	>180	>110

FOLLOW-UP RECOMMENDATIONS INITIAL SCREENING BP (MM HG)

Systolic	Diastolic	Action
<130	<85	Recheck in 2 years
130–139	85–89	Recheck in 1 yr
140–159	90–99	Confirm within 2 months
160–179	100–109	Evaluate or refer within 1 month
>180	>110	Evaluate or refer immediately or within 1 wk depending on the clinical situation

DERMATOLOGIC DESCRIPTIONS

Atrophy: Thinning of the surface of the skin with associated loss of normal markings. Examples: Aging, striae associated with obesity, scleroderma

Bulla: A superficial, well-circumscribed, raised, fluid-filled lesion greater than 1 cm in diameter. Examples: Bullous pemphigoid, pemphigus, dermatitis herpetiformis

Burrow: A subcutaneous linear track made by a parasite. Example: Scabies

Crust: A slightly raised lesion with irregular border and variable color resulting from dried blood, serum, or other exudate. Examples: Scab resulting from an abrasion, or impetigo

Ecchymoses: A flat, nonblanching, red-purple-blue lesion that results from extravasation of red blood cells into the skin. Differs from purpura in that ecchymoses are large purpura. Examples: Trauma, long-term steroid use

Erosion: A depressed lesion resulting from loss of epidermis due to rupture of vesicles or bullae. Example: Rupture of herpes simplex blister

Excoriation: A linear superficial lesion, which may be covered with dried blood. Early lesions with surrounding erythema. Often self-induced. Example: Scratching associated with pruritus from any cause

Fissure: A deep linear lesion into the dermis. Example: Cracks seen in athlete's foot

Keloid: Irregular, raised lesion resulting from scar tissue that is hypertrophied. Examples: Often seen with burns, and African-Americans are more prone to keloid formation.

Lichenification: A thickening of the skin with an increase in skin markings resulting from chronic irritation and rubbing. Example: Atopic dermatitis

Macule: A circumscribed nonpalpable discoloration of the skin less than 1 cm in diameter. Examples: Freckles, rubella, petechiae

Nodule: A solid, palpable, circumscribed lesion larger than a papule and smaller than a tumor. Examples: Erythema nodosum, gouty tophi

Papule: A solid elevated lesion less than 1 cm. Examples: Acne, warts, insect bites

Patch: A nonpalpable discoloration of the skin with an irregular border, greater than 1 cm in diameter. Example: Vitiligo

Petechiae: A flat pinhead-sized, nonblanching, red-purple lesion caused by hemorrhage into the skin. Example: Seen in DIC, ITP, SLE, meningococcemia (*Neisseria meningitidis*)

Plaque: A solid, flat, elevated lesion greater than 1 cm in diameter. Examples: Psoriasis, discoid lupus erythematosus, actinic keratosis

Purpura: A flat, nonblanching, red-purple lesion larger than petechiae caused by hemorrhage into the skin. Examples: Henoch–Schönlein purpura, TTP.

Pustule: A vesicle that is filled with purulent fluid. Examples: Acne, impetigo

Scales: Partial separation of the superficial layer of skin. Examples: Psoriasis, dandruff

Scar: Replacement of normal skin with fibrous tissue, often resulting from injury. Examples: Surgical scar, burn

Telangiectasia: Dilatation of capillaries resulting in red, irregular, clustered lines that blanch. Examples: Seen in scleroderma, Osler–Weber–Rendu disease, cirrhosis

Tumor: A solid, palpable, circumscribed lesion that is greater than 2 cm in diameter. Example: Lipoma

Ulcer: A depressed lesion resulting from loss of epidermis and part of the dermis. Examples: Decubitus ulcers, primary lesion of syphilis, venous stasis ulcer

Vesicle: A superficial, well-circumscribed, raised, fluid-filled lesion that is less than 1 cm in diameter. Examples: Herpes simplex, varicella (chickenpox)

Wheal: Slightly raised, red, irregular lesions that are transient and secondary to edema of the skin. Examples: Urticaria (hives), allergic reaction to injections or insect bites

DERMATOME AND CUTANEOUS INNERVATION

The diagrams (Figures 1–3A and B) demonstrate dermatome levels and cutaneous innervation distribution useful in the physical examination.

PHYSICAL SYMPTOMS AND EPONYMS

Allen's Test: (See Chapter 13, page 246.)

Apley's Test: Determination of meniscal tear in the knee by grinding the joint manually

Argyll–Robertson Pupil: Bilaterally small, irregular, unequal pupils that react to accommodation but not to light. Seen with tertiary syphilis

Austin Flint Murmur: Late diastolic mitral murmur; associated with aor1ic insufficiency with a normal mitral valve

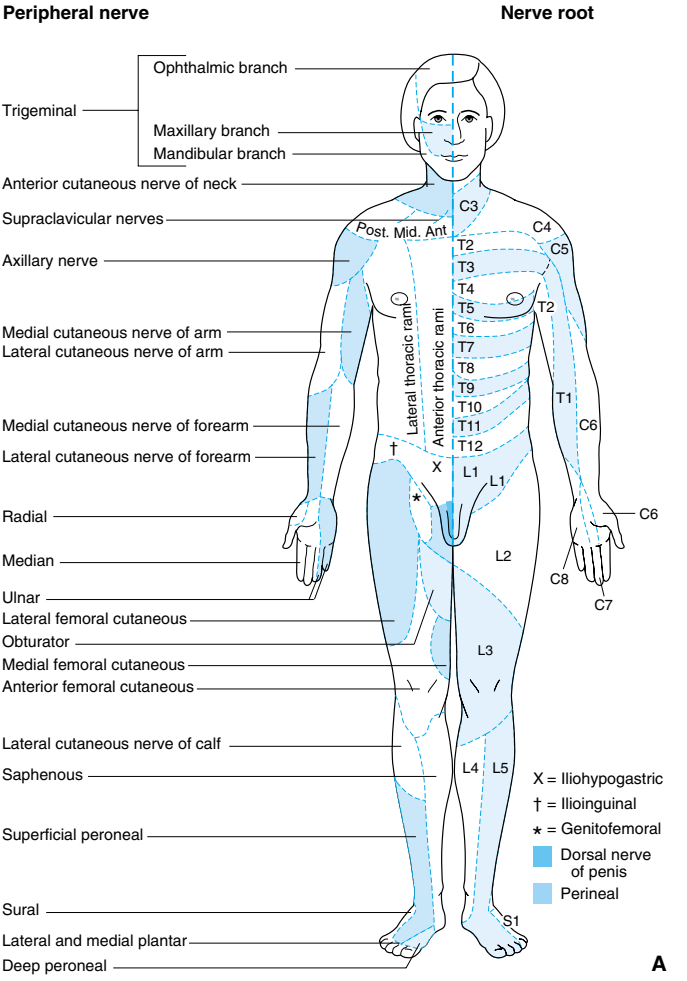


FIGURE 1–3 **A:** Dermatomes and cutaneous innervation patterns, anterior view. (Reprinted, with permission, from: Aminoff MJ et al [eds]: *Clinical Neurology,* 3rd ed, Appleton & Lange, Stamford CT, 1996.)

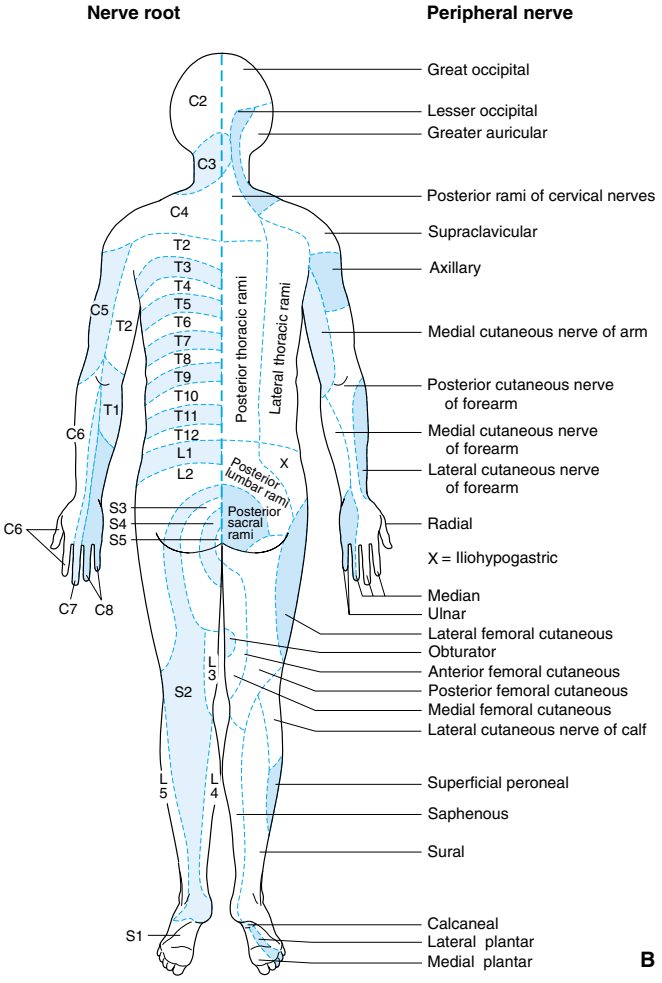


FIGURE 1–3 **B:** Dermatomes and cutaneous innervation patterns, posterior view. (Reprinted, with permission, from: Aminoff MJ et al [eds]: *Clinical Neurology,* 3rd ed, Appleton & Lange, Stamford CT, 1996.)

Babinski's Sign: Extension of the large toe with stimulation of the plantar surface of the foot instead of the normal flexion; indicative of upper motor neuron disease (normal in neonates)

Bainbridge's Reflex: Increased heart rate due to increased right atrial pressure

Battle's Sign: Ecchymosis behind the ear associated with basilar skull fractures.

Beau's Lines: Transverse depressions in nails due to previous systemic disease

Beck's Triad: JVD, diminished or muffled heart sounds, and decreased blood pressure associated with cardiac tamponade

Bell's Palsy: Lower motor neuron lesion of the facial nerve affecting muscles of upper and lower face. Easily distinguished from upper motor lesions, which affect predominately muscles of lower face since upper motor neurons from each side innervate muscles on both sides of the upper face

Bergman's Triad: Altered mental status, petechiae, and dyspnea associated with fat embolus syndrome

Biot's Breathing: Seen with brain injury; abruptly alternating apnea and equally deep breaths

Bisferious Pulse: A double-peaked pulse seen in severe chronic aortic insufficiency

Bitot's Spots: Small scleral white patches suggesting vitamin A deficiency

Blumberg' Sign: Pain felt in the abdomen when steady constant pressure is quickly released. Seen with peritonitis

Blumer's Shelf: Hardness palpable on rectal examination due to metastatic cancer of the rectouterine (pouch of Douglas) or rectovesical pouch

Bouchard's Nodes: Hard, nontender, painless nodules in the dorsolateral aspects of the proximal interphalangeal joints associated with osteoarthritis. Results from hypertrophy of the bone

Branham's Sign: With large AV fistulas, abrupt slowing of the heart rate with compression of the feeding artery

Brudzinski's Sign: Flexion of the neck causing flexion of the hips in meningitis

Chadwick's Sign: Bluish color of cervix and vagina, seen with pregnancy

Chandelier's Sign: Extreme pain elicited with movement of the cervix during bimanual pelvic examination. Indicates PID

Charcot's Triad: Right upper quadrant pain, fever (chills), and jaundice associated with cholangitis

Cheyne–Stokes Respiration: Repeating cycle of a gradual increase in depth of breathing followed by a gradual decrease to apnea; seen with CNS disorders, uremia, some normal sleep patterns

Chvostek's Sign: Tapping over the facial nerve causes facial spasm in hypocalcemia (tetany). May be normal finding in some patients

Corrigan's Pulse: A palpable hard pulse immediately followed by sudden collapse, seen in aortic regurgitation

Cullen's Sign: Ecchymosis around the umbilicus associated with severe intraperitoneal bleeding. Seen with ruptured ectopic pregnancy and hemorrhagic pancreatitis

Cushing's Triad: Hypertension, bradycardia, and irregular respiration associated with increased intracranial pressure

Darier's Sign: Stroking of the skin causes erythema and edema in mastocytosis

Doll's Eyes: Conjugated movement of eyes in one direction as head is briskly turned in the other direction in comatose patients. Tests oculocephalic reflex indicating intact brain stem

Drawer Sign: Forward (or backward) movement of the tibia with pressure, indicating laxity or a tear in the anterior (or posterior) cruciate ligament

Dupuytren's Contracture: Proliferation of fibrosis tissue of the palmar fascia resulting in contracture of the fourth and/or fifth digits, which is often bilateral. May be hereditary or seen in patients with chronic alcoholic liver disease or seizures

Duroziez's Sign: Found in aortic regurgitation a "to and fro" murmur when stethoscope is pressed over the femoral artery

Electrical Alternans: Beat to beat variation in the electrical axis, seen in large pericardial effusions, suggests impending hemodynamic compromise

Ewart's Sign: Dullness to percussion, increased fremitus and bronchial breathing beneath the angle of the left scapula found with pericardial effusion

Fong Lesion/Syndrome: Autosomal-dominant anomalies of the nails and patella associated with renal abnormalities

Frank's Sign: Fissure of the ear lobe; may be associated with CAD, diabetes, and hypertension

Gibbus: Angular convexity of the spine due to vertebral collapse; associated with osteoporosis or metastasis

Gregg's Triad: Cataracts, heart defects, and deafness with congenital rubella

Grey Turner's Sign: Ecchymosis in the flank associated with retroperitoneal hemorrhage

Grocco's Sign: Triangular area of paravertebral dullness, opposite side of a pleural effusion

Heberden's Nodes: Hard, nontender, painless nodules on the dorsolateral aspects of the distal interphalangeal joints associated with osteoarthritis. Results from hypertrophy of the bone

Hegar's Sign: Softening of the distal uterus. Reliable early sign of pregnancy

Hellenhorst's Plaque: A cholesterol plaque on retina seen on funduscopic examination associated with amaurosis fugax

Hill's Sign: Femoral artery pressure 20 mm Hg greater than brachial pressure seen in severe aortic regurgitation

Hoffmann's Sign/Reflex: Flicking of the volar surface of the distal phalanx causing fingers to flex; associated with pyramidal tract disease

Homans' Sign: Calf pain with forcible dorsiflexion of the foot, associated with venous thrombosis

Horner's Syndrome: Unilateral miosis, ptosis, and anhidrosis (absence of sweating). From destruction of ipsilateral superior cervical ganglion often from lung carcinoma, especially squamous cell carcinoma

Janeway's Lesion: Erythematous or hemorrhagic lesion seen on the palm or sole with subacute bacterial endocarditis

Joffroy's Reflex: Inability to wrinkle the forehead when patient asked to bend head and look up, seen in hyperthyroidism

Kayser–Fleischer Ring: Brown pigment lesion due to copper deposition seen in Wilson's disease

Kehr's Sign: Left shoulder and left upper quadrant pain associated with splenic rupture

Kernig's Sign: When the thigh is flexed at a right angle, complete extension of the leg is not possible because of inflammation of the meninges; seen with meningitis

Koplik's Spots: White papules on buccal mucosa opposite molars seen in measles

Korotkoff's Sounds: Low-pitched sounds resulting from vibration of the artery, detected when obtaining a blood pressure using the bell of the stethoscope. The last Korotkoff sound may be a more accurate estimate of the true diastolic blood pressure than the diastolic blood pressure obtained using the diaphragm.

Kussmaul's Respiration: Deep, rapid respiratory pattern seen in coma or DKA

Kussmaul's Sign: Paradoxical rise in the jugular venous pressure on inspiration in constrictive pericarditis or COPD

Kyphosis: Excessive rounding of the thoracic spinal convexity, associated with aging, especially in women

Lasègue's Sign/Straight-Leg-Raising Sign: The patient is extended in the supine position and raises the leg gently. Pain in the distribution of nerve root suggests sciatica.

Levine's Sign: Clenched fist over the chest while describing chest pain; associated with angina and AMI

Lhermitte's Sign: In MS, neck flexion results in a "shock sensation."

List: Lateral tilt of the spine, frequently associated with herniated disk and muscle spasm

Lordosis: Accentuated normal concavity of the lumbar spine, normal in pregnancy

Louvel's Sign: Coughing or sneezing causes pain in the leg with DVT

Marcus–Gunn Pupil: Dilation of pupils with swinging flashlight test. Results from unilateral optic nerve disease. Normal pupillary response is elicited when light is directed from the normal eye and a subnormal response when light is quickly directed from the normal eye into the abnormal eye. When light is directed into the abnormal eye, both pupils dilate rather than maintain the previous degree of miosis.

McBurney's Point/Sign: Point located one-third of the distance from the anterior superior iliac spine to the umbilicus on the right; tenderness at the site is associated with acute appendicitis.

McMurray's Test: External rotation of the foot produces a palpable or audible click on the joint line, suggesting medial meniscal injuries

Möbius' Sign: Weakness of convergence seen in thyrotoxicosis

Moro's Reflex (Startle Reflex): Abduction of hips and arms with extension of arms when infant's head and upper body is suddenly dropped several inches while being held. Normal reflex in early infancy

Murphy's Sign: Severe pain and inspiratory arrest with palpation of the right upper quadrant during deep inspiration; associated with cholecystitis

Musset's or de Musset's Sign: Rhythmic nodding or movement of the head with each heart beat caused by blood flow back into the heart in aortic insufficiency

Obturator Sign: Flexion and internal rotation of the thigh elicits hypogastric pain in cases of inflammation of the obturator internus; positive with pelvic abscess and appendicitis

Ortolani's Test/Sign: Sign is hip click that suggests congenital hip dislocation. With the infant supine, point the legs toward you and flex the legs to 90 degrees at the hips and knees.

Osler's Node: Tender, red, raised lesions on the hands or feet seen with SBE.

Pancoast's Syndrome: Carcinoma involving apex of lung, resulting in arm and or shoulder pain from involvement of brachial plexus and Horner's syndrome from involvement of the superior cervical ganglion

Pastia's Lines: Linear striations of confluent petechiae in axillary folds are antecubital fossa seen in scarlet fever

Phalen's Test: Prolonged maximum flexion of wrists while opposing dorsum of each hand against each other. A positive test results in pain and tingling in the distribution of the median nerve, indicating carpal tunnel syndrome

Psoas Sign (Iliopsoas Test): Flexion against resistance or extension of the right hip, producing pain; seen with inflammation of the psoas muscle; positive with appendicitis.

Pulsus Alternans: Fluctuation of pulse pressure with every other beat. Seen in aortic stenosis and CHF

Queckenstedt's Test: Tests patency of the subarachnoid space; compression of the internal jugular vein during lumbar puncture; should normally immediately raise CSF pressure

Quincke's Sign: Alternating blushing and blanching of the fingernail bed following light compression; seen in chronic aortic regurgitation

Radovici's Sign: A frontal release sign, scratching palm causes chin contractions

Raynaud's Phenomenon/Disease: Pain and tingling in fingers after exposure to cold with characteristic color changes of white to blue and then often red. May be seen with scleroderma, and SLE

Romberg's Test: Used to test position sense or cerebellar function. The patient stands with heels and toes together. Arms may be outstretched with palms facing upward or down or arms can be at the patient's side. The patient may be lightly tapped by the examiner with the eyes open and then closed. A positive test is a loss of balance. A loss of balance with the eyes open indicates cerebellar dysfunction. Normal balance with eyes open and loss of balance with eyes closed indicates loss of position sense.

Roth's Spots: Oval retinal hemorrhages with a pale central area occurring in patients with bacterial endocarditis

Rovsing's Sign: Pain in the right lower quadrant with deep palpation of the left lower quadrant. Seen in acute appendicitis

Schmorl's Node: Degeneration of the intervertebral disk resulting in herniation into the adjacent vertebral body

Scoliosis: Lateral curvature of the spine

Sentinel Loop: A single dilated loop of small or large bowel, usually occurs localized inflammation such as pancreatitis

Sister Mary Joseph's Sign/Node: Metastatic cancer to umbilical lymph node

Stellwag's Sign: Infrequent ocular blinking

Tinel's Sign: Radiation of an electric shock sensation in the distal distribution of the median nerve elicited by percussion of the flexor surface of the wrist when fully extended. Seen in carpal tunnel syndrome

Traube's Sign: Booming or pistol shot sounds heard over the femoral arteries in chronic aortic insufficiency

Trendelenburg's Test: Observe patient from behind while patient shifts weight from one leg to the other; a pelvis tilt to opposite side suggests hip disease and weakness of the gluteus medius muscle. If normal, pelvis will not tilt.

Trousseau's Sign: Carpal spasm produced by inflating a blood pressure cuff above the systolic pressure for 2–3 min, indicates hypocalcemia; also migratory thrombophlebitis associated with cancer

Turner's Sign: See Grey Turner's sign

Virchow's Node (Signal or Sentinel Node): A palpable, left supraclavicular lymph node; often first sign of a GI neoplasm, such as pancreatic or gastric carcinoma

von Graefe's Sign: Lid lag associated with thyrotoxicosis

Weber–Rinne Test: For the Weber test a 512- or 1024-Hz tuning fork is placed on the middle of the skull to determine if the sound lateralizes. For the Rinne test, the tuning fork is held against the mastoid process (BC) with the opposite ear covered. The patient indicates when the sound is gone. The tuning fork is then held next to the ear and the patient indicates whether the sound is present and when the sound (AC) disappears. Normally AC is better than BC. With sensorineural hearing loss, the Weber test lateralizes to the less affected ear and AC > BC; with conduction hearing loss, the Weber test lateralizes to the more affected ear and BC > AC.

Whipple's Triad: Hypoglycemia, CNS, and vasomotor symptoms (ie, diaphoresis, syncope); relief of symptoms with glucose; associated with insulinoma

EXAMPLE OF A WRITTEN HISTORY AND PHYSICAL EXAMINATION

(Adult Admitted to a Medical Service)

- 7/10/01 5:30 PM

Identification: Mr. Robert Jones is a 50-year-old male referred by Dr. Harry Doyle from Whitesburg, Kentucky. The informant is the patient, who seems reliable, and a photocopy of the ER records from Whitesburg Hospital accompanies the patient.

Chief Complaint: "Squeezing chest pain for 10 h, 4 d ago"

HPI: Mr. Jones awoke at 6 AM 3 d ago with squeezing substernal chest pain that felt "like a ton of bricks" sitting on his chest. The chest pain was a 9 on a 10-point scale, with 10 being pain from a kidney stone. The pain was progressively worse after its onset and decreased in intensity after going to the Whitesburg ER. The pain radiated to his left neck and elbow and was associated with dyspnea and diaphoresis. He denies experiencing any associated nausea. He notes the pain seemed to get worse with any movement, and nothing seemed to alleviate it.

He presented to the Whitesburg ER 10 h after the onset of pain and was given 3 NTG tablets SL and 2 mg morphine sulfate. ECG revealed 3 mm ST depression in leads V_1 through V_4. He was admitted to the ICU at Whitesburg Hospital and had an uneventful course. CPK increased to 850 at 24 h. He has been on aspirin 325 mg/d PO, isosorbide dinitrate 20 mg PO q6h, and diltiazem 60 mg PO q8h. He was transferred for possible cardiac catheterization.

He notes a similar chest pain that was less intense and occurred intermittently over the last 3 mo. The pain was precipitated by exercise and relieved with rest. He denies seeking medical attention in the past. He denies a history of orthopnea, paroxysmal nocturnal dyspnea, dyspnea on exertion, or pedal edema.

He has smoked two packs of cigarettes per day for 35 years, notes a 2-y history of hypertension for which he has been taking HCTZ 25 mg/d and denies a history of hypercholesterolemia or diabetes.

The patient's father died of an MI at age 54, and his brother underwent coronary artery bypass graft surgery last year at age 48.

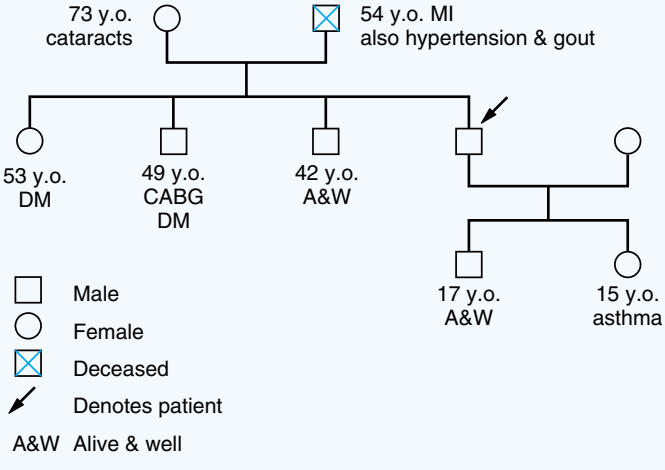
PMH

Medications. As above and ranitidine 300 mg PO qhs. Occasional ibuprofen 200 mg two to three tablets PO for back pain and acetaminophen 500 mg PO for headache

Vitamins. One-a-day
Herbals. None
Allergies. Penicillin, rash entire body 20 years of age
Surgeries. Appendectomy age 20, Dr. Smith, Whitesburg
Hospitalization. See above.
Trauma. Roof fall in mine accident 10 years ago, injured back. Notes occasional pain, which is relieved with ibuprofen 200 mg two or three tablets at a time
Transfusions. None
Illnesses. Denies asthma, emphysema, thyroid disease, kidney disease, peptic ulcer disease, cancer, bleeding disorders, tuberculosis, or hepatitis. He notes a several-year history of water brash/heartburn and has been on ranitidine for 1 year

Routine Health Maintenance. Last diphtheria/tetanus immunization 3 years ago. Stools for guaiac were negative times 3. Refused sigmoidoscopy. He has been seen by Dr. Doyle every 3–4 months for the last 2 years for hypertension.

Family History



Psychosocial History: Mr. Jones has been married for 25 years and has three children. He and his family live in a home on 3 acres about three miles from Whitesburg. He worked in a coal mine until 10 years ago when he was injured in a "roof fall." He is currently employed in a local chair factory. He graduated from high school. He is Baptist and attends church regularly. Hobbies include woodworking and gardening. He eats breakfast and supper every day and has a soft drink and crackers for lunch. He currently works 8 h/d Monday through Friday. He notes going to bed every day by 10:00 PM and awakens at 5:30 AM. He drinks one to two cups of coffee per day and denies drinking any alcohol. He denies drug use but smokes as noted earlier. He denies exposure to environmental toxins. He denies any financial problems but is concerned about how his illness will affect his income. He has "good" health insurance. He denies any other stressor in his life. His sources of support are his wife, minister, and a sister who lives near the patient.

ROS: Negative unless otherwise noted.

Eyes. Has worn reading glasses since 1995; notes blurred vision for 1 year; last eye appointment 1996. Denies loss of vision, double vision, or history of cataracts.

Respiratory. Notes cough every morning and has produced 1 teaspoon of gray sputum for years. Denies hemoptysis or pleuritic chest pain. Last chest x-ray prior to today was 3 years ago. All other ROS negative.

PHYSICAL EXAMINATION

General: Mr. Jones is a pleasant male lying comfortably supine in bed. He appears to be the stated age.

Vital Signs: Temp 98.6°F orally. Resp 16, HR 88 and regular, BP 110/70 left arm supine

Skin: Tattoo left arm, otherwise no lesions

Node: 1 × 1 left axillary node, nontender and mobile. No other lymphadenopathy

HEENT

Head. Normocephalic, atraumatic, nontender, no lesions

Eyes. Visual acuity 20/40 left and right corrected. External structures normal, without lesions, PERRLA. EOM intact. Visual fields intact. Funduscopic examination disks sharp bilaterally, moderate arteriolar narrowing and A-V nicking.

Ears. Hearing intact to watch tick at 3 ft bilaterally. Tympanic membranes intact with good cone of light bilaterally

Nose. Symmetrical. No lesions. Sinuses nontender

Mouth. Several dental fillings, otherwise normal dentition. No lesions

Neck. Full ROM without tenderness. No masses or lymphadenopathy. Carotids +2/4 bilaterally, no bruits. Internal jugular vein visible 2 cm above the sternal angle, patient at 30 degrees.

Chest: Symmetrical expansion. Fremitus by palpation bilaterally equal. Diaphragm moves 5.5 cm bilaterally by percussion. Lung fields clear to percussion. Breath sounds normal except end-inspiratory crackles heard at both bases that do not clear with coughing.

Breast: Normal to inspection and palpation

Heart: No cardiac impulse visible. Apical impulse palpable at the sixth intercostal space 2 cm lateral to the midclavicular line. Normal S_1, physiologically split S_2. S_4 heard at apex. No murmurs, rub, or S_3.

Abdomen: Flat, no scars. Positive bowel sounds. No bruits. Liver 10 cm midclavicular line. No CVA tenderness. No hepatomegaly or splenomegaly by palpation. No tenderness or guarding. No inguinal lymphadenopathy

Genital: Normal circumcised male, both testes descended without masses or tenderness

Rectal: Normal sphincter tone. No external lesions. Prostate smooth without tenderness or nodules. No palpable masses. Stool present, stool for occult blood negative

Musculoskeletal: Lumbar spine decreased flexion to 75 degrees, extension to 5 degrees, decreased rotary and lateral movement. Otherwise full ROM of all joints, no erythema, tenderness, or swelling. No clubbing cyanosis or edema

Peripheral Vascular: Radial, ulnar, brachial, femoral, dorsalis pedis, and posterior tibial pulses +2/4 bilaterally. Popliteal pulses nonpalpable. No femoral bruits

Neurologic: Cranial nerves: I through XII intact. Motor: +5/5 upper and lower extremity, proximally and distally. Sensory intact to pinprick upper and lower extremities proximally and distally. Vibratory sense intact in great toes and thumbs bilaterally. Stereognosis intact

Reflexes. Biceps, triceps, brachioradialis, quadriceps, and ankles +2/4 bilaterally. Toes down going bilaterally

Cerebellum. Romberg's sign negative. Intact finger-to-nose and heel-to-shin bilaterally; gait normal—normal heel-and-heel, toe-and-toe, and heel-to-toe gaits. Rapid alternating movements intact upper and lower extremities bilaterally

DATABASE

ECG. HR 80, NSR inverted T waves V_1 through V_5

CXR. Cardiomegaly, otherwise clear
UA. Normal
PT, PTT. Normal
Chemistry Profile. Normal. Except elevated CPK
CBC. 6700 WBC; 49 Hct; HBG 16; 40 S, 5 B, 44 L, 5 M, 6 E

ASSESSMENT AND PLAN

Coronary Artery Disease: Mr. Jones presented with a classic history for MI. The CPK and electrocardiogram support the diagnosis. The ST depression without evolving Q waves was consistent with a nontransmural MI. Mr. Jones is at risk for further MI since it was a nontransmural MI, and he will require further evaluation before discharge.

- Continue aspirin 325 mg/d PO and diltiazem 60 mg/d PO.
- Change isosorbide to tid prior to discharge.
- Monitor by telemetry unit for next 24–48 h.
- Stress test by modified Bruce protocol prior to discharge.
- Consider cardiac catheterization especially if any further pain or if an early positive stress test.
- Continue cardiac rehabilitation.

Hypertension: In view of the patient's age, sex, and degree of hypertension, and the fact that there is no evidence of a secondary cause, the hypertension is most likely primary in nature. It is important that blood pressure be well controlled after this infarct. Mr. Jones' blood pressure has been well controlled on diltiazem alone.

- Continue diltiazem.
- Dietary consult to instruct patient on low-sodium as well as low-fat diet prior to discharge.
- Continue discussion of other problems as shown earlier.

Signature: _____
Title: _____

Date Entered	Date of Onset	Problem	Active	Inactive	Date Inactive
7-10-01	4-01	1	Coronary artery disease		
7-10-01	7-7-01	1a	Subendocardial MI—anterior		
7-10-01	1998	2	Hypertension		
7-10-01	1997	3	Bronchitis		
7-10-01	1999	4	Heartburn/reflux esophagitis		
7-10-01	1990	5	Back injury		
7-10-01	7-10-01	6	Eosinophilia		
7-10-01	2000	7	Blurred vision		
7-10-01	1970	8		Appendicitis	1970

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2

CHARTWORK

HOW TO WRITE ORDERS

The following format is useful for writing concise admission, transfer, and postoperative orders. It involves the mnemonic "A.D.C. VAAN DIML," which stands for **A**dmit/Attending, **D**iagnosis, **C**ondition, **V**itals, **A**ctivity, **A**llergies, **N**ursing procedures, **D**iet, **I**ns and outs, **M**edications, and **L**abs.

A.D.C. Vaan Diml

Admit: Admitting team, room number
Attending: The name of the attending physician, the person legally responsible for the patient's care. Also include the resident's and intern's names.
Diagnosis: List admitting diagnosis or procedure if postop orders.
Condition: Stable, critical, etc
Vitals: Determine frequency of vital signs (temperature, pulse, blood pressure, central venous pressure, pulmonary capillary wedge pressure, weight, etc)
Activity: Specify bedrest, up ad lib, ambulate qid, bathroom privileges, etc
Allergies: Note any drug reactions or food or environmental allergies.
Nursing Procedures
Bed Position. Elevate head of bed 30 degrees, etc
Preps. Enemas, scrubs, showers
Respiratory Care. P&PD. TC&DB, etc
Dressing Changes, Wound Care. Change dressing bid, etc
Notify House Officer If. Temperature >101°F, BP <90 mm Hg, etc
Diet: NPO, clear liquid, regular, etc
Ins and Outs: Refers to all "tubes" a patient may have.
Record Daily I&O.
IV Fluids. Specify type and rate.
Drains. NG to low wall suction, Foley to gravity, etc

Endotracheal Tubes, Arterial Lines, Pulmonary-Artery Catheters. Specify care desired.

Medications: Write orders for specific medications (eg, diuretic, antibiotics, hormones, etc) and symptomatic drugs as needed (eg, pain medications, laxatives, "sleepers"). Include dose frequency and special instructions, ie, take with food.

Labs: Indicate studies and specify times desired if applicable. This includes ECGs, x-rays, nuclear scans, consultation requests, etc.

PROBLEM-ORIENTED PROGRESS NOTE

(See Chapter 20 for a sample ICU progress note.)

1. List each medical, surgical, psychiatric problem separately: pneumonia, pancreatitis, congestive heart failure, etc.
2. Give each problem a call number: 1, 2, 3,…(as on page 31).
3. Retain the number of each problem throughout the hospitalization.
4. When the problem is resolved, mark it as such and delete it from the daily progress note.
5. Evaluate each problem by number in the following SOAP format. Or, you may do a separate assessment and plan for each problem

Soap

Subjective
- How the patient feels, any complaints

Objective
- How the patient looks
- Vital signs
- Physical examination
- Laboratory data, etc

Assessment: (for each problem)
- Evaluation of the data and any conclusions that can be drawn

Plan: (for each problem)
- Any new lab tests or medications
- Changes or additions to orders
- Discharge or transfer plans

DISCHARGE SUMMARY/NOTE

A formal discharge note is usually required for any admission that is longer than 24 h at most hospitals. This note provides a framework for the complete dictated note as well as providing a reference, if needed, before the dictated note is transcribed and filed. The following skeleton includes most of the information needed for a discharge note.

Date of Admission:
Date of Discharge:
Admitting Diagnosis:
Discharge Diagnosis:
Attending Physician and Service Caring for Patient:
Referring Physician: Provide address if available.
Procedures: Include surgery and any invasive diagnostic procedures, eg, lumbar punctures, arteriograms.

Brief History, Pertinent Physical and Lab Data: Briefly review the main points of the history, physical, and admission lab tests. Do not repeat what is available in the admission note; summarize the most important points about the patient's admission.
Hospital Course: Briefly summarize the evaluation, treatment, and progress of the patient during the hospitalization.
Condition at Discharge: Note if improved, unchanged, etc.
Disposition: Where was the patient discharged to (eg, home, another hospital, nursing home)? Try to give specific address if transferred to another medical institution, and note who will be assuming responsibility for the patient.
Discharge Medications: List medications, dosing, refills.
Discharge Instructions and Follow-up: Clinic return date, diet instructions, activity restrictions, etc
Problem List: List active and past medical problems.

ON-SERVICE NOTE

Also known as a "pick-up note," the on-service note is written by a new member of the team taking over the care of a patient who has been on the service for some time. The note should be brief and summarize the hospital course to date as well as demonstrate that the new team member has reviewed the patient's care to date. The following skeleton includes most of the information needed in an on-service note.

Date of Admission:
Admitting Diagnosis:
Procedures (with Results) to Date:
Hospital Course to Date: This should be briefly summarized.
Brief Physical Examination: Pertinent to the patient's problems.
Pertinent Lab Data:
Problem List:
Assessment:
Plan:

OFF-SERVICE NOTE

This is written by the team member who is rotating off the service but who was primarily responsible for the patient before the patient is ready for discharge. The components are identical to the "On-Service" note in the previous section.

BEDSIDE PROCEDURE NOTE

Procedure: (eg, LP, thoracentesis, etc)
Indications: (eg, R/O meningitis, symptomatic pleural effusion)
Permit: Note risks and benefits explained and indicate signed and on chart
Physicians: Note physicians present and responsible for procedure
Description of Procedure: Indicate type of positioning, prep, anesthesia, and amount. Briefly describe technique and instruments used.
Complications: List.
EBL: List.
Specimens/Findings Obtained: (eg, opening pressure for LP, CSF appearance, and tubes sent to lab, etc)
Disposition: Describe patient's status after procedure (eg, Patient alert and oriented with no complaints; BP stable)

PREOPERATIVE NOTE

The specific items in the preoperative note depend on institutional guidelines, the nature of the procedure, and the age and health of the patient. For example, an ECG and blood set-up may not be necessary for a 2-year-old child being treated for a hernia but essential for a 70-year-old scheduled for vascular surgery. The following list includes most of the information needed in a preoperative note.

Preop Diagnosis: Such as "acute appendicitis"
Procedure: The planned procedure, eg, "exploratory laparotomy"
Labs: Results of CBC, electrolytes, PT, PTT, urinalysis, etc
CXR: Note results.
ECG: Note results.
Blood: T&C 2 units PRBC, blood not needed, etc
History and Physical: Should be "on chart."
Orders: Note any special preop orders, such as preop colon preps, vaginal douches, prophylactic antibiotics.
Permit: If completed, write "signed and on chart"; if not, indicate plans for obtaining permit.

OPERATIVE NOTE

The operative note is written immediately after surgery to summarize the operation for those who were not present and is meant to complement the formal operative summary dictated by the surgeon. The following list includes most of what is needed in an operative note.

Preop Diagnosis: Reason for the surgery, eg, "acute appendicitis"
Postop Diagnosis: Based on the operative findings, eg, "mesenteric lymphadenitis"
Procedure: Surgery performed, eg, "exploratory laparotomy"
Surgeons: List the attending physicians, residents, and students who scrubbed on the case, including their titles (MD, CCIV, MSII, etc). It is often helpful to identify the dictating surgeon.
Findings: Briefly note operative findings, eg, "normal appendix with marked lymphadenopathy."
Anesthesia: Specify the type of anesthesia, eg, local, spinal, general, endotracheal, etc.
Fluids: Amount and type of fluid administered during case, eg, 1500 mL NS, 1 unit PRBC, 500 mL albumin. This is usually obtained from the anesthesia records.
EBL: Usually obtained from the anesthesia or nursing records.
Drains: State location and type of drain, eg, "Jackson–Pratt drain in left upper quadrant," "T-tube in midline," etc.
Specimens: State any samples sent to pathology and the results of examination of any intraoperative frozen sections.
Complications: Note any complications during or after the surgery.
Condition: Note where the patient is taken immediately after surgery and the patient's condition. Example: "Transferred to the recovery room in stable condition."

NIGHT OF SURGERY NOTE (POSTOP NOTE)

This type of progress note is written several hours after or the night of surgery.

Procedure: Indicate the operation performed.
Level of Consciousness: Note if the patient is alert, drowsy, etc.

Vital Signs: BP, pulse, respiration.
I&O: Calculate amount of IV fluids, blood, urine output, and other drainage, and attempt to assess fluid balance.
Physical Examination: Examine and note the findings of the chest, heart, abdomen, extremities, and any other part of the physical examination pertinent to the surgery; examine the dressing for bleeding.
Labs: Review lab results if any were obtained since surgery.
Assessment: Evaluate the postop course thus far (stable, etc).
Plan: Note any changes in orders.

DELIVERY NOTE

__ -year-old (married or single) G __ now para __, AB __, clinic (note if patient received prenatal clinic care) patient with EDC __, and a prenatal course (uncomplicated or describe any problems). Any comments concerning labor (eg, Pitocin-induced, premature rupture) and draped in the usual sterile fashion. Under controlled conditions delivered a __ lb __ oz (__ g) viable male or female infant under __ (general, spinal, pudendal, none) anesthesia. Delivery was via SVD with midline episiotomy (or forceps or cesarean section). Apgars were __ at 1 min and __ at 5 min (for Apgar scoring, see Appendix). State delivery date and time. Cord blood sent to lab and placenta expressed intact with trailing membranes. Lacerations of the __ degree repaired by standard method with good hemostasis and restoration of normal anatomy.

- EBL:
- MBT:
- HCT (predelivery and postdelivery):
- RT:
- VDRL test:
- Condition of mother:

OUTPATIENT PRESCRIPTION WRITING

The format for outpatient prescription writing is outlined in the following list and illustrated in Figure 2–1. Controlled substances, such as narcotics, require a DEA number on the prescription and in some states may require that the controlled substance be written on a special type of prescription paper (see Chapter 22 for controlled drugs indicated by a [C]). For security, the DEA number should never be preprinted on a prescription pad but written by hand at the time the prescription is written.

Elements of an outpatient prescription include:

Patient's Name, Address, and Age: Print clearly where indicated.
Date: State requirements vary, but most prescriptions must be filled within 6 months.
Rx: Drug name, strength, and type (usually listed as the generic name); if you specifically want a brand name you must designate "no substitution." Rx is an abbreviation from the Latin for "recipe." List the strength of the product (usually in mg) and the form (eg, tablets, capsule, suspension, transdermal, etc).
Dispense: Amount of drug (number of capsules), or time period (1 month supply, etc).
Sig: Short for the Latin "signa," which means "mark through" on patient instructions. This part can be written out or noted in shorthand. Shorthand use is generally discouraged, however, because writing out the prescription decreases the likelihood of errors. Frequently used abbreviations are noted here with a more complete listing provided at the front of the book.

NICK PAVONA, MD
BENJAMIN FRANKLIN UNIVERSITY MEDICAL CENTER
CHADDS FORD, PA 19317

LICENSE PA MD 685-488-194 **DEA** NP–3612982

NAME NICK PAVONA, Sr. **AGE** 84

ADDRESS 34-10 75th Street **DATE** 10/24/2001
Wilmington, DE

Rx: minoxidil (Rogaine) 2% topical solution
DISP: 60 mL
SIG: Apply BID to scalp
Brand medically necessary

REFILL X5

SUBSTITUTION PERMISSIBLE ☐ *Nick Pavona* M.D.

TO ENSURE BRAND NAME DISPENSING, PRESCRIBER MUST SPECIFY "DISPENSE AS WRITTEN" ON THE PRESCRIPTION.*

*This can vary by state; some require that you write "Brand Medically Necessary" to specify a brand name and not a generic.

FIGURE 2–1 Example of an outpatient prescription. As a safety feature DEA numbers should **never** be preprinted on a prescription form. The "Dispense as Written" statement can vary by state requirements; this statement requests that the pharmacist fill the prescription as requested and not substitute a generic equivalent.

ad lib = freely at pleasure
PO = by mouth
PR = by rectum
OS = left eye
OD = right eye
qd = daily (this is a dangerous abbreviation and **should not be used;** see "Dangerous Practices," page 39)
PRN = as needed
$\dot{T}$ = one
$\ddot{T}$ = two
$\dddot{T}$ = three
qhs = every night at bedtime
bid = twice a day
tid = three times a day
q6h = every 6 h

qid = four times a day. (Note that qid and q6h are NOT the same orders: qid means that the medication is given four times a day while awake (eg, 8 AM, 12 noon, 6 PM, and 10 PM); q6h means that the medication is given four times a day but by the clock (eg, 6 AM, 12 noon, 6 PM, 12 midnight).

Refills: Indicate how many times this prescription can be refilled.

Substitution: Can a generic drug be used instead of the one prescribed?

Tips for Safe Prescription Writing

Legibility

1. Take time to write legibly.
2. Print if this would be more legible than handwriting.
3. Use a typewriter or computer if necessary. In the near future, physicians will generate all prescriptions by computer to eliminate legibility problems.
4. When prescribing a new or rarely used drug, carefully print the order to avoid misreading.

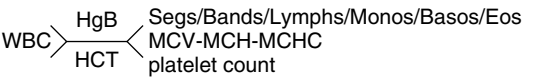
Dangerous Practices

1. NEVER use a trailing zero.
   Correct: 1 mg
   Dangerous: 1.0 mg. If the decimal is not seen, a 10-fold overdose can occur.
2. NEVER leave a decimal point "naked."
   Correct: 0.5 mL
   Dangerous: .5 mL. If the decimal point is not seen, a 10-fold overdose can occur.
3. NEVER abbreviate a drug name because the abbreviation may be misunderstood or have multiple meanings.
4. NEVER abbreviate U for units as it can easily be read as a zero, thus "6 U regular insulin" can be misread as 60 units. The order should be written as "6 units regular insulin."
5. NEVER use qd (abbreviation for once a day). When poorly written, the tail of the "q" can make it read qid or four times a day.

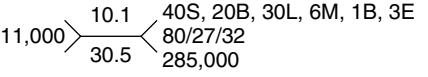
SHORTHAND FOR LABORATORY VALUES

(See Figure 2–2)

CBC



Example:



Electrolytes

sodium	chloride
potassium	bicarbonate

Example:

140	98
4.5	24

SMA-6 (Basic Metabolic Panel)

sodium	chloride	BUN
potassium	bicarbonate	(creatinine)
		glucose

Example:

140	98	10
4.5	24	(1.1)
		110

FIGURE 2–2 Shorthand notation for recording laboratory values. The basic metabolic panel is similar to the SMA-6 except that the creatinine is also listed.

3

DIFFERENTIAL DIAGNOSIS: SYMPTOMS, SIGNS, AND CONDITIONS

This chapter provides a general guide to commonly encountered symptoms and conditions and their frequent causes. Remember: "There are more uncommon presentations of common diseases than common presentations of uncommon diseases."

ABDOMINAL DISTENTION

Ascites, intestinal obstruction, cysts (ovarian or renal), tumors, hepatosplenomegaly, aortic aneurysm, uterine enlargement (pregnancy), bladder distention, inflammatory mass

ABDOMINAL PAIN

Diffuse: Intestinal angina, early appendicitis, colitis, diabetic ketoacidosis, hereditary angioedema, gastroenteritis, mesenteric thrombosis, mesenteric lymphadenitis, peritonitis, porphyria, sickle cell crisis, uremia, renal colic, renal infarct, pancreatitis

Right Upper Quadrant: Dissecting aneurysm, gallbladder disease (cholecystitis, cholangitis, choledocholithiasis), hepatitis, hepatomegaly, pancreatitis, peptic ulcer disease, pneumonia, PE, pyelonephritis, renal colic, renal infarct, appendicitis (retroperitoneal)

Left Upper Quadrant: Dissecting aneurysm, esophagitis, hiatal hernia, esophageal rupture, gastritis, pancreatitis, peptic ulcer disease, MI, pericarditis, pneumonia, PE, pyelonephritis, renal colic, renal infarct, splenic rupture or infarction

Lower Abdomen: Aortic aneurysm, colitis, diverticulitis including Meckel's, intestinal obstruction, hernias, perforated viscus, pregnancy, ectopic pregnancy, dysmenorrhea, endometriosis, mittelschmerz (ovulation), ovarian cyst or tumor (especially with torsion), PID, renal colic, UTI, rectal hematoma, bladder distention.

Right Lower Quadrant Specific: Appendicitis, ectopic pregnancy, ovarian cyst or tumor, salpingitis, mittelschmerz, cholecystitis, perforated duodenal ulcer, Crohn's disease

ADRENAL MASS

Adrenal adenoma, adrenal hyperplasia (unilateral or bilateral), adrenal metastasis (solid tumors, lymphoma, leukemia), adrenocortical carcinoma, pheochromocytoma, adrenal myelolipoma, adrenal cyst, Wolman's disease, adrenal varices, hemorrhage, congenital adrenal hyperplasia, ganglioneuroma, micronodular adrenal disease

ALOPECIA

Male pattern baldness (alopecia, androgenic type in both men and women), trauma and hair pulling, congenital, tinea capitis, bacterial folliculitis, telogen arrest, anagen arrest (chemotherapy/radiation therapy), alopecia areata, discoid lupus

AMENORRHEA

Pregnancy, menopause (physiologic or premature), severe illness, weight loss, stress, athletic training, "physiologically delayed puberty," anatomic (imperforate hymen, uterine agenesis, etc), gonadal dysgenesis (Turner's syndrome, etc), hypothalamic and pituitary tumors, virilizing syndromes (polycystic ovaries, idiopathic hirsutism, etc). Amenorrhea is categorized as primary (never had menses) or secondary (cessation of menses).

ANOREXIA

Hepatitis, carcinoma (most types, especially advanced), anorexia nervosa, generalized debilitating diseases, digitalis toxicity, uremia, depression, CHF, pulmonary failure, radiation exposure, chemotherapy

ANURIA

See Oliguria, page 49

ARTHRITIS

Osteoarthritis, bursitis, tendonitis, connective tissue disease (RA, SLE, rheumatic fever, scleroderma, gout, pseudogout, rheumatoid variants [ankylosing spondylitis, psoriatic arthritis, Reiter's syndrome]), infection (bacterial, viral, TB, fungal Lyme disease), trauma, sarcoidosis, sickle cell anemia, hemochromatosis, amyloidosis, coagulopathy

ASCITES

(See Chapter 13, page 296, under "Peritoneal Paracentesis" for more details.) CHF, tricuspid insufficiency, constrictive pericarditis, venous occlusion (including Budd–Chiari syndrome), cirrhosis, pancreatitis, peritonitis (ruptured viscus, TB, bile leak, spontaneous bacterial), tumors (most common ovarian, gastric, uterine, unknown primary, breast, lymphoma), trauma, Meigs' syndrome (ovarian fibroma associated with hydrothorax and ascites), myxedema, anasarca (hypoalbuminemia)

BACK PAIN

Herniated disk, spinal stenosis, ankylosing spondylitis, metastatic tumor, multiple myeloma, mechanical back sprain, referred pain (visceral, vascular), vertebral body fracture, osteoporosis induced fracture, infectious processes (diskitis, osteomyelitis, epidural abscess

BREAST LUMP

Cancer, fibroadenoma, fibrocystic breast disease, fat necrosis, gynecomastia (males, alcoholics)

CHEST PAIN

Deep, Dull, Poorly Localized: Angina, variant angina, unstable angina, AMI, aortic aneurysm, PE, tumor, gallbladder disease, pulmonary hypertension

Sharp, Well Localized: PE, pneumothorax, epidemic pleurodynia, pericarditis, atypical MI, hyperventilation, hiatal hernia, esophagitis, esophageal spasm, herpes zoster, aortic aneurysm, breast lesions, variety of bony and soft tissue abnormalities (rib fractures, costochondritis, muscle damage), perforated ulcer, acute cholecystitis, pancreatitis

CHILLS

Infection (bacterial with bacteremia, viral, TB, fungal), neoplasm (Hodgkin's disease), drug and transfusion reactions, hypothermia, malaria

CLUBBING

Pulmonary causes (bronchiectasis, lung abscesses, tuberculosis, neoplasms, fibrosis), AV malformations, cardiac (congenital cyanotic heart diseases, bacterial endocarditis), GI (ulcerative and regional enteritis, cirrhosis), hereditary, thyrotoxicosis

COMA

Use the mnemonic **AEIOU TIPS: A**lcohol; **E**ncephalitis (other CNS causes—epilepsy, hemorrhage, mass), **I**nsulin (hypoglycemia, hyperglycemia), **O**piates (drugs), **U**remia (and other metabolic conditions, such as hypernatremia, hyponatremia, hypercalcemia, hepatic failure, and thiamine deficiency), **T**rauma, **I**nfection, **P**sychiatric causes, **S**yncope (or decreased cardiac output such as from arrhythmias).

CONSTIPATION

Dehydration, lack of exercise, bedrest, medications (narcotics, anticholinergics, antidepressants, calcium channel blockers—verapamil, diuretics, clonidine, aluminum- or calcium-containing antacids), laxative abuse, megacolon, spastic colon, chronic suppression of the urge to defecate, fecal impaction (often with paradoxical diarrhea), neoplasm, intestinal obstruction, vascular occlusion to the bowel, inflammatory lesions (diverticulitis, proctitis), hemorrhoids, anal fissures, neurological disorders, depression, porphyria, hypothyroidism, hypercalcemia

COUGH

Acute: Tracheobronchitis, pneumonia, sinusitis, pulmonary edema, foreign body, toxic inhalation, allergy, pharyngitis (viral or bacterial), asthma, GERD ACE inhibitors, impacted cerumen or foreign body in ear

Chronic: Bronchitis (smoker), chronic sinusitis, emphysema, cancer (bronchogenic, head and neck, and esophageal), TB, sarcoidosis, fungal infection, bronchiectasis, mediastinal lymphadenopathy, thoracic aneurysm, GERD, ACE inhibitors

CYANOSIS

Peripheral: Arterial occlusion and insufficiency, vasospasm/Raynaud's disease, venous stasis, venous obstruction

Central: Hypoxia, congenital heart disease (right to left shunt), PE, pseudo-cyanosis (eg, polycythemia vera), methemoglobinemia

DELIRIUM

Metabolic: Hypoglycemia, hypoxia, sodium and calcium disorders, hypercarbia, uremia

Neurologic: Stroke, subdural and epidural hematoma, subarachnoid hemorrhage, postictal, concussion and contusion, meningitis, encephalitis, brain tumor

Drug or Toxin-Induced: Lithium intoxication, ethanol, steroids, anticholinergics, sympathomimetics, poisons (eg, mushrooms, carbon monoxide), drugs of abuse

DEMENTIA

Chronic CNS disease: Alzheimer's, senile dementia, Pick's disease, Parkinson's, chronic demyelinating disease (MS), ALS, brain tumor, normal pressure hydrocephalus, Wilson's disease, Huntington's disease, lipid storage diseases (eg, Tay–Sachs)

Metabolic: Usually chronic (hypoxia, hypoglycemia, hypocalcemia), hyperammonemia, dialysis, heavy-metal intoxication, pernicious anemia (B_{12} deficiency), niacin and thiamine

deficiency (usually chronic alcoholic) posthepatic coma, medications (barbiturates, phenothiazines, lithium, benzodiazepines, many others)

Infectious: AIDS encephalopathy, brain abscess, chronic meningoencephalitis (eg, fungal neurosyphilis), encephalitis, Jakob–Creutzfeldt disease

Vascular: Vasculitis, multicerebral/cerebellar infarcts

Traumatic: Contusion, hemorrhage, subdural hematoma

Psychiatric: Sensory deprivation, depression (pseudodementia)

DIARRHEA

Acute: Infections (bacterial, viral, fungal, protozoan, parasitic), toxic (food poisoning, chemical), drugs (antibiotics, cholinergic agents, lactulose, magnesium-containing antacids, quinidine, reserpine, guanethidine, metoclopramide, bethanechol), appendicitis, diverticular disease, GI bleeding, ischemic colitis, food intolerance, fecal impaction (paradoxical diarrhea), pseudomembranous colitis

Chronic: After gastrectomy or vagotomy, ZE syndrome, regional enteritis, ulcerative colitis, malabsorption, diverticular disease, carcinoma, villous adenoma, gastrinomas, lymphoma of the bowel, functional bowel disorders (irritable colon, mucous colitis), pseudomembranous colitis, endocrine disease (carcinoid, hyperthyroidism, Addison's disease), radiation enteritis, drugs, Whipple's disease, amyloidosis, AIDS

DIPLOPIA

Problems with the third, fourth, or sixth cranial nerve, such as from vascular disturbances, meningitis, tumor, demyelination, orbital blow-out fracture, hyperthyroid ocular myopathy

DIZZINESS

Hyperventilation, depression, hypoglycemia, anemia, volume depletion, hypoxia, trauma, Ménière's disease, benign positional vertigo, aminoglycoside toxicity, vestibular neuronitis, MS, brain stem ischemia or stroke, posterior fossa lesions, cerebellar ischemia or stroke, arrhythmias, aortic stenosis, carotid sinus hypersensitivity

DYSPHAGIA

Loss of tongue function, pharyngeal dysfunction (myasthenia gravis), Zenker's diverticulum, tumors (bronchogenic, head and neck, and esophageal), stricture, esophageal web, Schatzki's ring, lower esophageal sphincter spasm, foreign body, aortic aneurysm, achalasia, scleroderma, diabetic neuropathy, amyloidosis, infection (especially candidiasis), dermatomyositis, polymyositis, MS, brain stem infarctions

DYSPNEA

Laryngeal and tracheal infections and foreign bodies, tumors (both intrinsic and extrinsic), COPD, asthma, pneumonia, lung carcinoma, atelectasis, pneumothorax, pleural effusion, hemothorax, PE, pulmonary infarction, carbon monoxide poisoning, any cause of pain from respiratory movements, cardiac and noncardiac pulmonary edema, AMI, pericardial tamponade, anemia, abdominal distention, anxiety

DYSURIA

Urethral stricture, stones, blood clot, tumor (bladder, prostate, urethral), prostatic enlargement, infection (urethritis, cystitis, vaginitis, prostatitis), trauma, bladder spasm, dehydration

EARACHE

Otitis media and externa, mastoiditis, serous otitis, otic barotrauma, foreign body, impacted cerumen, referred pain (dental or TMJ)

EDEMA

CHF, constrictive pericarditis, liver disease (cirrhosis), nephrotic syndrome, nephritic syndrome, hypoalbuminemia, malnutrition, myxedema, hemiplegia, volume overload, thrombophlebitis, lymphatic obstruction, medications (nifedipine), venous stasis

EPISTAXIS

Trauma (nose picking, blunt trauma), neoplasm, polyps, foreign body, desiccation, coagulopathy, medications (use of cocaine, nasal sprays), infections (sinusitis), uremia, hypertension (more often a result rather than a cause of epistasis)

FAILURE TO THRIVE

Environmental: Social deprivation, decreased food intake

Organic: CNS disorder, intestinal malabsorption, CF, parasites, cleft palate, heart failure, endocrine diseases, hypercalcemia, Turner's syndrome, renal disease, chronic infection, malignancies

FEVER

Based on adult population studies an AM temperature above 98.8°F (37.2°C) or PM above 99.9°F (37.7°C) is generally defined as a fever. Rectal temperatures are generally 1°F (0.6°C) higher and reflect core temperature

Infections (viral, bacterial, mycobacterial, fungal, parasitic), neoplasm (lymphoma, leukemia, renal and hepatic carcinoma), connective tissue disease (SLE, vasculitis, RA, adult Still's disease, temporal arteritis), heat stroke, malignant hyperthermia, thyroid storm, adrenal insufficiency, PE, MI, atrial myxoma, inflammatory bowel disease, factitious, drugs (most common offenders: amphotericin, bleomycin, barbiturates, cephalosporins, methyldopa, penicillins, phenytoin, procainamide, sulfonamides, quinidine, cocaine, LSD, phencyclidine and amphetamines)

FEVER OF UNKNOWN ORIGIN (FUO)

Defined as a temperature of 101°F (38.3°C) or greater for at least 3 weeks and for which a diagnosis is not established after 1 week of hospitalization. In children, the minimum duration is 2 weeks and the temperature is at least 101.3°F (38.5°C): TB, fungal infection, endocarditis, abscess (especially hepatic), neoplasm (lymphoma, renal cell, hepatoma, preleukemia), atrial myxoma, connective tissue disease, drugs (see Fever, previous listing), PE, Crohn's disease, ulcerative colitis, hypothalamic injury, factitious; in elderly, temporal arteritis

FLATULENCE

Aerophagia, food intolerance, disturbances in bowel motility (diabetes, uremia), lactose intolerance, gallbladder disease, peptic ulcer fiber, cholestyramine

FREQUENCY

Infection (bladder, prostate), excessive fluid intake, use of diuretics (also coffee, tea, or colas), diabetes mellitus, diabetes insipidus, prostatic obstruction, bladder stones, bladder tumors, pregnancy, psychogenic bladder syndrome, neurogenic bladder, interstitial cystitis

GALACTORRHEA

Hyperprolactinemia, prolonged breast feeding, major stress, pituitary tumors, breast lesions (benign, cancer, inflammatory), idiopathic with menses and after oral contraceptive use

GYNECOMASTIA

Normal (Physiologic): Newborn, adolescence, aging

Pathologic: Medications or drug use(cimetidine, spironolactone, estrogens, gonadotropins, antiandrogens, marijuana), decreased testosterone (Klinefelter's syndrome, testicular failure or absence), increased estrogen production (hermaphroditism, testicular or lung cancers, adrenal and liver diseases)

HEADACHE

Includes cluster, tension, and migraine (classic or simple), benign exertional, headache associated with sexual activity, benign cough headache, ice-pick (idiopathic stabbing), vascular (menstruation, hypertension), eye strain, acute glaucoma, sinusitis, dental problems, TMJ dysfunction, trauma, subarachnoid hemorrhage, intracranial mass, fever, meningitis, pseudo-tumor cerebri, trigeminal neuralgia, temporal arteritis (especially in elderly), hypoglycemia, toxin exposure (carbon monoxide poisoning), drugs (vasodilators—nifedipine [Procardia]), vasculitis

HEARTBURN (PYROSIS)

GERD, esophagitis, hiatal hernia, peptic ulcer, gallbladder disease, medications, tumors, scleroderma, food intolerance. Myocardial ischemia maybe mistaken for heartburn.

HEMATEMESIS AND MELENA

Melena generally means that the bleeding site is in the upper GI tract (ie, proximal to the ligament of Treitz), but occasionally can be as distal as the right colon.) Swallowed blood (eg, epistaxis), esophageal varices, esophagitis, Mallory–Weiss syndrome, hiatal hernia, gastritis, peptic ulcer, duodenitis, carcinoma of the stomach, tumors (both small and large bowel), ischemic colitis, aortoenteric fistula, bleeding diathesis, anticoagulation (may unmask GI tract pathology)

HEMATOCHEZIA

Massive upper GI bleeding, hemorrhoids, diverticular disease, angiodysplasia, polyps, carcinoma, inflammatory bowel disease, ischemic colitis

HEMATURIA (see also page 111)

First rule out false-positives: myoglobinuria, hemoglobinuria, porphyria. GU neoplasms (malignant and benign), polycystic kidneys, trauma, infection (urethral, bladder, prostate, etc), stones, glomerulonephritis, renal infarction, renal vein thrombosis, anticoagulation (may unmask GU tract pathology), bleeding diathesis, enterovesical fistula, sickle cell anemia, vigorous exercise ("runners' hematuria"), accelerated hypertension, factitious, and vaginal and rectal bleeding

HEMOPTYSIS

Infection (pneumonia, bronchitis, fungal, TB), bronchiectasis, cancer (usually bronchogenic), PE, arteriovenous malformations, Wegener's granulomatosis, Goodpasture's syndrome, SLE, pulmonary hemosiderosis, foreign body, trauma, bleeding diatheses, excessive anticoagulation (may unmask respiratory tract pathology), pulmonary edema, mitral stenosis

HEPATOMEGALY

CHF, hepatitis (viral, alcoholic, drug-induced, autoimmune), cirrhosis (alcoholic, etc), tumors (primary and metastatic), amyloid, biliary obstruction, hemochromatosis, chronic granulomatous disease, infections (schistosomiasis, liver abscess). Riedel's lobe is a normal variant, elongated right lobe of the liver with normal liver volume.

HICCUPS (SINGULTUS)

Uremia, electrolyte disorders, diabetes, medications (benzodiazepines, barbiturates, others), emotionally induced (excitement, fright), gastric distention, CNS disorders, psychogenic, thoracic and diaphragmatic disorders (pneumonia, MI, diaphragmatic irritation), alcohol ingestion

HIRSUTISM

Idiopathic, familial, adrenal causes (Cushing's disease, congenital adrenal hyperplasia, virilizing adenoma or carcinoma), polycystic ovaries, medications (minoxidil, androgens)

IMPOTENCE (ERECTILE DYSFUNCTION)

Psychogenic, vascular, neurologic (cord injury, radical prostatectomy, rectal surgery, aortic bypass), pelvic radiation, medications (some common drugs: antihypertensives, thiazide diuretics, beta-blockers, methyldopa; antidepressants especially the SSRIs, anticholinergics; addictive medications: alcohol, narcotics; antipsychotics; antiandrogens: histamine H_2 blockers, finasteride, LHRH analogues, spironolactone, others; history of priapism, Peyronie's disease, testicular failure, hyperprolactinemia

INCONTINENCE (URINARY)

Cystitis, dementia and delirium, stroke, prostatic hypertrophy, fecal impaction, peripheral or autonomic neuropathy, medications (diuretics, sedatives, alpha blockers), diabetes, spinal cord trauma or lesions, MS, childbirth, surgery (prostate, rectal), aging, acute and chronic medical conditions, estrogen deficiency

JAUNDICE

Hepatitis (alcoholic, viral, drug-induced, autoimmune), Gilbert's disease, Crigler–Najjar syndrome, Dubin–Johnson syndrome, Wilson's disease, drug-induced cholestasis (phenothiazines and estrogen), gallbladder and biliary tract disease (including inflammation, infection, obstruction, and tumors—primary hepatic and metastatic), hemolysis, neonatal jaundice, cholestatic jaundice of pregnancy, total parenteral nutrition

LYMPHADENOPATHY AND SPLENOMEGALY

Infection (bacterial, fungal, viral, parasitic), benign neoplasm (histiocytosis), malignant neoplasm (primary lymphoma, metastatic), sarcoid, connective tissue disease, drugs (phenytoin, etc), AIDS, splenomegaly without lymphadenopathy (cirrhosis, hereditary spherocytosis, hemoglobinopathies, ITP, hairy cell leukemia, and amyloidosis)

MELENA

(See Hematemesis, page 47.)

NAUSEA AND VOMITING

Appendicitis, acute cholecystitis, chronic gallbladder disease, peptic ulcer disease, gastritis (especially alcoholic), pancreatitis, gastric distention (diabetic atony, pyloric obstruction), intestinal obstruction, peritonitis, food intolerance, intestinal infection (bacterial, viral, parasitic), acute systemic infections (especially in children), hepatitis, toxins (food poisoning), CNS disorders ([increased intracranial pressure often cause vomiting without headache], tumor, hemorrhagic stroke, hydrocephalus, meningitis, labyrinthitis, Ménière's disease, migraine headaches) AMI, CHF, endocrine disorders (DKA, adrenal crisis), hypercalcemia, hyperkalemia, hypokalemia, pyelonephritis, nephrolithiasis, uremia, hepatic failure, pregnancy, PID, drugs (opiates, digitalis, chemotherapeutic agents, L-dopa, NSAIDs), psychogenic vomiting, porphyria, radiation therapy

NYSTAGMUS

Congenital, vision loss early in life, MS, neoplasms, infarction, toxic or metabolic encephalopathy, alcoholic cerebellar degeneration, medications (anticonvulsants, barbiturates, phenothiazines, lithium, others), encephalitis, vascular brainstem lesions, Arnold– Chiari malformation, nonpathologic (extreme lateral gaze), opticokinetic nystagmus (attempt to fix gaze on rapidly moving object, eg, train)

OLIGURIA AND ANURIA

(See also Urinary Indices, page 119.)

Oliguria is <500 mL urine/24 h; **anuria** is <100 mL urine/24 h in adults.

Prerenal: Volume depletion, shock, heart failure, fluids in the third space, renal artery compromise

Renal: Glomerular disease, acute tubular necrosis, bilateral cortical necrosis, interstitial disease (acute and chronic interstitial nephritis, urate or hypercalcemic nephropathy), trans-

fusion reaction, myoglobulinuria, radiographic contrast media (especially in diabetics, dehydration, multiple myeloma and elderly), ESRD, drugs (aminoglycosides, amphotericin B, vancomycin, NSAIDs, cephalosporins, penicillins, and sulfonamides), emboli, thrombosis, and DIC

Postrenal: Bilateral ureteral obstruction, prostatic obstruction, neurogenic bladder

PLEURAL EFFUSION

(See Chapter 13, page 304, Thoracentesis, for more details.)

Transudate: (Pleural to serum protein ratio <0.5, and pleural to serum LDH ratio <0.6 and pleural LDH $<\frac{2}{3}$ the upper limits of normal for serum LDH), CHF, cirrhosis, nephrotic syndrome, peritoneal dialysis

Exudate: (Pleural to serum protein ratio >0.5, or pleural to serum LDH ratio >0.6, or pleural LDH $>\frac{2}{3}$ the upper limits of normal for serum LDH), bacterial or viral pneumonia, pulmonary infarction, TB, RA, SLE, malignancy (most common, breast, lung lymphoma, leukemia, ovarian, unknown primary, GI, mesothelioma, others), pancreatitis, pneumothorax, chest trauma, uremia

Chylothorax: Traumatic or postoperative complication

Empyema: Bacteria, fungi, TB, trauma, surgery

Hydrothorax: Usually iatrogenic (central venous catheter complication)

PRURITUS

Skin lesions (papulosquamous, vesicobullous, contact dermatitis, infestations [scabies, etc], infections), dry skin (especially in winter), liver disease, uremia, diabetes, gout, Hodgkin's disease, leukemias, polycythemia vera, intestinal parasites, drug reactions, pregnancy, psychosomatic, neurologic, or circulatory disturbances

SEIZURES

Types

Generalized: Grand mal and petit mal (absence), febrile

Partial Seizures: Partial motor, partial sensory, partial complex (psychomotor or temporal lobe, déjà vu, automatisms)

Causes: Primary, CNS tumors (primary, metastatic), trauma, metabolic (hypoglycemia, hyponatremia, hypernatremia, acidosis, alkalosis, porphyria, uremia, etc), fever (especially in children), infection (meningitis, encephalitis, and abscess), anoxia (arrhythmias, stroke, carbon monoxide poisoning), drugs (alcohol or barbiturate withdrawal, cocaine, amphetamines), collagen-vascular disease (SLE), chronic renal failure, trauma, hypertensive encephalopathy, toxemia of pregnancy, psychogenic

SPLENOMEGALY

(See Lymphadenopathy and Splenomegaly, page 49)

SYNCOPE

Includes vasovagal (simple faint), orthostatic (volume depletion, sympathectomy [either functional or surgical], diabetes, Shy–Drager [idiopathic], tricyclic antidepressants and diuretics) and hysterical. Cardiac syncope (Adams–Stokes attack), paroxysmal atrial tachycardia, atrial fibrillation, ventricular tachycardia, sinoatrial or atrioventricular block, pacemaker malfunction, aortic stenosis, IHSS, primary pulmonary hypertension, atrial myxoma, cough syncope, hypoglycemia, seizure disorder, subclavian steal syndrome, cerebrovascular accident, AMI, alcohol-related

TREMORS

Resting (decrease with movement): Parkinson's disease, Wilson's disease, brain tumors (rare), medications (SSRI antidepressants, metoclopramide, phenothiazines [tardive dyskinesia])

Action (present with movement): Benign essential tremor (familial and senile), cerebellar diseases, withdrawal syndromes (alcohol, benzodiazepines, opiates), normal/physiologic (induced by anxiety, fatigue)

Ataxic (worse at end of voluntary movement): MS, cerebellar diseases

Others: Medication-induced (caffeines [coffee, tea], steroids, valproic acid, bronchodilators) febrile, hypoglycemic, hyperthyroidism, pheochromocytoma

VAGINAL BLEEDING

Normal menstrual period, dysfunctional uterine bleeding (premenopausal bleeding, oral contraceptives, luteal phase defect), anovulatory abnormal uterine bleeding (hypothalamic/pituitary disorders, stress, thyroid and adrenal disease, endometriosis), pregnancy-related (ectopic pregnancy, threatened/spontaneous abortion, retained products of gestation), neoplasia (uterine fibroids; cervical polyps; and endometrial, cervical, ovarian, and vulvar carcinoma)

VAGINAL DISCHARGE

Vaginitis due to *Candida albicans, Trichomonas vaginalis, Gardnerella vaginalis, Neisseria gonorrhoeae, Chlamydia trachomatis, Mycoplasma,* herpesvirus, chronic cervicitis, tumors, irritants, foreign bodies, estrogen deficiency

VERTIGO

Ménière's disease (recurrent vertigo, deafness and tinnitus), labyrinthitis, aminoglycoside toxicity, benign positional vertigo, vestibular neuronitis, brainstem ischemia and infarction, basilar artery migraine, cerebellar infarction, acoustic neuroma motion sickness, excess of ethanol, quinine, and salicylic acid

VOMITING

(See Nausea and Vomiting page 49)

WEIGHT LOSS

Normal or Increased Appetite: Diabetes, hyperthyroidism, anxiety, drugs (thyroid), carcinoid, sprue, pancreatic deficiency, parasites

Decreased Appetite: Depression, anorexia nervosa, GI obstruction, neoplasm, liver disease, severe infection, severe cardiopulmonary disease, uremia, adrenal insufficiency, hypercalcemia, hypokalemia, intoxication (alcohol, lead), old age, drugs (amphetamines, digitalis, SSRIs, such as fluoxetine [Prozac]), AIDS

WHEEZING

Large airway difficulty (laryngeal stridor, tracheal stenosis, foreign body), endobronchial tumor, asthma, bronchitis, emphysema, pulmonary edema, PE, anaphylactic reactions, myocardial ischemia

4

LABORATORY DIAGNOSIS: CHEMISTRY, IMMUNOLOGY, AND SEROLOGY

Acetoacetate
Acid Phosphatase
ACTH
ACTH Stimulation Test
Albumin
Albumin/Globulin Ratio
Aldosterone
Alkaline Phosphatase
Alpha-fetoprotein (AFP)
ALT
Ammonia
Amylase
ASO Titer
AST
Autoantibodies
Base Excess/Deficit
Bicarbonate
Bilirubin
Blood Urea Nitrogen (BUN)
BUN/Creatinine Ratio
C-Peptide
C-Reactive Protein
CA 15-3
CA 19-9
CA-125
Calcitonin
Calcium, Serum
Captopril Test
Carbon Dioxide
Carboxyhemoglobin
Carcinoembryonic Antigen (CEA)
Catecholamines, Fractionated Serum
Chloride, Serum
Cholesterol
Clostridium difficile Toxin Assay, Fecal
Cold Agglutinins
Complement (C3, C4, CH_{50})
Cortisol, Serum
Counterimmunoelectrophoresis
Creatine Phosphokinase
Creatinine, Serum
Cryoglobulins, Serum
Cytomegalovirus Antibodies
Dehydroepiandrosterone
Dehydroepiandrosterone Sulfate
Dexamethasone Suppression Test
Erythropoietin
Estradiol, Serum
Estrogen/Progesterone Receptors
Ethanol
Fecal Fat
Ferritin
Folic Acid
Follicle-Stimulating Hormone (FSH)
FTA-ABS
Fungal Serologies
Gastrin, Serum
GGT
Glucose
Glucose Tolerance Test, Oral
Glycohemoglobin
Haptoglobin
Helicobacter pylori Antibody Titers
Hepatitis Testing
High-Density Lipoprotein Cholesterol
HLA
Homocysteine, Serum
Human Chorionic Gonadotropin (HCG)
Human Immunodeficiency Antibody Testing (HIV)
Immunoglobulins, Quantitative
Iron
Iron-Binding Capacity, Total
Lactate Dehydrogenase (LDH)

This chapter outlines commonly ordered blood chemistry, immunology, and serology tests with normal values and a guide to the diagnosis of common abnormalities. Other laboratory tests can be found in the following chapters: Hematology, Chapter 5; Urine Studies, Chapter 6; Microbiology, Chapter 7; and Blood Gases, Chapter 8.

With the institution of DRGs, it becomes imperative to understand appropriate, as well as economical, laboratory testing patterns. Laboratory testing should be guided by, but not a substitute for, an effective history, physical, and careful clinical assessment.

Most laboratories offer AMA recommended "panel" tests, whereby multiple determinations are performed on a single sample. Although your lab may vary, some common chemistry panels include:

Basic Metabolic Panel: BUN, calcium, creatinine, electrolytes (Na, K, Cl, CO_2), glucose
Cardiac Enzymes: CK-MB (if total CK >150 IU/L), troponin
Chem-7 Panel/SMA-7: BUN, creatinine, electrolytes (Na, K, Cl, CO_2),glucose

Comprehensive Metabolic Panel: Albumin, alkaline phosphatase, ALT (SGPT), AST (SGOT), bilirubin (total), BUN, calcium, creatinine, electrolytes (Na, K, Cl, CO_2), glucose, protein (total)
Electrolytes: Sodium, potassium, chloride, CO_2, (Na, K, Cl, CO_2)
Health Screen-12/SMA-12: Albumin, alkaline phosphatase, AST (SGOT), bilirubin (total), calcium, cholesterol, creatinine, glucose, LDH, phosphate, protein (total), uric acid
Hepatic Function Panel: Albumin, alkaline phosphatase, ALT (SGPT), AST (SGOT), bilirubin (total & direct), protein
Lipid Panel: Cholesterol, HDL cholesterol, LDL cholesterol (calculated), triglycerides

The Système International (SI) is a metric-based laboratory data-reporting system that is used internationally. The mole is the unit used most extensively in the system. The SI unit for expressing enzymatic activity is the "katal"; however, most countries have adopted units per liter (U/L) as an alternative measure of enzymatic activity. For most lab values, representative SI units have been included; however, each individual laboratory should be consulted for its "normal" values.

If an increased or decreased value is not clinically useful, it is usually not listed. Because each laboratory has its own set of normal reference values, the normals given should only be used as a guide. The range for common normal values is given in parentheses. Unless specified, values reflect normal adult levels. This section includes the method of collection since laboratories have attempted to standardize collection methods; however, be aware that some labs may have alternative collection methods. Blood specimen tubes are listed in Chapter 13, page 311.

ACETOACETATE (KETONE BODIES, ACETONE)

• Normal = negative • Collection: Red top tube

Positive: DKA, starvation, emesis, stress, alcoholism, infantile organic acidemias, isopropanol ingestion

ACID PHOSPHATASE (PROSTATIC ACID PHOSPHATASE, PAP)

• <3.0 ng/mL by RIA, or <0.8 IU/L by enzymatic • Collection: Tiger top tube

Not a useful screening test for cancer; most useful as a marker of response to therapy or in confirming metastatic disease. PSA is more sensitive in diagnosis of cancer.

Increased: Carcinoma of the prostate (usually outside of prostate), prostatic surgery or trauma (including prostatic massage), rarely in infiltrative bone disease (Gaucher's disease, myeloid leukemia), prostatitis, or BPH

ACTH (ADRENOCORTICOTROPIC HORMONE)

• 8 AM 20–140 pg/mL (SI: 20–140 ng/L), midnight, approximately 50% of AM value • Collection: Tiger top tube

Increased: Addison's disease (primary adrenal hypofunction), ectopic ACTH production (small [oat] cell lung carcinoma, pancreatic islet cell tumors, thymic tumors, renal cell carcinoma, bronchial carcinoid), Cushing's disease (pituitary adenoma), congenital adrenal hyperplasia (adrenogenital syndrome)

Decreased: Adrenal adenoma or carcinoma, nodular adrenal hyperplasia, pituitary insufficiency, corticosteroid use

ACTH STIMULATION TEST (CORTROSYN STIMULATION TEST)

• Collection: Tiger top tube

Used to help diagnose adrenal insufficiency. Cortrosyn (an ACTH analogue) is given at a dose of 0.25 mg IM or IV in adults or 0.125 mg in children <2 years. Collect blood at time 0, 30, and 60 min for cortisol and aldosterone.

Normal Response: Three criteria are required: basal cortisol of at least 5 mg/dL, an incremental increase after cosyntropin (Cortrosyn) injection of at least 7 mg/dL, and a final serum cortisol of at least 16 mg/dL at 30 or 18 mg/dL at 60 min or cortisol increase of >10 mg/dL. Aldosterone increases >5 ng/dL over baseline.

Addison's Disease (Primary Adrenal Insufficiency): Neither cortisol nor aldosterone increase over baseline.

Secondary Adrenal Insufficiency: Caused by pituitary insufficiency or suppression by exogenous steroids, cortisol does not increase, but aldosterone does.

ALBUMIN

• Adult 3.5–5.0 g/dL (SI: 35–50 g/L), child 3.8–5.4 g/dL (SI: 38–54 g/L) • Collection: Tiger top tube; part of SMA-12

Decreased: Malnutrition (see page 211), overhydration, nephrotic syndrome, CF, multiple myeloma, Hodgkin's disease, leukemia, metastatic cancer, protein-losing enteropathies, chronic glomerulonephritis, alcoholic cirrhosis, inflammatory bowel disease, collagen-vascular diseases, hyperthyroidism

ALBUMIN/GLOBULIN RATIO (A/G RATIO)

• Normal >1

A calculated value (Total protein minus albumin = globulins. Albumin divided by globulins = A/G ratio). Serum protein electrophoresis is a more informative test (see page 85).

Decreased: Cirrhosis, liver diseases, nephrotic syndrome, chronic glomerulonephritis, cachexia, burns, chronic infections and inflammatory states, myeloma

ALDOSTERONE

• Serum: Supine 3–10 ng/dL (SI: 0.083–0.28 nmol/L) early AM, normal sodium intake [3 g sodium/d] • Upright 5–30 ng/dL (SI: 0.138–0.83 nmol/L); urinary 2–16 mg/24 h (SI: 5.4–44.3 nmol/d) • Collection: Green or lavender top tube

Discontinue antihypertensives and diuretics 2 wk prior to test. Upright samples should be drawn after 2 h. Primarily used to screen hypertensive patients for possible Conn's syndrome (adrenal adenoma producing excess aldosterone).

Increased: Primary hyperaldosteronism, secondary hyperaldosteronism (CHF, sodium depletion, nephrotic syndrome, cirrhosis with ascites, others), upright posture

Decreased: Adrenal insufficiency, panhypopituitarism, supine posture

ALKALINE PHOSPHATASE

• Adult 20–70 U/L, child 20–150 U/L • Collection: Tiger top tube; part of SMA-12

A fractionated alkaline phosphatase was formerly used to differentiate the origin of the enzyme in the bone from that in the liver. Replaced by the GGT and 5′-nucleotidase determinations

Increased: Increased calcium deposition in bone (hyperparathyroidism), Paget's disease, osteoblastic bone tumors (metastatic or osteogenic sarcoma), osteomalacia, rickets, pregnancy, childhood, healing fracture, liver disease such as biliary obstruction (masses, drug therapy), hyperthyroidism

Decreased: Malnutrition, excess vitamin D ingestion

ALPHA-FETOPROTEIN (AFP)

• (<16 ng/mL (SI: <16 mL) • third trimester of pregnancy maximum 550 ng/mL (SI: 550 mL) • Collection: Tiger top tube

Increased: Hepatoma (hepatocellular carcinoma), testicular tumor (embryonal carcinoma, malignant teratoma), neural tube defects (in mother's serum [spina bifida, anencephaly, myelomeningocele]), fetal death, multiple gestations, ataxia–telangiectasia, some cases of benign hepatic diseases (alcoholic cirrhosis, hepatitis, necrosis)

Decreased: Trisomy 21 (Down syndrome) in maternal serum

ALT (ALANINE AMINOTRANSFERASE, ALAT) OR SGPT

• 0–35 U/L (SI: 0–0.58 mkat/L), higher in newborns • Collection: Tiger top tube

Increased: Liver disease, liver metastasis, biliary obstruction, pancreatitis, liver congestion (ALT is more elevated than AST in viral hepatitis; AST elevated more than ALT in alcoholic hepatitis.)

AMMONIA

• Adult 10–80 mg/dL (SI: 5–50 mmol/L) • To convert mg/dL to mmol/L, multiply by 0.5872 • Collection: Green top tube, on ice, analyze immediately

Increased: Liver failure, Reye's syndrome, inborn errors of metabolism, normal neonates (normalizes within 48 h of birth)

AMYLASE

• 50–150 Somogyi units/dL (SI: 100–300 U/L) • Collection: Tiger top tube

Increased: Acute pancreatitis, pancreatic duct obstruction (stones, stricture, tumor, sphincter spasm secondary to drugs), pancreatic pseudocyst or abscess, alcohol ingestion, mumps, parotiditis, renal disease, macroamylasemia, cholecystitis, peptic ulcers, intestinal obstruction, mesenteric thrombosis, after surgery

Decreased: Pancreatic destruction (pancreatitis, cystic fibrosis), liver damage (hepatitis, cirrhosis), normal newborns in the first year of life

ASO (ANTISTREPTOLYSIN O/ANTISTREPTOCOCCAL O) TITER (STREPTOZYME)

• <200 IU/mL (Todd units) school-age children • <100 IU/mL preschool and adults • varies with lab • Collection: Tiger top tube

Increased: Streptococcal infections (pharyngitis, scarlet fever, rheumatic fever, poststreptococcal glomerulonephritis), RA, and other collagen diseases

AST (ASPARTATE AMINOTRANSFERASE, ASAT) OR SGOT

• 8–20 U/L (SI: 0–0.58 mkat/L) • Collection: Tiger top tube; part of SMA-12
Generally parallels changes in ALT in liver disease.

Increased: AMI, liver disease, Reye's syndrome, muscle trauma and injection, pancreatitis, intestinal injury or surgery, factitious increase (erythromycin, opiates), burns, cardiac catheterization, brain damage, renal infarction

Decreased: Beriberi (vitamin B_6 deficiency), severe diabetes with ketoacidosis, liver disease, chronic hemodialysis

AUTOANTIBODIES

• Normal = negative • Collection: Tiger top tube

Antinuclear Antibody (ANA, FANA)

A useful screening test in patients with symptoms suggesting collagen–vascular disease, especially if titer is >1:160.

Positive: SLE, drug-induced lupus-like syndromes (procainamide, hydralazine, isoniazid, etc), scleroderma, MCTD, RA, polymyositis, juvenile RA (5–20%). Low titers are also seen in non-collagen–vascular disease.

Specific Immunofluorescent ANA Patterns

Homogenous. Nonspecific, from antibodies to DNP and native double-stranded DNA. Seen in SLE and a variety of other diseases. Antihistone is consistent with drug-induced lupus.

Speckled. Pattern seen in many connective tissue disorders. From antibodies to ENA, including anti-RNP, anti-Sm, anti-PM-1, and anti-SS. Anti-RNP is positive in MCTD and SLE. Anti-Sm is very sensitive for SLE. Anti-SS-A and anti-SS-B are seen in Sjögren's syndrome and subacute cutaneous lupus. The speckled pattern is also seen with scleroderma.

Peripheral Rim Pattern. From antibodies to native double-stranded DNA and DNP. Seen in SLE

Nucleolar Pattern. From antibodies to nucleolar RNA. Positive in Sjögren's syndrome and scleroderma

Anticentromere: Scleroderma, Raynaud's disease, CREST syndrome

Anti-DNA (Antidouble-stranded DNA): SLE (but negative in drug-induced lupus), chronic active hepatitis, mononucleosis

Antimitochondrial: Primary biliary cirrhosis, autoimmune diseases such as SLE

Antineutrophil Cytoplasmic: Wegener's granulomatosis, polyarteritis nodosa, and other vasculitides

Anti-SCL 70: Scleroderma

Antismooth Muscle: Low titers are seen in a variety of illnesses; high titers (>1:100) are suggestive of chronic active hepatitis.

Sjögren Syndrome Antibody (SS-A): Sjögren syndrome, SLE, RA

Antimicrosomal: Hashimoto's thyroiditis

BASE EXCESS/DEFICIT

• –2 to +2 • See Chapter 8, page 162

BICARBONATE (OR "TOTAL CO_2")

• 23–29 mmol/L • See CARBON DIOXIDE, page 61

BILIRUBIN

• Total, 0.3–1.0 mg/dL (SI: 3.4–17.1 mmol/L) • direct, <0.2 mg/dL (SI: <3.4 mmol/L) • indirect, <0.8 mg/dL (SI: <3.4 mmol/L) • To convert mg/dL to mmol/L, multiply by 17.10 • Collection: Tiger top tube

Increased Total: Hepatic damage (hepatitis, toxins, cirrhosis), biliary obstruction (stone or tumor), hemolysis, fasting.

Increased Direct (Conjugated): *Note:* Determination of the direct bilirubin is usually unnecessary with total bilirubin levels <1.2 mg/dL (SI: 21 mmol/L) Biliary obstruction/cholestasis (gallstone, tumor, stricture), drug-induced cholestasis, Dubin–Johnson and Rotor's syndromes

Increased Indirect (Unconjugated): *Note:* This is calculated as total minus direct bilirubin. So-called hemolytic jaundice caused by any type of hemolytic anemia (transfusion reaction, sickle cell, etc), Gilbert's disease, physiologic jaundice of the newborn, Crigler–Najjar syndrome

Bilirubin, Neonatal("Baby Bilirubin")

• Normal levels dependent on prematurity and age in days • "panic levels" usually >15–20 mg/dL (SI: >257–342 mmol/L in full-term infants) • Collection: Capillary tube

Increased: Erythroblastosis fetalis, physiologic jaundice (may be due to breast-feeding), resorption of hematoma or hemorrhage, obstructive jaundice, others

BLOOD UREA NITROGEN (BUN)

• Birth–1 year: 4–16 mg/dL (SI: 1.4–5.7 mmol/L) • 1–40 years 5–20 mg/dL (SI: 1.8–7.1 mmol/L)]] • Gradual slight increase with age • To convert mg/dL to mmol/L, multiply by 0.3570 • Collection: Tiger top tube

Less useful measure of GFR than creatinine because BUN is also related to protein metabolism

Increased: Renal failure (including drug-induced from aminoglycosides, NSAIDs), prerenal azotemia (decreased renal perfusion secondary to CHF, shock, volume depletion), postrenal (obstruction), GI bleeding, stress, drugs (especially aminoglycosides)

Decreased: Starvation, liver failure (hepatitis, drugs), pregnancy, infancy, nephrotic syndrome, overhydration

BUN/CREATININE RATIO (BUN/CR)

• Mean 10, range 6–20

Calculated based on serum levels

Increased: Prerenal azotemia (renal hypoperfusion), GI bleeding, high-protein diet, ileal conduit, drugs (steroids, tetracycline)

Decreased: Malnutrition, pregnancy, low-protein diet, ketoacidosis, hemodialysis, SIADH, drugs (cimetidine)

4

C-PEPTIDE, INSULIN ("CONNECTING PEPTIDE")

• Fasting, <4.0 ng/mL (SI: <4.0 mg/L) • Male >60 years, 1.5–5.0 ng/mL (SI: 1.5–5.0 mg/L) • Female 1.4–5.5 ng/mL (SI: 1.4–5.5 mg/L) • Collection: Tiger top tube

Differentiates between exogenous and endogenous insulin production/administration. Liberated when proinsulin is split to insulin; levels suggest endogenous production of insulin

Decreased: Diabetes (decreased endogenous insulin), insulin administration (factitious or therapeutic), hypoglycemia

C-REACTIVE PROTEIN (CRP)

• Normal = none detected • Collection: Tiger top tube

A nonspecific screen for infectious and inflammatory diseases, correlates well with ESR. In the first 24 h, however, ESR may be normal and CRP elevated.

Increased: Bacterial infections, inflammatory conditions (acute rheumatic fever, acute RA, MI, transplant rejection, embolus, inflammatory bowel disease), last half of pregnancy, oral contraceptives, some malignancies

CA 15-3

Used to detect breast cancer recurrence in asymptomatic patients and monitor therapy. Levels related to stage of disease

Increased: Progressive breast cancer, benign breast disease and liver disease

Decreased: Response to therapy (25% change considered significant)

CA 19-9

• <37 U/ml (SI:<37 kU/L) • Collection: Tiger top tube

Primary used to determine resectability of pancreatic cancers (ie, >1000U/mL 95% unresectable)

Increased: GI cancers such as pancreas, stomach, liver, colorectal, hepatobiliary, some cases of lung and prostate, pancreatitis

CA-125

• <35 U/mL (SI: <35 kU/L) • Collection: Tiger top tube

Not a useful screening test for ovarian cancer when used alone; best used in conjunction with ultrasound and physical examination. Rising levels after resection predictive for recurrence

Increased: Ovarian, endometrial, and colon cancer; endometriosis; inflammatory bowel disease; PID; pregnancy; breast lesions; and benign abdominal masses (teratomas)

CALCITONIN (THYROCALCITONIN)

• <19 pg/mL (SI: <19 ng/L) • Collection: Tiger top tube

Increased: Medullary carcinoma of the thyroid, C-cell hyperplasia (precursor of medullary carcinoma), small (oat) cell carcinoma of the lung, newborns, pregnancy, chronic renal insufficiency, Zollinger–Ellison syndrome, pernicious anemia.

CALCIUM, SERUM

• Infants to 1 month: 7–11.5 mg/dL (SI: 1.75–2.87 mmol/L) • 1 month to 1 year: 8.6–11.2 mg/dL (SI: 2.15–2.79 mmol/L) • >1 year and adults: 8.2–10.2 mg/dL (SI: 2.05–2.54 mmol/L) • Ionized: 4.75–5.2 mg/dL (SI: 1.19–1.30 mmol/L) • To convert mg/dL to mmol/L, multiply by 0.2495 • Collection: Tiger top tube; ionized requires green or red tube

When interpreting a total calcium value, albumin must be known. If it is not within normal limits, a corrected calcium can be roughly calculated by the following formula. Values for ionized calcium need no special corrections.

Corrected total Ca = 0.8 (Normal albumin − Measured albumin) + Reported Ca

Increased: (*Note:* Levels >12 mg/dL [2.99 mmol/L] may lead to coma and death) Primary hyperparathyroidism, PTH-secreting tumors, vitamin D excess, metastatic bone tumors, osteoporosis, immobilization, milk-alkali syndrome, Paget's disease, idiopathic hypercalcemia of infants, infantile hypophosphatasia, thiazide diuretics, chronic renal failure, sarcoidosis, multiple myeloma

Decreased: (*Note:* Levels <7 mg/dL [<1.75 mmol/L] may lead to tetany and death.) Hypoparathyroidism (surgical, idiopathic), pseudo-hypoparathyroidism, insufficient vitamin D, calcium and phosphorus ingestion (pregnancy, osteomalacia, rickets), hypomagnesemia, renal tubular acidosis, hypoalbuminemia (cachexia, nephrotic syndrome, CF), chronic renal failure (phosphate retention), acute pancreatitis, factitious decrease because of low protein and albumin

CAPTOPRIL TEST

• See Aldosterone, page 56, and renin (plasma renin), page 88, for normal values

Used in the evaluation of renovascular hypotension, the drug is an ACE inhibitor that blocks angiotensin II. Captopril is administered (25 mg IV at 8AM). Aldosterone decreases 2 h later from baseline in normals or essential hypertension, but does not suppress in patients with aldosteronism. For renovascular hypertension, the PRA increases >12 ng/mL/h and an absolute increase of 10 ng/mL/h plus a 400% increase in PRA if pretest level <3 ng/mL/h and >150% over baseline if the pretest PRA was >3 ng/mL/h. Test now also combined with nuclear renal scan to identify renal artery stenosis

CARBON DIOXIDE ("TOTAL CO_2" OR BICARBONATE)

• Adult 23–29 mmol/L, child 20–28 mmol/L • (See Chapter 8 for pCO_2 values • Collection: Tiger top tube, do not expose sample to air

Increased: Compensation for respiratory acidosis (emphysema) and metabolic alkalosis (severe vomiting, primary aldosteronism, volume contraction, Bartter's syndrome)

Decreased: Compensation for respiratory alkalosis, and metabolic acidosis (starvation, diabetic ketoacidosis, lactic acidosis, alcoholic ketoacidosis, toxins [methanol, ethylene glycol, paraldehyde], severe diarrhea, renal failure, drugs [salicylates, acetazolamide], dehydration, adrenal insufficiency)

CARBOXYHEMOGLOBIN (CARBON MONOXIDE)

• Nonsmoker <2%; smoker <9%; toxic >15%• Collection: Gray or lavender top tube; confirm with lab

Increased: Smokers, smoke inhalation, automobile exhaust inhalation, normal newborns

CARCINOEMBRYONIC ANTIGEN (CEA)

• Nonsmoker <3.0 ng/mL (SI: <3.0 µg/L) • smoker <5.0 ng/mL (SI: <5.0 µg/L) • Collection: Tiger top tube

Not a screening test; useful for monitoring response to treatment and tumor recurrence of adenocarcinomas of the GI tract

Increased: Carcinoma (colon, pancreas, lung, stomach), smokers, nonneoplastic liver disease, Crohn's disease, and ulcerative colitis

CATECHOLAMINES, FRACTIONATED SERUM

• Collection: Green or lavender tube; check with lab

Values vary and depend on the lab and method of assay used. Normal levels shown here are based on a HPLC technique. Patient must be supine in a nonstimulating environment with IV access to obtain sample.

Catecholamine	Plasma (Supine) Levels
Norepinephrine	70–750 pg/mL (SI: 414–4435 pmol/L)
Epinephrine	0–100 pg/mL (SI: 0–546 pmol/L)
Dopamine	<30 pg/mL (SI: 196 pmol/L)

Increased: Pheochromocytoma, neural CREST tumors (neuroblastoma), with extra-adrenal pheochromocytoma, norepinephrine may be markedly elevated compared with epinephrine.

CHLORIDE, SERUM

• 97–107 mEq/L (SI: 97–107 mmol/L) • Collection: Tiger top tube

Increased: Diarrhea, renal tubular acidosis, mineralocorticoid deficiency, hyperalimentation, medications (acetazolamide, ammonium chloride)

Decreased: Vomiting, diabetes mellitus with ketoacidosis, mineralocorticoid excess, renal disease with sodium loss

CHOLESTEROL

• Total • Normal, see Table 4–1; see also LIPID PROFILE/CHOLESTEROL SCREENING, page 79, and Figure 4–4, see page 80.• To convert mg/dL to mmol/L, multiply by 0.02586 • Collection: Tiger top tube

TABLE 4–1
Normal Total Cholesterol Levels by Age

Age	Standard Units (mg/dL)	SI Units (mmol/L)
<29	<200	<5.20
30–39	<225	<5.85
40–49	<245	<6.35

Increased: Idiopathic hypercholesterolemia, biliary obstruction, nephrosis, hypothyroidism, pancreatic disease (diabetes), pregnancy, oral contraceptives, hyperlipoproteinemia (types IIb, III, V)

Decreased: Liver disease (hepatitis, etc), hyperthyroidism, malnutrition (cancer, starvation), chronic anemias, steroid therapy, lipoproteinemias, AMI

High-Density Lipoprotein Cholesterol (HDL, HDL-C)

• Fasting 30–70 mg/dL (SI: 0.8–1.80 mmol/L) • Female 30–90 mg/dL (SI: 0.80–2.35)

HDL-C has the best correlation with the development of CAD; decreased HDL-C in males leads to an increased risk. Levels <45 mg/dL associated with increased risk of CAD

Increased: Estrogen (females), regular exercise, small ethanol intake, medications (nicotinic acid, gemfibrozil, others)

Decreased: Males, smoking, uremia, obesity, diabetes, liver disease, Tangier disease

Low-Density Lipoprotein Cholesterol (LDL, LDL-C)

• 50–190 mg/dL (SI: 1.30–4.90 mmol/L)

Increased: Excess dietary saturated fats, MI, hyperlipoproteinemia, biliary cirrhosis, endocrine disease (diabetes, hypothyroidism)

Decreased: Malabsorption, severe liver disease, abetalipoproteinemia

CLOSTRIDIUM DIFFICILE TOXIN ASSAY, FECAL

• Normal negative

Majority of patients with pseudomembranous colitis have positive *C. difficile* assay. Often positive in antibiotic associated diarrhea and colitis. Can be seen in some normals and neonates

COLD AGGLUTININS

• <1:32 • Collection: Lavender or blue top tube

Most frequently used to screen for atypical pneumonias.

Increased: Atypical pneumonia (mycoplasmal pneumonia), other viral infections (especially mononucleosis, measles, mumps), cirrhosis, parasitic infections, Waldenström's macroglobulinemia, lymphomas and leukemias, multiple myeloma

COMPLEMENT

• Collection: Tiger or lavender top tube

Complement describes a series of sequentially reacting serum proteins that participate in pathogenic processes and lead to inflammatory injury.

Complement C3

• 85–155 mg/dL, (SI: 800–1500 ng/L)

Decreased levels suggest activation of the classical or alternative pathway, or both.

Increased: RA (variable finding), rheumatic fever, various neoplasms (gastrointestinal, prostate, others), acute viral hepatitic, MI, pregnancy, amyloidosis

Decreased: SLE, glomerulonephritis (poststreptococcal and membranoproliferative), sepsis, SBE, chronic active hepatitis, malnutrition, DIC, gram-negative sepsis

Complement C4

• 20–50 mg/dL (SI: 200–500 ng/L)

Increased: RA (variable finding), neoplasia (gastrointestinal, lung, others)

Decreased: SLE, chronic active hepatitis, cirrhosis, glomerulonephritis, hereditary angioedema (test of choice).

Complement CH50 (Total)

• 33–61 mg/mL (SI: 330–610 ng/L)

Tests for complement deficiency in the classical pathway.

Increased: Acute-phase reactants (tissue injury, infections, etc)

Decreased: Hereditary complement deficiencies

CORTISOL, SERUM

• 8 AM, 5.0–23.0 mg/dL (SI: 138–365 nmol/L) • 4 PM, 3.0–15.0 mg/dL (SI: 83–414 nmol/L) • Collection: Green or red top tube

Increased: Adrenal adenoma, adrenal carcinoma, Cushing's disease, nonpituitary ACTH-producing tumor, steroid therapy, oral contraceptives

Decreased: Primary adrenal insufficiency (Addison's disease), congenital adrenal hyperplasia, Waterhouse-Friderichsen syndrome, ACTH deficiency

COUNTERIMMUNOELECTROPHORESIS (CIEP, CEP)

• Normal = negative

An immunologic technique that allows for rapid identification of infecting organisms from fluids, including serum, urine, CSF, and other body fluids. Organisms identified in-

clude *Neisseria meningitidis, Streptococcus pneumoniae, Haemophilus influenzae,* and group B *Streptococcus.*

CREATINE PHOSPHOKINASE (KINASE) (CP, CPK)

• 25–145 mU/mL (SI: 25–145 U/L) • Collection: Tiger top tube

Used in suspected MI or muscle diseases. Heart, skeletal muscle, and brain have high levels

Increased: Muscle damage (AMI, myocarditis, muscular dystrophy, muscle trauma [including injections], after surgery), brain infarction, defibrillation, cardiac catheterization and surgery, rhabdomyolysis, polymyositis, hypothyroidism

CPK Isoenzymes

MB: (Normal <6%, heart origin) increased in AMI (begins in 2–12 h, peaks at 12–40 h, returns to normal in 24–72 h), pericarditis with myocarditis, rhabdomyolysis, crush injury, Duchenne's muscular dystrophy, polymyositis, malignant hyperthermia, and cardiac surgery

MM: (Normal 94–100%, skeletal muscle origin) increased in crush injury, malignant hyperthermia, seizures, IM injections

BB: (Normal 0%, brain origin) brain injury (CVA, trauma), metastatic neoplasms (prostate), malignant hyperthermia, colonic infarction

CREATININE, SERUM

• Adult male <1.2 mg/dL (SI: 106 mmol/L) • Adult female <1.1 mg/dL (SI: 97 mmol/L) • Child 0.5–0.8 mg/dL (SI: 44–71 mmol/L) • To convert mg/dL to µmol/L, multiply by 88.40 • Collection: Tiger top tube

A clinically useful estimate of GFR. As a rule of thumb, serum creatinine doubles with each 50% reduction in the GFR. Creatine clearance is discussed in Chapter 6.

Increased: Renal failure (prerenal, renal, or postrenal obstruction or medication-induced [aminoglycosides, NSAIDs, others]), gigantism, acromegaly, ingestion of roasted meat, false-positive with DKA

Decreased: Pregnancy, decreased muscle mass, severe liver disease

CRYOGLOBULINS (CRYOCRIT)

<0.4% (or negative if qualitative) {·}

Collection: Tiger top tube, process immediately

These abnormal proteins precipitate out of serum at low temperatures. Cryocrit, a quantitative measure, is preferred over the qualitative method. Should be collected in nonanticoagulated tubes and transported at body temperature. Positive samples can be analyzed for immunoglobulin class, and light-chain type on request.

Monoclonal: Multiple myeloma, Waldenström's macroglobulinemia, lymphoma, CLL

Mixed Polyclonal or Mixed Monoclonal: Infectious diseases (viral, bacterial, parasitic), such as SBE or malaria; SLE; RA; essential cryoglobulinemia; lymphoproliferative diseases; sarcoidosis; chronic liver disease (cirrhosis)

CYTOMEGALOVIRUS (CMV) ANTIBODIES

• IgM <1:8, IgG <1:16 • Collection: Tiger top tube

Used in neonates (CMV is the most common intrauterine infection), posttransfusion CMV infection, and organ donors and recipients. Most of adults will have detectable titers.

Increased: Serial measurements 10–14 days apart with a 4× increase in titers or a single IgM >1:8 is suspicious for acute infection. Universally increased titers in AIDS. IgM most useful in neonatal infections

DEHYDROEPIANDROSTERONE (DHEA)

• Male 2.0–3.4 ng/mL (SI: 5.2–8.7 mmol/L) • Female, premenopausal 0.8–3.4 ng/mL (SI: 2.1–8.8 mmol/L) • Postmenopausal 0.1–0.6 ng/mL (SI: 0.3–1.6 mmol/L) • Collection: Tiger top tube

Increased: Anovulation, polycystic ovaries, adrenal hyperplasia, adrenal tumors

Decreased: Menopause

DEHYDROEPIANDROSTERONE SULFATE (DHEAS)

• Male 1.7–4.2 ng/mL (SI: 6–15 mmol/L) • Female 2.0–5.2 ng/mL (SI: 7–18 mmol/L) • Collection: Tiger top tube

Increased: Hyperprolactinemia, adrenal hyperplasia, adrenal tumor, polycystic ovaries, lipoid ovarian tumors

Decreased: Menopause

DEXAMETHASONE SUPPRESSION TEST

Used in the differential diagnosis of Cushing's syndrome (elevated cortisol)

Overnight Test: In the "rapid" version of this test, a patient takes 1 mg of dexamethasone PO at 11 PM and a fasting 8 AM plasma cortisol is obtained. Normally the cortisol level should be <5.0 mg/dL [138 nmol/L]. A value that is >5 mg/dL [138 nmol/L] usually confirms the diagnosis of Cushing's syndrome; however, obesity, alcoholism, or depression may occasionally show the same result. In these patients, the best screening test is a 24-h urine for free cortisol.

Low-Dose Test: After collection of baseline serum cortisol and 24-h urine-free cortisol levels, dexamethasone 0.5 mg is administered PO every 6 h for eight doses. Serum and urine cortisol are repeated on the second day. Failure to suppress to a serum cortisol of <5.0 mg/dL [138 nmol/L] and a urine-free cortisol of <30 µg/dL (82 nmol/L) confirms Cushing's syndrome.

High-Dose Test: After the low-dose test, dexamethasone, 2 mg PO every 6 h for eight doses will cause a fall in urinary-free cortisol to 50% of the baseline value in bilateral adrenal hyperplasia (Cushing's disease) but not in adrenal tumors or ectopic ACTH production.

ERYTHROPOIETIN (EPO)

• 5–36 mU/L (5–36 IU/L) • Collection: Tiger top tube

EPO is a renal hormone that stimulates RBC production.

Increased: Pregnancy, secondary polycythemia (high altitude, COPD, etc), tumors (renal cell carcinoma, cerebellar hemangioblastoma, hepatoma, others), PCKD, anemias with bone marrow unresponsiveness (aplastic anemia, iron deficiency, etc)

Decreased: Bilateral nephrectomy, anemia of chronic disease (ie, renal failure, nephrotic syndrome), primary polycythemia (*Note:* The determination of EPO levels before administration of recombinant EPO for renal failure is not usually necessary.)

ESTRADIOL, SERUM

• Collection: Tiger top tube

Serial measurements useful in assessing fetal well-being, especially in high-risk pregnancy. Also useful in evaluation of amenorrhea and gynecomastia in males.

Female	**Normal Values**
Follicular phase	25–75 pg/mL
Midcycle peak	200–600 pg/mL
Luteal phase	100–300 pg/mL
Pregnancy 1st trimester	1–5 ng/mL
2nd trimester	5–15 ng/mL
3rd trimester	10–40 ng/mL
Postmenopause	5–25 pg/mL
Oral contraceptives	<50 pg/mL
Male	
Prepubertal	2–8 pg/mL
Adult	10–60 pg/mL

ESTROGEN/PROGESTERONE RECEPTORS

These are typically determined on fresh surgical (breast cancer) specimens. The presence of the receptors is associated with a longer disease-free interval, survival from breast cancer, and increased likelihood of responding to endocrine therapy. Fifty to seventy-five percent of breast cancers are estrogen-receptor-positive.

ETHANOL (BLOOD ALCOHOL)

• 0 mg/dL (0 mmol/L) • Collection: Tiger top tube; do not use alcohol to clean venipuncture site, use povidone-iodine

Physiologic changes can vary with degree of alcohol tolerance of an individual.

- <50 mg/dL [<10.85 mmol/L]: Limited muscular incoordination
- 50–100 [10.85–21.71]: Pronounced incoordination
- 100–150 [21.71–32.57]: Mood and personality changes; legally intoxicated in most states
- 150–400 [32.57–87]: Nausea, vomiting, marked ataxia, amnesia, dysarthria
- ≥400: Coma, respiratory insufficiency and death

FECAL FAT

• 2–6 g/d on an 80–100 g/d fat diet • 72-h collection time • Sudan III stain, random <60 droplets fat/hpf

Increased: CF, pancreatic insufficiency, Crohn's disease, chronic pancreatitis, sprue

FERRITIN

• Male 15–200 ng/mL (SI: 15–200 mg/L) • Female 12–150 ng/mL (SI: 12–150 mg/L) • Collection: Tiger top tube

Increased: Hemochromatosis, hemosiderosis, sideroblastic anemia

Decreased: Iron deficiency (earliest and most sensitive test before red cells show any morphologic change), severe liver disease

FOLIC ACID

Serum Folate

• >2.0 ng/mL (SI: >5 nmol/L)

RBC

• 125–600 ng/mL (283–1360 nmol/L) • Collection: Lavender top tube

Serum folate can fluctuate with diet. RBC levels are more indicative of tissue stores. Vitamin B_{12} deficiency can result in the RBC unable to take up folate in spite of normal serum folate levels.

Increased: Folic acid administration

Decreased: Malnutrition/malabsorption (folic acid deficiency), massive cellular growth (cancer) or cell turnover, ongoing hemolysis, medications (trimethoprim, some anticonvulsants, oral contraceptives), vitamin B_{12} deficiency (low RBC levels), pregnancy

FOLLICLE-STIMULATING HORMONE (FSH)

• Males: <22 IU/L • Females: nonmidcycle <20 IU/L, midcycle surge <40 IU/L (Midcycle peak should be two times basal level • Postmenopausal 40–160 IU/L • Collection: Tiger top tube

Used in the workup of impotence, infertility in men, and amenorrhea in women

Increased: (Hypergonadotropic >40 IU/L) postmenopausal, surgical castration, gonadal failure, gonadotropin-secreting pituitary adenoma

Decreased: (Hypogonadotropic <5 IU/L) prepubertal, hypothalamic and pituitary dysfunction, pregnancy

FTA-ABS (FLUORESCENT TREPONEMAL ANTIBODY ABSORBED)

• Normal = nonreactive • Collection: Tiger top tube

FTA-ABS may be negative in early primary syphilis and remain positive in spite of adequate treatment.

Positive: Syphilis (test of choice to confirm diagnosis after a reactive VDRL test), other treponemal infections can cause false-positive (Lyme disease, leprosy, malaria)

FUNGAL SEROLOGIES

• Negative <1:8 • Collection: Tiger top tube

This is a screening technique for complement-fixed fungal antibodies, which usually detects antibodies to *Histoplasma capsulatum, Blastomyces dermatitidis, Cryptococcus neoformans, Aspergillus* species, *Candida* species, and *Coccidioides immitis.*

GASTRIN, SERUM

• Fasting <100 pg/mL (SI: 47.7 pmol/L) • Postprandial 95–140 pg/mL (SI: 45.3–66.7 pmol/L) • Collection: Tiger top tube, freeze immediately

Make sure patient is not on H_2 blockers or antacids.

Increased: Zollinger–Ellison syndrome, medications (antacids, cimetidine, others) pyloric stenosis, pernicious anemia, atrophic gastritis, ulcerative colitis, renal insufficiency, and steroid and calcium administration

Decreased: Vagotomy and antrectomy

GGT (SERUM GAMMA-GLUTAMYL TRANSPEPTIDASE, SGGT)

• Male 9–50 U/L • Female 8–40 U/L • Collection: Tiger top tube

Generally parallels changes in serum alkaline phosphatase and 5′-nucleotidase in liver disease. Sensitive indicator of alcoholic liver disease

Increased: Liver disease (hepatitis, cirrhosis, obstructive jaundice), pancreatitis.

GLUCOSE

• Fasting, 70–105 mg/dL (SI: 3.89–5.83 nmol/L) • 2 h postprandial <140 mg/dL (SI: <7.8 nmol/L) • To convert mg/dL to nmol/L, multiply by 0.05551 • Collection: Tiger top tube

American Diabetes Association Diagnostic Criterion for Diabetes: normal fasting <110, Impaired fasting 110–126, diabetes >126 or any random level >200 when associated with other symptoms. Confirm with repeat testing.

Increased: Diabetes mellitus, Cushing's syndrome, acromegaly, increased epinephrine (injection, pheochromocytoma, stress, burns, etc), acute pancreatitis, ACTH administration, spurious increase caused by drawing blood from a site above an IV line containing dextrose, elderly patients, pancreatic glucagonoma, drugs (glucocorticoids, some diuretics)

Decreased: Pancreatic disorders (pancreatitis, islet cell tumors), extrapancreatic tumors (carcinoma of the adrenals, stomach), hepatic disease (hepatitis, cirrhosis, tumors), endocrine disorders (early diabetes, hypothyroidism, hypopituitarism), functional disorders (after gastrectomy), pediatric problems (prematurity, infant of a diabetic mother, ketotic hypoglycemia, enzyme diseases), exogenous insulin, oral hypoglycemic agents, malnutrition, sepsis

GLUCOSE TOLERANCE TEST (GTT), ORAL (OGTT)

A fasting plasma glucose level >126 mg/dl (7.0 mmol/L) or a casual plasma glucose –200 mg/dL (11.1 mmol/L) meets the threshold for the diagnosis of diabetes, if confirmed on a subsequent day, and precludes the need for any glucose challenge. GTT is usually unnecessary to diagnose asymptomatic diabetes mellitus; it may be useful in gestational diabetes. The GTT is unreliable in the presence of severe infection, prolonged fasting, or after the injection of insulin. After an overnight fast, a fasting blood glucose is drawn, and the patient is given a 75-g oral glucose load (100 g for gestational diabetes screening, 1.75 mg/kg ideal body weight in children up to a dose of 75 g). Plasma glucose is then drawn at 30, 60, 120, and 180 min.

Interpretation of GTT

Adult-Onset Diabetes: Any fasting blood sugar >126, or >200 at both 120 min and one other time interval measured

Gestational Diabetes: Any fasting blood sugar >126, 60 min >180, 120 min >155, 180 min >140

GLYCOHEMOGLOBIN (GHB, GLYCATED HEMOGLOBIN, GLYCOHEMOGLOBIN, HBA_{1c}, HBA_1 HEMOGLOBIN A_{1c}, GLYCOSYLATED HEMOGLOBIN)

• 4.6–7.1% or new standard: Nondiabetic <6, near normal 6–7 • Excellent glucose control 7–8 • Good control 8–9 • Fair control 9–10 • Poor control >10 • Collection: Lavender top tube

Useful in long-term monitoring control of blood sugar in diabetics; reflects levels over preceding 3–4 months. Glycated serum protein (GSP) under study and may reflect serum glucose over the preceding 1–2 weeks

Increased: Diabetes mellitus (uncontrolled), lead intoxication

Decreased: Chronic renal failure, hemolytic anemia, pregnancy, chronic blood loss

HAPTOGLOBIN

• 40–180 mg/dL (SI: 0.4–1.8 g/L) • Collection: Tiger top tube

Increased: Obstructive liver disease, any cause of increased ESR (inflammation, collagen-vascular diseases)

Decreased: Any type of hemolysis (transfusion reaction, etc), liver disease, anemia, oral contraceptives, children and infants

HELICOBACTER PYLORI ANTIBODY TITERS

• IgG <0.17 = negative

Most patients with gastritis and ulcer disease (gastric or duodenal) have chronic *H. pylori* infection that should be treated. Positive in 35–50% asymptomatic patients (increases with age). Use in dyspepsia controversial. Four diagnostic methods are available to test for *H. pylori,* the organism associated with gastritis and ulcers. These include noninvasive (serology and a ^{13}C breath test) and invasive (gastric mucosal biopsy and the *Campylobacter*-like organism test). The IgG subclass is found in all patient populations; occasionally only IgA antibodies can be detected. Serology is most useful in the evaluation of newly diagnosed *H. pylori* infection or in monitoring response to therapy. IgG levels decrease slowly after treatment, but can remain elevated after clearing infection.

Positive: Active or recent *H. pylori* infection, some asymptomatic carriers

HEPATITIS TESTING

Recommended hepatitis panel tests based on clinical settings is shown in Table 4–2. Interpretation of testing patterns is shown in Table 4–3. Profile patterns of hepatitis A and B are shown in Figures 4–1 and 4–2, respectively.

Hepatitis Tests (Collection: Tiger top tube)

TABLE 4–2
Hepatitis Panel Testing to Guide the Ordering of Hepatitis Profiles for Given Clinical Settings

Clinical Setting	Test	Purpose
SCREENING TESTS		
Pregnancy	HBsAg*	All expectant mothers should be screened during third trimester
High-risk patients on admission (homosexuals, dialysis patients)	HBsAg	To screen for chronic or active infection
Percutaneous inoculation		
Donor	HBsAg Anti-HBc IgM Anti-Hep C	To test patient's blood (esp. dialysis and HIV patients) for infectivity with hepatitis B and C if a health care worker is exposed
Victim	HBsAg Anti-HBc Anti-Hep C	To test exposed health care worker for immunity or chronic infection
Pre-HBV vaccine	Anti-HBc Anti-HBs	To determine if an individual is infected or has antibodies to HBV
Screening blood donors	HBsAg Anti-HBc Anti-Hep C	Used by blood banks to screen donors for hepatitis B and C
DIAGNOSTIC TESTS		
Differential diagnosis of acute jaundice, hepatitis, or fulminant liver failure	HBsAg Anti-HBc IgM Anti-HAV IgM Anti-Hep C	To differentiate between HBV, HAV, and hepatitis C in an acutely jaundiced patient with hepatitis or fulminant liver failure
Chronic hepatitis	HBsAg HBeAg Anti-HBe Anti-HDV (total + IgM)	To diagnose HBV infection: if positive for HBsAg to determine infectivity If HBsAg patient worsens or is very ill, to diagnose concomitant infection with hepatitis delta virus
MONITORING		
Infant follow-up	HBsAg Anti-HBc	To monitor the success of vaccination and passive

(*continued*)

TABLE 4–2 (Continued)

Clinical Setting	Test	Purpose
	Anti-HBs	immunization for perinatal transmission of HBV 12–15 mo after birth
Postvaccination screening	Anti-HBs	To ensure immunity has been achieved after vaccination (CDC recommends "titer" determination, but usually qualitative assay is adequate)
Sexual contact	HBsAg Anti-HBc Anti-Hep C	To monitor sexual partners of a patient with chronic HBV or hepatitis C

*See text for abbreviations.

TABLE 4–3
Interpretation of Viral Hepatitis Serologic Testing Patterns

Anti-HAV (IgM)	HBsAg	Anti-HBc (IgM)	Anti-HBc (Total)	Anti-C (ELISA)	Interpretation
+	–	–	–	–	Acute hepatitis A
+	+	–	+	–	Acute hepatitis A in hepatitis B carrier
–	+	–	+	–	Chronic hepatitis B*
–	–	+	+	–	Acute hepatitis B
–	+	+	+	–	Acute hepatitis B
–	–	–	+	–	Past hepatitis B infection
–	–	–	–	+	Hepatitis C†
–	–	–	–	–	Early hepatitis C or other cause (other virus, toxin)

*Patients with chronic hepatitis B (either active hepatitis or carrier state) should have HBeAg and anti-HBe checked to determine activity of infection and relative infectivity. Anti-HBs is used to determine response to hepatitis B vaccination.
†Anti-C often takes 3–6 mo before being positive. PCR may allow earlier detection.

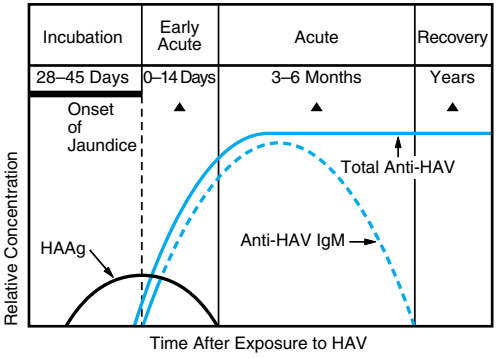


FIGURE 4–1 Hepatitis A diagnostic profile. (Courtesy of Abbott Laboratories, Diagnostic Division, North Chicago, Illinois.)

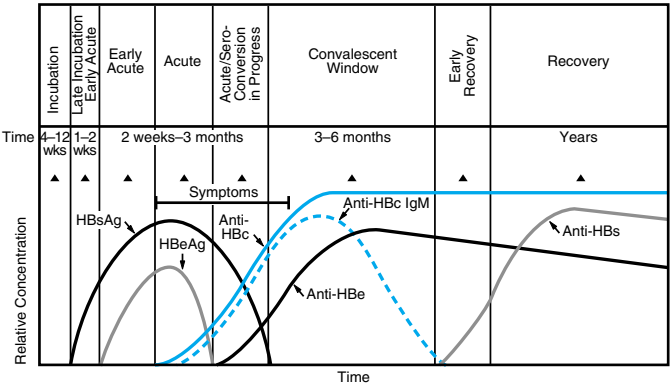


FIGURE 4–2 Hepatitis B diagnostic profile. (Courtesy of Abbott Laboratories, Diagnostic Division, North Chicago, Illinois.)

Hepatitis A

Anti-HAV Ab: Total antibody to hepatitis A virus; confirms previous exposure to hepatitis A virus, elevated for life.

Anti-HAV IgM: IgM antibody to hepatitis A virus; indicative of recent infection with hepatitis A virus; declines typically 1–6 months after symptoms

Hepatitis B

HBsAg: Hepatitis B surface antigen. Earliest marker of HBV infection. Indicates either chronic or acute infection with hepatitis B virus. Used by blood banks to screen donors; vaccination does not affect this test

Anti-HBc-Total: IgG and IgM antibody to hepatitis B core antigen; confirms either previous exposure to hepatitis B virus (HBV) or ongoing infection. Used by blood banks to screen donors

Anti-HBc IgM: IgM antibody to hepatitis B core antigen. Early and best indicator of acute infection with hepatitis B

HBeAg: Hepatitis Be antigen; when present, indicates high degree of infectivity. Order only when evaluating for chronic HBV infection

HBV-DNA: Most sensitive and specific for early evaluation of hepatitis B and may be detected when all other markers are negative

Anti-HBe: Antibody to hepatitis Be antigen; associated with resolution of active inflammation

Anti-HBs: Antibody to hepatitis B surface antigen; when present, typically indicates immunity associated with clinical recovery from HBV infection or previous immunization with hepatitis B vaccine. Order only to assess effectiveness of vaccine and request titer levels

Anti-HDV: Total antibody to delta hepatitis; confirms previous exposure. Order only in patients with known acute or chronic HBV infection.

Anti-HDV IgM: IgM antibody to delta hepatitis; indicates recent infection. Order only in cases of known acute or chronic HBV infection

Hepatitis C

Anti-HCV: Antibody against hepatitis C. Indicative of active viral replication and infectivity. Used by blood banks to screen donors. Many false-positives

HCV-RNA: Nucleic acid probe detection of current HCV infection

HIGH-DENSITY LIPOPROTEIN CHOLESTEROL

• See CHOLESTEROL, page 62.

HLA (HUMAN LEUKOCYTE ANTIGENS; HLA TYPING)

• Collection: Green top tube

This test identified a group of antigens on the cell surface that are the primary determinants of histocompatibility and useful in assessing transplantation compatibility. Some are associated with specific diseases but are not diagnostic of these diseases.

HLA-B27: Ankylosing spondylitis, psoriatic arthritis, Reiter's syndrome, juvenile RA

HLA-DR4/HLA DR2: Chronic Lyme disease arthritis

HLA-DRw2: MS

HLA-B8: Addison's disease, juvenile-onset diabetes, Grave's disease, gluten-sensitive enteropathy

HOMOCYSTEINE, SERUM

• Normal fasting 5 and 15 µmol/L • Fasting target <10 µmol/L

Under investigation as a risk factor for CAD and atherosclerosis. Moderate, intermediate, and severe hyperhomocystinemia refer to concentrations between 16 and 30, between 31 and 100, and >100 µmol/L, respectively. May be useful to screen high-risk patients and recommend strategies to obtain target of <10 (ie, dietary, lifestyle changes, vitamin supplementation)

Increased: Vitamin B_{12}, B_6 and folate deficiency, kidney and renal failure, medications (nicotinic acid, theophylline, methotrexate, L-dopa, anticonvulsants) advanced age, hypothyroidism, impaired kidney function, SLE, and certain medications

HUMAN CHORIONIC GONADOTROPIN, SERUM (HCG, BETA SUBUNIT)

• Normal, <3.0 mIU/mL • 10 days after conception, >3 mIU/mL • 30 days, 100–5000 mIU/mL • 10 weeks, 50,000–140,000 mIU/mL • >16 weeks, 10,000–50,000 mIU/mL • Thereafter, levels slowly decline (SI units IU/L equivalent to mIU/mL) • Collection: Tiger top tube

Increased: Pregnancy, some testicular tumors (nonseminomatous germ cell tumors, but not seminoma), trophoblastic disease (hydatidiform mole, choriocarcinoma levels usually >100,000 mIU/mL)

HUMAN IMMUNODEFICIENCY VIRUS (HIV) TESTING

See Figure 4–3 CDC guidelines. Any HIV-positive person over 13 years of age with a $CD4^+$ T-cell level <200/mL or an HIV-positive patient with a series of CDC-defined indicator conditions (eg, pulmonary candidiasis, disseminated histoplasmosis, HIV wasting, Kaposi's sarcoma, TB, various lymphomas, PCP, and others) is considered to have AIDS.

HIV Antibody

• Normal = negative • Collection: Tiger top tube

Assay kits recognize both HIV-1 and HIV-2 antibodies. Used in the diagnosis of AIDS and to screen blood for use in transfusion. Antibodies appear in blood 1–4 mo after infection in most cases.

HIV Antibody, ELISA

• Normal = negative

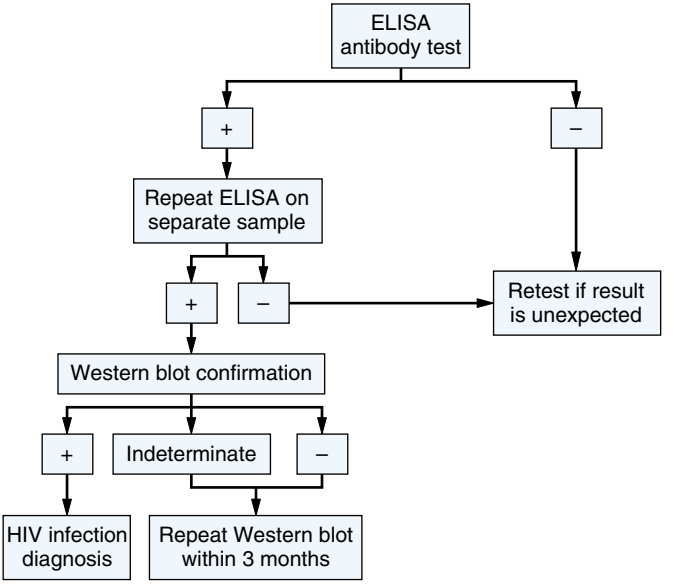


FIGURE 4–3 Diagnostic algorithm for HIV infection. (Courtesy of Burroughs-Wellcome Company, Research Triangle Park, North Carolina.)

Initial screen to detect HIV antibody; a positive test is often repeated or confirmed by Western blot.

Positive: AIDS, asymptomatic HIV infection

False-Positive: Flu vaccine within 3 months, hemophilia, rheumatoid factor, alcoholic hepatitis, dialysis patients

HIV Western Blot

- Normal = negative

The technique is used as the reference procedure for confirming the presence or absence of HIV antibody, usually after a positive

HIV Antibody by ELISA Determination

Positive: AIDS, asymptomatic HIV infection (if indeterminate, repeat in 1 mo or perform PCR for HIV-1 DNA or RNA)

False-Positive: Autoimmune or connective tissue diseases, hyperbilirubinemia, HLA antibodies, others

HIV DNA PCR

• Normal = negative

Performed on peripheral blood mononuclear cells. Preferred test to diagnose HIV infection in children <18 months of age

HIV RNA PCR

• Normal = <400 copies/mL

Used to quantify plasma "viral load." Establishes the diagnosis before antibody production begins or when HIV antibody test is indeterminate. Obtained at baseline diagnosis, serves as an important parameter to initiate or modify HIV therapy (see the following details of viral load). Not recommended for routine testing of children <18 months

HIV VIRAL LOAD

• Normal <50 copies/mL

Single best predictor of progression to AIDS and death among HIV-infected individuals. Also used as a baseline and for initiation and modification of HIV therapy, but not for diagnosis. For example, antiretroviral therapy is uniformly initiated when the viral load is >20,000 copies/mL RNA or RT PCR.

HIV Antigen (P-24 antigen)

• Normal = negative

Detects early HIV infection before antibody conversion, used along with PCR testing

IMMUNOGLOBULINS, QUANTITATIVE

• **IgG:** 65–1500 mg/dL or 6.5–15 g/L • **IgM:** 40–345 mg/dL or 0.4–3.45 mg/L • **IgA:** 76–390 mg/dL or 0.76–3.90 g/L • **IgE:** 0–380 IU/mL or KIU/L • **IgD:** 0–8 mg/dL or 0–80 mg/L • Collection: Tiger top tube

Levels are determined in the evaluation of immunodeficiency diseases, during replacement therapy, and to evaluate humoral immunity.

Increased: Multiple myeloma (myeloma immunoglobulin increased, other immunoglobulins decreased); Waldenström's macroglobulinemia (IgM increased, others decreased); lymphoma; carcinoma; bacterial infection; liver disease; sarcoidosis; amyloidosis; myeloproliferative disorders

Decreased: Hereditary immunodeficiency, leukemia, lymphoma, nephrotic syndrome, protein-losing enteropathy, malnutrition

IRON

• Males 65–175 mg/dL (SI: 11.64–31.33 mmol/L) • Females 50–170 mg/dL (SI: 8.95–30.43 mmol/L) • To convert mg/dL to mmol/L, multiply by 0.1791 • Collection: Tiger top tube

Increased: Hemochromatosis, hemosiderosis caused by excessive iron intake, excess destruction or decreased production of erythrocytes, liver necrosis

Decreased: Iron deficiency anemia, nephrosis (loss of iron-binding proteins), normochromic anemia of chronic diseases and infections

IRON-BINDING CAPACITY, TOTAL (TIBC)

• 250–450 mg/dL (SI: 44.75–80.55 mmol/L) • Collection: Tiger top tube

The normal iron/TIBC ratio is 20–50%. Decreased ratio (<10%) is almost diagnostic of iron deficiency anemia. Increased ratio is seen with hemochromatosis.

Increased: Acute and chronic blood loss, iron deficiency anemia, hepatitis, oral contraceptives

Decreased: Anemia of chronic diseases, cirrhosis, nephrosis/uremia, hemochromatosis, iron therapy overload, hemolytic anemia, aplastic anemia, thalassemia, megaloblastic anemia

LACTATE DEHYDROGENASE (LD, LDH)

• Adults <230 U/L, (<3.82 mkat/L) • Higher levels in childhood • Collection: Tiger top tube; carefully avoid hemolysis because this can increase LDH levels

Increased: AMI, cardiac surgery, prosthetic valve, hepatitis, pernicious anemia, malignant tumors, pulmonary embolus, hemolysis (anemias or factitious), renal infarction, muscle injury. megaloblastic anemia, liver disease

LDH Isoenzymes (LDH 1 to LDH 5)

Normally, the ratio LDH 1/LDH 2 is <0.6–0.7. If the ratio becomes >1 (also termed "flipped"), suspect a recent MI (change in ratio can also be seen in pernicious or hemolytic anemia). With an AMI, the LDH will begin to rise at 12–48 h, peak at 3–6 days, and return to normal at 8–14 days. LDH 5 is >LDH 4 in liver diseases. (Largely replaced by troponin.)

LACTIC ACID (LACTATE)

• 4.5–19.8 mg/dL (SI: 0.5–2.2 mmol/L) • Collection: Gray top tube on ice

Suspect lactic acidosis with elevated anion gap in the absence of other causes (renal failure, ethanol or methanol ingestion)

Increased: Lactic acidosis due to hypoxia, hemorrhage, shock, sepsis, cirrhosis, exercise, ethanol, DKA, regional ischemia (extremity, bowel) spurious (prolonged use of a tourniquet)

LAP SCORE (LEUKOCYTE ALKALINE PHOSPHATASE SCORE/STAIN)

• 50–150 • Collection: Finger stick blood sample directly on slide; air dry

Used to differentiate among various hematologic conditions

Increased: Leukemoid reaction, acute inflammation, Hodgkin's disease, pregnancy, liver disease

Decreased: Chronic myelogenous leukemia, nephrotic syndrome

LE (LUPUS ERYTHEMATOSUS) PREPARATION

• Normal = no cells seen

Positive: SLE, scleroderma, RA, drug-induced lupus (procainamide, others)

LEAD, BLOOD

• Adult <40 mg/dL (1.93 mmol/L) • Child <25 mg/dL (1.21 mmol/L) • Collection: Lavender, navy, or green top tube; lab-specific

Neurologic findings can be detected at 15 mg/dL in children and 30 mg/dL in adults; severe symptoms (lethargy, ataxia, coma) are present >60 mg/dL.

Increased: Lead poisoning, occupational exposure

LEGIONELLA ANTIBODY

• <1:32 titers

Obtain two sera, acute (within 2 wk of onset) and convalescent (at least 3 wk after onset of fever). A fourfold rise in titers or a single titer of 1:256 is diagnostic.

Increased: *Legionella* infection; false-positives with *Bacteroides fragilis, Francisella tularensis, Mycoplasma pneumoniae.*

LIPASE

• 0–1.5 U/mL (SI: 10–150 U/L) by turbidimetric method • Collection: Tiger top tube

Increased: Acute or chronic pancreatitis, pseudo-cyst, pancreatic duct obstruction (stone, stricture, tumor, drug-induced spasm), fat embolus syndrome, renal failure, dialysis (usually normal in mumps) gastric malignancy, intestinal perforation, diabetes (usually in DKA only)

LIPID PROFILE/LIPOPROTEIN PROFILE/LIPOPROTEIN ANALYSIS

• See also CHOLESTEROL, page 62, and TRIGLYCERIDES, page 91.

Usually includes cholesterol, HDL cholesterol, LDL cholesterol (calculated), triglycerides. Useful in the evaluation of CAD and allows classification of dyslipoproteinemias to direct treatment. Initial screening for cardiac risk includes total cholesterol and HDL as outlined in Figure 4–4 (page 80). The main lipids in the blood are cholesterol and triglycerides. These lipids are carried by lipoproteins. Lipoproteins are further classified by density (least dense to most dense):

- **Chylomicrons** (least dense, rise to surface of unspun serum) and are normally found only after a fatty meal is eaten (a "lipemic specimen" on a lab report usually refers to these chylomicrons).
- **VLDL** consist mainly of triglycerides.
- **LDL** in the fasting state; the LDL carry most cholesterol.
- **HDL** are the densest and consist of mostly apoproteins and cholesterol.

Table 4–4 (see page 81) indicates the dyslipoproteinemias based on the lipid profile.

LOW-DENSITY LIPOPROTEIN-CHOLESTEROL (LDL, LDL-C)

• See CHOLESTEROL, page 62.

LUTEINIZING HORMONE, SERUM (LH)

• Male 7–24 IU/L • Female 6–30 IU/L, midcycle peak increase two- to threefold over baseline, postmenopausal >35 IU/L • Collection: Tiger top tube

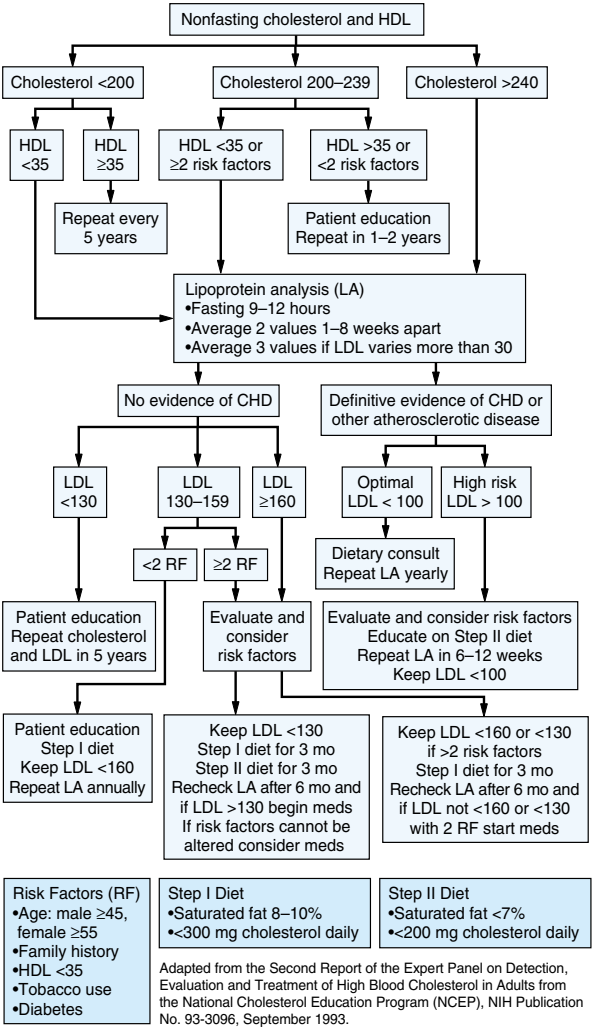


FIGURE 4–4 Cholesterol and lipoprotein screening. (Reprinted, with permission, from: Gordon JD [ed]: *Obstetrics, Gynecology, and Infertility,* 4th ed. Scub Hill Press, Menlo Park CA, 1995.)

TABLE 4–4
Lipoproteins

Fredrickson Classification System	Type I (Rare)	Type IIa (Common)	Type IIb (Common)	Type III (Uncommon)	Type IV (Uncommon)	Type V (Uncommon)
Cholesterol	N or slightly ⇑	Very ⇑	Very ⇑	Very ⇑	N or slightly ⇑	⇑
LDL	N	⇑	⇑	⇑	N	N
HDL	N or ⇓	N or ⇓	N or ⇓	N or ⇓	N or ⇓	N or ⇓
Triglycerides	Very ⇑	N	I	Very ⇑	Very ⇑	⇑
Increased lipoproteins	Chylomicrons	LDL	LDL, VLDL	IDL	VLDL	VLDL and chylomicrons
Atherogenesis risk	No increase	Very ⇑	⇑	⇑	No increase	No increase

Increased: (Hypergonadotropic >40 IU/L) postmenopausal, surgical or radiation castration, ovarian or testicular failure, polycystic ovaries

Decreased: (Hypogonadotropic <40 IU/L prepubertal) hypothalamic, and pituitary dysfunction, Kallmann's syndrome, LHRH analogue therapy

LYME DISEASE SEROLOGY

• Normal varies with assay, ELISA <1:8 • Western blot nonreactive

Most useful when comparing acute and convalescent serum levels for relative titers. Normal values differ among labs. IgM antibody becomes detectable 2–4 weeks after onset of rash; IgG rises in 4–6 weeks and peaks up to 6 mo after infection and may stay elevated for months to years.

Positive: Infection with *Borrelia burgdorferi,* syphilis, and other rickettsial diseases

Negative: After antibiotic therapy or during first few weeks of disease

MAGNESIUM

• 1.6–2.6 mg/dL (SI: 0.80–1.20 mmol/L) • Collection: Tiger top tube

Increased: Renal failure, hypothyroidism, magnesium-containing antacids, Addison's disease, diabetic coma, severe dehydration, lithium intoxication

Decreased: Malabsorption, steatorrhea, alcoholism and cirrhosis, hyperthyroidism, aldosteronism, diuretics, acute pancreatitis, hyperparathyroidism, hyperalimentation, NG suctioning, chronic dialysis, renal tubular acidosis, drugs (cisplatin, amphotericin B, aminoglycosides), hungry bone syndrome, hypophosphatemia, intracellular shifts with respiratory or metabolic acidosis

METYRAPONE TEST

• See Chapter 22, page 570

MHA-TP (MICROHEMAGGLUTINATION, *TREPONEMA PALLIDUM*)

• Normal <1:160 • Collection: Tiger top tube

Confirmatory test for syphilis, similar to FTA-ABS. Once positive, remains so, therefore cannot be used to judge effect of treatment. False-positives with other treponemal infections (pinta, yaws, etc), mononucleosis, and SLE

B_2-MICROGLOBULIN

• 0.1–0.26 mg/dL)1–2.6 mg/L) • Collection: Tiger top tube

A portion of the class I MHC antigen. A useful marker to follow the progression of HIV infections

Increased: HIV infection, especially during periods of exacerbation, lymphoid malignancies, renal diseases (diabetic nephropathy, pyelonephritis, ATN, nephrotoxicity from medications), transplant rejection, inflammatory conditions

Decreased: Treatment of HIV with AZT (zidovudine)

MONOSPOT

• Normal = negative • Collection: Tiger top tube

Positive: Mononucleosis, rarely in leukemia, serum sickness, Burkitt's lymphoma, viral hepatitis, RA

MYOGLOBIN

• 30–90 ng/mL • Collection: Tiger top tube

Increased: Skeletal muscle injury (crush, injection, surgical procedures), delirium tremens, rhabdomyolysis (burns, seizures, sepsis, hypokalemia, others)

5′-NUCLEOTIDASE

• 2–15 U/L

Used in the workup of increased alkaline phosphatase and biliary obstruction

Increased: Obstructive or cholestatic liver disease, liver metastasis, biliary cirrhosis

OLIGOCLONAL BANDING, CSF

• Normal = negative • Collection: Serum tiger top tube and simultaneous CSF sample collected in a plain tube by LP

This is performed simultaneously on CSF and serum samples when MS is clinically suspected. Agarose gel electrophoresis will reveal multiple bands in the IgG region not seen in the serum. Oligoclonal banding is present in up to 90% of patients with MS. Occasionally seen in other CNS inflammatory conditions and CNS syphilis

OSMOLALITY, SERUM

• 278–298 mOsm/kg (SI: 278–298 mmol/kg) • Collection: Tiger top tube

A rough estimation of osmolality is [2(Na) + BUN/2.8 + glucose/18]. Measured value is usually less than calculated value. If measured value is 15 mOsm/kg less than calculated, consider methanol, ethanol, or ethylene glycol ingestion.

Increased: Hyperglycemia; ethanol, methanol, mannitol, or ethylene glycol ingestion; increased sodium because of water loss (diabetes, hypercalcemia, diuresis)

Decreased: Low serum sodium, diuretics, Addison's disease, SIADH (seen in bronchogenic carcinoma, hypothyroidism), iatrogenic causes (poor fluid balance)

OXYGEN

• See Chapter 8, Table 8–1, page 162

P-24 ANTIGEN (HIV CORE ANTIGEN)

• Normal = negative • Collection: Tiger top tube • See also Human Immunodeficiency Virus Testing, page 75

Used to diagnose recent acute HIV infection; becomes positive earlier than HIV antibodies. Decreases "window" period. Can be positive as early as 2–4 weeks but becomes undetectable during antibody seroconversion (periods of latency). With progression of disease, P-24 usually becomes evident again. Used to screen blood donors

PARATHYROID HORMONE (PTH)

• Normal based on relationship to serum calcium, usually provided on the lab report • Also, reference values vary depending on the laboratory and whether the N-terminal, C-terminal or midmolecule is measured. • PTH midmolecule: 0.29– –0.85 ng/mL (SI: 29–85 pmol/L) • With calcium: 8.4–10.2 mg/dL (SI: 2.1–2.55 mmol/L) • Collection: Tiger top tube

4

Increased: Primary hyperparathyroidism, secondary hyperparathyroidism (hypocalcemic states, such as chronic renal failure, others)

Decreased: Hypercalcemia not due to hyperparathyroidism, hypoparathyroidism

PHOSPHORUS

• Adult 2.5–4.5 mg/dL (SI: 0.81–1.45 mmol/L) • Child 4.0–6.0 mg/dL (SI: 1.29–1.95 mmol/L) • To convert mg/dL to mmol/L, multiply by 0.3229 • Collection: Tiger top tube

Increased: Hypoparathyroidism (surgical, pseudo-hypoparathyroidism), excess vitamin D, secondary hyperparathyroidism, renal failure, bone disease (healing fractures), Addison's disease, childhood, factitious increase (hemolysis of specimen)

Decreased: Hyperparathyroidism, alcoholism, diabetes, hyperalimentation, acidosis, alkalosis, gout, salicylate poisoning, IV steroid, glucose or insulin administration, hypokalemia, hypomagnesemia, diuretics, vitamin D deficiency, phosphate-binding antacids

POTASSIUM, SERUM

• 3.5–5 mEq/L (SI: 3.5–5 mmol/L) • Collection: Tiger top tube

Increased: Factitious increase (hemolysis of specimen, thrombocytosis), renal failure, Addison's disease, acidosis, spironolactone, triamterene, ACE inhibitors, dehydration, hemolysis, massive tissue damage, excess intake (oral or IV), potassium-containing medications, acidosis

Decreased: Diuretics, decreased intake, vomiting, nasogastric suctioning, villous adenoma, diarrhea, Zollinger–Ellison syndrome, chronic pyelonephritis, renal tubular acidosis, metabolic alkalosis (primary aldosteronism, Cushing's syndrome)

PREALBUMIN

• See Chapter 11, page 211

PROGESTERONE

• Collection: Tiger top tube
Used to confirm ovulation and corpus luteum function

Sample Collection	Normal Values (female)
Follicular phase	<1 ng/mL
Luteal phase	5–20 ng/mL
Pregnancy	
1st trimester	10–30 ng/mL
2nd trimester	50–100 ng/mL
3rd trimester	100–400 ng/mL
Postmenopause	–1 ng/mL

PROLACTIN

• Males 1–20 ng/mL (SI: 1–20 mg/L) • Females 1–25 ng/mL (SI: 1–25 mg/L) • Collection: Tiger top tube

Used in the workup of infertility, impotence, hirsutism, amenorrhea, and pituitary neoplasm

Increased: Pregnancy, nursing after pregnancy, prolactinoma, hypothalamic tumors, sarcoidosis or granulomatous disease of the hypothalamus, hypothyroidism, renal failure, Addison's disease, phenothiazines, haloperidol

PROSTATE-SPECIFIC ANTIGEN (PSA)

• <4 ng/dL by monoclonal, eg, Hybritech assay

Most useful as a measure of response to therapy of prostate cancer; approved for screening for prostate cancer. Although any elevation increases suspicion of prostate cancer, levels >10.0 ng/dL are frequently associated with carcinoma. Age corrected levels gaining popularity (40–50 y 2.5 ng/dL; 50–60 y 3.5 ng/dL; 60–70 years 4.5 ng/dL; >70 years 6.5 ng/dL.)

Increased: Prostate cancer, acute prostatitis, some cases of BPH, prostatic infarction, prostate surgery (biopsy, resection), vigorous prostatic massage (routine rectal exam does not elevate levels), rarely postejaculation

Decreased: Radical prostatectomy, response to therapy of prostatic carcinoma (radiation or hormonal therapy)

PSA Velocity

A rate of rise in PSA of 0.75 ng/mL or greater per year is suspicious for prostate cancer based on at least three separate assays 6 mo apart.

PSA Free and Total

Patients with prostate cancer tend to have lower free PSA levels in proportion to total PSA. Measurement of the free/total PSA can improve the specificity of PSA in the range of total PSA from 2.0–10.0 ng/mL. Some recommend prostate biopsy only if the free PSA percentage is low. Threshold for biopsy is controversial, ranging from a ratio of less than 15% to less than 25%, with a higher threshold having improved sensitivity and lower threshold having improved specificity.

PROTEIN ELECTROPHORESIS, SERUM AND URINE (SERUM PROTEIN ELECTROPHORESIS, SPEP) (URINE PROTEIN ELECTROPHORESIS, UPEP)

Qualitative analysis of the serum proteins is often used in the workup of hypoglobulinemia, macroglobulinemia, α_1-antitrypsin deficiency, collagen disease, liver disease, myeloma, and occasionally in nutritional assessment. Serum electrophoresis yields five different bands (Figure 4–5 and Table 4–5, pages 86 and 87). If a monoclonal gammopathy or a low globulin fraction is detected, quantitative immunoglobulins should be ordered.

Urine protein electrophoresis can be used to evaluate proteinuria and can detect Bence Jones protein (light chain) that is associated with myeloma, Waldenström's macroglobulinemia, and Fanconi's syndrome.

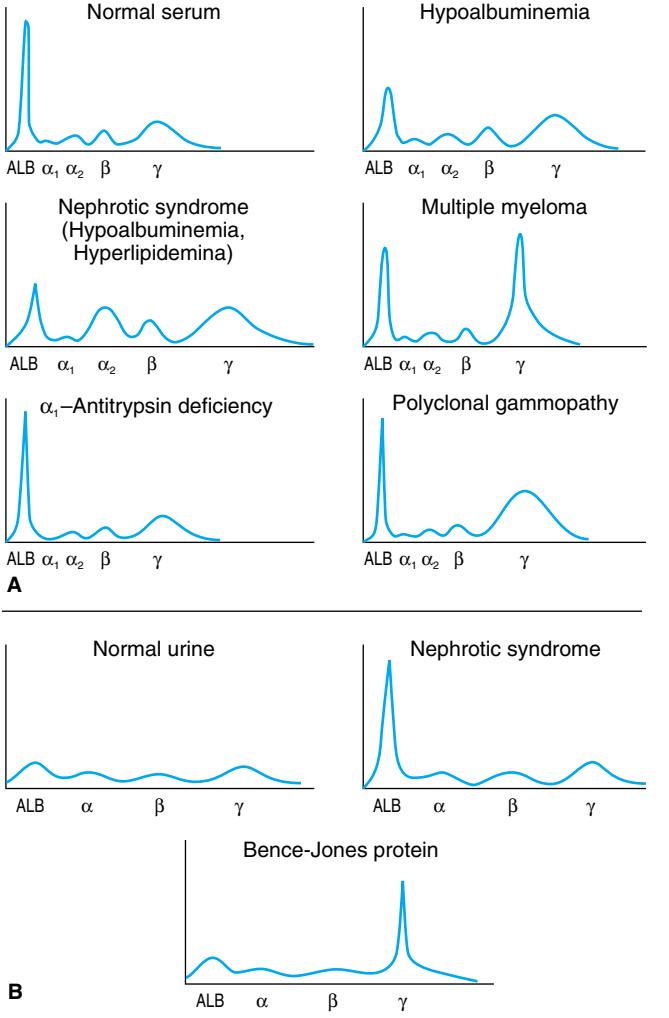


FIGURE 4–5 Examples of (**A**) serum and (**B**) urine protein electrophoresis patterns. See also Table 4–5. (Courtesy of Dr. Steven Haist.)

TABLE 4–5
Normal Serum Protein Components and Fractions as Determined by Electrophoresis, Along with Associated Conditions*

Protein Fraction	Percentage of Total Protein	Constituents	Increased	Decreased
Albumin	52–68	Albumin	Dehydration (only known cause)	Nephrosis, malnutrition, chronic liver disease
Alpha-1 (α_1) globulin	2.4–4.4	Thyroxine-binding globulin, antitrypsin, lipoproteins, glycoprotein, transcortin	Inflammation, neoplasia	Nephrosis, α_1-antitrypsin deficiency (emphysema related)
Alpha-2 (α_2) globulin	6.1–10.1	Haptoglobin, glycoprotein, macroglobulin, ceruloplasmin	Inflammation, infection, neoplasia, cirrhosis	Severe liver disease, acute hemolytic anemia
Beta (β) globulin	8.5–14.5	Transferrin, glycoprotein, lipoprotein	Cirrhosis, obstructive jaundice	Nephrosis
Gamma (γ) globulins (immunoglobulins)	10–21	IgA, IgG, IgM, IgD, IgE	Infections, collagen vascular diseases, leukemia, myeloma	Agammaglobulinemia, hypogammaglobulinemia, nephrosis

*(See also Figure 4–5).

PROTEIN, SERUM

• 6.0–8.0 g/dL • See also Serum Protein Electrophoresis, page 85. • Collection: Tiger top tube

Increased: Multiple myeloma, Waldenström's macroglobulinemia, benign monoclonal gammopathy, lymphoma, chronic inflammatory disease, sarcoidosis, viral illnesses

Decreased: Malnutrition, inflammatory bowel disease, Hodgkin's disease, leukemias, any cause of decreased albumin

RENIN

Plasma (Plasma Renin Activity [PRA])

• Adults, Normal sodium diet, upright 1–6 ng/mL/h (SI: 0.77–4.6 nmol/L/h) • Renal vein renin: L & R should be equal)

Useful in the diagnosis of hypertension associated with hypokalemia. Values highly dependent on salt intake and position. Stop diuretics, estrogens for 2–4 wk before testing.

Increased: Medications (ACE inhibitors, diuretics, oral contraceptives, estrogens), pregnancy, dehydration, renal artery stenosis, adrenal insufficiency, chronic hypokalemia, upright posture, salt-restricted diet, edematous conditions (CHF, nephrotic syndrome), secondary hyperaldosteronism

Decreased: Primary aldosteronism (renin will not increase with relative volume depletion, upright posture)

Renal Vein

• Normal L & R should be equal

A ratio of >1.5 (affected/nonaffected) suggestive of renovascular hypertension

RETINOL-BINDING PROTEIN (RBP)

• Adults 3–6 mg/dL • Children 1.5–3.0 mg/dL • Collection: Tiger top tube

Decreased: Malnutrition, vitamin A deficiency, intestinal malabsorption of fats, chronic liver disease

RHEUMATOID FACTOR (RA LATEX TEST)

• <15 IU by Microscan kit or <1:40 • Collection: Tiger top tube

Increased: Collagen-vascular diseases (RA, SLE, scleroderma, polyarteritis nodosa, others), infections (TB, syphilis, viral hepatitis), chronic inflammation, SBE, some lung diseases, MI

ROCKY MOUNTAIN SPOTTED FEVER ANTIBODIES (RMSF)

• Normal: <4(times) increase in paired acute and convalescent sera • IgG <1:64 • IgM <1:8 • Collection: Tiger top tube acute and convalescent

The diagnosis of RMSF is made by acute and convalescent titers that demonstrate a 4× rise or a single convalescent titer >1:64 in the clinical setting of RMSF. Occasional false-positives in late pregnancy

SEMEN ANALYSIS

• Volume 2–5 mL • Sperm count >20-40 × 10^6/mL • Motility >60% • Forward migration • Morphology >60% normal

Specimen must be collected after 48–72 h abstinence and analyzed within 1–2 h. Test may not be valid after a recent illness or high fever. Verify abnormal analysis by serial tests.

Decreased: After vasectomy (should be 0 sperm after 3 mo), varicocele, primary testicular failure (ie, Klinefelter's syndrome), secondary testicular failure (chemotherapy, radiation, infections),varicocele, after recent illness, congenital obstruction of the vas, retrograde ejaculation, endocrine causes (hyperprolactinemia, low testosterone, others)

SGGT (SERUM GAMMA-GLUTAMYL TRANSPEPTIDASE)

• See GGT, page 69.

SGOT (SERUM GLUTAMIC-OXALOACETIC TRANSAMINASE)

• See AST, page 58.

SGPT SERUM (GLUTAMIC-PYRUVIC TRANSAMINASE)

• See ALT, page 57.

SODIUM, SERUM

• 136–145 mmol/L • Collection: Tiger top tube

In factitious hyponatremia due to hyperglycemia, for every 100 mmol/L blood glucose above normal, serum sodium decreases 1.6. For example, a blood glucose of 800 and a sodium of 129 would factitiously lower the sodium value by about 7 × 1.6, or 11.6. Corrected serum sodium would therefore be 129 + 11 = 140.

Increased: Associated with low total body sodium (glycosuria, mannitol, or lactulose use urea, excess sweating), normal total body sodium (diabetes insipidus [central and nephrogenic], respiratory losses, and sweating), and increased total body sodium (administration of hypertonic sodium bicarbonate, Cushing's syndrome, hyperaldosteronism)

Decreased: Associated with excess total body sodium and water (nephrotic syndrome, CHF, cirrhosis, renal failure), excess body water (SIADH, hypothyroidism, adrenal insufficiency), decreased total body water and sodium (diuretic use, renal tubular acidosis, use of mannitol or urea, mineralocorticoid deficiency, vomiting, diarrhea, pancreatitis), and pseudo-hyponatremia (hyperlipidemia, hyperglycemia, and multiple myeloma)

STOOL FOR OCCULT BLOOD (HEMOCCULT TEST)

Normal-Negative: Apply small amount of stool to test site on Hemoccult card and close. Open test panel on other side of card and apply 2–3 drops developer to the test and the positive control panels; read in 30 s. Blue color is positive. Detects >5 mg hemoglobin/g feces. Repeat three times for maximum yield. (A positive test more informative than a negative test)

Positive: Any GI tract ulcerated lesion (ulcer, carcinoma, polyp, diverticulosis, inflammatory bowel disease), hemorrhoids, telangiectasias, drugs that cause GI irritation (eg, NSAIDs) swallowed blood, ingestion of rare red meat, certain foods (horseradish, turnips) (vitamin C [>500 mg/d], antacids may result in false-negative test)

SWEAT CHLORIDE

• 5–40 mEq/L (SI: 5–40 mmol/L) • Collection: 100–200 mg sweat on filter paper after electrical stimulation of sweating by pilocarpine iontophoresis on an extremity

Increased: CF (not valid on children <3 wk); Addison's disease, meconium ileus, and renal failure can occasionally raise levels.

T_3 RU (RESIN UPTAKE; THYROXINE-BINDING GLOBULIN RATIO)

• 30–40%

This test is used in conjunction with a T_4 to yield the Free T_4 Index [FTI]), an estimate of the free T_4.

Increased: Hyperthyroidism, medications (phenytoin [Dilantin], steroids, heparin, aspirin, others), nephrotic syndrome

Decreased: Hypothyroidism, medications (iodine, propylthiouracil, others), any cause of increased TBG, such as oral estrogen or pregnancy

TESTOSTERONE

• Male free: 9–30 ng/dL, total 300–1200 ng/dL • Female, see following table

Sample Collection	Normal Values (female)
Follicular phase	20–80 ng/dL
Midcycle peak	20–80 ng/dL
Luteal phase	20–80 ng/dL
Postmenopause	10–40 ng/dL

Increased: Adrenogenital syndrome, ovarian stromal hyperthecosis, polycystic ovaries, menopause, ovarian tumors.

Decreased: Some cases of impotence, hypogonadism, hypopituitarism, Klinefelter's syndrome

THYROGLOBULIN

• 1–20 ng/mL (mg/L) • Collection: Tiger top tube

Useful for following patients with nonmedullary thyroid carcinomas

Increased: Differentiated thyroid carcinomas (papillary, follicular), Graves' disease, nontoxic goiter

Decreased: Hypothyroidism, testosterone, steroids, phenytoin

THYROID-STIMULATING HORMONE (TSH)

• 0.7–5.3 mU/mL • Collection: Tiger top tube

Excellent screening test for hyperthyroidism as well as hypothyroidism. Differentiates between a low normal and a decreased TSH

Increased: Hypothyroidism

Decreased: Hyperthyroidism. Less than 1% of hypothyroidism is from pituitary or hypothalamic disease resulting in a decreased TSH.

THYROXINE (T_4 TOTAL)

• 5–12 mg/dL (SI: 65–155 nmol/L) • Males: >60 years, 5–10 mg/dL (SI: 65–129 nmol)
• Females: 5.5–10.5 µg/dL (SI: 71–135 nmol/L) • Collection: Tiger top tube

Good screening test for hyperthyroidism. Measures both bound and free T_4, therefore, can be affected by TBG levels.

Increased: Hyperthyroidism, exogenous thyroid hormone, estrogens, pregnancy, severe illness, euthyroid sick syndrome

Decreased: Hypothyroidism, euthyroid sick syndrome, any cause of decreased TBG

THYROXINE-BINDING GLOBULIN (TBG)

• 21–52 mg/dL (270–669 nmol/L) • Collection: Tiger top tube

Increased: Hypothyroidism, pregnancy, oral contraceptives, estrogens, hepatic disease, acute porphyria

Decreased: Hyperthyroidism, androgens, anabolic steroids, prednisone, nephrotic syndrome, severe illness, surgical stress, phenytoin, hepatic disease

THYROXINE INDEX, FREE (FTI)

• 6.5–1.25

Practically speaking, the FTI is equivalent to the free thyroxine. Useful in patients with clinically suspected hyper- or hypothyroidism. Determined as follows:

$$\text{Thyroxine (Total } T_4) \times T_3 \text{ RU}$$

Increased: Hyperthyroidism, high-dose beta-blockers, psychiatric illnesses

Decreased: Hypothyroidism, phenytoin (Dilantin)

TORCH BATTERY

• Normal = negative • Collection: Tiger top tube

Serial determinations best (acute and convalescent titers).

Test is based on serologic evidence of exposure to toxoplasmosis, rubella, cytomegalovirus, and herpesviruses.

TRANSFERRIN

• 220–400 mg/dL (SI: 2.20–4.0 g/L) • Collection: Tiger top tube, avoid hemolysis

Used in the workup of anemias; transferrin levels can also be assessed by the total iron-binding capacity.

Increased: Acute and chronic blood loss, iron deficiency, hemolysis, oral contraceptives, pregnancy, viral hepatitis

Decreased: Anemia of chronic disease, cirrhosis, nephrosis, hemochromatosis, malignancy

TRIGLYCERIDES

• Recommended values: • Males: 40–160 mg/dL (SI: 0.45–1.81 mmol/L) • Females: 35–135 mg/dL (SI: 0.40–1.53 mmol/L) • Can vary with age. • Collection: Tiger top tube • Fasting preferred • See also LIPID PROFILE page 79

Increased: Nonfasting specimen, hyperlipoproteinemias (types I, IIb, III, IV, V), hypothyroidism, liver diseases, poorly controlled diabetes mellitus, alcoholism, pancreatitis,

AMI, nephrotic syndrome, familial, medications (oral contraceptives, estrogens, beta-blockers, cholestyramine)

Decreased: Malnutrition, malabsorption, hyperthyroidism, Tangier disease, medications (nicotinic acid, clofibrate, gemfibrozil) congenital abetalipoproteinemia

TRIIODOTHYRONINE (T_3 RIA)

• 120–195 ng/dL (SI: 1.85–3.00 nmol/L) • Collection: Tiger top tube

Useful when hyperthyroidism is suspected, but T_4 is normal; not useful in the diagnosis of hypothyroidism

Increased: Hyperthyroidism, T_3 thyrotoxicosis, pregnancy, exogenous T_4, any cause of increased TBG, such as oral estrogen or pregnancy

Decreased: Hypothyroidism and euthyroid sick state, any cause of decreased TBG

TROPONIN, CARDIAC-SPECIFIC

• Troponin 1 (cTn1) <0.35 ng/mL • Troponin T cTnT <0.2 µg/L

Used to diagnose AMI; increases rapidly 3–12 h, peak at 24 h and may stay elevated for several days (cTn1 5–7 days, cTnT up to 14 days). More cardiac-specific than CK-MB

Positive: Myocardial damage, including MI, myocarditis (false-positive: renal failure)

URIC ACID (URATE)

• Males: 3.4–7 mg/dL (SI: 202–416 mmol/L) • Females: 2.4–6 mg/dL (SI: 143–357 mmol/L) • To convert mg/dL to mmol/L, multiply by 59.48 • Collection: Tiger top tube

Increased uric acid is associated with increased catabolism, nucleoprotein synthesis, or decreased renal clearing of uric acid (ie, thiazide diuretics or renal failure).

Increased: Gout, renal failure, destruction of massive amounts of nucleoproteins (leukemia, anemia, chemotherapy, toxemia of pregnancy), drugs (especially diuretics), lactic acidosis, hypothyroidism, PCKD, parathyroid diseases

Decreased: Uricosuric drugs (salicylates, probenecid, allopurinol), Wilson's disease, Fanconi's syndrome

VDRL TEST (VENEREAL DISEASE RESEARCH LABORATORY) OR RAPID PLASMA REAGIN (RPR)

• Normal = nonreactive • Collection: Tiger top tube

Good screening for syphilis. Almost always positive in secondary syphilis, but frequently becomes negative in late syphilis. Also, in some patients with HIV infection, the VDRL can be negative in primary and secondary syphilis.

Positive (Reactive): Syphilis, SLE, pregnancy and drug addiction. If reactive, confirm with FTA-ABS (false-positives with bacterial or viral illnesses).

VITAMIN B_{12} (EXTRINSIC FACTOR, CYANOCOBALAMIN)

• >100–700 pg/mL (SI: 74–516 pmol/L) • Collection: Tiger top tube

Increased: Excessive intake, myeloproliferative disorders

Decreased: Inadequate intake (especially strict vegetarians), malabsorption, hyperthyroidism, pregnancy

ZINC

• 60–130 mg/dL (SI: 9–20 mmol/L) • Collection: Check with lab; special collection to limit contamination

Increased: Atherosclerosis, CAD

Decreased: Inadequate dietary intake (parenteral nutrition, alcoholism); malabsorption; increased needs, such as pregnancy or wound healing; acrodermatitis enteropathica; dwarfism

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5

LABORATORY DIAGNOSIS: CLINICAL HEMATOLOGY

BLOOD COLLECTION

Venipuncture is discussed in detail in Chapter 13, page 39. The best CBC sample is venous blood drawn with at least a 22-gauge or larger needle. For a routine CBC, venous blood needs to be placed in a special hematology lab tube, usually a purple top tube, that has an anticoagulant (EDTA) and that is mixed gently. Blood for a CBC should be fresh, less than 3 h old. Most coagulation studies are submitted in a blue top (citrate) tube. (See page 311 for detailed description of blood collection tubes.)

If a **capillary fingerstick** or **heelstick** (see page 274) is used, the hematocrit may be falsely low. If the finger needs to be "milked," sludging of the RBCs can create a falsely high hematocrit. In practice, you can draw the blood up in a capillary tube, seal an end with clay, and spin a tube on the hematocrit centrifuge for 2–3 min and rapidly determine a hematocrit. Wright's staining can also be done and viewed as outlined in the next section.

BLOOD SMEARS: WRIGHT'S STAIN

Making the Blood Smear

In some clinical situations a quick interpretation of a smear can be useful.

1. Place a small drop of blood from the anticoagulated lab sample tube (usually purple top) in the center of a clean glass slide, about 1–2 cm from the end.
2. Place the spreading slide (a glass slide with a perfectly smooth edge) at a 45-degree angle on the slide with the blood sample and slowly move it back to make contact with the drop. The drop should spread out quickly along the line of contact between the two slides. The moment this occurs, spread the film by a rapid, smooth forward movement of the spreader (Figure 5–1).
3. The drop of blood should result in a film about 3 cm long. The faster a film is spread, the more even it is and the better the slide it produces. The ideal thickness shows some overlap by the RBCs throughout much of the film's length with separation and lack of distortion toward the feathered edge of the film. Leukocytes should be easily recognizable throughout the length of the film.

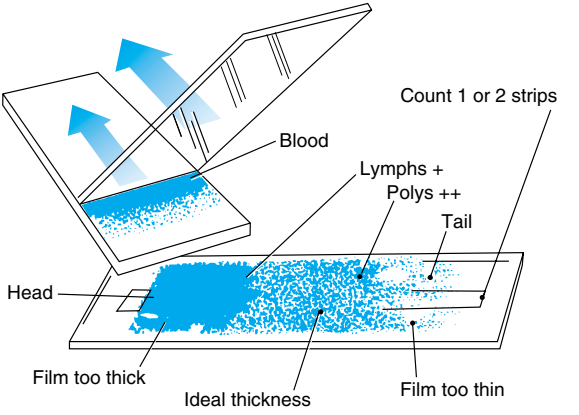

FIGURE 5–1 The technique of preparing a blood smear for staining and the distribution of white blood cells on the standard smear.

Staining the Blood Smear (Wright's stain)

Make sure that all reagents are fresh, or the slide may not turn out properly.

1. Let the slide air dry, and mark the patient's name and date in pencil on the blood film itself. It will not be removed by staining. An alternative method is to bring the slide to the hematology lab where instruments can automatically stain the slides.
2. Fix the slide in methanol for 1 min.
3. Shake off excess methanol from the slide, but do not rinse or dry it.
4. Flood the slide with Wright's stain, and allow the slide to stand for 3–5 min. (This time can vary with the batch of stain.)
5. Flood the slide with Wright's buffer (pH 6.4) until about 50% of the Wright's stain is washed off. Blow air gently over the top of the slide to mix the fluids, and look for a greenish copper sheen that appears on the surface. Let the slide stand for about 8 min.
6. Rinse the slide with tap water, wipe the back of the slide with methanol, and air dry it.

Viewing the Film: The Differential WBC

1. The film should not be so thick that the leukocytes in the body of the film shrink. Examine the smear in an area where the red cells approximate but do not overlap.
2. If the film is too thin or if a rough-edged spreader is used, up to 50% of the WBCs may accumulate in the edges and tail (See Fig. 5–1).
3. WBCs are NOT randomly dispersed even in a well-made smear. Polys and monos predominate at the margins and tail, and lymphs are prevalent in the middle of the film. To overcome this problem, use the "high dry" or oil immersion objective, and count cells in a strip running the whole length of the film. Avoid the lateral edges of the film.

TABLE 5–1
Estimated WBC Based on Cells Counted in a Blood Smear

WBC/hpf (high dry or 40×)	Estimated WBC (per mm^3)
2–4	4000–7000
4–6	7000–10,000
6–10	10,000–13,000
10–20	13,000–18,000

Abbreviations: WBC = white blood cell; hpf = high-power field.

4. If fewer than 200 cells are counted in a strip, count another strip until at least 200 are seen. The special white cell counter found in most labs is ideal for this purpose. In patients receiving chemotherapy, the total count may be so small that only a 25–50 cell differential is possible.
5. In smears of blood from patients with very high white counts, such as those with leukemia, count the cells in any well-spread area where the different cell types are easy to identify. Table 5–1 shows the correlation between the number of cells in a smear and the estimated white cell count. A platelet count can be estimated by averaging the number of platelets seen in 10 hpf (oil immersion) and multiplying by 20,000.

NORMAL CBC VALUES

A CBC panel generally includes WBC count, RBC count, hemoglobin, hematocrit, MCH, MCHC, MCV, and the RDW and platelets. The differential is usually ordered separately. Normal CBC, differential, and platelet values are outlined in Tables 5–2 and 5–3.

NORMAL CBC VARIATIONS

Hemoglobin and hematocrit are highest at birth (20 g/100 mL and 60%, respectively). The values fall steeply to a minimum at 3 mo (9.5 g/100 mL and 32%). Then they slowly rise to near adult levels at puberty, and thereafter both values are higher in males. A normal decrease occurs in pregnancy. The number of WBCs is highest at birth (mean of 25,000/mm^3) and slowly falls to adult levels by puberty. Lymphs predominate (up to 60% from the second week of life until age 5–7 y when polys begin to predominate.

HEMATOCRIT

The hematocrit is a simple screening test and can be performed on the medical floor as described previously (page 95). Always remember that because an equal amount of plasma and red cells are lost in acute blood loss, the hematocrit will not reflect the loss until sometime later (sometimes 2–3 h). If an anemia is suspected, the red cell indices and reticulocyte count should be checked.

THREE-CELL DIFFERENTIAL COUNT

Instead of a manual differential count of WBCs, many labs now rely on a **three-cell differential count** that is automatically performed by newer instruments. White cells are separated on the basis of three sizes: **small cells** (mostly normal lymphocytes), **middle cells**

TABLE 5–2
Normal CBC for Selected Age Ranges

Age	WBC Count (cells/mm^3) [SI: 10^9/L]	RBC Count (10^6/μL) [SI: 10^{12}/L]	Hemoglobin (g/dL) [SI: g/L]	Hematocrit (%)	MCH (pg) [SI: pg]	MCHC (g/dL) [SI: g/L]*	MCV (μm^3) [SI: fL]	RDW
Adult ♀	4500–11,000 [4.5–11.0]	4.73–5.49 [4.73–5.49]	14.40–16.60 [144–166]	42.9–49.1	27–31	33–37	76–100	11.5–14.5
Adult ♂	As above	4.15–4.87 [4.15–5.49]	12.2–14.7 [122–147]	37.9–43.9	As above	As above	As above	As above
11–15 years	4500–13,500	4.8	13.4	39	28	34	82	
6–10 years	5000–14,500	4.7	12.9	37.5	27	34	80	
4–6 years	5500–15,500	4.6	12.6	37.0	27	34	80	
2–4 years	6000–17,000	4.5	12.5	35.5	25	32	77	
4 mo–2 y	6000–17,500	4.6	11.2	35.0	25	33	77	
1 wk–4 mo	5500–18,000	4.7±0.9	14.0±3.3	42.0±7.0	30	33	90	
24 hr–1 wk	5000–21,000	5.1	18.3±4.0	52.5	36	35	103	
First day	9400–34,000	5.1±1.0	19.5±5.0	54.0±10.0	38	36	106	

*To convert standard reference value to SI units, multiply by 10.
Abbreviations: WBC = white blood cell; MCH = mean cell hemoglobin; MCHC = mean cell hemoglobin concentration; MCV = mean cell volume; RDW = red cell distribution width.

TABLE 5–3
Normal CBC for Selected Age Ranges

Age	Platelet Count (10^3/μL) [SI: 10^9/L]	Lymphocytes, Total (% WBC count)	Neutrophils, Band (% WBC count)	Neutrophils, Segmented (% WBC count)	Eosinophils (% WBC count)	Basophils (% WBC count)	Monocytes (% WBC count)
Adult ♀	238±49	34	3.0	56	2.7	0.5	4.0
Adult ♂	270±58	As above	As above	As above	As above	As above	As above
11–15 years	282±63	38	3.0	51	2.4	0.5	4.3
6–10 years	351±85	39	3.0	50	2.4	0.6	4.2
4–6 years	357±70	42	3.0	39	2.8	0.6	5.0
2–4 years	357±70	59	3.0	30	2.6	0.5	5.0
4 mo–2 y	As above	61	3.1	28	2.6	0.4	4.8
1 wk–4 mo	As above	56	4.5	30	2.8	0.5	6.5
24 hr–1 wk	240–380	24–41	6.8–9.2	39–52	2.4–4.1	0.5	5.8–9.1
First day	As above	24	10.2	58	2.0	0.6	5.8

Abbreviations: CBC = complete blood count; WBC = white blood cell.

(monocytes, eosinophils, large lymphocyte variants), and **large cells** (neutrophils [stabs and band cells]). Each lab sets its own reference ranges based on "normal" populations. If one of the three cell populations falls outside the reference range, the sample is made into a slide, and a microscopic differential count is performed. With the anticipated shortage of health care workers and the expense of manual counting, these types of determinations will become more widely used.

As an example of the three-cell count, a patient with sepsis may have a large-cell count of 95% and a small-cell count of 5% with no middle cells. On manual examination of the slide, there may be 70% segmented neutrophils and 25% stabs, for a total of 95%.

THE "LEFT SHIFT"

The degree of nuclear lobulation of PMNs is thought to give some indication of cell age. A predominance of immature cells with only one or two nuclear lobes separated by a thick chromatin band is called a "**shift to the left."** Conversely, a predominance of cells with four nuclear lobes is called a "**shift to the right."** (For historical information, left and right designations come from the formerly used manual lab counters, in which the keys for entering the stabs were located on the left of the keyboard.)

As a general rule, 40–50% of PMNs have three lobes, approximately 5% have two lobes, and 15–25% have four lobes. More than 20 five-lobed cells/100 WBCs suggest incipient megaloblastic anemia, and a six-lobed or seven-lobed poly is virtually diagnostic.

"Bands" or "stabs," the more immature forms of PMNs (the more mature are called "**segs"**), are identified by the fact that the connections between ends or lobes of a nucleus are greater than one-half the width of the hypothetical round nucleus. In bands or stabs, the connection between the lobes of the nucleus is by a thick band; in segs, by a thin filament. A band is defined as a connecting strip wide enough to reveal two distinct margins with nuclear material in between. A filament is so narrow that no intervening nuclear material is present. When in doubt if a cell is a band or seg, call it a seg.

For practical purposes, **a left shift is present in the CBC when more than 10–12% bands are seen or when the total PMN count (segs plus bands) is greater than 80.**

Left Shift: Bacterial infection, toxemia, hemorrhage

Right Shift: Liver disease, megaloblastic anemia, iron deficiency anemia

RETICULOCYTE COUNT

- Collection: Lavender top tube

The reticulocyte count is not a part of the routine CBC. The count is used in the initial workup of anemia (especially unexplained) and in monitoring the effect of hematinic or erythropoietin therapy, monitoring the recovery from myelosuppression or monitoring engraftment following bone marrow transplant. Reticulocytes are juvenile RBCs with remnants of cytoplasmic basophilic RNA. These are suggested by **basophilia** of the RBC cytoplasm on Wright's stain; however, confirmation requires a special reticulocyte stain. The result is reported as a percentage, and you should calculate the **corrected reticulocyte count** for interpretation of the results

$$\text{Corrected reticulocyte count} = \frac{\text{Reported count} \times \text{Patient's HCT}}{\text{Normal HCT}}$$

This corrected count is an excellent indicator of erythropoietic activity. The **normal corrected reticulocyte count is <1.5.**

Normal bone marrow responds to a decrease in erythrocytes (shown by a decreased hematocrit) with an increase in the production of reticulocytes. Lack of increase in a reticulocyte count with an anemia suggests a chronic disease, a deficiency disease, marrow replacement, or marrow failure.

CBC DIFFERENTIAL DIAGNOSIS

- See Tables 5–2 and 5–3 for normal age and sex-specific ranges.

Basophils

- 0–1%

Increased: Chronic myeloid leukemia, after splenectomy, polycythemia, Hodgkin's disease, and, rarely, in recovery from infection and from hypothyroidism

Decreased: Acute rheumatic fever, pregnancy, after radiation, steroid therapy, thyrotoxicosis, stress

Eosinophils

- 1–3%

Increased: Allergy, parasites, skin diseases, malignancy, drugs, asthma, Addison's disease, collagen–vascular diseases (handy mnemonic **NAACP: N**eoplasm, **A**llergy, **A**ddison's disease, **C**ollagen–vascular diseases, **P**arasites), pulmonary diseases including Löffler's syndrome and PIE

Decreased: Steroids, ACTH, after stress (infection, trauma, burns), Cushing's syndrome

Hematocrit (Male 40–54%; Female 37–47%)

Decreased: Megaloblastic anemia (folate or B_{12} deficiency); iron deficiency anemia; sickle cell anemia; acute or chronic blood loss; hemolysis; anemia due to chronic disease, dilution, alcohol, or drugs

Increased: Primary polycythemia (polycythemia vera), secondary polycythemia (reduced fluid intake or excess fluid loss, congenital and acquired heart disease, lung disease, high altitudes, heavy smoking, tumors [renal cell carcinoma, hepatoma], renal cysts)

Lymphocytes

- 24–44% • See also Lymphocyte Subsets, page 103

Increased: Virtually any viral infection (AIDS, measles, rubella, mumps, whooping cough, smallpox, chickenpox, influenza, hepatitis, infectious mononucleosis), acute infectious lymphocytosis in children, acute and chronic lymphocytic leukemias

Decreased: (Normal finding in 22% of population) Stress, burns, trauma, uremia, some viral infections, AIDS, AIDS-related complex, bone marrow suppression after chemotherapy, steroids, MS

Atypical Lymphocytes

>20%: Infectious mononucleosis, CMV infection, infectious hepatitis, toxoplasmosis

<20%: Viral infections (mumps, rubeola, varicella), rickettsial infections, TB

MCH (Mean Cellular [Corpuscular] Hemoglobin)

- 27–31 pg (SI: pg)

The weight of hemoglobin of the average red cell. Calculated by

$$\text{MCH} = \frac{\text{Hemoglobin (g / L)}}{\text{RBC } (10^6 \text{ / } \mu\text{L})}$$

Increased: Macrocytosis (megaloblastic anemias, high reticulocyte counts)

Decreased: Microcytosis (iron deficiency, sideroblastic anemia, thalassemia)

MCHC (Mean Cellular [Corpuscular] Hemoglobin Concentration)

- 33–37 g/dL (SI:330–370 g/L)

The average concentration of hemoglobin in a given volume of red cells. Calculated by the formula

$$\text{MCHC} = \frac{\text{Hemoglobin (g / dL)}}{\text{Hematocrit}}$$

Increased: Very severe, prolonged dehydration; spherocytosis

Decreased: Iron deficiency anemia, overhydration, thalassemia, sideroblastic anemia

MCV (Mean Cell [Corpuscular] Volume)

- 76–100 cu μm (SI: fL)

The average volume of red blood cells. Calculated by the formula

$$\text{MCV} = \frac{\text{Hematocrit} \times 1000}{\text{RBC } (10^6 \text{ / } \mu\text{L})}$$

Increased/Macrocytosis: Megaloblastic anemia (B_{12}, folate deficiency), macrocytic (normoblastic) anemia, reticulocytosis, myelodysplasias, Down syndrome, chronic liver disease, treatment of AIDS with AZT, chronic alcoholism, cytotoxic chemotherapy, radiation therapy, Dilantin use, hypothyroidism, newborns

Decreased/Microcytosis: Iron deficiency, thalassemia, some cases of lead poisoning or polycythemia

Monocytes

- 3–7%

Increased: Bacterial infection (TB, SBE, brucellosis, typhoid, recovery from an acute infection), protozoal infections, infectious mononucleosis, leukemia, Hodgkin's disease, ulcerative colitis, regional enteritis

Decreased: Lymphocytic leukemia, aplastic anemia, steroid use

Platelets

• 150–450,000 µL

Platelet counts may be normal in number, but abnormal in function as occurs in aspirin therapy. Abnormalities of platelet function are assessed by bleeding time.

Increased: Sudden exercise, after trauma, bone fracture, after asphyxia, after surgery (especially splenectomy), acute hemorrhage, polycythemia vera, primary thrombocytosis, leukemias, after childbirth, carcinoma, cirrhosis, myeloproliferative disorders, iron deficiency

Decreased: DIC, ITP, TTP, congenital disease, marrow suppressants (chemotherapy, alcohol, radiation), burns, snake and insect bites, leukemias, aplastic anemias, hypersplenism, infectious mononucleosis, viral infections, cirrhosis, massive transfusions, eclampsia and preeclampsia, prosthetic heart valve, more than 30 different drugs (NSAIDs, cimetidine, aspirins, thiazides, others)

PMNs (Polymorphonuclear Neutrophils) (Neutrophils)

• 40–76% • See also the "Left Shift" page 100.

Increased

Physiologic (Normal). Severe exercise, last months of pregnancy, labor, surgery, newborns, steroid therapy

Pathologic. Bacterial infections, noninfective tissue damage (MI, pulmonary infarction, pancreatitis, crush injury, burn injury), metabolic disorders (eclampsia, DKA, uremia, acute gout), leukemias

Decreased: Pancytopenia, aplastic anemia, PMN depression (a mild decrease is referred to as **neutropenia,** severe is called **agranulocytosis**), marrow damage (x-rays, poisoning with benzene or antitumor drugs), severe overwhelming infections (disseminated TB, septicemia), acute malaria, severe osteomyelitis, infectious mononucleosis, atypical pneumonias, some viral infections, marrow obliteration (osteosclerosis, myelofibrosis, malignant infiltrate), drugs (more than 70, including chloramphenicol, phenylbutazone, chlorpromazine, quinine), B_{12} and folate deficiencies, hypoadrenalism, hypopituitarism, dialysis, familial decrease, idiopathic causes

RDW (Red Cell Distribution Width)

• 11.5–14.5

RDW is a measure of the degree of anisocytosis (variation in RBC size) and measured by the automated hematology counters.

Increased: Many anemias (iron deficiency, pernicious, folate deficiency, thalassemias), liver disease

LYMPHOCYTE SUBSETS

Specific monoclonal antibodies are used to identify specific T and B cells. Lymphocyte subsets (also called lymphocyte marker assays, or T- and B-cell assay) are useful in the diagnosis of AIDS and various leukemias and lymphomas. The designation **CD ("clusters of differentiation")** has largely replaced the older antibody designations (eg, Leu 3a or OKT3). Results are most reliable when reported as an absolute number of cells/µL rather

than a percentage of cells. A CD4/CD8 ratio < 1 is seen in patients with AIDS. Absolute CD4 count is used to initiate therapy with antiretrovirals or prophylaxis for PCP (see page 75). The CDC includes in the category of AIDS any patient with a CD4 count < 200 who is HIV-positive.

Normal Lymphocyte Subsets

- Total lymphocytes 0.66–4.60 thousand/μL
- T cell 644–2201 μL (60–88%)
- B cell 82–392 μL (3–20%)
- T helper/inducer cell (CD4, Leu 3a, OKT4) 493–1191 μL (34–67%)
- Suppressor/cytotoxic T cell (CD8, Leu 2, OKT8) 182–785 μL (10–42%)
- CD4/CD8 ratio > 1

RBC MORPHOLOGY DIFFERENTIAL DIAGNOSIS

The following lists some erythrocyte abnormalities and the associated conditions. General terms include **poikilocytosis** (irregular RBC shape such as sickle or burr) and **anisocytosis** (irregular RBC size such as microcytes and macrocytes).

Basophilic Stippling: Lead or heavy-metal poisoning, thalassemia, severe anemia

Burr Cells (Acanthocytes): Severe liver disease; high levels of bile, fatty acids, or toxins

Helmet Cells (Schistocytes): Microangiopathic hemolysis, hemolytic transfusion reaction, transplant rejection, other severe anemias, TTP

Howell–Jolly Bodies: After splenectomy, some severe hemolytic anemias, pernicious anemia, leukemia, thalassemia

Nucleated RBCs: Severe bone marrow stress (hemorrhage, hemolysis, etc), marrow replacement by tumor, extramedullary hematopoiesis

Polychromasia (Basophilia): The appearance of a bluish gray red cell on routine Wright's stain suggests reticulocytes.

Sickling: Sickle cell disease and trait

Spherocytes: Hereditary spherocytosis, immune or microangiopathic hemolysis, severe burns, ABO transfusion reactions

Target Cells (Leptocytes): Thalassemia, hemoglobinopathies, obstructive jaundice, any hypochromic anemia, after splenectomy

WBC MORPHOLOGY DIFFERENTIAL DIAGNOSIS

The following gives conditions associated with certain changes in the normal morphology of WBCs.

Auer Rods: AML

Döhle's Inclusion Bodies: Severe infection, burns, malignancy, pregnancy

Hypersegmentation: Megaloblastic anemias

Toxic Granulation: Severe illness (sepsis, burn, high temperature)

COAGULATION AND OTHER HEMATOLOGIC TESTS

The coagulation cascade is shown in Figure 5–2. A variety of coagulation-related and other blood tests follow.

Activated Clotting Time (ACT)

• 114–186 s • Collection: Black top tube from instrument manufacturer

This is a bedside test used in the operating room, dialysis unit, or other facility to document neutralization of heparin (ie, after coronary artery bypass, heparin is reversed.)

Increased: Heparin, some platelet disorders, severe clotting factor deficiency

Antithrombin-III (AT-III)

• 17–30 mg/dL or 80–120% of control • Collection: Blue top tube, patient must be off heparin for 6 h

Used in the evaluation of thrombosis. Heparin must interact with AT-III to produce anticoagulation effect.

Decreased: Autosomal-dominant familial AT-III deficiency, PE, severe liver disease, late pregnancy, oral contraceptives, nephrotic syndrome, heparin therapy (>3 days)

Increased: Coumadin, after MI

Bleeding Time

• Duke, Ivy <6 min; Template <10 min • Collection: Specialized bedside test performed by technicians. A small incision is made, and the wound is wicked with filter paper every 30 s until the fluid is clear.

In vivo test of hemostasis that tests platelet function, local tissue factors, and clotting factors. Nonsteroidal medications should be stopped 5–7 d before the test because these agents can affect platelet function.

Increased: Thrombocytopenia (DIC, TTP, ITP), von Willebrand's disease, defective platelet function (NSAIDs such as aspirin)

Coombs' Test, Direct (Direct Antiglobulin Test)

• Normal = negative • Collection: Purple top tube

Uses patient's erythrocytes; tests for the presence of antibody on the patient's cells and used in the screening for autoimmune hemolytic anemia.

Positive: Autoimmune hemolytic anemia (leukemia, lymphoma, collagen–vascular diseases), hemolytic transfusion reaction, some drug sensitizations (methyldopa, levodopa, cephalosporins, penicillin, quinidine), hemolytic disease of the newborn (erythroblastosis fetalis)

Coombs' Test, Indirect (Indirect Antiglobulin Test/Autoantibody Test)

• Normal = negative • Collection: Purple top tube

Uses serum that contains antibody, usually from the patient. Used to check cross-match prior to blood transfusion in the blood bank.

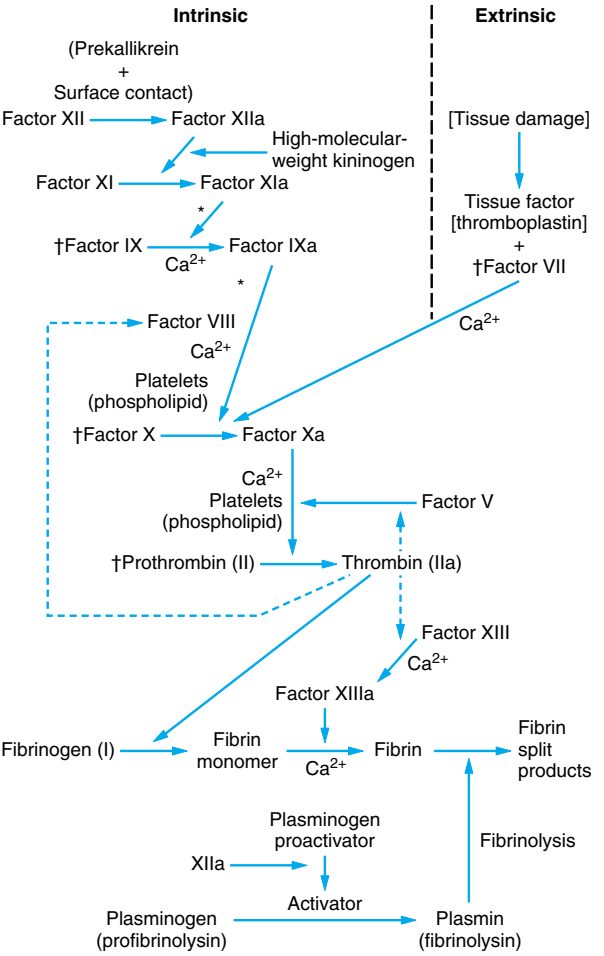

FIGURE 5–2 Blood coagulation cascade. Nearly all of the coagulation factors apparently exist as inactive proenzymes (Roman numeral) that, when activated (Roman numeral + a), serve to activate the next proenzyme in the sequence. *Symbol key:* * = Heparin acts to inhibit. ^{U} = Plasma content decreased by Coumadin. (Reprinted, with permission, from: Krupp MA [ed]: *The Physician's Handbook*. Lange Medical Publications, Los Angeles CA, 1985.)

Positive: Isoimmunization from previous transfusion, incompatible blood due to improper cross-matching or medications such as methyldopa.

Fibrin D-Dimers

• Negative or <0.5 µg/mL • Collection: Blue, green, or purple top tube
Fibrin broken into various D-dimer fragments by plasmin.

Increased: DIC, thromboembolic diseases (PE, arterial or venous thrombosis)

Fibrin Degradation Products (FDP), Fibrin Split Products (FSP)

• <10 µg/mL • Collection: Blue top tube
Generally replaced by the fibrin D-dimer as a screen for DIC

Increased: DIC (usually >40 µg/mL), any thromboembolic condition (DVT, MI, PE), hepatic dysfunction

Fibrinogen

• 200–400 mg/dL (SI:2.0–4.0 g/L) • Collection: Blue top tube
Most useful in the diagnosis of DIC and congenital hypofibrinogenemia. Fibrinogen is cleaved by thrombin to form insoluble fragments that polymerize to form a stable clot.

Increased: Inflammatory reactions, oral contraceptives, pregnancy, cancer (kidney, stomach, breast)

Decreased: DIC (sepsis, amniotic fluid embolism, abruptio placentae), surgery (prostate, open heart), neoplastic and hematological conditions, acute severe bleeding, burns, venomous snake bite, congenital

Lee-White Clotting Time

• 5–15 min • Collection: Draw into plain plastic syringe; clotting time measured in separate tube

Increased: Heparin therapy, plasma–clotting factor deficiency (except Factors VII and XIII). (*Note:* This is not a sensitive test and so is therefore not considered a good screening test.)

Partial Thromboplastin Time (Activated Partial Thromboplastin Time, PTT, APTT)

• 27–38 s • Collection: Blue top tube
Evaluates the intrinsic coagulation system (See Figure 5–2). Most commonly used to monitor heparin therapy

Increased: Heparin and any defect in the **intrinsic coagulation system** (includes Factors I, II, V, VIII, IX, X, XI, and XII), prolonged use of a tourniquet before drawing a blood sample, hemophilia A and B

Prothrombin Time (PT)

• 11.5–13.5 s • Figure 5–2, page 106 • Collection: Blue top tube

PT evaluates the **extrinsic coagulation system** that includes Factors I, II, V, VII, and X. The use of **INR** instead of the Patient/Control ratio to guide anticoagulant (Coumadin) therapy is becoming standard. **INR provides a more universal and standardized result because it measures the control against a WHO standard reference reagent.** Therapeutic INR levels are 2–3 for DVT, PE, TIAs, and atrial fibrillation. Recurrent DVT on adequate treatment requires an INR of 3–4.5. Mechanical heart valves require an INR of 3–4.5 (See also Chapter 22, Table 22–10 [page 637].)

Increased: Drugs (sodium warfarin [Coumadin]), vitamin K deficiency, fat malabsorption, liver disease, prolonged use of a tourniquet before drawing a blood sample, DIC

Sedimentation Rate (Erythrocyte Sedimentation Rate, ESR)

• Collection: Lavender top tube

The ESR is a very nonspecific test with a high sensitivity and a low specificity. Most useful in serial measurement to follow the course of disease (eg, polymyalgia rheumatica or temporal arteritis). ZETA rate is not affected by anemia. ESR correlates well with C-reactive protein levels.

Wintrobe Scale: Males, 0–9 mm/h, females, 0–20 mm/h

ZETA Scale: 40–54% normal, 55–59% mildly elevated, 60–64% moderately elevated, >65% markedly elevated

Westergren Scale: Males <50 years 15 mm/h, >50 years 20 mm/h; female <50 years 20 mm/h, >50 years 30 mm/h

Increased: Any type of infection, inflammation, rheumatic fever, endocarditis, neoplasm, AMI

Thrombin Time

• 10–14 s • Collection: Blue top tube

A measure of the rate of conversion of fibrinogen to fibrin and fibrin polymerization. Used to detect the presence of heparin and hypofibrinogenemia and as an aid in the evaluation of prolonged PTT

Increased: Systemic heparin, DIC, fibrinogen deficiency, congenitally abnormal fibrinogen molecules

6

LABORATORY DIAGNOSIS: URINE STUDIES

URINALYSIS PROCEDURE

For a routine screening urinalysis, a fresh (less than 1-h old), clean-catch urine is acceptable. If it cannot be interpreted immediately, it should be refrigerated (urine standing at room temperature for long periods causes lysis of casts and red cells and becomes alkalinized.) See Chapter 13 under Urinary Tract Procedures, page 306, for the different ways to collect the sample.

1. Pour about 5–10 mL of well-mixed urine into a centrifuge tube. Check the specific gravity with a urinometer or optic refractory urinometer (refractometer) on the remaining sample.
2. Check for appearance (color, turbidity, odor).
3. Spin the capped sample at 3000 rpm (450 g) for 3 min.
4. While the sample is in the centrifuge and using the dipstick (Chemstrip, etc) supplied by your lab, perform the dipstick evaluation on the remaining portion of the sample. Read the results according to the color chart and instructions on the bottle. Make sure to allow the time noted before reading the test because reading before the time (up to 60 s) may yield false results. Record glucose, ketones, blood, protein, pH, nitrite, and leukocyte esterase if available. Be sure to recap the bottle tightly after use. Agents that color the urine (phenazopyridine [Pyridium]) may interfere with the results of the dipstick.
5. Decant and discard the supernatant. Mix the remaining sediment by flicking it with your finger and pour or pipette one or two drops on a microscope slide. Cover with a coverslip. If a urine sample looks very grossly cloudy, it is sometimes advisable to examine an unspun sample. If an unspun sample is used, note this on the report. In general, for routine urinalysis, a spun sample is more desirable.
6. Examine 10 lpf (10× objective) for epithelial cells, casts, crystals, and mucus. Casts are usually reported per low-power field. Casts tend to collect around the periphery of the coverslip.
7. Examine several high-power fields (40× objective) for epithelial cells, crystals, RBCs, WBCs, bacteria, and parasites (trichomonads). RBCs, WBCs, and bacteria are usually reported per high-power field. Two reporting systems are commonly used:

System One	System Two
Rare = <2 per field	Trace = <¼ of field
Occasional = 3–5 per field	1+ = ¼ of field
Frequent = 5–9 per field	2+ = ½ of field
Many = "large number" per field	3+ = ¾ of field
TNTC = too numerous to count	4+ = field is full

URINALYSIS, NORMAL VALUES

1. **Appearance:** "Yellow, clear," or "straw-colored, clear"
2. **Specific Gravity**
   a. Neonate: 1.012
   b. Infant: 1.002–1.006
   c. Child and Adult: 1.001–1.035 (with normal fluid intake 1.016–1.022)
3. **pH**
   a. Newborn/Neonate: 5–7
   b. Child and Adult: 4.6–8.0
4. **Negative for:** Bilirubin, blood, acetone, glucose, protein, nitrite, leukocyte esterase, reducing substances
5. **Trace:** Urobilinogen
6. **RBC:** Male 0–3/hpf, female 0–5/hpf
7. **WBC:** 0–4/hpf
8. **Epithelial Cells:** Occasional
9. **Hyaline Casts:** Occasional
10. **Bacteria:** None
11. **Crystals:** Some limited crystals based on urine pH (see below)

DIFFERENTIAL DIAGNOSIS FOR ROUTINE URINALYSIS

Appearance

Colorless: Diabetes insipidus, diuretics, excess fluid intake

Dark: Acute intermittent porphyria, malignant melanoma

Cloudy: UTI (pyuria), amorphous phosphate salts (normal in alkaline urine), blood, mucus, bilirubin

Pink/Red:

Heme-positive. Blood, hemoglobin, sepsis, dialysis, myoglobin
Heme-negative. Food coloring, beets, sulfa drugs, nitrofurantoin, salicylates

Orange/Yellow: Dehydration, phenazopyridine (Pyridium), rifampin, bile pigments

Brown/Black: Myoglobin, bile pigments, melanin, cascara, iron, nitrofurantoin, alkaptonuria

Green: Urinary bile pigments, indigo carmine, methylene blue

Foamy: Proteinuria, bile salts

pH

Acidic: High-protein (meat) diet, ammonium chloride, mandelic acid and other medications, acidosis, (due to ketoacidosis [starvation, diabetic], COPD)

Basic: UTI, renal tubular acidosis, diet (high-vegetable, milk, immediately after meals), sodium bicarbonate therapy, vomiting, metabolic alkalosis

Specific Gravity

Usually corresponds with osmolarity except with osmotic diuresis. Value >1.023 indicates normal renal concentrating ability. Random value 1.003–1.030

Increased: Volume depletion; CHF; adrenal insufficiency; diabetes mellitus; SIADH; increased proteins (nephrosis); if markedly increased (1.040–1.050), suspect artifact or excretion of radiographic contrast media

Decreased: Diabetes insipidus, pyelonephritis, glomerulonephritis, water load with normal renal function

Bilirubin

Positive: Obstructive jaundice (intrahepatic and extrahepatic), hepatitis. (*Note:* False-positives occur with stool contamination.)

Blood

Note: If the dipstick is positive for blood, but no red cells are seen, free hemoglobin from trauma may be present; a transfusion reaction may have occurred, from lysis of RBCs (RBCs will lyse if the pH is <5 or >8); or myoglobin may be present because of a crush injury, burn, or tissue ischemia.

Positive: Stones, trauma, tumors (benign and malignant, anywhere in the urinary tract), urethral strictures, coagulopathy, infection, menses (contamination), polycystic kidneys, interstitial nephritis, hemolytic anemia, transfusion reaction, instrumentation (Foley catheter, etc)

Glucose

Positive: Diabetes mellitus, pancreatitis, pancreatic carcinoma, pheochromocytoma, Cushing's disease, shock, burns, pain, steroids, hyperthyroidism, renal tubular disease, iatrogenic causes. (*Note:* Glucose oxidase technique in many kits is specific for glucose and will not react with lactose, fructose, or galactose.)

Ketones

Detects primarily acetone and acetoacetic acid and not β-hydroxybutyric acid.

Positive: Starvation, high-fat diet, DKA, vomiting, diarrhea, hyperthyroidism, pregnancy, febrile states (especially in children)

Nitrite

Many bacteria will convert nitrates to nitrite. (See also the section on Leukocyte Esterase, page 112.)

Positive: Infection (A negative test does not rule out infection because some organisms, such as *Streptococcus faecalis* and other gram-positive cocci, do not produce nitrite, and the urine must also be retained in the bladder for several hours to allow the reaction to take place.)

Protein

Indication by dipstick of persistent proteinuria should be quantified by 24-h urine studies.

Positive: Pyelonephritis, glomerulonephritis, Kimmelstiel–Wilson syndrome (diabetes), nephrotic syndrome, myeloma, postural causes, preeclampsia, inflammation and malignancies of the lower tract, functional causes (fever, stress, heavy exercise), malignant hypertension, CHF

Leukocyte Esterase

Test detects ≥5 WBC/hpf or lysed WBCs. When combined with the nitrite test, it has a predictive value of 74% for UTI if both tests are positive and a value of >97% if both tests are negative.

Positive: UTI (false-positive with vaginal contamination)

Reducing Substances

Positive: Glucose, fructose, galactose, false-positives (vitamin C, salicylates, antibiotics, etc)

Urobilinogen

Positive: Cirrhosis, CHF with hepatic congestion, hepatitis, hyperthyroidism, suppression of gut flora with antibiotics

URINE SEDIMENT

Many labs no longer do microscopic examinations unless specifically requested or if evidence exists for an abnormal finding on dipstick test (such as positive leukocyte esterase). Figure 6–1 is a pictorial representation of materials found in urine sediments.

Red Blood Cells (RBCs): Trauma, pyelonephritis, genitourinary TB, cystitis, prostatitis, stones, tumors (malignant and benign), coagulopathy, and any cause of blood on dipstick test (See previous section on blood pH, page 111.)

White Blood Cells (WBCs): Infection anywhere in the urinary tract, TB, renal tumors, acute glomerulonephritis, radiation, interstitial nephritis (analgesic abuse)

Epithelial Cells: ATN, necrotizing papillitis. (Most epithelial cells are from an otherwise unremarkable urethra.)

Parasites: *Trichomonas vaginalis, Schistosoma haematobium* infection

Yeast: *Candida albicans* infection (especially in diabetics, immunosuppressed patients, or if a vaginal yeast infection is present)

Spermatozoa: Normal in males immediately after intercourse or nocturnal emission

Crystals

Abnormal. Cystine, sulfonamide, leucine, tyrosine, cholesterol

Normal. Acid urine: Oxalate (small square crystals with a central cross), uric acid. *Alkaline urine:* Calcium carbonate, triple phosphate (resemble coffin lids)

Contaminants: Cotton threads, hair, wood fibers, amorphous substances (all usually unimportant)

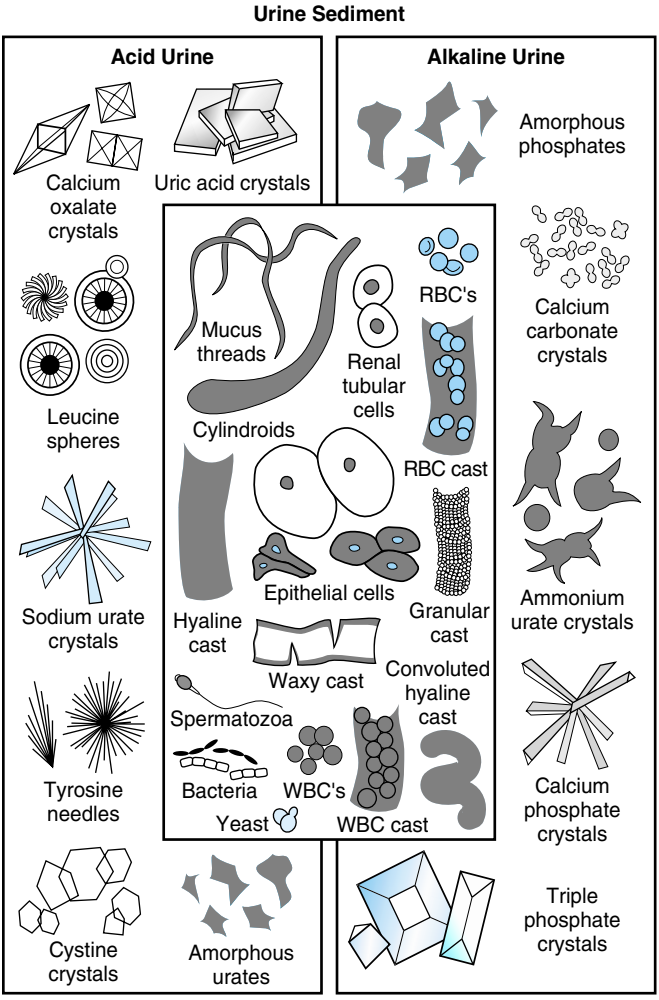

FIGURE 6–1 Urine sediment as seen under the microscope. (Reprinted, with permission, from: Greene MG [ed]: *The Harriet Lane Handbook: A Manual for Pediatric House Officers,* 12th ed,. Yearbook Medical Publishers, Chicago IL, 1991.)

Mucus: Large amounts suggest urethral disease (normal from ileal conduit or other forms of urinary diversion)

Glitter Cells: WBCs lysed in hypotonic solution

Casts: The presence of casts in a urine localizes some or all of the disease process to the kidney itself.

Hyaline Casts. (Acceptable unless they are "numerous"), benign hypertension, nephrotic syndrome, after exercise

RBC Casts. Acute glomerulonephritis, lupus nephritis, SBE, Goodpasture's disease, after a streptococcal infection, vasculitis, malignant hypertension

WBC Casts. Pyelonephritis

Epithelial (Tubular) Casts. Tubular damage, nephrotoxin, virus

Granular Casts. Breakdown of cellular casts, leads to waxy casts; "dirty brown granular casts" typical for ATN

Waxy Casts. (End stage of granular cast). Severe chronic renal disease, amyloidosis

Fatty Casts. Nephrotic syndrome, diabetes mellitus, damaged renal tubular epithelial cells

Broad Casts. Chronic renal disease

SPOT OR RANDOM URINE STUDIES

The so-called spot urine, which is often ordered to aid in diagnosing various conditions, relies on only a small sample (10–20 mL) of urine.

Spot Urine for β_2-microglobulin

- <0.3 mg/L

  A marker for renal tubular injury

Increased: Diseases of the proximal tubule (ATN, interstitial nephritis, pyelonephritis), drug-induced nephropathy (aminoglycosides), diabetes, trauma, sepsis, HIV, lymphoproliferative and lymphodestructive diseases

Spot Urine for Electrolytes

The usefulness of this assay is limited because of large variations in daily fluid and salt intake, and the results are usually indeterminate if a diuretic has been given.

1. **Sodium <10 mEq/L (mmol/L)**: Volume depletion, hyponatremic states, prerenal azotemia (CHF, shock, etc), hepatorenal syndrome, glucocorticoid excess
2. **Sodium >20 mEq/L (mmol/L)**: SIADH, ATN (usually >40 mEq/L), postobstructive diuresis, high salt intake, Addison's disease, hypothyroidism, interstitial nephritis
3. **Chloride <10 mEq/L (mmol/L)**: Chloride-sensitive metabolic alkalosis (vomiting, excessive diuretic use), volume depletion
4. **Potassium <10 mEq/L (mmol/L)**: Hypokalemia, potassium depletion, extrarenal loss

Spot Urine for Erythrocyte Morphology

The morphology of red blood cells in a sample of urine that tests positive for blood may give some indication of the nature of the hematuria. **Eumorphic red cells** are typically seen in cases of postrenal, nonglomerular bleeding. **Dysmorphic red cells** are more likely associated with glomerular causes of bleeding. Each reference lab has standards, but as a general rule, the

presence of >90% dysmorphic erythrocytes in patients with asymptomatic hematuria indicates a renal glomerular source of bleeding, especially if associated with proteinuria and or casts (ie, IgA nephropathy, poststreptococcal glomerular, sickle cell disease or trait, etc). If ≥90% eumorphic erythrocytes or even "mixed" results (10–90% eumorphic erythrocytes) indicates a postrenal cause of hematuria requiring a complete urologic evaluation (ie, hypercalciuria, urolithiasis, cystitis, trauma, tumors, hemangioma, exercise induced, BPH, etc).

Spot Urine for Microalbumin

- Normal <30 µg albumin/mg creatinine

Used to determine which patients with diabetes are at risk for nephropathy. Clinical albuminuria occurs at >300 µg albumin/mg creatinine. Base test on two or three separate determinations over 6 mo. Diabetic patients with levels between 30–300 µg have microalbuminuria and are usually initiated on ACE inhibitor or angiotensin receptor blocker.

Spot Urine for Myoglobin

- Qualitative negative

Positive: Skeletal muscle conditions (crush injury, electrical burns, carbon monoxide poisoning, delirium tremens, surgical procedures, malignant hyperthermia), polymyositis.

Spot Urine for Osmolality

- 75–300 mOsm/kg (mmol/kg) • Varies with water intake

Patients with normal renal function should concentrate >800 mOsm/kg (mmol/kg) after a 14-h fluid restriction; <400 mOsm/kg (mmol/kg) is a sign of renal impairment.

Increased: Dehydration, SIADH, adrenal insufficiency, glycosuria, high-protein diet

Decreased: Excessive fluid intake, diabetes insipidus, acute renal failure, medications (acetohexamide, glyburide, lithium)

Spot Urine for Protein

- Normal <10 mg/dL (0.1 g/L) or <20 mg/dL (0.2 g/L) for a sample taken in the early AM

See page 112 for the differential diagnosis of protein in the urine.

CREATININE AND CREATININE CLEARANCE

Normal

Adult Male. Total creatinine 1–2 g/24 h (8.8–17.7 mmol/d); clearance 85–125 mL/min/1.73 m^2

Adult Female. Total creatinine 0.8–1.8 g/24 h (7.1–15.9 mmol/d); clearance 75–115 mL/min 1.73 m^2 (1.25–1.92 mL/s/1.73 m^2)

Child. Total creatinine (>3 years) 12–30 mg/kg/24 h; clearance 70–140 mL/min/1.73 m^2(1.17–2.33 mL/s/1.73 m^2)

Decreased: A decreased creatinine clearance results in an increase in serum creatinine usually secondary to renal insufficiency. See Chapter 4, page 65, for differential diagnosis of increased serum creatinine.

Increased: Early diabetes mellitus, pregnancy

Creatinine Clearance Determination

Creatinine clearance is one of the most sensitive indicators of early renal insufficiency. Clearances are ordered for patients with suspected renal disease and are useful for following patients who are taking nephrotoxic medications, (eg, gentamicin). Clearance normally decreases with age. A creatinine clearance of 10–20 mL/min indicates severe renal failure, and a clearance of <10 mL/min usually indicates the need for dialysis.

To determine a creatinine clearance, order a concurrent serum creatinine and a 24-h urine creatinine. A shorter time interval can be used, for example, 12 h, but remember that the formula must be corrected for this change and that a 24-h sample is less prone to collection error.

Example: (A quick formula is also found under "Aminoglycoside Dosing," page 620.) The following are calculations of (a) the creatinine clearance from a 24-h urine sample with a volume of 1000 mL, (b) a urine creatinine of 108 mg/100 mL, and (c) a serum creatinine of 1 mg/100 mL (1 mg/dL).

$$\text{Clearance} = \frac{\text{Urine creatinine} \times \text{Total urine volume}}{\text{Plasma creatinine} \times \text{Time}}$$

where time = 1440 min if 24-h collection.

$$\text{Clearance} = \frac{(108 \text{ mg} / 100 \text{ mL})\ (1000 \text{ mL})}{(1 \text{ mg} / 100 \text{ mL})\ (1440 \text{ min})} = 75 \text{ mL} / \text{min}$$

To see if the urine sample is valid, some clinicians advocate a preliminary evaluation by determining first if the sample contains at least 18–25 mg/kg/24 h of creatinine for adult males or 12–20 mg/kg/24 h for adult females. This preliminary test is not a requirement, but can confirm if a 24–h sample was collected or if some of the sample was lost.

If the patient is an adult (150 lb = body surface area of 1.73 m^2), adjustment of the clearance for body size is not routinely done. Adjustment for pediatric patients is a necessity. If the values in the previous example were for a 10-year-old boy who weighed 70 lb (1.1 m^2), the clearance would be:

$$75 \text{ mL} / \text{min} \times \frac{1.73 \text{ m}^2}{1.1 \text{ m}^2} = 118 \text{ mL} / \text{min}$$

24-HOUR URINE STUDIES

A wide variety of diseases, most of them endocrine, can be diagnosed by assays of 24-h urine samples. The following information gives the normal values for certain agents and the conditions associated with changes in these values.

Calcium, Urine

Normal: On a calcium-free diet <150 mg/24 h (3.7 mmol/d), average calcium diet (600–800 mg/24 h) 100–250 mg/24 h (2.5–6.2 mmol/d)

Increased: Hyperparathyroidism, hyperthyroidism, hypervitaminosis D, distal renal tubular acidosis (type I), sarcoidosis, immobilization, osteolytic lesions (bony metastasis, multiple myeloma), Paget's disease, glucocorticoid excess, immobilization, furosemide

Decreased: Medications (thiazide diuretics, estrogens, oral contraceptives), hypothyroidism, renal failure, steatorrhea, rickets, osteomalacia

Catecholamines, Fractionated

Used to evaluate neuroendocrine tumors, including pheochromocytoma and neuroblastoma. Avoid caffeine and methyldopa (Aldomet) prior to test

Normal: Values are variable and depend on the assay method used. Norepinephrine 15–80 mg/24 h [SI: 89–473 nmol/24 h], epinephrine 0–20 mg/24 h [0–118 nmol/24 h], dopamine 65–400 mg/24 h [SI: 384–2364 nmol/24 h].

Increased: Pheochromocytoma, neuroblastoma, epinephrine administration, presence of drugs (methyldopa, tetracyclines cause false increases)

Cortisol, Free

Used to evaluate adrenal cortical hyperfunction, screening test of choice for Cushing's syndrome

Normal: 10–110 mg/24 h [SI: 30–300 nmol]

Increased: Cushing's syndrome (adrenal hyperfunction), stress during collection, oral contraceptives, pregnancy

Creatinine

• See pages 65 and 115

Cysteine

Used to detect cystinuria, homocystinuria, monitor response to therapy

Normal: 40–60 mg/g creatinine

Increased: Heterozygotes < 300 mg/g creatinine/day; homozygotes > 250 mg/g creatinine

5-HIAA (5-Hydroxyindoleacetic Acid)

5–HIAA is a serotonin metabolite useful in diagnosing carcinoid syndrome.

Normal: (2–8 mg [SI: 10.4–41.6] mmol/24–h urine collection)

Increased: Carcinoid tumors (except rectal), certain foods (banana, pineapple, tomato, walnuts, avocado), phenothiazine derivatives

Metanephrines

Detects metabolic products of epinephrine and norepinephrine, a primary screening test for pheochromocytoma

Normal: <1.3 mg/24 h (7.1 mmol/L) for adults, but variable in children

Increased: Pheochromocytoma, neuroblastoma (neural crest tumors), false-positive with drugs (phenobarbital, guanethidine, hydrocortisone, MAO inhibitors)

Protein

• See also Urine Protein Electrophoresis, pages 85 and 112.

Normal: <150 mg/24 h (<0.15 g/d)

Increased: Nephrotic syndrome usually associated with >4 g/24 h

17-Ketogenic Steroids (17-KGS, Corticosteroids)

Overall adrenal function test, largely replaced by serum or urine cortisol levels

Normal: Males 5–24 mg/24 h (17–83 mmol/24 h); females 4–15 mg/24 h (14–52 mmol/24 h)

Increased: Adrenal hyperplasia (Cushing's syndrome), adrenogenital syndrome

Decreased: Panhypopituitarism, Addison's disease, acute steroid withdrawal

17-Ketosteroids, Total (17-KS)

Measures DHEA, androstenedione (adrenal androgens); largely replaced by assay of individual elements

Normal: Adult males 8–20 mg/24 h (28–69 mmol/L); adult female 6–15 mg/dL (21–52 mmol/L). *Note:* Low values in prepubertal children

Increased: Adrenal cortex abnormalities (hyperplasia [Cushing's disease], adenoma, carcinoma, adrenogenital syndrome), severe stress, ACTH or pituitary tumor, testicular interstitial tumor and arrhenoblastoma (both produce testosterone)

Decreased: Panhypopituitarism, Addison's disease, castration in men

Vanillylmandelic Acid

VMA is the urinary product of both epinephrine and norepinephrine; good screening test for pheochromocytoma, also used to diagnose and follow up neuroblastoma and ganglioneuroma

Normal: <7–9 mg/24 h (35–45 mmol/L)

Increased: Pheochromocytoma, other neural crest tumors (ganglioneuroma, neuroblastoma), factitious (chocolate, coffee, tea, methyldopa)

OTHER URINE STUDIES

Drug Abuse Screen

• Normal = negative

Tests urine for common drugs of abuse, often used for employment screening for critical jobs. Assay will vary by facility and may include tests for amphetamines, barbiturates, benzodiazepines, marijuana (cannabinoid metabolites), cocaine metabolites, opiates, phencyclidine.

Xylose Tolerance Test (D-Xylose Absorption Test)

• 5 g xylose in 5-h urine specimen after 25 g oral dose of xylose or 1.2 g after 5-g oral dose • Collection: Patient is NPO after midnight except for water. • After voiding at 8 AM, 25 g of D-xylose (or 5 g if GI irritation is a concern) is dissolved in 250 mL water. • An additional 750 mL water is drunk and the urine collected for the next 5 h.

TABLE 6–1
Urinary Indices Useful in the Differential Diagnosis of Oliguria

Index	Prerenal	Renal (ATN)*
Urine osmolality	>500	<350
Urinary sodium	<20	>40
Urine/serum creatinine	>40	<20
Urine/serum osmolarity	>1.2	<1.2
Fractional excreted sodium†	<1	>1
Renal failure index (RFI)‡	<1	>1

*Acute tubular necrosis (intrinsic renal failure).

†Fractional excreted sodium = $\frac{\text{Urine / Serum sodium}}{\text{Urine / Serum creatinine}} \times 100$

‡Renal failure index = $\frac{\text{Urine sodium} \times \text{Serum creatinine}}{\text{Urine creatinine}}$

Used to assess proximal bowel function; differentiates between malabsorption due to pancreatic insufficiency or intestinal problems.

Decreased: Celiac disease (nontropical sprue, gluten-sensitive enteropathy), false decreas0e with renal disease

URINARY INDICES IN RENAL FAILURE

Use Table 6–1 to help differentiate the causes (renal or prerenal) of oliguria. (See also Oliguria and Anuria, page 49.)

URINE OUTPUT

Although clinical situations vary greatly, the usual, minimal acceptable urine output for an adult is 0.5–1.0 mL/kg/h (daily volume normally 1000–1600 mL/d).

URINE PROTEIN ELECTROPHORESIS

See Protein Electrophoresis, Serum and Urine, page 85, and Figure 4–5, page 86.

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7

CLINICAL MICROBIOLOGY

STAINING TECHNIQUES

Acid-Fast Stain (AFB Smear, Kinyoun Stain)

Clinical microbiology labs can also perform a "modified" acid-fast stain for organisms that are weakly acid-fast-staining (eg, *Nocardia* species).

Procedure

1. Spread the smear on a slide, allow it to air dry, and then gently heat fix it.
2. Stain the smear for 3–5 min with terpinol in carbol-fuchsin red solution.
3. Rinse the slide with tap water.
4. Decolorize with acid–alcohol solution for no longer than 30 s.
5. Rinse with tap water.
6. Counterstain with methylene blue for 1 min.
7. Rinse the slide with tap water and allow it to air dry.
8. Examine the smear with high dry and oil immersion lenses; search for the acid-fast bacilli that stain red to bright pink against the light blue background (*Mycobacterium tuberculosis* [TB], *M. scrofulaceum, M. avium-intracellulare,* others). These organisms have a beaded rod appearance under oil immersion.
9. These organisms must be cultured on specialized media. Rapid-growing AFB include *M. abscessus, M. chelonae, M. fortuitum* and can usually be cultured in fewer than 7 days. Most other AFB (*M. tuberculosis, M. avium* complex, *M. kansasii, M. marinum*) require at least 7–10 d to grow. *M. gordonae* is thought to be nonpathogenic.

Darkfield Examination

Darkfield examination is used to identify *Treponema pallidum,* the organism responsible for syphilis. Rectal and oral lesions cannot be examined by this technique due to the presence of nonpathogenic spirochetes.

Procedure

1. The chancre is cleansed with a saline-moistened swab and a slide is touched on the lesion and examined under darkfield illumination within 15 min of applying the specimen to the slide.
2. The organisms resemble tight corkscrews and are 1–1½ times the diameter of an RBC in length.

Giemsa Stain

Used to identify intracellular organisms such as chlamydiae, *Plasmodium* spp. (malaria), and other parasites.

Gonorrhea Smear (See the following section on Gonorrhea [GC] Cultures)

Gram Stain

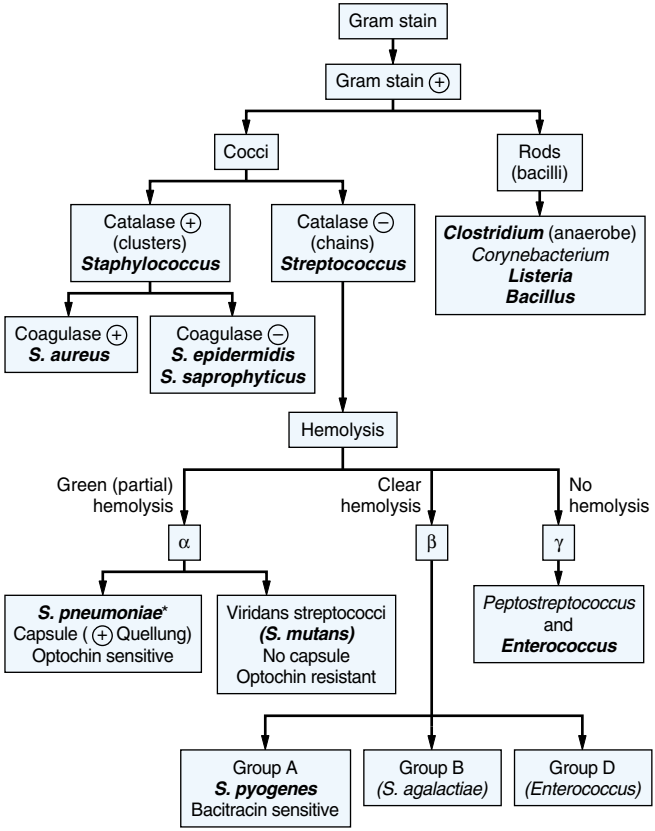
The Gram stain is used to determine whether an organism can be decolorized with alcohol after being stained with crystal violet. This determination is based on the organism's cell wall characteristics. Gram staining is performed on bacteria from a variety of body fluids, including exudates, abscesses, sputum, and others as clinically indicated.

Procedure

1. Smear the specimen (sputum, peritoneal fluid, etc) on a glass slide in a fairly thin coat. If time permits, allow the specimen to air dry. The smear may also be fixed under very low heat (excessive heat can cause artifacts). If a Bunsen burner is not available, other possible methods for heating the sample include using a hot light bulb or setting an alcohol swab on fire. Heat the slide until it is warm, but not hot, when touched to the back of the hand.
2. Timing for the stain is not critical, but allow at least 10 s for each set of reagents.
3. Apply the **crystal violet (Gram stain**), rinse the slide with tap water, apply iodine solution, and rinse with water.
4. Decolorize the slide carefully with the acetone–alcohol solution until the blue color is barely visible in the runoff. (Be careful; this is the step where most Gram stains are ruined.)
5. Counterstain with a few drops of safranin, rinse the slide with water, and blot it dry with lint-free bibulous or filter paper.
6. Use the high dry (100×) and oil immersion lenses on the microscope to examine the slide. If the Gram stain is satisfactory, any polys on the slide should be pink with light blue nuclei. On a Gram stain of **sputum,** an excessive number of epithelial cells (>25/hpf) means the sample contained more saliva than sputum. **Gram-positive organisms stain dark blue to purple; gram-negative ones stain red.**

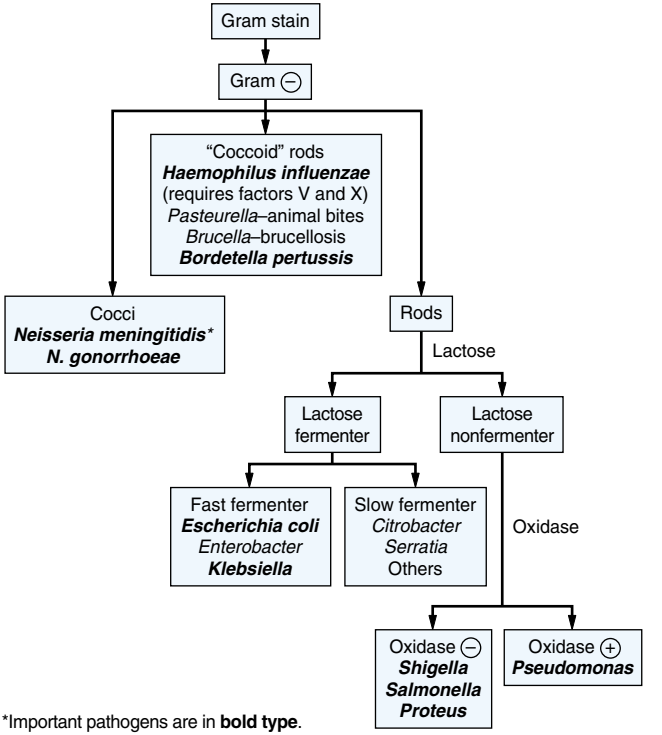
Gram Stain Characteristics of Common Pathogens:

Initial lab reports identify the Gram stain characteristics of the organisms. Complete identification usually requires culturing the organism. The lab algorithm for gram-positive and



*Important pathogens are in **bold type**.
Note: Enterococcus is Group D but it is not β-hemolytic; it is α- or γ-hemolytic.

FIGURE 7–1 Lab algorithm for the identification of gram-positive organisms. (Reprinted, with permission, from: Bhushan V [ed]: *First Aid for the USMLE, Step 1,* Appleton & Lange, Norwalk, CT, 1999.)



*Important pathogens are in **bold type**.

FIGURE 7–2 Lab algorithm for the identification of gram-negative organisms. (Reprinted, with permission, from: Bhushan V [ed]: *First Aid for the USMLE, Step 1*, Appleton & Lange, Norwalk, CT, 1999.)

TABLE 7–1
Gram Stain Characteristics and Key Features of Common Organisms*

Gram Staining Pattern and Organisms	Identifying Key Features
GRAM-POSITIVE COCCI	
Enterococcus spp. (*E. faecalis*) (*Note:* These are equivalent group D *Streptococcus*)	Pairs, chains; catalase-negative
Peptostreptococcus spp.	Anaerobic
Staphylococcus spp.	Clusters; catalase-positive
Staphylococcus aureus	Clusters; catalase-positive; coagulase-negative; beta-hemolytic; yellow pigment
Staphylococcus epidermidis	Clusters; catalase-positive; coagulase-positive; skin flora
Staphylococcus saprophyticus	Clusters; catalase-positive; coagulase-positive
Streptococcus spp.	Pairs, chains; catalase-negative
Streptococcus agalactiae (group B)	Pairs, chains; catalase-negative; vaginal flora
Streptococcus bovis (group D *Enterococcus*)	Pairs, chains; catalase-negative
Streptococcus faecalis (group D *Enterococcus*)	Pairs, chains; catalase-negative
Streptococcus pneumoniae (*Pneumococcus*, group B)	Pairs, lancet-shaped; alpha-hemolytic; Optochin-sensitive
Streptococcus pyogenes (group A)	Beta-hemolytic
Streptococcus viridans	Pairs, chains; catalase-negative; alpha-hemolytic, Optochin-resistant
GRAM-NEGATIVE COCCI	
Acinetobacter spp.	Filamentous, branching pattern
Moraxella (*Branhamella*) *catarrhalis*	Diplococci in pairs
Neisseria gonorrhoeae (gonococcus)	Diplococci in pairs, often intracellular; ferments glucose but not maltose
Neisseria meningitidis (meningococcus)	Diplococci in pairs;ferments glucose and maltose
Veillonella spp.	Anaerobic
GRAM-POSITIVE BACILLI	
Actinomyces	Branching, beaded, rods; anaerobic
Bacilli anthracis (anthrax)	Spore forming rod

(*continued*)

TABLE 7–1 (Continued)

Gram Staining Pattern and Organisms	Identifying Key Features
GRAM-POSITIVE BACILLI	
Clostridium spp. (*C. difficile, C. botulinum, C. tetani*)	Large, with spores; anaerobic
Corynebacterium spp. (*C. diphtheriae*)	Small, pleomorphic diphtheroid; skin flora
Eubacterium spp.	Anaerobic
Lactobacillus spp.	Common vaginal bacterium; anaerobic
Listeria monocytogenes	Beta-hemolytic
Mycobacterium spp. (limited staining)	Only rapidly growing species gram stain (*M. abscessus, M. chelonae, M. fortuitum*)
Nocardia	Beaded, branched rods; partially acid-fast-staining
Propionibacterium acne	Small, pleomorphic diphtheroid; anaerobic
GRAM-NEGATIVE BACILLI	
Acinetobacter spp.	Lactose-negative, oxidase-negative
Aeromonas hydrophilia	Lactose-negative (usually), oxidase-positive
Bacteroides fragilis	Anaerobic
Bordetella pertussis	Coccoid rod
Brucella (brucellosis)	Coccoid rod
Citrobacter spp.	Lactose-positive (usually)
Enterobacter spp.	Lactose-positive (usually)
Escherichia coli	Lactose-positive
Fusobacterium spp.	Long, pointed shape; anaerobic
Haemophilus ducreyi (chancroid)	Gram-negative bacilli
Haemophilus influenzae	Coccoid rod, requires chocolate agar to support growth
Klebsiella spp.	Lactose-positive
Legionella pneumophila	Stains poorly, use silver stain and special media
Morganella morganii	Lactose-negative, oxidase-negative
Proteus mirabilis	Lactose-negative, oxidase-negative, indole-negative
Proteus vulgaris	Lactose-negative, oxidase-negative, indole-positive

(*continued*)

TABLE 7–1 (Continued)

Gram Staining Pattern and Organisms	Identifying Key Features
GRAM-NEGATIVE BACILLI	
Providencia spp.	Lactose-negative, oxidase-negative
Pseudomonas aeruginosa	Lactose-negative, oxidase-positive blue-green pigment
Salmonella spp.	Lactose-negative, oxidase-negative
Serratia spp.	Lactose-negative, oxidase-negative
Serratia marcescens	Lactose-negative, oxidative-negative, red pigment
Shigella spp.	Lactose-negative, oxidase-negative
Stenotrophomonas (*Xanthomonas*) *maltophilia*	Lactose-negative, oxidase-negative
Vibrio cholerae (cholera)	Gram-negative bacilli
Yersinia enterocolitica	Gram-negative bacilli
Yersinia pestis (bubonic plague)	Gram-negative bacilli

*Organisms are aerobic unless otherwise specified.

gram-negative organisms is shown in Figures 7–1 and 7–2. Gram stain characteristics of clinically important bacteria are shown in Table 7–1.

India Ink Preparation

India ink is used primarily on CSF to identify fungal organisms (especially cryptococci).

KOH Preparation

KOH (potassium hydroxide) preps are used to diagnose fungal infections. Vaginal KOH preps are discussed in detail in Chapter 13, page 291.

Procedure

1. Apply the specimen (vaginal secretion, sputum, hair, skin scrapings) to a slide. Skin scrapings of a lesion are usually obtained by gentle scraping with a #15 scalpel blade (see page 242 for description).
2. Add 1–2 drops of 10% KOH solution and mix. Gentle heating (optional) may accelerate dissolution of the keratin. A fishy odor from a vaginal prep suggests the presence of *Gardnerella vaginalis* (see page 291)
3. Put a coverslip over the specimen, and examine the slide for the branching hyphae and blastospores that indicate the presence of a fungus. KOH should destroy most elements other than fungus. If dense keratin and debris are present, allow the slide to sit for several hours and then repeat the microscopic examination. Lowering the substage condenser provides better contrast between organisms and the background.

Stool Leukocyte Stain (Fecal Leukocytes, Löeffler Methylene Blue Stain)

Used to differentiate treatable diarrhea (ie, bacterial) from other causes. This method detects causes from Crohn's disease, ulcerative colitis, TB, and amebic infection as well, but it should be remembered that many causes of severe diarrhea are viral. The positive predictive value of the bacterial pathogen as a cause for the diarrhea is 70%.

Procedure

1. Mix a small amount of stool or mucus on a slide with 2 drops of Löeffler (methylene blue) stain. Mucus is preferred; if no mucus is present, use a small amount of stool from the outside of a formed stool.

2. Examine the smear after 2–3 min to allow the white cells to take up the stain; then place a coverslip. The presence of many leukocytes suggests a bacterial cause. Increased white cells (usually polys) are seen in *Shigella, Salmonella, Campylobacter, Clostridium difficile,* and enteropathogenic *Escherichia coli* infections, as well as ulcerative colitis and pseudo-membranous colitis-related diarrhea. White cells are absent or normal in cholera and in *Giardia* and viral (rotavirus, Norwalk virus, etc) infections.

Tzanck Smear

This technique (named after Arnault Tzanck) is used in the diagnosis of herpesvirus infections (ie, herpes zoster or simplex).

Procedure

1. Clean a vesicle (not a pustule or crusted lesion) with alcohol, allow it to air dry, and gently unroof it with a #15 scalpel blade. Scrape the base with the blade, and place the material on a glass slide.
2. Allow the sample to air dry, and stain with Wright's stain as used for peripheral blood. Giemsa stain can also be used, however, the sample must be fixed for 10 min with methyl alcohol before the Giemsa is applied.
3. Scan the slide under low power, and identify cellular areas. Then use high-power oil immersion to identify multinucleated giant cells (epithelial cells infected with herpes viruses). This strongly suggests viral infection; culture is necessary to identify the specific virus.

Vaginal Wet Preparation

• See Chapter 13, page 291

Wayson Stain

Wayson stain is a good quick scout stain that colors most bacteria.

Procedure

1. Spread the smear on a slide, and air or heat dry it.
2. Pour freshly filtered Wayson stain onto the slide, and allow it to stand for 10–20 s (timing is not critical).
3. Rinse the slide gently with tap water, and dry it with filter paper.
4. Use the high dry and oil immersion lenses to examine the slide.

GONORRHEA (GC) CULTURES AND SMEAR

Neisseria gonorrhea can be cultured from many different sites, including female genital tract (endocervix is the preferred site), male urethra, urine, anorectum, throat, and synovial fluid, and the specimen is plated on selective (**Thayer–Martin** or **Transgrow**) media. Due to the high incidence of coinfection with *Chlamydia* and *T. pallidum* (syphilis), *Chlamydia* cultures and syphilis serology should also be performed, especially in females with genital infections with GC. Anorectal stains may contain nonpathogenic *Neisseria* species; avoid fecal contact; apply swab to anal crypts. In males with a urethral discharge, insert a **calcium alginate swab (Calgiswab)** into the urethra to collect the specimen and then plate.

The GC smear (see Chapter 13, page 291) has a low sensitivity (<50% in female endocervical smear, but is fairly reliable (>95%) in males with urethral discharge. A rapid enzyme immunoassay (**gonococcal antigen assay [Gonozyme]**) is available to diagnose cervical or urethral GC (not throat or anus) infections in less than 1 h. DNA probe testing is becoming widespread for rapid diagnosis.

NASOPHARYNGEAL CULTURES

Ideally, the specimen for culture should be obtained from deep in the nasopharynx and not the anterior nares, and the swab should not touch the skin. Cultures of nasopharyngeal specimens are useful in identifying *Staphylococcus aureus* and *N. meningitidis* infections. Normal nasal flora include *Staphylococcus epidermidis* and *S. aureus, Streptococcus pneumoniae, Haemophilus influenzae,* and several others.

BLOOD CULTURES

Blood cultures are not usually indicated for the routine workup of fever. The best use is for

1. Fever of unknown origin, especially in adults with white blood counts of > 15,000/mm^3 and no localizing signs or symptoms to suggest the source.
2. Clinical situations in which the diagnosis is established by a positive blood culture (eg, acute and SBE).
3. Febrile elderly, neutropenic, or immunocompromised patients.

Chills and fever usually ensue from ½–2 h after sudden entry of bacteria into the circulation (bacteremia). If bacteremia is suspected, several sets of cultures are usually needed to improve the chances of culturing the offending organism. Ideally, more than one set of cultures should be done at least 1 h apart; drawing more than three sets of specimens a day does not usually increase the yield. Obtain the blood through venipuncture, and avoid sampling through venous lines. Each "set" of specimens for blood culture consists of both an aerobic and anaerobic culture bottle. If possible, culture the specimens before antibiotics are initiated; if the patient is already on antibiotics, use **ARD** culture bottles, which absorb the antibiotic that may otherwise destroy any bacteria. *Legionella, Mycobacterium, Bordetella,* and *Histoplasma* may require special blood collection devices.

Procedure

1. Review the section on the technique of venipuncture (Chapter 13 page 309). Apply a tourniquet above the chosen vein.

2. Paint the venipuncture site with a povidone–iodine solution. Repeat this procedure three times with a different pad. Then wipe the area around the vein with alcohol and allow the alcohol to dry.

3. Use an 18–22-gauge needle (or smaller if needed) and a 10–20-mL syringe. Enter the skin over the prepped vein, and aspirate a sufficient volume of blood (10–20 mL in adults,

1–5 mL in children); adequate volume will increase the detection rate. **Be careful not to touch the needle or the prepped skin site.** Draw about 10 mL of blood. Remove the tourniquet, and compress the venipuncture site and apply an adhesive bandage.

4. Discard the needle used in the puncture and replace it with a **new, sterile** 20–22-gauge needle. Place the blood in each of the bottles by allowing the vacuum to draw in the appropriate volume, usually specified on the collection device. Submit the samples to the lab promptly with the appropriate lab slips completed including current antibiotics being given.

Interpretation

Preliminary results are usually available in 12–48 h; cultures should not be formally reported as negative before 4 d. A single blood culture that is positive for one of the following organisms usually suggests contamination; however, on rare occasions these agents are the causative pathogen: *Staphylococcus epidermidis, Bacillus* sp., *Corynebacterium diphtheriae* (and other diphtheroids), *Streptococcus viridans.* Negative results do not rule out bacteremia, and false-positives can result for the contaminants noted. Gram-negative organisms, fungi, and anaerobes are considered to be pathogenic until proven otherwise.

SPUTUM CULTURES

Cultures of sputum remain controversial. Many clinicians do not even order them and treat only based on the Gram stain and clinical findings. One problem is that "sputum" samples often contain only saliva. If you do a Gram stain on the specimen and see only a few squamous cells, with many polys and histiocytes, the sample is good, and the culture will probably be reliable. Excessive numbers of squamous cells (see previous section on Gram stain) suggests that the sample is more saliva than sputum. An early morning sample is most likely to be from deep within the bronchial tree.

Steps to improve the quality of the sputum collection

1. Careful instructions to the patient.
2. If the patient cannot mobilize the secretions, P&PD along with nebulizer treatments may help.
3 Careful nasotracheal suctioning using a specimen trap.

In general most labs will not accept anaerobic sputum cultures (critical in the diagnosis of aspiration pneumonia and lung abscesses) unless obtained by **transtracheal aspirate** or **endobronchial endoscopic collection** and submitted in special anaerobic transport media. Viral, *Legionella, Mycoplasma,* and TB cultures require special culture materials available at most labs. **PCP** can be diagnosed by sputum culture only about 10% of the time; therefore open-lung biopsy, endobronchial lavage, or other invasive techniques must be used to demonstrate the organisms. Specialized staining techniques for identifying ***Pneumocystis carinii*** include the methenamine silver, Giemsa, and toluidine blue stains.

STOOL CULTURES

Stool cultures are most often done to diagnose the cause of diarrhea or to identify disease carriers. A fresh sample is essential to isolate the organisms. Most common pathogens (*Salmonella, Shigella,* enteropathogenic *E. coli,* etc) can be grown on standard media. *Yersinia* and *Campylobacter,* however, usually require a special culture medium, and a special lab request is usually necessary.

A quick bedside test for bacterial causes of diarrhea is to check the stool for white cells (fecal leukocyte smear) see page 128.

Clostridium difficile Assay

Clostridium difficile is usually best diagnosed by determining the presence of ***C. difficile*** enterotoxin on the stool and not by culture. A positive *C. difficile* assay is found in the following cases: >90% of pseudo-membranous colitis; 30–40% antibiotic associated colitis, and 6–10% cases of antibiotic-associated diarrhea.

Stool for Ova and Parasites

With toxic diarrhea, the possibility of parasitic disease must be considered and stool for **"ova and parasites"** should be ordered. Protozoa (ameba [*Entamoeba histolytica,* others], *Blastocystis, Giardia*) cannot be cultured and are identified by seeing mature, mobile organisms or cysts on microscopic examination of freshly passed feces. Immunosuppressed (eg,. HIV-positive) individuals may demonstrate *Cryptosporidium, Microsporidia,* and *Strongyloides.* The ova are most frequently identified in the stool of parasites such as nematodes (*Ascaris, Strongyloides*), cestodes (*Taenia, Hymenolepsis*), and trematodes (*Schistosoma*).

THROAT CULTURES

Used to differentiate viral from bacterial (usually group A beta-hemolytic streptococci, eg, *Streptococcus pyogenes*) pharyngitis.

Procedure

1. The best culture is obtained with the help of a tongue blade and a good light source.
2. **If epiglottitis (croup) is suspected (stridor, drooling), a culture should not be attempted.**
3. The goal is to use the culture swab and try not to touch the oral mucosa or tongue, but only the involved area. In the uncooperative patient, an arch-like swath touching both the tonsillar areas and posterior pharynx should be attempted.

Many labs perform a specific **"strep screen"** to rapidly identify group A beta-hemolytic streptococci. Normal flora on routine culture can include alpha-hemolytic strep, nonhemolytic staph, saprophytic *Neisseria* species, *Haemophilus, Klebsiella, Candida,* and diphtheroids.

Other pathogens can cause pharyngitis. If ***Neisseria gonorrhoeae*** is suspected, use the Thayer–Martin medium. Diphtheria (***C. diphtheriae***) with its characteristic pseudo-membrane, should be cultured on special media and the lab notified.

URINE CULTURES

As is true for sputum cultures, culturing for urinary tract pathogens is often controversial. Some clinicians base their decision to treat only when the culture is positive, whereas others rely on the presence of white blood cells or bacteria in the urinalysis, using cultures only for sensitivities in refractory infections. The introduction of urine dipsticks to detect leukocytes (by the detection of leukocyte esterase) aids in the decision making when cultures are not obtained or are confusing. Routine cultures fail to diagnose other urinary tract pathogens such as *N. gonorrhea* or *Chlamydia.*

A clean-catch urine (see Chapter 13, page 306) is about 85% accurate in women and uncircumcised males. In general, a positive culture is a colony count of >100,000 bacteria/mL of urine or a count from 10,000–100,000 bacteria/mL of urine in the presence of pyuria. If the culture is critical for diagnosis, obtain an in-and-out catheterized urine (page

308) or suprapubic aspiration in children (page 309). Any growth of bacteria on an in-and-out catheterized or suprapubic specimen is considered to represent a true infection.

If a urine specimen cannot be taken to the lab within 60 min, refrigerate it. The lab assumes that more than three organisms growing on a culture represents a contaminant and the specimen collection should be repeated. The exception occurs in patients with a chronic indwelling Foley catheter that may be colonized with multiple bacterial or fungal organisms; the lab should be told to "culture all organisms" in such cases.

VIRAL CULTURES AND SEROLOGY

The laboratory provides the proper collection container for the specific virus. Common pathogenic viruses cultured include **herpes simplex** (from genital vesicles, throat), **CMV** (from urine or throat), **varicella-zoster** (from skin vesicles in children with chickenpox and adults with shingles), and enterovirus (rectal swab, throat).

For serologic testing, obtain an **acute specimen (titer)** as early as possible in the course of the illness, and take a **convalescent specimen (titer)** 2–4 wk later. A fourfold or greater rise in the convalescent titer compared with the acute titer indicates an active infection (see Chapter 4 for selected viral antibody titers). With the development of PCR techniques, biopsies performed on older lesions may yield useful information when cultures might be negative.

SCOTCH TAPE TEST

Also known as a "pinworm preparation," this method is used to identify infestation with *Enterobius vermicularis.* A 3-in. piece of CLEAR Scotch tape is attached around a glass slide (sticky side out). The slide is applied to the perianal skin in four quadrants and examined under the microscope for pinworm eggs. The best sample is collected either in the early morning prior to bathing or several hours after retiring.

MOLECULAR MICROBIOLOGY

Molecular techniques can now identify many bacterial and viral organisms without culturing. Many tests rely on DNA probes to identify the pathogens. The following includes some microbes commonly identified from clinical specimens (ie, swab, serum, tissue). Availability varies with each clinical facility.

Common Microorganisms Identifiable by PCR/DNA Probe

- *Chlamydia trachomatis*
- *Borrelia burgdorferi* (Lyme disease)
- HIV
- *Mycoplasma pneumoniae*
- *Mycobacterium tuberculosis*
- *Neisseria gonorrhoeae*
- Hepatitis B
- HPV
- Many others under development

SUSCEPTIBILITY TESTING

To more effectively treat a specific infection by choosing the right antibiotic, many labs routinely provide the MIC or MBC. For more complex infections (endocarditis), Schlichter testing is sometimes used.

MIC (Minimum Inhibitory Concentration)

This is the lowest concentration of antibiotic that prevents an in vitro growth of bacteria. The organism is tested against a battery of antimicrobials in concentrations normally achieved in vivo and reported as

Susceptible (S): The organism is inhibited by the agent in the usual dose and route, and the drug should be effective.

Intermediate (I): Sometimes also reported as "indeterminate," this implies that high doses of the drug, such as those achieved with parenteral therapy (IM, IV), most likely inhibit the organism.

Resistant (R): The organism is resistant to the usual levels achieved by the drug.

MBC (Minimum Bactericidal Concentration)

Similar to the MIC, but indicates the lowest antibiotic concentration that will kill 99.9% of the organisms. The MBC results in killing the organisms, and the MIC prevents growth but may not kill the organism.

Schlichter Test (Serum Bacteriocidal Level)

Used to determine the antibacterial level of the serum or CSF of patients who are receiving antibiotic therapy. The test uses eight serial dilutions of the patient's serum (1:1 through 1:128) to determine what dilution is bactericidal to the infecting organism. The test is usually coordinated by the departments of infectious disease and microbiology. One set of blood or CSF cultures must be negative for the infecting organism before the test is performed. Opinion varies greatly as to interpretation of the results. Optimal killing of the organism occurs at dilutions of blood (and CSF) ranging anywhere from a trough of 1:4 to a peak of 1:8. That is, a result such as "*S. aureus* bactericidal level = 1:8" means the infecting organism was killed at a serum dilution of 1:8. Some data suggest higher titers (1:32) are needed to treat bacterial endocarditis. For the test to be performed, the organisms responsible for the infection must be isolated from a patient specimen.

DIFFERENTIAL DIAGNOSIS OF COMMON INFECTIONS AND EMPIRIC THERAPY

The pathogens causing common infectious diseases are outlined in Table 7–2 along with some empiric therapeutic recommendations. The antimicrobial drug of choice for the treatment of infection is usually the most active drug against the pathogenic organism or the least toxic alternative among several effective agents. The choice of drugs is modified by the site of infection, clinical status (allergy, renal disease, pregnancy, etc), and susceptibility testing.

Tables 7–3 through 7–7 provide empiric treatment guidelines for some common infectious diseases, including bacterial, fungal, viral, HIV, parasitic, and tick-borne diseases.

TABLE 7–2
Organisms Responsible for Common Infectious Diseases with Recommended Empiric Therapy*

Site/Condition	Common Uncommon but Important	Common Empiric Therapy (Modify based on clinic factors such as Gram stain)
BONES AND JOINTS		
Osteomyelitis	*Staphylococcus aureus* Enterobacteriaceae If nail puncture: *Pseudomonas* spp.	Oxacillin, nafcillin
Joint, septic arthritis	*S. aureus* Group A strep Enterobacteriaceae Gonococci	Oxacillin; ceftriaxone if gonococci
Joint, prosthetic	*S. aureus, S. epididymis, Streptococcus* spp.	Vancomycin plus ciprofloxacin
BREAST		
Mastitis, postpartum	*S. aureus*	Cefazolin, nafcillin, oxacillin
BRONCHITIS	In adolescent/young patient: *Mycoplasma pneumoniae* Respiratory viruses In chronic adult infection: *Streptococcus pneumoniae* *Haemophilus influenzae* *M. catarrhalis* *Chlamydia pneumoniae*	Treatment controversial because most infections are viral; treat if febrile, or associated with sinusitis, positive sputum culture in patients with COPD or if duration >7 days; doxycycline, erythromycin, azithromycin, clarithromycin

(*continued*)

TABLE 7–2
(Continued)

Site/Condition	Common Uncommon but Important	Common Empiric Therapy (Modify based on clinic factors such as Gram stain)
CERVICITIS (nongonococcal)	*Chlamydia, M. hominis, Ureaplasma,* others	Azithromycin single dose, doxycycline (evaluate and treat partner)
CHANCHROID	*Haemophilus ducreyi*	Ceftriaxone or azithromycin as single dose
CHLAMYDIA		
Urethritis, cervicitis, conjunctivitis, proctitis	*Chlamydia trachomatis*	Azithromycin, doxycycline (amoxicillin if pregnant)
Neonatal ophthalmia, pneumonia		Erythromycin
Lymphogranuloma venereum	*C. trachomatis* (specific serotypes, L1, L2, L3)	Doxycycline
DIVERTICULITIS (no perforation or peritonitis)	Enterobacteriaceae, enterococci, bacteroids	TMP–SMX, ciprofloxacin plus metronidazole
EAR		
Acute mastoiditis	*S. pneumoniae* Group A strep *S. aureus*	Amoxicillin, ampicillin/clavulanic acid, cefuroxime
Chronic mastoiditis	Polymicrobial: Anaerobes Enterobacteriaceae *Rarely: M. tuberculosis*	Ticarcillin/clavulanic acid, imipenem
Otitis externa (swimmer's ear)	*Pseudomonas* spp. Enterobacteriaceae	Topical agents such as Cortisporin otic, TobraDex

(*continued*)

TABLE 7–2 (Continued)

Site/Condition	Common Uncommon but Important	Common Empiric Therapy (Modify based on clinic factors such as Gram stain)
EAR		
Otitis externa (continued)	In diabetic or malignant otitis: *Pseudomonas* spp.	Malignant otitis externa: acutely aminoglycoside, plus ceftazidime, imipenem or piperacillin
Otitis media	*S. pneumoniae, H. influenzae, M. catarrhalis,* viral causes *S. aureus,* group A strep In nasal intubation: Enterobacteriaceae, *Pseudomonas* spp.	Amoxicillin, ampicillin/clavulanic acid, cefuroxime
EMPYEMA *ENDOCARDITIS*	*S. pneumoniae, S. aureus*	Cefotaxime, ceftriaxone
Native valve	*S. viridans* *S. pneumoniae* Enterococci *S. bovis*	Parenteral: penicillin or ampicillin plus oxacillin or nafcillin plus gentamicin; vancomycin plus gentamicin
IV drug user	*S. aureus* *Pseudomonas* spp.	Nafcillin plus gentamicin
Prosthetic valve	If early (<6 mo after implant) *S. epidermidis* *S. aureus* Enterobacteriaceae	Vancomycin plus rifampin plus gentamicin

(*continued*)

TABLE 7–2
(Continued)

Site/Condition	Common Uncommon but Important	Common Empiric Therapy (Modify based on clinic factors such as Gram stain)
Prosthetic valve (continued)	If late (>6 mo after implant) *S. viridans* Enterococci *S. epidermidis* *S. aureus*	
EPIGLOTTITIS	*H. influenzae* *S. pneumoniae* *S. aureus* Group A strep	Chloramphenicol plus ceftriaxone, cefotaxime or ampicillin
GALL BLADDER		
Cholecystitis	Acute: *E. Coli, Klebsiella, Enterococcus* Chronic obstruction: anaerobes, coliforms, *Clostridium*	Ampicillin plus gentamicin w/wo metronidazole, imipenem
Cholangitis	*E. coli, Klebsiella, Enterococcus*	
GASTROENTERITIS		
Afebrile, no gross blood or no WBC in stool	Virus, mild bacterial infection	Supportive care only
Febrile, gross blood, and WBC in stool	Enteropathogenic *E. coli* *Shigella* *Salmonella*	Empiric treatment pending cultures: ciprofloxacin, norfloxacin

(*continued*)

TABLE 7–2 (Continued)

Site/Condition	Common Uncommon but Important	Common Empiric Therapy (Modify based on clinic factor such as Gram stain)
Febrile gastroenteritis (continued)	*Campylobacter* *Vibrio* *C. difficile* *L. monocytogenes*	
GRANULOMA INGUINALE	*Calymmatobacterium granulomatis*	Doxycycline, trimethoprim/sulfamethoxazole
GONORRHEA (urethra, cervix, rectal, pharyngeal)	*N. gonorrhea*	Cefixime, ciprofloxacin, ofloxacin, ceftriaxone all as single dose; (treat also for *Chlamydia*)
MENINGITIS (Empiric therapy before cultures)		
Neonate	Group B strep, *E. coli, Listeria monocytogenes*	Ampicillin plus cefotaxime
Infant 1–3 mo	*S. pneumoniae* *N. meningitidis*	
Child/adult, community acquired	*S. pneumoniae* *N. meningitidis, H. influenzae*	Vancomycin plus ceftriaxone
Postoperative or traumatic	*S. epidermitis, S. aureus, S. pneumoniae, Pseudomonas*	Vancomycin plus ceftazidime
Immunosuppressed (ie steroids)	Gram-negative bacilli, *L. monocytogenes*	Ampicillin plus ceftazidime
History of alcohol abuse	*S. pneumoniae* *N. meningitidis,* gram-negative bacilli	Ampicillin plus ceftriaxone or cefotaxime

(*continued*)

TABLE 7–2
(Continued)

Site/Condition	Common Uncommon but Important	Common Empiric Therapy (Modify based on clinic factors such as Gram stain)
Meningitis (continued)	*Pseudomonas* spp. *H. influenzae*	
HIV infection	*Cryptococcus*	Amphotericin B (acutely), fluconazole
NOCARDIOSIS	*Nocardia asteroides*	Sulfisoxazole, TMP–SMX
PELVIC INFLAMMATORY DISEASE	Gonococci Enterobacteriaceae *Bacteroides* spp. *Chlamydia* Enterococci *M. hominis*	Ofloxacin and metronidazole or ceftriaxone (single dose) plus doxycycline; parenteral cefotetan or cefoxitin plus doxycycline
PERITONITIS		
Primary (spontaneous)	*S. pneumoniae* Enterobacteriaceae	Cefotaxime or ceftriaxone
Secondary to (bowel perforation, etc)	Enterobacteriaceae, *Bacteroides* spp. Enterococci *Pseudomonas* spp.	Suspect small bowel: piperacillin, mezlocillin, meropenem, cefoxitin Suspect large bowel: clindamycin plus aminoglycoside
Peritoneal dialysis-related	*S. epidermidis* *S. aureus* Enterobacteriaceae *Candida*	Based on culture

(*continued*)

TABLE 7–2 (Continued)

Site/Condition	Common Uncommon but Important	Common Empiric Therapy (Modify based on clinic factors such as Gram stain)
PHARYNGITIS	Respiratory virus Group A strep Gonococci *C. diphtheria* Epstein–Barr virus (infectious mono); spirochetes, anaerobes	Exudative (group A strep): benzathine penicilllin G, erythromycin, loracarbef, azithromycin
PNEUMONIA		
Neonate	Viral (CMV, herpes), bacterial (group B strep, *L. monocytogenes*, coliforms, *S. aureus, Chlamydia*)	Ampicillin or nafcillin plus gentamicin
Infant (1–24 mo)	Most viral such as RSV; *S. pneumonia, Chlamydia, Mycoplasma*	Cefuroxime; if critically ill, cefotaxime, ceftriaxone plus cloxacillin
Child (3 mo– 5 y)	As above	Erythromycin, clarithromycin; if critically ill, cefuroxime plus erythromycin
Child (5–18 y)	*Mycoplasma,* respiratory viruses, *S. pneumoniae, C. pneumoniae*	Clarithromycin, azithromycin; erythromycin
Adult community-acquired	*M. pneumoniae, C. pneumoniae, S. pneumoniae* Smokers: As above plus *M. catarrhalis, H. influenzae*	Clarithromycin, azithromycin If hospitalized, third-generation cephalosporin plus erythromycin or azithromycin

(*continued*)

TABLE 7–2
(Continued)

Site/Condition	Common Uncommon but Important	Common Empiric Therapy (Modify based on clinic factors such as Gram stain)
Adult, community-acquired aspiration	*S. pneumoniae* oral flora, including anaerobes (eg, *Fusobacterium, Bacteroides* sp.) Enterobacteriaceae	Clindamycin
Adult hospital-acquired or ventilator-associated	*S. pneumonia,* coliforms, *Pseudomonas, Legionella*	Imipenem, meropenem
HIV-associated	*Pneumocystis* Others as above TB, fungi	Pneumocystis: TMP–SMX; may require steroids
SINUSITIS	*S. pneumoniae* *H. influenzae* *M. catarrhalis* Anaerobes In nosocomial, nasal intubations, etc: *S. aureus* *Pseudomonas* spp. Enterobacteriaceae	Acute: TMP-SMX ampicillin, amoxicillin/clavulanic acid, ciprofloxacin, clarithromycin
SKIN/SOFT TISSUE		
Acne	*Propionibacterium acne*	Tetracycline, minocycline, topical clindamycin
Acne rosacea	Possible skin mite	Topical: metronidazole, doxycycline
Burns	*S. aureus,* Enterobacteriaceae,	Topical: silver sulfadiazine

(*continued*)

TABLE 7–2 (Continued)

Site/Condition	Common Uncommon but Important	Common Empiric Therapy (Modify based on clinic factors such as Gram stain)
Burns (continued)	*Pseudomonas, Proteus* Herpes simplex virus, *Providencia, Serratia, Candida*	Sepsis: Aztreonam or tobramycin plus cefoperazone, ceftazidime or piperacillin
Bite (human and animal)	Anaerobes *P. multiloculada*	Ampicillin/sulbactam IV or amoxicillin/clavulanic acid PO
Cellulitis	*Streptococcus* spp. (group, A. B. C, G) *S. aureus* Anaerobic	Diabetic: nafcillin, oxacillin with or without penicillin; if anaerobic, high-dose penicillin G, cefoxitin, cefotetan
Decubitus	Group A strep (*S. pyogenes*) Anaerobes, *S. aureus,* Enterobacteria Polymicrobial anaerobic	If acutely ill: imipenem, meropenem, ticarcillin/clavulanic acid
Erysipelas	Group A strep *(S. pyogenes*)	Nafcillin, oxacillin, dicloxacillin, cefazolin
Impetigo	Group A strep *S. arueus*	Penicillin, erythromycin; oxacillin or nafcillin if S. aureus
Tinea capitis (scalp) "ringworm"	Fungus: *Trichophyton* spp., *Microsporum* spp.	Terbinafine, itraconazole, fluconazole,
Tinea corporis (body)	Fungus: *Trichophyton* spp., *Epidermophyton*	Topical: ciclopirox, clotrimazole, econazole, ketoconazole, miconazole, terconazole, others
Tinea unguium	Various fungi	Itraconazole, fluconazole, terbinafine

(*continued*)

TABLE 7–2
(Continued)

Site/Condition	Common Uncommon but Important	Common Empiric Therapy (Modify based on clinic factors such as Gram stain)
SYPHILIS (less than 1 y duration)	*Treponema pallidum*	Benzathine penicillin G one dose; doxycycline, tetracycline, ceftriaxone
TUBERCULOSIS	*Mycobacterium tuberculosis*	
Pulmonary, HIV (–)		INH, rifampin ethambutol plus pyrazinamide at least 6 mo (+/– pyridoxine)
TB exposure, PPD (–)		Children <5 INH X3 mo (+/– pyridoxine), others observe
Prophylaxis in high-risk patients (diabetics, IV drug users, immuno-suppressed, etc)		INH 6–12 mo (+/– pyridoxine)
PPD + conversion		INH 6–12 mo (+/– pyridoxine)
URINARY TRACT INFECTIONS		
Cystitis	Enterobacteriaceae (*E. coli* most common) *S. saprophyticus* (young female) *Candida*	Quinolone, TMP–SMX Candida: fluconazole or amphotericin B bladder irrigation
Urethritis	Gonococci, *C. trachomatis,* Trichomonas	Ceftriaxone, cefixime, ciprofloxacin, ofloxacin (all one dose) plus

(*continued*)

TABLE 7–2 (Continued)

Site/Condition	Common Uncommon but Important	Common Empiric Therapy (Modify based on clinic factors such as Gram stain)
Urethritis (continued)	Herpesvirus *Ureaplasma urealyticum*	azithromycin (single dose) or doxycycline (treat partner)
Prostatitis, acute <35 y	*C. trachomatis* Gonococci Coliforms Cryptococcus (AIDS)	Ofloxacin
Prostatitis, acute >35 y	Coliforms	Quinolone, TMP–SMX; if acutely ill gentamicin/ampicillin IV
Prostatitis, chronic bacterial	Coliforms, enterococci, *Pseudomonas*	Long-term ciprofloxacin or ofloxacin
Pyelonephritis	Enterobacteriaceae (*E. coli*) Enterococci *Pseudomonas* spp.	If acutely ill, gentamicin/ampicillin IV; quinolone, TMP–SMX
ULCER DISEASE (duodenal or gastric, not NSAID related)	*Helicobacter pylori*	Omeprazole plus amoxicillin plus clarithromycin
VAGINA Candidiasis	*C. albicans* *C. glabrata, C. tropicalis*	Fluconazole, itraconazole

(*continued*)

TABLE 7–2
(Continued)

Site/Condition	Common Uncommon but Important	Common Empiric Therapy (Modify based on clinic factors such as Gram stain)
Trichomonas	*Trichomonas vaginalis*	Metronidazole (treat partner)
Vaginosis, bacterial	Polymicrobial (*Gardnerella vaginalis, Bacteroides, M. hominis*	Metronidazole (PO or vaginal gel); clindamycin, PO or intravaginally

*All antimichrobial therapy should be based on complete clinical data, including results of Gram's stains and cultures. See also Tables 7–3 (Viral), 7–4 (HIV), 7–5 (Fungal), and 7–6 (Parasitic) 7–7 (Tick-Borne).
Note: These guidelines are based on agents commonly involved in adult infections. Actual microbial treatment should be guided by microbiologic studies interpreted in the clinical setting.
Abbreviations: AIDS = acquired immunodeficiency syndrome; COPD = chronic obstructive pulmonary disease; HIV = human immunodeficiency virus; INH = isoniazid; IV = intravenous; NSAID = nonsteroidal antiinflammatory drug; PO = by mouth; PPD = purified protein derivative; TB = tuberculosis; TMP–SMX = trimethoprim–sulfamethoxazole.

TABLE 7–3
Pathogens and Drugs of Choice for Treating Common Viral Infections*

Viral Infection	Drug of Choice	Adult Dosage
CMV		
Retinitis, colitis, esophagitis	Ganciclovir (*Cytovene*)†	5 mg/kg IV q12h × 14–21d, 5 mg/kg/d IV or 6 mg/kg IV 5×/wk or 1 g PO tid
	(*Vitrasert*) implants	4.5 mg intraocularly q 5–8 mo
	or Foscarnet (*Foscavir*)	60 mg/kg IV q8h or 90 mg/kg IV q1–2 h x 14–21 d followed by 90–120 mg/kg/d IV
	or Cidofovir (*Vistide*)	5 mg/kg/wk IV × 2 wk, then 5 mg/kg IV q2 wk
	or Fomivirsen (*Vitravene*)	330 μg intravitreally q2 wk × 2 then 1/mo
EBV		
Infectious mononucleosis	None	
HAV	None, but gamma globulin within 2 wk of exposure may limit infection	0.2 mL/kg IM × 1
HBV		
Chronic hepatitis	Lamivudine (*Epivir HBV*)	100 mg PO 1×/d × 1–3 y
	Interferon alfa-2b (*Intron A*)	5 million units/d or 10 million units 3×/wk SC or IM × 4 mo
HCV		
Chronic hepatitis	Interferon alfa-2b plus Ribavirin (*Rebetron*)	3 million units 3×/wk SC plus ribavirin 1000–1200 mg/d PO × 12 mo
	Interferon alfa-2b (*Intron A*)	3 million units SC or IM 3x/wk × 12–24 mo
	Interferon alfa-2a (*Roferon-A*)	3 million units SC or IM 3x/wk × 12–24 mo

(*continued*)

TABLE 7–3
(Continued)

Viral Infection	Drug of Choice	Adult Dosage
Chronic hepatitis (continued)	Interferon alfacon-1 (*Infergen*)	9 μg 3×/wk × 6 mo
HSV		
Orolabial herpes in the immunocompetent with multiple recurrences	Penciclovir (*Denavir*)	1% cream applied q2h while awake × 4 d
Genital herpes		
first episode	Acyclovir (*Zovirax*)	400 mg PO tid or 200 mg PO 5×/d × 7–10 d
	or Famciclovir (*Famvir*)	250 mg PO tid × 5–10 d
	or Valacyclovir (*Valtrex*)	1 g PO bid × 7–10 d
recurrence	Acyclovir (*Zovirax*)	400 mg PO tid × 5 d
	or Famciclovir (*Famvir*)	125 mg PO bid × 5 d 17
	or Valacyclovir (*Valtrex*)	500 mg PO bid × 5 d
chronic suppression	Acyclovir (*Zovirax*)	400 mg PO bid
	or Valacyclovir (*Valtrex*)	500–1000 mg PO 1×/d
	or Famciclovir (*Famvir*)	250 mg PO bid
Mucocutaneous in the immunocompromised	Acyclovir (*Zovirax*)	5 mg/kg IV q8h × 7–14 d
	or Acyclovir (*Zovirax*)	400 mg PO 5x/d × 7–14 d
Encephalitis	Acyclovir (*Zovirax*)	10–15 mg/kg IV q8h × 14–21 d
Neonatal	Acyclovir (*Zovirax*)	20 mg/kg IV q8h × 14–21 d
Acyclovir-resistant	Foscarnet (*Foscavir*)	40 mg/kg IV q8h × 14–21 d
Keratoconjunctivitis	Trifluridine (*Viroptic*)	1 drop 1% solution topically, q2h, up to 9 gtt/d × 10 d
HIV (See Table 7–4)		
INFLUENZA A AND B VIRUS	Zanamivir (*Relenza*)	10 mg bid × 5d by inhaler
	Oseltamivir (*Tamiflu*)	75 mg PO bid × 5 d

(*continued*)

TABLE 7–3
(Continued)

Viral Infection	Drug of Choice	Adult Dosage
INFLUENZA A VIRUS	Rimantadine (*Flumadine*) Amantadine (*Symmetrel*)	200 mg PO 1×/d or 100 mg PO bid × 5 d 100 mg PO bid × 5 d
MEASLES		
Children	None (immunize, See Table 22–9)	
Adults	None or ribavirin	20–35 mg/kg/d × 7 d
PAPILLOMA VIRUS (HPV)		
Anogenital warts	Podofilox or podophyllin Interferon alfa-2b *(Intron A)* Imiquimod, 5% cream (*Aldara*)	Topical application (see Chapter 22) 1 million units intralesional 3×/wk × 3 wk Apply 3/wk hs, remove 6–10 h later up to 16 wk
RSV		
(bronchiolitis)	Ribavirin (*Virazole*)	Aerosol treatment 12–18 h/d × 3–7 d
VZV		
Exposure prophylaxis in the immunocompromised (HIV, steroids, etc)	VZIG, Varicella Zoster Immune Globulin	See package insert
Varicella (>12 y old)	Acyclovir (*Zovirax*)	20 mg/kg (800 mg max) PO qid × 5 d
Herpes zoster	Valacyclovir (*Valtrex*) or Famciclovir (*Famvir*) or Acyclovir (*Zovirax*)	1 g PO tid × 7 d 500 mg PO tid × 7 d 800 mg PO 5x/d × 7–10 d

(*continued*)

TABLE 7–3
(Continued)

Viral Infection	Drug of Choice	Adult Dosage
Varicella or zoster in the immunocompromised	Acyclovir (*Zovirax*)	10 mg/kg IV q8h × 7 d
Acyclovir-resistant	Foscarnet (*Foscavir*)	40 mg/kg IV q8h × 10 d

*Based on Guidelines from the CDC published in MMWR and the *Medical Letter* Vol. 41 December 3, 1999.
†The generic drug name appears in regular type; the trade name appears in parentheses afterward in *italics*.
Abbreviations: CMV = cytomegalovirus; EBV = Epstein–Barr virus; HAV = hepatitis A virus; HBV = hepatitis B virus; HCV = hepatitis C virus; HIV = human immunodeficiency virus; HPV = human papilloma virus; HSV = herpes simplex virus; RSV = respiratory syncytial virus; VZV = varicella zoster virus.

TABLE 7–4
Drugs of Choice for Treating HIV Infection in Adults

DRUGS OF CHOICE

2 nucleosides[1] + 1 protease inhibitor[2]
2 nucleosides[1] + 1 nonnucleoside[3]
2 nucleosides[1] + ritonavir[4] + another protease inhibitor[5]

ALTERNATIVES

1 protease inhibitor[2] + 1 nucleoside + 1 nonnucleoside[3]
2 protease inhibitors (each in low dose)[5] + 1 nucleoside + 1 nonnucleoside[3]
abacavir + 2 other nucleosides[1]
2 protease inhibitors (each full dose)

1. One of the following: zidovudine + lamivudine; zidovudine + didanosine; stavudine + lamivudine; stavudine + didanosine; zidovudine + zalcitabine.
2. Nelfinavir, indinavir, saquinavir soft gel capsules, amprenavir or ritonavir. Ritonavir is used less frequently because of troublesome adverse effects. The Invirase formulation of saquinavir generally should not be used.
3. Efavirenz is often preferred. Nevirapine causes more adverse effects. Nevirapine and delavirdine require more doses, and have had shorter follow-up in reported studies. Combinations of Efavirenz and nevirapine with protease inhibitors require increasing the dosage of the protease inhibitor.
4. Ritonavir is usually given in dosage of 100–400 mg bid when used with another protease inhibitor.
5. Protease inhibitors that have been combined with ritonavir 100–400 mg bid include indinavir 400–800 mg bid, amprenavir 600–800 mg bid, saquinavir 400–600 mg bid and nelfinavir 500–750 mg bid.

Source: Reproduced, with permission, from *The Medical Letter* Vol 42, Issue 1089, January 10, 2000.

TABLE 7–5
Systemic Drugs for Treating Fungal Infections

Infection	Drug of Choice	Alternatives
ASPERGILLOSIS	Amphotericin B or itraconazole	Amphotericin B lipid complex, amphotericin cholesteryl complex liposomal amphotericin B
BLASTOMYCOSIS	Itraconazole or amphotericin B	Fluconazole
CANDIDIASIS		
Oral (thrush)	Fluconazole or itraconazole	Nystatin lozenge or swish and swallow
Stomatitis, eosphagitis, vaginitis in AIDS	Fluconazole or itraconazole	Parenteral or oral amphotericin B
Systemic	Amphotericin B or fluconazole	
Cystitis/vaginitis	See Table 7–2	
COCCIDIOIDOMYCOSIS		
Pulmonary (normal individual)	No drug usually recommended	
Pulmonary (high risk)	Itraconazole or fluconazole	Amphotericin B
CRYPTOCOCCOSIS		
In non-AIDS patient	Amphotericin B or fluconazole	Amphotericin B fluconazole
Meningitis (HIV/AIDS)	Amphotericin B plus 5-flucytosine; then long-term suppression with fluconazole	Amphotericin B lipid complex
HISTOPLASMOSIS		
Pulmonary, disseminated		
Normal individual	Moderate disease: itraconazole	Severe: amphotericin B
HIV/AIDS	Amphotericin B, followed by itraconazole suppression	Itraconazole

(*continued*)

TABLE 7–5 (Continued)

Infection	Drug of Choice	Alternatives
MUCORMYCOSIS	Amphotericin B	No dependable alternative
PARACOCCIDIOIDOMYCOSIS	Itraconazole	Amphotericin B
SPOROTRICHOSIS		
Cutaneous	Itraconazole	Potassium iodide 1–5 mL tid
Systemic	Itraconazole	Amphotericin B

Abbreviations: AIDS = acquired immunodeficiency syndrome; HIV = human immunodeficiency virus.

TABLE 7–6
Drugs for Treating Selected Parasitic Infections

Infection	Drug
Amebiasis (*Entamoeba histolytica*)	
Asymptomatic	Iodoquinol or paramomycin
Mild to moderate intestinal disease	Metronidazole or tinidazole
Severe intestinal disease, hepatic abscess	Metronidazole or tinidazole
Ascariasis (*Ascaris lumbricoides,* roundworm)	Albendazole, mebendazole or pyrantel pamoate
Cryptosporidiosis (*Cryptosporidium*)	Paromomycin
Cutaneous larva migrans (creeping eruption, dog and cat hookworm	Albendazole, thiabendazole or ivermectin
***Cyclospora* infection**	Trimethoprim–sulfamethoxazole
Enterobius vermicularis (pinworm)	Pyrantel pamoate, mebendazole or albendazole
Filariasis (*Wuchereria bancrofti, Brugia malayi, Loa loa*)	Diethylcarbamazine
Giardiasis (*Giardia lamblia*)	Metronidazole
Hookworm infection (*Ancylostoma duodenale, Necator americanus*)	Albendazole, mebendazole, or pyrantel pamoate
Isosporiasis (*Isospora belli*)	Trimethoprim–sulfamethoxazole
Lice (*Pediculus humanus, P. capitis, Phthirus pubis*)	1% permethrin (topical) or 0.5% malathion
Malaria (*Plasmodium falciparum, P. ovale, P. vivax,* and *P. malariae*)	
Chloroquine-resistant *P. falciparum*	Quinine sulfate plus doxycycline, tetracycline, clindamycin or pyrimethamine–sulfadoxine (oral)
Chloroquine-resistant *P. vivax*	Quinine sulfate plus doxycycline, or pyrimethamine–sulfadoxine (oral)
All *Plasmodium* except chloroquine-resistant *P. falciparum*	Chloroquine phosphate (oral)
All *Plasmodium* (parenteral)	Quinine gluconate or quinine dihydrochloride
Prevention of relapses: *P. vivax,* and *P. ovale* only	Primaquine phosphate
Malaria, prevention	
Chloroquine-sensitive areas	Chloroquine phosphate
Chloroquine-resistant areas	Mefloquine or doxycycline
Mites, see Scabies	
Pinworm, see *Enterobius*	
***Pneumocystis carinii* pneumonia**	Trimethoprim–sulfamethoxazole Alternative: pentamidine
Primary and secondary prophylaxis	Trimethoprim–sulfamethoxazole

(*continued*)

TABLE 7–6 (Continued)

Infection	Drug
Roundworm, see Ascariasis	
Scabies (*Sarcoptes scabiei*)	5% Permethrin topically Alternatives: ivermectin, 10% crotamiton
Strongyloidiasis (*Strongyloides stercoralis*)	Ivermectin
Tapeworm infection	
—Adult (intestinal stage)	
Diphyllobothrium latum (fish), *Taenia saginata* (beef), *Taenia solium* (pork), *Dipylidium caninum* (dog), *Hymenolepis nana* (dwarf tapeworm)	Praziquantel
—Larval (tissue stage)	
Echinococcus granulosus (hydatid cyst)	Albendazole
Cysticercus cellulosae (cysticercosis)	Albendazole or praziquantel
Toxoplasmosis (*Toxoplasma gondii*)	Pyrimethamine plus sulfadiazine
Trichinosis (*Trichinella spiralis*)	Steroids for severe symptoms plus mebendazole
Trichomoniasis (*Trichomonas vaginalis*)	Metronidazole or tinidazole
Hairworm infection (*Trichostrongylus colubriformis*)	Pyrantel pamoate
Trypanosomiasis (*Trypanosoma cruzi,* Chagas' disease)	Benznidazole
Trichuriasis (Trichuris trichiuria, whipworm)	Mebendazole or albendazole
Visceral larva migrans, toxocariasis (*Toxocara canis*)	Albendazole or mebendazole

Source: Based on data from *The Medical Letter* March 2000 www.medletter.com.

TABLE 7–7
Guide to Common Tick-borne Diseases

Disease	Causative Agent	Season	Vector Habits
Rocky Mountain spotted fever	*Rickettsia rickettsii* (bacterium)	Mostly spring, summer	*American Dog Tick* Found in high grass and low shrubs, fields *Lone Star Tick* Found in woodlands, forest edge, and old fields
Human granulocytic ehrlichiosis	*Ehrlichia* spp. (bacterium)	Under study	*Deer* (black-legged) *Tick* found in woodlands, old fields, landscaping with significant ground cover vegetation
Lyme disease	*Borrelia burgdorferi* (bacterium)	Mostly spring, but year-around	Same as for the deer tick
Babesiosis	*Babesia microti* (protozoan)	Mostly spring/summer	Same as for the deer tick

(*continued*)

TABLE 7–7 (Continued)

Classic Clinical Presentation	Incubation Period	Diagnosis	Treatment
Sudden moderate to high fever, severe headache, maculopapular rash (with planer/palmer presentation)	2–14 d	Clinical serology	Adults—doxycycline Children/pregnant women—chloramphenicol
Fever, headache, constitutional symptoms	1–30 d	Clinical serology	Adults—tetracyclines Children/pregnant women—consult specialist
EM rash, constitutional symptoms, arthritis, cardiovascular- and nervous system involvement	3–30 d	Clinical serology, culture	Doxycycline, amoxicillin, cefuroxime for 14–21 d
Fever, hemolytic anemia, constitutional symptoms	1–52 wk	Thick and thin blood smears	Clindamycin/quinine

Abbreviation: EM = erythema multiforme.

Secretion/Discharge Precautions: (Handwashing and gloves with direct patient contact) Conjunctivitis, minor skin wounds, decubiti, colonization (but not infection that requires Wound and Skin Precautions) with MRSA, herpes, mucocutaneous candidiasis, ulcerative STDs, coccidioidomycosis, others

Pregnancy Precautions: (Handwashing) CMV, rubella, parvovirus

SBE PROPHYLAXIS

The following recommendations are based on guidelines published by the American Heart Association. (*JAMA* 1997;**277:**1794–1801). The guidelines now specify which patients are at high, moderate, or low risk of bacteremia and provide general guidelines for procedures that are more likely to be associated with bacterial endocarditis. SBE prophylaxis is recommended only for patients who are at high or moderate risk. See Tables 7–8 and 7–9 for regimens.

High-risk: Prosthetic cardiac valves, history of bacterial endocarditis, complex cyanotic congenital heart disease, surgically constructed systemic pulmonary shunts

Moderate-risk: Most other congenital cardiac malformations (other than those in the previous or following lists), acquired valvular disease (eg, rheumatic heart disease), hypertrophic cardiomyopathy, mitral valve prolapse with regurgitation or thickened leaflets

Low-risk: Isolated ASD secundum; repair of atrial/ventricular septal defect, or PDA; prior CABG; mitral valve prolapse without regurgitation; innocent heart murmurs; previous Kawasaki disease or rheumatic fever without valve dysfunction; pacemakers or implanted defibrillator

ISOLATION PROTOCOLS

To prevent the spread of infectious diseases from patient to patient, visitors, and hospital personnel, isolation procedures are recommended for various pathogens and clinical settings by various agencies such as the CDC in Atlanta, Georgia. Local hospital procedures may vary slightly from these recommendations.

Strict Isolation: (Single room, controlled airflow, handwashing, gown, gloves, mask) Varicella, herpes (localized, disseminated, neonatal), wound or burns infected with *S. aureus* or group A *Streptococcus, S. aureus* or group A *Streptococcus pneumoniae,* congenital rubella, rabies, smallpox, others

Contact Isolation: (Single room, controlled airflow, handwashing, gown, gloves, mask) All acute respiratory infections in infants and children (cough, cold, pneumonia, croup, pharyngitis, etc), extensive impetigo, gonococcal conjunctivitis in the newborn, others

Respiratory Isolation: (Single room, controlled airflow, handwashing, mask) TB (known or suspected), measles, mumps, rubella, pertussis, meningitis (suspected *N. meningitidis* or *H. influenzae* infection), pneumonia due to *H. influenzae,* epiglottitis, others

Wound and Skin Precautions: (Single room; handwashing; for direct contact with patient secretions: gown, gloves, mask) Major wound and skin infections, group A streptococcal endometritis, gas gangrene. Scabies and lice require only 24 h after effective therapy.

Enteric Precautions: (Single room; handwashing; for direct contact with patient secretions: gown, gloves) Known or suspected infectious gastroenteritis, including from rotavirus, enterovirus, *Salmonella, Shigella, E. coli, Giardia, and C. difficile* enterocolitis, acute hepatitis (all types)

Blood and Body Fluid Precautions: (Handwashing; for direct contact with patient secretions: gown, gloves) Known or suspected HIV infection, hepatitis (in acute and chronic carriers), syphilis, malaria, Lyme disease, all rickettsial infections, others

TABLE 7–8 SBE Prophylaxis for Oral, Respiratory or Esophageal Procedures*

Prophylaxis	Agent	Regimen†
Standard prophylaxis	Amoxicillin	Adults: 2.0 g; children: 50 mg/kg PO 1 h before procedure
Unable to take oral medications	Ampicillin	Adults: 2.0 g IM or IV; children: 50 mg/kg or IV 30 min before procedure
Allergic to penicillin	Clindamycin or	Adults: 600 mg; children: 20 mg/kg PO 1 h before procedure
	Cephalexin or cefadroxil	Adults: 2.0 g; children; 50 mg/kg PO 1 h before procedure
	Azithromycin or clarithromycin	Adults: 500 mg; children: 15 mg/kg PO 1 h before procedure Adults: 600 mg; children: 20 mg/kg IV 30 min before procedure
Penicillin allergic and unable to take oral medications	Clindamycin or cefazolin	Adults: 1.0 g; children: 25 mg/kg IM or IV 30 min before procedure

*See text page 157 for recommended risk groups.
†Total children's dose should not exceed adult dose.

TABLE 7–9
SBE Prophylaxis for GU/GI (Excluding Esophageal) Procedures*

Patient	Agents	Regimen
High-risk	Ampicillin + gentamicin	Adults: ampicillin 2.0 g IM/IV + gentamicin 1.5 mg/kg (max 120 mg) within 30 min of procedure; 6 h later, ampicillin 1 g IM/IV or amoxicillin 1 g PO Children: ampicillin 50 mg/kg IM or IV (2.0 g max) + gentamicin 1.5 mg/kg within 30 min of procedure; 6 h later, ampicillin 25 mg/kg IM/IV or amoxicillin 25 mg/kg PO
High-risk allergic to ampicillin/ amoxicillin	Vancomycin + gentamicin	Adults: vancomycin 1.0 g IV over 1–2 h + gentamicin 1.5 mg/kg IV/IM (120 mg max); dose within 30 min of starting procedure Children: vancomycin 20 mg/kg IV over 1–2 h + gentamicin 1.5 mg/kg IV/IM; complete dose within 30 min of starting procedure
Moderate-risk	Amoxicillin or ampicillin	Adults: amoxicillin 2.0 g PO 1 h before procedure, or ampicillin 2.0 g IM/IV within 30 min of starting procedure Children: amoxicillin 50 mg/kg PO 1 h before procedure, or ampicillin 50 mg/kg IM/IV within 30 min of starting procedure
Moderate-risk allergic to ampicillin/ amoxicillin	Vancomycin	Adults: vancomycin 1.0 g IV over 1–2 h complete infusion within 30 min of starting procedure Children: vancomycin 20 mg/kg IV over 1–2 h; complete infusion within 30 min of starting procedure

*See text page 157 for recommended risk groups.
Total children's dose should not exceed adult dose.

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8

BLOOD GASES AND ACID–BASE DISORDERS

NORMAL BLOOD GAS VALUES

The results of testing ABG are usually given as pH, pO_2, pCO_2, [HCO_3^-], base excess/deficit (difference), and oxygen saturation. This test gives information on acid–base homeostasis (pH, pCO_2, [HCO_3^-], and base difference) and on blood oxygenation (pO_2, O_2 saturation). Less frequently, venous blood gases and mixed venous blood gases are measured. Normal values for blood gas analysis are given in Table 8–1, page 162, and capillary blood gases are discussed in a following section. Note that the HCO_3^- from the blood gas is a calculated value and should not be used in the interpretation of the blood gas levels, instead the HCO_3^- from a chemistry panel should be used. The ABG and the chemistry panel [HCO_3^-] should be obtained at the same time.

VENOUS BLOOD GASES

There is little difference between arterial and venous pH and bicarbonate (except in cases of CHF and shock); therefore, the venous blood gas level may occasionally be used to assess acid–base status. Venous oxygen levels, however, are significantly less than arterial levels (see Table 8–1).

CAPILLARY BLOOD GASES

A CBG is obtained from a highly vascularized capillary bed. (The heel is the most commonly used site.) The CBG is often used for pediatric patients because it is easier to obtain than the ABG and is less traumatic (no risk of arterial thrombosis, hemorrhage). The procedure is fully described in Chapter 13, page 274, under Heelstick.

When interpreting a CBG, apply the following rules:

- **pH:** Same as arterial or slightly lower (Normal = 7.35–7.40)
- **pCO_2:** Same as arterial or slightly higher (Normal = 40–45)
- **pO_2:** Lower than arterial (Normal = 45–60)
- **O_2 Saturation:** >70% is acceptable. Saturation is probably more useful than the pO_2 itself when interpreting a CBG.

TABLE 8–1
Normal Blood Gas Values

Measurement	Arterial Blood	Mixed Venous*	Venous
pH	7.40	7.36	7.36
(range)	(7.37–7.44)	(7.31–7.41)	(7.31–7.41)
pO_2 (mm Hg)	80–100	35–40	30–50
(decreases with age)			
pCO_2 (mm Hg)	36–44	41–51	40–52
O_2 saturation	>95	60–80	60–85
(decreases with age)			
HCO_3^-(mEq/L)	22–26	22–26	22–28
[SI: mmol/L]			
Base difference	–2 to +2	–2 to +2	–2 to +2
(deficit/excess)			

*Obtained from the right atrium, usually through a pulmonary artery catheter.

GENERAL PRINCIPLES OF BLOOD GAS DETERMINATIONS

(Oxygen values are discussed on page 171.)

1. The blood gas machines in most labs actually measure the pH and the pCO_2 (as well as the pO_2). The $[HCO_3^-]$ and the base difference are calculated values using the **Henderson–Hasselbalch equation:**

$$\text{pH} = pK_a + \frac{\log[\text{HCO}_3^-] \text{ in mEq / L}}{0.03 \times \text{pCO}_2 \text{ in mmHg}}$$

   or the **Henderson equation:**

$$[\text{H}^+] \text{ in mEq / L} = \frac{24 \times \text{pCO}_2 \text{ in mmHg}}{[\text{HCO}_3^-] \text{ in mEq / L}}$$

2. For a rough estimate of $[H^+]$, $[H^+] = (7.80 - \text{pH}) \times 100$. This is accurate from a pH 7.25 – 7.48; 40 mEq/L = $[H^+]$ at the normal pH of 7.40. Also pH is a log scale, and for every change of 0.3 in pH from 7.40 the $[H^+]$ doubles or halves. For pH 7.10 the $[H^+] = 2 \times 40$, or 80 nmol/L, and for pH 7.70 the $[H^+] = ½ \times 40$, or 20 nmol/L.
3. The calculated $[HCO_3^-]$ should be within 2 mEq/L of the bicarbonate concentration from a venous chemistry determination (eg, BMP) drawn at the same time. If not, an error has been made in the collection or the determination of the values, and the blood gas and serum bicarbonate should be recollected.
4. Two additional relationships that are derived from the Henderson–Hasselbalch equation should be committed to memory. These two rules are helpful in interpreting blood gas results, particularly in defining a simple versus a mixed blood gas disorder:

Rule I: A change in pCO_2 up or down 10 mm Hg is associated with an increase or decrease in pH of 0.08 units. As the pCO_2 decreases, the pH increases; as the pCO_2 increases, the pH decreases.

Rule II: A pH change of 0.15 is equivalent to a base change of 10 mEq/L. A decrease in base (ie, $[HCO_3^-]$) is termed a **base deficit,** and an increase in base is termed a **base excess.**

ACID–BASE DISORDERS: DEFINITION

1. Acid–base disorders are very common clinical problems. **Acidemia** is a pH <7.37, and alkalemia is a pH >7.44. **Acidosis and alkalosis** are used to describe how the pH changes. The primary causes of acid–base disturbances are abnormalities in the respiratory system and in the metabolic or renal system. As from the Henderson–Hasselbalch equation, a respiratory disturbance leading to an abnormal pCO_2 alters the pH, and similarly a metabolic disturbance altering the $[HCO_3^-]$changes the pH.
2. Any primary disturbance in acid–base homeostasis invokes a **normal compensatory response.** A primary metabolic disorder leads to respiratory compensation, and a primary respiratory disorder leads to an acute metabolic response due to the buffering capacity of body fluids, *and* a more chronic compensation (1–2 days) due to alterations in renal function.
3. The degree of compensation is well known and can be expressed in terms of the degree of the primary acid–base disturbance. Table 8–2, page 164, lists the major categories of primary acid–base disorders, the primary abnormality, the secondary compensatory response, and the expected degree of compensation in terms of the magnitude of the primary abnormality. These changes are defined graphically in Figure 8–1, page 165. The types of simple acid–base disorders are discussed in the following sections.

MIXED ACID–BASE DISORDERS

1. Most acid–base disorders result from a single primary disturbance with the normal physiologic compensatory response and are called **simple acid–base disorders.** In certain cases, however, particularly in seriously ill patients, two or more different primary disorders may occur simultaneously, resulting in a **mixed acid–base disorder.** The net effect of mixed disorders may be additive (eg, metabolic acidosis and respiratory acidosis) and result in extreme alteration of pH; or they may be opposite (eg, metabolic acidosis and respiratory alkalosis) and nullify each other's effects on the pH.
2. To determine a mixed acid–base disorder from a blood gas value, follow the six steps in the Interpretation of Blood Gases (in the following section). Alterations in either $[HCO_3^-]$ or pCO_2 that differ from expected compensation levels indicate a second process. Two of the examples given in the following section illustrate the strategies employed in identifying a mixed acid–base disorder.

INTERPRETATION OF BLOOD GASES

Use a uniform, stepwise approach to the interpretation of blood gases. (See also Figure 8–1.)

Step 1: Determine if the numbers fit.

$$[H^+] = \frac{24 \times pCO_2}{[HCO_3^-]}$$

TABLE 8–2
Simple Acid–Base Disturbances

Acid–Base Disorder	Primary Abnormality	Expected Compensation	Expected Degree of Compensation
Metabolic acidosis	$\downarrow\downarrow\downarrow[HCO_3^-]$	$\downarrow\downarrow pCO_2$	$pCO_2 = (1.5 \times [HCO_3])+8$
Metabolic alkalosis	$\uparrow\uparrow\uparrow[HCO_3^-]$	$\uparrow\uparrow pCO_2$	$\uparrow$ in $pCO_2 = \Delta\ [HCO_3^-] \times 0.6$
Acute respiratory acidosis	$\uparrow\uparrow\uparrow pCO_2$	$\uparrow[HCO_3^-]$	$\uparrow$ in $[HCO_3^-] = \Delta pCO_2/10$
Chronic respiratory acidosis	$\uparrow\uparrow\uparrow pCO_2$	$\uparrow\uparrow[HCO_3^-]$	$\uparrow$ in $[HCO_3^-] = 4 \times \Delta pCO_2/10$
Acute respiratory alkalosis	$\downarrow\downarrow\downarrow pCO_2$	$\downarrow[HCO_3^-]$	$\downarrow$in $[HCO_3^-] = 2 \times \Delta pCO_2/10$
Chronic respiratory alkalosis	$\downarrow\downarrow\downarrow pCO_2$	$\downarrow\downarrow[HCO_3^-]$	$\downarrow$in $[HCO_3^-] = 5 \times \Delta pCO_2/10$

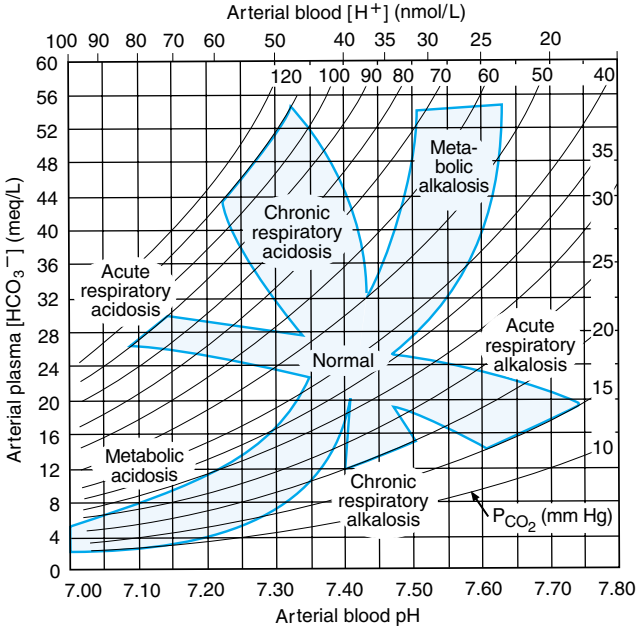

FIGURE 8–1 Nomogram for acid–base disorders. (Reprinted, with permission, from: Cogan MG: *Fluid and Electrolytes,* Appleton & Lange, Norwalk CT, 1991.)

The right side of the equation should be within about 10% of the left side. If the numbers do not fit, you need to obtain another ABG and chemistry panel for HCO_3^-.

Example. pH 7.25, pCO_2 48, HCO_3^- 29 mmol/L

$$56 = 24 \times \frac{48}{29}$$

$$56 \neq 40$$

The blood gas is uninterpretable, and the ABG and HCO_3^- need to be recollected. The most common reason for the numbers not fitting is that the ABG and the chemistry panel [HCO_3^-] were obtained at different times.

Step 2: Next, determine if an acidemia (pH <7.37) or an alkalemia (pH >7.44) is present.

Step 3: Identify the primary disturbance as metabolic or respiratory. For example, if acidemia is present, is the pCO_2 >44 mm Hg (respiratory acidosis), or is the $[HCO_3^-]$ <22 mmol/L (metabolic acidosis). In other words, identify which component, respiratory or metabolic, is altered in the same direction as the pH abnormality. If both components act in the same direction (eg, both respiratory [pCO_2 > 44 mm Hg] and metabolic [HCO_3^- <22 mmol/L] acidosis are present), then this is a **mixed acid–base problem,** discussed later in this section. The primary disturbance will be the one that varies from normal the greatest, that is, with a $[HCO_3^-]$ = 6 mmol/L and pCO_2 = 50 mm Hg, the primary disturbance would be a metabolic acidosis, the $[HCO_3^-]$ is about one-quarter normal, whereas the increase in pCO_2 is only 25%.

Step 4: After identifying the primary disturbance, use the equations in Table 8–2, page 164, to calculate the expected compensatory response. If the difference between the actual value and the calculated value is significant, then a mixed acid–base disturbance is present.

Step 5: Calculate the anion gap. Anion gap = $Na^+ - (Cl^- + HCO_3^-)$. Normal anion gap is 8–12 mmol. If the anion gap is increased, proceed to step 6.

Step 6: If the anion gap is elevated, then compare the changes from normal between the anion gap and $[HCO_3^-]$. If the change in the anion gap is greater than the change in the $[HCO_3^-]$ from normal, then a metabolic alkalosis is present in addition to a gap metabolic acidosis. If the change in the anion gap is less than the change in the $[HCO_3^-]$ from normal, then a nongap metabolic acidosis is present in addition to a gap metabolic acidosis. See Examples 5, 6, and 7, page 174.

Finally, be sure the interpretation of the blood gas is consistent with the clinical setting.

METABOLIC ACIDOSIS: DIAGNOSIS AND TREATMENT

Metabolic acidosis represents an increase in acid in body fluids reflected by a decrease in $[HCO_3^-]$ and a compensatory decrease in pCO_2.

Differential Diagnosis

The diagnosis of metabolic acidosis (Figure 8–2) can be classified as an anion gap or a nonanion gap acidosis. The **anion gap** (Normal range, 8–12 mmol/L) is calculated as:

$$\text{Anion gap} = [Na^+] - ([Cl^-] + [HCO_3^-])$$

Anion Gap Acidosis: Anion gap >12 mmol/L; caused by a decrease in $[HCO_3^-]$ balanced by an increase in an unmeasured acid ion from either endogenous production or exogenous ingestion (**normochloremic acidosis**).

Nonanion Gap Acidosis: Anion gap = 8–12 mmol/L; caused by a decrease in $[HCO_3^-]$ balanced by an increase in chloride (**hyperchloremic acidosis**). Renal tubular acidosis is a type of nongap acidosis that can be associated with a variety of pathologic conditions (Table 8–3 page 168). The anion gap is helpful in identifying metabolic gap acidosis, nongap acidosis, mixed metabolic gap and nongap acidosis. If an elevated anion gap is present, a closer look at the anion gap and the bicarbonate helps differentiate among (a) a pure metabolic gap acidosis, (b) a metabolic nongap acidosis, (c) mixed metabolic gap and nongap acidosis, and (d) a metabolic gap acidosis and metabolic alkalosis.

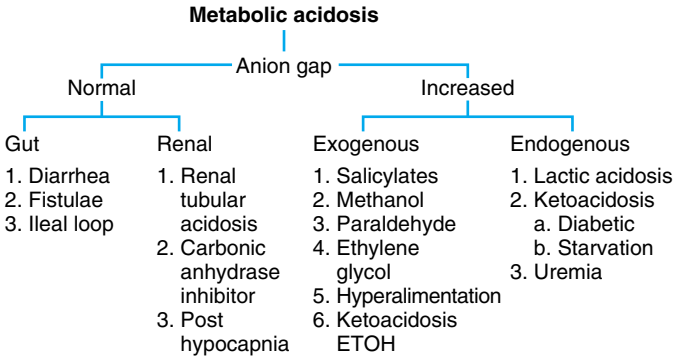

FIGURE 8–2 Differential diagnosis of metabolic acidosis.

Treatment of Metabolic Acidosis

1. Correct any underlying disorder (control diarrhea, etc).
2. Treatment with bicarbonate should be reserved for severe metabolic gap acidosis. If the pH <7.20, correct with sodium bicarbonate. The total replacement dose of $[HCO_3^-]$ can be calculated as follows:

$$[HCO_3^-] \text{ needed in mEq} = \frac{\text{Base deficit (mEq)} \times \text{Patient's weight (kg)}}{4}$$

3. Replace with **one-half the total amount of bicarbonate over 8–12 h** and reevaluate. Be aware of sodium and volume overload during replacement. Normal or isotonic bicarbonate drip is made with 3 ampules $NaHCO_3$ (50 mmol $NaHCO_3$/ampule) in 1 L D_5W.

METABOLIC ALKALOSIS: DIAGNOSIS AND TREATMENT

Metabolic alkalosis represents an increase in $[HCO_3^-]$ with a compensatory rise in pCO_2.

Differential Diagnosis

In two basic categories of diseases the kidneys retain $[HCO_3^-]$ (Figure 8–3). They can be differentiated in terms of response to treatment with sodium chloride and also by the level of urinary $[Cl^-]$ as determined by ordering a "spot," or "random" urinalysis for chloride (U_{Cl}).

Chloride-Sensitive (Responsive) Metabolic Alkalosis: The initial problem is a sustained loss of chloride out of proportion to the loss of sodium (either by renal or GI

TABLE 8–3
Renal Tubular Acidosis: Diagnosis and Management

Clinical Condition	Renal Defect	GFR	Serum $[HCO_3^-]$ (meq/L)	Serum [K+] (mEq/L)	Minimal Urine pH	Associated Disease States	Treatment
Normal	None	N	24–28	3.5–5	4.8–5.2	None	N/A
Proximal RTA (type II RTA)	Proximal H^+ secretion	N	15–18	↓	<5.5	Drugs, Fanconi's syndrome, various genetic disorders, dysproteinemic states, secondary hyperparathyroidism, toxins (heavy metals), tubulointerstitial diseases, nephrotic syndrome, paroxysmal nocturnal hemoglobinuria	$NaHCO_3$ or $KHCO_3$ (10–15 mEq/kg/d), thiazides
Classic distal RTA (type I RTA)	Distal H^+ secretion	N	20–30	↓	>5.5	Various genetic disorders, autoimmune diseases, nephrocalcinosis, drugs, toxins, tubulointerstitial diseases, hepatic cirrhosis, empty sella syndrome	$NaHCO_3$ (1–3 meq/kg/d)
Buffer deficiency (type III RTA)	Distal NH_3 delivery	↓	15–18	N	<5.5	Chronic renal insufficiency, renal osteodystrophy, severe hypophosphatemia	$NaHCO_3$ (1–3 mEq/kg/d)
Generalized distal RTA (type IV RTA)	Distal Na+ reabsorption, K^+ secretion, and H^+ secretion	↓	24–28	↑	<5.5	Primary mineralocorticoid deficiency (eg, Addison's Disease), hyporeninemic hypoaldosteronism, diabetes mellitus, tubulointerstitial diseases, nephrosclerosis, drugs), salt-wasting mineralocorticoid-resistant hyperkalemia	Fludrocortisone (0.1–0.5 mg/d) dietary K^+ restriction, $NaHCO_3$ (1–3 meq/kg/d) furosemide (40–160 mg/d)

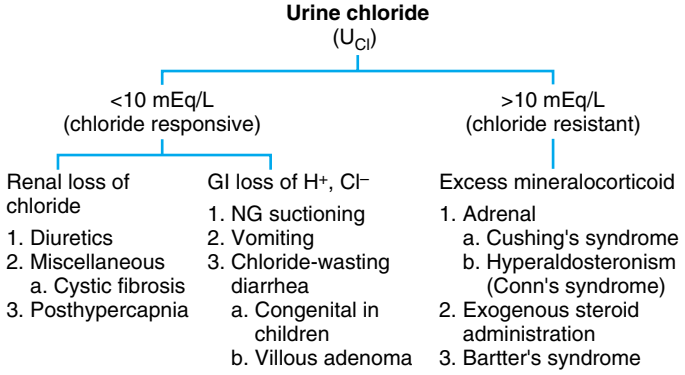

FIGURE 8–3 Differential diagnosis of metabolic alkalosis.

losses). This chloride depletion results in renal sodium conservation leading to a corresponding reabsorption of [HCO_3^-] by the kidney. In this category of metabolic alkalosis, the urinary [Cl^-] is <10 mEq/L, and the disorders respond to treatment with intravenous NaCl.

Chloride-Insensitive (Resistant) Metabolic Alkalosis: The pathogenesis in this category is direct stimulation of the kidneys to retain bicarbonate irrespective of electrolyte intake and losses. The urinary [Cl^-] >10 mEq/L, and these disorders do not respond to NaCl administration.

Treatment of Metabolic Alkalosis

Correct the underlying disorder.

1. **Chloride-responsive**
   - **a.** Replace volume with NaCl if depleted.
   - **b.** Correct hypokalemia if present.
   - **c.** NH_4Cl and HCl should be reserved for extreme cases.
2. **Chloride-resistant**
   - **a.** Treat underlying problem, such as stopping exogenous steroids.

RESPIRATORY ACIDOSIS: DIAGNOSIS AND TREATMENT

Respiratory acidosis is a primary rise in pCO_2 with a compensatory rise in plasma [HCO_3^-]. Increased pCO_2 occurs in clinical situations in which decreased alveolar ventilation occurs.

Differential Diagnosis

1. **Neuromuscular Abnormalities with Ventilatory Failure**
   - **a.** Muscular dystrophy, myasthenia gravis, Guillain–Barré syndrome, hypophosphatemia

2. **Central Nervous System**
   - **a.** Drugs: Sedatives, analgesics, tranquilizers, ethanol
   - **b.** CVA
   - **c.** Central sleep apnea
   - **d.** Spinal cord injury (cervical)
3. **Airway Obstruction**
   - **a.** Chronic (COPD)
   - **b.** Acute (asthma)
   - **c.** Upper airway obstruction
   - **d.** Obstructive sleep apnea
4. **Thoracic–Pulmonary Disorders**
   - **a.** Bony thoracic cage: Flail chest, kyphoscoliosis
   - **b.** Parenchymal lesions: Pneumothorax, severe pulmonary edema, severe pneumonia
   - **c.** Large pleural effusions
   - **d.** Scleroderma
   - **e.** Marked obesity (Pickwickian syndrome)

Treatment of Respiratory Acidosis

Improve Ventilation: Intubate patient and place on ventilator, increase ventilator rate, reverse narcotic sedation with naloxone (Narcan), etc

RESPIRATORY ALKALOSIS: DIAGNOSIS AND TREATMENT

Respiratory alkalosis is a primary fall in pCO_2 with a compensatory decrease in plasma [HCO_3^-]. Respiratory alkalosis occurs with increased alveolar ventilation.

Differential Diagnosis

1. **Central stimulation**
   - **a.** Anxiety, hyperventilation syndrome, pain
   - **b.** Head trauma or CVA with central neurogenic hyperventilation
   - **c.** Tumors
   - **d.** Salicylate overdose
   - **e.** Fever, early sepsis
2. **Peripheral stimulation**
   - **a.** PE
   - **b.** CHF (mild)
   - **c.** Interstitial lung disease
   - **d.** Pneumonia
   - **e.** Altitude
   - **f.** Hypoxemia: Any cause (See the section on Hypoxia, page 171.)
3. **Miscellaneous**
   - **a.** Hepatic insufficiency
   - **b.** Pregnancy
   - **c.** Progesterone
   - **d.** Hyperthyroidism
   - **e.** Iatrogenic mechanical overventilation

Treatment of Respiratory Alkalosis

Correct the underlying disorder.

Hyperventilation Syndrome: Best treated by having the patient rebreathe into a paper bag to increase pCO_2, decrease ventilator rate, increase amount of dead space with ventilator, or treat underlying cause.

HYPOXIA

1. The second type of information gained from a blood gas level, in addition to acid–base results, pertains to the level of oxygenation. Usually, results are given as pO_2 and oxygen saturation (See Table 8–1 for normal values in page 162). These two parameters are related to each other.
2. Oxygen saturation at any given pO_2 is influenced by temperature, pH, and the level of 2,3-DPG as shown in Figure 8–4.

Differential Diagnosis

1. **V/Q abnormalities**
   - **a.** COPD: Emphysema, chronic bronchitis
   - **b.** Asthma
   - **c.** Atelectasis
   - **d.** Pneumonia
   - **e.** PE
   - **f.** ARDS
   - **g.** Pneumothorax

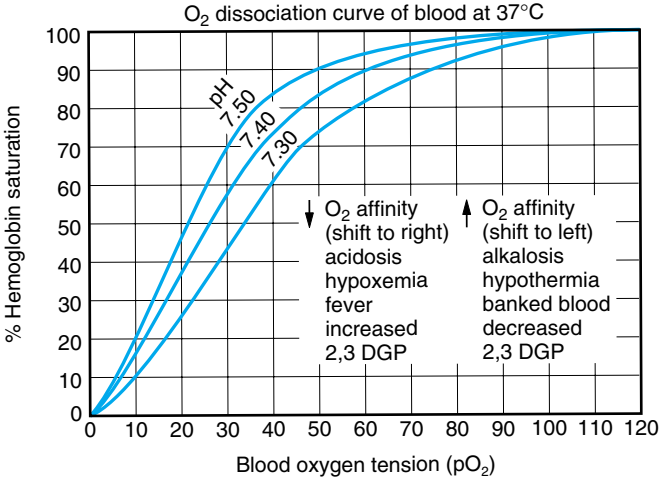

FIGURE 8–4 Oxyhemoglobin dissociation curve.

   h. Pneumoconiosis
   i. CF
   j. Obstructed airway
2. **Alveolar hypoventilation**
   a. Skeletal abnormalities
   b. Neuromuscular disorders
   c. Pickwickian syndrome
   d. Sleep apnea
3. **Decreased pulmonary diffusing capacity**
   a. Pneumoconiosis
   b. Pulmonary edema
   c. Drug-induced pulmonary fibrosis (Bleomycin)
   d. Collagen–vascular diseases
4. **Right-to-left shunt**
   a. Congenital heart disease: Tetralogy of Fallot, transposition, etc

SAMPLE ACID–BASE PROBLEMS

In each of the following examples, use the technique for blood gas interpretation on page 163 in this chapter to identify the acid–base disorder.

Example 1

A patient with COPD has a blood gas of pH 7.34, pCO_2 55, and $[HCO_3^-]$ of 29.

Step 1:

$$46 = 24 \times \frac{55}{29}$$
$$46 \approx 45$$

The numbers fit because the difference between the calculated and observed is <10%.

Step 2: pH < 7.37, the problem is an acidemia.

Step 3: pCO_2 > 44 and $[HCO_3^-]$ is **not** < 22, so it represents a respiratory acidosis.

Step 4: Normal compensation for chronic (COPD) respiratory acidosis (from Table 8–2).

$$\Delta[HCO_3^-] = 4 \times \Delta\,(pCO_2 / 10) = 4 \times \frac{15}{10} = 6$$

Expected $[HCO_3^-]$ is 24 mEq/L + 6 = 30, which is reasonably close to the measured $[HCO_3^-]$ of 29, therefore this is a simple respiratory acidosis. This patient has a chronic respiratory acidosis due to hypoventilation (simple acid–base disorder).

Example 2

Immediately after a cardiac arrest a patient has a pH 7.25, pCO_2 28, and $[HCO_3^-]$ 12.

Step 1:

$$56 = 24 \times \frac{28}{12}$$
$$56 = 56$$

The numbers fit.

Step 2: pH < 7.37, so the problem is an acidemia.

Step 3: $[HCO_3^-]$ is < 22 mEq/L and pCO_2 is **not** > 44, so this is a metabolic acidosis.

Step 4: (See Table 8–2, page 164)

$$pCO_2 = (1.5 \times [HCO_3] + 8) = (1.5 \times 12) + 8 = 26$$

The expected pCO_2 of 26 mm Hg is very similar to the actual measured value of 28 mm HG, so this is a simple metabolic acidosis. This patient has a lactic acidosis following a cardiopulmonary arrest (simple acid–base disorder).

Example 3

A young man with a fever of 103.2°F and a fruity odor on his breath has a blood gas with pH = 7.36, pCO_2 = 9, and $[HCO_3^-]$ = 5.

Step 1:

$$45 = \frac{24}{5} \times 9$$
$$43 \approx 45$$

The numbers fit.

Step 2: The pH < 7.37 indicates an acidemia.

Step 3: $[HCO_3^-]$ < 22 and pCO_2 is **not** >44, thus a metabolic acidosis is present.

Step 4: The expected compensation in pCO_2 can be calculated as follows (formula from Table 8–2):

$$\begin{aligned} pCO_2 &= (1.5 \times [HCO_3^-]) + 8 \\ &= (1.5 \times 9) + 8 \\ &= 21.5 \end{aligned}$$

The expected pCO_2 is 15.5, but the actual result is 9 mm Hg, indicating a second process, which is a respiratory alkalosis. This patient had a metabolic acidosis due to diabetic ketoacidosis and a concomitant respiratory alkalosis due to early sepsis and fever (mixed acid–base disorder).

Example 4

A 30-y-old 30-wk pregnant female presents with nausea and vomiting. Blood gas reveals a pH 7.55, pCO_2 = 25 and $[HCO_3^-]$ = 22.

Step 1:

$$28 = 24 \times \frac{25}{22}$$
$$28 \approx 27$$

The numbers fit.

Step 2: pH < 7.44 indicates alkalemia.

Step 3: pCO_2 < 36 and the $[HCO_3^-]$ is **not** >26, thus a respiratory alkalosis is present.

Step 4: The expected compensation for a chronic (pregnancy) respiratory alkalosis is calculated from Table 8–2, page 164:

$$\Delta[HCO_3^-] = 5 \times \Delta pCO_2 / 10$$
$$= 5 \times \frac{15}{10} = 7.5$$

The calculated $[HCO_3^-]$ is then 24 – 7.5, or 16–17 mmol, but the actual bicarbonate level is 22, indicating a relative secondary metabolic alkalosis ($[HCO_3^-]$ is higher than expected).

This patient has a respiratory acidosis due to pregnancy and a relative secondary metabolic alkalosis due to vomiting.

Example 5

A 19-y-old diabetic has an anion gap of 29 and a $[HCO_3^-]$ of 6.

Step 1:

29 mmol/L actual gap
–10 mmol/L normal gap
19 mmol/L expected change in $[HCO_3^-]$

Step 2:

24 mmol/L normal $[HCO_3^-]$
–19 mmol/L expected change in $[HCO_3^-]$
5 mmol/L expected change in $[HCO_3^-]$

Actual bicarbonate is 6 mmol/L, which is very close to the expected of 5 mmol/L. Thus, a pure metabolic gap acidosis is present from DKA.

Example 6

A 21-y-old diabetic presents with nausea, vomiting, and abdominal pain. The anion gap was 23, and the $[HCO_3^-]$ was 18.

Step 1:

23 mmol/L actual gap
–10 mmol/L normal gap
13 mmol/L expected change in $[HCO_3^-]$ from normal

Step 2:

24 mmol/L normal $[HCO_3^-]$
–13 mmol/L expected change in $[HCO_3^-]$
11 mmol/L expected change in $[HCO_3^-]$

Actual bicarbonate is 18 mmol and not the 11 mmol/L expected from a pure metabolic gap acidosis. Because the actual bicarbonate was higher than expected, this must be a mixed metabolic gap acidosis and metabolic alkalosis. The patient has a metabolic gap acidosis from DKA and a metabolic alkalosis from the vomiting.

Example 7

A 55-y-old alcoholic with a 2-wk history of diarrhea. The anion gap was 17, and [HCO_3^-] was 10.

Step 1:

17 mmol/L actual gap
−10 mmol/L normal gap
7 mmol/L expected change in [HCO_3^-] from normal

Step 2:

24 mmol/L normal [HCO_3^-]
−7 mmol/L expected change in [HCO_3^-]
17 mmol/L expected change in [HCO_3^-]

Actual bicarbonate is 10 mmol/L and not the expected 17 mmol/L if there was a pure metabolic gap acidosis. Since the actual bicarbonate is lower than expected, there must be a mixed metabolic gap acidosis and metabolic nongap acidosis. The patient has a metabolic nongap acidosis from diarrhea and a metabolic gap acidosis from the alcoholic ketoacidosis.

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9 FLUIDS AND ELECTROLYTES

PRINCIPLES OF FLUIDS AND ELECTROLYTES

Fluid Compartments

- Example: 70-kg male

Total Body Water: 42,000 mL (60% of BW)

- Intracellular: 28,000 mL (40% of BW)
- Extracellular: 14,000 mL (20% of BW)
- Plasma: 3500 mL (5% of BW)
- Interstitial: 10,500 mL (15% of BW)

Total Blood Volume

Total blood volume = 5600 mL (8% of BW)

Red Blood Cell Mass

Male, 20–36 mL/kg (1.15–1.21 L/m^2); female, 19–31 mL/kg (0.95–1.0 L/m^2)

Water Balance

- 70-kg male

The minimum obligate water requirement to maintain homeostasis (assuming normal temperature and renal concentrating ability and minimal solute [urea, salt] excretion) is about 800 mL/d, which would yield 500 mL of urine.

"Normal" Intake: 2500 mL/d (about 35 mL/kg/d baseline)

- Oral liquids: 1500 mL
- Oral solids: 700 mL
- Metabolic (endogenous): 300 mL

"Normal" Output: 1400–2300 mL/d

- Urine: 800–1500 mL
- Stool: 250 mL

- Insensible loss: 600–900 mL (lungs and skin). (With fever, each degree above 98.6°F adds 2.5 mL/kg/d to insensible loss; insensible losses are decreased if a patient is on a ventilator; free water gain may occur from humidified ventilation.)

Baseline Fluid Requirement

Afebrile 70-kg Adult: 35 mL/kg/24 h

If not a 70-kg Adult: Calculate the water requirement according to the following **"kg Method":**

- For the first 10 kg of body weight: 100 mL/kg/d plus
- For the second 10 kg of body weight: 50 mL/kg/d plus
- For the weight above 20 kg: 20 mL/kg/d

Electrolyte Requirements

- 70-kg adult, unless otherwise specified

Sodium (as NaCl): 80–120 mEq (mmol)/d (Pediatric patients, 3–4 mEq/kg/ 24 h [mmol/kg/24 h])

Chloride: 80–120 mEq (mmol)/d, as NaCl

Potassium: 50–100 mEq/d (mmol/d) (Pediatric patients, 2–3 mEq/kg/24 h [mmol/kg/24 h]). In the absence of hypokalemia and with normal renal function, most of this is excreted in the urine. Of the total amount of potassium, 98% is intracellular, and 2% is extracellular. Thus, assuming the serum potassium level is normal, about 4.5 mEq/L (mmol/L), the total extracellular pool of $K^+ = 4.5 \times 14$ L = 63 mEq (mmol). Potassium is easily interchanged between intracellular and extracellular stores under conditions such as acidosis. Potassium demands increase with diuresis and building of new body tissues (anabolic states).

Calcium: 1–3 gm/d, most of which is secreted by the GI tract. Routine administration is not needed in the absence of specific indications.

Magnesium: 20 mEq/d (mmol/d). Routine administration is not needed in the absence of specific indications, such as parenteral hyperalimentation, massive diuresis, ethanol abuse (frequently needed) or preeclampsia.

Glucose Requirements

100–200 g/d (65–75 g/d/m^2). During starvation, caloric needs are supplied by body fat and protein; the majority of protein comes from the skeletal muscles. Every gram of nitrogen in the urine represents 6.25 g of protein broken down. The **protein-sparing effect** is one of the goals of basic IV therapy. The administration of at least 100 g of glucose/d reduces protein loss by more than one-half. Virtually all IV fluid solutions supply glucose as dextrose (pure dextrorotatory glucose). Pediatric patients require about 100–200 mg/kg/h.

COMPOSITION OF PARENTERAL FLUIDS

Parenteral fluids are generally classified based on molecular weight and oncotic pressure. Colloids have a molecular weight of >8000 and have high oncotic pressure; crystalloids have a molecular weight of <8000 and have low oncotic pressure.

Colloids

- Albumin (see page 200)
- Blood products (RBCs, single-donor plasma, etc) (Chapter 10, page 197)
- Plasma protein fraction (Plasmanate) (See Chapter 22)
- Synthetic colloids (hetastarch [Hespan], dextran) (Chapter 22)

Crystalloids

Table 9–1 describes common crystalloid parenteral fluids.

COMPOSITION OF BODY FLUIDS

Table 9–2 gives the average daily production and the amount of some major electrolytes present in various body fluids.

ORDERING IV FLUIDS

One of the most difficult tasks to master is choosing appropriate IV therapy for a patient. The patient's underlying illness, vital signs, serum electrolytes, and a host of other variables all must be considered. The following are general guidelines for IV therapy. Specific requirements for each patient can vary tremendously from these guidelines.

Maintenance Fluids

These amounts provide the minimum requirements for routine daily needs:

1. **70-kg Male:** Five% dextrose in one-quarter concentration normal saline (D5¼NS) with 20 mEq KCl/L (20 mmol/L) at 125 mL/h. (This will deliver about 3 L of free water/day.)
2. **Other Adult Patients:** Also use D5¼ NS with 20 mEq KCl/L. Determine their 24-h water requirement by the "kg method" (page 178) and divide by 24 h to determine the hourly rate.
3. **Pediatric Patients:** Use the same solution, but determine the daily fluid requirements by either of the following methods:
   a. *kg Method:* (page 181)
   b. *Meter Squared Method:* Maintenance fluids are 1500 mL/m^2/d. Divide by 24 to get the flow rate per hour. To calculate the surface area, use Table 9–3, page 181 "rule of sixes nomogram." Formal body surface area charts are in the Appendix.

Specific Replacement Fluids

These fluids are used to replace excessive, nonphysiologic losses.

Gastric Loss (Nasogastric Tube, Emesis): D_5½ NS with 20 mEq/L (mmol/L) potassium chloride (KCl)

Diarrhea: D_5LR with 15 mEq/L (mmol/L) KCl. Use body weight as a replacement guide (about 1 L for each 1 kg, or 2.2 lb, lost)

Bile Loss: D_5LR with 25 mEq/L (½ ampule) of sodium bicarbonate mL for mL

Pancreatic Loss: D_5LR with 50 mEq/liter (1 amp) HCO_3 mL for mL.

Burn Patients: Use the Parkland or "Rule of Nines" Formulas:

TABLE 9–1
Composition of Commonly Used Crystalloids

Fluid	Glucose (g/L)	Electrolytes (mEq/L)							
		Na^+	Cl^-	K^+	Ca^{2+}	HCO_3^-*	Mg^{2+}	HPO_4^{-2}	kcal/L
D_5W (5% dextrose in water)	50	—	—	—	—	—	—	—	170
$D_{10}W$ (10% dextrose in water)	100	—	—	—	—	—	—	—	340
$D_{20}W$ (20% dextrose in water)	200	—	—	—	—	—	—	—	680
$D_{50}W$ (50% dextrose in water)	500	—	—	—	—	—	—	—	1700
½ NS (0.45% NaCl)	—	77	77	—	—	—	—	—	—
3% NS	—	513	513	—	—	—	—	—	—
NS (0.9% NaCl)	—	154	154	—	—	—	—	—	—
D_5¼NS	50	38	38	—	—	—	—	—	170
D_5¼NS (0.45% NaCl)	50	77	77	—	—	—	—	—	170
D_5½NS (0.9% NaCl)	50	154	154	—	—	—	—	—	170
D_5LR (5% dextrose in lactated Ringer's)	50	130	110	4	3	27	—	—	180
Lactated Ringer's	—	130	110	4	3	27	—	—	<10
Ionosol MB	50	25	22	20	—	23	3	3	170
Normosol M	50	40	40	13	—	16	3	—	170

*HCO_3 is administered in these solutions as lactate that is converted to bicarbonate.

TABLE 9–2
Composition and Daily Production of Body Fluids

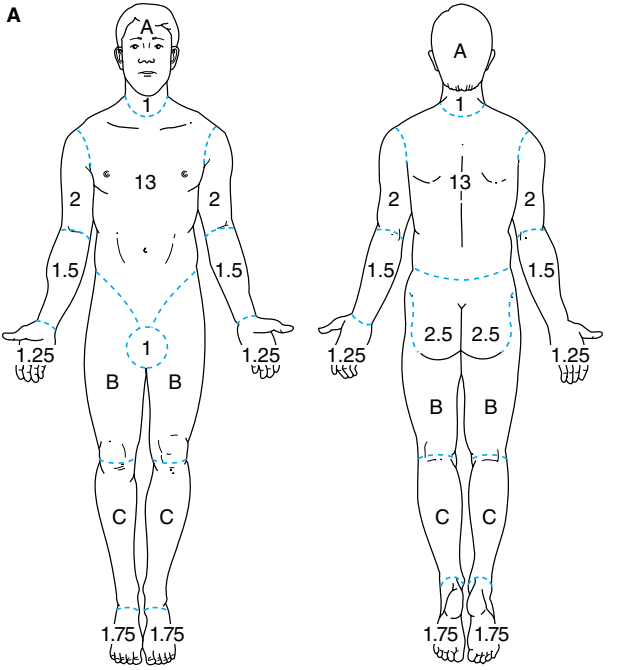
	Electrolytes (mEq/L)				
Fluid	Na^+	Cl^-	K^+	HCO_3^-	Average Daily Production* (mL)
Sweat	50	40	5	0	Varies
Saliva	60	15	26	50	1500
Gastric juice	60–100	100	10	0	1500–2500
Duodenum	130	90	5	0–10	300–2000
Bile	145	100	5	15	100–800
Pancreatic juice	140	75	5	115	100–800
Ileum	140	100	2–8	30	100–9000
Diarrhea	120	90	25	45	—

*In adults.

TABLE 9–3
"Rule of Sixes" Nomogram for Calculating Fluids in Children*

Weight (lb)	Body Surface Area (m^2)
3	0.1
6	0.2
12	0.3
18	0.4
24	0.5
30	0.6
36	0.7
42	0.8
48	0.9
60†	1.0

*Over 100 lb, treat as an adult.
†After 60 lb, add 0.1 for each additional 10 lb.

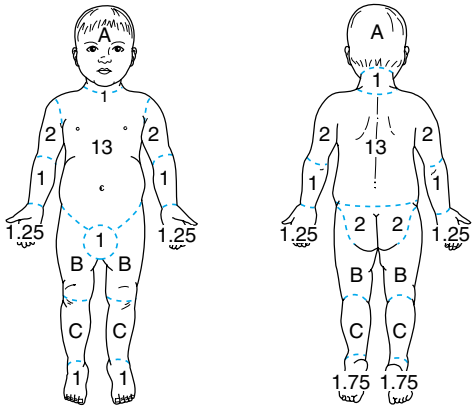


Relative Percentages of Areas Affected by Growth

Area	Age		
	10	15	Adult
A = half of head	5.5	4.5	3.5
B = half of one thigh	4.25	4.5	4.75
C = half of one leg	3	3.25	3.5

FIGURE 9–1 Tables for estimating the extent of burns in adults and children. In adults, a reasonable system for calculating the percentage of the body surface burned is the "rule of nines": Each arm equals 9%, the head equals 9%, the anterior and posterior each equal 18%, and the perineum equals 1%. (Reprinted, with permission, from: Way LW [ed]: *Current Surgical Diagnosis and Treatment,* 10th ed,. Appleton & Lange, Norwalk CT, 1994.)

B



Relative Percentages of Areas Affected by Growth

Area	Age		
	0	1	5
A = half of head	9.5	8.5	6.5
B = half of one thigh	2.75	3.25	4
C = half of one leg	2.5	2.5	2.75

FIGURE 9–1 Continued.

Parkland Formula.

$$\text{Total fluid required during the first 24 h} = (\%\ \text{body burn}) \times (\text{body weight in kg}) \times 4\ \text{mL}$$

Replace with lactated Ringer's solution over 24 h. Use

- One-half the total over first 8 h (from time of burn)
- One-quarter of the total over second 8 h. One-quarter of the total over third 8 h
- *Rule of Nines.* Used for estimating percentage of body burned in adults. See Figure 9–1 for the exact calculation for the body burn in adults and children. This is also useful for determining ongoing fluid losses from a burn until it is healed or grafted. Fluid losses can be estimated as

$$\text{Loss in mL} = (25 \times \%\ \text{Body burn}) \times \text{m}^2\ \text{Body surface area}$$

DETERMINING AN IV RATE

Most IV infusions are regulated by infusion pumps. If a mechanical infusion device is not available, use the following formulas to determine the infusion rate.

For a MAXI Drip Chamber: Use 10 drops/mL; thus

- 10 drops/min = 60 mL/h or
- 16 drops/min = 100 mL/h

For a MINI Drip Chamber: Use 60 drops/mL; thus

- 60 drops/min = 60 mL/h or
- 100 drops/min = 100 mL/h

ELECTROLYTE ABNORMALITIES: DIAGNOSIS AND TREATMENT

In all of the following situations, the primary goal should be to correct the underlying condition. Unless specified, all dosages are for adults. The complete differential diagnosis of laboratory findings can be found in Chapter 4.

Hypernatremia (Na^+ >144 mEq/L [mmol/L])

Mechanisms: Most frequently, a deficit of total body water.

- **Combined Sodium and Water Losses ("hypovolemic hypernatremia").** Water loss in excess of sodium loss results in low total body sodium. Due to renal (diuretics, osmotic diuresis due to glycosuria, mannitol, etc) or extrarenal (sweating, GI, respiratory) losses
- **Excess Water Loss ("isovolemic hypernatremia").** Total body sodium remains normal, but total body water is decreased. Caused by diabetes insipidus (central and nephrogenic), excess skin losses, respiratory loss, others.
- **Excess Sodium ("hypervolemic hypernatremia").** Total body sodium increased, caused by iatrogenic sodium administration (ie, hypertonic dialysis, sodium-containing medications) or adrenal hyperfunction (Cushing's syndrome, hyperaldosteronism).

Symptoms: Depend on how rapidly the sodium level has changed

- Confusion, lethargy, stupor, coma
- Muscle tremors, seizures

Signs: Hyperreflexia, mental status changes

Treatment: Check the serum sodium levels frequently while attempting to correct hypernatremia.

- **Hypovolemic Hypernatremia.** Determine if the patient volume is depleted by determining if orthostatic hypotension (see page 286) is present; if volume is depleted, rehydrate with NS until hemodynamically stable, then administer hypotonic saline (½ NS).
- **Euvolemic/Isovolemic.** (No orthostatic hypotension) calculate the volume of free water needed to correct the Na^+ to normal as follows:

$$\text{Body water deficit} = \text{Normal TBW} - \text{Current TBW}$$

where

$$\text{Normal TBW} = 0.6 \times \text{Body weight in kg}$$

and

$$\text{Current TBW} = \frac{\text{Normal serum sodium} \times \text{TBW}}{\text{Measured serum sodium}}$$

- Give free water as D_5W, one-half the volume in the first 24 h and the full volume in 48 h. (**Caution:** The rapid correction of the sodium level using free water (D_5W) can cause cerebral edema and seizures.)
- **Hypervolemic Hypernatremia.** Avoid medications that contain excessive sodium (carbenicillin, etc).Use furosemide along with D_5W.

Hyponatremia (Na^+ <136 mEq/L [mmol/L])

Mechanisms: Most often due to excess body water as opposed to decreased body sodium. To define the cause, determine serum osmolality.

- **Isotonic Hyponatremia.** Normal osmolality
- **Pseudo-Hyponatremia.** An artifact caused by hyperlipidemia or hyperproteinemia.
- **Hypertonic Hyponatremia.** High osmolality. Water shifts from intracellular to extracellular in response to high concentrations of such solutes as glucose or mannitol. The shift in water lowers the serum sodium; however, the total body sodium remains the same.
- **Hypotonic Hyponatremia.** Low osmolality. Further classified based on clinical assessment of extracellular volume status
- *Isovolemic.* No evidence of edema, normal BP. Caused by water intoxication (urinary osmolality <80 mOsm), SIADH, hypothyroidism, hypoadrenalism, thiazide diuretics, beer potomania
- *Hypovolemic.* Evidence of decreased skin turgor and an increase in heart rate and decrease in BP after going from lying to standing. Due to renal loss (urinary sodium >20 mEq/L) from diuretics, postobstructive diuresis, mineralocorticoid deficiency (Addison's disease, hypoaldosteronism) or extrarenal losses (urinary sodium <10 mEq/L) from sweating, vomiting, diarrhea, third spacing fluids (burns, pancreatitis, peritonitis, bowel obstruction, muscle trauma)
- *Hypervolemic.* Evidence of edema.(urinary sodium <10 mEq/L). Seen with CHF, nephrosis, renal failure, and liver disease
- **Excess Water Intake.** Primary (psychogenic water drinker) or secondary (large volume of sterile water used in procedures, eg, transurethral resection of the prostate or multiple tap water enemas)

Symptoms: Usually with Na^+ <125 mEq/L (mmol/L); severity of symptoms correlates with the rate of decrease in Na^+.

- Lethargy, confusion, coma
- Muscle twitches and irritability, seizures
- Nausea, vomiting

Signs: Hyporeflexia, mental status changes

Treatment: Based on determination of volume status. Evaluate volume status by physical examination HR and BP lying and standing after 1 min, skin turgor, edema and by determination of the plasma osmolality. Do not need to treat hyponatremia from pseudo-hyponatremia (increased protein or lipids) or hypertonic hyponatremia (hyperglycemia), treat underlying disorder (see above).

- **Life-Threatening.** (Seizures, coma) 3–5% NS can be given in the ICU setting. Attempt to raise the sodium to about 125 mEq/L with 3–5% NS.
- **Isovolemic Hyponatremia.** (SIADH)

Restrict fluids (1000–1500 mL/d).
Demeclocycline can be used in chronic SIADH.

- **Hypervolemic Hyponatremia**

Restrict sodium and fluids (1000–1500 mL/d).
Treat underlying disorder. CHF may respond to a combination of ACE inhibitor and furosemide.

- **Hypovolemic Hyponatremia**

Give D_5NS or NS.

Hyperkalemia

- (K^+ >5.2 mEq/L (mmol/L)

Mechanisms: Most often due to iatrogenic or inadequate renal excretion of potassium.

- **Pseudo-Hyperkalemia.** Due to leukocytosis, thrombocytosis, hemolysis, poor venipuncture technique (prolonged tourniquet time)
- **Inadequate Excretion.** Renal failure, volume depletion, medications that block potassium excretion (spironolactone, triamterene, others), hypoaldosteronism (including adrenal disorders and hyporeninemic states [such as Type IV renal tubular acidosis], NSAIDs, ACE inhibitors), long-standing use of heparin, digitalis toxicity, sickle cell disease, renal transplant
- **Redistribution.** Tissue damage, acidosis (a 0.1 decrease in pH increases serum K^+ approximately 0.5–1.0 mEq/L due to extracellular shift of K^+), beta-blockers, decreased insulin, succinylcholine
- **Excess Administration.** Potassium-containing salt substitutes, oral replacement, potassium in IV fluids

Symptoms: Weakness, flaccid paralysis, confusion.

Signs:

- Hyperactive deep tendon reflexes, decreased motor strength
- ECG changes, such as, peaked T waves, wide QRS, loss of P wave, sine wave, asystole
- K^+ = 7–8 mEq/L (mmol/L) yields ventricular fibrillation in 5% of cases
- K^+ = 10 mEq/L (mmol/L) yields ventricular fibrillation in 90% of cases

Treatment

- Monitor patient on ECG if symptomatic or if K^+ >6.5 mEq/L; discontinue all potassium intake, including IV fluids; order a repeat stat potassium to confirm.
- Pseudo-hyperkalemia should be ruled out. If doubt exists, obtain a plasma potassium in a heparinized tube; the plasma potassium will be normal if pseudo-hyperkalemia is present.
- **Rapid Correction.** These steps only protect the heart from potassium shifts, and total body potassium must be reduced by one of the treatments shown under Slow Correction.

Calcium chloride, 500 mg, slow IV push (only protects heart from effect of hyperkalemia)
Alkalinize with 50 mEq (1 ampule) sodium bicarbonate (causes intracellular potassium shift)
50 mL D50, IV push, with 10–15 units regular insulin, IV push (causes intracellular potassium shift)

- **Slow Correction**

Sodium polystyrene sulfonate (Kayexalate) 20–60 g given orally with 100–200 mL of sorbitol or 40 g Kayexalate with 40 g sorbitol in 100 mL water given as an enema. Repeat doses qid as needed.
Dialysis (hemodialysis or peritoneal)

- **Correct Underlying Cause.** Such as stopping potassium-sparing diuretics, ACE inhibitors, mineralocorticoid replacement for hypokalemia

Hypokalemia

- K^+ <3.6 mEq/L (mmol/L)

Mechanisms: Due to inadequate intake, loss, or intracellular shifts

- **Inadequate Intake.** Oral or IV
- **GI Tract Loss.** (Urinary chloride usually <10 mEq/d; "chloride-responsive alkalosis") vomiting, diarrhea, excess sweating, villous adenoma, fistula
- **Renal Loss.** Diuretics and other medications (amphotericin, high-dose penicillins, aminoglycosides, cisplatin), diuresis other than diuretics (osmotic, eg, hyperglycemia or ethanol-induced), vomiting (from metabolic alkalosis from volume depletion), renal tubular disease (renal tubular acidosis type II [distal], and [proximal]), Bartter's syndrome (due to increased renin and aldosterone levels), hypomagnesemia, natural licorice ingestion, mineralocorticoid excess (primary and secondary hyperaldosteronism, Cushing's syndrome, steroid use), and ureterosigmoidostomy
- **Redistribution (Intracellular Shifts**). Metabolic alkalosis (each 0.1 increase in pH lowers serum K^+ approximately 0.5–1.0 mEq/L, due to intracellular shift of K^+), insulin administration, beta-adrenergic agents, familial periodic paralysis, treatment of megaloblastic anemia

Symptoms

- Muscle weakness, cramps, tetany
- Polyuria, polydipsia

Signs

- Decreased motor strength, orthostatic hypotension, ileus
- ECG changes, such as flattening of T waves, "U" wave becomes obvious (U wave is the upward deflection after the T wave.)

Treatment: The therapy depends on the cause.

- A history of hypertension, GI symptoms, or use of certain medications may suggest the diagnosis.
- A 24-h urine for potassium may be helpful if the diagnosis is unclear. Levels <20 mEq/d suggest extrarenal/redistribution, >20 mEq/d suggest renal losses.

- A serum potassium level of 2 mEq/L (mmol/L) probably represents a deficit of at least 200 mEq (mmol) in a 70-kg adult; to change potassium from 3 mEq/L (mmol/L) to 4 mEq/L (mmol/L) takes about 100 mEq (mmol) of potassium in a 70-kg adult.
- Treat underlying cause.
- Hypokalemia potentiates the cardiac toxicity of digitalis. In the setting of digoxin use, hypokalemia should be aggressively treated.
- Treat hypomagnesemia if present. It will be difficult to correct hypokalemia in the presence of hypomagnesemia.
- **Rapid Correction.** Give KCl IV. Monitor heart with replacement >20 mEq/h. IV potassium can be painful and damaging to veins.

Patient <40 kg: 0.25 mEq/kg/h × 2 h
Patient >40 kg: 10–20 mEq/h × 2 h
Severe [<2 mEq/L (mmol/L)]: Maximum 40 mEq/h IV in adults
In all cases check a stat potassium following each 2–4 h of replacement.

- **Slow Correction.** Give KCl orally (see also Table 22–8, page 626) for potassium supplements).

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Adult: 20–40 mEq two to three times a day (bid or tid)
Pediatric patients: 1–2 mEq/kg/d in divided doses

Hypercalcemia

- Ca^{2+} > 10.2 mg/dL (2.55 mmol/L)

Mechanisms

- **Parathyroid-Related.** Hyperparathyroidism with secondary bone resorption
- **Malignancy-Related.** Solid tumors with metastases (breast, ovary, lung, kidney), or paraneoplastic syndromes, (squamous cell, renal cell, transitional cell carcinomas, lymphomas, and myeloma)
- **Vitamin-D-Related.** Vitamin D intoxication, sarcoidosis, other granulomatous disease
- **High Bone Turnover.** Hyperthyroidism, Paget's disease, immobilization, vitamin A intoxication
- **Renal Failure.** Secondary hyperparathyroidism, aluminum intoxication
- **Other.** Thiazide diuretics, milk–alkali syndrome, exogenous intake

Symptoms

- Stones (renal colic) bones (osteitis fibrosa), moans (constipation), and groans (neuropsychiatric symptoms—confusion), as well as polyuria, polydipsia, fatigue, anorexia, nausea, vomiting

Signs

- Hypertension, hyporeflexia, mental status changes
- Shortening of the QT interval on the ECG.

Treatment: Usually emergency treatment if patient is symptomatic and Ca^{+2} >13 mEq/L (3.24 mmol/L)

- Use saline diuresis: D_5NS at 250–500 mL/h.

- Give furosemide (Lasix) 20–80 mg or more IV (saline and Lasix will treat most cases).
- Euvolemia or hypervolemia must be maintained. Hypovolemia results in calcium reabsorption.
- **Other Second-Line Therapies:**

Calcitonin 2–8 IU/kg IV or SQ q6–12h if diuresis has not worked after 2–3 h
Pamidronate 60 mg IV over 24 h (one dose only)
Gallium nitrate 200 mg/m^2 IV infusion over 24 h for 5 d
Plicamycin 25 µg/kg IV over 2–3 h (use as last resort—very potent)
Corticosteroids. Hydrocortisone 50–75 mg IV every 6 h.
Consider hemodialysis.

- **Chronic Therapy:**

Treat underlying condition, discontinue contributing medications (ie, thiazides).
Oral medications (prednisone 30 mg PO bid or phosphorus/potassium/sodium supplement [Neutra-Phos] 250–500 mg PO qid) can be effective in chronic therapy for such diseases as breast cancer or sarcoidosis.

Hypocalcemia

- Ca^{2+} < 8.4 mg/dL (2.1 mmol/L)

Mechanisms: Decreased albumin can result in decreased calcium (see discussion on page 61).

- **PTH.** Responsible for the immediate regulation of calcium levels
- **Critical Illness.** Sepsis and other ICU-related conditions can cause decreased calcium because of the fall in albumin often seen in critically ill patients, ionized calcium may be normal.
- **PTH Deficiency.** Acquired (surgical excision or injury, infiltrative diseases such as amyloidosis or hemachromatosis and irradiation) hereditary hypoparathyroidism (pseudo-hypoparathyroidism), hypomagnesemia
- **Vitamin D deficiency.** Chronic renal failure, liver disease, use of phenytoin or phenobarbital, malnutrition, malabsorption (chronic pancreatitis, postgastrectomy)
- **Other.** Hyperphosphatemia, acute pancreatitis, osteoblastic metastases, medullary carcinoma of the thyroid, massive transfusion

Symptoms

- Hypertension, peripheral and perioral paresthesia, abdominal pain and cramps, lethargy, irritability (in infants)

Signs

- Hyperactive DTRs, carpopedal spasm (Trousseau's sign, see page 27).
- Positive Chvostek's sign (facial nerve twitch, can be present in up to 25% of normal adults).
- Generalized seizures, tetany, laryngospasm
- Prolonged QT interval on ECG

Treatment

- **Acute Symptomatic**

100–200 mg of elemental calcium IV over 10 min in 50–100 mL of D_5W followed by an infusion containing 1–2 mg/kg/h over 6–12 h
10% calcium gluconate contains 93 mg of elemental calcium.
10% calcium chloride contains 272 mg of elemental calcium.
Check magnesium levels and replace if low.

- **Chronic**

For renal insufficiency, use vitamin D along with oral calcium supplements (see the following lists) and phosphate-binding antacids (Phospho gel, ALTernaGEL).

Calcium supplements

Calcium carbonate (Os-Cal) 650 mg PO qid (28% calcium)
Calcium citrate (Critical) 950-mg tablets (21% calcium)
Calcium gluconate 500- or 1000-mg tablets (9% calcium)
Calcium glubionate (Neo-Calglucon) syrup 115 mg/5 mL (6.4% calcium)
Calcium lactate 325- or 650-mg tablets (13% calcium)

Hypermagnesemia

- Mg^{2+} > 2.1 mEq/L (mmol/L)

Mechanisms

- **Excess Administration.** Treatment of preeclampsia with magnesium sulfate
- **Renal Insufficiency.** Exacerbated by ingestion of magnesium-containing antacids
- **Others.** Rhabdomyolysis, adrenal insufficiency

Symptoms and Signs

- 3–5 mEq/L(mmol/L): Nausea, vomiting, hypotension
- 7–10 mEq/L (mmol/L): Hyperreflexia, weakness, drowsiness
- >12 mEq/L (mmol/L): Coma, bradycardia, respiratory failure

Treatment: Clinical hypermagnesemia requiring therapy is infrequently encountered in the patient with normal renal function.

- Calcium gluconate: 10 mL of 10% solution (93 mg elemental calcium) over 10–20 min in 50–100 mL of D_5W given IV to reverse symptoms (useful in patients being treated for eclampsia).
- Stop magnesium-containing medications (hypermagnesemia is most often encountered in patients in renal failure on magnesium-containing antacids).
- Insulin and glucose as for hyperkalemia (page 186). Furosemide and saline diuresis
- Dialysis

Hypomagnesemia

- Mg^{2+} <1.5 mEq/L (mmol/L)

Mechanisms

- **Decreased Intake or Absorption.** Malabsorption, chronic GI losses, deficient intake (alcoholics), TPN without adequate supplementation
- **Increased Loss.** Diuretics, other medications (gentamicin, cisplatin, amphotericin B, others), RTA, diabetes mellitus (especially DKA), alcoholism, hyperaldosteronism, excessive lactation
- **Other.** Acute pancreatitis, hypoalbuminemia, vitamin D therapy.

Symptoms

- Weakness, muscle twitches, asterixis
- Vertigo
- Symptoms of hypocalcemia (hypomagnesemia may cause hypocalcemia and hypokalemia)

Signs

- Tachycardia, tremor, hyperactive reflexes, tetany, seizures
- ECG may show prolongation of the PR, QT, and QRS intervals as well as ventricular ectopy, sinus tachycardia

Treatment

- **Severe: Tetany or Seizures**

Monitor patient with ECG in ICU setting.
2 g magnesium sulfate in D_5W infused over 10–20 min. Follow with magnesium sulfate: 1 g/h for 3–4 h follow DTR and levels. Repeat replacement if necessary.
These patients are often hypokalemic and hypophosphatemic as well and should be supplemented.
Hypocalcemia may also result from hypomagnesemia.

- **Moderate**

Mg^{2+} <1.0 mg/dL but asymptomatic
Magnesium sulfate: 1 g/h for 3–4 h, follow TR and levels and repeat replacement if necessary.

- **Mild**

Magnesium oxide: 1 g/d PO (available over the counter in 140-mg capsules, and in 400- and 420-mg tablets). May cause diarrhea.

Hyperphosphatemia

- PO_4^{-3} > 4.5 mg/dL (1.45 mmol/L)

Mechanisms

- **Increased Intake/Absorption.** Iatrogenic, abuse of laxatives or enemas containing phosphorus, vitamin D, granulomatous disease
- **Decreased Excretion** (Most Common Cause). Renal failure, hypoparathyroidism, adrenal insufficiency, hyperthyroidism, acromegaly, sickle cell anemia
- **Redistribution/Cellular Release.** Rhabdomyolysis, acidosis, chemotherapy-induced tumor lysis, hemolysis, plasma cell dyscrasias

Symptoms and Signs: Mostly related to tetany as a result of hypocalcemia (see page 189) caused by the hyperphosphatemia or metastatic calcification (deposition of calcium phosphate in various soft tissues)

Treatment

- Low-phosphate diet
- Phosphate binders like aluminum hydroxide gel (Amphojel) or aluminum carbonate gel (Basaljel) orally
- Acute, severe cases: Acetazolamide 15 mg/kg q4h or insulin and glucose infusion, dialysis as last resort

Hypophosphatemia

- PO_4^{-3} < 2.5 mg/dL (0.8 mmol/L)

Mechanisms

- **Decreased Dietary Intake.** Starvation, alcoholism, iatrogenic (hyperalimentation without adequate supplementation), malabsorption, vitamin D deficiency, phosphate-binding antacids (ie, ALTernaGEL)
- **Redistribution.** Conditions associated with respiratory or metabolic alkalosis (alcohol withdrawal, salicylate poisoning, etc), endocrine (insulin, catecholamine, etc), anabolic steroids, hyper- or hypothermia, leukemias and lymphomas, hypercalcemia, hypomagnesemia
- **Renal Losses.** RTA, diuretic phase of ATN, hyperparathyroidism, hyperthyroidism, hypokalemia, diuretics, hypomagnesemia, alcohol abuse, diabetes mellitus (poorly controlled)
- **Other.** Refeeding in the setting of severe protein-calorie malnutrition, severe burns, treatment of DKA

Symptoms and Signs: < 1 mg/dL (0.32 mmol/L): Weakness, muscle pain and tenderness, paresthesia, cardiac and respiratory failure, CNS dysfunction (confusion and seizures). rhabdomyolysis, hemolysis, impaired leukocyte and platelet function

Treatment: IV therapy is reserved for severe potentially life-threatening hypophosphatemia (<1.0–1.5 mg/dL) because too rapid correction can lead to severe hypocalcemia. With mild to moderate hypophosphatemia (1.5–2.5 mg/dL), oral replacement is preferred.

- **Severe.** (<1.0–1.5 mg/dL)

Potassium or sodium phosphate. 2 mg/kg (0.08 mM/kg) given IV over 6 h. (**Caution:** Rapid replacement can lead to hypocalcemic tetany.)

- **Mild to Moderate.** (levels > 1.5 mg/dL)

Sodium–potassium phosphate (Neutra-Phos) or potassium phosphate (K-Phos): 1–2 tablets (250–500 mg PO_4 or 8 mM/tablet) PO bid or tid

Sodium phosphate (Fleet's Phospho-soda). 5 mL PO, bid or tid (128 mg PO_4 or 4 mM/mL)

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BLOOD COMPONENT THERAPY

BLOOD BANKING PROCEDURES

T&S or T&H: The blood bank types the patient's blood (ABO and Rh) and screens for antibodies. If a rare antibody is found, the physician will usually be notified, and if it is likely that blood will be needed, the type and screen order may be changed to a type and cross. This usually takes less than 1 h.

T&C: The blood bank types and screens the patient's blood as described in the previous section and matches specific donor units for the patient. The cross-match involves testing the recipient's serum against the donor blood cells.

STAT Requests: The bank sets up blood immediately and usually holds it for 12 h. For routine requests, the blood is set up at a date and time that you specify and usually held for 36 h.

ROUTINE BLOOD DONATION

Voluntary blood donation is the mainstay of the blood system in the United States. Donors must usually be >18 y old, in good health, afebrile. and weigh >110 lb. Donors are usually limited to 1 unit every 8 wk and 6 donations/y. Patients with a history of hepatitis, HB_sAg positivity, insulin-dependent diabetes, IV drug abuse, heart disease, anemia, and homosexual activity are excluded from routine donation. Patients are counseled about high-risk behaviors that may risk others if they have transmissible diseases and donate blood. Donor blood is tested for ABO, Rh, antibody screen, HB_sAg, antihepatitis B core antigen, hepatitis C antibody, anti-HIV-1 and 2, and anti-HTLV-1 and 2.

AUTOLOGOUS BLOOD DONATION

Preadmission autologous blood banking (predeposit phlebotomy) is popular for some patients anticipating elective surgery in which blood may be needed. General guidelines for autologous banking include good overall health status, a hematocrit greater than 34%, and

arm veins that can accommodate a 16-gauge needle. Patients can usually donate up to 1 unit every 3–7 days, until 3–7 days prior to surgery (individual blood banks have their own specifications), depending on the needs of the planned surgery. Iron supplements (eg, ferrous gluconate 325 mg PO tid) are usually given prior to and several months after the donation. The use of erythropoietin is being investigated in this preoperative setting. Units of whole blood can be held for up to 35 days.

DONOR-DIRECTED BLOOD PRODUCTS

This method of donation involves a relative or friend donating blood for a specific patient. This technique cannot be used in the emergency setting because it takes up to 48 h to process the blood for use.

This system has some drawbacks: Relatives may be unduly pressured to give blood, risk factors that would normally exclude the use of the blood (hepatitis or HIV positivity) become problematic, and ultimately the routine donation of blood for emergency transfusion may be adversely affected. These units are usually stored as packed red cells and released into the general transfusion pool 8 h after surgery unless otherwise requested.

IRRADIATED BLOOD COMPONENTS

Transfusion-associated GVHD, a frequently fatal condition, can be minimized through the highly selected irradiation of blood components. Patients who are at risk for GVHD include recipients of donor-directed units or HLA-matched platelets, fetal intrauterine transfusions, and selected immunocompromised and bone marrow recipients.

APHERESIS

Apheresis procedures are used to collect single-donor platelets (**plateletpheresis**) or white blood cells (**leukapheresis**); the remaining components are returned to the donor. **Therapeutic apheresis** is the separation and removal of a particular component to achieve a therapeutic effect (eg, **erythrocytapheresis** to treat polycythemia).

PREOPERATIVE BLOOD SET-UP

Most institutions have established parameters (MSBOS) for setting up blood before procedures. Some typical guidelines are given in Table 10–1 for the number of units of packed red cells or if only a T&S is requested.

EMERGENCY TRANSFUSIONS

Non-cross-matched blood is rarely transfused because most blood banks can do a complete cross-match within 1 h. In cases of massive, exsanguinating hemorrhage, type-specific blood (ABO- and Rh-matched only), usually available in 10 min, can be used. If even this delay is too long, type O, Rh-negative, packed red blood cells can be used as a last resort. When possible, it is generally preferable to support blood pressure with colloid or crystalloid until properly cross-matched blood is available.

BLOOD GROUPS

Table 10–2 gives information on the major blood groups and their relative occurrences. O– is the **"universal donor"** and AB+ is the **"universal recipient."**

TABLE 10–1
Guidelines for Blood Required for Surgical Procedures

Procedure	Number of Units Needed
Amputation (lower extremity)	2
Cardiac procedure (CABG, valve)	4
Cholecystectomy (open and laparoscopic)	T&S
Colon resection	2
Colostomy	T&S
Cystectomy, radical with diversion	4
Esophageal resection	2
Exploratory laparotomy	2
Gastrectomy	2
Gastrostomy	T&S
Hemorrhoidectomy	T&S
Hernia	T&S
Hysterectomy	2
Liver resection	6
Live transplant	6
Mastectomy	T&S
Nephrectomy	2
Pancreatectomy	4
Parathyroidectomy	T&S
Pulmonary resection	2
Radical neck dissection	2
Radical prostatectomy	3—4
Renal transplant	2
Small bowel resection	2
Splenectomy	2
Thyroidectomy	T&S
Tracheostomy	2
Total hip replacement	2
TURP	2
VASCULAR PROCEDURES	
Abdominal aortic aneurysm	6
Aortofemoral bypass	4
Aortoiliac bypass	4
Carotid endarterectomy	T&S
Femoral popliteal bypass	4
Iliofemoral bypass	4
Portacaval shunt	6
Splenorenal shunt	6
Vein stripping	T&S

Abbreviations: CABG = coronary artery bypass graft; T&S = type and screen; TURP = transurethral resection of the prostate.

TABLE 10–2
Blood Groups and Guidelines for Transfusion

Type (ABO/Rh)	Occurrences	Can Usually Receive* Blood From
O+	1 in 3	O (+/–)
O–	1 in 15	O (–)
A+	1 in 3	A (+/–) or O (+/–)
A–	1 in 16	A (–) or O (–)
B+	1 in 12	B (+/–) or O (+/–)
B–	1 in 67	B (–) or O (–)
AB+	1 in 29	AB, A, B, or O (all + or –)
AB–	1 in 167	AB, A, B, or O (all –)

*First choice is always the identical blood type, other acceptable combinations are shown. An attempt is also made to match Rh status of donor and recipient; Rh negative can usually be given to an RH+ recipient safely

BASIC PRINCIPLES OF BLOOD COMPONENT THERAPY

Table 10–3 provides some common indications and uses for transfusion products. The following are the basic transfusion principles for adults.

Red Cell Transfusions

Acute Blood Loss: Normal, healthy individuals can usually tolerate up to 30% blood loss without need for transfusion; patients may manifest tachycardia, mild hypotension without evidence of hypovolemic shock. Replace loss with volume (IV fluids, etc) replacement.

- Hgb >10 g/dL, rarely needs transfusion.
- Hgb 6–10 g/dL, transfuse based on clinical symptoms, unless patient has severe medical problems (ie, CAD, respiratory conditions).
- Hgb <6 g/dL usually requires transfusion.

"Allowable Blood Loss": Often used to guide acute transfusion in the operating room setting. Losses less than allowable are usually managed with IV fluid replacement.

Weight in kg x 0.08 = Total blood volume

Total volume x 0.3 = Allowable blood loss (assumes normal hemoglobin)

Example: A 70-kg adult

Estimated allowable blood loss = 70 x 0.08 = 5600 mL x 0.3 = 1680 mL

Chronic Anemia: Common in certain chronic conditions such as renal failure, rarely managed with blood transfusion; typically managed with pharmacologic therapy (eg, erythropoietin). However, transfusion is generally indicated if Hgb < 6 g/dL or in the face of symptoms due to low hemoglobin.

TABLE 10–3
Blood Bank Products

Product	Description	Common Indications
Whole blood (see also page 196)	No elements removed 1 unit = 450 mL ± 45 mL (HCT ≈ 40%) Contains RBC, WBC, plasma and platelets (WBC & platelets may be nonfunctional) Deficient in factors V & VII	Not for routine use Acute, massive bleeding Open heart surgery Neonatal total exchange
Packed Red Cells (PRBC) (see also page 196)	Most plasma, WBC, platelets removed; unit = 250–300 mL. (HCT ≈ 75%) 1 unit should raise HCT 3%	Replacement in chronic and acute blood loss, GI bleeding, trauma
Universal Pedi-Packs	250–300 mL divided into 3 bags Contains red cells, some white cells, some plasma and platelets	Transfusion of infants
Leukocyte-Poor (Leukocyte-reduced) Red Cells	Most WBC removed by filtration to make it less antigenic $<5 \times 10^6$ WBC, few platelets, minimal plasma 1 unit = 200–250 mL	Potential renal transplant patients Previous febrile transfusion reactions Patients requiring multiple transfusions (leukemia, etc.)
Washed RBCs	Like leukocyte-poor red cells, but WBC almost completely removed $<5 \times 10^8$ WBC, no plasma 1 unit = 300 mL	As for leukocyte-poor red cells, but very expensive and much more purified

(*continued*)

TABLE 10–3 (Continued)

Product	Description	Common Indications
Granulocytes (pheresis)	1 unit = ≈220 mL Some RBC, >1 × 10^{10} PMN/unit, Lymphocytes, platelets	See page 194
Platelets (see also page 201)	1 "pack" should raise count by 5000–8000 "6-pack" means a pool of platelets from 6 units of blood	Decreased production or destruction (ie, aplastic anemia, acute leukemia, postchemo, etc) Counts <5000–10,000 (risk of spontaneous hemorrhage) must transfuse
	1 pack = about 50 mL >5 × 10^{10} platelets unit, contains RBC, WBC	Counts 10,000–30,000 if risk of bleeding (headache, GI losses, contiguous petechiae) or active bleeding Counts <50,000 if life-threatening bleed Prophylactic transfusion >20,000 for minor surgery or >50,000 for major surgery Usually not indicated in ITP or TTP unless life-threatening bleeding or preoperatively
Platelets, pheresis	>3 × 10^{10} platelets/unit 1 unit = 300 mL	See Platelets, may be HLA matched
Platelets, leukocyte-reduced	As above, but <5 × 10^{6} WBC/unit	See Platelets, may decrease febrile reactions and CMV transmission, alloimmunization to HLA antigens
Cryoprecipitated Antihemophilic Factor ("Cryo")	Contains factor VIII, factor XIII, von Willebrand's factor, and fibrinogen 1 unit = 10 mL	Hemophilia A (factor VII deficiency), when safer factor VIII concentrate not available; von Willebrand's disease, fibrinogen deficiency, fibrin surgical glue

(*continued*)

TABLE 10–3
(Continued)

Product	Description	Common Indications
Fresh-Frozen Plasma (FFP)	Contains factors II, VII, IX, X, XI, XII, XIII and heat-labile V and VII About 1 h to thaw 150–250 mL (400–600 mL if single-donor pheresis)	Emergency reversal of Coumadin Massive transfusion (>5 L in adults) Hypoglobulinemia (IV immune globulin preferred) Suspected or documented coagulopathy (congenital or acquired) with active bleeding or before surgery) Clotting factor replacement when concentrate unavailable Not recommended for volume replacement If PT <22 s or PTT <70 s, 1 unit is usually sufficient
Single Donor Plasma	Like FFP, but lacks factors V and VIII About 1 h to thaw; 150–200 ml	No longer routinely used for plasma replacement Stable clotting factor replacement Coumadin reversal, hemophilia B (Christmas disease)
Rho Gam (Rho D immune globulin)	Antibody against Rh factor (volume = 1 mL)	Rh-mother with Rh+ baby, within 72 h of delivery, to prevent hemolytic disease of newborn; autoimmune thrombocytopenia

(*continued*)

TABLE 10–3 (Continued)

Product	Description	Common Indications
ALL OF THE AFOREMENTIONED ITEMS USUALLY REQUIRE A "CLOT TUBE" TO BE SENT FOR TYPING. THE FOLLOWING PRODUCTS ARE USUALLY DISPENSED BY MOST H OSPITAL PHARMACIES AND ARE USUALLY ORDERED AS A MEDICATION.		
Factor VII (purified antihemophilic factor)	From pooled plasma, pure Factor VIII Increased hepatitis risk	Routine for hemophilia A (factor VII deficiency)
Factor IX concentrate (prothrombin complex)	Increased hepatitis risk Factors II, VII, IX, and X Equivalent to 2 units of plasma	Active bleeding in Christmas disease (Hemophilia B or factor IX deficiency)
Immune serum globulin	Precipitate from plasma "gamma globulin"	Immune globulin deficiency Disease prophylaxis (hepatitis A, measles, etc.)
5% Albumin or 5% plasma protein fraction	Precipitate from plasma (see Drugs, Chapter 22)	Plasma volume expanders in acute blood loss
25% Albumin	Precipitate from plasma	Hypoalbuminemia, volume expander, burns Draws extravascular fluid into circulation

Abbreviations: RBC = red blood cells; WBC = white blood cells; HCT = hematocrit; GI = gastrointestinal; ITP = idiopathic thrombocytopenic purpura; TTP = thrombotic thrombocytopenic purpura; HLA = histocompatibility locus antigen; PT = prothrombin time; PTT = partial thromboplastin time.

RBC Transfusion Formula: As a guide, one unit of packed RBCs raises the HCT by 3% (Hgb 1 g/dL) in the average adult. To roughly determine the volume of whole blood or packed red cells needed to raise a hematocrit to a known amount, use the following formula:

$$\text{Volume of cells} = \frac{\text{Total blood volume of patient} \times (\text{Desired HCT} - \text{Actual HCT})}{\text{HCT of transfusion product}}$$

where total blood volume is 70 mL/kg in adults, 80 mL/kg in children; the HCT of packed cells is approximately 70, and that of whole blood is approximately 40.

White Cell Transfusions

- The use of white cell transfusions is rarely indicated today due to the use of genetically engineered myeloid growth factors such as GM-CSF (see Chapter 22)
- Indicated for patients being treated for overwhelming sepsis and severe neutropenia (<500 PMN/μL)

Platelet Transfusions

For indications, see Table 10–3

Platelet Transfusion Formula: Platelets are often transfused at a dose of 1 unit/10 kg of body weight. After administration of 1 unit of multiple-donor platelets, the count should rise 5000–8000/mm^3 within 1 h of transfusion and 4500 mm^3 within 24 h. Normally, stored platelets that are transfused survive in vivo 6–8 d after infusion. Clinical factors (DIC, alloimmunization) can significantly shorten these intervals. To standardize the corrected platelet count to an individual patient, use the CCI. Measure the platelet count immediately before and 1 h after the platelet infusion. If the correction is less than expected, do a workup to determine the possible cause (antibodies, splenomegaly, etc). Many institutions are now using platelet pheresis units. One platelet pheresis unit has enough platelets to raise the count by 6000–8000/mm^3. Using a single unit has the advantage of exposing the patient to only one donor versus possibly six to eight. This limits HLA exposures and reduces the risks of infection transmission.

$$\text{CCI} = \frac{\text{Posttransfusion platelet count} - \text{Pretransfusion count} \times \text{Body surface area } (m^2)}{\text{Platelets given} \times 10^{11}}$$

BLOOD BANK PRODUCTS

Table10–3 describes products used in blood component therapy and gives recommendations for use of these products.

TRANSFUSION PROCEDURES

1. Draw a clot tube (red top), and sign the lab slips to verify that the sample came from the correct patient. The patient should be identified by referring to the ID bracelet and asking the patient, if able, to state his or her name. Place the patient's name, hospital number, date, and your signature on the tube label. **Prestamped labels are not accepted by most blood banks.**
2. Obtain the patient's informed consent by discussing the reasons for the transfusion and the potential risks and benefits from it. Follow hospital procedure regarding the need

for the patient to sign a specific consent form. At most hospitals, chart documentation is usually all that is necessary.

3. When the blood products become available, ensure good venous access for the transfusion (18-gauge needle or larger is preferred in an adult).
4. Verify the information on the request slip and blood bag with another person, such as a nurse, and with the patient's ID bracelet. Many hospitals have defined protocols for this procedure; check your institutional guidelines.
5. Mix blood products to be transfused with isotonic (0.9%) NS only. Using hypotonic products such as D_5W may result in hemolysis of the blood in the tubing. Lactated Ringer's should NOT be used because the calcium could chelate the anticoagulant citrate.
6. Red cells are infused through a special filter. Specific leukocyte reduction filters are available and may be used in very specific circumstances (febrile transfusion reactions, to reduce potential CMV transmission, to reduce risk of alloimmunization to WBC antigens).
7. When transfusing large volumes of packed red cells (>10 units), monitor coagulation, Mg^{2+}, Ca^{2+}, and lactate levels. It is usually necessary to also transfuse platelets and FFP. Also, a calcium replacement is sometimes needed because the preservative used in the blood is a calcium binder and hypocalcemia can result after large amounts of blood are transfused. Also, for massive transfusions (usually >50 mL/min in adults and 15 mL/min in children), the blood should be warmed to prevent hypothermia and cardiac arrhythmias.

TRANSFUSION REACTIONS

Several types of transfusion reactions are possible:

1. **Acute intravascular hemolysis.** Over 85% of adverse hemolytic reactions involving the transfusion of RBCs result from clerical error.. Usually caused by ABO incompatible transfusion. Can result in renal failure (<1/250,000 units transfused).
2. **Nonhemolytic febrile reaction.** Usually mild, fever, chills, rigors, mild dyspnea. Due to a reaction to donor white cells (HLA) and more common in patients who have had multiple transfusions or delivered several children. (≅2–3:100 units transfused)
3. **Mild allergic reaction.** Urticaria or pruritus can be caused by sensitization to plasma proteins in transfusion product. (≅1/100 units transfused)
4. **Anaphylactic reaction.** Acute hypotension, hives, abdominal pain and respiratory distress; seen mostly in IgA-deficient recipients. (<1/1000 units transfused)
5. **Sepsis.** Usually caused by transfusion of a bacterially infected transfusion product, with platelets becoming an increasing risk. *E. coli, Pseudomonas, Serratia, Salmonella,* and *Yersinia* some of the more commonly implicated bacteria. (<1/500,000 RBC units transfused, 1/12,000 platelet units transfused)
6. **Acute lung injury.** Fever, chills, and life-threatening respiratory failure; probably induced by antibodies from donor against recipient white cells. (<1/5000 units transfused)
7. **Volume overload.** Usually due to excess volume infusion; can exacerbate CHF.

Detection of a Transfusion Reaction

1. Spin an HCT to look for a pink plasma layer (indicates hemolysis).
2. Order serum for free hemoglobin and serum haptoglobin assays (haptoglobin decreases with a reaction) and urine for hemosiderin levels. Obtain a stat CBC to determine the presence of schistocytes, which can be present with a reaction.

3. If you suspect acute hemolysis, request a DIC screen (PT, PTT, fibrinogen, and fibrin degradation products).

Treatment of Transfusion Reactions

1. Stop the blood product immediately, and notify the blood bank.
2. Keep the IV line open with NS, and monitor the patient's vital signs and urine output carefully.
3. Save the blood bag, and have the lab verify the type and cross-match. Verify that the proper patient received the proper transfusion. Redraw blood samples for the blood bank.
4. Make specific recommendations, using the following guidelines; modifications should be based on clinical judgment.

- **Nonhemolytic febrile reaction:** Antipyretics can be used and the transfusion continued with monitoring. Use leukocyte-washed transfusion products in future.
- **Mild allergic reaction:** Administer Benadryl (25–50 mg IM/PO/IV). Resume the transfusion carefully only if the patient improves promptly.
- **Anaphylactic reaction.** Terminate transfusion, monitor closely, give antihistamines (Benadryl 25–50 mg IM/PO/IV), corticosteroids (Solu-Medrol 125 mg IV, 2 mg/kg Peds IV), epinephrine (1:1000 0.3–0.5 mL SQ adults, 0.1 mL/kg Peds), and pressors as needed. Premedicate (antihistamines, steroids) for future transfusions; use only leukocyte-washed red cells.
- **Acute lung injury.** Give ventilatory support as needed; use only leukocyte-washed red cells for future transfusions.
- **Sepsis:** Culture the transfusion product and specimens from the patient; treat sepsis empirically by monitoring and administering pressors and antibiotics (third/fourth-generation cephalosporin or piperacillin/tazobactam along with an aminoglycoside) until cultures return.
- **Volume overload.** Employ a slow rate of infusion with selective use of diuretics.
- **Acute intravascular hemolysis.** Prevent acute renal failure. Place a Foley catheter, monitor the urine output closely, and maintain a brisk diuresis with plain D_5W, mannitol (1–2 g/kg IV), furosemide (20–40 mg IV), and/or dopamine (2–10 µg/kg/min IV) as needed. Consider alkalinization of the urine with bicarbonate (see Chapter 22). Beware of DIC. A renal and hematology consult are usually indicated with a severe hemolytic reaction. Support pressure as needed (fluids, vasopressors such as dopamine).

TRANSFUSION-ASSOCIATED INFECTIOUS DISEASE RISKS

Hepatitis

Incidence of posttransfusion hepatitis for Hep B is 1:63,000 units transfused and for Hep C is 1:103,000 units transfused. Anicteric hepatitis is much more common than hepatitis with jaundice. Screening of donors for HB_sAg and hepatitis C has greatly reduced these forms of hepatitis. Historically, the greatest risk is with pooled factor products (concentrates of Factor VIII). Use of albumin and globulins involves no risk of hepatitis.

HIV

Incidence is <1:600,000 units transfused. Antibody testing is routinely performed on the donor's blood. A positive antibody test means that the donor may be infected with the HIV virus; a confirmatory Western blot is necessary. Do a follow-up test on any donor found to

be HIV-positive because false-positives can occur. With screening, AIDS transmission has decreased. Because there is a delay of 22 d between HIV exposure and the development of the HIV antibody, a potential risk of HIV transmission exists even with blood from a donor who is HIV-negative. Newer molecular detection methods should decrease this to approximately 11 d.

CMV

Incidence in donors is very high (approaches 100% in many series), but clinically represents a major risk mostly for immunocompromised recipients and neonates. Leukocyte filters can reduce the risk of transmission if procedures are strictly followed.

HTLV-I, II

Very rare (<<1/641,000 units transfused). Use of leukocyte filters can decrease risk of transmission of HTLV.

Bacteria and Parasites

Sepsis due to bacteria is discussed on page 414. Parasites are very rarely transmitted, but careful donor screening is necessary, especially in endemic regions (eg, Chagas' disease in Central America).

11

DIETS AND CLINICAL NUTRITION

HOSPITAL DIETS

The most commonly ordered standard hospital diets and their indications are listed in Table 11–1, page 206. The vast majority of patients admitted to the hospital can be given one of these hospital diets without any specific supplementation or modification. Most hospitals have diet manuals available for reference, and registered dietitians are usually on staff for nutritional consultation. A physician order for diet instruction by a clinical dietitian is recommended for all patients being discharged with a therapeutic or modified diet.

NUTRITIONAL ASSESSMENT

Nutritional screening should be incorporated into the history and physical evaluation of all patients. Identifying patients at nutrition risk is crucial because malnutrition is prevalent among hospitalized patients and has been associated with adverse clinical outcomes. Situations that predispose a patient to malnutrition include recent and continuing nausea, vomiting, diarrhea, inability to feed oneself, inadequate food intake (cancer-related, others), decreased nutrient absorption or utilization, and increased nutrient losses and nutritional requirements. If needed, detailed nutritional assessment may be needed for some patients and is discussed in the following section.

Although many patients are admitted to the hospital in a nutritionally depleted state, some patients become malnourished during their hospital stay. According to guidelines from the American Society for Parenteral and Enteral Nutrition, "patients should be considered malnourished or at risk of developing malnutrition if they have inadequate nutrient intake for 7 days or more or if they have a weight loss of 10% or more of their preillness body weight."

Formal evaluation is often necessary to identify patients at nutritional risk and to provide a baseline to assess whether therapeutic goals are being achieved with specialized nutritional support. The patient's history is useful in evaluating weight loss; dietary intolerance, including that for glucose or lactose; and disease states that may influence nutritional tolerance. Anthropometric evaluations include comparisons of actual body weight to ideal and usual body weight. Other anthropometric measurements, such as MAMC and TCF, have much

TABLE 11–1
Hospital Diets

Diet	Guidelines	Indications
House/regular	Adequate in all essential nutrients All foods are permitted Can be modified according to patient's food preferences	No diet restrictions or modifications
Mechanical soft	Includes soft-textured or ground foods that are easily masticated and swallowed	Decreased ability to chew or swallow Presence of oral mucositis or esophagitis May be appropriate for some patients with dysphagia
Pureed	Includes liquids as well as strained and pureed foods	Inability to chew or swallow solid foods Presence of oral mucositis or esophagitis May be appropriate for some patients with dysphagia
Full liquid	Includes foods that are liquid at body temperature Includes milk/milk products Can provide approximately: 2500–3000 mL fluid 1500–2000 Cal 60–80 g high-quality protein <10 g dietary fiber 60–80 g fat per day	May be appropriate for patients with severely impaired chewing ability Not appropriate for a lactase-deficient patient unless commercially available lactase enzyme tablets are provided
Clear liquid	Includes foods that are liquid at body temperature Foods are very low in fiber lactose-free virtually fat-free Can provide approximately: 2000 mL fluid 400–600 Cal	Ordered as initial diet in the transition from NPO to solids Used for bowel preparation before certain medical or surgical procedures For management of acute medical conditions warranting minimized biliary contraction or pancreatic exocrine secretion

(*continued*)

TABLE 11–1 (Continued)

Diet	Guidelines		Indications
Clear liquid (continued)	<7 g low-quality protein <1 g dietary fiber <1 g fat/day This diet is inadequate in all nutrients and should not be used >3 d without supplementation		
Low-fiber	Foods that are low in indigestible carbohydrates Decreases stool volume, transit time, and frequency		Management of acute radiation enteritis and inflammatory bowel disease when narrowing or stenosis of the gut lumen is present
Carbohydrate controlled diet (ADA)	Calorie level should be adequate to maintain or achieve desirable body weight Total carbohydrates are limited to 50–60% of total calories Ideally fat should be limited to ≈30% of total calories		Diabetes mellitus
Acute renal failure	Protein (g/kg DBW) Calories Sodium (g/day) Potassium (g/day) Fluid (mL/day)	0.6 35–50 1–3 Variable Urine output + 500	For patients in renal failure who are not undergoing dialysis
Renal failure/ Hemodialysis	Protein (g/kg DBW) Calories (per kilogram DBW) Sodium (g/d) Potassium (g/d) Fluid (mL/d)	1.0–1.2 30–35 1–2 1.5–3 Urine output + 500	For patients in renal failure on hemodialysis

(*continued*)

TABLE 11–1 (Continued)

Diet	Guidelines	Indications
Peritoneal dialysis	Protein (g/kg DBW) 1.2–1.6 Calories (per kilogram DBW) 25–35 Sodium (g/d) 3—4 Potassium (g/d) 3–4 Fluid (mL/d) Urine output + 500	For patients in renal failure on peritoneal dialysis
Liver failure	In the absence of encephalopathy do not restrict protein In the presence of encephalopathy initially restricted protein to 40–60 g/d then liberalize in increments of 10 g/d as tolerated Sodium and fluid restriction should be specified based on severity of ascites and edema	Management of chronic liver disorders
Low lactose/ Lactose-free	Limits or restricts mild products Commercially available lactase enzyme tablets are available on the market	Lactase deficiency
Low-fat	<50 g total fat per day	Pancreatitis Fat malabsorption
Fat/cholesterol restricted	Total fat >30% total calories Saturated fat limited to 10% of calories <300 mg cholesterol <50% calories from complex carbohydrates	Hypercholesterolemia
Low-sodium	Sodium allowance should be as liberal as possible to maximize nutritional intake yet control symptoms "No-added salt" is 4 g/d; no added salt or highly salted food; 2 g/d avoids processed foods (ie, meats) <1 g/d is unpalatable and thus compromises adequate intake	Indicated for patients with hyptertension, ascites, and edema associated with the underlying disease

interobserver variability and are generally not useful unless performed by an experienced evaluator. Absolute lymphocyte count is sometimes used as a marker of visceral proteins and immunocompetence. Visceral protein markers, such as prealbumin and transferrin, may be helpful in evaluating nutritional insult as well as catabolic stress. Although the most commonly quoted laboratory parameter of nutritional status is albumin, the albumin concentration often reflects hydration status and metabolic response to injury (ie, the acute phase response) more than the nutritional state of the patient, especially in patients with intravascular volume deficits. Due to its long half-life, albumin may be normal in the malnourished patient. Prealbumin is superior as an indicator of malnutrition only because of its shorter half-life. Use of these serum proteins as indicators of malnutrition is subject to the same limitation, however, because they are all affected by catabolic stress. Table 11–2, page 210, lists the parameters for identifying potentially malnourished patients; however, no single criterion should be used to assess a patient's nutritional status. Patients can generally be classified as mildly, moderately, or severely nutritionally depleted based on these parameters.

NUTRITIONAL REQUIREMENTS

Determining the patient's nutritional requirements is one of the first steps in prescribing a modified diet order or supplementation for a patient. The following list provides guidelines for estimating nutritional needs. Monitoring the patient's progress and adjusting nutritional goals on the basis of clinical judgment is important for ensuring that the patient's specific needs are being met. Caloric needs can be determined by one of two means: the Harris–Benedict BEE and the "rule of thumb" method.

Caloric Needs

A patient's caloric needs can be calculated by the following methods:

Harris–Benedict BEE

For men:

$$\text{BEE} = 66.47 + 13.75\ (w) + 5.00\ (h) - 6.76\ (a)$$

For women:

$$\text{BEE} = 655.10 + 9.56\ (w) + 1.85\ (h) - 4.689\ (a)$$

where w = weight in kilograms; h = height in centimeters; and a = age in years.

After the BEE has been determined from the Harris–Benedict equation, the patient's total daily maintenance energy requirements are estimated by multiplying the BEE by an activity factor and a stress factor.

$$\text{Total energy requirements} = \text{BEE} \times \text{Activity factor} \times \text{Stress factor}$$

Use the following correction factors:

Activity Level	**Correction Factor**
Bedridden	1.2
Ambulatory	1.3
Level of Physiologic Stress	**Correction Factor**
Minor operation	1.2
Skeletal trauma	1.35
Major sepsis	1.60
Severe burn	2.10

TABLE 11–2
Parameters Used to Identify the Malnourished Patient

Parameters	Measurement/Interpretation	Usefulness/Limitations
ANTHROPOMETRIC MEASUREMENT		
Actual body weight (ABW) compared with ideal body weight (IBW)	"Rule-of-thumb" method to determine IBW Step 1 For men: IBW (lb) = 106 lb for 5 ft of height, plus 6 lb for each inch of height over 5 ft For women: IBW (lb) = 100 lb for first 5 ft of height plus an additional 5 lb for each inch over 5 ft Step 2 $\% \text{ IBW} = \frac{\text{ABW}}{\text{IBW}} \times 100$ % of IBW 90–110 Normal nutritional status 80–90 Mild malnutrition 70–80 Moderate malnutrition <70 Severe malnutrition	
Actual body weight compared with usual body weight (UBW)	$\% \text{ UBW} = \frac{\text{ABW}}{\text{UBW}} \times 100$ % of UBW 85–95% Mild malnutrition 75–84% Moderate malnutrition <75% Severe malnutrition	

(*continued*)

TABLE 11–2
(Continued)

Parameters	Measurement/Interpretation		Usefulness/Limitations
BIOCHEMICAL PARAMETERS			
Serum albumin	3.5–5.2 g/dL 2.8–3.4 g/dL 2.1–2.7 g/dL <2 g/dL	Normal Mild depletion Moderate depletion Severe depletion	Routinely available Valuable prognostic indicator: depressed levels predict increased mortality and morbidity Inexpensive Large body stores and relatively long half-life (approximately 20 d) limit usefulness in evaluating short-term changes in nutritional status
Transferrin (TFN)	200–300 mg/dL 150–200 mg/dL 100–150 mg/dL <100 mg/dL TFN can be calculated from the total iron-binding capacity (TIBC) as follows: TFN = (0.8 × TIBC) – 43	Normal Mild visceral depletion Moderate depletion Severe depletion	Frequently available Depressed levels predict increased mortality and morbidity Smaller body pool and shorter half-life (8–10 days) than serum albumin If TFN is calculated from TIBC, levels will be increased with the presence of iron deficiency or chronic blood loss Levels are increased during pregnancy Levels are decreased if iron stores are increased as a result of hemosiderosis, hemochromatosis, thalassemia

(*continued*)

TABLE 11–2
(Continued)

Parameters	Measurement/Interpretation		Usefulness/Limitations
Prealbumin	16–30 mg/dL 10–15 mg/dL 5–10 mg/dL <5 mg/dL	Normal Mild depletion Moderate depletion Severe depletion	Half-life is 2 d. Thus is more sensitive indicator of acute change in nutritional status than is albumin or TFN Not routinely available Levels are quickly depleted after trauma or acute infection. Also decreased in response to cirrhosis, hepatitis, and dialysis, and therefore, should be interpreted with caution
Absolute lymphocyte count (calculated as WBC × % lymphocytes)	1400–2000 900–1400 <900	Mild depletion Moderate depletion Severe depletion	May not be valid in cancer patients. Not used by some nutritionists

"Rule of Thumb" Method

- Maintenance of the patient's nutritional status without significant metabolic stress requires 25–30 Cal/kg body weight/d.
- Maintenance needs for the hypermetabolic, severely stressed patient or for supporting weight gain in the underweight patient without significant metabolic stress requires 35–40 Cal/kg body weight/d.
- Greater than 40 Cal/kg body weight/d may be needed to meet the needs of severely burned patients.

Protein Needs

Maintenance requirements for nonstressed patients are 0.8 g of protein per kilogram of body weight. Repletion requirements of the nutritionally compromised patient are 1.2–2.5 g of protein per kilogram of body weight.

DETERMINING THE ROUTE OF NUTRITIONAL SUPPORT

Once nutritional support is indicated, the route for administration is chosen. Enteral supplementation by mouth or tube and parenteral nutrition are the main routes for providing nutritional support.

Enteral Supplementation and Tube Feeding

Enteral nutrition encompasses both supplementation by mouth and feeding by tube into the GI tract. If the patient's oral intake is inadequate, every effort should be made to increase intake by providing nutrient-dense foods, frequent feedings, or oral supplements. If such attempts are unsuccessful, tube feeding may be indicated. In addition, patients who have a functioning GI tract but for whom oral nutrition intake is contraindicated should be considered for tube feedings.

If the GI tract is functioning and can be used safely, tube feedings should be ordered instead of parenteral nutrition when nutrition support is necessary because it

- Is more easily absorbed physiologically
- Is associated with fewer complications than TPN
- Maintains the gut barrier to infection
- Maintains the integrity of the GI tract
- Is more cost-effective than TPN
- Contraindications to tube feeding can be found in Table 11–3.

Parenteral Nutrition

Parenteral nutrition usually offers no advantage to the patient with a functioning GI tract. Because it does not achieve greater anabolism nor provide greater control over a patient's nutritional regimen, parenteral nutrition is indicated only when the enteral route is not usable; therefore, the following rule applies: If the gut works, use it.

Some patients, because of their disease states, cannot be fed enterally and require parenteral feedings. Enteral nutrition is to be avoided in the situations noted in Table 11–3. TPN is typically used in these patients and is discussed in detail in Chapter 12.

Although parenteral nutrition can be given either via central veins (TPN) or by peripheral veins (PPN), the tonicity of the fluid required to administer all nutritional requirements

TABLE 11–3
Contraindications to Tube Feeding

Complete bowel obstruction
GI bleeding
High-output (>500 mL/d) enterocutaneous fistula or fistula not located in the proximal or distal GI tract
Hypovolemic or septic shock
Ileus
Inability to obtain safe enteral tube feeding access
Poor prognosis not warranting invasive nutritional support
Severe acute pancreatitis
Severe intractable diarrhea
Severe intractable nausea and vomiting
Severe malabsorption
Anticipated duration of tube feeding therapy <5 d

intravenously requires central administration, and thus PPN may be used as a supplement, but is not adequate to provide all nutritional requirements.

PRINCIPLES OF ENTERAL TUBE FEEDING

The factors involved in choosing the route for enteral nutrition include the projected duration of feeding by this method, GI tract pathophysiology, and the risk for aspiration. Nasally placed tubes are the most frequently used. Patient comfort is maximized by using a small-bore flexible tube. When enteral feedings are started, it is often important to assess gastric residual volumes. The small-bore tubes do not allow for aspiration of residual volumes, however, which may be significant if gastric emptying is questionable. Thus, larger bore tubes are often used to start, and, once feeding tolerance is ensured, the tube is changed to a small-bore tube, which can be left in place comfortably for prolonged periods. Feeding directly into the stomach (as opposed to the bowel) is often preferable because the stomach is the best line of defense against hyperosmolarity. Patients at risk for aspiration require longer tubes into the jejunum or duodenum. Types of feeding tubes and placement procedures are discussed in detail in Chapter 13, page 272.

When long-term feeding is anticipated, a tube enterostomy is usually required. **PEG tubes** can usually be placed without general anesthesia. Patients with tumors, GI obstruction, adhesions, or abnormal anatomy, however, may require open surgical placement. A jejunal feeding tube may be threaded through a PEG for small-bowel feeding. The placement of a needle catheter or Witzel's jejunostomy during surgery generally allows for earlier postoperative feeding with an elemental formulation than waiting for the return of gastric emptying and colonic function.

Enteral Products

A variety of enteral products and tube feedings are available (see Table 11–4, page 215, for some examples). Check the enteral formulary for the specific products available in your facility.

TABLE 11–4
Composition of Some Commonly Available Enteral Formulas

Product	Component (per 100 kcal)						
	kcal/mL	Protein (g)	Fat (g)	Carbohydrates (g)	Na^+ (mEq)	K^+ (mEq)	mOsm/kg
Meal replacements	Require normal proteolytic and lipolytic function. Contain lactose.						
Compleat B	1.00	4.00	4.00	12.0	5.20	3.40	390
Lactose-free	Provides proximal absorption. Requires normal proteolytic and lipolytic function. Low residue.						
Ensure	1.06	3.70	3.70	14.5	3.60	4.0	450
Ensure Plus	1.50	5.50	5.30	19.7	4.90	5.90	600
Isocal	1.06	3.70	3.80	14.4	2.40	2.60	300
Magnacal	2.0	3.5	4.0	12.5	2.20	1.60	590
Osmolite	1.06	3.70	3.80	14.4	2.40	2.60	300
Sustacal	1.00	6.10	2.30	13.8	4.10	5.40	620–700
Travasorb MCT	1.00	4.90	3.30	12.2	1.50	4.50	312
Elemental formulas	Provide rapid proximal absorption. Indicated for pancreatic-biliary dysfunction, selective malabsorption, fistulas, and short bowel syndrome (SBS). Low residue. Nutrients predigested.						
Peptamen	1.0	4.0	3.9	12.7	2.20	3.21	270
Reabilan	1.0	3.15	4.30	13.2	3.05	3.20	350
Reabilan HN	1.33	4.36	4.30	11.9	3.26	3.18	490
Vital HN	1.00	4.20	1.00	18.8	2.70	3.40	450
Vivonex TEN	1.00	3.82	0.28	20.5	2.00	2.00	630
Vivonex	1.00	2.04	0.15	22.6	2.00	3.00	550

(*continued*)

TABLE 11–4 (Continued)

Product	kcal/mL	Protein (g)	Fat (g)	Carbohydrates (g)	Na^+ (mEq)	K^+ (mEq)	mOsm/kg
	Component (per 100 kcal)						
Special metabolic	May require vitamin-mineral supplement if used as principal source of nutrition.						
Amin-Aid	2.00	1.90	4.70	37.3	>1	>1	850
Glucerna	1.0	4.18	5.57	9.37	4.03	4.0	375
Pulmocare	1.5	4.17	6.14	7.04	3.80	2.95	490
Hepatic Aid II	1.17	4.30	3.60	16.8	>1	>1	560
Travasorb Hepatic	1.10	2.90	1.40	20.9	1.9	2.9	690
Travasorb Renal	1.35	2.30	1.80	27.1	>1	>1	590
Fiber-containing	Nutritionally complete tube feeding that may help maintain normal bowel function and useful in patients who demonstrate intolerance to low-residue feedings.						
Enrich	1.1	3.62	3.39	14.3 (1.3 g fiber)	3.35	3.94	480
Jevity	1.06	4.20	3.48	14.4 (1.36 g fiber)	3.81	3.77	310

Note: Formulation of products at the time of publication. Actual components may vary slightly.

To simplify selection, the nutritional components and osmolality of the enteral product are listed and help classify the formulations. The protein component can be supplied as intact proteins, partially digested hydrolyzed proteins, or crystalline amino acids. Each gram of protein provides 4 Cal. The carbohydrate source may be intact complex starches, glucose polymers, or simpler disaccharides such as sucrose. Carbohydrates provide 4 Cal/g. Fat in enteral products is usually supplied as long-chain fatty acids. Some enteral products, however, contain MCTs, which are transported directly in the portal circulation rather than via chyle production. Because MCT oil does not contain essential fatty acids, it cannot be used as the sole fat source. Long-chain fatty acids provide 9 Cal/g, and MCT oil provides 8 Cal/g.

The osmolality of an enteral product is determined primarily by the concentration of carbohydrates, electrolytes, amino acids, or small peptides. The clinical importance of osmolality is often debated. Hyperosmolal formulations, with osmolalities exceeding 450 mOsm/L, may contribute to diarrhea by acting in a manner similar to osmotic cathartics. Hyperosmolal feedings are well tolerated when delivered into the stomach (as opposed to the small bowel) because gastric secretions dilute the feeding before it leaves the pylorus to traverse the small bowel. Thus, feedings administered directly to the small bowel (eg, via feeding jejunostomy) should not exceed 450 mOsm/L.

Oral supplements differ from other enteral feedings in that they are designed to be more palatable so as to improve compliance. Although most enteral products do not contain lactose (Ensure, Osmolite, others), several oral supplements, commonly referred to as "meal replacements" (such as Compleat B) contain lactose and are therefore not appropriate for patients with lactase deficiency and are not normally used for tube feedings.

Based on osmolality and macronutrient content, enteral products can be classified into several categories. Low-osmolality formulas are isotonic and contain intact macronutrients. They usually provide 1 Cal/mL and require approximately 2 L to provide the RDA for vitamins. These products are appropriate for the general patient population and include products such as Ensure.

High-density formulas may provide up to 2 Cal/mL. These concentrated solutions are hyperosmolar and also contain intact nutrients. The RDA for vitamins can be met with volumes of 1500 mL or less. These products are used for volume-restricted patients. Examples are Nutren 2.0 and Ensure Plus HN.

Chemically defined or elemental formulas provide the macronutrients in the predigested state. These formulations are usually hyperosmolar and have poor palatability. Patients with compromised nutrient absorption abilities or GI function may benefit from elemental type feedings. Vivonex and Peptamen are two such products.

Disease-specific (special metabolic) enteral formulas have been developed for various disease states. Products for pulmonary patients, such as Pulmocare, contain a higher percentage of calories from fat to decrease the carbon dioxide load from the metabolism of excess glucose. Patients with hepatic insufficiency may benefit from formulations (eg, Hepatic-Aid II) containing a higher concentration of the branched-chain amino acids and a lower concentration of aromatic amino acids in an attempt to correct their altered serum amino acid profile. Formulas containing only essential amino acids have been marketed for the patient in renal failure (Amin-Aid). A low-carbohydrate, high-fat product for persons with diabetes (Glucerna) is available that also contains fiber to help regulate glucose control. Other fiber-containing enteral feedings are available to help regulate bowel function (Enrich, Jevity). The clinical utility of many of the specialty products remains controversial.

Initiating Tube Feedings

Guidelines for ordering enteral feedings are outlined in Table 11–5, page 218. In summary, when using enteral feedings:

TABLE 11–5
Routine Orders for Enteral Nutrition Administered by Tube Feeding

1. Confirm tube placement. (Usually by x-ray)
2. Elevate head of bed to 30–45 degrees
3. Check gastric residuals in patients receiving gastric feedings. Hold feedings if >1.5–2x infusion rate. Significant residuals should be reinstilled and rechecked in 1 h. If continues to be elevated, hold tube feeding and begin NG suction.
4. Check patient weight 3x/wk.
5. Record strict I&O
6. Request routine laboratory studies

1. Determine nutritional needs.
2. Assess GI tract function and appropriateness of enteral feedings.
3. Determine fluid requirements and volume tolerance based on overall status and concurrent disease states.
4. Select an appropriate enteral feeding product and method of administration.
5. Verify that the regimen selected satisfies micronutrient requirements.
6. Monitor and assess nutritional status to evaluate the need for changes in the selected regimen.

The tube feeding can be given into the stomach (bolus, intermittent gravity drip, or continuous) or into the small intestine by continuous infusion (Table 11–6, page 219). Enteral nutrition is best tolerated when instilled into the stomach because this method produces fewer problems with osmolarity or feeding volumes. The stomach serves as a barrier to hyperosmolarity, thus the use of isotonic feedings is mandated only when instilling nutrients directly into the small intestine. The use of gastric feedings is thus preferable and should be used whenever appropriate. Patients at risk for aspiration or with impaired gastric emptying may need to be fed past the pylorus into the jejunum or the duodenum. Feedings via a jejunostomy placed at the time of surgery can often be initiated on the first postoperative day, obviating the need for parenteral nutrition.

Although enteral nutrition is generally safer than parenteral nutrition, aspiration can be a significant morbid event in the care of these patients. Appropriate monitoring for residual volumes in addition to keeping the head of the bed elevated can help prevent this complication. A "significant residual" may be defined as 1½ times the instillation rate. This can be treated in a number of ways. Any transient postoperative ileus can best be treated by waiting for the ileus to resolve. Metoclopramide or erythromycin may be useful pharmacologic therapy for postop ileus (Chapter 22). Patients who have been tolerating feedings and develop intolerance should be carefully assessed for the cause. Feeding intolerance is characterized by vomiting, abdominal distention, diarrhea, or high gastric residual volumes.

Complications of Enteral Nutrition

Diarrhea: Diarrhea occurs in about 10–60% of patients receiving enteral feedings. The physician must be certain to evaluate the patient for other causes of diarrhea. Formula-related causes include contamination, excessively cold temperature, lactose intolerance, osmolality, and an incorrect method or route of delivery. Eliminate potential causes before using antidiarrheal medications.

TABLE 11–6
Tube Feeding Delivery Methods

Delivery Site/ Indication	Delivery Method	Notes	Suggested Feeding Progression
INTRAGASTRIC Appropriate for alert patients with intact gag and cough reflexes and for those with normal gastric emptying	Bolus	Rapid infusion of formula into the stomach by syringe or other feeding reservoir; generally 240–480 mL of formula is given every 3–6 h Feedings are usually given over a period of 5–15 min Associated symptoms of GI distress, such as bloating, nausea, and distention	Typical starter regimen: 60–120 mL of full-strength formula is generally provided Typical feeding progression: Volume of formula provided at each feeding may be increased in 60–120 mL increments every 12 h or as tolerated
INTRAGASTRIC	Intermittent gravity drip	Generally 240–480 mL of formula is allowed to drip from a feeding container through tubing over a 30–60 min period four to eight times per day Rate of formula administration is controlled with a clamp in the tubing May reduce the incidence of GI complications associated with bolus delivery Highly viscous formulas, such as those that contain 2 Cal/mL, may not flow through the tubing	Typical starter regimen: 60–120 mL of full-strength formula is generally provided Typical feeding progression: Volume of formula provided at each feeding may be increased to 60–120 mL increments every 12 h or as tolerated

(*continued*)

TABLE 11–6 (Continued)

Delivery Site/ Indication	Delivery Method	Notes	Suggested Feeding Progression
		More expensive than bolus method because feeding containers are necessary Not recommended for critically ill patients	
INTRAGASTRIC	Continuous	Preferred method to administer formula if gastric feeding is necessary for a critically ill patient because it reduces risk of aspiration Use of a feeding pump to deliver precise volumes of formula at a constant rate Goal feeding rates are typically between 80 and 125 mL/h, depending on the individual's nutritional requirements Volume- and rate-controlled delivery minimizes gastric emptying and reduces the incidence of osmotic diarrhea secondary to dumping syndrome	Typical starter regimen: Full-strength formula is generally initiated at a rate of 40 or 50 mL/h Typical feeding progression: Feeding rate is generally increased in increments of 10–15 mL/h every 12 h or as tolerated until the goal feeding rate is achieved

(*continued*)

TABLE 11–6
(Continued)

Delivery Site/ Indication	Delivery Method	Notes	Suggested Feeding Progression
		In the hospital setting, the formula is usually provided over a 24-h period; home patients may cycle feedings over an 8–14-h period May be necessary to deliver formulas with high viscosity Necessity of feeding pump in addition to feeding bag and tubing increases cost Restricts ambulation in patients who are not critically ill	
INTRAINTESTINAL Appropriate for patients who are at high risk for aspiration, including those who cannot keep the proper position during feeding (head of bed 30 degrees upright)	Continuous	Feeding pump required because excessively rapid formula delivery, as would occur with bolus or gravity drip administration, would probably result in dumping syndrome, allows tube feeding formula to be delivered in a more physiologic manner Goal rates are usually	Typical starter regimen: Full-strength formula is generally initiated at a rate of 40–50 mL/h; markedly hypertonic formulas (>600 mOsm/L) occasionally may be diluted to half-strength if dumping syndrome is present or if a prolonged period without enteral nutrition has elapsed Typical feeding progression: Feeding rate is generally increased in increments of

(*continued*)

TABLE 11–6 (Continued)

Delivery Site/ Indication	Delivery Method	Notes	Suggested Feeding Progression
and those without an intact gag reflex Required feeding route when proximal (ie, oral, esophageal, or gastric) GI obstruction or impairment is present Preferred delivery site for critically ill patients		80–125 mL/h, depending on the patient's nutritional needs Usually 24-h infusions are given in the hospital, but cyclic infusions are an option for the ambulatory or home patient Associated with high cost because of necessity of feeding containers and infusion pump Continuous infusions may restrict patient ambulation	10–12 mL/h every 12 h or as tolerated until the goal feeding rate is achieved; if hypertonic formula was initially diluted, the patient can be switched to full-strength formula after the goal feeding rate is achieved

- Check medication profile for possible drug-induced cause.
- Rule out *Clostridium difficile* colitis in patients receiving antibiotics (see Chapter 7).
- Attempt to decrease the feeding rate or try an alternative regimen such as bolus feeding.
- Change the formulation, for example, limit lactose or reduce the osmolality.
- Use pharmacologic therapy only after eliminating treatable causes (eg, give *Lactobacillus* powder [one packet tid to replenish gut flora]; most effective in patients on antibiotics) or antidiarrheal medications (loperamide [Lomotil], calcium carbonate).

Constipation: Although less common than diarrhea, constipation can occur in the enterally fed patient. Check to ensure that adequate fluid volume is being given. Patients with additional requirements may benefit from water boluses or dilution of the enteral formulation. Fiber can be added to help regulate bowel function.

Aspiration: Aspiration is a serious complication of enteral feedings and is more likely to occur in the patient with diminished mental status. The best approach is prevention. Elevate the head of the bed and carefully monitor residual fluid volume. Further evaluate any patient who may have aspirated or who is assessed as being at increased risk for aspiration prior to instituting enteral feedings. Such patients may not be candidates for gastric feedings, and small-bowel feedings may be necessary.

Drug Interactions: The vitamin K content of various enteral products varies from 22 to 156 mg/1000 Cal. This can significantly affect the anticoagulation profile of a patient receiving warfarin therapy. Tetracycline products should not be administered 1 h before or 2 h after enteral feedings to avoid the inhibition of absorption. Similarly, enteral feedings should be stopped 2 h before and after the administration of phenytoin.

POSTOPERATIVE NUTRITIONAL SUPPORT

Most patients can be started on oral feedings postoperatively, the question is when to begin them. Begin feedings once the bowel recovers motility. Motility is delayed in patients undergoing laparotomy, whereas feedings begin fairly quickly for patients who undergo surgery on other parts of the body, once they recover consciousness sufficiently to protect their airway. Remember that the gut recovers motility as follows: The small intestine never loses motility (peristalsis is observed in the OR), the stomach regains motility about 24 h postoperatively, and the colon is the last to recover at 72–96 h postoperatively. Thus, by the time a patient reports flatus, one can assume that the entire gut has regained motility. Feedings then begin, depending on the exact operation performed and the resulting gastrointestinal anatomy. Patients who are to begin oral feedings are usually started on clear liquids (see Table 11–1). As long as the patient is willing to eat regular food, there is no reason not to progress to a regular diet rapidly (after one meal of clear liquids), and there is **no need** to step through a progression from clear liquids to full liquids to a regular diet.

INFANT FORMULAS AND FEEDING

Bottle feeding is often chosen by the mother and, in general, commercially available formulas are recommended over homemade formulas because of their ease of preparation and their standardization of nutrients. Occasionally, special formulas are medically indicated and can only be supplied by commercially available formulas. Commonly used formulas are outlined in Table 11–7.

TABLE 11–7
Commonly Used Infant Formulas

Formula	Indications*
Human milk	
Donor	Preterm infant <1200 g
Maternal	All infants
Breast milk fortifiers	
Standard formulas	
Isoosmolar	
Enfamil 20	Full-term infants: as supplement to breast milk
Similac 20	Preterm infants >1800–2000 g
SMA 20	
Higher Osmolality	
Enfamil 24	Term infants: for infants on fluid restriction or
Similac 24 & 27	who cannot handle required volumes of 20-Cal
SMA† 24 & 27	formula to grow
Low Osmolality	
Similac 13	Preterm and term infants: for conservative initial feeding in infants who have not been fed orally for several days or weeks. Not for long-term use.
Soy formulas	
ProSobee (lactose- and sucrose-free)	Term infants: milk sensitivity, galactosemia, carbohydrate intolerance. Do not use in preterm infants. Phytates can bind calcium and cause rickets
Isomil (lactose-free)	
Nursoy (lactose-free)	
Protein hydrosylate formulas	
Nutramigen	Term infants: Gut sensitivity to proteins, multiple food allergies, persistent diarrhea, galactosemia.
Pregestimil	Preterm and term infants: disaccharidase deficiency, diarrhea, GI defects, cystic fibrosis, food allergy, celiac disease, transition from TPN to oral feeding
Alimentum	Term infants: protein sensitivity, pancreatic insufficiency, diarrhea, allergies, colic, carbohydrate and fat malabsorption
Special formulas	
Portagen	Preterm and term infants: pancreatic or bile acid insufficiency, intestinal resection
Similac PM 60/40	Preterm and term infants: problem feeders on standard formula; infants with renal, cardiovascular, digestive diseases that require decreased protein and mineral levels, breast-feeding supplement, initial feeding

(*continued*)

TABLE 11–7 (Continued)

Formula	Indications*
Premature formulas	
Low osmolality	
Similac Special Care 20 Enfamil Premature 20 Preemie SMA 20	Premature infants (<1800–2000 g) who are growing rapidly. These formulas promote growth at intrauterine rates. Vitamin and mineral concentrations are higher to meet the needs of growth. Usually started on 20 Cal/oz and advanced to 24 Cal/oz as tolerated.
Isoosmolar	
Similac Special Care 24 Enfamil Special Care 24 Preemie SMA 24	Same as for low-osmolality premature formulas

*Multivitamin supplementation such as Polyvisol (Mead Johnson) ½ mL/d may be needed for commercial formulas if baby is taking <2 oz/d.
†SMA has decreased sodium content and can be used in patients with congestive heart failure, bronchopulmonary dysplasia, and cardiac disease. Modified and produced with permission from Gomella, TL (ed) Neonatology, 4th ed. Norwalk, CT, Appleton & Lange, 1999

Principles of Infant Feeding

Criteria for Initiating Infant Feeding: Most normal full-term infants are fed within the first 4 h after birth. The following criteria should usually be met before initiating infant feedings.

- The infant should have no history of excessive oral secretions, vomiting, or bile-stained gastric aspirate.
- An examination should have been performed with particular attention to the abdomen. The examination should be normal with normal bowel sounds and a nondistended, soft abdomen.
- The infant should be clinically stable.
- At least 6 h should pass before recently extubated infants are fed. The infant should be tolerating extubation well and have little respiratory distress.
- The respiratory rate should be <60 breaths/min for oral feeding and <80 breaths/min for gavage (tube) feeding. Tachypnea increases the risk of aspiration.

Prematurity: Considerable controversy remains concerning the timing of initial enteral feeding for the preterm infant. For the stable larger (>1500 g) premature infant, the first feeding may be given within the first 24 h of life. Early feeding may allow the release of enteric hormones that exert a trophic effect on the intestinal tract. On the other hand, appre-

hension about necrotizing enterocolitis (mostly in very low birth weight infants) in the following circumstances often precludes the initiation of enteral feeding: perinatal asphyxia, mechanical ventilation, presence of umbilical vessel catheters, patent ductus arteriosus, indomethacin treatment, sepsis, and frequent episodes of apnea and bradycardia.

No established policies are available, and delay and duration of delay in establishing feeding with those conditions varies for every institution. In general, enteral feeding is started in the first 3 d of life, with the objective of reaching full enteral feeding by 2–3 wk of life. Parenteral nutrition including amino acids and lipids should be started at the same time to provide for adequate caloric intake.

Choice of Formula: (See Table 11–7, page 224.) Human breast milk is recommended for feeding infants whenever possible. Breast-feeding has many advantages: It is ideal for virtually all infants, produces fewer infantile allergies, is immunoprotective to the infant due to the presence of immunoglobulins, is convenient and economical, and offers several theoretical psychologic benefits to both the mother and child. Occasionally, an infant cannot be breast-fed due to extreme prematurity or other problems such as a cleft palate.

If commercial infant formula is chosen, no special considerations are needed for normal full-term newborns. Selection of the best formula for preterm infants may require more care. The majority of infant formulas are isoosmolar (Similac 20, Enfamil 20, and SMA 20 with and without iron). These formulas are used most often for healthy infants. Formulas for premature infants, containing 24 Cal/oz (Similac 24, Enfamil 24, "preemie" SMA 24), are also isoosmolar and are indicated for rapidly growing premature infants. Many other "specialty" formulas are available for such conditions as milk and protein sensitivity, among others. Many pediatricians recommend vitamin supplements with some formulas if the infant is taking <32 oz/day. An iron-containing formula is generally recommended.

Feeding Guidelines

1. **Initial feeding.** For the initial feeding for all infants, use sterile water or 5% dextrose in water (D_5W) if the infant is not being breast-fed. Ten % dextrose in water ($D_{10}W$) should not be used because it is a hypertonic solution.
2. **Subsequent feedings.** There is controversy over whether infant formulas should be diluted for the next several feedings if the infant tolerates the initial one. Some clinicians advocate diluting formulas with sterile water and advance as tolerated (eg, ¼ strength, increase to ½ and then ¾ strength). Others feel this is unnecessary and that full-strength formula can be used if infants tolerate the initial feeding without difficulty. Breast milk is never diluted.

Oral Rehydration Solutions: Infants with mild or moderate dehydration, often due to diarrhea or vomiting, may benefit from oral rehydration formulas. These solutions typically include glucose, sodium, potassium, and bicarbonate or citrate. Common formulations include **Pedialyte, Lytren, Infalyte, Resol** and **Hydrolyte.**

12

TOTAL PARENTERAL NUTRITION

COMMON INDICATIONS

Total parenteral nutrition, also called "hyperalimentation," is the provision of all essential nutrients—protein, carbohydrates, lipids, vitamins, electrolytes, and trace elements—by the intravenous route. Nutrients may be supplied by either a peripheral or central vein. To provide a patient's entire nutritional requirement by vein, however, a central venous line must be used because of the tonicity of the fluid required. Peripheral veins simply cannot tolerate these hypertonic fluids, and thus peripheral IV alimentation can be used only as a supplement. Parenteral nutrition bypasses the GI tract and should be reserved for patients who are unable to receive nutritional support enterally. The principle of "if the gut works use it" is sound practice. How to determine the route of nutritional support is discussed on page 213. The following indications are appropriate for TPN initiation:

- Preoperatively, in the malnourished patient. There is no benefit for patients who are not malnourished.
- Postoperatively, for patients with a slow return of GI function or in patients with complications that limit or prohibit the use of the GI tract. The interval between surgery and initiation of nutritional support to prevent complications is not definitively known. However, many practitioners wait 7–10 d after surgery, anticipating the return of bowel function. If this does not occur, nutritional support is begun.
- Patients with Crohn's disease, ulcerative colitis, pancreatitis, fistulas, and short-bowel syndrome.
- Patients who are malnourished secondary to a disease or injury that results in inadequate oral intake. This may include patients with organ failure, severe metabolic stress, malignancies, burns, or trauma.

NUTRITIONAL PRINCIPLES

Nutritional assessment to determine the need for TPN requires a history (which includes weight changes over the previous 6 mo), physical, and laboratory evaluation. Indicators of long-term nutritional depletion include serum albumin and prealbumin levels,

anthropometrics, and total lymphocyte count. Nutritional assessment is presented in detail in Chapter 11, page 206.

To establish the appropriate caloric amount for TPN therapy, estimate the patient's daily nonprotein calories and nitrogen requirements. The best method for calculating the BEE requirements for nonprotein calories is the Harris–Benedict equation (Chapter 11, page 209). The weight used in this equation determines the amount of calories needed to maintain that weight; therefore, if the patient is morbidly obese, the ideal weight should be established as a goal.

Calculation of Caloric Requirements in Stressed Patients

The BEE obtained from the Harris–Benedict equation reflects the number of calories from carbohydrate and fat that should be provided to maintain the patient's weight under nonstressed conditions. Stress, in nutritional terms, is correlated with the amount of catecholamines and cortisol released endogenously. These biochemical mediators promote protein breakdown, which is necessary to provide glucose for the brain and red blood cells.

- Mild stress: Supply total calories at approximately 1.2–1.4 × BEE.
- Moderate stress: 1.5–1.75 × BEE.
- Severe stress: 1.75–2.0 × BEE.
- Ideally, 25–35 Cal/kg/d should be the dosing range. Bear in mind the patient's safety may be of concern should these values exceed a daily intake greater than 3000 Cal. In the event this occurs, dose conservatively until nitrogen balance data confirms the need for more aggressive caloric replacement.

Nutritional Component Considerations

The fundamental principle of TPN is the administration of sufficient protein to avoid catabolism of endogenous protein (muscle). Carbohydrates must be given to supply necessary calories (at a ratio of 150 Cal/g of nitrogen) to support these anabolic processes. Fat is given as a source of essential fatty acids. The basis for using TPN explains the necessity for protein, carbohydrate, and fat administration. In addition, TPN includes all necessary fluids, electrolytes, vitamins, and trace elements required to support life.

Studies have shown that doses between 4–7 mg/kg/min of carbohydrate (generally, do not exceed 5 mg/kg/min) provide optimal protein sparing with minimal liver toxicity. Assessment of the carbohydrate intake is important in order to limit complications from TPN.

Lipid calories should not exceed 3 g/kg/d due to increased complications. Additionally, no more than 50% of total daily calories should be administered as fat.

The best method for establishing a protein need for a given patient is the 24-h urine sample testing for **UUN levels.** This value reflects the amount of protein catabolism occurring daily. Urinary losses of 8–12 g/d are consistent with a mild stress condition, 14–18 g/d moderate stress, and greater than 20 g/d with severe stress.

Protein dosing should be modified based on the 24-h UUN and daily nitrogen balance. Initially, however, if the patient is considered mildly stressed, 0.8–1.2 g/kg/d is appropriate. In cases of moderate and severe stress (burned and head injured patients) 1.3–1.75 g/kg/d and 2–2.5 g/kg/d may be required, respectively. (*Note:* Generally, do not exceed 2.0 g/kg/d.) Several studies suggest that doses of protein in this range exceed the patients utilization capacity and may increase BUN. Adequate renal function must be present to provide such high protein loads. Patients with renal failure who are not receiving dialysis may be dosed at the minimum daily allowance, 0.6 g/kg/d, until a decision for dialysis is made. Once the patient is receiving dialysis, normal dosing may be instituted.

NITROGEN BALANCE

The best method for determining the adequacy of nutritional support is the calculation of nitrogen balance. A **positive nitrogen balance** implies that the amount of protein being administered is sufficient to cover the losses of endogenous protein that occur secondary to catabolism. This is the best therapeutic goal for TPN because it is impossible to determine whether the prescribed protein is preventing muscle breakdown or not. Once positive nitrogen balance has been achieved, however, protein replacement has been optimized. In critical care patients, nitrogen losses may be very high, and an attempt should be made to at least achieve nitrogen equilibrium. This may be impossible in the acute phase of injury, in severe trauma, or in burn cases. Thus, minimizing protein loss (–2 to –4 g/d) may be the goal during this period.

A **negative nitrogen balance** is indicative of insufficient protein replacement for the degree of skeletal muscle loss. Under most circumstances, an attempt to achieve positive nitrogen balance should be made. Patients with renal dysfunction or those who are severely stressed may not be able to achieve a positive balance due to safety concerns. The efficacy of protein doses exceeding 2.5 g/kg/d has not been established. Investigational agents (growth hormone, IGF-1) and specialized formulas (branched-chain amino acids, essential amino acids, glutamine) are being studied in these populations to assess their potential in improving nitrogen retention under these circumstances. The following are key concepts in determining nitrogen balance:

- Nitrogen balance = Nitrogen input – Nitrogen output.
- 1 g of nitrogen = 6.25 g of protein.
- Nitrogen input = (Protein in grams/6.25 g nitrogen).
- Nitrogen output = 24-h UUN + 4 g/d (nonurine loss).
- The conditions and disease states that increase the amount of nonurine losses for nitrogen include high-output fistulas and massive diarrhea. Fecal nitrogen measurements can be obtained but are difficult for nursing staff to perform.

Sample Determination of Nitrogen Balance

A patient is receiving 2 L TPN/24 h with 27.5 g crystalline amino acid (protein) solution per liter.

1. 27.5 g protein/L × 2 L = 55 g protein/24 h.
2. Recall that 1 g of nitrogen = 6.25 g of protein.
3. Nitrogen input = 55 g protein/6.25 g protein per gram N = 8.8 g.
4. Patient voided 22.5 dL urine/ 24 h with UUN 66 mg/dL.
5. Nitrogen lost in urine = 22.5 dL × 66 mg/dL = 1485 mg, or about 1.5 g.
6. Add 4.0 g for nonurine nitrogen loss.
7. Nitrogen output = 1.5 g + 4.0 = 5.5 g.
8. Nitrogen balance = Input – output = 8.8 – 5.5 = +3.3 g nitrogen.

TPN SOLUTIONS

Different strength CAA solutions are available (Table 12–1) to which the pharmacy can add varying concentrations of dextrose, electrolytes, vitamins, and trace elements. Most hospitals supply a "house," or standard, formula for patients with normal renal and hepatic function. Changes in the standard formulas can be made when necessary while a TPN solution is being infused based on measured laboratory parameters. Administration of TPN is never an emergency and in most cases can be provided within 24 h of prescribing. If a formula change is necessary based on a change in patient status, discontinue the TPN and replace it with $D_{10}W$ at the same rate until a new bag of TPN can be provided.

TABLE 12–1
Typical TPN Solutions for Adults

Component	Solution 1	Solution 2
CAA	4.25% (42.5 g/L)	4.25% (42.5 g/L)
Dextrose	25% (250 g/L, 850 Cal/L)	12.5% (125 g/L, 425 Cal/L)
Na	50 mEq/L	50 mEq/L
K	50 mEq/L	50 mEq/L
Ca	6 mEq/L	6 mEq/L
Mg	6 mEq/L	6 mEq/L
PO_4	15 mMol/L	15 mMol/L
Cl	45 mEq/L	45 mEq/L

Abbreviation: CAA = crystalline amino acids.

Amino acid formulas are supplied as CAA or SAA in concentrations ranging from 3.5–15%. These are diluted by the pharmacy to varying concentrations to provide for the necessary protein dose (2.75%, 4.25%, etc). The final concentrations of dextrose vary, but are usually either 12.5% or 25%. Examples of typical TPN solutions for adults are provided in Table 12–1.

The maximum rate of infusion of solution 1 from Table 12–1 should be 100–125 mL/h to avoid excessive glucose administration (remember to consider the patient's weight and the dosing guidelines of 4–7 mg/kg/min). Fat emulsions should be given with solution 1 to provide essential fatty acids (10%, 500 mL 3×/wk) or as an additional calorie source. Solution 2 is designed to be given at a maximum rate of 125 mL/h, but this only provides 1275 Cal from dextrose and must be supplemented with a fat emulsion (10% 500 mL = 550 Cal, 20% 500 mL = 1000 Cal).

Many hospitals have adopted a "three-in-one" solution for the standard house formula. This involves the administration of protein, carbohydrate, and fat from the same TPN bag over a 24-h period; in other words, the fat is not administered peripherally through a separate site. Caution should be used when altering the standard formula in this situation because the fat emulsion may be less stable to additives and makes incompatibilities less visible. For example, the solution will be milky in color, and a calcium–phosphate problem, normally easily seen, would not be apparent. Additions to these formulations should be done in conjunction with a pharmacist to ensure that precautions are taken for appropriate additive concentrations.

Remember, the solutions described in Table 12–1 contain full concentrations of electrolytes and are for patients with normal renal function. For patients with renal impairment, the concentrations of potassium, magnesium, phosphorus, and protein should be reduced (see page 235).

PERIPHERAL PARENTERAL NUTRITION

If a deep line is contraindicated or impossible, a peripheral TPN solution (<7% dextrose with 2.75% SAA, electrolytes, and vitamins) can be given. The majority of nonprotein calories must be given as an IV fat emulsion. In this case, caloric goals will not be met. A posi-

tive nitrogen balance will not be achieved in most patients receiving parenteral nutrition by this route. This is usually used only as a supplement to enteric feedings.

TPN ADDITIVES

Vitamins are a necessary component to TPN solutions. A product conforming to recommendations of the American Medical Association Nutrition Advisory Group is usually used, such as multivitamin infusion-12 (MVI-12). The contents of 2 vials is added to 1 L of TPN solution daily (Table 12–2).

In addition to MVI-12, 5–10 mg of vitamin K (phytonadione) must be given IM weekly. Vitamin K may also be added to the TPN and given as a 1-mg IV dose daily.

Several manufacturers sell a trace element supplement that conforms to the AMA group's guidelines. Each milliliter contains 1.0 mg zinc, 0.4 mg copper, 4.0 mg chromium, and 0.1 mg manganese. Suggested doses for trace elements are listed in Table 12–3, page 232.

Trace element deficiencies are rare in hospitalized patients receiving short-term TPN supplements. Supplementation should be routine, however, to ensure trace element availability for cell restoration. In patients receiving long-term support or home TPN, additional trace element supplementation may be necessary.

Iron can be given as an injectable iron–dextran complex (Dexferrum, InFeD). Note, however, that owing to the inconvenience of its administration, many clinicians avoid injectable iron–dextran. A complete medical and hematologic work-up is often indicated before instituting parenteral iron replacement. Prior to receiving the first dose, a test IV dose of 0.5 mL is recommended. Anaphylaxis is rare, but a period of 1h should elapse before the therapeutic dose of iron is administered. Use the following equation to determine the dose of iron:

$$\text{Total replacement dose (mL)} = 0.0476 \times \text{Weight (kg)} \times [\text{Desired hemoglobin (g/dL)} - \text{Measured hemoglobin (g/dL)}] + 1\ \text{mL/5 kg weight (max 14 mL)}$$

Maximum Daily Dose: Adults >50 kg: 100 mg iron; Peds <5 kg: 25 mg iron, 5–10 kg: 50 mg iron, 0–50 kg: 100 mg iron

The iron–dextran is supplied in an injectable form of 50 mg (Fe)/mL. The calculated dose should be added to TPN at 2 mL/L until the entire dose has been given.

TABLE 12–2
Typical Vitamins Provided in 1 L of TPN by Adding 2 Vials of Standard MVI–12

Ascorbic acid	100 mg	Pyridoxine (B_6) 4 mg
Vitamin A	3300 IU	Dexpanthenol 15 mg
Vitamin D	200 IU	Vitamin E (α tocopherol) 10 IU
Biotin	60 µg	Thiamine (B_1) 3 mg
Folic acid	400 µg	Riboflavin (B_2) 3.6 mg
Vitamin B_{12}	5 µg	Niacin 40 mg

Abbreviation: MVI–12 = multivitamin infusion–12.

TABLE 12–3
Suggested Trace Element Dosing

Trace Element	Parenteral Dose per Day
Zinc	2.5–4.0 mg*
Copper	0.5–1.5 mg
Selenium	20–40mg
Chromium	10–15mg
Manganese	0.15–0.8 mg

*May be higher, up to 15 mg/d, in severe stress or in patients with high-output fistulas.

Insulin, when required, can be given subcutaneously as regular insulin using a sliding scale, as shown in Table 12–4. **But the preferred method is to add the insulin directly to the TPN solution.** This allows a constant infusion of insulin along with the infusion of dextrose, which avoids the peaks and valleys in blood glucose that occur when the sliding scale is used. The usual starting dose per liter of TPN is 10 units of regular insulin. Doses from 10 to 90 units/L may often be required. Insulin drips are not advised because TPN can be temporarily or permanently discontinued, which would then stop the insulin. Other additives include H_2 antagonists and heparin.

FAT EMULSIONS

Lipid emulsions were initially used only to provide essential fatty acids (linoleic acid, and linolenic acid in children). This could be done with minimal supplementation; as little as 4% of total calories per day would prevent the syndrome of EFAD. Most clinicians prescribe 500 mL of 10% lipid emulsion three times weekly to prevent this syndrome. The signs and symptoms of this deficiency include scaling skin rash, alopecia, and wound healing failure.

TABLE 12–4
Sliding Scale for Insulin Orders

Urine Glucose*	Regular Insulin Dose (Units, given SQ)
0–1+	0
2+	5
3+	10
4+	15
Any acetone: call house officer	

*Should be checked every 6 h as part of standing TPN orders.

Linoleic acid is a precursor to arachidonic acid, which is essential for prostaglandin and leukotriene synthesis. Once data became available establishing the problems associated with overfeeding of carbohydrate calories, the use of lipid for caloric supplementation became more recognized.

Commercially available intravenous fat emulsions are derived from soybean oil, with one product (**Liposyn II**) combining both soybean and safflower oil. The 10% products provide 1.1 Cal/mL, and the 20% products provide 2.0 Cal/mL. Pediatricians often prefer the Liposyn II product because of its higher percentage of linolenic acid.

Because the particle size of these emulsions closely approximates naturally occurring chylomicrons, parenteral infusion is possible. In addition, the emulsions are cleared from the bloodstream in a manner and rate similar to that for chylomicrons.

Before beginning the IV fat emulsion, the serum triglyceride level should be checked to ensure that hypertriglyceridemia is not present. Provided that the serum triglyceride level is below 400 mg/dL, the fat emulsion can be given over a 6–12-h period. The longer infusion rate is preferred. The first bottle should be given slowly (1 mL/min for 15 min to check for hypersensitivity reaction). Adverse reactions can include dyspnea, fever, chills, chest tightness, wheezing, headaches, and nausea.

Currently, the only absolute contraindication to the use of IV fat emulsion is type IV hypertriglyceridemia, although isolated cases of nontype IV intolerance to the solution have been reported. To monitor for the clearing of the fat from the bloodstream, a trough serum triglyceride level should be tested 8–12 h following the daily infusion of the fat emulsion. Because fat emulsions are primarily composed of triglycerides (essentially cholesterol free), if the blood is mistakenly drawn while the fat is being infused or shortly thereafter, the serum triglyceride level will be markedly elevated. Other possible contraindications include lipoid nephrosis, severe hepatic failure, and allergy to eggs (egg phosphatides are used as the emulsifying agent).

Fat emulsions can be administered through peripheral veins, although the vein may be damaged and cease to be functional in 2–3 days. For this reason, it is usually recommended that the fat emulsion be infused into the central line under strict aseptic technique via a sterile Y-connector. As mentioned earlier, some institutions combine the lipid with the TPN formula in one bag for 24-h administration. This limits the clinicians ability to validate fat clearance from the blood and makes baseline triglyceride data extremely important.

STARTING TPN

In general, TPN should not be started until a patient has a stable fluid and electrolyte profile. It is usually unwise to begin TPN in a patient who requires large amounts of fluid, may need resuscitation for trauma, or is septic. Once a patient's fluid and electrolyte requirements are reasonably stable, TPN can be started safely. The initiation of TPN is never an emergency.

Placement of a deep line must be done aseptically, as outlined in Chapter 13, page 253. Infection (bacteremia, fungemia) arising from the catheter or the catheter–skin interface is the most common complication of TPN. Many hospitals now have standardized order forms for starting patients on TPN.

1. **Baseline laboratory tests:**
   - **a.** CBC with differential and platelets
   - **b.** PT and PTT
   - **c.** SMA-7 and SMA-12; in particular check phosphate, glucose, and routine electrolytes (Na, K, Cl)
   - **d.** Urinalysis
   - **e.** Baseline weight

2. **Order the type of TPN** desired along with the additives and supplements. Medications are generally not added to TPN solutions except insulin and H_2 receptor blockers. A 0.22-µm filter should be used with aqueous TPN (no fat). A 1.2-µm filter should be used with three-in-one TPN.
3. **Nursing orders:**
   - **a.** Check urine for sugar and acetone every 6-8 h, house officer should be called if sugar is >2+ or acetone is present.
   - **b.** Take vital signs every shift.
   - **c.** Change tubing and deep-line dress every other day (or per hospital procedure).
   - **d.** Weigh patient every other day.
   - **e.** Monitor daily fluid balance
4. **Laboratory monitoring:**
   - **a.** SMA-7 daily until patient is stable, then every other day.
   - **b.** CBC with differential, platelets, PT/PTT, twice weekly.
   - **c.** SMA-12 twice weekly (especially liver function tests).
   - **d.** Triglyceride trough level (obtained at least 6 h after infusion has stopped, preferably prior to hanging next bottle of fat) once or twice weekly.
   - **e.** 24-h urine for nitrogen balance determinations and creatinine clearance once or twice weekly.
5. **Begin the solution at 25–50 mL/h** when using a 25% or 50–75 mL/h when using a 12.5% dextrose solution. Increase by 25 mL/h every 24 h, providing the urine sugar levels are negative. Advance to the maximum rate based on the calculated daily caloric need (page 209). **Begin the IV fat emulsion the next day,** provided that the serum triglyceride levels are less than 400 mg/dL. Remember that glucose intolerance is the major adverse effect seen during the initial infusion period. Urine sugar and acetone levels should be less than 2+, and serum glucose values less than 180–200 mg/dL. If the sugar level rises above these levels, insulin must be given to achieve the desired level of caloric intake. If glucose intolerance develops when using a 25% dextrose solution, consider decreasing the amount of calories from dextrose and increasing the calories from fat. (Be sure to check that overfeeding is not occurring, ie, >4–7 mg/kg/min, in this case reduce the dose of carbohydrate prior to the addition of insulin). Glucose intolerance arising once the patient has been stabilized may signify sepsis.

ASSESSING TPN THERAPY

Nitrogen balance is a good measure of the success of the TPN regimen because the goal is protein-sparing (see page 229). Serum albumin will not change appreciably during TPN therapy lasting less than 3 wk. This is due to albumin's long half-life of 22–24 d. In stressed patients, albumin often falls due to reduced production because the body shifts to increased production of acute-phase reactant proteins.

STOPPING TPN

TPN can usually be stopped when necessary. Although widely practiced, there is rarely a need for a formal weaning schedule. If there are concerns about hypoglycemia, then a 10% dextrose solution can be administered after cessation of the TPN.

DISEASE-SPECIFIC TPN FORMULATIONS

Cardiac Failure: In patients with CHF, reduce water from 1 to 0.5 mL/Cal or 500 mL insensible loss plus measured water losses. This limits overloading with water from TPN. Other considerations include providing energy needs at the BEE + 30% for initiation of TPN calories, limiting protein initially to 0.8–1 g/kg and reducing sodium to 0.5–1.5 g/d.

Diabetes: Consider increasing the percentage of calories provided from fat. Ideally, blood sugar should be well controlled or at least not >200 when initiating TPN. Remember that no more than 50% of total intake should be from fat and not more than 3 g/kg/d. Fat provides 9 Cal/g. Commercial lipid emulsions provide 1.1 or 2 Cal/mL. Insulin should be added to the solution initially at 5–10 units/bag in patients requiring >20 units of insulin daily.

Geriatrics: Patients older than 75 years have a documented need for fewer calories. Use caution in monitoring total fluids to prevent overload.

Inflammatory Bowel Disease: TPN can be initiated in these patients at approximately 1.5 × RME at 30 Cal/kg of ideal body weight. Protein needs vary from 1 to 2 g/kg of ideal body weight daily. Dose the protein based on a 24-h UUN. *Note:* Patients with fistulas lose nitrogen via this route and need additional protein. Zinc losses may be greater in this group of IBD patients also.

Liver Disease: Specialized formulas of amino acids that contain primarily branched-chain amino acids (leucine, isoleucine, and valine) are available for use in cases of liver disease. Theoretically, these products may improve arousal from hepatic encephalopathy by competing with the aromatic amino acids that are precursors for some centrally active amines. There is no definitive evidence that branched-chain formulas improve patient outcome. The specialized formulas should only be used in cases of severe hepatic disease accompanied by encephalopathy. In other clinical conditions of liver disease, standard formulas should be used. Lipid emulsions are not recommended in cases of severe hepatic failure when hypertriglyceridemia is present.

Pancreatic Disease: Total energy needs may be high in this disease (35 Cal/kg). Protein should be initiated at 1.5 g/kg/d. Intravenous fat may be administered in these cases because it is metabolized by peripheral tissue lipases. A reasonable nonprotein system would be 70% carbohydrate and 30% fat.

Pulmonary Disease: Carbohydrate metabolism produces higher amounts of CO_2 than does fat metabolism. Consequently, the patient with CO_2 retention problems often is stressed if overfed with carbohydrates. Increasing the percentage of daily nonprotein calories provided by fat (not >60%) may decrease the CO_2 load and assist with ventilator weaning. Higher fat percentages influence oxygen diffusion capacity and are not beneficial, especially in cases of mild pulmonary compromise. Phosphate depletion is a second clinically relevant concern in this population due to the depression of the hypoxic ventilatory drive. Once patients are started on TPN, PO_4^{-2} often decreases due to the incorporation into ATP. Adequate supplementation and monitoring is very important in this group of patients.

Renal Failure: Several considerations become important in this disease. If a patient is not receiving dialysis or is not a dialysis candidate, protein must be restricted to 0.6–0.8 g/kg/d, and total energy needs must be limited to approximately 30 Cal/kg/d. Weight should be ideal or admission weight, so as to control for the influence of water

retention. Specialized amino acid formulas have been developed for this group of patients. These products provide higher concentrations of essential amino acids than the standard amino acid products. Theoretically, the nitrogen waste products are recycled to make the nonessential amino acids, thereby reducing the BUN content. Risks exist, however, for elevations in ammonia when arginine is not also supplemented. Consequently, manufacturers have modified the original formulas to include several nonessential amino acids. Due to these changes, the renal products provide a very similar amino acid profile to those of the SAA solutions at very low concentrations (2.5%). The cost differential can be significant. It is therefore recommended that patients with renal dysfunction receive SAA formulas at a reduced concentration to provide the minimum daily allowance of protein. TPN should not be supplemented with potassium or magnesium, and sodium should be reduced to 40–180 mEq/d once the GFR is <10 mL/min.

Patients receiving hemodialysis or peritoneal dialysis may be fed protein similarly to patients without renal disease. Doses of 1–1.2 g/kg/d may be used. Nitrogen balance calculations are not useful in this population due to the problem of renal clearance of urea waste inherent to kidney disease.

Sepsis or Trauma: Sepsis and trauma causes hypermetabolism and requires greater numbers of calories from nonprotein (30–35 Cal/kg) and protein (2–2.5 g/kg/d) sources. Estimates of RME should be increased by 50% initially, and some cases may support up to 100%. Note that feeding >3000 Cal/d is not recommended. Specialized amino acid formulas are also available for this group of patients. Again, these formulas include higher concentrations of the branched-chain amino acids. The reason for their inclusion in this population is to provide substrate directly to the skeletal muscle undergoing catabolism to provide gluconeogenic precursors. Although these formulas have been shown to normalize the amino acid profile and in some cases improve nitrogen balance, no studies have demonstrated an improved patient outcome. The additional cost of these formulas is a deterrent to their routine use in these populations until further data are available. Additional zinc supplementation is often recommended in this group of patients. Studies have shown losses to be increased in stress; therefore, daily supplementation of up to 15 mg of zinc may be appropriate.

COMMON TPN COMPLICATIONS

Hyperosmolar Nonketotic Coma: Usually found in improperly monitored patients with impaired insulin responses. Caused by excessive glucose levels, usually corrected by administration of insulin and rehydration. Sustained hyperglycemia (>220 mg/dL) depresses monocyte activity and could compromise the immune defenses.

Infection (Sepsis): The care of the deep-line site and tubing must be meticulous. Suspect sepsis if a previously stable patient becomes glucose-intolerant. If the patient becomes septic, the deep line should be considered a possible source. If no other source of infection can be identified, the deep line must be removed or changed and the tip sent for routine culture and sensitivity. *Candida albicans* is the most frequently encountered pathogen on the catheter, followed by *Staphylococcus aureus, Staphylococcus epidermidis* and gram-negative rods.

Hypophosphatemia: Severe hypophosphatemia can occur in patients started on TPN after severe weight loss and those with conditions such as anorexia nervosa (refeeding syndrome). This may also result from increased metabolic processes requiring phosphate and can significantly hamper weaning from the ventilator.

Elevated Liver Function Tests: The usual cause is excessive glucose infusion. When the primary metabolic pathway for glucose becomes saturated, excess glucose is converted to intracellular triglycerides in the liver. This is especially seen when rates exceed 4–7 mg/kg/min. A reduction in carbohydrate calories, supplementing with fat, is recommended.

Cholestasis: This often occurs secondary to overfeeding of fat calories (>3 g/kg/d or >60% of total nonprotein calories).

Hyperkalemia: This is the most common electrolyte disturbance seen with TPN. Most TPN formulations contain potassium 40–50 mEq/L and are intended for patients with normal renal function. Excess potassium over and above that required for maintenance and urine losses (usually 3–5 mEq/g nitrogen) is included. Potassium must be closely followed in the elderly and those with impaired renal function. Additionally, many drugs contribute to potassium balance problems. These include some antibiotics that are potassium salts (eg, penicillins); oral phosphate supplements (Neutra-Phos); ACE inhibitors, which reduce potassium excretion (Captopril, Enalapril); and potassium-sparing diuretics (triamterene, spironolactone).

Metabolic Alkalosis: Modern SAAs are present as the acetate salt (80–100 mEq/L), which is converted to bicarbonate in vivo. In postoperative patients with nasogastric tubes, the loss of chloride, together with the high infusion of the acetate, can lead to a metabolic alkalosis. The increased use of histamine blockers and antacids in intensive care patients has also contributed to a higher incidence of this problem. Treating this condition requires increasing the chloride level in the solution and reducing the acetate.

Hyponatremia: Serum sodium levels of 127–135 mEq/L are commonly seen in patients on TPN. The cause is controversial but is probably due to mild SIADH; therefore the problem is probably an excess of water and not deficiency of sodium. It is usually asymptomatic and does not require a change in formula unless the sodium drops below 125 mEq/L.

Hypermagnesemia: This is usually seen in patients with renal failure. Antacid therapy may also contribute to this condition. If potassium is reduced in the TPN, magnesium should also be reduced.

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13

BEDSIDE PROCEDURES

PROCEDURE BASICS

Universal Precautions

Universal precautions should be used whenever an invasive procedure exposes the operator to potentially infectious body fluids. Not all patients infected with transmissible pathogens can be identified at the time of hospital admission or even later in their course. Because pathogens transmitted by bloody and body fluids pose a hazard to personnel caring for such patients, particularly during invasive procedures, certain precautions are now *required* for *routine* care of **all** patients whether or not they have been placed on isolation precautions of any type. For these reasons, the CDC calls these Universal Precautions.

1. Wash hands before and after **all** patient contact.
2. Wash hands before and after **all** invasive procedures.
3. Wear gloves in **every** instance in which contact with blood is certain or likely. For example, wear gloves for all venipunctures, for all IV starts, for IV manipulation, and for wound care.
4. Wear gloves once and discard. Do not wear the same pair to perform tasks on two different patients or two different tasks at different sites on the same patient.
5. Wear gloves in **every** instance in which contact with any body fluid is likely, including urine, feces, wound secretions, respiratory tract care, thoracentesis, paracentesis, etc.

6. Wear gown when splatter of blood or of body fluids on clothing seems likely.
7. Additional barrier precautions may be necessary for certain invasive procedures when significant splatter or aerosol generation seems likely. This does not occur during most routine patient care activities. It may occur in certain instances in the operating room, emergency room, the ICUs, during invasive procedures, and during cardiopulmonary resuscitation. Always wear masks when goggles are worn and vice versa.

Informed Consent

Patients should be counseled before any procedure concerning the reason for it and the potential risks and benefits from it. Explaining the various steps often can make the patient more cooperative and the procedure easier on both parties. In general, procedures such as bladder catheterization, NG intubation, or venipuncture do not require a written informed consent beyond normal hospital sign in protocols. More invasive procedures, such as thoracentesis or lumbar puncture, for example, require written consent and must be obtained by a licensed physician.

Basic Equipment

Table 13–1 lists useful collections of instruments and supplies, often packaged together, that aid in the completion of the procedures outlined in this chapter. Local anesthesia is discussed in Chapter 17.

The size of various catheters, tubes and needles is often designated by **French unit (1 french = ⅓ mm in diameter)** or by "gauge." Reference listings for these designations can be found in Figure 13–1A. Designations of surgical scalpels, used in the performance of many basic bedside procedures and in the operating room are shown in Figure 13–1B.

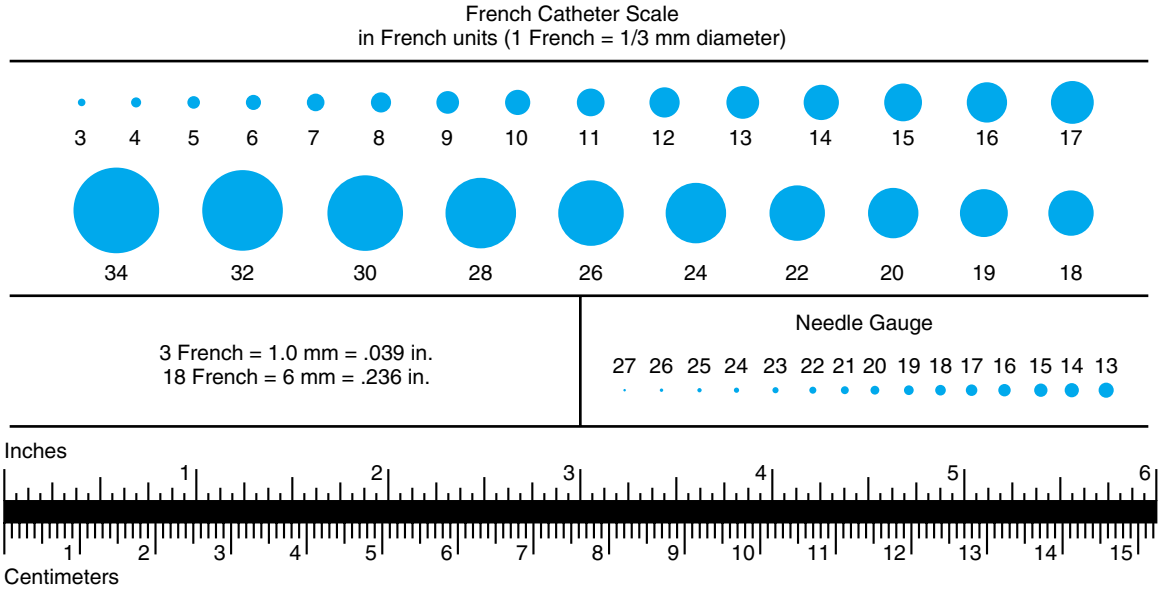
TABLE 13–1 Instruments and Supplies Used in the Completion of Common Bedside Procedures

MINOR PROCEDURE TRAY

Sterile gloves
Sterlile towels/drapes
4×4 gauze sponges
Povidone–iodine (Betadine) prep solution
Syringes: 5-, 10-, 20-mL
Needles: 18-, 20-, 22-, 25-gauge
1% Lidocaine (with or without epinephrine)
Adhesive tape

INSTRUMENT TRAY

Scissors
Needle holder
Hemostat
Scalpel and blade (No. 10 for adult, No. 15 for children or delicate work)
Suture of choice (2-0 or 3-0 silk or nylon on cutting needle; cutting needle best for suturing to skin)



A

FIGURE 13–1A: French catheter guide and needle gauge reference. (Courtesy Cook Urological.)

FIGURE 13–1B: Commonly used scalpel blades. From left to right: Number 10, 11, 12, 15, and 20. The No. 10 is the standard surgical blade; No. 11 is useful for press cuts into abscesses; No. 12 is used to open tubular structures; No. 15 is widely used for bedside procedures and for more delicate work; the No. 20 blade is used when large incisions are called for.

AMNIOTIC FLUID FERN TEST

Indication

- Assessment of rupture of membranes

Materials

- Sterile speculum and swab
- Glass slide and microscope
- Nitrazine paper (optional)

Procedure

1. After placing a sterile speculum in the vagina, a sample of fluid which has "pooled" in the vault is swabbed onto a glass slide and allowed to air dry.
2. Amniotic fluid produces a microscopic arborization or "fern" pattern, which may be visualized with 10× magnification. False-positive results may occur if cervical mucus is collected; however, the ferning pattern of mucus is coarser. This test is unaffected by meconium, vaginal pH, and blood-to-amniotic-fluid ratios ≤ 1:10. Samples heavily contaminated with blood may not fern.

ACTIONS: Class 1A antiarrhythmic
DOSAGE: ***Adults.*** PAC, PVCs: 200–300 mg PO tid–qid. *Conversion of AF or flutter:* Use after digitalization, 200 mg q2–3h for 8 doses; then ↑ daily dose to a max of 3–4 g or until normal rhythm. ***Peds.*** 15–60 mg/kg/24h PO in 4–5 ÷ dose
SUPPLIED: *Sulfate:* Tabs 200, 300 mg; SR tabs 300 mg; *Gluconate:* SR tabs 324 mg; inj 80 mg/mL
NOTES: Contra in digitalis toxicity and AV block; follow serum levels if available (see Table 22–7, pages 631–634); extreme hypotension seen with IV administration. Sulfate salt contains 83% quinidine; gluconate salt contains 62% quinidine; dosage adjustment in renal impairment

Quinupristin/Dalfopristin (Synercid)

COMMON USES: Infections caused by vancomycin-resistant *Entercoccus faecium,* and other gram+ organisms
ACTIONS: Inhibits both the early and late phase of protein synthesis at the ribosomes
DOSAGE: ***Adults & Peds.*** 7.5 mg/kg IV q8–12h
SUPPLIED: Inj 500 mg (150 mg quinupristin/350 mg dalfopristin)
NOTES: Administer through central line if possible; NOT compatible with saline or heparin, therefore flush IV lines with dextrose

Rabeprazole (Aciphex)

COMMON USES: Peptic ulcers, GERD, and hypersecretory conditions
ACTIONS: Proton pump inhibitor
DOSAGE: 20 mg/d; may be ↑ to 60 mg/d
SUPPLIED: Tabs 60 mg
NOTES: Do NOT crush tabs

Raloxifene (Evista)

COMMON USES: Prevention of osteoporosis
ACTIONS: Partial antagonist of estrogen that behaves like estrogen
DOSAGE: 60 mg/d
SUPPLIED: Tabs 60 mg

Ramipril (Altace)

COMMON USES: HTN and heart failure
ACTIONS: ACE inhibitor
DOSAGE: 2.5–20 mg/d PO ÷ qd–bid
SUPPLIED: Caps 1.25, 2.5, 5, 10 mg
NOTES: May use in combination with diuretics; may cause a nonproductive cough; dosage adjustment in renal impairment

Ranitidine (Zantac)

COMMON USES: Duodenal ulcer, active benign ulcers, hypersecretory conditions, and GERD
ACTIONS: H_2-receptor antagonist
DOSAGE: ***Adults.*** Ulcer: 150 mg PO bid, 300 mg PO hs, or 50 mg IV q6–8h; or 400 mg IV/d cont inf, then maintenance of 150 mg PO hs. *Hypersecretion:* 150 mg PO bid, up to 600 mg/d. *GERD:* 300 mg PO bid; maintenance 300 mg PO hs. ***Peds.*** 0.75–1.5 mg/kg/dose IV q6–8h or 1.25–2.5 mg/kg/dose PO q12
SUPPLIED: Tabs 75, 150, 300 mg; syrup 15 mg/mL; inj 25 mg/mL
NOTES: ↓ Dose with renal failure; oral and parenteral doses are different

Repaglinide (Prandin)

COMMON USES: Type 2 DM
ACTIONS: Stimulates insulin release from pancreas
DOSAGE: 0.5–4 mg ac
SUPPLIED: Tabs 0.5, 1, 2 mg

Reteplase (Retavase)

COMMON USES: Post-AMI
ACTIONS: Thrombolytic agent
DOSAGE: 10 U IV over 2 min, 2nd dose 30 min later of 10 U IV over 2 min
SUPPLIED: Inj 10.8 U/2 mL

Ribavirin (Virazole)

COMMON USES: RSV infection in infants and; hepatitis C, (in combination with interferon alfa-2b)
ACTIONS: Unknown
DOSAGE: *RSV:* 6 g in 300 mL of sterile water inhaled over 12–18 h. *Hep C:* 600 mg PO bid in combination with interferon alfa-2b (See Rebetron, page 000)
SUPPLIED: Powder for aerosol 6 g; caps 200 mg
NOTES: Aerosolized by a SPAG ; may accumulate on soft contact lenses; monitor H/H frequently; PRG test monthly

Rifabutin (Mycobutin)

COMMON USES: Prevention of *M. avium* complex infection in AIDS patients with a CD4 count <100
ACTIONS: Inhibits DNA-dependent RNA polymerase activity
DOSAGE: 150–300 mg/d PO
SUPPLIED: Caps 150 mg
NOTES: Adverse effects and drug interactions similar to rifampin

Rifampin (Rifadin)

COMMON USES: TB and Rx and prophylaxis of *N. meningitidis, H. influenzae,* or *S. aureus* carriers
ACTIONS: Inhibits DNA-dependent RNA polymerase activity
DOSAGE: ***Adults.*** N. meningitidis and *H. influenzae carrier:* 600 mg/d PO for 4 d. *TB:* 600 mg PO or IV qd or 2×/wk with combination-therapy regimen. ***Peds.*** 10–20 mg/kg/dose PO or IV qd–bid
SUPPLIED: Caps 150, 300 mg; inj 600 mg
NOTES: Multiple drug interactions; causes orange-red discoloration of bodily secretions, including tears; never used as a single agent to treat active TB

Rifapentine (Priftin)

COMMON USES: TB
ACTIONS: Inhibits DNA-dependent RNA polymerase activity
DOSAGE: *Intensive phase:* 600 mg PO 2×/wk for 2 mo; separate doses by 3 or more days. *Continuation phase:* 600 mg/wk
SUPPLIED: Tabs 150 mg
NOTES: Adverse effects and drug interactions similar to rifampin

Rimantadine (Flumadine)

COMMON USES: Prophylaxis and Rx of influenza A virus infections
ACTIONS: Antiviral agent
DOSAGE: ***Adults.*** 100 mg PO bid. ***Peds.*** 5 mg/kg/d PO, NOT to exceed 150 mg/d
SUPPLIED: Tabs 100 mg; syrup 50 mg/5 mL
NOTES: Dosage adjustment in severe renal or hepatic impairment; initiate within 48 h of symptom onset

Rimexolone (Vexol Ophthalmic)

COMMON USES: Postop inflammation and uveitis
ACTIONS: Steroid
DOSAGE: ***Adults & Peds > 2 y.*** Uveitis: 1–2 gtt/h daytime and q2h at night, taper to 1 gtt q4h; postop 1–2 gtt qid up to 2 wk

SUPPLIED: 1% susp
NOTES: Taper dose to zero

Risedronate (Actonel)

COMMON USES: Prevention and Rx of postmenopausal osteoporosis; Paget's disease
ACTIONS: Bisphosphonate; inhibits osteoclast-mediated bone resorption
DOSAGE: 5 mg/d PO with 6–8 oz water; 30 mg/d for 2 mo for Paget's disease
SUPPLIED: Tabs 5, 30 mg
NOTES: Take 30 min before first food or drink of the day; maintain upright position for at least 30 min after administration, interaction with calcium supplements; may cause GI distress and arthralgia; NOT recommended in moderate to severe renal impairment

Risperidone (Risperdal)

COMMON USES: Psychotic disorders
ACTIONS: Benzisoxazole antipsychotic agent
DOSAGE: 1–6 mg PO bid
SUPPLIED: Tabs 1, 2, 3, 4 mg
NOTES: ↓ Starting doses in elderly, renal or hepatic impairment; orthostatic hypotension; extrapyramidal reactions with higher doses

Ritonavir (Norvir)

COMMON USES: HIV infection when therapy is warranted
ACTIONS: Protease inhibitor; inhibits maturation of immature noninfectious virions to mature infectious virus
DOSAGE: 600 mg PO bid or 400 mg PO bid in combination with Saquinavir
SUPPLIED: Caps 100 mg; soln 80 mg/mL
NOTES: Titrate dose over 1 wk to avoid GI complications; take with food; has many drug interactions; may cause perioral and peripheral paresthesias; store in refrigerator

Rivastigmine (Exelon)

COMMON USES: Mild to moderate dementia associated with Alzheimer's disease
ACTIONS: Enhances cholinergic activity
DOSAGE: 1.5 mg bid; ↑ to 6 mg bid, with dosage increases at 2-wk intervals
SUPPLIED: Caps 1.5, 3, 4.5, 6 mg; soln 2 mg/mL
NOTES: Associated with significant dose-related GI adverse effects

Rizatriptan (Maxalt)

COMMON USES: Acute migraine attacks
ACTIONS: Serotonin 5-HT_1 receptor antagonist
DOSAGE: 5–10 mg PO; may repeat once in 2 h
SUPPLIED: Tabs 5, 10 mg; disintegrating tabs 5, 10 mg

Rofecoxib (Vioxx)

COMMON USES: Osteoarthritis, acute pain, and primary dysmenorrhea
ACTIONS: NSAID; COX-2 inhibitor
DOSAGE: 12.5–50 mg/d
SUPPLIED: Tabs 12.5, 25 mg; susp 12.5 mg/5 mL, 25 mg/5 mL
NOTES: Alert patients to be aware of GI ulceration or bleeding; use with caution in renal impairment; ↓ dose in elderly

Rosiglitazone (Avandia)

COMMON USES: Type 2 DM
ACTIONS: ↑ Insulin sensitivity
DOSAGE: 4–8 mg/d PO or in 2 ÷ doses

SUPPLIED: Tabs 2, 4, 8 mg
NOTES: May be taken without regard to meals; do NOT use in active liver disease

Salmeterol (Serevent)

COMMON USES: Asthma and exercise-induced bronchospasm
ACTIONS: Sympathomimetic bronchodilator
DOSAGE: 2 inhal bid
SUPPLIED: Met-dose inhaler; NOT for relief of acute attacks

Saquinavir (Fortovase)

COMMON USES: HIV infection
ACTIONS: HIV protease inhibitor
DOSAGE: 1200 mg PO tid within 2 h pc
SUPPLIED: Caps 200 mg

Sargramostim [GM-CSF] (Leukine)

COMMON USES: Myeloid recovery following BMT or cancer chemotherapy
ACTIONS: Activates mature granulocytes and macrophages
DOSAGE: ***Adults & Peds.*** 250 mg/m^2/d IV for 21 d (BMT)
SUPPLIED: Inj 250, 500 mg
NOTES: May cause bone pain

Scopolamine, Transdermal (Transderm-Scop)

COMMON USES: Prevention of nausea and vomiting associated with motion sickness
ACTIONS: Anticholinergic, antiemetic
DOSAGE: Apply 1 TD patch behind the ear q 3 d; 0.3–0.65 IM/IV/SC, repeat PRN q4–6h
SUPPLIED: Patch 1.5 mg, injectable forms
NOTES: May cause dry mouth, drowsiness, and blurred vision. Apply at least 4 h before exposure

Secobarbital (Seconal) [C-II]

COMMON USES: Insomnia
ACTIONS: Rapid-acting barbiturate
DOSAGE: ***Adults.*** 100–200 mg IM hs PRN. ***Peds.*** 3–5 mg/kg/dose IM hs PRN, up to 100 mg
SUPPLIED: Inj 50 mg/mL
NOTES: Beware of respiratory depression; tolerance acquired within 1–2 wk

Selegiline (Eldepryl)

COMMON USES: Parkinson's disease
ACTIONS: Inhibits MAO activity
DOSAGE: 5 mg PO bid
SUPPLIED: Tabs 5 mg
NOTES: May cause nausea and dizziness

Selenium Sulfide (Exsel Shampoo, Selsun Blue Shampoo, Selsun Shampoo)

COMMON USES: Scalp seborrheic dermatitis, itching and flaking of the scalp due to dandruff; treatment of tinea versicolor
ACTIONS: Antiseborrheic
DOSAGE: *Dandruff, seborrhea:* Massage 5–10 mL into wet scalp, leave on 2–3 min, rinse and repeat; use 2×/wk, then once q 1–4 wk PRN. *Tinea versicolor:* Apply qd for 7 d, 2.5% on area and lather with small amounts of water; leave on skin for 10 min, then rinse
SUPPLIED: Shampoo 1, 2.5%

Sertraline (Zoloft)

COMMON USES: Depression
ACTIONS: Inhibits neuronal uptake of serotonin
DOSAGE: 50–200 mg/d PO
SUPPLIED: Tabs 25, 50, 100 mg
NOTES: Can activate manic/hypomanic state; has caused weight loss in clinical trials; caution in hepatic impairment

Sibutramine (Meridia)

COMMON USES: Obesity
ACTIONS: Blocks uptake of norepinephrine, serotonin, and dopamine
DOSAGE: 10 mg/d, may ↓ to 5 mg after 4 wk
SUPPLIED: Caps 5, 10, 15 mg
NOTES: Use with low-calorie diet, monitor BP

Sildenafil (Viagra)

COMMON USES: Erectile dysfunction
ACTIONS: Smooth muscle relaxation and increased inflow of blood to the corpus cavernosum; inhibits phosphodiesterase type 5 responsible for cGMP breakdown resulting in increased cGMP activity
DOSAGE: 25–100 mg 1 h prior to attempted sexual activity, max dosing is once daily
SUPPLIED: Tabs 25, 50, 100 mg
NOTES: Contra with nitrates of any form; adjust dose in persons >65 y, hepatic/severe renal impairment, potent CYP3A4 inhibitors (ie, protease inhibitors); may cause headache, blue haze visual disturbance, usually reversible; cardiac events in the absence of nitrate use debatable

Silver Nitrate (Dey-Drop)

COMMON USES: Prevention of ophthalmia neonatorium due to GC; removal of granulation tissue, warts and cauterization of wounds
ACTIONS: Caustic antiseptic and astringent
DOSAGE: ***Adults & Peds.*** Apply to moist surface 2–3×/wk for several weeks or until desired effect. ***Peds.*** Newborns: Apply 2 gtt into conjunctival sac immediately after birth
SUPPLIED: Topical impregnated applicator sticks, 10% oint, 10, 25, 50% soln; ophth 1% amp
NOTES: May stain tissue black, usually resolves

Silver Sulfadiazine (Silvadene)

COMMON USES: Prevention of sepsis in 2nd- and 3rd-degree burns
ACTIONS: Bactericidal
DOSAGE: ***Adults & Peds.*** Aseptically cover the affected area with ⅛-in. coating bid
SUPPLIED: Cream 1%
NOTES: Can have systemic absorption with extensive application

Simethicone (Mylicon)

COMMON USES: Flatulence
ACTIONS: Defoaming action
DOSAGE: ***Adults & Peds.*** 40–125 mg PO pc and hs PRN
SUPPLIED: Tabs 40, 80, 125 mg; caps 125 mg; gtt 40 mg/0.6 mL

Simvastatin (Zocor)

COMMON USES: Reduction of elevated cholesterol levels
ACTIONS: HMG-CoA reductase inhibitor
DOSAGE: 5–80 mg PO hs
SUPPLIED: Tabs 5, 10, 20, 40 mg
NOTES: Avoid concurrent use of gemfibrozil

Sirolimus [Rapamycin] (Rapamune)

COMMON USES: Prophylaxis of organ rejection
ACTIONS: Inhibits T-lymphocyte activation
DOSAGE: 2 mg/d PO
SUPPLIED: Soln 1 mg/mL
NOTES: Dilute in water or orange juice; do NOT drink grapefruit juice while on sirolimus; take 4 h after cyclosporin; dosage adjustment in hepatic impairment. Routine blood levels not needed except in Peds or liver failure (trough 9–17 ng/mL)

Sodium Bicarbonate

Used for emergency cardiac care (see Chapter 21)
COMMON USES: Alkalinization of urine, RTA, metabolic acidosis
DOSAGE: ***Adults.*** Emergency cardiac care: Initiate adequate ventilation, 1 mEq/kg/dose IV ; can repeat 0.5 mEq/kg in 10 min once or based on acid–base status. *Metabolic acidosis:* 2–5 mEq/kg IV over 8 h and PRN based on acid–base status. *Alkalinize urine:* 4 g (48 mEq) PO, then 1–2 g q4h; adjust based on urine pH. *Chronic renal failure:* 1–3 mEq/kg/d. *Distal RTA:* 1 mEq/kg/d PO. ***Peds.*** >1 y: Emergency cardiac care: See Adult. *<1 y: Emergency cardiac care:* Initiate adequate ventilation, 1:1 dilution 1 mEq/mL dosed 1 mEq/kg IV; can repeat with 0.5 mEq/kg in 10 min once or based on acid–base status. *Chronic renal failure:* See Adult. *Distal RTA:* 2–3 mEq/kg/d PO. *Proximal RTA:* 5–10 mEq/kg/d titrate based on serum bicarbonate levels. *Urine alkalinization:* 84–840 mg/kg/d (1–10 mEq/kg/d) ÷ doses; adjust based on urine pH
SUPPLIED: IV inf, powder, and tabs. 300 mg = 3.6 mEq; 325 mg = 3.8 mEq; 520 mg = 6.3 mEq; 600 mg = 7.3 mEq; 650 mg = 7.6 mEq
NOTES: 1 g neutralizes 12 mEq of acid; in infants, do NOT exceed 10 mEq/min inf

Sodium Citrate (Bicitra)

COMMON USES: Alkalinization of urine; dissolve uric acid and cysteine stones
ACTIONS: Urinary alkalinizer
DOSAGE: ***Adults:*** 2–6 tsp (10–30 mL) diluted in 1–3 oz water pc and hs. ***Peds.*** 1–3 tsp (5–15 mL) diluted in 1–3 oz water pc and hs
SUPPLIED: 15- or 30-mL unit dose: 16 (473 mL) or 4 (118 mL) fl oz
NOTES: Do NOT give to patients on aluminum-based antacids. Contra in patients with severe renal impairment of sodium-restricted diets

Sodium Polystyrene Sulfonate (Kayexalate)

COMMON USES: Hyperkalemia
ACTIONS: Sodium and potassium ion-exchange resin
DOSAGE: ***Adults.*** 15–60 g PO or 30–60 g PR q6h based on serum K^+. ***Peds.*** 1 g/kg/dose PO or PR q6h based on serum K^+
SUPPLIED: Powder; susp 15 g/60 mL sorbitol
NOTES: Can cause hypernatremia; given with an agent, eg, sorbitol to promote movement through the bowel

Sorbitol

COMMON USES: Constipation
ACTIONS: Laxative
DOSAGE: 30–60 mL of a 20–70% soln PRN
SUPPLIED: Liq 70%

Sotalol (Betapace)

COMMON USES: Ventricular arrhythmias
ACTIONS: β-Adrenergic-blocking agent
DOSAGE: 80 mg PO bid; may be ↑ to 240–320 mg/d

SUPPLIED: Tabs 80, 120, 160, 240 mg
NOTES: Adjust dosage for renal insufficiency

Spironolactone (Aldactone)

COMMON USES: Hyperaldosteronism, essential HTN, and edematous states (CHF, cirrhosis)
ACTIONS: Aldosterone antagonist; K-sparing diuretic
DOSAGE: ***Adults.*** 25–100 mg PO qid. ***Peds.*** 1–3.3 mg/kg/24h PO ÷ bid–qid. *Neonates:* 0.5–1 mg/kg/dose q8h
SUPPLIED: Tabs 25, 50, 100 mg
NOTES: Can cause hyperkalemia and gynecomastia; avoid prolonged use; diuretic of choice for cirrhotic edema and ascites

Stavudine (Zerit)

COMMON USES: Advanced HIV disease
ACTIONS: Reverse-transcriptase inhibitor
DOSAGE: ***Adults.*** >60 kg: 40 mg bid. *<60 kg:* 30 mg bid
SUPPLIED: Caps 15, 20, 30, 40 mg; soln 1 mg/mL
NOTES: May cause peripheral neuropathy; not a cure for HIV; dosage adjustment in renal impairment

Steroids, Systemic (see also Table 22–5, page 627)

The following relates only to the commonly used systemic glucocorticoids.
COMMON USES: Endocrine disorders (adrenal insufficiency), rheumatoid disorders, collagen-vascular diseases, dermatologic diseases, allergic states, edematous states (cerebral, nephrotic syndrome), immunosuppression for transplantation, hypercalcemia, malignancies (breast, lymphomas), preoperatively (in any patient who has been on steroids in the previous year, known hypoadrenalism, preop for adrenalectomy); injection into joints/tissue
ACTIONS: Glucocorticoid
DOSAGE: Varies with use and institutional protocols. *Adrenal insufficiency, acute (Addisonian crisis):* ***Adult.*** Hydrocortisone: 100 mg IV q8h; then 300 mg/d ÷ q8h; convert to 50 mg PO q8h × 6 doses, taper to 30–50 mg/d ÷ bid. ***Peds.*** Hydrocortisone: 1–2 mg/kg IV; then 150–250 mg/d ÷ tid. *Adrenal insufficiency, chronic (physiologic replacement*): May need mineralocorticoid supplementation such as Florinef ***Adults.*** Hydrocortisone 20 mg PO qAM, 10 mg PO qPM; cortisone 0.5–0.75 mg/kg/d ÷ bid; cortisone 0.25–0.35 mg/kg/d IM; dexamethasone 0.03–0.15 mg/kg/d or 0.6–0.75 mg/m^2/d in ÷ q6–12h PO, IM, IV. ***Peds.*** Hydrocortisone 0.5–0.75 mg/kg/d PO tid; hydrocortisone succinate 0.25–0.35 mg/kg/d IM. *Asthma, acute:* ***Peds.*** Prednisolone 1–2 mg/kg/d or prednisone 1–2 mg/kg/d ÷ qd–bid for up to 5 d; prednisolone 2–4 mg/kg/d IV ÷ tid. *Congenital adrenal hyperplasia:* ***Peds.*** Initially hydrocortisone 30–36 mg/m^2/d PO ÷ ⅓ dose q AM, ⅔ dose q PM; maintenance: 20–25 mg/m^2/d ÷ bid. *Extubation/airway edema:* Dexamethasone 0.5–1 mg/kg/d IM/IV ÷ q6h, start beginning 24 h prior to extubation; continue for 4 additional doses. *Immunosuppressive/antiinflammatory:* ***Adults & Older Peds.*** Hydrocortisone 15–240 mg PO, IM, IV q12h; methylprednisolone: 4–48 mg/d PO, taper to lowest effective dose; methylprednisolone sodium succinate 10–80 mg/d IM. ***Adults.*** Prednisone or prednisolone 5–60 mg/d PO, ÷ qd–qid. ***Infants and Younger Children.*** 2.5–10 mg/kg/d hydrocortisone PO ÷ q6–8h; 1–5 mg/kg/d IM/IV ÷ bid. *Nephrotic syndrome:* ***Peds.*** Prednisolone or prednisone 2 mg/kg/d PO ÷ tid–qid until urine is protein-free for 5 d, use up to 28 d; for persistent proteinuria, 4 mg/kg/dose PO qod max 120 mg/d for an additional 28 d; maintenance: 2 mg/kg/dose qod for 28 d; taper over 4–6 wk (max 80 mg/d). *Septic shock:* ***Adults.*** Hydrocortisone 500 mg–1 g IM/IV q2–6h. ***Peds.*** Hydrocortisone 50 mg/kg IM/IV, repeat q4–24h PRN. *Status asthmaticus:* ***Adult and Peds.*** Hydrocortisone 1–2 mg/kg/dose IV q6h; then by 0.5–1 mg/kg q6h. *Rheumatic disease:* ***Adults.*** Intraarticular: Hydrocortisone acetate 25–37.5 mg large joint; 10–25 mg small joint; methylprednisolone acetate 20–80 mg large joint, 4–10 mg small joint. *Intrabursal:* Hydrocortisone acetate 25–37.5 mg. *Intraganglial:* Hydrocortisone acetate 25–37.5 mg. *Tendon sheath:* Hydrocortisone acetate 5–12.5 mg. *Perioperative steroid coverage:* Hydrocortisone 100 mg IV night before surgery, 1 h preop, intraop, and 4, 8, and

12 h postop; pod #1 100 mg IV q6h; pod #2 100 mg IV q8h; pod #3 100 mg IV q12h; pod #4 50 mg IV q12h; pod #5 25 mg IV q12h; then resume prior oral dosing if chronic use or discontinue if only perioperative coverage required. *Cerebral edema:* Dexamethasone 10 mg IV; then 4 mg IV q4–6h
NOTES: See Table 22–5, page 627. All can cause hyperglycemia, "steroid psychosis," adrenal suppression; never acutely stop steroids, especially if chronic treatment; taper dose. Hydrocortisone succinate administered systemically, acetate form intraarticular

Steroids, Topical

See Table 22–6 (pages 628–630)
COMMON USES: Relief of inflammatory and pruritic manifestations of corticosteroid-response dermatoses
ACTIONS: Corticosteroid, antiinflammatory
DOSAGE: Varies with indication and formulation (See Table 22–6 (pages 628–630) for frequency of application)
SUPPLIED: See Table 22–6, pages 628–630

Streptokinase (Streptase, Kabikinase)

Used for emergency cardiac care (see Chapter 21)
COMMON USES: Coronary artery thrombosis, acute massive PE, DVT, and some occluded vascular grafts
ACTIONS: Activates plasminogen to plasmin that degrades fibrin; fibrinolytic
DOSAGE: ***Adults.*** PE: Loading dose of 250,000 IU IV through a peripheral vein over 30 min, then 100,000 IU/h IV for 24–72 h. *Coronary artery thrombosis:* 1.5 million U IV over 60 min. *DVT or arterial embolism:* Load as with PE, then 100,000 IU/h for 72 h. ***Peds.*** 3500–4000 U/kg over 30 min, followed by 1000–1500 U/kg/h
SUPPLIED: Powder for inj 250,000, 600,000, 750,000, 1,500,000 IU
NOTES: If maintenance inf inadequate to maintain thrombin clotting time 2–5 × control, refer to the package insert, or the *American Hospital Formulary* Service for adjustments. Antibodies remain 3–6 mo following dose

Streptomycin

COMMON USES: TB or serious *Enterococcus* infections
ACTIONS: Aminoglycoside; interferes with protein synthesis
DOSAGE: 1–4 g/d IM in 1–2 ÷ doses (endocarditis); TB 15 mg/kg/d
SUPPLIED: Inj 400 mg/mL
NOTES: Increased incidence of vestibular toxicity; adjust dose in renal impairment

Streptozocin (Zanosar)

COMMON USES: Pancreatic islet cell tumors and carcinoid tumors
ACTIONS: DNA–DNA (interstrand) cross-linking; DNA, RNA, and protein synthesis inhibitor
DOSAGE: 1–1.5 g/m^2 q 4 wk (single agent); 500 mg –1 g/m^2/d for 5 d q 4–6 wk (combination regimens)
SUPPLIED: Inj 1 g
NOTES: *Toxicity symptoms:* Nausea and vomiting and duodenal ulcers; myelosuppression rare (20%) and mild; nephrotoxicity (proteinuria and azotemia often heralded by hypophosphatemia) can be dose-limiting. Hypo- or hyperglycemia may occur; phlebitis and pain at the site of inj may also occur. Use with caution; adjust dose in renal impairment

Succimer (Chemet)

COMMON USES: Lead poisoning
ACTIONS: Heavy metal-chelating agent
DOSAGE: ***Adults & Peds.*** 8–15 kg: 100 mg PO; *16–23 kg:* 200 mg PO; *24–34 kg:* 300 mg PO; *35–44 kg:* 400 mg PO; *>45 kg:* 500 mg PO. Give dose noted q8h for 5 d, q12h for 14 d

SUPPLIED: Caps 100 mg
NOTES: May cause a rash; patients should drink a lot of fluids

Succinylcholine (Anectine, Quelicin, Sucostrin)

COMMON USES: Adjunct to general anesthesia to facilitate endotracheal intubation and to induce skeletal muscle relaxation during surgery or mechanically supported ventilation
ACTIONS: Depolarizing neuromuscular blocking agent
DOSAGE: ***Adults.*** 0.6 mg/kg IV over 10–30 s, followed by 0.04–0.07 mg/kg as needed to maintain muscle relaxation. ***Peds.*** 1–2 mg/kg/dose IV, followed by 0.3–0.6 mg/kg/dose at intervals of 10–20 min
SUPPLIED: Inj 20, 50, 100 mg/mL; powder for inj 100 mg, 500 mg, 1 g/vial
NOTES: May precipitate malignant hyperthermia; respiratory depression or prolonged apnea may occur; many drug interactions potentiating activity of succinylcholine; observe for cardiovascular effects; use only freshly prepared solutions; ↓ in severe liver disease

Sucralfate (Carafate)

COMMON USES: Duodenal and gastric ulcers
ACTIONS: Forms ulcer-adherent complex that protects against acid, pepsin, and bile acid
DOSAGE: ***Adults.*** 1 g PO qid, 1 h prior to meals and hs. ***Peds.*** 40–80 mg/kg/d ÷ q6h
SUPPLIED: Tabs 1 g; susp 1 g/10 mL
NOTES: Continue treatment for 4–8 wk unless healing is demonstrated by x-ray or endoscopy; constipation most frequent side effect

Sufentanil (Sufenta) [C-II]

COMMON USES: Analgesic adjunct to maintain balanced general anesthesia
ACTIONS: Potent synthetic opioid
DOSAGE: Adjunctive: 1–8 µg/kg with nitrous oxide/oxygen; maintenance of 10–50 µg PRN. *General anesthesia:* 8–30 µg/kg with oxygen and a skeletal muscle relaxant. *Maintenance:* 25–50 µg PRN.
SUPPLIED: Inj 50 µg/mL
NOTES: Respiratory depressant effects persisting longer than the analgesic effects; 80 times more potent than morphine

Sulfacetamide (Bleph-10, Cetamide, Sodium Sulamyd)

COMMON USES: Conjunctival infections
ACTIONS: Sulfonamide antibiotic
DOSAGE: 10% Oint apply qid and hs; soln for keratitis apply q2–3h depending on severity
SUPPLIED: Oint 10%; soln 10, 15, 30%

Sulfacetamide Prednisolone (Blephamide, others)

COMMON USES: Steroid-responsive inflammatory ocular conditions with infection or a risk of infection
ACTIONS: Antibiotic and antiinflammatory
DOSAGE: ***Adult and Peds > 2 y.*** Apply oint to lower conjunctival sac qd–qid; soln 1–3 gtt 2–3 h while awake
SUPPLIED: Oint: Sulfacetamide 10%/prednisolone 0.5%, sulfacetamide 10%/prednisolone 0.2%, sulfacetamide 10%/prednisolone 0.25%; susp: sulfacetamide 10%/prednisolone/0.25%, sulfacetamide 10%/prednisolone 0.5%, sulfacetamide sodium 10%/prednisolone 0.2%, sulfacetamide 10% and prednisolone 0.25%
NOTES: Ophth susp can be used as an otic agent

Sulfasalazine (Azulfidine)

COMMON USES: Ulcerative colitis
ACTIONS: Sulfonamide; actions not clear

DOSAGE: ***Adults.*** Initially, 1 g tid–qid; ↑ to a max of 8 g/d in 3–4 ÷ doses; maintenance 500 mg PO qid. ***Peds.*** Initially, 40–60 mg/kg/24h PO ÷ q4–6h; maintenance 20–30 mg/kg/24h PO ÷ q6h
SUPPLIED: Tabs 500 mg; EC tabs 500 mg; oral susp 250 mg/5 mL
NOTES: Can cause severe GI upset; discolors urine

Sulfinpyrazone (Anturane)

COMMON USES: Acute and chronic gout
ACTIONS: Inhibits renal tubular absorption of uric acid
DOSAGE: 100–200 mg PO bid for 1 wk, then ↑ as needed to maintenance of 200–400 mg bid
SUPPLIED: Tabs 100 mg; caps 200 mg
NOTES: Avoid in renal impairment; take with food or antacids, take with plenty of fluids; avoid salicylates

Sulindac (Clinoril)

COMMON USES: Arthritis and pain
ACTIONS: NSAID; inhibits prostaglandin synthesis
DOSAGE: 150–200 mg bid
SUPPLIED: Tabs 150, 200 mg

Sumatriptan (Imitrex)

COMMON USES: Acute treatment of migraine attacks
ACTIONS: Vascular serotonin receptor agonist
DOSAGE: *SC:* 6 mg SC as a single dose, PRN, to a max of 12 mg/24h; *Oral:* 25 mg, repeat in 2 h, PRN, 100 mg/d max oral dose; max 300 mg/d. *Nasal spray:* 1 single spray into 1 nostril, may repeat in 2 h, max 40 mg/24hh
SUPPLIED: Inj 12 mg/mL; tabs 25, 50 mg; nasal spray 5, 20 mg
NOTES: May cause pain and bruising at the injection site; avoid in angina, ischemic heart disease, uncontrolled HTN, and ergot administration

Tacrine (Cognex)

COMMON USES: Mild to moderate dementia
ACTIONS: Cholinesterase inhibitor
DOSAGE: 10–40 mg PO qid, up to 160 mg/d
SUPPLIED: Caps 10, 20, 30, 40 mg
NOTES: May cause elevations in transaminases; monitor LFT regularly; separate doses from food

Tacrolimus [FK 506] (Prograf)

COMMON USES: Prophylaxis of organ rejection
ACTIONS: Macrolide immunosuppressant
DOSAGE: *IV:* 0.05–0.1 mg/kg/d as cont inf. *PO:* 0.15–0.3 mg/kg/d ÷ into 2 doses
SUPPLIED: Caps 1, 5 mg; inj 5 mg/mL
NOTES: May cause neurotoxicity and nephrotoxicity; ↓ in renal impairment; may need to ↓ in hepatic impairment

Tamoxifen (Nolvadex)

COMMON USES: Breast cancer (postmenopausal, estrogen receptor-positive), endometrial cancer, melanoma, reduction of breast cancer in high-risk women
ACTIONS: Nonsteroidal antiestrogen; mixed agonist–antagonist effect
DOSAGE: 20–40 mg/d (typically 10 mg bid or 20 mg/d)
SUPPLIED: Tabs 10, 20 mg
NOTES: *Toxicity symptoms:* Menopausal symptoms (hot flashes, nausea, and vomiting) in premenopausal patients. Vaginal bleeding and menstrual irregularities. Skin rash, pruritus vulvae, dizziness, headache, and peripheral edema. Acute flare of bone metastasis pain and hypercalcemia.

With high doses, retinopathy. Increased risk of pregnancy in sexually active premenopausal women by inducing ovulation

Tamsulosin (Flomax)

COMMON USES: Benign prostatic hyperplasia
ACTIONS: Antagonist of α-receptors on the prostate
DOSAGE: 0.4 mg/d
SUPPLIED: Caps 0.4 mg; do NOT crush, chew, or open caps

Tazarotene (Tazorac)

COMMON USES: Facial acne vulgaris; stable plaque psoriasis up to 20% body surface area
ACTIONS: Keratolytic
DOSAGE: ***Adults & Peds > 12 y.*** Acne: Cleanse face, dry, and apply thin film qd hs on acne lesions. *Psoriasis:* Apply hs
SUPPLIED: Gel 0.05, 0.1%

Telmisartan (Micardis)

COMMON USES: HTN
ACTIONS: Angiotensin II receptor antagonists
DOSAGE: 40–80 mg/d
SUPPLIED: Tabs 40, 80 mg
NOTES: Avoid use during PRG

Temazepam (Restoril) [C-IV]

COMMON USES: Insomnia
ACTIONS: Benzodiazepine
DOSAGE: 15–30 mg PO hs PRN
SUPPLIED: Caps 7.5, 15, 30 mg
NOTES: ↓ Dose in elderly

Tenecteplase (TNKase)

COMMON USES: Reduction of mortality associated with AMI
ACTIONS: Thrombolytic; TPA
DOSAGE: 30–50 mg; see following table

Weight (kg)	TNKase Volume (mg)	TNKase[a] (mL)
<60	30	6
≥60–<70	35	7
≥70–<80	40	8
≥80–<90	45	9
≥90	50	10

[a]From one vial of reconstituted TNKase.

SUPPLIED: Inj 50 mg, reconstituted with 10 mL sterile water

Teniposide [VM-26] (Vumon)

COMMON USES: ALL (refractory pediatric), small-cell lung cancer, Kaposi's sarcoma, non-Hodgkin's lymphoma

ACTIONS: Topoisomerase II inhibitor, interfering with strand passage and DNA ligase activities of topoisomerase II. Cell cycle-specific activity late S, early G_2 phase
DOSAGE: 45–60 mg/m^2/d × 5 d q 21 d; 120–160 mg/m^2 on d 1, 3, and 5 q 21 d; 100 mg/m^2 on d 1 and 2 q 3 wk; 100 mg/m^2/wk
SUPPLIED: Inj 10 mg/mL
NOTES: *Toxicity symptoms:* Myelosuppression (especially leukopenia and thrombocytopenia), hypotension, chemical phlebitis, skin rashes, HTN, hypersensitivity reactions (urticaria, flushing, rashes, or hypotension), and secondary leukemia. Adjust dose in significant renal impairment; consider adjustment in hepatic impairment

Terazosin (Hytrin)

COMMON USES: BPH and HTN
ACTIONS: α-1 Blocker (blood vessel and bladder neck/prostate)
DOSAGE: Initially, 1 mg PO hs; ↑ to a max of 20 mg/d PO
SUPPLIED: Tabs 1, 2, 5, 10 mg; caps 1, 2, 5, 10 mg
NOTES: Hypotension and syncope following first dose; dizziness, weakness, nasal congestion, peripheral edema common; should be used with thiazide diuretic for HTN

Terbinafine (Lamisil)

COMMON USES: Onychomycosis, athlete's foot
ACTIONS: Inhibits squalene epoxidase resulting in fungal death
DOSAGE: *Oral:* 250 mg/d PO for 6–12 wk. *Topical:* Apply to affected area
SUPPLIED: Tabs 250 mg; cream 1%
NOTES: Full clinical effect may take months due to need for new nail growth; NO occlusive dressings; dosage adjustment in renal impairment

Terbutaline (Brethine, Bricanyl)

COMMON USES: Reversible bronchospasm (asthma, COPD); inhibition of labor
ACTIONS: Sympathomimetic
DOSAGE: ***Adults.*** Bronchodilator: 2.5–5 mg PO qid or 0.25 mg SC; may repeat in 15 min (max 0.5 mg in 4 h). *Met-dose inhaler:* 2 inhal q4–6h. *Premature labor:* Acutely 2.5–10 mg/min/IV, gradually ↑ as tolerated q 10–20 min; maintenance 2.5 – 10 mg PO q 4–6h until term; or 0.25 mg SC q 30 min. ***Peds.*** Oral: 0.05–0.15 mg/kg/dose PO tid; max 5 mg/24h
SUPPLIED: Tabs 2.5, 5 mg; inj 1 mg/mL; met-dose inhaler
NOTES: Caution with diabetes, HTN, hyperthyroidism; high doses may precipitate β-1-adrenergic effects

Terconazole (Terazol [vaginal])

COMMON USES: Vaginal fungal infections
ACTIONS: Topical antifungal
DOSAGE: 1 applicatorful or 1 supp intravaginally hs for 7 d
SUPPLIED: Vaginal cream 0.4%, vaginal supp 80 mg

Tetanus Immune Globulin [TIG]

COMMON USES: Passive immunization against tetanus for any person with a suspected contaminated wound and unknown immunization status (Chapter 17)
ACTIONS: Passive immunization
DOSAGE: ***Adults & Peds.*** 250–500 U IM (higher doses if delay in initiation of therapy)
SUPPLIED: Inj 250-U vial or syringe
NOTES: May begin active immunization series at different inj site if required

Tetanus Toxoid

COMMON USES: Protection against tetanus
ACTIONS: Active immunization

DOSAGE: See Chapter 17 and Table 22–9, page 636 for tetanus prophylaxis
SUPPLIED: Inj tetanus toxoid, fluid, measured in limes flocculation (Lf) units of toxoid: 4–5 Lf units/0.5 mL; tetanus toxoid, adsorbed, 5, 10 Lf units/0.5 mL

Tetracycline (Achromycin V, Sumycin)

COMMON USES: Broad-spectrum antibiotic treatment against *Staphylococcus, Streptococcus, Chlamydia, Rickettsia,* and *Mycoplasma*
ACTIONS: Bacteriostatic; inhibits protein synthesis
DOSAGE: ***Adults.*** 250–500 mg PO bid–qid. ***Peds >8 y.*** 25–50 mg/kg/24h PO q6–12h. Do NOT use in children <8 y old
SUPPLIED: Caps 100, 250, 500 mg; tabs 250, 500 mg; oral susp 250 mg/5 mL
NOTES: Can stain enamel and depress bone formation in children; caution with use in pregnancy; do NOT use in the presence of impaired renal function (see Doxycycline page 531)

Theophylline (Theolair, Theo-Dur, Somophyllin, others)

COMMON USES: Asthma, bronchospasm
ACTIONS: Relaxes smooth muscle of the bronchi and pulmonary blood vessels
DOSAGE: ***Adults.*** 900 mg PO ÷ q6h; SR products may be ÷ q8–12h × (maintenance). ***Peds.*** 16–22 mg/kg/24h PO ÷ q6h; SR products may be ÷ q8–12h × (maintenance)
SUPPLIED: Elixir 80, 150 mg/15 mL; liq 80, 160 mg/15 mL; caps 100, 200, 250 mg; tabs 100, 125, 200, 225, 250, 300 mg; SR caps 50, 75, 100, 125, 200, 250, 260, 300 mg; SR tabs 100, 200, 250, 300, 400, 450, 500 mg
NOTES: See drug levels in Table 22–7 (pages 631–634); many drug interactions; side effects include nausea, vomiting, tachycardia, and seizures

Thiamine [Vitamin B_1]

COMMON USES: Thiamine deficiency (beriberi); alcoholic neuritis; Wernicke's encephalopathy
ACTIONS: Dietary supplementation
DOSAGE: ***Adults.*** Deficiency: 100 mg/d IM for 2 wk, then 5–10 mg/d PO for 1 mo. *Wernicke's encephalopathy:* 100 mg IV in single dose, then 100 mg/d IM for 2 wk. ***Peds.*** 10–25 mg/d IM for 2 wk, then 5–10 mg/24h PO for 1 mo
SUPPLIED: Tabs 5, 10, 25, 50, 100, 500 mg; inj 100, 200 mg/mL
NOTES: IV thiamine administration associated with anaphylactic reaction; give IV slowly

Thiethylperazine (Torecan)

COMMON USES: Nausea and vomiting
ACTIONS: Antidopaminergic antiemetic
DOSAGE: 10 mg PO, PR, or IM qd–tid
SUPPLIED: Tabs 10 mg; supp 10 mg; inj 5 mg/mL
NOTES: Extrapyramidal reactions may occur

6-Thioguanine [6-TG] (Tabloid)

COMMON USES: AML, ALL, CML
ACTIONS: Purine-based antimetabolite (substitutes for natural purines interfering with nucleotide synthesis)
DOSAGE: 2–3 mg/kg/d
SUPPLIED: Tabs 40 mg
NOTES: *Toxicity symptoms:* Myelosuppression (especially leukopenia and thrombocytopenia), nausea and vomiting, anorexia, stomatitis, and diarrhea. Hepatotoxicity rare; dosage adjustment in renal or hepatic impairment

Thioridazine (Mellaril)

COMMON USES: Psychotic disorders; short-term treatment of depression, agitation, organic brain syndrome

ACTIONS: Phenothiazine antipsychotic
DOSAGE: ***Adults.*** Initially, 50–100 mg PO tid; maintenance 200–800 mg/24h PO in 2–4 ÷ doses. ***Peds >2 y.*** 0.5–3 mg/kg/24h PO in 2–3 ÷ doses
SUPPLIED: Tabs 10, 15, 25, 50, 100, 150, 200 mg; oral conc 30, 100 mg/mL; oral susp 25, 100 mg/5 mL
NOTES: Low incidence of extrapyramidal effects; may cause ventricular arrhythmias

Thiothixene (Navane)

COMMON USES: Psychotic disorders
ACTIONS: Antipsychotic
DOSAGE: ***Adults & Peds >12 y.*** Mild to moderate psychosis: 2 mg PO tid, up to 20–30 mg/d. *Severe psychosis:* 5 mg PO bid; ↑ to a max of 60 mg/24h PRN. *IM use:* 16–20 mg/24h ÷ bid–qid; max 30 mg/d. ***Peds <12 y.*** 0.25 mg/kg/24h PO ÷ q6–12h
SUPPLIED: Caps 1, 2, 5, 10, 20 mg; oral conc 5 mg/mL; inj 2, 5 mg/mL
NOTES: Drowsiness and extrapyramidal side effects most common

Tiagabine (Gabitril)

COMMON USES: Adjunctive therapy in treatment of partial seizures
ACTIONS: Inhibition of GABA
DOSAGE: Initial 4 mg/d, ↑ by 4 mg during 2nd wk; may keep increasing by 4–8 mg/d until clinical response achieved; max dose 56 mg/d
SUPPLIED: Tabs 4, 12, 16, 20 mg
NOTE: Use gradual withdrawal; used in combination with other anticonvulsants

Ticarcillin (Ticar)

COMMON USES: Infections caused by susceptible strains of gram (–) bacteria (including *Klebsiella, Proteus, E. coli, Enterobacter, P. aeruginosa,* and *Serratia*) involving the skin, bone, respiratory tract, urinary tract, abdomen, and septicemia
ACTIONS: Bactericidal; inhibits cell wall synthesis
DOSAGE: ***Adults.*** 3 g IV q4–6h. ***Peds.*** 200–300 mg/kg/d IV ÷ q4–6h
SUPPLIED: Inj
NOTES: Often used in combination with aminoglycoside; dosage adjustment in renal impairment

Ticarcillin/Potassium Clavulanate (Timentin)

COMMON USES: Infections caused by susceptible strains of gram (–) bacteria (including *Klebsiella, Proteus, E. coli, Enterobacter, P. aeruginosa,* and *Serratia*) involving the skin, bone, respiratory tract, urinary tract, abdomen, and septicemia
ACTIONS: Bactericidal; inhibits cell wall synthesis
DOSAGE: ***Adults.*** 3.1 g IV q4–6h. ***Peds.*** 200–300 mg/kg/d IV ÷ q4–6h
SUPPLIED: Inj
NOTES: Often used in combination with aminoglycosides; dosage adjustment in renal impairment

Ticlopidine (Ticlid)

COMMON USES: Reduces the risk of thrombotic stroke
ACTIONS: Platelet aggregation inhibitor
DOSAGE: 250 mg PO bid
SUPPLIED: Tabs 250 mg
NOTES: Administer with food; may cause neutropenia, monitor WBC and LFTs

Timolol (Blocadren)

COMMON USES: HTN and MI
ACTIONS: Competitively blocks β-adrenergic receptors, β_1, β_2
DOSAGE: *HTN:* 10–20 mg bid, up to 60 mg/d. *MI:* 10 mg bid
SUPPLIED: Tabs 5, 10, 20 mg

Timolol, Ophthalmic (Timoptic)

COMMON USES: Glaucoma
ACTIONS: β-Blocker
DOSAGE: 0.25% 1 gt bid; ↓ to qd when controlled; use 0.5% if needed; 1 gt gel qd
SUPPLIED: Soln 0.25/0.5%; Timoptic XE (0.25, 0.5%) gel-forming soln

Tioconazole (Vagistat)

COMMON USES: Vaginal fungal infections
ACTIONS: Topical antifungal
DOSAGE: 1 applicatorful intravaginally hs (single dose)
SUPPLIED: Vaginal oint 6.5%

Tirofiban (Aggrastat)

COMMON USES: Acute coronary syndrome
ACTIONS: Glycoprotein IIb/IIIa inhibitor
DOSAGE: Initial 0.4 μg/kg/min for 30 min, followed by 0.1 μg/kg/min
SUPPLIED: Inj 50 μg/mL, 250 μg/mL
NOTES: Adjust dose in renal insufficiency; use in combination with heparin

Tobramycin (Nebcin)

COMMON USES: Serious gram– infections, especially *Pseudomonas*
ACTIONS: Aminoglycoside; inhibits protein synthesis
DOSAGE: ***Adults.*** 1–2.5 mg/kg/dose IV q8–24h (see page 620). ***Peds.*** 2.5 mg/kg/dose IV q8h
SUPPLIED: Inj 10, 40 mg/mL
NOTES: Nephrotoxic and ototoxic; ↓ with renal insufficiency; monitor creatinine clearance and serum concentrations for dosage adjustments (see Table 22–7, pages 631–634, and page 620).

Tobramycin Ophthalmic (AK Tob, Tobrex)

COMMON USES: Ocular bacterial infections
ACTIONS: Aminoglycoside antibiotic
DOSAGE: 1–2 gtt q4h; oint bid–tid; if severe infections, use oint q3–4h, or 2 gtt q 30–60 min, then less frequently
SUPPLIED: Oint and soln tobramycin 0.3%

Tobramycin and Dexamethasone Ophthalmic (TobraDex)

COMMON USES: Ocular bacterial infections associated with significant inflammation
ACTIONS: Antibiotic with antiinflammatory
DOSAGE: 0.3% oint apply q3–8h or soln 0.3% apply 1–2 gtt q1–4h
SUPPLIED: Oint and soln tobramycin 0.3% and dexamethasone 0.1%

Tocainide (Tonocard)

COMMON USES: Suppression of ventricular arrhythmias, including PVCs, and ventricular tachycardia
ACTIONS: Class IB antiarrhythmic
DOSAGE: 400–600 mg PO q8h, up to 2400 mg/d
SUPPLIED: Tabs 400, 600 mg
NOTES: Properties similar to those of lidocaine; ↓ dose in renal failure; CNS and GI side effects common

Tolazamide (Tolinase)

COMMON USES: Type 2 DM
ACTION: Sulfonylurea. Stimulates the release of insulin from the pancreas; increases insulin sensitivity at peripheral sites; reduces glucose output from the liver
DOSAGE: 100–500 mg/d
SUPPLIED: Tabs 100, 250, 500 mg

Tolazoline (Priscoline)

COMMON USES: Persistent pulmonary vasoconstriction and HTN of the newborn, peripheral vasospastic disorders
ACTIONS: Competitively blocks α-adrenergic receptors
DOSAGE: ***Adults.*** 10–50 mg IM/IV/SC qid
Neonates. 1–2 mg/kg IV over 10–15 min, followed by 1–2 mg/kg/h
SUPPLIED: Inj 25 mg/mL

Tolbutamide (Orinase)

COMMON USES: Type 2 DM
ACTION: Sulfonylurea. Stimulates the release of insulin from the pancreas; increases insulin sensitivity at peripheral sites; reduces glucose output from the liver
DOSAGE: 500–1000 mg bid
SUPPLIED: Tabs 500 mg
NOTES: May require dosage adjustment in hepatic impairment

Tolmetin (Tolectin)

COMMON USES: Arthritis and pain
ACTIONS: NSAID; inhibits prostaglandin synthesis
DOSAGE: 200–600 mg tid, to a max of 2000 mg/d
SUPPLIED: Tabs 200, 600 mg; caps 400 mg

Tolnaftate [OTC] (Tinactin)

COMMON USES: Tinea pedis, tinea cruris, tinea corporis, tinea manus, tinea versicolor
ACTIONS: Topical antifungal
DOSAGE: Apply to area bid for 2–4 wk
SUPPLIED: OTC 1% liq; gel; powder; cream; soln

Tolterodine (Detrol, Detrol LA)

COMMON USES: Management of overactive bladder (frequency, urgency, urge incontinence)
ACTIONS: Anticholinergic
DOSAGE: Detrol 1–2 mg PO bid; Detrol LA 2–4 mg/d
SUPPLIED: Detrol tabs 1, 2 mg; Detrol LA tabs 2, 4 mg
NOTES: Do not administer to patients with urinary retention, gastric retention, or uncontrolled narrow-angle glaucoma; dry mouth common side effect

Topiramate (Topamax)

COMMON USES: Partial onset seizures
ACTIONS: Anticonvulsant
DOSAGE: Total dose 400 mg/d. See product information for 8-wk titration schedule
SUPPLIED: Tabs 25, 100, 200 mg; caps sprinkles 15, 25, 50 mg
NOTES: May precipitate kidney stones; dosage adjustment in renal impairment

Topotecan (Hycamtin)

COMMON USES: Ovarian cancer (cisplatin-refractory), small-cell lung cancer, and non-Hodgkin's lymphoma
ACTIONS: Topoisomerase I inhibitor; interferes with DNA synthesis
DOSAGE: 1.5 mg/m^2/d as an 1-h IV inf for 5 consecutive days, repeated q 3 wk
SUPPLIED: Vials containing 4 mg of lyophilized drug reconstituted in sterile water and diluted in NS or 5% dextrose
NOTES: *Toxicity symptoms:* Myelosuppression, nausea and vomiting, diarrhea, drug fever, and skin rash. ↓ Dose for renal dysfunction

Torsemide (Demadex)

COMMON USES: Edema, HTN, CHF, and hepatic cirrhosis
ACTIONS: Loop diuretic; inhibits reabsorption of sodium and chloride in the ascending loop of Henle and distal tubule
DOSAGE: 5–20 mg/d PO or IV
SUPPLIED: Tabs 5, 10, 20, 100 mg; inj 10 mg/mL

Tramadol (Ultram)

COMMON USES: Moderate to severe pain
ACTIONS: Centrally acting analgesic
DOSAGE: 50–100 mg PO q4–6h PRN, not to exceed 400 mg/d
SUPPLIED: Tabs 50 mg
NOTES: Lowers seizure threshold, tolerance or dependence may develop

Trandolapril (Mavik)

COMMON USES: HTN, CHF, LVD, post-AMI
ACTIONS: ACE inhibitor
DOSAGE: *HTN:* 2–4 mg/d. *CHF/LVD:* 4 mg/d
SUPPLIED: Tabs 1, 2, 4 mg
NOTES: Dosage adjustment in renal or hepatic impairment

Trazodone (Desyrel)

COMMON USES: Depression
ACTIONS: Antidepressant; inhibits reuptake of serotonin and norepinephrine
DOSAGE: ***Adults & Adolescents.*** 50–150 mg PO qd–qid; max 600 mg/d
SUPPLIED: Tabs 50, 100, 150, 300 mg
NOTES: May take 1–2 wk for symptomatic improvement; anticholinergic side effects

Tretinoin, Systemic [Tretinoic Acid] (Vesanoid)

COMMON USES: APL induction therapy
ACTIONS: Differentiating agent; all *trans* retinoic acid
DOSAGE: 45 mg/m^2/d in ÷ doses for approximately 40 d
SUPPLIED: Caps 10 mg
NOTES: *Toxicity symptoms:* Cutaneous (dryness, chafing), neurologic (headache), hypertriglyceridemia, and treatment-related leukocytosis reported in APL, as well as "retinoic acid syndrome"

Tretinoin, Topical [Retinoic Acid] (Retin-A, Avita)

COMMON USES: Acne vulgaris, sun-damaged skin, some skin cancers
ACTIONS: Exfoliant retinoic acid derivative
DOSAGE: ***Adults & Peds> 12.*** Apply qd hs; if irritation develops, ↓ frequency
SUPPLIED: Cream 0.025, 0.05, 0.1%; gel 0.01, 0.025, 0.1%; liq 0.05%
NOTES: Avoid sunlight

Triamcinolone and Nystatin (Mycolog-II)

COMMON USES: Cutaneous candidiasis
ACTIONS: Antifungal and antiinflammatory
DOSAGE: Apply lightly to area bid; max 25 d
SUPPLIED: Cream and oint 15, 30, 60, 120 mg
NOTES: Contra in varicella

Triamterene (Dyrenium)

COMMON USES: Edema associated with CHF, cirrhosis
ACTIONS: Potassium-sparing diuretic
DOSAGE: ***Adults.*** 100–300 mg/24h PO ÷ qd–bid. ***Peds.*** 2–4 mg/kg/d in 1–2 ÷ doses

SUPPLIED: Caps 50, 100 mg
NOTES: Can cause hyperkalemia, blood dyscrasias, liver damage, and other reactions; dosage adjustment in renal or hepatic impairment

Triazolam (Halcion) [C-IV]

COMMON USES: Short-term management of insomnia
ACTIONS: Benzodiazepine
DOSAGE: 0.125–0.25 mg/d PO hs PRN
SUPPLIED: Tabs 0.125, 0.25 mg
NOTES: Additive CNS depression with alcohol and other CNS depressants; ↓ dose; avoid in cirrhosis

Triethanolamine (Cerumenex)

COMMON USES: Cerumen removal
ACTIONS: Ceruminolytic agent
DOSAGE: Fill the ear canal and insert the cotton plug; irrigate with water after 15 min; repeat as needed
SUPPLIED: Soln 6, 12 mL

Triethylene-Triphosphoramide [Thiotepa, TESPA, TSPA] (Thioplex)

COMMON USES: Hodgkin's and non-Hodgkin's lymphomas; leukemia; breast, ovarian, and bladder cancers (IV and intravesical therapy), preparative regimens for allogeneic and autologous BMT in high doses
ACTIONS: Polyfunctional alkylating agent
DOSAGE: 0.5 mg/kg q 1–4 wk, 6 mg/m^2 IM or IV × 4 d q 2–4 wk, 15–35 mg/m^2 by cont IV inf over 48 h; 60 mg instilled into the bladder and retained 2 h q 1–4 wk; 900–125 mg/m^2 in ABMT regimens (the highest dose that can be administered without ABMT is 180 mg/m^2); 1–10 mg/m^2 (typically 15 mg) IT once or twice a week; 0.8 mg/kg in 1–2 L of soln may be instilled intraperitoneally
SUPPLIED: Inj 15 mg
NOTES: *Toxicity symptoms:* Myelosuppression, nausea, vomiting, dizziness, headache, allergy, and paresthesias

Trifluoperazine (Stelazine)

COMMON USES: Psychotic disorders
ACTIONS: Phenothiazine; blocks postsynaptic mesolimbic dopaminergic receptors in the brain
DOSAGE: ***Adults.*** 2–10 mg PO bid. ***Peds 6–12 y.*** 1 mg PO qd–bid initially, then gradually ↑ up to 15 mg/d
SUPPLIED: Tabs 1, 2, 5, 10 mg; oral conc 10 mg/mL; inj 2 mg/mL
NOTES: ↓ Dose in elderly and debilitated patients; oral conc must be diluted to 60 mL or more prior to administration; requires several weeks for onset of effects

Trifluridine (Viroptic)

COMMON USES: Herpes simplex keratitis and conjunctivitis
ACTIONS: Antiviral
DOSAGE: 1 gt q2h (max 9 gtt/d); ↓ to 1 gt q4h after healing begins; treat up to 14 d
SUPPLIED: 1% soln

Trihexyphenidyl (Artane)

COMMON USES: Parkinson's disease
ACTIONS: Blocks excess acetylcholine at cerebral synapses
DOSAGE: 2–5 mg PO qd–qid
SUPPLIED: Tabs 2, 5 mg; SR caps 5 mg; elixir 2 mg/5 mL
NOTES: Contra in narrow-angle glaucoma

Trimethobenzamide (Tigan)

COMMON USES: Nausea and vomiting
ACTIONS: Inhibits medullary chemoreceptor trigger zone
DOSAGE: ***Adults.*** 250 mg PO or 200 mg PR or IM tid–qid PRN. ***Peds.*** 20 mg/kg/24h PO or 15 mg/kg/24h PR or IM in 3–4 ÷ doses (NOT recommended for infants)
SUPPLIED: Caps 100, 250 mg; supp 100, 200 mg; inj 100 mg/mL
NOTES: In the presence of viral infections, may mask emesis or mimic CNS effects of Reye's syndrome; may cause parkinsonian-like syndrome

Trimethoprim (Trimpex, Proloprim)

COMMON USES: UTI due to susceptible gram+ and gram– organisms; often used for suppression of UTI
ACTIONS: Inhibits dihydrofolate reductase
DOSAGE: ***Adults.*** 100 mg/d PO bid or 200 mg/d PO. ***Peds.*** 4 mg/kg/d in 2 ÷ doses
SUPPLIED: Tabs 100, 200 mg; oral soln 50 mg/5 mL
NOTES: ↓ Dose in renal failure

Trimethoprim-Sulfamethoxazole [Co-trimoxazole] (Bactrim, Septra)

COMMON USES: UTI, otitis media, sinusitis, bronchitis, and *Shigella, P. carinii,* and *Nocardia* infections
ACTIONS: Dual effect of SMX-inhibiting synthesis of dihydrofolic acid and TMP-inhibiting dihydrofolate reductase to impair protein synthesis
DOSAGE: ***Adults.*** 1 DS tab PO bid or 5–20 mg/kg/24h (based on TMP component) IV in 3–4 ÷ doses. *P. carinii*: 15–20 mg/kg/d IV or PO (TMP component) in 4 ÷ doses. *Nocardia*: 10–15 mg/kg/d IV or PO (TMP component) in 4 ÷ doses. ***Peds.*** 8–10 mg/kg/24h (TMP) PO ÷ into 2 doses or 3–4 doses IV; do NOT use in newborns
SUPPLIED: Regular tabs 80 mg of TMP and 400 mg of SMX; DS tabs 160 mg of TMP and 800 mg of SMX; oral susp 40 mg of TMP and 200 mg of SMX/ 5 mL; inj 80 mg of TMP and 400 mg of SMX/5 mL
NOTES: Synergistic combination; reduce dosage in renal failure; maintain adequate hydration

Trimetrexate (Neutrexin)

COMMON USES: Moderate to severe PCP
ACTIONS: Inhibits dihydrofolate reductase
DOSAGE: 45 mg/m^2 IV q24h for 21 d
SUPPLIED: Inj
NOTES: Administer with leucovorin 20 mg/m^2 IV q6h for 24 d; use cytotoxic precautions; infuse over 60 min; ↓ in hepatic impairment

Trimipramine (Surmontil)

COMMON USES: Depression
ACTIONS: Tricyclic antidepressant; increases synaptic concentration of serotonin and/or norepinephrine in CNS
DOSAGE: 50–300 mg/d PO hs
SUPPLIED: Caps 25, 50, 100 mg

Urokinase (Abbokinase)

COMMON USES: PE, DVT, restore patency to IV catheters
ACTIONS: Converts plasminogen to plasmin that causes clot lysis
DOSAGE: ***Adults & Peds.*** Systemic effect: 4400 IU/kg IV over 10 min, followed by 4400–6000 IU/kg/h for 12 h. *Restore catheter patency:* Inject 5000 IU into catheter and gently aspirate
SUPPLIED: Powder for inj 5000 IU/mL, 250,000 IU vial
NOTES: Do NOT use systemically within 10 d of surgery, delivery, or organ biopsy

Valacyclovir (Valtrex)

COMMON USES: Herpes zoster; genital herpes
ACTIONS: Prodrug of acyclovir, inhibits viral DNA replication
DOSAGE: 1 g PO tid; genital herpes treatment 500 mg bid × 7 d, prophylaxis 500–1000 mg/d
SUPPLIED: Caplets 500 mg
NOTES: Dosage adjustment in renal impairment

Valproic Acid and Divalproex (Depakene, Depakote)

COMMON USES: Rx epilepsy, mania; prophylaxis of migraines
ACTIONS: Anticonvulsant; increases the availability of GABA
DOSAGE: ***Adults & Peds.*** Seizures: 30–60 mg/kg/24h PO ÷ tid (after initiation of 10–15 mg/dh/24h). *Mania:* 750 mg in 3 ÷ doses, ↑ to a max of 60 mg/kg/d. *Migraines:* 250 mg bid, ↑ to 1000 mg/d
SUPPLIED: *Valproic acid:* caps 250 mg; syrup 250 mg/5 mL. *Divalproex:* EC tabs 125, 250, 500; caps 125 mg
NOTES: Monitor LFT and follow serum levels (see Table 22–7, pages 631–634); concurrent use of phenobarbital and phenytoin may alter serum levels of these agents; ↓ dose in hepatic impairment

Valrubicin (Valstar)

COMMON USES: Intravesical treatment of BCG-refractory CIS when immediate cystectomy would be associated with unacceptable morbidity or mortality
ACTIONS: Semisynthetic doxorubicin analogue; cytotoxic
DOSAGE: 800 mg intravesically weekly for 6 wk
SUPPLIED: Liq 200 mg/5 mL
NOTES: Dilute 800 mg in approximately 75 mL NS; minimal systemic absorption with intact bladder. Do NOT use within 1–2 wk of biopsy as systemic absorption can cause myelosuppression; can cause local bladder symptoms; contra with bladder capacity of < 75 mL or active UTI

Valsartan (Diovan)

COMMON USES: HTN
ACTIONS: Angiotensin II receptor antagonist
DOSAGE: 80 –160 mg/d
SUPPLIED: Caps 80, 160 mg
NOTES: Use with caution with K-sparing diuretics or K supplements

Vancomycin (Vancocin, Vancoled)

COMMON USES: Serious MRSA infections and in enterococcal endocarditis in combination with aminoglycosides in penicillin-allergic patients; oral treatment of *C. difficile* pseudomembranous colitis
ACTIONS: Inhibits cell wall synthesis
DOSAGE: ***Adults.*** 1 g IV q12h; for colitis 125–500 mg PO q6h. ***Peds (NOT neonates***). 40 mg/kg/24h IV in ÷ doses q6–12h
SUPPLIED: Caps 125, 250 mg; powder for oral soln; powder for inj 500 mg, 1000 mg, 10 g/vial
NOTES: Ototoxic and nephrotoxic; NOT absorbed orally, provides local effect in gut only; IV dose must be given slowly over 1 h to prevent "red-man syndrome"; adjust dose in renal failure (for drug levels, see Table 22–7, pages 631–634)

Varicella Virus Vaccine (Varivax)

COMMON USES: Prevention of varicella (chicken pox) infection
ACTIONS: Active immunization
DOSAGE: ***Adults & Peds.*** 0.5 mL SC, repeated in 4–8 wk
SUPPLIED: Powder for inj
NOTES: Live virus; do NOT administer to immunocompromised

Vasopressin [Antidiuretic Hormone (ADH)] (Pitressin)

COMMON USES: Diabetes insipidus; relief of gaseous GI tract distention; severe GI bleeding
ACTIONS: Posterior pituitary hormone, potent GI vasoconstrictor
DOSAGE: ***Adults & Peds.*** Diabetes insipidus: 2.5–10 U SC or IM tid–qid or 1.5–5.0 U IM q 1–3 d of the tannate. *GI hemorrhage:* 0.2–0.4 U/min
SUPPLIED: Inj 20 U/mL
NOTES: Use with caution with any vascular disease

Vecuronium (Norcuron)

COMMON USES: Skeletal muscle relaxation during surgery or mechanical ventilation
ACTIONS: Nondepolarizing neuromuscular blocker
DOSAGE: ***Adults & Peds.*** 0.08–0.1 mg/kg IV bolus; maintenance of 0.010–0.015 mg/kg after 25–40 min followed with additional doses q 12–15 min
SUPPLIED: Powder for inj 10 mg
NOTES: Drug interactions leading to an increased effect of vecuronium include aminoglycosides, tetracycline, and succinylcholine; fewer cardiac effects than with pancuronium

Venlafaxine (Effexor)

COMMON USES: Depression
ACTIONS: Potentiation of neurotransmitter activity in the CNS
DOSAGE: 75–375 mg/d ÷ into 2–3 equal doses
SUPPLIED: Tabs 25, 37.5, 50, 75, 100 mg; ER caps 37.5, 75, 150 mg
NOTES: Dosage adjustment in renal or hepatic impairment

Verapamil (Calan, Isoptin)

Used for emergency cardiac care (see Chapter 21)
COMMON USES: Angina, essential HTN, and arrhythmias
ACTIONS: Ca channel-blocker
DOSAGE: ***Adults.*** Arrhythmias: See Chapter 21. *Angina:* 80–120 mg PO tid, up to 480 mg/24h. *HTN:* 80–180 mg PO tid or SR tabs 120– 240 mg PO qd to 240 mg bid. ***Peds.*** <1 y: 0.1–0.2 mg/kg IV over 2 min (may repeat in 30 min). *1–16 y:* 0.1–0.3 mg/kg IV over 2 min (may repeat in 30 min); do NOT exceed 5 mg. *Oral: 1–5 y:* 4–8 mg/kg/d in 3 ÷ doses. *>5 y:* 80 mg q6–8h
SUPPLIED: Tabs 40, 80, 120 mg; SR tabs 120, 180, 240 mg; SR caps 120, 180, 240, 360 mg; inj 5 mg/2 mL
NOTES: Use caution with elderly patients; ↓ dose in renal or hepatic failure; constipation common

Vinblastine (Velban, Velbe)

COMMON USES: Hodgkin's and non-Hodgkin's lymphomas, mycosis fungoides, testicular cancer, choriocarcinoma, breast cancer, histiocytosis X, non-small-cell lung cancer, AIDS-related Kaposi's sarcoma, renal cell carcinoma
ACTIONS: Inhibits microtubule assembly through binding to tubulin
DOSAGE: 0.1–0.5 mg/kg/wk (4–20 mg/m^2)
SUPPLIED: Inj 1 mg/mL
NOTES: *Toxicity symptoms:* Myelosuppression (especially leukopenia), nausea and vomiting (rare), constipation, neurotoxicity (similar to that listed for vincristine but less frequent), alopecia, rash; myalgia and tumor pain common; dosage adjustment in hepatic impairment

Vincristine (Oncovin, Vincasar PFS)

COMMON USES: ALL, breast carcinoma, sarcoma (including Ewing's and rhabdomyosarcoma), Wilms' tumor, Hodgkin's and non-Hodgkin's lymphomas, neuroblastoma, small-cell lung cancer, multiple myeloma
ACTIONS: Promotes disassembly of mitotic spindle, causing metaphase arrest
DOSAGE: 0.4–1.4 mg/m^2 (single doses do NOT usually exceed 2 mg)
SUPPLIED: Inj 1 mg/mL

NOTES: *Toxicity symptoms:* Neurotoxicity commonly dose-limiting, jaw pain (trigeminal neuralgia), fever, fatigue and anorexia, constipation and paralytic ileus, bladder atony, no significant myelosuppression observed with standard doses. Soft tissue necrosis possible with extravasation; dosage adjustment in hepatic impairment

Vinorelbine (Navelbine)

COMMON USES: Non-small-cell lung cancer (single agent or with cisplatin), breast cancer
ACTIONS: Inhibits polymerization of microtubules, impairing mitotic spindle formation, semisynthetic vinca alkaloid
DOSAGE: 30 mg/m^2/wk
SUPPLIED: Inj 10 mg
NOTES: *Toxicity symptoms:* Myelosuppression (especially leukopenia), mild GI effects and infrequent neurotoxicity (6– 29%), constipation and paresthesias (rare). Tissue damage can result from extravasation. Dosage adjustment in hepatic impairment

Vitamin B_1

See Thiamine (page 609)

Vitamin B_6

See Pyridoxine (page 596)

Vitamin B_{12}

See Cyanocobalamin (page 521)

Vitamin K

See Phytonadione (page 589)

Warfarin (Coumadin)

COMMON USES: Prophylaxis and Rx of PE and DVT, AF with embolization, other postoperative indications
ACTIONS: Inhibits vitamin K-dependent production of clotting factors in the order VII-IX-X-II
DOSAGE: See Table 22–10 (page 637) for anticoagulation guidelines. ***Adults.*** Individualize dose to keep INR 2.0–3.0 for most indications, for mechanical heart valves desired INR is 2.5–3.5. ACCP guidelines recommend initiation with 5 mg, unless rapid attainment of therapeutic INR is necessary (use 7.5–10 mg) if patient elderly or has other bleeding risk factors (↓). others recommend 10–15 mg PO, IM, or IV qd for 1–3 d; then maintenance, 2–10 mg/d PO, IV, or IM; follow daily INR during initial phase to guide dosage. ***Peds.*** 0.05–0.34 mg/kg/24h PO, IM, or IV. Follow PT/INR closely to adjust dosage
SUPPLIED: Tabs 1, 2, 2.5, 3, 4, 5, 6, 7.5, 10 mg; inj
NOTES: INR now the preferred test rather than PT; Check INR periodically on maintenance dose; beware of bleeding caused by over anticoagulation (PT >3 × control or INR >5.0– 6.0); to rapidly correct over coumadinization, use vitamin K or FFP or both; highly teratogenic; do NOT use in pregnancy. Caution patient on taking Coumadin with other medications, especially aspirin. *Common warfarin interactions:* Potentiates acetaminophen, alcohol (with liver disease), amiodarone, cimetidine, ciprofloxacin, co-trimoxazole, erythromycin, fluconazole, flu vaccine, isoniazid, itraconazole, metronidazole, omeprazole, phenytoin, propranolol, quinidine, tetracycline. Inhibits barbiturates, carbamazepine, chlordiazepoxide, cholestyramine, dicloxacillin, nafcillin, rifampin, sucralfate, high vitamin K foods

Witch Hazel (Tucks Pads, others)

COMMON USES: After bowel movement cleansing to decrease local irritation or relieve hemorrhoids; after anorectal surgery and episiotomy
DOSAGE: Apply PRN
SUPPLIED: Presoaked pads, liq

Zafirlukast (Accolate)

COMMON USES: Prophylaxis and chronic Rx of asthma
ACTIONS: Selective and competitive inhibitor of leukotriene D4 and E4
DOSAGE: 20 mg bid
SUPPLIED: Tabs 20 mg
NOTES: NOT for acute exacerbations of asthma, contra in nursing women; associated with hepatic dysfunction, which has been reversible on discontinuation

Zalcitabine [DdC] (Hivid)

COMMON USES: HIV patients intolerant of zidovudine and didanosine
ACTIONS: Antiretroviral agent
DOSAGE: 0.75 mg PO tid
SUPPLIED: Tabs 0.375, 0.75 mg
NOTES: May be used in combination with zidovudine; may cause peripheral neuropathy; dosage adjustment in renal impairment

Zaleplon (Sonata)

COMMON USES: Insomnia
ACTION: A nonbenzodiazepine sedative hypnotic, a pyrazolopyrimidine
DOSAGE: 5–20 mg hs PRN
SUPPLIED: Caps 5, 10 mg

Zanamivir (Relenza)

COMMON USES: Influenza
ACTIONS: Inhibits viral neuraminidase
DOSAGE: 2 inhal (10 mg) bid for 5 d
SUPPLIED: Powder for inhal 5 mg
NOTES: Uses a Diskhaler for administration; initiate within 48 h of symptom onset; do NOT use in pulmonary disease

Zidovudine (Retrovir)

COMMON USES: HIV infections
ACTIONS: Inhibits reverse transcriptase
DOSAGE: ***Adults.*** 200 mg PO tid or 300 mg PO bid or 1–2 mg/kg/dose IV q4h. *Pregnancy:* 100 mg PO 5×/d until the start of labor, then during labor 2 mg/kg over 1 h followed by 1 mg/kg/h until clamping of the umbilical cord. ***Peds.*** 160 mg/m^2/dose q8h
SUPPLIED: Caps 100 mg; tabs 300 mg; syrup 50 mg/5 mL; inj 10 mg/mL
NOTES: Not a cure for HIV infections; hematologic toxicity; dosage adjustment in renal impairment

Zidovudine and Lamivudine (Combivir)

COMMON USES: HIV infections
ACTIONS: Combination inhibitors of reverse transcriptase
DOSAGE: ***Adults & Peds 12 y.*** 1 tab bid
SUPPLIED: Caps zidovudine 300 mg/lamivudine 150 mg
NOTES: An alternative to ↓ number of caps for combination therapy with the two agents

Zileuton (Zyflo)

COMMON USES: Prophylaxis and chronic treatment of asthma
ACTIONS: Inhibitor of 5-lipoxygenase
DOSAGE: 600 mg qid
SUPPLIED: Tabs 600 mg
NOTES: MUST take on a regular basis; does NOT treat acute exacerbation; hepatotoxic/do NOT use in hepatic impairment

Zolmitriptan (Zomig)

COMMON USES: Acute treatment of migraine
Action: Selective agonist of serotonin to cause vasoconstriction
DOSAGE: Initial 2.5 mg, may repeat after 2 h to a max of 10 mg in 24 h
NOTES: Use with caution in hepatic impairment; do NOT use in PRG

Zolpidem (Ambien) [C-IV]

COMMON USES: Short-term treatment of insomnia
ACTIONS: Hypnotic agent
DOSAGE: 5–10 mg PO hs PRN
SUPPLIED: Tabs 5, 10 mg

Zonisamide (Zonegran)

COMMON USES: Partial seizures
ACTIONS: Anticonvulsant
DOSAGE: Initial 100 mg/d; may be ↑ to 400 mg/d
SUPPLIED: Caps 100 mg
NOTES: Contra in persons with hypersensitivity to sulfonamides

Aminoglycoside Dosing

Table 22–7 (pages 631–634) gives information on the trough and peak levels of the aminoglycosides gentamicin, tobramycin, and amikacin. Peak levels should be drawn 30 min after the dose is completely infused; trough levels should be drawn 30 min prior to the dose. As a general rule, draw the peak and trough around the fourth maintenance dose. Therapy can be initiated with the recommended guidelines that follow.

Procedure (Adult)

1. Calculate estimated CrCl based on SCr, age, and weight (in kg), or a formal CrCl can also be ordered, if time permits.
2. Select loading dose:

   Gentamicin: 1.5–2.0 mg/kg
   Tobramycin: 1.5–2.0 mg/kg
   Amikacin: 5.0–7.5 mg/kg

3. By using Table 22–8 (page 635), select maintenance dose (as a percentage of the chosen loading dose) most appropriate for the renal function of patient based on the CrCl and dosing interval. Shaded areas are suggested percentages and intervals for any given CrCl. This is only an empiric dose to begin therapy. Monitor serum levels routinely for optimal therapy. Use Table 22–7 (pages 631–634) for the drug levels to follow for each drug.

IMMUNIZATION SCHEDULE (SEE TABLE 22–9, PAGE 636)

Perform active immunization of normal infants and children based on Table 22–9 (page 636). In addition, perform TB tine test at 15–19 mo and again at the entry to school (4–6 y). Hep B = hepatitis B vaccine; DtaP = diphtheria and tetanus toxoids and acellular pertussis vaccine. Td = Tetanus toxoid. Hib = *Haemophilus* influenza type b vaccine. IPV = all-inactivated polio virus vaccine. MMR = measles-mumps-rubella vaccine. Var = varicella. Hep A = hepatitis A vaccine. For additional details refer to *MMWR* Vol 50, No 01; Jan 12, 2001.

TABLE 22–1
Quick Guide to Dosing of Acetaminophen Based on the Tylenol Product Line

	Suspension* Drops and Original Drops 80 mg/0.8 ml Dropperful	Chewable* Tablets 80 mg tabs	Suspension* Liquid and Original Elixir 160 mg/5 ml	Junior* Strength 160 mg Caplets/ Chewables	Regular† Strength 325 mg Caplets/ Tablets	Extra Strength† 500 mg Caplets/ Gelcaps
Q–3 mo/6–11 lb/2.5–5.4 kg	½ dppr‡ (0.4 mL)					
4–11 mo/12–17 lb/5.5–7.9 kg	1 dppr‡ (0.8 mL)		½ tsp			
12–23 mo/18–23 lb/8.0–10.9 kg	1½ dppr‡ (1.2 mL)		¾ tsp			
2–3 y/24–35 lb/11.09–15.9 kg	2 dppr‡ (1.6 mL)	2 tab	1 tsp			
4–5 y/36–47 lb/16.0–21.9 kg		3 tab	1½ tsp			
6–8 y/48–59 lb/22.0–26.9 kg		4 tab	2 tsp	2 cap/tab		
9–10 y/60–71 lb/27.0–31.9 kg		5 tab	2½ tsp	2½ cap/tab		
11 y/72–95 lb/32.0–43.9 kg		6 tab	4 tsp	3 cap/tab		
Adults & children 12 y and over/96 lb and over/44.0 kg and over				4 cap/tab	1 or 2 caps/tabs	2 caps/gel

*Doses should be administered 4 or 5 times daily or as directed by your doctor. Do not exceed 5 doses in 24 h.
†No more than 8 dosage units in any 24-h period. Not to be taken for pain for more than 10 days or for fever for more than 3 days unless directed by a physician.
‡Dropperful.

TABLE 22–2
Comparison of Insulins

Type of Insulin	Onset (h)	Peak (h)	Duration (h)
Ultra Rapid			
Humalog (Lispro)	Immediate	0.5–1.5	3–5
NovoLog (Insulin aspart)	Immediate	0.5–1.5	3–5
Rapid			
Regular Iletin II	0.25–0.5	2.0–4.0	5–7
Humulin R	0.5	2.5–4.0	6–8
Novolin R	0.5	2.0–5.0	5–8
Velosulin	0.5	2.0–5.0	6–8
Intermediate			
NPH Iletin II	1.0–2.0	6–12	18–24
Lente Iletin II	1.0–2.0	6–12	18–24
Humulin N	1.0–2.0	6–12	14–24
Novulin L	2.5–5.0	7–15	18–24
Novulin 70/30	0.5	7–12	24
Prolonged			
Ultralente	4.0–6.0	14–24	28–36
Humulin U	4.0–6.0	8–20	24–28
Lantus (insulin glargine)	4.0–6.0	No peak	24
Combination Insulins			
Humalog Mix (lispro protamine/ lispro)	0.25–0.5	1–4	24

TABLE 22–3
Some Oral Contraceptives

Drug (Manufacturer)	Estrogen (μg)*	Progestin (mg)†
MONOPHASICS		
Alesse 21, 28 (Wyeth-Ayerst)	Ethinyl estradiol (20)	Desogestrel (0.15)
Brevicon 21, 28 (Watson)‡	Ethinyl estradiol (35)	Norethindrone (0.5)
Demulen 1/35 21 (Searle)‡	Ethinyl estradiol (35)	Ethynodiol diacetate (1)
Demulen 1/50 21 (Searle)‡	Ethinyl estradiol (50)	Ethynodiol diacetate
Desogen (Organon)	Ethinyl estradiol (30)	Desogestrel (0.15)
Genora 1/50 28 (Physicians total care)	Mestranol (50)	Norethindrone (1)
Genora 1/35 21, 28 (Physicians total care)	Ethinyl estradiol (35)	Norethindrone (1)
Levlen 21, 28 (Berlex)	Ethinyl estradiol (30)	Levonorgestrel (0.15)
Levlite 21, 28 (Berlex)	Ethinyl estradiol (20)	Levonorgestrel (0.1)
Levora 21, 28 (Watson)	Ethinyl estradiol (30)	Levonorgestrel (0.15)
Loestrin 1.5/30 21, 28 (Parke-Davis)	Ethinyl estradiol (30)	Norethindrone acetate (1.5)
Loestrin 1/20 21, 28 (Parke-Davis)	Ethinyl estradiol (20)	Norethindrone acetate (1)
Lo/Ovral (Wyeth-Ayerst)‡	Ethinyl estradiol (30)	Norgestrel (0.3)
Low-Ogestrel (Watson)	Ethinyl estradiol (30)	Norgestrel (0.3)
Modicon 28 (Ortho-McNeil)	Ethinyl estradiol (35)	Norethindrone (0.5)
Necon 1/50 21, 28 (Watson)	Mestranol (50)	Norethindrone (1)
Necon 0.5/35E 21, 28 (Watson)	Ethinyl estradiol (35)	Norethindrone (0.5)
Necon 1/35 21, 28 (Watson)	Ethinyl estradiol (35)	Norethindrone (1)
Nelova 0.5/35E 21 (Warner-Chilcott)‡	Ethinyl estradiol (35)	Norethindrone (0.5)
Nelova 1/35 21 (Warner-Chilcott)	Ethinyl estradiol (35)	Norethindrone (1)
Nelova 1/50 21 (Warner-Chilcott)‡	Mestranol (50)	Norethindrone (1)
Nordette-21 (Wyeth-Ayerst)‡	Ethinyl estradiol (30)	Levonorgestrel (0.15)
Norinyl 1/35 21, 28 (Watson)	Ethinyl estradiol (35)	Norethindrone (1)
Norinyl 1/50 21, 28 (Watson)	Mestranol (50)	Norethindrone (1)

(*continued*)

TABLE 22–3 (Continued)

Drug	Estrogen (μg)*	Progestin (mg)†
Ogestrel-28 (Watson)	Ethinyl estradiol (50)	Norgestrel (0.5)
Ortho-Cept 21 (Ortho-McNeil)‡	Ethinyl estradiol (30)	Desogestrel (0.15)
Ortho-Cyclen 21 (Ortho-McNeil)‡	Ethinyl estradiol (35)	Norgestimate (0.25)
Ortho-Novum 1/35 21 (Ortho-McNeil)‡	Ethinyl estradiol (35)	Norethindrone (1)
Ortho-Novum 1/50 21 (Ortho-McNeil)‡	Mestranol (50)	Norethindrone (1)
Ovcon 35 21, 28 (Warner Chilcott)	Ethinyl estradiol (35)	Norethindrone (0.4)
Ovcon 50 21, 28 (Warner Chilcott)	Ethinyl estradiol (50)	Norethindrone (1)
Ovral (Wyeth-Ayerst)‡	Ethinyl estradiol (50)	Norgestrel (0.5)
Zovia 1/50E 21, 28 (Watson)	Ethinyl estradiol (50)	Ethynodiol diacetate (1)
Zovia 1/35E 21, 28 (Watson)	Ethinyl estradiol (35)	Ethynodiol diacetate (1)
BIPHASICS		
Jenest-28 (Organon)	Ethinyl estradiol (35)	Norethindrone (0.5, 1)
Necon 10/11 21, 28 (Watson)	Ethinyl estradiol (35)	Norethindrone (0.5, 1)
Nelova 10/11 21 (Warner-Chilcott)	Ethinyl estradiol (35)	Norethindrone (0.5, 1)
Ortho-Novum 10/11 21 (Ortho-McNeil)‡	Ethinyl estradiol (35, 35)	Norethindrone (0.5, 1.0)
TRIPHASICS§		
Estrostep 28 (Parke-Davis)	Ethinyl estradiol (20, 30, 35)	Norethindrone acetate (1)
Mircette 28 (Organoon)	Ethinyl estradiol (20, 0, 10)	Desogestrel (0.15)
Ortho Tri-Cyclen (Ortho-McNeil)‡	Ethinyl estradiol (35, 35, 35)	Norgestimate (0.18, 0.215, 0.25)

(*continued*)

TABLE 22–3
(Continued)

Drug	Estrogen (μg)*	Progestin (mg)†
Ortho-Novum 7/7/7 21 (Ortho-McNeil)‡	Ethinyl estradiol (35, 35, 35)	Norethindrone (0.5, 0.75, 1.0)
Tri-Levlen 21, 28 (Berlex)	Ethinyl estradiol (30, 40, 30)	Levonorgestrel (0.05, 0.075, 0.125)
Tri-Norinyl 21, 28 (Watson)	Ethinyl estradiol (35, 35, 35)	Norethindrone (0.5, 1.0, 0.5)
Triphasil–21 (Wyeth-Ayerst)‡	Ethinyl estradiol (30, 40, 30)	Levonorgestrel (0.05, 0.075, 0.125)
Trivora-28 (Watson)	Ethinyl estradiol (30, 40, 30)	Levonorgestrel (0.05, 0.075, 0.125)
PROGESTIN ONLY		
Micronor (Ortho-McNeil)	None	Norethindrone (0.35)
Nor-QD (Watson)	None	Norethindrone (0.35)
Ovrette (Wyeth-Ayerst)	None	Norgestrel (0.075)

*Ethinyl estradiol and mestranol are not equivalent milligram for milligram; the results of some studies indicate that 35 μg of ethinyl estradiol is equivalent to 50 mg of mestranol.
†Different progestins are not equivalent milligram for milligram.
‡Also available in a 28-day regimen at slightly different cost.
§Estrogen/progesterone dose varies based on the time of the cycle (ie, days 1–7, 8–14, 15–21).

TABLE 22-4
Some Common Oral Potassium Supplements (see page 592)

Brand Name	Salt	Form	meq potassium/ Dosing Unit
Glu-K	Gluconate	Tablet	2 meq/tablet
Kaochlor 10%	KCl	Liquid	20 meq/15 mL
Kaochlor S-F 10% (sugar-free)	KCl	Liquid	20 meq/15 mL
Kaochlor Eff	Bicarbonate/KCl/ citrate	Effervescent tablet	20 meq/tablet
Kaon elixir	Gluconate	Liquid	20 meq/mL
Kaon	Gluconate	Tablets	5 meq/tablet
Kaon-Cl	KCl	Tablet, SR	6.67 meq/tablet
Kaon-Cl 20%	KCl	Liquid	40 meq/15 mL
KayCiel	KCl	Liquid	20 meq/15 mL
K-Lor	KCl	Powder	15 or 20 meq/packet
Klorvess	Bicarbonate/KCl	Liquid	20 meq/15 mL
Klotrix	KCl	Tablet, SR	10 meq/tablet
K-Lyte	Bicarbonate/ citrate	Effervescent tablet	25 meq/tablet
K-Tab	KCl	Tablet, SR	10 meq/tablet
Micro-K	KCl	Capsules, SR	8 meq/capsule
Slow-K	KCl	Tablet, SR	8 meq/tablet
Tri-K	Acetate/bicarbonate and citrate	Liquid	45 meq/15 mL
Twin-K	Citrate/gluconate	Liquid	20 meq/5 mL

Abbreviation: SR = sustained release.

TABLE 22–5
Comparison of Systemic Steroids (see page 603)

Drug	Relative Equivalent Dose (mg)	Mineralocorticoid Activity	Duration (h)	Route
Betamethasone	0.75	0	36–72	PO, IM
Cortisone (Cortone)	25.00	2	8–12	PO, IM
Dexamethasone (Decadron)	0.75	0	36–72	PO, IV
Hydrocortisone (Solu-Cortef, Hydrocortone)	20.00	2	8–12	PO, IM, IV
Methylprednisolone acetate (Depo-Medrol)	4.00	0	36–72	PO, IM, IV
Methylprednisolone succinate (Solu-Medrol)	4.00			PO, IM, IV
Prednisone (Deltasone)	5.00	1	12–36	PO
Prednisolone (Delta-Cortef)	5.00	1	12–36	PO, IM, IV

TABLE 22–6
Topical Steroid Preparations (See page 604 for additional information)

Agent	Common Trade Names	Potency	Apply
Aclometasone dipropionate	Aclovate, cream, oint 0.05%	Low	bid/tid
Amcinonide	Cyclocort, cream, lotion, oint 0.1%	High	bid/tid
Betamethasone			
Betamethasone valerate	Valisone cream, lotion 0.01%	Low	qd/bid
Betamethasone valerate	Valisone cream, 0.01, 0.1%, oint, lotion 0.1%	Intermediate	qd/bid
Betamethasone dipropionate	Diprosone cream (0.05%) Diprosone aerosol (0.1%)	High	qd/bid
Betamethasone dipropionate, augmented	Diprolene oint, gel 0.05%	Ultra high	qd/bid
Clobetasol propionate	Temovate cream, gel, oint, scalp, soln 0.05%	Ultra high	bid (2 wk max)
Clocortolone pivalate	Cloderm cream 0.1%	Intermediate	qd–qid
Desonide	DesOwen, cream, oint, lotion 0.05%	Low	bid–qid
Desoximetasone			
Desoximetasone 0.05%	Topicort LP cream, gel 0.05%	Intermediate	
Desoximetasone 0.25%	Topicort cream, oint	High	
Dexamethasone base	Aeroseb-Dex aerosol 0.01% Decadron cream 0.1%	Low	bid–qid
Diflorasone diacetate	Psorcon cream, oint 0.05%	Ultrahigh	bid/qid
Fluocinolone			
Fluocinolone acetonide 0.01%	Synalar cream, soln 0.01%	Low	bid/tid

(*continued*)

TABLE 22–6
(Continued)

Agent	Common Trade Names	Potency	Apply
Fluocinolone acetonide 0.025%	Synalar oint, cream 0.025%	Intermediate	bid/tid
Fluocinolone acetonide 0.2%	Synalar-HP cream 0.2%	High	bid/tid
Fluocinonide 0.05%	Lidex, anhydrous cream, gel, soln 0.05% Lidex-E aqueous cream 0.05%	High	bid/tid oint
Flurandrenolide	Cordran cream, oint 0.025%	Intermediate	bid/tid
	cream, lotion, oint 0.05%	Intermediate	bid/tid
	tape, 4 μg/cm^2	Intermediate	qd
Fluticasone propionate	Activate cream 0.05%, oint 0.005%	Intermediate	bid
Halobetasol	Cutivate cream, oint 0.05%	Very High	bid
Halcinonide	Halog cream 0.025%, emollient base 0.1% cream, oint, solution 0.1%	High	qd/tid
Hydrocortisone			
Hydrocortisone	Cortisone, Caldecort, Hycort, Hytone, etc. aerosol 1%, cream: 0.5, 1,2.5%, gel 0.5% oint 0.5, 1, 2.5%, lotion 0.5, 1, 2.5% paste 0.5% soln 1%	Low	tid/qid
Hydrocortisone acetate	Corticaine cream, oint 0.5, 1%	Low	tid/qid
Hydrocortisone butyrate	Locoid oint, soln 0.1%	Intermediate	bid/tid
Hydrocortisone valerate	Westcort cream, oint 0.2% oint, lotion 0.025%	Intermediate	bid/tid

(*continued*)

TABLE 22–6
(Continued)

Agent	Common Trade Names	Potency	Apply
Mometasone furoate	Elocon 0.1% cream, oint, lotion	Intermediate	qd
Prednicarbate	Dermatop 0.1% cream	Intermediate	bid
Triamcinolone			
Triamcinolone acetonide 0.025%	Aristocort, Kenalog cream,	Low	tid/qid
Triamcinolone acetonide 0.1%	Aristocort, Kenalog cream, oint, lotion 0.1% Aerosol 0.2 mg/2-sec spray	Intermediate	tid/qid
Triamcinolone acetonide 0.5%	Aristocort, Kenalog cream, oint 0.5%	High	tid/qid

TABLE 22–7
Common Drug Levels

Drug	When to Sample	Therapeutic Levels	Usual Half-life	Potentially Toxic Levels
ANTIBIOTICS				
Gentamicin	Peak: 30 min after 30-min infusion (peak level not necessary if extended interval dosing: 6 mg/kg/dose) Trough: <0.5 h before next dose	Peak: 5–8 μg/mL Trough <2 mg/mL <1.0 μg/mL for extended intervals (6 mg/kg/dose) Peak levels not needed with extended-interval dosing	2 h	Peak: >12 μg/mL
Tobramycin	Same as above	Same as above	Same as above	
Amikacin	Same as above	Peak: 20–30 μg/mL	2 h	Peak: >35 μg/mL
Vancomycin	Peak: 1 h after 1 h-infusion Trough: <0.5 h before next dose	Peak: 30–40 μg/mL	6–8 h	Peak: >50 μg/mL Trough: >15 μg/mL
ANTICONVULSANTS				
Carbamazepine	Trough: just before next oral dose	8–12 μg/mL (monotherapy) 4–8 μg/mL (polytherapy)	15–20 h	Trough: >12 μg/mL
Ethosuximide	Trough: just before next oral dose	40–100 μg/mL	30–60 h	Trough: >100 μg/mL
Phenobarbital	Trough: just before next dose	15–40 μg/mL	40–120 h	Trough: >40 μg/mL
Phenytoin	Use free phenytoin to monitor Trough: just before next dose	5–12 μg/mL	Concentration-dependent	>2 μg/mL

(*continued*)

TABLE 22–7 (Continued)

Drug	When to Sample	Therapeutic Levels	Usual Half-life	Potentially Toxic Levels
Primidone	Trough just before next dose (note-primidone is metabolized to phenobarb. Order levels separately)	5–12 μg/mL	10–12 h	>12 μg/mL
Valproic acid	Trough: just before next dose	50–100 μg/mL	5–20 h	>100 μg/mL
BRONCHODILATORS				
Caffeine	Trough: just before next dose	Adults 5–15 μg/mL Neonate 6–11 mg/mL	Adults 3–4 h Neonates 30–140 h	20 μg/mL
Theophylline (IV)	IV: 12–24 h after infusion started	5–15 μg/mL	Nonsmoking adult-8 h Children and smoking adults -4 h	>20 μg/mL
Theophylline (PO)	Peak levels: not recommended Trough level: just before next dose	5–15 μg/mL		
CARDIOVASCULAR AGENTS				
Amiodarone	Trough: just before next dose	1–2.5 μg/mL	30–100 days	>2.5 μg/mL

(*continued*)

TABLE 22–7 (Continued)

Drug	When to Sample	Therapeutic Levels	Usual Half-life	Potentially Toxic Levels
Digoxin	Trough: just before next dose (levels drawn earlier than 6 h after a dose will be artificially elevated)	0.8–2.0 ng/mL	36 h	>2 ng/mL
Disopyramide	Trough: just before next dose	2–5 µg/mL	4–10 h	>5 µg/mL
Flecainide	Trough: just before next dose	0.2–1.0 µg/mL	11–14 h	>1.0 µg/mL
Lidocaine	Steady-state levels are usually achieved after 6–12 h	1.2–5.0 µg/mL	1.5 h	>6 µg/mL
Procainamide	Trough: just before next oral dose	4–10 µg/mL NAPA + Procain: 5–30 µg/mL	Procaine: 3–5 h NAPA: 6–10 h	>10 µg/mL >30 µg/mL (NAPA + Procain)
Quinidine	Trough: just before next oral dose	2–5 µg/mL	6 h	0.5 µg/mL
OTHER AGENTS				
Amitriptyline plus nortriptyline	Trough: just before next dose	120–250 ng/mL		
Nortriptyline	Trough: just before next dose	50–140 ng/mL		
Lithium	Trough: just before next dose	0.5–1.5 meq/mL	18–20 h	>1.5 meq/mL
Imipramine plus desipramine	Trough: just before next dose	150–300 ng/mL		
Desipramine	Trough: just before next dose	50–300 ng/mL		
Methotrexate	By protocol	<0.5 µmol/L after 48 h		

(*continued*)

TABLE 22–7 (Continued)

Drug	When to Sample	Therapeutic Levels	Usual Half-life	Potentially Toxic Levels
Cyclosporine	Trough: just before next dose	Highly variable Renal: 150–300 ng/mL (RIA) Hepatic: 150–300 ng/mL	Highly variable	
Doxepin	Trough: just before next dose	100–300 ng/mL		
Trazodone	Trough: just before next dose	900–2100 ng/mL		

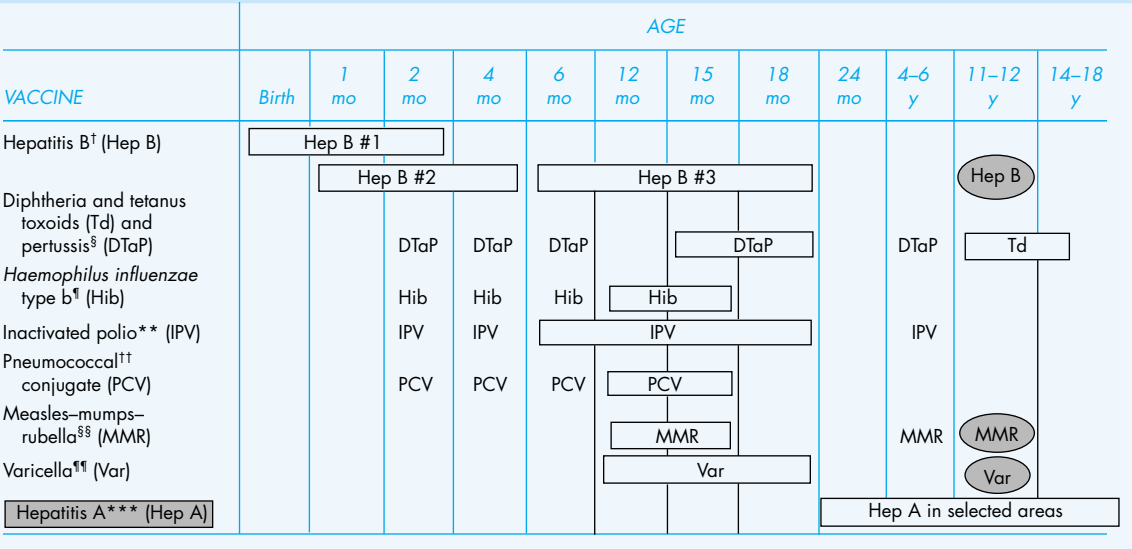
*Results of therapeutic drug monitoring must be interpreted in light of the complete clinical situation. For information on dosing or interpretation of drug levels contact the pharmacist or an order for a pharmacokinetic consult may be written in the patient's chart. Based on data from Pharmacy and Therapeutics Committee Formulary, 41st edition, Thomas Jefferson University Hospital, Philadelphia, PA.

TABLE 22–8
Percentage of Loading Dose Required for Dosage Interval Chosen for Aminoglycosides (see page 620 for dosing information)

CrCl	Dosing Interval		
(mL/min)	8 h	12 h	24 h
90	90	—	—
90	88	—	—
70	84	—	—
60	79	91	—
50	74	87	—
40	66	80	—
30	57	72	92
25	51	66	88
20	45	54	83
15	37	50	75
10	29	40	64
7	24	33	55
5	20	28	48
2	14	20	35
0	9	13	25

Source: Based on data from Hull JH, Sarubbi FA: Gentamicin serum concentrations: Pharmacokinetic predictions. *Ann Intern Med* 1976;**85:**183–189. Shaded boxes indicate suggested dosage intervals. *Abbreviation:* CrCl = creatinine clearance.

TABLE 22–9
Recommended Childhood Immunization Schedule (United States, January–December 2001)



Source: *MMWR* Vol. 50/No. 1, Jan. 12, 2001.

Range of recommended ages for vaccination.

Vaccines to be given if previously recommended doses were missed or were given earlier than the recommended minimum age.

Recommended in selected states and/or regions.

See text for abbreviations.

TABLE 22–10
Oral Anticoagulant Standards of Practice (see Warfarin, page 618)

Thromboembolic Disorder	INR	Duration
Deep Venous Thrombosis		
Prophylaxis (high-risk surgery)	2–3	<3 mo or until ambulatory
Treatment: single episode	2–3	3–6 mo
Recurrent systemic embolism	2–3	Indefinite
Prevention of Systemic Embolism		
Atrial fibrillation (AF)	2–3	Indefinite
AF: cardioversion	2–3	3 wk prior; 4 wk post sinus rhythm
Valvular heart disease	2–3	Indefinite
Cardiomyopathy	2–3	Indefinite
Acute Myocardial Infarction		
Prevention of systemic embolization	2–3	<3 mo
Prevention of recurrence	2.5–3.5	Indefinite
Prosthetic Valves		
Tissue heart valves	2–3	3 mo
Bileaflet mechanical valve in aortic position	2–3	Indefinite
Other mechanical prosthetic valves[a]	2.5–3.5	Indefinite

Source: Based on data published in *Chest* 1998;114 Supplement 439S–769S.
[a]May add aspirin 81 mg to warfarin in patients with ball–cage valves or with additional risk factors.
Abbreviation: INR: international normalized ratio.

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APPENDIX

APGAR SCORES

Apgar scores (Table A–1) are a numerical expression of a newborn infant's physical condition. Usually determined 1 min after birth and again at 5 min, the score is the sum of points gained on assessment of color, heart rate, reflex irritability, muscle tone, and respirations.

BODY SURFACE AREA

Adult

Figure A–1 is a nomogram for determining the body surface area of an adult.

Children

Figure A–2 is a nomogram for determining the body surface area of children.

BODY WEIGHTS, DESIRABLE

Table A–2 gives desirable body weights for men and women.

CANCER SCREENING RECOMMENDATIONS

Table A–3 lists the recommendations from the American Cancer Society for cancer screening programs in average risk, asymptomatic people. These are the recommendations of the ACS and may not be supported by other organizations.

EPIDEMIOLOGY BASICS

$$\text{Prevalence} = \frac{\text{Number of persons who have a disease at one point in time}}{\text{Number of persons at risk at that point}}$$

(continued on page 645)

TABLE A–1
Apgar Scores

	Score		
Sign	0	1	2
Appearance (color)	Blue or pale	Pink body with blue extremities	Completely pink
Pulse (heart rate)	Absent	Slow (<100/min)	>100/min
Grimace (reflex irritability	No response	Grimace	Cough or sneeze
Activity (muscle tone)	Limp	Some flexion	Active movement
Respirations	Absent	Slow, irregular	Good, crying

TABLE A–2
Desirable Weights (in lb) for Men and Women*

	Age	
Height	19–34	35 Years and Older
5′0″	97–128	108–138
5′1″	101–132	111–143
5′2″	104–137	115–148
5′3″	107–141	119–152
5′4″	111–146	122–157
5′5″	114–150	126–162
5′6″	118–156	130–167
5′7″	121–160	134–172
5′8″	125–164	138–178
5′9″	129–169	142–183
5′10″	132–174	146–188
5′11″	136–179	151–194
6′0″	140–184	155–199
6′1″	144–189	159–205
6′2″	148–195	164–210

*Weights are based on weighing in without shoes or clothes.
Source: United States Department of Agriculture and United States Department of Health and Human Resources, 1990.

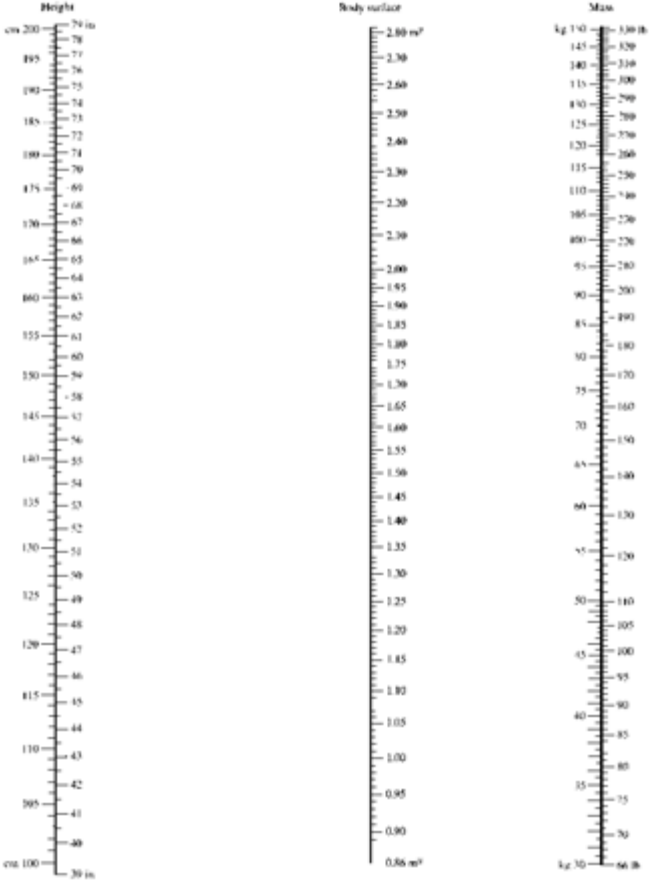

FIGURE A–1 Body surface area: Adult. Use a straight edge to connect the height and mass. The point of intersection on the body surface line gives the body surface area (in m^2). (Reprinted, with permission, from: Lentner C [ed]: *Geigy Scientific Tables,* 8th ed. Ciba-Geigy, San Francisco CA, 1981, Vol. 1, p. 226.)

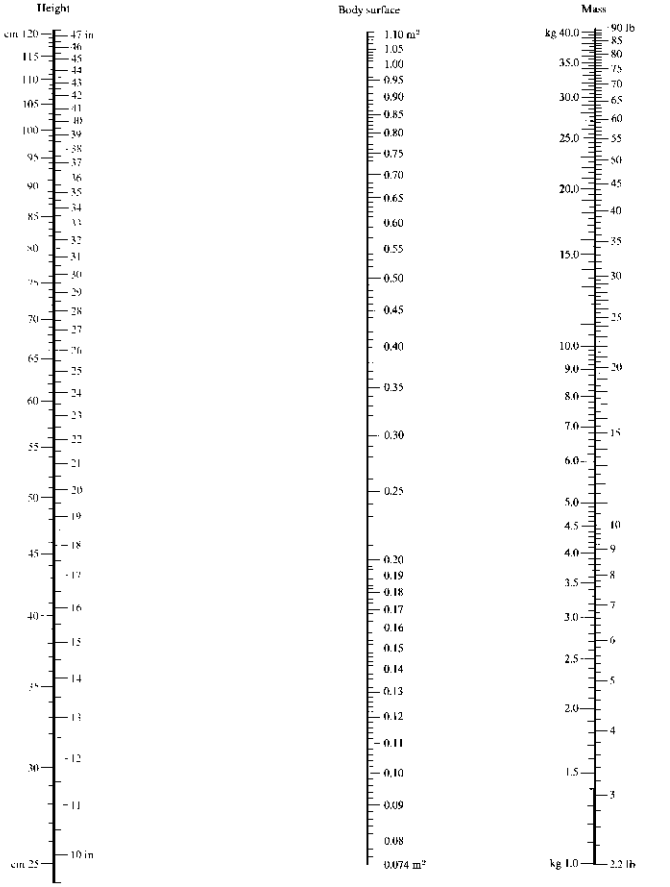

FIGURE A–2 Body surface area: Child. Use a straight edge to connect the height and mass. The point of intersection on the body surface line gives the body surface area (in m^2). (Reprinted, with permission, from: Lentner C [ed]: *Geigy Scientific Tables,* 8th ed. Ciba-Geigy, San Francisco CA, 1981, Vol. 1, p. 227.)

TABLE A–3
Recommendations for Cancer Screening for Average Risk, Asymptomatic People

Cancer Site	Population	Test or Procedure	Frequency
Breast	Women, age 20+	Breast self-examination	Monthly, starting at age 20
		Clinical breast examination	Every 3 years, ages 20–39 Annual, starting at age 40*
		Mammography	Annual, starting at age 40
Colorectal	Men & women, age 50+	Fecal occult blood test & flexible sigmoidoscopy†	Annual fecal occult blood test and flexible sigmoidoscopy at age 50; thereafter, fecal occult blood test every year and flexible sigmoidoscopy every 5 years
		-or-	
		Double contrast barium enema†	Double contrast barium enema at age 50; thereafter, every 5–10 y
		-or-	
		Colonoscopy†	Colonoscopy every 10 y starting at age 50
Prostate	Men, age 50+	Digital rectal examination & prostate specific antigen test	Annual digital rectal examination and prostate-specific antigen test should be offered to men starting at age 50‡
Cervix	Women, age 18+	Pap test and pelvic examination	All women who are, or have been, sexually active, or have reached age 18 should have an annual Pap test and pelvic examination. After a woman has had 3 or more consecutive satisfactory normal annual examinations, the Pap test may be performed less frequently at the discretion of the physician.

(*continued*)

TABLE A–3 (Continued)

Cancer Site	Population	Test or Procedure	Frequency
Cancer-related check-up	Men & women age 20+	Examinations every 3 y from ages 20–39 y and annually after age 40. The cancer-related check-up should include examination for cancers of the thyroid, testicles, ovaries, lymph nodes, oral cavity, and skin, as well as health counseling about tobacco, sun exposure, diet and nutrition, risk factors, sexual practices, and environmental and occupational exposures.	

*Beginning at age 40, annual clinical breast examination should be performed prior to mammography.
†Digital rectal examination should be performed at the time of sigmoidoscopy, barium enema, and colonoscopy.
‡Information should be provided to men regarding potential risks and benefits of screening.
Source: Reprinted, with permission, from *Cancer J Clin* 2000:**50;39.**

(continued from page 639)

$$\text{Incidence} = \frac{\text{Number of new cases of a disease over a period of time}}{\text{Number of persons at risk during that period}}$$

Sensitivity = Proportion of subjects with the disease who have a positive test
= $(a/a + c)$

Specificity = Proportion of subjects without the disease who have a negative test
= $(d/b + d)$

Predictive value = Positive: likelihood of a positive test indicates disease
= $(a/a + b)$
= Negative: likelihood of a negative test indicates lack of disease
= $(d/c + d)$

		Disease: + (Present)	Disease: − (Absent)
Test	(+)	a	b
	(−)	c	d

GLASCOW COMA SCALE

The Glasgow Coma Scale (*EMV* Scale) gives a fairly reliable, objective way to monitor changes in levels of consciousness. It is based on *E*ye opening, *M*otor responses, and *V*erbal responses. A person's EMV score is based on the total of the three responses. The score ranges from 3 (lowest) to 15 (highest) (Table A–4).

TABLE A–4
Glasgow Coma Scale

Parameter	Response		Score
Eyes	Open: Spontaneously		4
		To verbal command	3
		To pain	2
		No response	1
Best motor response	To verbal command To painful stimulus	Obeys	6
		Localized pain	5
		Flexion-withdrawal	4
		Decorticate (flex)	3
		Decerebrate (extend)	2
		No response	1
Best verbal response		Oriented, converses	5
		Disoriented, converses	4
		Inappropriate responses	3
		Incomprehensible sounds	2
		No response	1

MEASUREMENTS

Equivalents (Approximate)

Length

1 centimeter (cm) = 0.4 in.
1 meter (m) = 39.4 in.

Household

1 teaspoon (tsp) = 5 mL
1 tablespoon (tbsp) = 15 mL
1 ounce (oz) = 30 mL
8 ounces (oz) = 1 cup = 240 mL
1 quart (qt) = 946 mL

Apothecary

1 grain (gr) = 60 mg
30 gram (g) = 1 oz
1 g = 15 gr

SI PREFIXES AND SYMBOLS

Factor	Prefix	Symbol
10^{9}	giga	G
10^{6}	mega	M
10^{3}	kilo	k
10^{2}	hecto	h
10^{1}	deka	da
10^{-1}	deci	d
10^{-2}	centi	c
10^{-3}	milli	m
10^{-6}	micro	μ
10^{-9}	nano	n
10^{-12}	pico	p
10^{-15}	femto	f

PERFORMANCE STATUS SCALES

Table A–5 lists the most common performance scales used clinically.

RADIATION TERMINOLOGY

Measure	Old Term	SI Unit
Activity	curie	becquerel (Bq)
Absorbed dose	rad	gray (Gy)

TEMPERATURE CONVERSION

Table A–6 gives information for converting temperature from the Fahrenheit (F) scale to the centigrade, or Celsius (C), scale and vice versa.

(continued on page 649)

TABLE A–5
Performance Status Scales

Karnofsky			ECOG		AJCC	
Functional Status	% Normal Status	Activity Level	Grade	Activity Level	Grade	Activity
Able to carry on normal activity; no special care needed	100	Normal; no complaints; no evidence of disease;	0	Normal activity	H0	Normal activity
	90	Able to carry on normal activity; minor sign or symptoms of disease				
	80	Normal activity with effort; some signs or symptoms of disease	1	Symptoms but ambulatory	H1	Symptomatic and ambulatory; cares for self
Unable to work; able to live at home; cares for most personal needs; varying amount of assistance needed	70	Cares for self; unable to carry on normal activity or progressing rapidly to active work				
	60	Requires occasional assistance but able to care for self	2	In bed 50% of time	H2	Ambulatory 50% of time; occasionally needs assistance
	50	Requires considerable assistance and frequent medical care				

(*continued*)

TABLE A–5
(Continued)

Karnofsky			ECOG		AJCC	
Functional Status	% Normal Status	Activity Level	Grade	Activity Level	Grade	Activity
Unable to care for self; requires equivalent of needed institutional or hospital care; may be progressing rapidly	40	Disabled; requires special care and assistance	3	In bed 50% of time	H3	Ambulatory 50% of time; nursing care
	30	Severely disabled; hospitalization indicated through death not imminent				
	20	Very sick; hospitalization necessary	4	100% bedridden	H4	Bedridden; may need hospitalization
	10	Moribund; fatal processes				
	0	Dead				

Abbreviations: ECOG = Eastern Cooperative Oncology Group; AJCC = American Joint Committee on Cancer.
Source: Reprinted, with permission, from *Practical Oncology*. Cameron R (ed). Appleton & Lange, Stamford, CT, 1993.

TABLE A–6
Temperature Conversion Table

F	C	C	F
0	–17.7	0	32.0
95.0	35.0	35.0	95.0
96.0	35.5	35.5	95.9
97.0	36.1	36.0	96.8
98.0	36.6	36.5	97.7
98.6	37.0	37.0	98.6
99.0	37.2	37.5	99.5
100.0	37.7	38.0	100.4
101.0	38.3	38.5	101.3
102.0	38.8	39.0	102.2
103.0	39.4	39.5	103.1
104.0	40.0	40.0	104.0
105.0	40.5	40.5	104.9
106.0	41.1	41.0	105.8
$C = (F - 32) \times 5/9$		$F = (C \times 9/5) + 32$	

Abbreviations: F = degrees Fahrenheit; C = degrees Celsius.

TNM AND OTHER SYSTEMS OF CLASSIFICATION FOR COMMON TUMORS

TNM stands for "tumor, nodes, metastasis" and is a universally accepted classification system for malignancy staging. The UICC (Union Internationale Contre le Cancer) and the AJCC (American Joint Committee on Cancer) have adopted this system and have published this system in *TNM Classification of Malignant Tumours,* 5th ed John Wiley & Sons, New York, 1997. The following is a highly selected listing of commonly encountered solid tumors (breast, bladder, cervix, colon and rectum, kidney, lung, melanoma, ovary, stomach, thyroid, uterus, and prostate) as well as the classification for lymphomas. Where appropriate, other common staging systems are noted (ie, Duke's classification of colon cancer)

TNM CLASSIFICATION

Breast

Primary Tumor (T)

TX Primary tumor cannot be assessed

T0 No evidence of primary tumor

Tis Carcinoma in situ: Intraductal carcinoma, lobular carcinoma in situ, or Paget's disease of the nipple with no tumor. *Note:* Paget disease associated with a tumor is classified according to the size of the tumor.

T1 Tumor 2 cm or less in greatest dimension

T1mic Microinvasion 0.1 cm or less in greatest dimension

T1a More than 0.1 cm but not more than 0.5 cm in greatest dimension

T1b More than 0.5 cm but not more than 1 cm in greatest dimension
T1c More than 1 cm but not more than 2 cm in greatest dimension
T2 Tumor more than 2 cm but not more than 5 cm in greatest dimension
T3 Tumor more than 5 cm in greatest dimension
T4 Tumor of any size with direct extension to chest wall or skin
T4a Extension to chest wall
T4b Edema (including peau d'orange) or ulceration of the skin of breast or satellite skin nodules confined to same breast
T4c Both T4a and T4b
T4d Inflammatory carcinoma

Lymph Node (N)

NX Regional lymph nodes cannot be assessed
N0 No regional lymph node metastasis
N1 Metastasis to movable ipsilateral axillary lymph nodes(s)
N2 Metastasis to ipsilateral axillary lymph node(s) fixed to one another or to other structures
N3 Metastasis to ipsilateral internal mammary lymph node(s)

Distant Metastasis (M)

MX Presence of distant metastasis cannot be assessed
M0 No distant metastasis
M1 Distant metastasis (includes metastasis to ipsilateral supraclavicular lymph nodes)

Pathologic Classification (pTNM)

Primary Tumor (pT)
The pT categories correspond to the T categories.
Regional Lymph Nodes (pN)
pNX Regional lymph nodes cannot be assessed
pN0 No regional lymph node metastasis
pN1 Metastasis to movable ipsilateral axillary lymph node(s)
pN1a Only micrometastasis (none larger than 0.2 cm)
pN1b Metastasis to lymph nodes, any larger than 0.2 cm
pN1bi Metastasis in 1–3 lymph nodes, any more than 0.2 cm and all less than 2 cm in greatest dimension
pN1bii Metastasis to 4 or more lymph nodes, any more than 0.2 cm and all less than 2 cm in greatest dimension
pN1biii Extension of tumor beyond the capsule of a lymph node metastasis less than 2 cm in greatest dimension
pN1biv Metastasis to a lymph node 2 cm or more in greatest dimension
pN2 Metastasis to ipsilateral axillary nodes that are fixed
pN3 Metastasis to ipsilateral internal mammary lymph nodes(s)

Pathologic Classification

The pM category corresponds to the M category above.

Bladder

Primary Tumor (T)

TX Primary tumor cannot be assessed
T0 No evidence of primary tumor
Tis Carcinoma in situ: "flat tumor"

Ta Noninvasive papillary carcinoma
T1 Tumor invades subepithelial connective tissue
T2 Tumor invades muscle
T2a Tumor invades superficial muscle (inner half)
T2b Tumor invades deep muscle (outer half)
T3 Tumor invades perivesical tissue
T3a Microscopically
T3b Macroscopically (extravesical mass)
T4 Tumor invades any of the following: prostate, uterus, vagina, pelvic wall, abdominal wall
T4a Tumor invades prostate or uterus or vagina
T4b Tumor invades pelvic wall or abdominal wall

Lymph Node (N)
NX Regional lymph nodes cannot be assessed
N0 No regional lymph node metastasis
N1 Metastasis in a single lymph node, 2 cm or less in greatest dimension
N2 Metastasis in a single lymph node, more than 2 cm but not more than 5 cm in greatest dimension, or multiple lymph nodes, none more than 5 cm in greatest dimension
N3 Metastasis in a lymph node more than 5 cm in greatest dimension

Distant Metastasis (M)
MX Presence of distant metastasis cannot be assessed
M0 No distant metastasis
M1 Distant metastasis

Pathologic Classification (pTNM)
The pT, pN, and pM categories correspond to the T, N , and M categories.

Cervix

Primary Tumor (T)
TX Primary tumor cannot be assessed
T0 No evidence of primary tumor
Tis Carcinoma in situ
T1 Cervical carcinoma confined to uterus
T1a Preclinical invasive carcinoma diagnosed by microscopy only
T1ai Stromal invasion no greater than 3.0 mm in depth and 7.0 mm or less in horizontal spread
T1aii Stromal invasion more than 3.0 mm and not more than 5.0 mm with a horizontal spread 7.0 mm or less
T1b Clinically visible lesion confined to the cervix or microscopic lesion greater than T1a2
T1bi Clinically visible lesion 4 cm or less in greatest dimension
T1bii Clinically visible lesion more than 4 cm in greatest dimension
T2 Cervical carcinoma invades beyond uterus but not to pelvic wall or to the lower third of vagina
T2a Tumor without parametrial invasion
T2b Tumor with parametrial invasion
T3 Cervical carcinoma extends to pelvic wall and/or involves lower third of vagina and/or causes hydronephrosis or nonfunctioning kidney
T3a Tumor involves lower third of the vagina, no extension to pelvic wall

T3b Tumor extends to pelvic wall and/or causes hydronephrosis or nonfunctioning kidney

T4 Tumor invades mucosa of bladder or rectum and/or extends beyond the true pelvis

Note: The presence of bullous edema is not sufficient to classify a tumor as T4.

Lymph Node (N)

NX Regional lymph nodes cannot be assessed
N0 No regional lymph node metastasis
N1 Regional lymph node metastasis

Distant Metastasis (M)

MX Presence of distant metastasis cannot be assessed
M0 No distant metastasis
M1 Distant metastasis

Pathologic Classification (pTNM)

The pT, pN and pM categories correspond to the T, N , and M categories.

Colon and Rectum

Primary Tumor (T)

TX Primary tumor cannot be assessed
T0 No evidence of primary tumor
Tis Carcinoma in situ: intraepithelial or invasion of lamina propria*
T1 Tumor invades submucosa
T2 Tumor invades muscularis propria
T3 Tumor invades through muscularis propria into subserosa, or into nonperitonealized pericolic or perirectal tissues
T4 Tumor perforates visceral peritoneum or directly invades other organs or structures

Lymph Node (N)

NX Regional lymph nodes cannot be assessed
N0 No regional lymph node metastasis
N1 Metastasis in 1– 3 pericolic or perirectal lymph nodes
N2 Metastasis in 4 or more pericolic or perirectal lymph nodes

Distant Metastasis (M)

MX Presence of distant metastasis cannot be assessed
M0 No distant metastasis
M1 Distant metastasis

Pathologic Classification (pTNM)

The pT, pN and pM categories correspond to the T, N , and M categories.

DUKES' CLASSIFICATION (ASTER–COLLER MODIFICATION) OF COLON CANCER

STAGE A:	Into muscularis propria, nodes negative
STAGE B1:	Extends through entire wall, nodes negative
STAGE B2:	Extends into muscularis propria, nodes positive
STAGE C1:	Extends through entire wall, 1–3 nodes positive

*Tis includes cancer cells confined within the glandular basement membrane (intraepithelial) or lamina propria (intramucosal) with no extension through muscularis mucosa into submucosa.

STAGE C2: ≥ 4 nodes positive
STAGE D: Metastatic disease

Kidney

Primary Tumor (T)

TX Primary tumor cannot be assessed
T0 No evidence of primary tumor
T1 Tumor 7 cm or less in greatest dimension limited to the kidney
T2 Tumor more than 7 cm in greatest dimension limited to the kidney
T3 Tumor extends into major veins or invades adrenal gland or perinephric tissues but not beyond Gerota's fascia
- **T3a** Tumor invades adrenal gland or perinephric tissues but not beyond Gerota's fascia
- **T3b** Tumor grossly extends into renal vein(s) or vena cava below diaphragm
- **T3c** Tumor grossly extends into vena cava above diaphragm

T4 Tumor invades beyond Gerota's fascia

Lymph Node (N)

NX Regional lymph nodes cannot be assessed
N0 No regional lymph node metastasis
N1 Metastasis in a single regional lymph node
N2 Metastasis in more than one regional lymph node

Distant Metastasis (M)

MX Presence of distant metastasis cannot be assessed
M0 No distant metastasis
M1 Distant metastasis

Pathologic Classification (pTNM)

The pT, pN and pM categories correspond to the T, N , and M categories.

Lung

Primary Tumor (T)

TX Primary tumor cannot be assessed, or tumor proven by presence of malignant cells in sputum or bronchial washings but not visualized by imaging or bronchoscopy
T0 No evidence of primary tumor
Tis Carcinoma in situ
T1 Tumor 3 cm or less in greatest dimension, surrounded by lung or visceral pleura, without bronchoscopic evidence of invasion more proximal than the lobar bronchus
T2 Tumor with *any* of the following features of size or extent: More than 3 cm in greatest dimension; involves main bronchus, 2 cm or more distal to the carina; invades the visceral pleura; associated with atelectasis or obstructive pneumonitis that extends to the hilar region but does not involve the entire lung
T3 Tumor of any size that directly invades any of the following: chest wall (including superior sulcus tumors), diaphragm, mediastinal pleura, parietal pericardium; or tumor in the main bronchus less than 2 cm distal to the carina but without involvement of the carina; or associated atelectasis or obstructive pneumonitis of the entire lung
T4 Tumor of any size that invades any of the following: mediastinum, heart, great vessels, trachea, esophagus, vertebral body, carina; or tumor with a malignant pleural effusion

Lymph Node (N)

NX Regional lymph nodes cannot be assessed
N0 No regional lymph node metastasis
N1 Metastasis in ipsilateral peribronchial and/or ipsilateral hilar lymph nodes, including direct extension
N2 Metastasis in ipsilateral mediastinal and/or subcarinal lymph node(s)
N3 Metastasis in contralateral mediastinal, contralateral hilar, ipsilateral or contralateral scalene, or supraclavicular lymph node(s)

Distant Metastasis (M)

MX Presence of distant metastasis cannot be assessed
M0 No distant metastasis
M1 Distant metastasis

Pathologic Classification (pTNM)

The pT, pN and pM categories correspond to the T, N , and M categories.

ANN ARBOR STAGING CLASSIFICATION

Lymphoma (Hodgkin's Disease and Non-Hodgkin's Lymphoma)

STAGE	DEFINITION
I	Limited to one area
II	Involvement of two or more areas on the same side of the diaphragm
III	Involvement of two or more areas on both sides of the diaphragm III_1 Upper abdomen, spleen, splenic and hilar nodes III_2 Lower abdominal nodes
IV	Extra lymph node involvement

Melanoma of the Skin (Excluding Eyelid)

Primary Tumor (pT)

pTX Primary tumor cannot be assessed
pT0 No evidence of tumor
pTis Melanoma in situ (atypical melanotic hyperplasia, severe melanotic dysplasia), not an invasive lesion (Clark's level I)
pT1 Tumor 0.75 mm or less in thickness and invades the papillary dermis (Clark's level II)
pT2 Tumor more than 0.75 mm but not more than 1.5 mm in thickness and/or invades to papillary–reticular dermal interface (Clark's level III)
pT3 Tumor more than 1.5 mm but not more than 4 mm in thickness and/or invades the reticular dermis (Clark's level IV)
pT3a Tumor more than 1.5 mm but not more than 3 mm in thickness
pT3b Tumor more than 3 mm but not more than 4 mm in thickness
pT4 Tumor more than 4 mm in thickness and/or invades the subcutaneous tissue (Clark's level V) and/or satellite(s) within 2 cm of the primary tumor
pT4a Tumor more than 4 mm in thickness and/or invades the subcutaneous tissue
pT4b Satellite(s) with 2 cm of primary tumor

Lymph Node (N)

NX Regional lymph nodes cannot be assessed
N0 No regional lymph node metastasis

N1 Metastasis 3 cm or less in greatest dimension in any regional lymph node(s)
N2 Metastasis more than 3 cm in greatest dimension in any regional lymph node(s)
- **N2a** Metastasis more than 3 cm in greatest dimension in any regional lymph node(s) and/or in-transit metastasis
- **N2b** In-transit metastasis
- **N2c** Both (N2a and N2b)

Distant Metastasis (M)

MX Presence of distant metastasis cannot be assessed
M0 No distant metastasis
M1 Distant metastasis
- **M1a** Metastasis in skin or subcutaneous tissue or lymph node(s) beyond the regional lymph nodes
- **M1b** Visceral metastasis

Ovary

Primary Tumor (T)

TNM	FIGO*	DEFINITION
TX		Primary tumor cannot be assessed
T0	I	No evidence of primary tumor
T1		Tumor limited to ovaries
T1a	Ia	Tumor limited to one ovary; capsule intact, no tumor on ovarian surface
T1b	Ib	Tumor limited to both ovaries; capsules intact, no tumor on ovarian surface
T1c	Ic	Tumor limited to one or both ovaries with any of the following: capsule ruptured, tumor on ovarian surface, malignant cells in ascites, or peritoneal washings
T2	II	Tumor involves one or both ovaries with pelvic extension
T2a	IIa	Extension or implants on uterus or tubes
T2b	IIb	Extension to other pelvic tissues
T2c	IIc	Pelvic extension (2a or 2b) with malignant cells in ascites or peritoneal washing
T3	III	Tumor involves one or both ovaries with microscopically confirmed and/or N1 peritoneal metastasis outside the pelvis or regional lymph node metastasis
T3a	IIIa	Microscopic peritoneal metastasis beyond pelvis
T3b	IIIb†	Macroscopic peritoneal metastasis beyond pelvis 2 cm or less in greatest dimension
T3c	IIIc	Peritoneal metastasis beyond pelvis more than 2 cm in greatest and/or N1 dimension or regional lymph node metastasis

Lymph Node (N)

NX Regional lymph nodes cannot be assessed
N0 No regional lymph node metastasis
N1 Regional lymph node metastasis

*FIGO = Fédération Internationale de Gynécologie et d'Obstétrique.

†Liver capsule metastasis is T3/stage III, liver parenchymal metastasis M1/stage IV. Pleural effusion must have positive cytology for M1/stage IV.

Distant Metastasis (M)

TNM	FIGO	DEFINITION
MX		Presence of distant metastasis cannot be assessed
M0		No distant metastasis
M1	IV	Distant metastasis (excludes peritoneal metastasis)

Stomach

Primary Tumor (T)

TX Primary tumor cannot be assessed
T0 No evidence of primary tumor
Tis Carcinoma in situ: Intraepithelial tumor without invasion of lamina propria
T1 Tumor invades lamina propria or submucosa
T2 Tumor invades muscularis propria or subserosa
T3 Tumor penetrates serosa (visceral peritoneum) without invasion of adjacent structures
T4 Tumor invades adjacent structures

Lymph Node (N)

NX Regional lymph node(s) cannot be assessed
N0 No regional lymph node metastasis
N1 Metastasis in 1–6 regional lymph node(s)
N2 Metastasis in 7–15 regional lymph nodes(s)
N3 Metastasis in more than 15 regional lymph nodes(s)

Distant Metastasis (M)

MX Presence of distant metastasis cannot be assessed
M0 No distant metastasis
M1 Distant metastasis

Pathologic Classification (pTNM)

The pT, pN and pM categories correspond to the T, N, and M categories.

Thyroid Gland

Primary Tumor (T)

All categories may be subdivided: (a) solitary; (b) multifocal–measure the largest for classification

TX Primary tumor cannot be assessed
T0 No evidence of primary tumor
T1 Tumor 1 cm or less in greatest dimension limited to the thyroid
T2 Tumor more than 1 cm but not more than 4 cm in greatest dimension limited to the thyroid
T3 Tumor more than 4 cm in greatest dimension limited to the thyroid
T4 Tumor of any size extending beyond the thyroid capsule

Lymph Node (N)

Regional nodes are the cervical and upper mediastinal lymph nodes

NX Regional lymph nodes cannot be assessed
N0 No regional lymph node metastasis
N1 Regional lymph node metastasis
  N1a Metastasis in ipsilateral cervical lymph nodes
  N1b Metastasis in bilateral, midline, or contralateral cervical or mediastinal lymph nodes

Distant Metastasis (M)

MX Presence of distant metastasis cannot be assessed

M0 No distant metastasis
M1 Distant metastasis

Pathologic Classification (pTNM)
The pT, pN, and pM categories correspond to the T, N, and M categories.

Uterus

Primary Tumor (T)

TNM	FIGO	DEFINITION
TX		Primary tumor cannot be assessed
T0		No evidence of primary tumor
T**is**	0	Carcinoma in situ
T1	I	Tumor confined to corpus
T1a	Ia	Tumor limited to endometrium
T1b	Ib	Tumor invades up to less than one half of myometrium
T1c	Ic	Tumor invades up to more than one half of myometrium
T2	II	Tumor invades cervix but does not extend beyond uterus
T2a	IIa	Endocervical glandular involvement only
T2b	IIb	Cervical stomal invasion
T3	III	Local and/or regional spread as specified in T3a, b, N1, and FIGO IIIA, B, C.
T3a	IIIa	Tumor involves serosa and/or adnexa (direct extension or metastasis) and/or cancer cells in ascites or peritoneal washings
T3b	IIIb	Vaginal involvement (direct extension or metastasis)
N1	IIIc	Metastasis to pelvic and/or paraaortic lymph nodes
T4*	IVa	Tumor invades bladder mucosa and/or bowel mucosa

Lymph Node (N)
NX Regional lymph nodes cannot be assessed
N0 No regional lymph node metastasis
N1 Regional lymph node metastasis

Distant Metastasis (M)

TNM	FIGO†	DEFINITION
MX		Presence of distant metastasis cannot be assessed
M0		No distant metastasis
M1	Ivb	Distant metastasis (excluding metastasis to vagina, pelvic serosa, or adnexa, including metastasis to intraabdominal lymph nodes other than paraaortic and/or inguinal nodes)

Pathologic Classification (pTNM)
The pT, pN, and pM categories correspond to the T, N, and M categories.

Prostate

T0 No evidence of primary tumor
T1 Nonpalpable disease (old stage "A")
- **T1a** Three or fewer microscopic foci of carcinoma
- **T1b** More than 3 microscopic foci of carcinoma
- **T1c** No palpable tumor, diagnosed by elevated PSA

*The presence of bullous edema is not sufficient evidence to classify a tumor T4.

†FIGO = Fédération Internationale de Gynécologie et d'Obstétrique

T2 Tumor presents clinically or grossly, limited to the gland (old stage "B")
- **T2a** Tumor involves one lobe
- **T2b** Tumor involves both lobes

T3 Tumor extends through the prostatic capsule (old stage "C")
- **T3a** Extracapsular extension (unilateral or bilateral)
- **T3b** Tumor invades seminal vesical(s)

T4 Tumor is fixed or invades adjacent structures other than seminal vesicles: bladder neck, external sphincter, rectum, levator muscles, and/or pelvic wall.

Regional Lymph Nodes (N)

NX Regional lymph nodes cannot be assessed
N0 No regional lymph node metastasis
N1 Regional lymph node metastasis

Distant Metastasis (M)

MX Distant metastasis cannot be assessed
M0 No distant metastasis
M1 Distant metastasis
- **M1a** Nonregional lymph node(s)
- **M1b** Bone(s)
- **M1c** Other site(s)

Pathologic Classification (pTNM)

The pT, pN and pM categories correspond to the T, N, and M categories. However, there is no pT1 category because there is insufficient tissue to assess the highest pT category.

WEIGHT CONVERSION

Table A–7 gives information for converting weight in pounds (lb) to weight in kilograms (kg) and vice versa.

TABLE A–7 Weight Conversion Table

lb	kg	kg	lb
1	0.5	1	2.2
2	0.9	2	4.4
4	1.8	3	6.6
6	2.7	4	8.8
8	3.6	5	11.0
10	4.5	6	13.2
20	9.1	8	17.6
30	13.6	10	22.0
40	18.2	20	44.0
50	22.7	30	66.0
60	27.3	40	88.0
70	31.8	50	110.0
80	36.4	60	132.0
90	40.9	70	154.0
100	45.4	80	176.0
150	68.2	90	198.0
200	90.8	100	220.9

kg = lb × 0.454 lb = kg × 2.2

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NOTE: Page numbers followed by *f* indicate figures; those followed by *t* indicate tables.

D

E

J

K

M

N

P

Q

S

T

W

Eptifibatide (Integrilin)	**ACS:** 180 µg/kg IV bolus then 2 µg/kg/min. **PCI:** 135 µg/kg IV bolus then 0.5 µg/kg/min; bolus again in 10 min
Esmolol (Brevibloc)	0.5 mg/kg over 1 min, then 0.05 mg/kg/min
Heparin (Unfractionated)	Bolus 60 IU/kg (max 4000 IU); then 12 IU/kg/h (max 1000 IU/h for patients >70 kg) round to nearest 50 IU; keep PTT 1.5–2.0 × control 48 h or until angiography
Isoproterenol (Isuprel)	2–10 µg/min titrate
Labetalol (Trandate)	10 mg IV over 1–2 min; repeat or double dose q 10 min (150 mg max); or initial bolus, then 2–8 µg/min
Lidocaine	**Cardiac arrest from VF/VT:** Initial: 1.0–1.5 mg/kg IV. **Refractory VF:** additional 0.5–0.75 mg/kg IV push, repeat in 5–10 min, max total 3 mg/kg. ET: 2–4 mg/kg. **Perfusing stable VT, wide complex tachycardia or ectopy:** 1.0–1.5 mg/kg IV push; repeat 0.5–0.75 mg/kg q 5–10 min; max total 3 mg/kg; Maint 1–4 mg/min (30–50 µg/min)
Magnesium Sulfate	**Cardiac arrest:** 1–2 g IV push (2–4 mL 50% solution) in10 mL D5W **AMI:** Load 1–2 g in 50–100 mL D_5W, over 5–60 min IV; then 0.5–1.0 g/h IV up to 24 h
Metoprolol (Lopressor)	5 mg slow IV q 5 min, total 15 mg
Morphine	2–4 mg IV (over 1–5 min) every 5–30 min
Nitroglycerin	IV bolus: 12.5–25 µg; infuse at 10–20 µg/min. SL: 0.3–0.4 mg, repeat q 5 min. Aerosol spray: Spray 0.5–1.0 s at 5-min intervals
Procainamide (Pronestyl)	**Recurrent VF/VT**: 20–50 mg/min IV; max total 17 mg/kg. **Others:** 20 mg/min IV until one these: arrhythmia stopped, hypotension, QRS widens >50%, total 17 mg/kg; then 1–4 mg/min
Propanolol (Inderal)	0.1 mg/kg slow IV push, divided 3 equal doses q 2–3 min, max 1 mg/min; repeat in 2 min PRN
Reteplase, recombinant (Retavase)	10 U IV bolus over 2 min; 30 min later, 10 U IV bolus over 2 min NS flush before and after each dose
Sodium Bicarbonate	1 mEq/kg IV bolus; repeat ½ dose q 10 min PRN
Streptokinase	1.5 million IU in a 1-h inf
Tirofiban (Aggrastat)	**ACS or PCI**: 0.4 µg/kg/min IV for 30 min, then 0.1 µg/kg/min
Verapamil (Verapamil)	2.5–5.0 mg IV over 1–2 min; repeat 5–10 mg, in 5–30 min PRN; or 5-mg bolus q 15 min (max 30 mg)

AM I= acute MI; ACS = acute coronary syndrome; PCI = percutaneous coronary intervention; NA = not available or not appropriate; q = every; PEA: pulseless electrical activity, PRN =as needed.