A. Evaluating the Patient (H&P)

1. **THE MEDICAL HISTORY**

1. **CC:** reason for seeking medical attention; when possible, it should be stated in the patient’s own words.

2. **HPI:** chronologic narrative of the patient’s medical problems. The description of the sx should include the following: location, radiation, quality (deep, sharp, stinging), quantity or severity, timing (onset, duration, frequency), aggravating or relieving factors, associated manifestations, prior investigations, prior treatment.

3. **PMHx:** general state of health, significant childhood and adult illnesses, prior hospitalizations (medical, surgical).

4. **Allergies:** foods, drugs; describe the type of allergic reaction.

5. **Current medications:** dose, frequency, and duration of present drug regimen; include all nonprescription drugs and herbal products.

6. **FHx:** age and health status or age and cause of death of each immediate family member. Inquire about FHx of diabetes, heart disease, HTN, cancer, arthritis, mental disorder, or any hereditary conditions.

7. **SHx:**
   a. Lifestyle, home situation, significant others
   b. Cigarette smoking (quantity in pack years), EtOH usage, drugs
   c. Occupational hx
   d. Religious beliefs relevant to health
   e. Sexual preference (if relevant to health)

8. **ROS:**
   a. General: overall state of health (usual weight, recent weight change, fever, night sweats, sleeping habits, appetite)
   b. Skin: rashes, pruritus, color change, pigmentation
   c. Head: headaches, trauma
   d. Eyes: vision, visual disturbances, last eye exam
   e. Ears: hearing, tinnitus, vertigo, infections, d/c
   f. Nose and sinuses: epistaxis, nasal stuffiness, sinusitis, sense of smell
   g. Mouth and throat: condition of teeth, last dental exam, presence of sore throat or mouth lesions
   h. Neck: lumps, “swollen glands,” pain in the neck region
   i. Breast: pain, h/o lumps, bleeding, nipple d/c; if female, inquire if she performs self-exam
   j. Respiratory: cough, wheezing, sputum (quantity, color), shortness of breath, pain associated w/breathing
   k. Cardiac: chest pain, palpitations, orthopnea, edema, heart murmurs, h/o HBP
   l. GI: N/V, change in bowel habits, GI bleeding, constipation, diarrhea, abd pain, increased girth
   m. GU: dysuria, frequency, urgency, nocturia, d/c, STDs, libido, sexual problems, bleeding
2 THE PHYSICAL EXAMINATION

1. VS: Record pulse, respiration, temperature, and BP (measured in both arms).

2. General description: Observe state of health, general appearance, nutritional status, body development, personal hygiene, posture, signs of anxiety, and apparent age.

3. Skin:
   a. Observe texture, color, temperature, and turgor and note any lesions.
   b. Note distribution, amount, and texture of hair.
   c. Note color of nail beds and shape of nails.

4. Lymph nodes: Note size, consistency, mobility, and tenderness of lymph nodes.

5. Head: Note size, shape, symmetry, and any unusual lesions.

6. Eyes: Note position and alignment of eyes. Inspect lacrimal glands, eyelids, cornea, sclera, and pupils; test visual fields and pupillary reactions; closely examine the fundi; observe range of eye movements, note visual field defects; assess near vision.
   
   **Clinical Pearl:** The *Argyll Robertson pupil* is a pupil constricted 1 to 2 mm that reacts to accommodation but is nonreactive to light. Classically associated with neurosyphilis, it can be seen with sarcoidosis, MS, DM, Lyme disease, CNS tumors or hemorrhage, Wernicke’s encephalopathy, and other conditions associated with lesions in the area of the Edinger-Westphal nucleus. *Adie’s tonic pupil* is a pupil dilated 3 to 6 mm that reacts little in response to light and accommodation. It is often associated with diminished or absent DTRs. Its cause is unknown.

7. Ears: Inspect auricles, canals, and tympanic membranes; check auditory acuity by whispering in the patient’s ear or by placing a watch against the patient’s ear.

8. Nose and sinuses: Inspect the external nose, nasal mucosa, and septum; palpate frontal and maxillary sinuses for evidence of tenderness.

9. Mouth and throat: Inspect lips, gums, teeth, tongue, palate, and pharynx.

10. Neck:
    a. Palpate thyroid gland, inspect and palpate cervical nodes, and examine trachea.
    b. When palpating the carotid arteries, never do both simultaneously (may cause syncope).
    c. Auscultate carotids for pulses, upstroke, and presence of bruits.
    d. Note presence of JVD and angle of distention.
    e. Note range of neck movements and any nuchal rigidity.

11. Back: Inspect and palpate spine and muscles of back; note any kyphosis or scoliosis; note presence or absence of tenderness and range of motion of back.

12. Chest:
    a. Inspect, palpate, and percuss lungs.
    b. Observe respiratory movements and use of respiratory muscles.
    c. Listen to quality and intensity of breath sounds.
    d. Listen for e to change with whispered pectoriloquy (ninety-nine).
13. Heart:
   a. Inspect and palpate precordium; locate apical impulse.
   b. Using both bell and diaphragm, auscultate for S1, S2 (intensity, splitting), abnl heart sounds (S3, S4, clicks, rubs, hums, snaps), murmurs (note timing, intensity, pitch, location, radiation, quality).

14. Breasts:
   a. Inspect breasts w/patient’s arms relaxed, elevated, and then w/patient’s hands pressed against hips.
   b. Note symmetry, contour, abnl shapes, skin color, retraction, thickening, edema, venous pattern.
   c. Inspect nipples for size, shape, inversion, rashes, ulceration, d/c.
   d. Palpate for presence of masses and tenderness; feel for the presence of axillary adenopathy.

15. Abdomen:
   a. Observe skin color, contour, scars, masses, obesity, rigidity, ascites, venous pattern, and pulsatile masses.
   b. Auscultate for bowel sounds and abdominal bruits.
   c. Percuss abd and note tympany, shifting dullness, and size of liver and spleen.
   d. Note size, shape, consistency, and tenderness.

16. Rectal examination:
   a. Examine anus and rectal wall for lesions, inflammation, and sphincter tone; note any nodules or other abnormalities.
   b. Test any fecal material for occult blood.
   c. In male patients, palpate prostate and identify lateral lobes (note size, shape, and consistency of prostate).

17. Genitalia:
   a. Male
      i. Inspect distribution of pubic hair.
      ii. Examine penis (note any ulcers, nodules, scars, signs of inflammation); gently compress glans and note any d/c or tenderness.
      iii. Inspect scrotum (note any lumps, swelling, nodules, ulcers, size and shape of both testicles); transilluminate any swelling.
      iv. Inspect inguinal and femoral areas for bulges; examine patient for presence of hernias.
   b. Female
      i. Inspect external genitalia (labia clitoris, urethral orifice, vaginal opening) and note distribution of pubic hair; note any nodules, d/c, bulges, and swelling.
      ii. Perform internal examination (if indicated): insert speculum and note vaginal wall and cervical os; obtain specimen for cervical cytology; perform bimanual exam w/index and middle finger (placing the other hand above abd); identify position and mobility of cervix; note any uterine and ovarian masses, enlargement, or tenderness.
      iii. Perform rectovaginal exam; note any nodules or other lesions.

18. Inguinal area: Palpate for inguinal nodes; palpate femoral arteries (describe pulses, note any bruits).

19. Neurologic examination:
   a. Mental status and speech: check orientation, memory, and expression; check quality, quantity, and organization of speech. Consider "mini-cog exam" or “Folstein MMSE” (Table 1-3) in patients w/mental status changes or dementia.
   b. Cranial nerves
   c. Sensory: pinprick, light touch, joint position, temperature, vibration
   d. Cerebellar functions: evaluate rapid alternating hand movements, heel-to-shin, finger-to-nose, and gait.
   e. Motor: check muscle strength, muscle tone, coordination; check Romberg’s sign, reflexes, plantar responses; note any abnl reflexes.
3 THE ELDERLY PATIENT

1. Geriatric screening questions:
   a. Are you having trouble with your memory?
   b. Have you fallen in the past year?
   c. Do you have trouble hearing?
   d. Do you have trouble with your vision? Do you wear glasses?
   e. Have you lost more than 10 pounds in the past 6 months?
   f. Do you feel sad or depressed?

2. ADLs:
   a. Toileting: Do you ever lose urine when you don’t want to? Do you have difficulty getting to the bathroom?
   b. Feeding: Do you have any difficulty feeding yourself? Are you able to feed yourself? Do you have a special diet?
   c. Dressing: Are you able to dress yourself? Do you have any difficulty with dressing?
   d. Grooming: Do you need assistance with cutting your nails, brushing your hair?
   e. Walking: How far are you able to walk?
   f. Bathing: Are you able to bathe yourself? Do you need assistance with bathing? Do you have a shower chair? Are you afraid to fall in the shower?

3. Instrumental ADLs (IADLs):
   a. Telephone: Are you able to use the telephone? Who would you call if there was an emergency? Do you have a lifeline?
   b. Shopping: Do you do your own shopping? If not, who helps you?
   c. Food preparation: Do you cook your own food? Who prepares or delivers your meals?
   d. Housekeeping: Are you able to do housework?
   e. Laundry: Are you able to do your laundry?
   f. Transportation: Do you drive? How do you get to your doctor’s appointments? Do you rely on anyone for transportation?
   g. Medication: How do you take your medication? Do you have a pill box? Does someone set up the medications for you? Are you having difficulty paying for your medications?
   h. Finances: Do you pay your own bills? Does anyone help you with your finances?

4. Mini-Cog:
   a. Instruct the patient to listen carefully and to remember three unrelated words (e.g., red, Broadway, 42), then repeat the three words back to you (to be sure the patient heard them).
   b. Instruct the patient to draw the face of a clock (blank page or with circle already on it).
   c. After the patient puts numbers on the clock face, ask the patient to draw the hands of the clock to read 8:20. No further instructions are to be given. If the clock draw test (CDT) (Fig. 1-1) is not finished after 3 minutes, go to the next step.

![Clock Draw Test Example](image_url)

FIGURE 1-1. Example of clock draw test. The patient was instructed to have the clock read 3:00.
d. Ask the patient to repeat the three previously presented words.
e. Scoring:
  i. Recall: 0-3 points (1 point for each recalled word after CDT)
  ii. CDT: 0 points for abnl CDT, 2 points for nl CDT (all numbers depicted once, in correct order and position; hands show requested time)
  iii. Add recall and CDT scores to get mini-cog score: 0-5
f. Interpretation: nl >3; abnl <2
5. Get Up and Go Test:
a. Ask patient to sit in an armless chair.
b. Instruct patient to stand w/o using hands, walk to a mark 10 feet away, turn, walk back to the chair, and sit again. (If patient is unable to get up w/o the use of hands, then allow the patient to use hands.)
c. Tell patient that she/he will be timed.
d. Time get up and go test.
e. Closely observe body posture while seated, initial stance, stride length, quality of turning, and spatial awareness when seated.
f. Scoring: time >9 seconds indicates a twofold fall risk.
g. Check for patient’s comfort. Stand close to the patient to assist if the patient needs support.
6. End-of-life care discussion:
a. Transition statement: We’ve talked about your current and past medical history. I’d like to ask you about your thoughts regarding your future medical care.
b. As you look forward in your life, what are some of the things you hope your doctors and family will think about in taking care of you?
c. What are the things that are most important to you regarding your medical care?
d. What are the things you worry most about when you think about your medical care in the future?
e. If appropriate: We’ve just been learning about advanced directives; do you have a living will or durable power of attorney?
f. If yes: Can you tell me about it?

<table>
<thead>
<tr>
<th>TABLE 1-1 Grading of Cardiac Murmurs</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Grade</strong></td>
</tr>
<tr>
<td>-----------</td>
</tr>
<tr>
<td>1</td>
</tr>
<tr>
<td>2</td>
</tr>
<tr>
<td>3</td>
</tr>
<tr>
<td>4</td>
</tr>
<tr>
<td>5</td>
</tr>
<tr>
<td>6</td>
</tr>
</tbody>
</table>
7. Spinal dermatomes (Fig. 1-3).
8. Key areas determining sensory level (Box 1-1).
9. Key muscles determining motor level (Box 1-2).
10. Grading of muscle strength (Table 1-6).
11. Grading of DTRs (Table 1-7).

ROSENBAUM POCKET VISION SCREENER

Card is held in good light 14 inches from eye. Record vision for each eye separately with and without glasses. Presbyopic patients should read thru bifocal segment. Check myopes with glasses only.

PUPIL GAUGE (mm.)

FIGURE 1-2. Rosenbaum chart for testing near vision.
TABLE 1-2  ■ Response of Selected Murmurs to Physiologic Intervention

<table>
<thead>
<tr>
<th>Cardiac Murmur</th>
<th>Accentuation</th>
<th>Decrease</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Systolic</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Aortic stenosis</td>
<td>Valsalva release</td>
<td>Handgrip</td>
</tr>
<tr>
<td></td>
<td>Sudden squatting</td>
<td>Valsalva Standing</td>
</tr>
<tr>
<td></td>
<td>Passive leg raising</td>
<td></td>
</tr>
<tr>
<td>Hypertrophic obstructive cardiomyopathy</td>
<td>Valsalva strain</td>
<td>Handgrip</td>
</tr>
<tr>
<td></td>
<td>Standing</td>
<td>Squatting Leg elevation</td>
</tr>
<tr>
<td>Mitral regurgitation</td>
<td>Sudden squatting</td>
<td>Valsalva Standing</td>
</tr>
<tr>
<td></td>
<td>Isometric handgrip</td>
<td></td>
</tr>
<tr>
<td>Pulmonic stenosis</td>
<td>Valsalva release</td>
<td>Expiration</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Diastolic</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Aortic insufficiency</td>
<td>Sudden squatting</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Isometric handgrip</td>
<td></td>
</tr>
<tr>
<td>Mitral stenosis</td>
<td>Exercise</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Left lateral position</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Isometric handgrip</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Coughing</td>
<td></td>
</tr>
<tr>
<td>Tricuspid stenosis</td>
<td>Inspiration</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Passive leg raising</td>
<td>Expiration</td>
</tr>
</tbody>
</table>

**TABLE 1-3  ■ The Mini-Mental State Examination (MMSE)**

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Score</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Orientation:</strong> What is the month, day, date, year, season? Where are you? What floor, city, country, state? (Score 1 point for each item correct.)</td>
<td>10</td>
</tr>
<tr>
<td><strong>Registration:</strong> State three items (ball, flag, tree). (Score 1 point for each item that the patient registers without having to repeat the words. You may repeat the words until the patient is able to register the words, but do not give the patient credit. You must also tell the patient that he/she should memorize those words and that you will ask him/her to recall those words later.)</td>
<td>3</td>
</tr>
<tr>
<td><strong>Attention:</strong> Can you spell the word WORLD forward, then backward? Can you subtract 7 from 100, and keep subtracting 7? (100-93-86-79-72) (Do both items but give credit for the best of the two performances.)</td>
<td>5</td>
</tr>
<tr>
<td><strong>Memory:</strong> Can you remember those three words I asked you to memorize? (Do not give clues or multiple choice.)</td>
<td>3</td>
</tr>
<tr>
<td><strong>Language:</strong></td>
<td></td>
</tr>
<tr>
<td><strong>Naming:</strong> Can you name (show) a pen and a watch?</td>
<td>2</td>
</tr>
<tr>
<td><strong>Repetition:</strong> Can you repeat “No if’s, and’s, or but’s”?</td>
<td>1</td>
</tr>
<tr>
<td><strong>Comprehension:</strong> Can you take this piece of paper in your right hand, fold it in half, then put it on the floor? (Score 1 point for each item done correctly.)</td>
<td>3</td>
</tr>
<tr>
<td><strong>Reading:</strong> Read and obey “Close your eyes.”</td>
<td>1</td>
</tr>
<tr>
<td><strong>Writing:</strong> Can you write a sentence?</td>
<td>1</td>
</tr>
<tr>
<td><strong>Visuospatial:</strong> Have patient copy intersecting pentagons.</td>
<td>1</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td>30</td>
</tr>
</tbody>
</table>

**Interpretation:** Traditionally, with use of a cutoff score of 23 of 30, the sensitivity and specificity of the MMSE have been reported to be 87% and 82%, respectively, for detection of delirium or dementia in hospitalized patients. However, cognitive performance as measured by the MMSE varies within the population by age and education. To adjust for these variables, it has been proposed that a cutoff score of 19 is appropriate for patients with 0 to 4 years of education and will identify those individuals performing below the level of 75% of their peers; the cutoff score should be 23 for those with 5 to 8 years of education and 27 for those with 9 to 12 years of education. A score below 29 would be abnormal in 75% of individuals with a college education.
### TABLE 1-5  The Glasgow Coma Scale

<table>
<thead>
<tr>
<th>Cranial Nerves</th>
<th>Action</th>
</tr>
</thead>
<tbody>
<tr>
<td>I  Olfactory</td>
<td>Sense of smell</td>
</tr>
<tr>
<td>II  Optic</td>
<td>Vision (visual acuity, visual fields, color)</td>
</tr>
<tr>
<td>III Oculomotor</td>
<td>Extraocular movement, pupillary constriction (oculomotor), elevation of upper lids, abduction of eye</td>
</tr>
<tr>
<td>IV Trochlear</td>
<td></td>
</tr>
<tr>
<td>VI  Abducens</td>
<td></td>
</tr>
<tr>
<td>V  Trigeminal</td>
<td>Mastication; sensory of forehead, face, and jaw</td>
</tr>
<tr>
<td>VII  Facial</td>
<td>Facial expression; taste in anterior two thirds of tongue</td>
</tr>
<tr>
<td>VIII Acoustic</td>
<td>Hearing and balance</td>
</tr>
<tr>
<td>IX  Glossoharyngeal</td>
<td>Sensory and motor functions of pharynx and larynx (gag reflex, position of uvula, swallowing)</td>
</tr>
<tr>
<td>X Vagus</td>
<td></td>
</tr>
<tr>
<td>XI Accessory</td>
<td>Shripping of shoulders, movement of head, motor to trapezius, sternocleidomastoid</td>
</tr>
<tr>
<td>XII Hypoglossal</td>
<td>Motor control of tongue</td>
</tr>
</tbody>
</table>

**Eye opening**

- **Spontaneously**
  - 4: Reticular activating system is intact; patient may not be aware
- **To verbal command**
  - 3: Opens eyes when told to do so
- **To pain**
  - 2: Opens eyes in response to pain
- **None**
  - 1: Does not open eyes to any stimuli

**Verbal response**

- **Oriented-converses**
  - 5: Relatively intact CNS
- **Disoriented-converses**
  - 4: Well articulated, organized, but patient is disoriented
- **Inappropriate words**
  - 3: Random, exclamatory words
- **Incomprehensible**
  - 2: Moaning, no recognizable words
- **No response**
  - 1: No response or intubated

**Motor response**

- **Obey verbal commands**
  - 6: Readily moves limbs when told to
- **Localizes to painful stimuli**
  - 5: Moves limb in an effort to remove painful stimuli
- **Flexion withdrawal**
  - 4: Pulls away from pain in flexion
- **Abnormal flexion**
  - 3: Decorticate rigidity
- **Extension**
  - 2: Decerebrate rigidity
- **No response**
  - 1: Hypotonia, flaccid: suggests loss of medullary function or concomitant spinal cord injury
**Box 1-1 • Key Areas Determining Sensory Level**

<table>
<thead>
<tr>
<th>Level</th>
<th>Area</th>
</tr>
</thead>
<tbody>
<tr>
<td>C2</td>
<td>Occipital protuberance</td>
</tr>
<tr>
<td>C3</td>
<td>Supraclavicular fossa</td>
</tr>
<tr>
<td>C4</td>
<td>Top of the acromioclavicular joint</td>
</tr>
<tr>
<td>C5</td>
<td>Lateral side of the antecubital fossa</td>
</tr>
<tr>
<td>C6</td>
<td>Thumb</td>
</tr>
<tr>
<td>C7</td>
<td>Middle finger</td>
</tr>
<tr>
<td>C8</td>
<td>Little finger</td>
</tr>
<tr>
<td>T1</td>
<td>Medial side of the antecubital fossa</td>
</tr>
<tr>
<td>T2</td>
<td>Apex of the axilla</td>
</tr>
<tr>
<td>T3</td>
<td>Third intercostal space</td>
</tr>
<tr>
<td>T4</td>
<td>Fourth intercostal space, nipple line</td>
</tr>
<tr>
<td>T5</td>
<td>Fifth intercostal space</td>
</tr>
<tr>
<td>T6</td>
<td>Sixth intercostal space, xiphisternum</td>
</tr>
<tr>
<td>T7-9</td>
<td>Intercostal spaces</td>
</tr>
<tr>
<td>T10</td>
<td>Umbilicus</td>
</tr>
<tr>
<td>T11</td>
<td>Intercostal space</td>
</tr>
<tr>
<td>T12</td>
<td>Inguinal ligament</td>
</tr>
<tr>
<td>L1</td>
<td>Upper anterior thigh</td>
</tr>
<tr>
<td>L2</td>
<td>Midanterior thigh</td>
</tr>
<tr>
<td>L3</td>
<td>Medial femoral condyle</td>
</tr>
<tr>
<td>L4</td>
<td>Medial malleolus</td>
</tr>
<tr>
<td>L5</td>
<td>Dorsum of the foot at the third metatarsal</td>
</tr>
<tr>
<td>S1</td>
<td>Lateral heel</td>
</tr>
<tr>
<td>S2</td>
<td>Popliteal fossa in the midline</td>
</tr>
<tr>
<td>S3</td>
<td>Ischial tuberosity</td>
</tr>
<tr>
<td>S4-5</td>
<td>Perianal area</td>
</tr>
</tbody>
</table>
**Box 1-2 • Key Muscles Determining Motor Level**

<table>
<thead>
<tr>
<th>C1-4</th>
<th>Diaphragm</th>
</tr>
</thead>
<tbody>
<tr>
<td>C5</td>
<td>Elbow flexors (biceps)</td>
</tr>
<tr>
<td>C6</td>
<td>Wrist extensors</td>
</tr>
<tr>
<td>C7</td>
<td>Elbow extensors (triceps)</td>
</tr>
<tr>
<td>C8</td>
<td>Finger flexors, distal phalanx</td>
</tr>
<tr>
<td>T1</td>
<td>Hand intrinsics (interossei)</td>
</tr>
<tr>
<td>T2-L1</td>
<td>Use sensory level and Beevor’s sign</td>
</tr>
<tr>
<td>L2</td>
<td>Hip flexors (iliopsoas)</td>
</tr>
<tr>
<td>L3</td>
<td>Knee extensors (quadriceps)</td>
</tr>
<tr>
<td>L4</td>
<td>Ankle dorsiflexors (tibialis anterior)</td>
</tr>
<tr>
<td>L5</td>
<td>Long toe extensors (extensor hallucis longus)</td>
</tr>
<tr>
<td>S1</td>
<td>Ankle plantar flexors (gastrocnemius)</td>
</tr>
<tr>
<td>S2-5</td>
<td>Use sensory level and sphincter ani</td>
</tr>
</tbody>
</table>

**TABLE 1-6 • Grading of Muscle Strength**

<table>
<thead>
<tr>
<th>Grade</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>Absent muscle contraction</td>
</tr>
<tr>
<td>1</td>
<td>Minimal contraction</td>
</tr>
<tr>
<td>2</td>
<td>Active movement with gravity eliminated</td>
</tr>
<tr>
<td>3</td>
<td>Active movement against gravity only</td>
</tr>
<tr>
<td>4</td>
<td>Active movement against gravity and some resistance</td>
</tr>
<tr>
<td>5</td>
<td>Normal muscle strength</td>
</tr>
</tbody>
</table>

**TABLE 1-7 • Grading of Deep Tendon Reflexes**

<table>
<thead>
<tr>
<th>Grade</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>Absent</td>
</tr>
<tr>
<td>+</td>
<td>Hypoactive</td>
</tr>
<tr>
<td>++</td>
<td>Normal</td>
</tr>
<tr>
<td>+++</td>
<td>Brisker than average</td>
</tr>
<tr>
<td>++++</td>
<td>Hyperactive, often indicative of disease</td>
</tr>
</tbody>
</table>

**B. Charting**

1. **ADMISSION ORDERS**

   **A.** Admit to: indicate ward where patient is being admitted and attending physician (e.g., coronary care unit [CCU], Dr. Smith’s service).

   **B.** Because: indicate admitting dx (e.g., chest pain).

   **C.** Condition: patient’s general condition (stable, fair, poor, critical).

   Code status: DNR, full code, CMO.

   Consults:

   **D.** Diet: specify whether regular, clear liquids, NAS, ADA, low cholesterol, other.

   DVT prophylaxis:

   **A.** Allergies: indicate medications (including OTC medications) and specific food products to which the patient has experienced an allergic reaction.

   Activity: specify bed rest, ad lib, bathroom privileges.

   **V.** Vital signs: specify frequency (e.g., qid, q4h); also indicate any special nursing orders (e.g., VS and neurologic signs qh × 24h, then q4h if stable).

   **I.** IV fluids: specify any IV solutions and rate of infusion.

   **D.** Diagnostic tests: laboratory tests, x-rays, ECG, special tests.

   Drugs: indicate medication, dose, frequency, special restrictions (e.g., atenolol 50 mg PO qd; if HR <50 bpm, hold atenolol and notify house officer).
DICTATING THE H&P

1. VS:
   a. BP:
   b. Pulse:
   c. Respirations:
   d. Temperature:
2. General description: The patient is a [age, sex] who looks her stated age, is pleasant, appears to be well nourished, and seems in a good state of health.
3. Skin: The skin is warm and dry; turgor is adequate; color is normal. There is no icterus, purpura, rash, or unusual pigmentation noted. Hair is normal in appearance, distribution, and texture.
4. Lymph nodes: There is no cervical, supraclavicular, axillary, epitrochlear, or inguinal adenopathy.
5. HEENT:
   a. Head: Normocephalic and atraumatic; no lesions noted.
   b. Eyes: Cornea is without lesion, conjunctiva is clear, sclera is white. Pupils are equal, measuring approximately 3 mm in diameter, round, and reactive to light and accommodation. Extraocular movements are within normal limits without any nystagmus or strabismus. Fundi appear benign. Disks are well delineated. There are no hemorrhages or exudates. Visual acuity is 20/20 bilaterally, and visual fields are within normal limits.
   c. Ears: Ears are normal in appearance. Auditory canal appears clean and without lesions. The tympanic membranes are intact. Hearing is adequate.
   d. Nose: Septum appears to be within normal limits and without deviation. Nasal mucosa appears pink and without any abnormal discharge. No nasal polyps or other lesions are noted. Frontal and maxillary sinuses are nontender.
   e. Mouth and throat: Lips are without cyanosis or pallor. Buccal mucosa is normal in appearance. Teeth appear to be in good condition. Tongue shows no lesions or tremor. Pharyngeal mucosa is pink and does not reveal any lesions, exudates, erythema, or evidence of inflammation. Gag reflex is intact.
6. Neck: Neck is supple. Full range of motion is present. There is no evidence of tracheal deviation, JVD, or lymphadenopathy. Carotid pulses are 2+, equal bilaterally, and without bruits. Carotid upstroke is within normal limits. Thyroid gland is normal in size; its palpation does not reveal any nodules or masses.
7. Back: Spinal curvature is normal; there is no scoliosis, kyphosis, or tenderness present. Full range of motion is present.
8. Chest: Thorax is symmetric. Full expansion is noted bilaterally. Anterior-posterior diameter is within normal limits.
9. Lungs: Fremitus is equal bilaterally. Lung fields are resonant throughout. Breath sounds and voice sounds are normal. There are no rales or rhonchi.
10. Heart: Palpation reveals no heaves or thrills. The PMI is medial to the midclavicular line, fourth intercostal space. Auscultation reveals S1, S2 of normal intensity. There are no S3, S4, rubs, clicks, or other abnormal heart sounds. Heart rate is approximately 70 bpm and rhythm is regular.
11. Breasts (female patient): Breasts are symmetric and have a normal contour. Skin is of normal color and appearance; there is no edema, ulceration, or erythema. Nipples are of normal size and shape; there is no nipple retraction, ulceration, or discharge. Palpation does not reveal any tenderness or masses.
12. Abdomen: Abdomen is of normal size and contour. There are no capillary dilatations, skin lesions, or surgical scars noted. Auscultation
reveals normoactive bowel sounds and no abdominal bruits. Palpation reveals no abdominal tenderness, guarding, or masses. The liver edge is felt approximately 1 inch below the right costal margin; it is firm, sharp, and smooth. The liver percusses to approximately 8 to 10 cm in total span. The spleen is not palpable.

13. Rectal examination: Rectal examination reveals no external anal lesions. Sphincter tone is normal. There are no internal or external hemorrhoids. Rectal mucosa appears normal, and there are no nodules or masses present. Stool is brown and negative for occult blood. Male patient: Prostate is normal in size, no nodules.

14. Genitalia: Inspection reveals normal distribution of pubic hair. Female patient: Clitoris and labia are without lesions. Internal examination with speculum reveals normal vaginal wall. The cervical os is well visualized. No lesions or discharges are noted. A specimen was obtained for cervical cytology. Bimanual examination reveals no cervical tenderness or masses. Uterus and ovaries are nontender and of normal size.

15. Inguinal area: There is no lymphadenopathy noted. Femoral pulses are 2+ and equal bilaterally. Auscultation reveals no femoral bruits.

16. Extremities: There is no clubbing, cyanosis, or edema. Brachial, radial, popliteal, dorsalis pedis, and posterior tibial pulses are 2+ and equal bilaterally. Musculoskeletal examination reveals no joint deformities and full range of motion. There is no bone, joint, or muscle tenderness noted.

17. Neurologic: Patient is alert and oriented to time, person, and place. Cranial nerves II to XII are within normal limits. Speech, memory, and expression are within normal limits. Muscle strength is 5/5 in both upper and lower extremities. There is no muscle atrophy or involuntary movement noted. Testing of cerebellar function reveals normal gait, negative Romberg test result, and good coordination in finger-to-nose, heel-to-shin, and alternate motion testing. Sensory is intact to light touch, pain, and vibratory stimuli. There are no focal motor or sensory deficits present. Deep tendon reflexes are 2+ and equal bilaterally.

4 PROGRESS (SOAP) NOTE

S. Subjective: observations, patient complaints.
O. Objective: description of physical findings and recording of laboratory, x-ray, or ECG data. 
A. Assessment: analysis of data and tentative dx.
P. Plan: diagnostic studies and therapeutic regimen.

5 CONSULT NOTE

■ Date/time
■ Reason for consult
■ HPI
■ Current medications
■ Physical exam
■ Impression
■ Recommendations

6 PREOPERATIVE NOTE

■ Date and time
■ Preoperative dx
■ Surgeon of record
■ Planned procedure
■ Consent
■ Labs
■ CXR
■ ECG
■ Blood
■ Important imaging studies summarized (CT, angiography, MRI)
■ Orders
Chapter 1  Surviving the Wards

7 OPERATIVE NOTE
- Date and time
- Preoperative dx (presumed dx)
- Postoperative dx (actual dx)
- Primary surgeon
- Assistants
- Indications
- Operation performed
- CPT code (if known)
- Wound class (if known)
- Procedure in detail (include abx, time-out procedure, consent documented in chart, amount of local anesthetic, DVT prophylaxis, sponge count)
- Anesthesia
- Findings (include important aspects of the operation, e.g., tumor margins, frozen pathology, type of anastomosis and involved vessels, intraoperative imaging results [such as cholangiography, angiography, fluoroscopy], perforated or nonperforated appendix)
- Fluids (type and amount; include blood products)
- Estimated blood loss
- Urine output
- Drains or tubes (type and site)
- Specimens and cultures
- Complications
- Disposition (patient status at end of case)
- Presence of attending surgeon (e.g., the attending was present and participated in all aspects of the case)

8 PROCEDURE NOTE
- Date and time
- Procedure
- Consent form
- Indications
- Physicians
- Description
- Findings
- Complications
- Disposition

9 DISCHARGE SUMMARY
The discharge summary should contain only essential information about the investigation and treatment of the patient’s illness. It should briefly describe the following:
- Why the patient entered the hospital: a brief statement of the CC, admission dx, and HPI.
- The pertinent laboratory, x-ray, and physical findings; negative findings may be as pertinent as positive findings.
- The medical or surgical treatment, including the patient’s response, any complications, and consultations; a rationale for what was or was not done.
- The patient’s condition when discharged (ambulation, self-care, ability to work).
- Instructions given on continuing care, such as medication by name and specific dosage, diet, type and amount of physical activity, other therapeutic measures, referrals, and appointments.
- The principal dx and additional or secondary diagnoses.

10 PRONOUNCING DEATH WHILE ON CALL
The legal criteria of death fall within state jurisdiction. One should become familiar with the accepted definition of death in one’s own state. When called to pronounce a patient dead, the following steps should be followed:
1. Identify the patient (examine hospital ID tag on the patient’s wrist).
2. Examine patient for:
   a. Response to verbal or tactile stimuli (none)
   b. Spontaneous respiration (none)
   c. Heart sounds and pulses (absent)
   d. Pupillary response (pupils fixed and dilated)
3. Document the time the patient was pronounced dead (legal time of death).
4. Notify attending physician (if not already done by the nursing staff) and inquire if family requests autopsy. Notify the organ bank for possible organ donation, if this is consistent with your hospital’s policy.
5. Document findings in patient’s chart (e.g., “Called by charge nurse to pronounce Mr. John Smith dead. Patient examined, unresponsive to verbal or tactile stimuli, no spontaneous respiration noted, heart sounds not audible, pulses absent, pupils fixed and dilated. Patient pronounced dead at 11:10 PM. Attending notified. Next of kin to be contacted by attending.”) The attending will often not be available, and you will be asked to notify the next of kin.
   a. Familiarize yourself with the patient’s medical hx and mode of death.
   b. Identify yourself to the family in a humble and caring manner and inform them that their next of kin has expired. Inform them of the time that the patient was pronounced dead, and always try to comfort them that their relative died peacefully.
   c. If it is not clear from the patient’s records, inquire if the family requests an autopsy.
   d. Ask the next of kin if the family will be coming to the hospital to view the body before it is transported to the hospital morgue. Notify the charge nurse of their decision.

11 DISCHARGE AGAINST MEDICAL ADVICE (AMA)

1. Discharge AMA, in which a patient chooses to leave the hospital before the treating physician recommends discharge, occurs in nearly 2% of medical admissions.
2. Risk factors are h/o substance or EtOH abuse, lack of insurance or Medicaid, younger age, and male sex.
3. Strategies for preventing AMA discharges include proactively addressing substance abuse issues and recognizing and treating psychological factors. Motivational interviewing, which relies on the principle of patient-centered interviewing and use of nonjudgmental empathetic questioning, is an effective modality in lowering the risk of discharge AMA.
4. If prevention of discharge AMA is not successful, informed consent is a crucial element in managing an AMA discharge. An informed decision means that the decision has been made by the patient in consultation with the physician without being coerced and with a full understanding of the risks, benefits, and alternatives of the decision.
5. The evaluation of the patient being discharged AMA should include the following:
   a. Does the patient understand and appreciate the admission dx, prognosis, and risks and benefits of leaving the hospital? It is important to document that the patient understands the information, terminology, and language (has adequate health literacy).
   b. Is the patient aware of alternative treatments outside of the hospital and associated risks and benefits?
   c. Is the patient able to make and communicate his/her choice?
   d. Can the patient articulate a reason for the choice that is consistent with his/her choice?
6. If a patient is deemed to be without decision-making capacity and has no surrogate, consultation with a psychiatrist may be helpful to keep the patient in the hospital against his/her will.
7. Managing an AMA discharge also includes ensuring that the discharge is as safe as possible under the circumstances and helping the patient follow up after discharge.
C. Evaluating the Labs

This section covers more than 200 laboratory tests. Each test is approached with the following format:

1. Laboratory test.
2. Normal range in adult patients.
3. Common abnormalities (e.g., positive test result, increased or decreased value).
4. Causes of abnormal result.

The normal ranges may differ slightly, depending on the laboratory. The reader should be aware of the “normal range” of the particular laboratory performing the test. Every attempt has been made to present current laboratory test data with emphasis on practical considerations. It is important to remember that lab tests do not make diagnoses, physicians do. As such, any lab results should be integrated with the complete clinical picture and radiographic studies (if needed) to make a dx.

ACE LEVEL; see ANGIOTENSIN-CONVERTING ENZYME

ACETONE (Serum or Plasma)
Normal: Negative.
Elevated in: DKA, starvation, isopropanol ingestion.

ACETYLCHOLINE RECEPTOR (AChR) ANTIBODY
Normal: <0.03 nmol/L.
Elevated in: myasthenia gravis. Changes in AChR concentration correlate with the clinical severity of myasthenia gravis after Rx and during Rx with prednisone and immunosuppressants. False-positive AChR Ab results may be found in pts w/Eaton-Lambert syndrome.

ACID PHOSPHATASE (Serum)
Normal range: enzymatic, prostatic, 0-5.5 U/L; enzymatic, total, 2-12 U/L.
Elevated in: carcinoma of prostate, other neoplasms (breast, bone), Paget’s disease of bone, hemolysis, MM, osteogenesis imperfecta, malignant invasion of bone, Gaucher’s disease, myeloproliferative disorders, prostatic palpation or surgery, hyperparathyroidism, liver disease, chronic renal failure, ITP.

ACTIVATED CLOTTING TIME (ACT)
Normal: This test is used to determine the dose of protamine sulfate to reverse the effect of heparin as an anticoagulant during angioplasty, cardiac surgery, and hemodialysis. The accepted goal during cardiopulmonary bypass surgery is usually 400 to 500 seconds.

ACTIVATED PARTIAL THROMBOPLASTIN TIME (APTT); see PARTIAL THROMBOPLASTIN TIME

ADRENOCORTICOTROPIC HORMONE (ACTH)
Normal: 9-52 pg/mL.
Decreased in: secondary adrenocortical insufficiency, hypopituitarism, adrenal adenoma or adrenal carcinoma.
ALANINE AMINOTRANSFERASE (ALT, SGPT)

Normal range: 8-35 U/L (female); 10-40 U/L (male).
Elevated in: liver disease (e.g., hepatitis, cirrhosis, Reye’s syndrome), EtOH abuse, drugs (e.g., acetaminophen, statins, NSAIDs, abx, anabolic steroids, narcotics, heparin, labetalol, amiodarone, chlorpromazine, phenytoin), hepatic congestion, infectious mononucleosis, liver mets, MI, myocarditis, severe muscle trauma, dermatomyositis or polymyositis, muscular dystrophy, malignant neoplasms, renal and pulmonary infarction, convulsions, eclampsia, dehydration (relative increase), Chinese herbs.
Decreased in: azotemia, advanced malnutrition, chronic renal dialysis, chronic alcoholic liver disease, metronidazole.

ALBUMIN (Serum)

Normal range: 4-6 g/dL.
Elevated in: dehydration (relative ↑), IV alb infusion.
Decreased in: liver disease, nephrotic syndrome, poor nutritional status, rapid IV hydration, protein-losing enteropathies (IBD), severe burns, neoplasia, chronic inflammatory diseases, pregnancy, prolonged immobilization, lymphomas, hypervitaminosis A, chronic GN.

ALDOLASE (Serum)

Normal range: 0-6 U/L.
Elevated in: rhabdo, dermatomyositis or polymyositis, trichinosis, acute hepatitis and other liver diseases, muscular dystrophy, MI, prostatic carcinoma, hemorrhagic pancreatitis, gangrene, delirium tremens, burns.
Decreased in: loss of muscle mass, late stages of muscular dystrophy.

ALDOSTERONE (Plasma)

Normal: 3-16 ng/dL (adult supine); 7-30 ng/dL (adult upright); 200-800 ng/dL (adrenal vein).
Elevated in: aldosterone-secreting adenoma, bilateral adrenal hyperplasia, secondary aldosteronism (diuretics, CHF, laxatives, nephritic syndrome, cirrhosis w/ascites, Bartter’s syndrome, pregnancy, starvation).

ALKALINE PHOSPHATASE (Serum)

Normal range: 30-120 U/L.
Elevated in: biliary obstruction, cirrhosis (particularly PBC), liver disease (hepatitis, infiltrative liver diseases, fatty metamorphosis), Paget’s disease of bone, osteitis deformans, rickets, osteomalacia, hypervitaminosis D, hyperparathyroidism, hyperthyroidism, UC, bowel perforation, bone mets, healing fxs, bone neoplasms, acromegaly, infectious mononucleosis, CMV infections, sepsis, pulmonary infarction, hypernephroma, leukemia, myelofibrosis, MM, drugs (estrogens, alb, erythromycin and other abx, cholestasis-producing drugs [phenothiazines]), pregnancy, puberty, postmenopausal females.
Decreased in: hypothyroidism, pernicious anemia, hypophosphatemia, hypervitaminosis D, malnutrition.

ALPHA, FETOPROTEIN (Serum)

Normal range: 0-20 ng/mL.
Elevated in: Hepatocellular carcinoma (usually values >1000 ng/mL), germinal neoplasms (testis, ovary, mediastinum, retroperitoneum), liver disease (alcoholic cirrhosis, acute hepatitis, chronic active hepatitis), fetal anencephaly, spina bifida, basal cell carcinoma, breast carcinoma, pancreatic carcinoma, gastric carcinoma, retinoblastoma, esophageal atresia.
Chapter 1  Surviving the Wards

ALT; see ALANINE AMINOTRANSFERASE

ALUMINUM (Serum)

Normal range: 0-6 ng/mL.

Elevated in: chronic renal failure on dialysis, parenteral nutrition, industrial exposure.

AMA; see MITOCHONDRIAL ANTIBODY

AMMONIA (Serum)

Normal range: 15-45 µg/dL (adults); 29-70 µg/dL (children).

Elevated in: hepatic failure, hepatic encephalopathy, Reye’s syndrome, portacaval shunt, drugs (diuretics, polymyxin B, methicillin).

Decreased in: drugs (neomycin, lactulose), renal failure.

AMYLASE (Serum)

Normal range: 0-130 U/L.

Elevated in: acute pancreatitis, macroamylasemia, salivary gland inflammation, mumps; pancreatic neoplasm, abscess, pseudocyst, ascites; perforated peptic ulcer; intestinal obstruction, intestinal infarction; acute cholecystitis, appendicitis, ruptured ectopic pregnancy, peritonitis, burns, DKA, renal insufficiency; drugs (morphine); carcinomatosis of lung, esophagus, ovary; acute ethanol ingestion; prostate tumors; post-ERCP; bulimia, anorexia nervosa.

Decreased in: advanced chronic pancreatitis, hepatic necrosis, cystic fibrosis.

AMYLASE, URINE; see URINE AMYLASE

ANA; see ANTINUCLEAR ANTIBODY

ANCA; see ANTINEUTROPHIL CYTOPLASMIC ANTIBODY

ANDROSTENEDIONE (Serum)

Normal: 75-205 ng/dL (male); 85-275 ng/dL (female).

Elevated in: congenital adrenal hyperplasia, polycystic ovary syndrome, ectopic ACTH-producing tumor, Cushing’s syndrome, hirsutism, hyperplasia of ovarian stroma, ovarian neoplasm.

Decreased in: ovarian failure, adrenal failure, sickle cell anemia.

ANGIOTENSIN II

Normal: 10-60 pg/mL.

Elevated in: HTN, CHF, cirrhosis, renin-secreting renal tumor, volume depletion.

Decreased in: ACEIs, ARB drugs, primary aldosteronism, Cushing’s syndrome.

ANGIOTENSIN-CONVERTING ENZYME (ACE Level)

Normal range: <40 nmol/mL/min.

Elevated in: sarcoidosis, PBC, alcoholic liver disease, hyperthyroidism, hyperparathyroidism, DM, amyloidosis, MM, lung disease (asbestosis, silicosis, berylliosis, allergic alveolitis, coccidioidomycosis), Gaucher’s disease, leprosy.

Decreased in: ACEI Rx.

ANION GAP

Normal range: 9-14 mEq/L.

Elevated in: lactic acidosis, ketoacidosis (DKA, alcoholic starvation), uremia (chronic renal failure), ingestion of toxins (paraldehyde, methanol, salicylates, ethylene glycol), hyperosmolar nonketotic coma, abx (carbenicillin).
Decreased in: hypoalbuminemia, severe hypermagnesemia, IgG myeloma, lithium toxicity, laboratory error (falsely decreased sodium or overestimation of HCO₃ or chloride), hypercalcemia of parathyroid origin, abx (e.g., polymyxin).

ANTICARDIOLIPIN ANTIBODY (ACA)
Normal range: negative. Test includes detection of IgG, IgM, and IgA Ab to phospholipid, cardiolipin.
Present in: antiphospholipid Ab syndrome, chronic HCV infection.

ANTICOAGULANT; see CIRCULATING ANTICOAGULANT

ANTIDIURETIC HORMONE (ADH)
Normal: 295-300 mOsm/kg; 4-12 pg/mL.
Elevated in: SIADH, antipsychotic meds, ectopic ADH from systemic neoplasm, GBS, CNS infections, brain tumors, nephrogenic diabetes insipidus.
Decreased in: central diabetes insipidus, nephritic syndrome, psychogenic polydipsia, demeclocycline, lithium, phenytoin, EtOH.

ANTI-DNA
Normal range: absent.
Present in: SLE, chronic active hepatitis, infectious mononucleosis, biliary cirrhosis.

ANTI-DS DNA
Normal: <25 U.
Elevated in: SLE.

ANTIGLOBULIN TEST, DIRECT; see COOMBS, DIRECT

ANTI–GLomerular Basement Antibody; see GLOMERULAR BASEMENT MEMBRANE ANTIBODY

ANTI-HCV; see HEPATITIS C ANTIBODY

ANTIHISTONE
Normal: <1 U.
Elevated in: drug-induced lupus erythematosus.

ANTIMITOCHONDRIAL ANTIBODY (AMA)
Normal range: <1:20 titer.
Elevated in: PBC (85%-95%), chronic active hepatitis (25%-30%), cryptogenic cirrhosis (25%-30%).

ANTINEUTROPHIL CYTOPlasMIC ANTIBODY (ANCA)
Positive test result:
- Cytoplasmic pattern (cANCA): positive in Wegener’s granulomatosis.
- Perinuclear pattern (pANCA): positive in IBD, PBC, PSC, autoimmune chronic active hepatitis, crescentic GN.

ANTINUCLEAR ANTIBODY (ANA)
Normal range result: <1:20 titer.
Positive test: SLE (more significant if titer >1:160), drugs (phenytoin, ethosuximide, primidone, methyldopa, hydralazine, carbamazepine, PCN, procarbazine, chlorpromazine, griseofulvin, thiazides), chronic active hepatitis, age >60 years (particularly age >80 years), RA, scleroderma, MCTD, necrotizing vasculitis, Sjögren’s syndrome.

Figure 1-5 describes diagnostic tests and diagnoses to consider from ANA pattern.
**Homogeneous pattern** (diffuse)  
Associated with  
SLE  
MCTD

**Outline pattern** (peripheral)  
Associated with  
SLE

**Speckled pattern**  
Associated with  
SLE  
Scleroderma  
Rheumatoid arthritis  
MCTD  
Sjögren’s syndrome  
Polymyositis

**Nucleolar pattern**  
Associated with  
Scleroderma  
Polymyositis

**FIGURE 1-5.** Patterns of immunofluorescent staining of antinuclear antibodies and the diseases with which they are associated.

**ANTIPHOSPHOLIPID ANTIBODY; see LUPUS ANTICOAGULANT**

**ANTI-RNP ANTIBODY; see EXTRACTABLE NUCLEAR ANTIGEN**

**ANTI–SCL-70**

*Normal:* absent.  
*Elevated in:* scleroderma.

**ANTI–SM (ANTI-SMITH) ANTIBODY; see EXTRACTABLE NUCLEAR ANTIGEN**

**ANTI–SMOOTH MUSCLE ANTIBODY; see SMOOTH MUSCLE ANTIBODY**

**ANTISTREPTOLYSIN O TITER (Streptozyme, ASO, ASLO Titer)**

*Normal range for adults:* <160 Todd units.  
*Elevated in:* streptococcal upper airway infection, acute rheumatic fever, AGN, increased levels of β-lipoprotein (false-positive ASLO test result).
**ANTITHROMBIN III**

**Normal range:** 81%-120% of nl activity; 17-30 mg/dL.

**Decreased in:** hereditary deficiency of antithrombin III, DIC, PE, cirrhosis, thrombolytic Rx, chronic liver failure, postsurgery, third trimester of pregnancy, oral contraceptives, nephrotic syndrome, IV heparin >3 days, sepsis, acute leukemia, carcinoma, thrombophlebitis.

**Elevated in:** warfarin Rx, post-MI.

**APOLIPOPROTEIN A-1 (Apo A-1)**

**Normal:** familial hyperalphalipoproteinemia, statins, niacin, estrogens, weight loss, familial cholesteryl ester transfer protein (CETP) deficiency.

**Decreased in:** familial hypoalphalipoproteinemia, Tangier disease, diuretics, androgens, cigarette smoking, hepatocellular disorders, chronic renal failure, nephritic syndrome, coronary heart disease, cholestasis.

**APOLIPOPROTEIN B (Apo B)**

**Normal:** desirable <100 mg/dL; high risk >120 mg/dL.

**Elevated in:** high-saturated fat diet, high-cholesterol diet, hyperapobetalipoproteinemia, familial combined hyperlipidemia, anabolic steroids, diuretics, β-blockers, corticosteroids, progestins, diabetes, hypothyroidism, chronic renal failure, liver disease, Cushing’s syndrome, coronary heart disease.

**Decreased in:** statins, niacin, low-cholesterol diet, malnutrition, abetalipoproteinemia, hypobetalipoproteinemia, hyperthyroidism.

**ARTERIAL BLOOD GASES (ABGs)**

**Normal range:**
- Po₂: 75-100 mm Hg
- PcO₂: 35-45 mm Hg
- HCO₃⁻: 24-28 mEq/L
- pH: 7.35-7.45

**Abnormal values:** Refer to individual acid-base disturbances in Section 3.

**ASLO TITER; see ANTISTREPTOLYSIN O TITER**

**ASPARTATE AMINOTRANSFERASE (AST, SGOT)**

**Normal range:** 0-35 U/L.

**Elevated in:** liver disease (hepatitis, hemochromatosis, cirrhosis, Reye’s syndrome, Wilson’s disease), EtOH abuse, drugs (acetaminophen, statins, NSAIDs, ACEIs, hepatic, labetalol, phenytoin, amiodarone, chlorpromazine), hepatic congestion, infectious mononucleosis, MI, myocarditis, severe muscle trauma, dermatomyositis and polymyositis, muscular dystrophy, malignant neoplasia, renal and pulmonary infarction, convulsions, eclampsia.

**Decreased in:** uremia, vitamin B₆ deficiency.

**BASOPHIL COUNT**

**Normal range:** 0.4%-1% of total WBCs: 40-100/mm³.

**Elevated in:** inflammatory processes, leukemia, PV, Hodgkin’s lymphoma, hemolytic anemia, after splenectomy, myeloid metaplasia, myxedema.

**Decreased in:** stress, hypersensitivity reaction, steroids, pregnancy, hyperthyroidism.

**BICARBONATE**

**Normal:** 21-28 mEq/L (arterial); 22-29 mEq/L (venous).

**Elevated in:** metabolic alkalosis, compensated respiratory acidosis, diuretics, corticosteroids, laxative abuse.

**Note:** A fourfold increase in titer between acute and convalescent specimens is diagnostic of streptococcal upper airway infection regardless of the initial titer.
**Chapter 1  Surviving the Wards**

**Decreased in:** metabolic acidosis, compensated respiratory alkalosis; acetazolamide, cyclosporine, cholestyramine, methanol or ethylene glycol poisoning.

**BLOOD VOLUME, TOTAL**

<table>
<thead>
<tr>
<th>Normal</th>
<th>Elevated in</th>
</tr>
</thead>
<tbody>
<tr>
<td>60-80 mL/kg</td>
<td>anemia, hemorrhage, vomiting, diarrhea, dehydration, burns, starvation.</td>
</tr>
</tbody>
</table>

**BLOOD VOLUME, TOTAL**

<table>
<thead>
<tr>
<th>Normal</th>
<th>Elevated in</th>
</tr>
</thead>
<tbody>
<tr>
<td>60-80 mL/kg</td>
<td>P vera, pulmonary disease, CHF, renal insufficiency, pregnancy, acidosis, thyrotoxicosis.</td>
</tr>
</tbody>
</table>

**BILIRUBIN, DIRECT (Conjugated Bilirubin)**

<table>
<thead>
<tr>
<th>Normal range</th>
<th>Elevated in</th>
</tr>
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<tbody>
<tr>
<td>0-0.2 mg/dL</td>
<td>hepatocellular disease, biliary obstruction, drug-induced cholestasis, hereditary disorders (Dubin-Johnson syndrome, Rotor’s syndrome), advanced neoplastic states.</td>
</tr>
</tbody>
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**BILIRUBIN, INDIRECT (Unconjugated Bilirubin)**

<table>
<thead>
<tr>
<th>Normal range</th>
<th>Elevated in</th>
</tr>
</thead>
<tbody>
<tr>
<td>0-1.0 mg/dL</td>
<td>hemolysis, liver disease (hepatitis, cirrhosis, neoplasm), hepatic congestion caused by CHF, hereditary disorders (Gilbert’s disease, Crigler-Najjar syndrome).</td>
</tr>
</tbody>
</table>

**BILIRUBIN, TOTAL**

<table>
<thead>
<tr>
<th>Normal range</th>
<th>Elevated in</th>
</tr>
</thead>
<tbody>
<tr>
<td>0-1.0 mg/dL</td>
<td>liver disease (hepatitis, cirrhosis, cholangitis, neoplasm, biliary obstruction, infectious mononucleosis), hereditary disorders (Gilbert’s disease, Dubin-Johnson syndrome), drugs (steroids, diphenylhydantoin, phenothiazines, PCN, erythromycin, clindamycin, captopril, amphotericin B, sulfonamides, azathioprine, isoniazid, 5-aminosalicylic acid, allopurinol, methyldopa, indomethacin, halothane, oral contraceptives, procainamide, tolbutamide, labetalol), hemolysis, pulmonary embolism or infarct, hepatic congestion resulting from CHF.</td>
</tr>
</tbody>
</table>

**BLEEDING TIME (Modified Ivy Method)**

<table>
<thead>
<tr>
<th>Normal range</th>
<th>Elevated in</th>
</tr>
</thead>
<tbody>
<tr>
<td>2-9.5 minutes</td>
<td>thrombocytopenia, capillary wall abnormalities, platelet abnormalities (Bernard-Soulier disease, Glanzmann’s disease), drugs (ASA, warfarin, anti-inflammatory medications, streptokinase, urokinase, dextran, β-lactam abx, moxalactam), DIC, cirrhosis, uremia, myeloproliferative disorders, vWD.</td>
</tr>
</tbody>
</table>

**Comments:** The bleeding time test as a method to evaluate suspected hemostatic incompetence has been replaced in many laboratories by platelet function analysis (PFA-100 assay). The bleeding time test’s ability to predict excessive bleeding in clinical situations, such as surgery or invasive diagnostic procedures, is poor. It may play a limited residual role in the evaluation of suspected hereditary disorders of hemostasis.

**BILIRUBIN, URINE; see URINE BILE**

**BILE, URINE; see URINE BILE**

**BILE ACID BREATH TEST**

<table>
<thead>
<tr>
<th>Normal</th>
<th>Elevated in</th>
</tr>
</thead>
<tbody>
<tr>
<td>The test determines the radioactivity of $^{14}$CO$_2$ in breath samples at 2 and 4 hours.</td>
<td>GI bacterial overgrowth, cimetidine.</td>
</tr>
<tr>
<td>2 hours after dose: 0.11 ± 0.14</td>
<td></td>
</tr>
<tr>
<td>4 hours after dose: 0.52 ± 0.09</td>
<td></td>
</tr>
</tbody>
</table>

**BILIRUBIN, URINE; see URINE BILE**
BNP; see B-TYPE NATRIURETIC PEPTIDE

BRCA-1, BRCA-2
This test involves the detection of carriers of mutations in the genes characterized by predisposition to breast and ovarian cancers. These mutations occur in about 1 in 300 to 500 women in the general population and in about 2% of Ashkenazi Jewish women. Women found to carry the mutation should undergo earlier and more intensive surveillance for breast cancer. Pre-test counseling should be provided before genetic testing. The U.S. Preventive Services Task Force recommends screening in the following:
1. Non-Ashkenazi women:
   a. Two first-degree relatives w/breast or ovarian cancer (including one diagnosed ≤50 years of age).
   b. Three or more first- or second-degree relatives w/breast cancer.
   c. Both breast cancer and ovarian cancer among first- and second-degree relatives.
   d. A first-degree relative w/bilateral breast cancer.
   e. Two or more first- or second-degree relatives w/ovarian cancer.
   f. A first- or second-degree relative w/both breast and ovarian cancer.
   g. A male relative w/breast cancer.
2. Ashkenazi women:
   a. Any first-degree relative w/breast or ovarian cancer.
   b. Two second-degree relatives on the same side of the family w/breast or ovarian cancer.

BREATHE HYDROGEN TEST
Normal: This test is for bacterial overgrowth H₂ excretion; fasting: 4.6 ± 5.1; after lactulose: early increase <12. Lactulose usually results in a colonic response >30 minutes after ingestion.
Elevated in: A high fasting breath H₂ level and an increase of at least 12 ppm within 30 minutes after lactulose challenge are indicative of bacterial overgrowth in the small intestine. The increase must precede the colonic response.
Fast positives in: accelerated gastric emptying, laxative use.
Fast negatives in: use of abx and pts who are non–hydrogen producers.

B-TYPE NATRIURETIC PEPTIDE (BNP)
Normal range: up to 100 µg/L. Natriuretic peptides are secreted to regulate fluid volume, BP, and electrolyte balance. They have activity in the central and peripheral nervous system. In humans, the main source of circulatory BNP is the heart ventricles.
Elevated in: heart failure. This test is useful in the emergency department setting to differentiate heart failure pts from those w/COPD presenting w/dyspnea. Levels are also increased in asymptomatic left ventricular dysfunction, arterial and pulmonary HTN, cardiac hypertrophy, valvular heart disease, arrhythmia, and ACS.

BUN; see UREA NITROGEN
C3; see COMPLEMENT C3
C4; see COMPLEMENT C4

CALCITONIN (Serum)
Normal range: <100 pg/mL.
Elevated in: medullary carcinoma of the thyroid (particularly if level >1500 pg/mL), carcinoma of the breast, apudomas, carcinoids, renal failure, thyroiditis.

CALCIUM (Serum)
Normal range: 8.8-10.3 mg/dL.
Abnormal values: Refer to Section 3.
CALCIUM, URINE; see URINE CALCIUM

CAPTOPRIL STIMULATION TEST
Normal: The test is performed by giving 25 mg captopril PO after an overnight fast. The patient should be seated during the test. After captopril, aldosterone <15 ng/dL, renin >2 ng angiotensin I/mL/hr.
Interpretation: In pts w/primary aldosteronism, plasma aldosterone remains high and PRA remains low after captopril.

CARBON DIOXIDE, PARTIAL PRESSURE
Normal: 35-48 mm Hg (males); 32-45 mm Hg (females).
Elevated in: respiratory acidosis.
Decreased in: respiratory alkalosis.

CARBON MONOXIDE; see CARBOXYHEMOGLOBIN

CARBOXYHEMOGLOBIN
Normal range: saturation of Hgb <2%; smokers <9% (coma, 50%; death, 80%).
Elevated in: smoking, exposure to smoking, exposure to automobile exhaust fumes, malfunctioning gas-burning appliances.

CARCINOEMBRYONIC ANTIGEN (CEA)
Normal range: 0-2.5 ng/mL (nonsmokers); 0-5 ng/mL (smokers).
Elevated in: colorectal carcinomas, pancreatic carcinomas, and metastatic disease usually produce higher elevations (>20 ng/mL); carcinomas of the esophagus, stomach, small intestine, liver, breast, ovary, lung, and thyroid usually produce lesser elevations; benign conditions (smoking, IBD, hypothyroidism, cirrhosis, pancreatitis, infections) usually produce levels <10 ng/mL.

CARDIAC TROTONINS; see TROTONINS

CARDIO CRP; see C-REACTIVE PROTEIN

CAROTENE (Serum)
Normal range: 50-250 µg/dL.
Elevated in: carotenemia, chronic nephritis, DM, hypothyroidism, nephrotic syndrome, hyperlipidemia.
Decreased in: fat malabsorption, steatorrhea, pancreatic insufficiency, lack of carotenoids in diet, high fever, liver disease.

CATECHOLAMINES, URINE; see URINE CATECHOLAMINES

CBC; see COMPLETE BLOOD COUNT

CD4+ T-LYMPHOCYTE COUNT (CD4+ T Cells)
Calculated as total WBC x % lymphocytes x % lymphocytes stained w/CD4.
This test is used primarily to evaluate immune dysfunction in HIV infection and should be done every 3 to 6 months in all HIV-infected persons. It is useful as a prognostic indicator and as a criterion for initiation of prophylaxis for several opportunistic infections that are sequelae of HIV infection. Progressive depletion of CD4+ T lymphocytes is associated w↑ likelihood of clinical complications. Adolescents and adults w/HIV infection are classified as having AIDS if their CD4+ lymphocyte count is below 200/µL or if their CD4+ T-lymphocyte percentage is <14%. HIV-infected pts whose CD4+ count is <200/µL and who acquire certain infectious diseases or malignant neoplasms are also classified as having AIDS. Corticosteroids ↓ CD4+ T-cell percentage and absolute number.

CD40 LIGAND
Normal: <5 µg/L. CD40 ligand is a soluble protein that is shed from activated leukocytes and platelets and used in risk stratification for ACS.
Elevated in: ACS. Increased CD40 ligand is associated w/higher incidence of death or nonfatal MI.
CEA; see CARCINOEMBRYONIC ANTIGEN

CERULOPLASMIN (Serum)

Normal range: 20-35 mg/dL.
Elevated in: pregnancy, estrogens, oral contraceptives, neoplastic diseases (leukemias, Hodgkin’s lymphoma, carcinomas), inflammatory states, SLE, PBC, RA.
Decreased in: Wilson’s disease (values often <10 mg/dL), nephrotic syndrome, advanced liver disease, malabsorption, TPN, Menkes’ syndrome.

CHLAMYDIA GROUP ANTIBODY SEROLOGIC TEST

Test description: Acute and convalescent serum samples are drawn 2 to 4 weeks apart. A fourfold increase in titer between acute and convalescent sera is necessary for confirmation. A single titer ≥1:64 is considered indicative of psittacosis or lymphogranuloma venereum.

CHLORIDE (Serum)

Normal range: 95-105 mEq/L.
Elevated in: dehydration, sodium loss > chloride loss, respiratory alkalosis, excessive infusion of NS solution, cystic fibrosis, hyperparathyroidism, renal tubular disease, metabolic acidosis, prolonged diarrhea, acetazolamide administration, diabetes insipidus, ureterosigmoidostomy.
Decreased in: vomiting, gastric suction, primary aldosteronism, CHF, SIADH, Addison’s disease, salt-losing nephritis, continuous infusion of D5W, thiazide diuretic administration, diaphoresis, diarrhea, burns, DKA.

CHLORIDE, SWEAT; see URINE CHLORIDE

CHOLESTEROL, LOW-DENSITY LIPOPROTEIN; see LOW-DENSITY LIPOPROTEIN CHOLESTEROL

CHOLESTEROL, HIGH-DENSITY LIPOPROTEIN; see HIGH-DENSITY LIPOPROTEIN CHOLESTEROL

CHOLESTEROL, TOTAL

Normal range: Generally <200 mg/dL.
Elevated in: primary hypercholesterolemia, biliary obstruction, DM, nephrotic syndrome, hypothyroidism, PBC, diet high in cholesterol and total and saturated fat, third trimester of pregnancy, drugs (steroids, phenothiazines, oral contraceptives).
Decreased in: use of lipid-lowering agents (statins, niacin, ezetimibe, cholestyramine, colesve-lam); starvation, malabsorption, abetalipoproteinemia, hyperthyroidism; hepatic failure, carcinoma, infection, inflammation.

CHORIONIC GONADOTROPINS, HUMAN (Serum)

Normal range, serum: <0.8 IU/L (female, premenopausal); <3.3 IU/L (female, postmenopausal); <0.7 IU/L (male).
Elevated in: pregnancy, choriocarcinoma, gestational trophoblastic neoplasia (including molar gestations), placent al site trophoblastic tumors; human antimouse antibodies (HAMA) can produce false serum assay for hCG.

The principal use of this test is to diagnose pregnancy. The concentration of hCG increases significantly during the initial 6 weeks of pregnancy. Peak values approaching 100,000 IU/L occur 60 to 70 days after implantation.
hCG levels generally double every 1 to 3 days. In pts w/concentration <2000 IU/L, an increase of serum hCG <66% after 2 days is suggestive of spontaneous abortion or ruptured ectopic gestation.

**CHYMOTRYPSIN**

**Normal:** <10 mcg/L.

**Elevated in:** acute pancreatitis, chronic renal failure, oral enzyme preparations, gastric cancer, pancreatic cancer.

**Decreased in:** chronic pancreatitis, late cystic fibrosis.

**CIRCULATING ANTICOAGULANT (Antiphospholipid Antibody, Lupus Anticoagulant)**

**Normal:** negative.

**Detected in:** SLE, drug-induced lupus, long-term phenothiazine Rx, MM, UC, RA, post partum, hemophilia, neoplasms, chronic inflammatory states, AIDS, nephrotic syndrome.

**Note:** The name is a misnomer because these pts are prone to hypercoagulability and thrombosis.

**CK; see CREATINE KINASE**

**CLONIDINE SUPPRESSION TEST**

**Interpretation:** Clonidine inhibits neurogenic catecholamine release and will cause a decrease in plasma norepinephrine into the reference interval in hypertensive subjects w/o pheochromocytoma. The test is performed by giving 4.3 µg clonidine/kg PO after an overnight fast. Norepinephrine is measured at 3 hours. The result should be within established reference range and decrease to <50% of baseline concentration. Lack of decrease in norepinephrine is suggestive of pheochromocytoma.

**CLOSTRIDIUM DIFFICILE TOXIN ASSAY (Stool)**

**Normal:** negative.

**Detected in:** abx-associated diarrhea and pseudomembranous colitis.

**CO; see CARBOXYHEMOGLOBIN**

**COAGULATION FACTORS**

**Factor reference ranges:**

- V: >10%
- VII: >10%
- VIII: 50%-170%
- IX: 60%-136%
- X: >10%
- XI: 50%-150%
- XII: >30%

**Figure 1-6** illustrates the blood coagulation pathways.

**COLD AGGLUTININS TITER**

**Normal range:** <1:32.

**Elevated in:** primary atypical pneumonia (*Mycoplasma* pneumonia), infectious mononucleosis, CMV infection, others (hepatic cirrhosis, acquired hemolytic anemia, frostbite, MM, lymphoma, malaria).

**COMPLEMENT (C3, C4)**

**Normal range:**

- C3: 70-160 mg/dL
- C4: 20-40 mg/dL

**Abnormal values:**

- Decreased C3: active SLE, immune complex disease, AGN, inborn C3 deficiency, membranoproliferative GN, infective endocarditis, serum sickness, autoimmune-type chronic active hepatitis.
- Decreased C4: immune complex disease, active SLE, infective endocarditis, inborn C4 deficiency, hereditary angioedema, hypergammaglobulinemic states, cryoglobulinemic vasculitis.
FIGURE 1-6. Coagulation cascade. Fibrin clot formation results from the generation of thrombin, which is dependent on the sequential interaction of proenzymes and activated coagulation factors in the intrinsic, extrinsic, and common pathways of coagulation. FDP, fibrin degradation product; HMW, high molecular weight; PL, phospholipid; TF, tissue factor; TPA, tissue plasminogen activator.

**COMPLETE BLOOD COUNT**

**WBCC**: 3200-9800/mm³
**RBCs**: 4.3-5.9 10⁹/mm³ (male); 3.5-5.0 10⁹/mm³ (female)
**Hgb**: 13.6-17.7 g/dL (male); 12-15 g/dL (female)
**Hct**: 39%-49% (male); 33%-43% (female)
**MCV**: 76-100 µm³
**MCH**: 27-33 pg
**MCHC**: 33-37 g/dL
**RDW**: 11.5%-14.5%
**Platelet count**: 130-400 × 10⁹/mm³
**Diff**: 2-6 bands (early mature neutrophils); 60-70 segs (mature neutrophils); 1-4 eosinophils; 0-1 basophils; 2-8 monocytes; 25-40 lymphocytes

**CONJUGATED BILIRUBIN**: see **BILIRUBIN, DIRECT**

**COOMBS, DIRECT (Antiglobulin Test, Direct, DAT)**

**Normal**: negative.
**Positive**: AIHA, erythroblastosis fetalis, transfusion reactions, drugs (methyldopa, PCNs, tetracycline, sulfonamides, levodopa, cephalosporins, quinidine, insulin).
**False positive**: may be seen w/cold agglutinins.

**COOMBS, INDIRECT**

**Normal**: negative.
**Positive**: acquired hemolytic anemia, incompatible crossmatched blood, anti-Rh antibodies, drugs (methyldopa, mefenamic acid, levodopa).

**COPPER (Serum)**

**Normal range**: 70-140 µg/dL.
**Decreased in**: Wilson’s disease, malabsorption, malnutrition, nephrosis, TPN, acute leukemia in remission.
**Elevated in**: aplastic anemia, biliary cirrhosis, SLE, hemochromatosis, hyperthyroidism, hypothyroidism, infection, iron deficiency anemia, leukemia, lymphoma, oral contraceptives, pernicious anemia, RA.
CORTICOTROPIN-RELEASING HORMONE (CRH) STIMULATION TEST

Normal: A dose of 0.5 mg of dexamethasone is given every 6 hours for 2 days; 2 hours after the last dose, 1 µg/kg CRH is given IV. Samples are drawn after 15 minutes. There is normally a twofold to fourfold increase in mean baseline concentration of ACTH or cortisol. Cortisol >1.4 µg/L is virtually 100% specific and 100% diagnostic.

Normal or exaggerated response: pituitary Cushing’s disease.

No response: ectopic ACTH-secreting tumor.

A positive response to CRH or a suppressed response to high-dose dexamethasone has a 97% positive predictive value for Cushing’s disease. However, a lack of response to either test excludes Cushing’s disease in only 64% to 78% of patients. When the tests are considered together, negative responses from both have a 100% predictive value for ectopic ACTH secretion.

CORTISOL (Plasma)

Normal range: varies w/time of collection (circadian variation):
- 8 AM: 4-19 µg/dL
- 4 PM: 2-15 µg/dL

Elevated in: ectopic ACTH production (i.e., oat cell carcinoma of lung), loss of nl diurnal variation, pregnancy, chronic renal failure, iatrogenic, stress, adrenal or pituitary hyperplasia or adenomas.

Decreased in: primary adrenocortical insufficiency, anterior pituitary hypofunction, secondary adrenocortical insufficiency, adrenogenital syndromes.

C-PEPTIDE

Normal range (serum): 0.51-2.70 ng/mL.

Elevated in: insulinoma, sulfonylurea administration, type 2 DM, renal failure.

Decreased in: type 1 DM, factitious insulin administration.

CPK; see CREATINE KINASE

C-REACTIVE PROTEIN (CRP)

Normal range: <1 mg/dL. CRP levels are valuable in the clinical assessment of chronic inflammatory disorders such as RA, SLE, vasculitis syndromes, and IBD.

Elevated in: inflammatory and neoplastic diseases, MI, third trimester of pregnancy (acute-phase reactant), oral contraceptives. Moderately high CRP concentrations (3-10 mg/L) predict increased risk of MI and stroke. Markedly high levels (>10 mg/L) have been shown to predict CV risk.

Note: high-sensitivity C-reactive protein (hs-CRP, Cardio CRP) is used as a cardiac risk marker. It is ↑ in pts w/silent atherosclerosis for a prolonged period before a CV event and is independent of cholesterol level and other lipoproteins. It can be used to help stratify cardiac risk.

Interpretation of results: Table 1-8.

<table>
<thead>
<tr>
<th>TABLE 1-8</th>
<th>C-Reactive Protein: Interpretation of Results</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cardio</td>
<td>CRP Level (mg/L)</td>
</tr>
<tr>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>&lt;0.6</td>
</tr>
<tr>
<td></td>
<td>0.7-1.1</td>
</tr>
<tr>
<td></td>
<td>1.2-1.9</td>
</tr>
<tr>
<td></td>
<td>2.0-3.8</td>
</tr>
<tr>
<td></td>
<td>3.9-4.9</td>
</tr>
<tr>
<td></td>
<td>&gt;5.0</td>
</tr>
</tbody>
</table>

Chapter 1  Surviving the Wards
CREATINE KINASE (CK, CPK)

**Normal range**: 0-130 U/L.

**Elevated in**: vigorous exercise, IM injections, MI, myocarditis, rhabdo, myositis, crush injury or trauma, polymyositis, dermatomyositis, muscular dystrophy, myxedema, seizures, malignant hyperthermia syndrome, CVA, pulmonary embolism and infarction, acute dissection of aorta.

**Decreased in**: steroids, decreased muscle mass, connective tissue disorders, alcoholic liver disease, metastatic neoplasms.

CREATINE KINASE ISOENZYMES

**CK-MB**

**Elevated in**: MI, myocarditis, pericarditis, muscular dystrophy, cardiac defibrillation, cardiac surgery, extensive rhabdo, strenuous exercise (e.g., marathon runners), MCTD, cardiomyopathy, hypothermia.

**Note**: CK-MB exists in the blood in two subforms. MB2 is released from cardiac cells and converted in the blood to MB1. Rapid assay of CK-MB subforms can detect MI (CK-MB2 ≥ 1.0 U/L, w/a ratio of CK-MB2/CK-MB1 ≥ 1.5) within the first 6 hours of onset of sx.

**CK-MM**

**Elevated in**: crush injury, seizures, malignant hyperthermia syndrome, rhabdo, myositis, polymyositis, dermatomyositis, vigorous exercise, muscular dystrophy, IM injections, acute dissection of aorta.

**CK-BB**

**Elevated in**: CVA, subarachnoid hemorrhage, neoplasms (prostate, GI tract, brain, ovary, breast, lung), severe shock, bowel infarction, hypothermia, meningitis.

CREATININE (Serum)

**Normal range**: 0.6-1.2 mg/dL.

**Elevated in**: renal insufficiency (acute and chronic), decreased renal perfusion (hypotension, dehydration, CHF), rhabdo, administration of contrast dyes, ketonemia, drugs (abx [AGs, cephalosporins], ACEIs [in pts w/RAS], diuretics).

**Falsely elevated in**: DKA, administration of some cephalosporins (e.g., cefoxitin, cephalothin).

**Decreased in**: decreased muscle mass (including amputees and elderly), pregnancy, prolonged debilitation.

CREATININE CLEARANCE

**Normal range**: 75-124 mL/min.

**Elevated in**: pregnancy, exercise.

**Decreased in**: renal insufficiency, drugs (e.g., cimetidine, procainamide, abx, quinidine).

CREATININE, URINE; see URINE CREATININE

CRYOGLOBULINS (Serum)

**Normal range**: not detectable.


CRYPTOSPORIDIUM ANTIGEN BY EIA (Stool)

**Normal range**: not detected.

**Present in**: cryptosporidiosis.

CYSTATIN C

**Normal**: Cystatin C is a cysteine protease inhibitor that is produced at a constant rate by all nucleated cells. It is freely filtered by the glomerulus and reabsorbed (but not secreted) by the renal tubules w/no extrarenal excretion. Its concentration is not affected by diet, muscle mass, or acute inflammation. NI range when measured by particle-enhanced nephelometric immunoassay (PENIA) is <0.28 mg/L.
Elevated in: renal disorders; good predictor of the severity of ATN. Cystatin C ↑ more rapidly than Cr in the early stages of GFR impairment. The cystatin C concentration is an independent risk factor for heart failure in older adults and appears to provide a better measure of risk assessment than the serum Cr concentration.

**CYSTIC FIBROSIS PCR**

**Test description:** The test can be performed on whole blood or tissue. Common mutations in the cystic fibrosis transmembrane regulator (CFTR) gene can be used to detect 75% to 80% of mutant alleles.

**CYTOMEGALOVIRUS BY PCR**

**Test description:** The test can be performed on whole blood, plasma, or tissue. Qualitative PCR is highly sensitive but may not be able to differentiate between latent and active infection.

**D-DIMER**

**Normal range:** <0.5 µg/mL.

**Elevated in:** DVT, PE, high levels of RF, activation of coagulation and fibrinolytic systems from any cause.

D-dimer assay by ELISA assists in the dx of DVT and PE. This test has significant limitations because it can be elevated whenever the coagulation and fibrinolytic systems are activated and can also be falsely elevated w/high RF levels.

**DEHYDROEPIANDROSTERONE SULFATE**

**Normal:**

- Males:
  - Age 19-30: 125-619 µg/dL
  - Age 31-50: 59-452 µg/dL
  - Age 51-60: 20-413 µg/dL
  - Age 61-83: 10-285 µg/dL
- Females:
  - Age 19-30: 29-781 µg/dL
  - Age 31-50: 12-379 µg/dL
  - Postmenopausal: 30-260 µg/dL

**Elevated in:** hirsutism, congenital adrenal hyperplasia, adrenal carcinomas, adrenal adenomas, polycystic ovary syndrome, ectopic ACTH-producing tumors, Cushing’s disease, spironolactone.

**DEOXYCORTICOSTERONE (11-DEOXYCORTICOSTERONE, DOC) (Serum)**

**Normal:** 2-19 ng/dL; nl secretion is dependent on ACTH and is suppressible by dexamethasone.

**Elevated in:** androgenital syndromes due to 17- and 11-hydroxylase deficiencies, pregnancy.

**Decreased in:** preeclampsia.

**DEXAMETHASONE SUPPRESSION TEST, OVERNIGHT**

**Normal:** The test is performed by giving 1 mg dexamethasone PO at 11 PM and measuring serum cortisol at 8 AM on the following morning; nl response is cortisol suppression to <3 µg/dL. If dose of 4 mg dexamethasone is given, cortisol suppression will be to <50% of baseline.

**Interpretation:** Cushing’s syndrome (>10 µg/dL), endogenous depression (half of pts suppress test values >5 µg/dL). Most pts w/pituitary Cushing’s disease demonstrate suppression, whereas pts w/adrenal adenoma, carcinoma, and ectopic ACTH-producing tumors do not.

**DIGOXIN (LANOXIN)**

**Normal therapeutic range:** 0.5-2 ng/mL.

**Elevated in:** impaired renal function, excessive dosing; concomitant use of quinidine, amiodarone, verapamil, fluoxetine, nifedipine.
DIHYDROTESTOSTERONE (Serum, Urine)

Normal:  
- Serum: 30-85 ng/dL (males); 4-22 ng/dL (females)
- Urine, 24-hour: 20-50 µg/day (males); <8 µg/day (females)

Elevated in: hirsutism.
Decreased in: 5α-reductase deficiency, hypogonadism.

DISACCHARIDE ABSORPTION TESTS

Normal: The test is used to diagnose malabsorption due to disaccharide deficiency. It is performed by giving disaccharide PO 1 g/kg BW to a total of 25 g. Blood is drawn at 0, 30, 60, 90, and 120 minutes. NI response is a change in glucose concentration from fasting value >30 mg/dL, inconclusive when ↑ is 20 to 30 mg/dL, abnl when ↑ is <20 mg/dL. The test can also be performed by measuring air at 0, 30, 60, 90, and 120 minutes. NI is H2 >20 ppm above baseline level before a colonic response.

Decreased in: disaccharide deficiency (lactose, fructose, sorbitol), celiac disease, sprue, acute gastroenteritis.

DOC: see DEOXYCORTICOSTERONE

DONATH-LANDSTEINER (D-L) TEST FOR PAROXYSMAL COLD HEMOGLOBINURIA

Normal: no hemolysis.
Interpretation: hemolysis indicates presence of bithermic cold hemolysins or Donath-Landsteiner antibodies (D-L Ab).

DOPAMINE

Normal range: 0-175 pg/mL.
Elevated in: pheochromocytomas, neuroblastomas, stress, vigorous exercise, certain foods (bananas, chocolate, coffee, tea, vanilla).

ELECTROPHORESIS, HEMOGLOBIN; see HEMOGLOBIN ELECTROPHORESIS

ELECTROPHORESIS, PROTEIN; see PROTEIN ELECTROPHORESIS

ENA COMPLEX; see EXTRACTABLE NUCLEAR ANTIGEN

ENDOMYSIAL ANTIBODIES

Normal: not detected.
Present in: celiac disease, dermatitis herpetiformis.

EOSINOPHIL COUNT

Normal range: 1%-4% eosinophils (0-440/mm³).
Elevated in: allergy, parasitic infestations (trichinosis, aspergillosis, hydatidosis), angioneurotic edema, drug reactions, warfarin sensitivity, collagen-vascular diseases, acute hypereosinophilic syndrome, eosinophilic nonallergic rhinitis, myeloproliferative disorders, Hodgkin’s lymphoma, radiation Rx, NHL, L-tryptophan ingestion, urticaria, pernicious anemia, pemphigus, IBD, bronchial asthma.

EPINEPHRINE (Plasma)

Normal range: 0-90 pg/mL.
Elevated in: pheochromocytomas, neuroblastomas, stress, vigorous exercise, certain foods (bananas, chocolate, coffee, tea, vanilla), hypoglycemia.

EPSTEIN-BARR VIRUS SEROLOGY

Normal range:
- IgG anti-VCA <1:10 or negative
- IgM anti-VCA<1:10 or negative
- Anti-EBNA <1.5 or negative
Abnormal:
- IgG anti-VCA >1:10 or positive indicates either current or previous infection.
- IgM anti-VCA >1:10 or positive indicates current or recent infection.
- Anti-EBNA ≥1.5 or positive indicates previous infection.

ERYTHROCYTESEDIMENTATION RATE (ESR) (Westergren)

Normal range: 0-15 mm/hr (male); 0-20 mm/hr (female).

Elevated in: inflammatory states (acute-phase reactant), collagen-vascular diseases, infections, MI, neoplasms, hyperthyroidism, hypothyroidism, rouleaux formation, elderly, pregnancy.

Note: Sedimentation rates >100 mm/hr are strongly associated w/serious underlying disease (collagen-vascular, infection, malignant disease). Some clinicians use ESR as a “sickness index”; high rates encountered w/o obvious reason should be repeated rather than pursuing extensive search for occult disease.

Decreased in: sickle cell disease, polycythemia, corticosteroids, spherocytosis, anisocytosis, hypofibrinogenemia, ↑ serum viscosity, microcytosis.

ERYTHROPOIETIN

Normal: 3.7-16.0 IU/L by radioimmunoassay. Erythropoietin is a glycoprotein secreted by the kidneys that stimulates RBC production by acting on erythroid committed stem cells.

Increased in:
- Extremely high: generally seen in pts w/severe anemia (Hct <25, Hgb <7), such as in cases of aplastic anemia, severe hemolytic anemia, hematologic cancers.
- Very high: pts w/mild to moderate anemia (Hct 25-35, Hgb 7-10).
- High: patient w/mild anemia (e.g., AIDS, myelodysplasia).
- Erythropoietin can be inappropriately elevated in pts w/malignant neoplasms, renal cysts, post–renal transplantation, meningioma, hemangioblastoma, and leiomyoma.

Decreased in: renal failure, PV, autonomic neuropathy.

ESTRADIOL (Serum)

Normal range:
- Female, premenopausal: 30-400 pg/mL (depending on phase of menstrual cycle)
- Female, postmenopausal: 0-30 pg/mL
- Male, adult: 10-50 pg/mL

Decreased in: ovarian failure.

Elevated in: tumors of ovary, testis, adrenal, or nonendocrine sites (rare).

ESTROGENS, TOTAL

Normal:
- Female: 60-200 pg/mL (follicular phase); 160-400 pg/mL (luteal phase); <130 pg/mL (postmenopausal)
- Male: 20-80 pg/mL

Elevated in: ovarian tumor producing estrogens, testicular tumors, tumors or hyperplasia of adrenal cortex, chorioepithelioma.

Decreased in: menopause, primary ovarian failure, hypopituitarism, anorexia nervosa, GnRH deficiency, psychogenic stress.

ETHANOL (Blood)

Normal range: negative (values <10 mg/dL are considered negative). Ethanol is metabolized at 10-25 mg/dL/hr. Levels ≥80 mg/dL are considered evidence of impairment for driving. Fatal blood concentration is considered to be >400 mg/dL, although levels >400 mg/dL may be seen in chronic alcoholics.
EXTRACTABLE NUCLEAR ANTIGEN (ENA Complex, Anti-RNP Antibody, Anti-Sm, Anti-Smith)

Normal: negative.
Present in: SLE, RA, Sjögren’s syndrome, MCTD.

FACTOR V LEIDEN

Test description: PCR test is performed on whole blood or tissue. This single mutation, found in 2% to 8% of the general white population, is the single most common cause of hereditary thrombophilia.

FBS; see GLUCOSE, FASTING

FDP; see FIBRIN DEGRADATION PRODUCT

FECAL FAT, QUALITATIVE; see SUDAN III STAIN

FECAL FAT, QUANTITATIVE (72-Hour Collection)

Normal range: 2-6 g/24 hr.
Elevated in: malabsorption syndrome.

FECAL GLOBIN IMMUNOCHEMICAL TEST

Normal: negative. This test is performed by immunochromatography on a cellulose strip that has been impregnated w/various antibodies. The test uses a small amount of toilet water as the specimen, which is placed onto absorbent pads of card similar to traditional OB card. There is no direct handling of stool. This test is specific for the globin portion of the Hgb molecule that confers lower GI bleeding specificity. It specifically detects blood from lower GI tract; guaiac tests are not lower GI specific. It is more sensitive than the typical hemoccult test (detection limit 50 µg Hgb/g feces versus >500 µg Hgb/g feces for hemoccult). It has no dietary restrictions and gives no false-positive results from plant peroxidases and red meats. It has no medication restrictions. Iron supplements and NSAIDs do not cause false-positive results. Vitamin C does not cause false-negative results.
Positive in: lower GI bleeding.

FERRITIN (Serum)

Normal range: 18-300 ng/mL.
Elevated in: inflammatory states, liver disease (ferritin elevated from necrotic hepatocytes), hyperthyroidism, neoplasms (neuroblastomas, lymphomas, leukemia, breast carcinoma), iron replacement Rx, hemochromatosis, hemosiderosis.
Decreased in: iron deficiency anemia.

FIBRIN DEGRADATION PRODUCT (FDP)

Normal range: <10 µg/mL.
Elevated in: DIC, primary fibrinolysis, PE, severe liver disease.
Note: The presence of RF may cause falsely elevated FDP.

FIBRINOGEN

Normal range: 200-400 mg/dL.
Elevated in: tissue inflammation or damage (acute-phase protein reactant), oral contraceptives, pregnancy, acute infection, MI.
Decreased in: DIC, hereditary afibrinogenemia, liver disease, primary or secondary fibrinolysis, cachexia.

FLUORESCENT TREponemAL ANTIBODY; see FTA-ABS

FOLATE (Folic Acid)

Normal range:
- Plasma: <3.4 ng/mL (low); >5.4 ng/mL (nl)
- RBC: >280 ng/mL
**Chapter 1  Surviving the Wards**

**Decreased in:** folic acid deficiency (inadequate intake, malabsorption), alcoholism, drugs (MTX, trimethoprim, phenytoin, oral contraceptives, sulfasalazine), vitamin B₁₂ deficiency (defective red cell folate absorption), hemolytic anemia.

**Elevated in:** folic acid Rx.

**FOLLICLE-STIMULATING HORMONE (FSH)**

**Normal range:**
- **Female,** adult: <40 IU/L (midcycle); <20 IU/L (non-midcycle); 40-160 IU/L (postmenopausal)
- **Male,** adult: <22 IU/L

**Elevated in:** primary hypogonadism, gonadal failure, alcoholism, Klinefelter’s syndrome, testicular feminization, anorchia, castration.

**Decreased in:** precocious puberty related to adrenal tumors, congenital adrenal hyperplasia. NI FSH in adult nonovulating female is indicative of hypothalamic or pituitary dysfunction.

**FREE T₄; see T₄, FREE**

**FREE THYROXINE INDEX**

**Normal range:** 1.1-4.3.

Serum free T₄ directly measures unbound thyroxine. Free T₄ can be measured by equilibrium dialysis (gold standard of free T₄ assays) or by immunometric techniques (influenced by serum levels of lipids, proteins, and certain drugs). The FTI can also be easily calculated by multiplying T₄ times T₃RU and dividing the result by 100; the FTI corrects for any abnl T₄ values secondary to protein binding: FTI = T₄ × T₃RU/100.

**FSH; see FOLLICLE-STIMULATING HORMONE**

**FTA-ABS (Serum)**

**Normal:** nonreactive.

**Reactive in:** syphilis, other treponemal diseases (yaws, pinta, bejel), SLE, pregnancy.

**FUROSEMIDE STIMULATION TEST**

**Normal:** The test is performed by giving 60 mg furosemide PO after overnight fast. Patient should be on a nl diet w/o medications the week before the test. NI results: renin 1-6 ng angiotensin l/ml/hr.

**Elevated in:** renovascular HTN, Bartter’s syndrome, high-renin essential HTN, pheochromocytoma.

**No response in:** primary aldosteronism, low-renin essential HTN, hyporeninemic hypoaldosteronism.

**GAMMA-GLUTAMYLTRANSFERASE (GGT); see γ-GLUTAMYLTRANSFERASE**

**GASTRIN (Serum)**

**Normal range:** 0-180 pg/mL.

**Elevated in:** Zollinger-Ellison syndrome (gastrinoma), use of PPIs, chronic renal failure, gastric ulcer, chronic atrophic gastritis, pyloric obstruction, malignant neoplasms of the stomach, H₂ blockers, Ca Rx, UC, RA.

**GASTRIN STIMULATION TEST**

**Normal:** Gastrin stimulation test after Ca infusion is performed by giving a Ca infusion (15 mg Ca/kg in 500 mL NS during 4 hours). Serum is drawn in fasting state before infusion and at 1, 2, 3, and 4 hours. NI response is little or no increase over baseline gastrin level.

**Elevated in:** gastrinoma (gastrin >400 pg/mL), duodenal ulcer (gastrin level increase <400 ng/L).

**Decreased in:** pernicious anemia, atrophic gastritis.
**GH; see GROWTH HORMONE**

**GHRH; see GROWTH HORMONE–RELEASING HORMONE**

**GLIADIN ANTIBODIES, IGA AND IGG**

**Normal:** <25 U; equivocal, 20-25 U; positive, >25 U. The test is useful to monitor compliance w/gluten-free diet in pts w/celiac disease.

**Elevated in:** celiac disease w/dietary noncompliance.

**GLOMERULAR BASEMENT MEMBRANE ANTIBODY**

**Normal:** negative.

**Present in:** Goodpasture’s syndrome.

**GLOMERULAR FILTRATION RATE**

**Normal:**
- Age 20-29: 116 mL/min/1.73 m²
- Age 30-39: 107 mL/min/1.73 m²
- Age 40-49: 99 mL/min/1.73 m²
- Age 50-59: 93 mL/min/1.73 m²
- Age 60-69: 85 mL/min/1.73 m²
- Age ≥70: 75 mL/min/1.73 m²

**Decreased in:** renal insufficiency, ↓ renal blood flow.

**GLUCAGON**

**Normal:** 20-100 pg/mL.

**Elevated in:** glucagonoma (900–7800 pg/mL), chronic renal failure, DM, glucocorticoids, insulin, nifedipine, danazol, sympathomimetic amines.

**Decreased in:** hyperlipoproteinemia (types III, IV), β-blockers, secretin.

**GLUCOSE, FASTING (Fasting Blood Sugar, FBS)**

**Normal range:** 60-99 mg/dL.

**Elevated in:** DM, stress, infections, MI, CVA, Cushing’s syndrome, acromegaly, acute pancreatitis, glucagonoma, hemochromatosis, drugs (glucocorticoids, diuretics [thiazides, loop diuretics]), impaired glucose tolerance.

**Decreased in:** prolonged fasting, excessive dose of insulin or hypoglycemic agents, insulinoma.

**GLUCOSE, POSTPRANDIAL**

**Normal range:** <140 mg/dL.

**Elevated in:** DM, impaired glucose tolerance.

**Decreased in:** post–gastrointestinal resection, reactive hypoglycemia, hereditary fructose intolerance, galactosemia, leucine sensitivity.

**GLUCOSE TOLERANCE TEST**

**Normal values above fasting:**
- 30 minutes: 30-60 mg/dL
- 60 minutes: 20-50 mg/dL
- 120 minutes: 5-15 mg/dL
- 180 minutes: fasting level or below

**Abnormal in:** impaired glucose tolerance, DM, Cushing’s syndrome, acromegaly, pheochromocytoma, gestational diabetes.

**GLUCOSE-6-PHOSPHATE DEHYDROGENASE SCREEN (Blood)**

**Normal:** G6PD enzyme activity is detected.

**Abnormal:** If a deficiency is detected, quantitation of G6PD is necessary; a G6PD screen may be falsely interpreted as “normal” after an episode of hemolysis because most G6PD-deficient cells have been destroyed.

**γ-GLUTAMYLTRANSFERASE (GGT)**

**Normal range:** 0-30 U/L.

**Elevated in:** chronic alcoholic liver disease, neoplasms (hepatoma, metastatic disease to the liver, carcinoma of the pancreas), nephrotic syndrome, sepsis, cholestasis, drugs (phenytoin, barbiturates).
GLYCOHEMOGLOBIN (HbA1c, Glycated Hemoglobin, Glycosylated Hemoglobin)

**Normal range:** 4.0%-6.0% (Table 1-9).

**Elevated in:** uncontrolled DM (glycated Hgb levels reflect the level of glucose control during the preceding 120 days), lead toxicity, alcoholism, iron deficiency anemia, hypertriglyceridemia.

**Decreased in:** hemolytic anemias, decreased RBC survival, pregnancy, acute or chronic blood loss, chronic renal failure, insulinoma, congenital spherocytosis: HbS, HbC, HbD diseases.

<table>
<thead>
<tr>
<th>Table 1-9</th>
<th>Glycohemoglobin Levels</th>
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<tbody>
<tr>
<td>HbA1c</td>
<td>Estimated Average Glucose (mg/dL)</td>
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<tr>
<td>5</td>
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<td>12</td>
<td>298</td>
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</table>

**GROWTH HORMONE (GH)**

**Normal:** 1-9 ng/mL (male); 1-16 ng/mL (female).

**Elevated in:** pituitary gigantism, acromegaly, ectopic GH secretion, cirrhosis, renal failure, anorexia nervosa, stress, exercise, prolonged fasting, amphetamines, β-blockers, insulin, levodopa, metoclopramide, clonidine, vasopressin.

**Decreased in:** hypopituitarism, pituitary dwarfism, adrenocortical hyperfunction, bromocriptine, corticosteroids, glucose.

**GROWTH HORMONE–RELEASING HORMONE (GHRH)**

**Normal:** <50 pg/mL.

**Elevated in:** acromegaly caused by GHRH secretion by neoplasms.

**GROWTH HORMONE SUPPRESSION TEST (After Glucose)**

**Normal:** The test is done by giving 1.75 g glucose/kg PO after overnight fast. Blood is drawn at baseline and after 60 minutes and after 120 minutes of glucose load. Normal response is GH suppression to <2 ng/mL or undetectable levels.

**Abnormal:** There is no or incomplete suppression from the high basal level in gigantism or acromegaly.

**HAPTOGLOBIN (Serum)**

**Normal range:** 50-220 mg/dL.

**Elevated in:** inflammation (acute-phase reactant), collagen-vascular diseases, infections (acute-phase reactant), drugs (androgens), obstructive liver disease.

**Decreased in:** hemolysis (intravascular more than extravascular), megaloblastic anemia, severe liver disease, large tissue hematomas, infectious mononucleosis, drugs (oral contraceptives).

**HDL;** see HIGH-DENSITY LIPOPROTEIN CHOLESTEROL

**HELICOBACTER PYLORI (Serology, Stool Antigen)**

**Normal range:** not detected.

**Detected in:** H. pylori infection. Positive serology can indicate current or past infection. Positive stool antigen test result indicates acute infection (sensitivity and specificity >90%). Stool testing should be delayed at least 2 weeks after eradication Rx.
HEMATOCRIT
Normal range: 39%-49% (male); 33%-43% (female).
Elevated in: PV, smoking, COPD, high altitudes, dehydration, hypovolemia.
Decreased in: blood loss (GI, GU), anemia, pregnancy.

HEMOGLOBIN
Normal range: 13.6-17.7 g/dL (male); 12.0-15.0 g/dL (female).
Elevated in: hemoconcentration, dehydration, PV, COPD, high altitudes, false elevations (hyperlipemic plasma, WBCs >50,000 mm³), stress.
Decreased in: hemorrhage (GI, GU), anemia.

HEMOGLOBIN ELECTROPHORESIS
Normal range:
- HbA₁: 95%-98%
- HbA₂: 1.5%-3.5%
- HbF: <2%
- HbC: absent
- HbS: absent

HEMOGLOBIN, URINE; see URINE HEMOGLOBIN

HEMOSIDERIN, URINE; see URINE HEMOSIDERIN

HEPARIN-INDUCED THROMBOCYTOPENIA ANTIBODIES
Normal: antigen assay: negative, <0.45; weak, 0.45-1.0; strong, >1.0.
Elevated in: HIT.

HEPATITIS A ANTIBODY
Normal: negative.
Present in: viral hepatitis A; can be IgM or IgG (if IgM, acute hepatitis A; if IgG, previous infection w/hepatitis A).

HEPATITIS B ANTIGEN AND ANTIBODY
Normal: negative. These tests are ordered together and should be used only in pts who are chronically HBsAg positive. The main utility of these tests is to assess response of hepatitis B infection to Rx.
Present in: Presence of HBeAg implies that infective HBV is present in serum. However, its absence on conversion to anti-HBe does not r/o infectivity, especially in persons infected w/genotypes other than A. Measurement of HBV DNA is useful in persons w/↑ ALT but negative HBeAg.

HEPATITIS B CORE ANTIBODY
Normal: negative.
Present in: hepatitis B. Anti-HBc assay is the first Ab test to become positive w/exposure to HBV and persists the longest after resolution of acute infection.

HEPATITIS B DNA
Normal: negative.
Present in: active hepatitis B infection. It implies infectivity of the serum. Currently used to assess response of hepatitis B to Rx.

HEPATITIS B SURFACE ANTIBODY
Normal: negative.
Present in: post-vaccination for hepatitis B (a level >10 U/L for post-vaccine testing is the accepted concentration that indicates protection), post-infection w/hepatitis B (it generally appears several weeks after disappearance of HBsAg).

HEPATITIS B SURFACE ANTIGEN (HBsAG)
Normal: not detected.
Detected in: acute viral hepatitis type B, chronic hepatitis B.
HEPATITIS C ANTIBODY (Anti-HCV)

**Normal:** negative.

**Present in:** hepatitis C. CDC guidelines recommend confirmation w/RIBA before reporting of anti-HCV as positive. HCV RNA can also be obtained if there is a high clinical suspicion of HCV despite a negative anti-HVC, especially in immunosuppressed individuals or in the setting of acute hepatitis. Anti-HCV and the RIBA often do not become positive during an acute infection; thus, repeated testing several months later is required if HCV RNA is negative.

HEPATITIS C RNA

**Normal:** negative.

**Elevated in:** hepatitis C. Detection of hepatitis C RNA is used to confirm current infection and to monitor treatment. Quantitative assays (viral load) are needed before treatment to assess response (<2 log ↓ after 12-week treatment indicates lack of response).

HEPATITIS DELTA ANTIGEN AND ANTIBODY

**Normal:** negative.

**Elevated in:** hepatitis delta. Hepatitis delta is a replication-defective RNA virus that requires the surface coat of hepatitis B (HBsAg) to become an infectious virus. Testing for hepatitis delta is therefore done only in pts positive for HBsAg. It is useful in pts w/chronic hepatitis B if there is an exacerbation of stable hepatitis.

HER-2/neu

**Normal:** negative.

**Present in:** 25%-30% of primary breast cancers. It can also be found in other epithelial tumors, including lung, hepatocellular, pancreatic, colon, stomach, ovarian, cervical, and bladder cancer. Trastuzumab (Herceptin) is a humanized monoclonal Ab against Her-2/neu. The test is useful to identify pts w/metastatic, recurrent, or treatment-refractory unresectable locally advanced breast cancer for trastuzumab treatment.

HETEROPHILE ANTIBODY

**Normal:** negative.

**Positive in:** infectious mononucleosis.

HFE SCREEN FOR HEREDITARY HEMOCROMATOSIS

**Test description:** PCR test can be performed on whole blood or tissue. One mutation (C282Y) and two polymorphisms (H63D, S65C) account for the majority of alleles associated w/this disease.

HIGH-DENSITY LIPOPROTEIN (HDL) CHOLESTEROL

**Normal range:** 45-70 mg/dL (male); 50-90 mg/dL (female).

**Increased in:** use of fenofibrate, gemfibrozil, nicotinic acid, estrogens, regular aerobic exercise, mild to moderate (1-oz) daily EtOH intake.

**Decreased in:** familial deficiency of apoproteins, liver disease, probucol ingestion, sedentary lifestyle, acute MI, CVA, starvation.

**Note:** A cholesterol/HDL ratio ≥4.5 is associated w/↑ risk of CAD.

HOMOCYSTEINE (Plasma)

**Normal range:**

- 0-30 years: 4.6-8.1 µmol/L
- 30-59 years: 6.3-11.2 µmol/L (males); 4.5-7.9 µmol/L (females)
- >59 years: 5.8-11.9 µmol/L

**Increased in:** thrombophilic states; B6, B12, folic acid, riboflavin deficiency; pregnancy; homocystinuria.

**Note:** An increased homocysteine level is an independent risk factor for atherosclerosis.
hs-CRP; see C-REACTIVE PROTEIN

HUMAN IMMUNODEFICIENCY VIRUS ANTIBODY, TYPE 1 (HIV-1)

Normal range: not detected.
Abnormal result: HIV antibodies usually appear in the blood 1 to 4 months after infection.

Testing sequence:
1. ELISA is the recommended initial screening test. Sensitivity and specificity are >99%. False-positive ELISA results may occur w/ autoimmune disorders, administration of immune globulin manufactured before 1985 within 6 weeks of testing, presence of RF, presence of DLA-DR antibodies in multigravida woman, administration of influenza vaccine within 3 months of testing, hemodialysis, positive plasma reagin test response, and certain medical disorders (hemophilia, hypergammaglobulinemia, alcoholic hepatitis).
2. A positive ELISA result is confirmed w/Western blot. False-positive Western blot may be caused by connective tissue disorders, human leukocyte antigen antibodies, polyclonal gammopathies, hyperbilirubinemia, presence of Ab to another human retrovirus, cross-reaction w/other non–virus-derived proteins in healthy persons. Undetermined Western blot may occur in AIDS pts w/advanced immunodeficiency (from loss of antibodies) and in recent HIV infections.
3. PCR is used to confirm indeterminate Western blot results or negative results in persons w/suspected HIV infection.

5-HYDROXYINDOLEACETIC ACID, URINE; see URINE 5-HYDROXYINDOLEACETIC ACID

IMMUNE COMPLEX ASSAY

Normal: negative.
Detected in: collagen-vascular disorders, GN, neoplastic diseases, malaria, PBC, chronic acute hepatitis, bacterial endocarditis, vasculitis.

IMMUNOGLOBULINS

Normal range:
- IgA: 50-350 mg/dL
- IgD: <6 mg/dL
- IgE: <25 µg/dL
- IgG: 800-1500 mg/dL
- IgM: 45-150 mg/dL

Elevated in:
- IgA: lymphoproliferative disorders, Berger’s nephropathy, chronic infections, autoimmune disorders, liver disease.
- IgE: allergic disorders, parasitic infections, immunologic disorders, IgE myeloma, AIDS, pemphigoid.
- IgG: chronic granulomatous infections, infectious diseases, inflammation, myeloma, liver disease.
- IgM: PBC, infectious diseases (brucellosis, malaria), Waldenström’s macroglobulinemia, liver disease.

Decreased in:
- IgA: nephrotic syndrome, protein-losing enteropathy, congenital deficiency, lymphocytic leukemia, ataxia-telangiectasia, chronic sinopulmonary disease.
- IgE: hypogammaglobulinemia, neoplasm (breast, bronchial, cervical), ataxia-telangiectasia.
- IgG: congenital or acquired deficiency, lymphocytic leukemia, phenytoin, methylprednisolone, nephrotic syndrome, protein-losing enteropathy.
- IgM: congenital deficiency, lymphocytic leukemia, nephrotic syndrome.
Chapter 1  Surviving the Wards

INR; see INTERNATIONAL NORMALIZED RATIO

INSULIN AUTOANTIBODIES

Normal: negative.
Present in: exogenous insulin from insulin Rx. The presence of islet cell antibodies indicates ongoing beta cell destruction. This test is useful in the early dx of type 1A DM and in the identification of pts at high risk for type 1A diabetes.

INSULIN, FREE

Normal: <17 μU/mL.
 Elevated in: insulin OD, insulin resistance syndromes, endogenous hyperinsulinemia.
 Decreased in: inadequately treated type 1 DM.

INSULIN-LIKE GROWTH FACTOR 1 (IGF-1) (Serum)

Normal range:
- Age 16-24: 182-780 ng/mL
- Age 25-39: 114-492 ng/mL
- Age 40-54: 90-360 ng/mL
- Age >55: 71-290 ng/mL
 Elevated in: adolescence, acromegaly, pregnancy, precocious puberty, obesity.
 Decreased in: malnutrition, delayed puberty, DM, hypopituitarism, cirrhosis, old age.

INSULIN-LIKE GROWTH FACTOR 2

Normal: 288-736 ng/mL.
 Elevated in: hypoglycemia associated w/non–islet cell tumors, hepatoma, and Wilms’ tumor.
 Decreased in: GH deficiency.

INTERNATIONAL NORMALIZED RATIO (INR)

The INR is a comparative rating of PT ratios. The INR represents the observed PT ratio adjusted by the International Reference Sensitivity Index. INR = PT patient/PT mean. The INR provides a universal result indicative of what the patient’s PT result would have been if measured by use of the primary World Health Organization International Reference reagent. For proper interpretation of INR values, the patient should be on stable anticoagulant Rx. NI range of INR is 0.8-1.2

Recommended INR ranges: Table 1-10.

<table>
<thead>
<tr>
<th>Disorder</th>
<th>INR Range</th>
</tr>
</thead>
<tbody>
<tr>
<td>Proximal deep venous thrombosis</td>
<td>2-3</td>
</tr>
<tr>
<td>Pulmonary embolism</td>
<td>2-3</td>
</tr>
<tr>
<td>Transient ischemic attacks</td>
<td>2-3</td>
</tr>
<tr>
<td>Atrial fibrillation</td>
<td>2-3</td>
</tr>
<tr>
<td>Mechanical prosthetic valves</td>
<td>3-4.5</td>
</tr>
<tr>
<td>Recurrent venous thromboembolic disease</td>
<td>3-4.5</td>
</tr>
</tbody>
</table>

TABLE 1-10  Recommended INR Ranges
INTRINSIC FACTOR ANTIBODIES

Normal: negative.
Present in: pernicious anemia (>50% of pts). Cyanocobalamin may give false-positive results.

IRON (Serum)

Normal: 65-175 µg/dL (male); 50-1170 µg/dL (female).
Elevated in: hemochromatosis, excessive iron Rx, repeated transfusions, lead poisoning, hemolytic anemia, aplastic anemia, pernicious anemia.
Decreased in: iron deficiency anemia, hypothyroidism, chronic infection.

IRON-BINDING CAPACITY (TIBC)

Normal range: 250-460 µg/dL.
Elevated in: iron deficiency anemia, pregnancy, polycythemia, hepatitis, weight loss.
Decreased in: anemia of chronic disease, hemochromatosis, chronic liver disease, hemolytic anemias, malnutrition (protein depletion).

IRON SATURATION (% Transferrin Saturation)

Normal: 20%-50% (male); 15%-50% (female).
Elevated in: hemochromatosis, excessive iron intake, aplastic anemia, thalassemia, vitamin B₉ deficiency.
Decreased in: hypochromic anemias, GI malignant disease.

LACTATE (Blood)

Normal range: 0.5-2.0 mEq/L.
Elevated in: tissue hypoxia (shock, respiratory failure, severe CHF, severe anemia, CO or cyanide poisoning), systemic disorders (liver or renal failure, seizures), abnl intestinal flora (l-lactic acidosis), drugs or toxins (salicylates, ethanol, methanol, ethylene glycol), G6PD deficiency.

LACTATE DEHYDROGENASE (LDH)

Normal range: 50-150 U/L.
Elevated in: infarction of myocardium, lung, kidney; diseases of cardiopulmonary system, liver, collagen, CNS; hemolytic anemias; megaloblastic anemias; transfusions; seizures; muscle trauma; muscular dystrophy; acute pancreatitis; hypotension; shock; infectious mononucleosis; inflammation; neoplasia; intestinal obstruction; hypothyroidism.

LACTATE DEHYDROGENASE ISOENZYMES

Normal range:
- LDH₁: 22%-36% (cardiac, RBCs)
- LDH₂: 35%-46% (cardiac, RBCs)
- LDH₃: 13%-26% (pulmonary)
- LDH₄: 3%-10% (striated muscle, liver)
- LDH₅: 2%-9% (striated muscle, liver)

Normal range:
- LDH₁ < LDH₂
- LDH₃ < LDH₄

Abnormal values:
- LDH₁ > LDH₂: MI (can also be seen w/hemolytic anemias, pernicious anemia, folate deficiency, renal infarct)
- LDH₅ > LDH₄: liver disease (cirrhosis, hepatitis, hepatic congestion)

LACTOSE TOLERANCE TEST (Serum)

Normal: The test is performed by giving 2 g/kg BW lactose PO and drawing glucose level at 0, 30, 45, 60, and 90 minutes. NI response is change in glucose from fasting value to >30 mg/dL. Inconclusive response is ↑ of 20 to 30 mg/dL; abnl response is ↑ <20 mg/dL.

Abnormal in: lactase deficiency.
**LANOXIN**; see **DIGOXIN**

**LAP SCORE**; see **LEUKOCYTE ALKALINE PHOSPHATASE**

**LDH**; see **LACTATE DEHYDROGENASE**

**LDL**; see **LOW-DENSITY LIPOPROTEIN CHOLESTEROL**

**LEAD**

Normal: <10 µg/dL (child); <25 µg/dL (adult); <50 µg/dL (acceptable for industrial exposure).

Elevated in: lead exposure, lead poisoning.

**LEGIONELLA TITER**

Normal: negative.

Positive in: Legionnaire’s disease (presumptive, ≥1:256 titer; definitive, fourfold titer increase to ≥1:128).

**LEUKOCYTE ALKALINE PHOSPHATASE (LAP)**

Normal range: 13-100.

Elevated in: leukemoid reactions, neutrophilia resulting from infections (except in sickle cell crisis—no significant increase in LAP score), Hodgkin’s disease, PV, hairy cell leukemia, aplastic anemia, Down syndrome, myelofibrosis.

Decreased in: acute and chronic granulocytic leukemia, thrombocytopenic purpura, PNH, hypophosphatemia, collagen disorders.

**LH**; see **LUTEINIZING HORMONE**

**LIPASE**

Normal range: 0-160 U/L.

Elevated in: acute pancreatitis, perforated peptic ulcer, carcinoma of pancreas (early stage), pancreatic duct obstruction, bowel infarction, intestinal obstruction.

**LIPOPROTEIN(a)**

Normal: 1.35-19.6 mg/dL (male); 1.24-20.1 mg/dL (female).

Elevated in: CAD, uncontrolled diabetes, hypothyroidism, chronic renal failure, pregnancy, tobacco use, infections, nephritic syndrome.

Decreased in: niacin, omega-3 fatty acids, estrogens, tamoxifen.

**LIPOPROTEIN CHOLESTEROL, LOW DENSITY**; see **LOW-DENSITY LIPOPROTEIN CHOLESTEROL**

**LIPOPROTEIN CHOLESTEROL, HIGH DENSITY**; see **HIGH-DENSITY LIPOPROTEIN CHOLESTEROL**

**LIVER-KIDNEY MICROSOME TYPE 1 ANTIBODIES (LKM1)**

Normal: <20 U.

Elevated in: autoimmune hepatitis type 2.

**LOW-DENSITY LIPOPROTEIN (LDL) CHOLESTEROL**

Normal range: <130 mg/dL (<70 mg/dL in diabetics and pts w/CV risk factors).

Elevated in: diet high in saturated fat, familial hyperlipidemia, sedentary lifestyle, poorly controlled DM, nephritic syndrome, hypothyroidism.

Decreased in: use of lipid-lowering agents (statins, niacin, ezetimibe, cholestyramine, colesevelam), starvation, malabsorption, abetalipoproteinemia, hyperthyroidism, hepatic failure, carcinoma, infection, inflammation.

**LUPUS ANTICOAGULANT (LA) TEST**

Normal: negative.

Present in: antiphospholipid Ab syndrome. False-positive results may occur w/oral anticoagulant Rx, factor deficiency, specific factor inhibitors.
**LUTEINIZING HORMONE (LH) (Blood)**

**Normal range:**
- Female, adult: 1.0-18.0 IU/L (follicular phase); 20.0-80.0 IU/L (midcycle phase); 0.5-18.0 IU/L (luteal phase); postmenopausal: 12.0-55.0 IU/L
- Male, adult: 1.0-9.0 IU/L

**Elevated in:** gonadal failure, anorchia, menopause, testicular feminization syndrome.

**Decreased in:** primary pituitary or hypothalamic failure.

**LYMPHOCYTES**

**Normal range:** 15%-40%.
- Total lymphocyte count: 800-2600/mm³
- Total T lymphocytes: 800-2200/mm³
- CD4 lymphocytes: ≥400/mm³
- CD8 lymphocytes: 200-800/mm³
- Normal CD4/CD8 ratio is 2.0.

**Elevated in:** chronic infections, infectious mononucleosis and other viral infections, CLL, Hodgkin’s disease, UC, hypoadrenalism, ITP.

**Decreased in:** HIV infection, bone marrow suppression from chemotherapeutic agents or chemotherapy, aplastic anemia, neoplasms, steroids, adrenocortical hyperfunction, neurologic disorders (MS, myasthenia gravis, GBS).

CD4 lymphocytes are calculated as total WBCs × % lymphocytes × % lymphocytes stained w/CD4. They are decreased in AIDS and other forms of immune dysfunction.

**MAGNESIUM (Serum)**

**Normal range:** 1.8-3.0 mg/dL.

**Abnormal:** Refer to hypomagnesemia and hypermagnesemia in Section 3.

**MEAN CORPUSCULAR VOLUME (MCV)**

**Normal range:** 76-100 µm³.

**Elevated in:** EtOH abuse, reticulocytosis, vitamin B₁₂ deficiency, folic acid deficiency, liver disease, hypothyroidism, marrow aplasia, myelofibrosis.

**Decreased in:** Iron deficiency, anemia of chronic disease, thalassemia trait or syndrome, other hemoglobinopathies, sideroblastic anemia, chronic renal failure, lead poisoning.

**METANEPHRINES, URINE; see URINE METANEPHRINES**

**METHYLMALONIC ACID (Serum)**

**Normal:** <0.2 µmol/L.

**Elevated in:** vitamin B₁₂ deficiency, pregnancy, methylmalonic acidemia.

**MITOCHONDRIAL ANTIBODY (AMA Antimitochondrial Antibody)**

**Normal:** negative.

**Present in:** PBC (>90% of pts).

**MONOCYTE COUNT**

**Normal range:** 2%-8%.

**Elevated in:** viral diseases, parasites, infections, neoplasms, IBD, monocytic leukemia, lymphomas, myeloma, sarcoidosis.

**Decreased in:** viral syndrome, glucocorticoid administration, aplastic anemia, lymphocytic leukemia.

**MYCOPLASMA PNEUMONIAE PCR**

**Test description:** PCR can be performed on sputum, BAL fluid, nasopharyngeal and throat swabs, other respiratory fluids, and lung tissue.

**MYELIN BASIC PROTEIN (Cerebrospinal Fluid)**

**Normal:** <2.5 ng/mL.

**Elevated in:** MS, CNS trauma, stroke, encephalitis.
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MYOGLOBIN, URINE; see URINE MYOGLOBIN

NATRIURETIC PEPTIDE; see B-TYPE NATRIURETIC PEPTIDE

NEUTROPHIL COUNT
Normal range: 50%-70%.
Subsets:
- Bands (early mature neutrophils): 2%-6%
- Segs (mature neutrophils): 60%-70%
Decreased in: viral infections, aplastic anemias, immunosuppressive drugs, radiation Rx to bone marrow, agranulocytosis, drugs (abx, antithyroidals), lymphocytic and mononuclear leukemias.

NOREPINEPHRINE
Normal range: 0-600 pg/mL.
Elevated in: pheochromocytomas, neuroblastomas, stress, vigorous exercise, certain foods (bananas, chocolate, coffee, tea, vanilla).

5’-NUCLEOTIDASE
Normal range: 2-16 IU/L.
Elevated in: biliary obstruction, metastatic neoplasms to liver, PBC, renal failure, pancreatic carcinoma, chronic active hepatitis.

OSMOLALITY, SERUM
Normal range: 280-300 mOsm/kg. It can also be estimated by the following formula: 2([Na] + [K]) + Glucose/18 + BUN/2.8.
Elevated in: dehydration, hypernatremia, diabetes insipidus, uremia, hyperglycemia, mannitol Rx, ingestion of toxins (ethylene glycol, methanol, ethanol), hypercalcaemia, diuretics.
Decreased in: SIADH, hyponatremia, overhydration, Addison’s disease, hypothyroidism.

OSMOLALITY, URINE; see URINE OSMOLALITY

OSMOTIC FRAGILITY TEST
Normal: Hemolysis begins at 0.50, w/v [5.0 g/L] and is complete at 0.30, w/v [3.0 g/L] NaCl.
Elevated in: hereditary spherocytosis, hereditary stomatocytosis, spheroctosis associated with acquired immune hemolytic anemia.
Decreased in: iron deficiency anemia, thalassemias, liver disease, leptocytosis associated with asplenia.

PARATHYROID HORMONE
Normal: 10-65 pg/mL (serum, intact molecule); 1.0-5.0 pmol/L (plasma).
Elevated in: hyperparathyroidism (primary or secondary), pseudohypoparathyroidism, anticonvulsants, corticosteroids, lithium, isoniazid, rifampin, phosphates, Zollinger-Ellison syndrome, hereditary vitamin D deficiency.
Decreased in: hypoparathyroidism, sarcoidosis, cimetidine, beta-blockers, hyperthyroidism, hypomagnesemia.

PARIETAL CELL ANTIBODIES
Normal: negative.
Present in: pernicious anemia (>90%), atrophic gastritis (up to 50%), thyroiditis (30%), Addison’s disease, myasthenia gravis, Sjögren’s syndrome, type 1 DM.
PARTIAL THROMBOPLASTIN TIME (PTT), ACTIVATED PARTIAL THROMBOPLASTIN TIME (APTT)

**Normal range:** 25-41 seconds.

**Elevated in:** heparin Rx, coagulation factor deficiency (I, II, V, VIII, IX, X, XI, XII), liver disease, vitamin K deficiency, DIC, circulating anticoagulant, warfarin Rx, specific factor inhibition (PCN reaction, RA), thrombolytic Rx, nephrotic syndrome.

**Note:** useful to evaluate the intrinsic coagulation system.

PEPSINOGEN I

**Normal:** 124-142 ng/mL.

**Elevated in:** Zollinger-Ellison syndrome, duodenal ulcer, acute gastritis.

**Decreased in:** atrophic gastritis, gastric carcinoma, myxedema, pernicious anemia, Addison’s disease.

PFA: see PLATELET FUNCTION ANALYSIS (PFA-100 ASSAY)

pH, BLOOD

**Normal values:** 7.35-7.45 (arterial); 7.32-7.42 (venous).

**Abnormal values:** Refer to arterial blood gases.

pH, URINE; see URINE pH

PHOSPHATASE, ACID; see ACID PHOSPHATASE

PHOSPHATASE, ALKALINE; see ALKALINE PHOSPHATASE

PHOSPHATE (Serum)

**Normal range:** 2.5-5 mg/dL

**Elevated in:** Refer to hyperphosphatemia and hypophosphatemia in Section 3.

PLASMINOGEN

**Normal:** Immunoassay (antigen), <20mg/dL.

**Elevated in:** infection, trauma, neoplasm, MI (acute-phase reactant), pregnancy, bilirubinemia.

**Decreased in:** DIC, severe liver disease, thrombolytic Rx w/streptokinase or urokinase, alteplase.

PLATELET AGGREGATION

**Normal:** full aggregation (generally >60%) in response to epinephrine, thrombin, ristocetin, ADP, collagen.

**Elevated in:** heparin, hemolysis, lipemia, nicotine; hereditary and acquired disorders of platelet adhesion, activation, and aggregation.

**Decreased in:** ASA, some PCNs, chloroquine, chlorpromazine, clofibrate, captopril, Glanzmann’s thrombasthenia, Bernard-Soulier syndrome, Wiskott-Aldrich syndrome, cyclooxygenase deficiency. In vWD, there is nl aggregation w/ADP, collagen, and epinephrine but abnl agglutination w/ristocetin.

PLATELET ANTIBODIES

**Normal:** absent.

**Present in:** ITP (>90% of pts w/chronic ITP). Pts w/nonimmune thrombocytopenias may have false-positive results.

PLATELET COUNT

**Normal range:** 130-400 x 10^5/mm^3.

**Elevated in:** iron deficiency, post-hemorrhage, neoplasms (GI tract), CML, PV, myelofibrosis w/myeloid metaplasia, infections, after splenectomy, post partum, hemophilia, pancreatitis, cirrhosis.

**Decreased:** See thrombocytopenia in Section 3.
PLATELET FUNCTION ANALYSIS (PFA-100 ASSAY)

Normal: This test is a two-component assay in which blood is aspirated through two capillary tubes, one of which is coated w/collagen and ADP (COL/ADP) and the other w/collagen and epinephrine (COL/EPI). The test measures the ability of platelets to occlude an aperture in a biologically active membrane treated with COL/ADP and COL/EPI. During the test, the platelets adhere to the surface of the tube and cause blood flow to cease. The closing time refers to the cessation of blood flow and is reported in conjunction w/the Hct and platelet count. Hct count must be >25% and platelet count >50 K/μL for the test to be performed.

- COL/ADP: 70-120 seconds
- COL/EPI: 75-120 seconds

Elevated in: acquired platelet dysfunction, vWD, anemia, thrombocytopenia, use of ASA and NSAIDs.

POTASSIUM (Serum)

Normal range: 3.5-5 mEq/L.

Elevated or decreased: See hypokalemia and hyperkalemia in Section 3.

POTASSIUM, URINE; see URINE POTASSIUM

PROGESTERONE (Serum)

Normal:
- Female: 15-70 ng/dL (follicular phase); 200-2500 ng/dL (luteal phase)
- Male: 15-70 ng/dL

Elevated in: congenital adrenal hyperplasia, clomiphene, corticosterone, 11-deoxycortisol, dihydroprogesterone, molar pregnancy, lipid ovarian tumor.

Decreased in: primary or secondary hypogonadism, oral contraceptives, ampicillin, threatened abortion.

PROLACTIN

Normal range: <20 ng/mL.

Elevated in: prolactinomas (level >200 highly suggestive), drugs (phenothiazines, cimetidine, tricyclic antidepressants, metoclopramide, estrogens, antihypertensives [methylodopa, verapamil], haloperidol), post partum, stress, hypoglycemia, hypothyroidism.

PROSTATE-SPECIFIC ANTIGEN (PSA)

Normal range: 0-4 ng/mL. There is no PSA level below which prostate cancer can be ruled out and no level above which prostate cancer is certain. The individual’s PSA level is only part of the equation. Other risk factors need to be considered, such as age, race, FHx, findings on digital rectal examination, percentage free PSA ratio, and PSA velocity (rate of change from prior PSA measurement).


Note: Measurement of free PSA is useful to assess the probability of prostate cancer in pts w/nl findings on digital rectal examination and total PSA level between 4 and 10 ng/mL. In these pts, the global risk of prostate cancer is 25% to 40%. However, if the free PSA is >25%, the risk of prostate cancer decreases to 8%; whereas if the free PSA is <10%, the risk of cancer increases to 56%. Free PSA is also useful to evaluate the aggressiveness of prostate cancer. A low free PSA percentage generally indicates a high-grade cancer, whereas a high free PSA percentage is generally associated w/a slower growing tumor.

Elevated in: finasteride, dutasteride, bed rest, antiandrogens.

PROSTATIC ACID PHOSPHATASE

Normal: 0-0.8 U/L.

Elevated in: prostate cancer (especially in metastatic prostate cancer), BPH, prostatitis, after prostate surgery or manipulation, hemolysis, androgens, clofibrate.

Decreased in: ketoconazole Rx.
**PROTEIN (Serum)**

**Normal range:** 6-8 g/dL.

**Elevated in:** dehydration, sarcoidosis, collagen-vascular diseases, MM, Waldenström’s macroglobulinemia.

**Decreased in:** malnutrition, cirrhosis, nephrosis, low-protein diet, overhydration, malabsorption, pregnancy, severe burns, neoplasms, chronic diseases.

**PROTEIN C ASSAY**

**Normal:** 70%-140%.

**Elevated in:** oral contraceptives, stanozol.

**Decreased in:** congenital protein C deficiency, warfarin Rx, vitamin K deficiency, renal insufficiency, consumptive coagulopathies.

**PROTEIN ELECTROPHORESIS (Serum)**

**Normal range:**
- Alb: 60%-75%; 3.6-5.2 g/dL
- Alpha1: 1.7%-5%; 0.1-0.4 g/dL
- Alpha2: 6.7%-12.5%; 0.4-1.0 g/dL
- Beta: 8.3%-16.3%; 0.5-1.2 g/dL
- Gamma: 10.7%-20%; 0.6-1.6 g/dL

**Elevated in:**
- Alb: dehydration
- Alpha1: neoplastic diseases, inflammation
- Alpha2: neoplasms, inflammation, infection, nephrotic syndrome
- Beta: hypothyroidism, biliary cirrhosis, DM
- Gamma: see immunoglobulins

**Decreased in:**
- Alb: malnutrition, chronic liver disease, malabsorption, nephrotic syndrome, burns, SLE
- Alpha1: emphysema (alpha1-antitrypsin deficiency), nephrosis
- Alpha2: hemolytic anemias (decreased haptoglobin), severe hepatocellular damage
- Beta: hypocholesterolemia, nephrosis
- Gamma: see immunoglobulins

**PROTEIN S ASSAY**

**Normal:** 65%-140%.

**Elevated in:** presence of lupus anticoagulant.

**Decreased in:** hereditary deficiency, acute thrombotic events, DIC, surgery, oral contraceptives, pregnancy, hormone replacement Rx, L-asparaginase treatment.

**PROTHROMBIN TIME (PT)**

**Normal range:** 11-13.2 seconds.

**Note:** The PT is reported as absolute clotting time in seconds and also as a derivative number called the INR. This ratio is derived from the actual PT of the patient divided by the mean PT of a group of healthy subjects. INR should always be used in interpreting PT.

**Elevated in:** liver disease, oral anticoagulants (warfarin), heparin, factor deficiency (I, II, V, VII, X), DIC, vitamin K deficiency, afibrinogenemia, dysfibrinogenemia, drugs (salicylate, chloral hydrate, diphenylhydantoin, estrogens, antacids, phenylbutazone, quinidine, abx, allopurinol, anabolic steroids).

**Decreased in:** vitamin K supplementation, thrombophlebitis, drugs (glutethimide, estrogens, griseofulvin, diphenhydramine).

**PROTOPORPHYRIN (Free Erythrocyte)**

**Normal range:** 16-36 µg/dL of RBCs.

**Elevated in:** iron deficiency, lead poisoning, sideroblastic anemias, anemia of chronic disease, hemolytic anemias, erythropoietic protoporphyrin.
**PSA; see PROSTATE-SPECIFIC ANTIGEN**

**PT; see PROTHROMBIN TIME**

**PTT; see PARTIAL THROMBOPLASTIN TIME**

**RDW; see RED BLOOD CELL DISTRIBUTION WIDTH**

### RED BLOOD CELL COUNT

**Normal range:** 4.3–5.9 × 10⁶/mm³ (male); 3.5-5.0 × 10⁶/mm³ (female).

**Elevated in:** hemoconcentration and dehydration, stress, PV, smokers, high altitude, CV disease, renal cell carcinoma and other erythropoietin-producing neoplasms.

**Decreased in:** anemias, hemolysis, chronic renal failure, hemorrhage, failure of marrow production.

### RED BLOOD CELL DISTRIBUTION WIDTH (RDW)

RDW measures variability of red cell size (anisocytosis).

**Normal range:** 11.5-14.5.

**Normal RDW and:**
- Elevated MCV: aplastic anemia, preleukemia.
- Normal MCV: normal, anemia of chronic disease, acute blood loss or hemolysis, CLL, CML, non-anemic enzymopathy or hemoglobinopathy.
- Decreased MCV: anemia of chronic disease, heterozygous thalassemia.

**Elevated RDW and:**
- Elevated MCV: vitamin B₁₂ deficiency, folate deficiency, immune hemolytic anemia, cold agglutinins, CLL w/high count, liver disease.
- Normal MCV: early iron deficiency, early vitamin B₁₂ deficiency, early folate deficiency, anemic globinopathy.
- Decreased MCV: iron deficiency, RBC fragmentation, HbH disease, thalassemia intermedia.

### RED BLOOD CELL FOLATE; see FOLATE

### RED BLOOD CELL MASS (Volume)

**Normal range:**
- Male: 20–56 mL/kg of BW (1.15-1.21 L/m² BSA)
- Female: 19-31 mL/kg of BW (0.95-1.00 L/m² BSA)

**Elevated in:** P vera, hypoxia (smokers, high altitude, CV disease), hemoglobinopathies w/high oxygen affinity, erythropoietin-producing tumors (renal cell carcinoma).

**Decreased in:** hemorrhage, chronic disease, failure of marrow production, anemias, hemolysis.

### RENIN (Serum)

**Elevated in:** renal HTN, reduced plasma volume, secondary aldosteronism, drugs (thiazides, estrogen, minoxidil), chronic renal failure, Bartter’s syndrome, pregnancy (ni), pheochromocytoma.

**Decreased in:** primary aldosteronism, adrenocortical HTN, increased plasma volume, drugs (propranolol, reserpine, clonidine).

### RETICULOCYTE COUNT

**Normal range:** 0.5%-1.5%.

**Elevated in:** hemolytic anemia (sickle cell crisis, thalassemia major, autoimmune hemolysis), hemorrhage, post–anemia Rx (folic acid, ferrous sulfate, vitamin B₁₂), chronic renal failure.

**Decreased in:** aplastic anemia, marrow suppression (sepsis, chemotherapeutic agents, radiation), hepatic cirrhosis, blood transfusion, anemias of disordered maturation (iron deficiency anemia, megaloblastic anemia, sideroblastic anemia, anemia of chronic disease).
RHEUMATOID FACTOR (RF)

Normal: negative.


RNP; see EXTRACTABLE NUCLEAR ANTIGEN

SEDIMENTATION RATE; see ERYTHROCYTE SEDIMENTATION RATE

SEmen Analysis

Normal:
- Volume: 2-6 mL
- Sperm density: >20 million/mL
- Total number of spermatozoa: >80 million/ejaculate
- Progressive motility score evaluated 2-4 hours after ejaculate: 3-4
- Live spermatozoa: ≥50% of total
- Normal spermatozoa: ≥60% of total
- Immature forms: <4%

Decreased in: cryptorchidism, testicular failure, obstruction of ejaculatory system, post-vasectomy, medications (cimetidine, ketoconazole, nitrofurantoin, cancer chemotherapy agents, sulfasalazine), testicular radiation.

SGOT; see ASPARvATE AMINOTRANSFERASE

SGPT; see ALANINE AMINOTRANSFERASE

SiCKLE CELL TEST

Normal: negative.

Positive in: sickle cell anemia, sickle cell trait; combination of Hgb S gene w/other disorders, such as α-thalassemia, β-thalassemia.

SMOOTH MUSCLE ANTIBODY

Normal: negative.

Present in: chronic active hepatitis (≥1:80), PBC (≥1:80), infectious mononucleosis.

SODIUM (Serum)

Normal range: 135-147 mEq/L.

Elevated or decreased: See hyponatremia and hypernatremia in Section 3.

STREPTOZYME; see ANTISTREPTOlysin O TiTER

SUDAN III STAIN (Qualitative Screening for Fecal Fat)

Normal: negative. The test should be preceded by a diet containing 100 to 150 g of dietary fat/day for 1 week, avoidance of high-fiber diet, and avoidance of suppositories or oily material before specimen collection.

Positive in: steatorrhea, use of castor oil or mineral oil droplets.

T3 (TRiiodoTHYRiONiNE)

Normal range: 75-220 ng/dL.

Abnormal values: See hypothyroidism and hyperthyroidism in Section 3.

T3 RESiN UPTAKE (T3Ru)

Normal range: 25%-35%.

Abnormal values: ↑ in hyperthyroidism. T3 resin uptake (T3RU or RT3U) measures the percentage of free T3 (not bound to protein); it does not measure serum T3 concentration. T3RU and other tests that reflect thyroid hormone binding to plasma protein are also known as thyroid hormone-binding ratios (THBR).
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**T₄, SERUM T₄, AND FREE T₄ (Free Thyroxine)**

**Normal range:** 0.8-2.8 ng/dL.

**Abnormal values:** See hyperthyroidism in Section 3. Serum thyroxine test measures both circulating thyroxine bound to protein (represents >99% of circulating T₄ and unbound [free] thyroxine). Values vary with protein binding; changes in the concentration of T₄ secondary to changes in thyroxine-binding globulin (TBG) can be caused by the following:

- **Increased TBG (↑ T₄):** pregnancy, estrogens, acute infectious hepatitis, oral contraceptives, familial, fluorouracil, clofibrate, heroin, methadone.
- **Decreased TBG (↓ T₄):** androgens, glucocorticoids, nephrotic syndrome, cirrhosis, acromegaly, hypoproteinemia, familial, phenytoin, ASA and other NSAIDs, high-dose PCN, asparaginase, chronic debilitating illness.

To eliminate the suspected influence of protein binding on thyroxine values, two additional tests are available: T₃ resin uptake and serum free thyroxine. Serum free T₄ directly measures unbound thyroxine. Free T₄ can be measured by equilibrium dialysis (gold standard of free T₄ assays) or by immunometric techniques (influenced by serum levels of lipids, proteins, and certain drugs).

The FTI can also be easily calculated by multiplying T₄ times T₃RU and dividing the result by 100; the FTI corrects for any abnl T₄ values secondary to protein binding: FTI = T₄ × T₃RU/100. NI values equal 1.1 to 4.3.

**TESTOSTERONE**

**Normal range:** variable with age and sex.

- Serum/plasma: 280-1000 ng/dL (males); 15-70 ng/dL (females)
- Urine: 50-135 µg/day (males); 2-12 µg/day (females)

**Elevated in:** adrenogenital syndrome, polycystic ovary disease.

**Decreased in:** Klinefelter’s syndrome, male hypogonadism.

**THIAMINE**

**Normal:** 275-675 ng/g.

**Elevated in:** PV, leukemia, Hodgkin’s disease.

**Decreased in:** alcoholism, dietary deficiency (beri-beri), excessive consumption of tea (contains antithiamine factor) or raw fish (contains a microbial thiaminase), chronic illness, prolonged illness, barbiturates.

**THROMBIN TIME (TT)**

**Normal range:** 11.3-18.5 seconds.

**Elevated in:** thrombolytic and heparin Rx, DIC, hypofibrinogenemia, dysfibrinogenemia.

**THYROGLOBULIN**

**Normal:** 3-40 ng/mL. Thyroglobulin is a tumor marker for monitoring the status of pts w/papillary or follicular thyroid cancer after resection.

**Elevated in:** papillary or follicular thyroid cancer, Hashimoto’s thyroiditis, Graves’ disease, subacute thyroiditis.

**THYROID MICROsomAL ANTIBODIES**

**Normal:** undetectable. Low titers may be present in 5% to 10% of nl individuals.

**Elevated in:** Hashimoto’s disease, thyroid carcinoma, early hypothyroidism, pernicious anemia.

**THYROID-STIMULATING HORMONE (TSH)**

**Normal range:** 2-11.0 µU/mL.

**Elevated:** See hypothyroidism in Section 3.

**THYROTROPIN (TSH) RECEPTOR ANTIBODIES**

**Normal:** <130% of basal activity.

**Elevated in:** Values between 1.3 and 2.0 are found in 10% of pts w/thyroid disease other than Graves’ disease. Values >2.8 have been found only in pts w/Graves’ disease.
TIBC; see IRON-BINDING CAPACITY

TISSUE TRANSGLUTAMINASE ANTIBODY

Normal: negative.
Present in: celiac disease (specificity, 94%-97%; sensitivity, 90%-98%), dermatitis herpetiformis.

TRANSFERRIN

Normal range: 170-370 mg/dL.
Elevated in: iron deficiency anemia, oral contraceptive administration, viral hepatitis, late pregnancy.
Decreased in: nephrotic syndrome, liver disease, hereditary deficiency, protein malnutrition, neoplasms, chronic inflammatory states, chronic illness, thalassemia, hemochromatosis, hemolytic anemia.

TRIGLYCERIDES

Normal range: <160 mg/dL.
Elevated in: hyperlipoproteinemias (types I, IIb, III, IV, V), diet high in saturated fats, hypothyroidism, pregnancy, estrogens, pancreatitis, EtOH intake, nephrotic syndrome, poorly controlled DM, sedentary lifestyle, glycogen storage disease.
Decreased in: malnutrition, vigorous exercise, congenital abetalipoproteinemias, drugs (e.g., gemfibrozil, fenofibrate, nicotinic acid, metformin, clofibrate).

TRIIODOTHYRONINE; see T₃

TROTONINS (Serum)

Normal range: 0-0.4 ng/mL (negative). If there is clinical suspicion of evolving acute MI or ischemic episode, repeated testing in 5 to 6 hours is recommended.
Indeterminate: 0.05-0.49 ng/mL. Suggest further tests. In a patient w/unstable angina and this troponin I level, there is an increased risk of a cardiac event in the near future.

Strong probability of acute MI: ≥0.50 ng/mL.
- Cardiac troponin T (cTnT) is a highly sensitive marker for myocardial injury for the first 48 hours after MI and for up to 5 to 7 days. It may also be elevated in renal failure, chronic muscle disease, and trauma.
- Cardiac troponin I (cTnI) is highly sensitive and specific for myocardial injury (≥CK-MB) in the initial 8 hours, peaks within 24 hours, and lasts up to 7 days. With progressively higher levels of cTnI, the risk of mortality increases because the amount of necrosis increases.
Elevated in: In addition to ACS, many diseases such as sepsis, hypovolemia, AF, CHF, PE, myocardial contusion, and renal failure can be associated w/↑ in troponin level.

TSH; see THYROID-STIMULATING HORMONE

TT; see THROMBIN TIME

UNCONJUGATED BILIRUBIN; see BILIRUBIN, INDIRECT

UREA NITROGEN

Normal range: 8-18 mg/dL.
Elevated in: dehydration, renal disease (GN, pyelonephritis, diabetic nephropathy), urain tract obstruction (prostatic hypertrophy), drugs (AGS and other abx, diuretics, lithium, corticosteroids), GI bleeding, decreased renal blood flow (shock, CHF, MI).
Decreased in: liver disease, malnutrition, third trimester of pregnancy.

URIC ACID (Serum)

Normal range: 2-7 mg/dL.
Elevated in: hereditary enzyme deficiency (hypoxanthine-guanine phosphoribosyltransferase), renal failure, gout, excessive cell lysis
(chemotherapeutic agents, radiation Rx, leukemia, lymphoma, hemolytic anemia), acidosis, myeloproliferative disorders, diet high in purines or protein, drugs (diuretics, low doses of ASA, ethambutol, nicotinic acid), lead poisoning, hypothyroidism.

**Decreased in**: drugs (allopurinol, high doses of ASA, probenecid, warfarin, corticosteroid), deficiency of xanthine oxidase, SIADH, renal tubular deficits (Fanconi’s syndrome), alcoholism, liver disease, diet deficient in protein or purines, Wilson’s disease, hemochromatosis.

**URINALYSIS**

**Normal range:**
- Color: light straw
- Appearance: clear
- pH: 4.5-8.0 (average, 6.0)
- Specific gravity: 1.005-1.030
- Protein: absent
- Ketones: absent
- Glucose: absent
- Occult blood: absent
- Microscopic examination:
  - RBC: 0-5 (high-power field)
  - WBC: 0-5 (high-power field)
  - Bacteria (spun specimen): absent
  - Casts: 0-4 hyaline (low-power field)

**URINE AMYLASE**

**Normal range**: 35-260 U Somogyi/hr.

**Elevated in**: pancreatitis, carcinoma of the pancreas.

**URINE BILE**

**Normal**: absent.

**Abnormal**:
- Urine bilirubin: hepatitis (viral, toxic, drug induced), biliary obstruction.
- Urine urobilinogen: hepatitis (viral, toxic, drug induced), hemolytic jaundice, liver cell dysfunction (cirrhosis, infection, mets).

**URINE CALCIUM**

**Normal**: 6.2 mmol/dL (CF, 0.02495; SMI, 0.1 mmol/dL).

**Elevated in**: primary hyperparathyroidism, hypervitaminosis D, bone mets, MM, increased Ca intake, steroids, prolonged immobilization, sarcoidosis, Paget’s disease, idiopathic hypercalciuria, renal tubular acidosis.

**Decreased in**: hypoparathyroidism, pseudohypoparathyroidism, vitamin D deficiency, vitamin D-resistant rickets, diet low in Ca, drugs (thiazide diuretics, oral contraceptives), familial hypocalciuric hypercalcemia, renal osteodystrophy, potassium citrate Rx.

**URINE cAMP**

**Elevated in**: hypercalciuria, familial hypocalciuric hypercalcemia, primary hyperparathyroidism, pseudohypoparathyroidism, rickets.

**Decreased in**: vitamin D intoxication, sarcoidosis.

**URINE CATECHOLAMINES**

**Normal range**: <100 µg/24 hr (norepinephrine); <10 µg/24 hr (epinephrine).

**Elevated in**: pheochromocytoma, neuroblastoma, severe stress.

**URINE CHLORIDE**

**Normal range**: 110-250 mEq/day.

**Elevated in**: corticosteroids, Bartter’s syndrome, diuretics, metabolic acidosis, severe hypokalemia.

**Decreased in**: chloride depletion (vomiting), colonic villous adenoma, chronic renal failure, renal tubular acidosis.
**URINE CREATININE (24-Hour)**

*Normal range:* 0.8-1.8 g/day (male); 0.6-1.6 g/day (female).

*Note:* useful test as an indicator of completeness of 24-hour urine collection.

**URINE CRYSTALS**

- **Uric acid:** acid urine, hyperuricosuria, uric acid nephropathy.
- **Sulfur:** abx containing sulfa.
- **Calcium oxalate:** ethylene glycol poisoning, acid urine, hyperoxaluria.
- **Calcium phosphate:** alkaline urine.
- **Cystine:** cystinuria.

**URINE EOSINOPHILS**

*Normal:* absent.

*Present in:* interstitial nephritis, ATN, UTI, kidney transplant rejection, HRS.

**URINE GLUCOSE (QUALITATIVE)**

*Normal:* absent.

*Present in:* DM, renal glycosuria (decreased renal threshold for glucose), glucose intolerance.

**URINE HEMOGLOBIN, FREE**

*Normal:* absent.

*Present in:* hemolysis (w/saturation of serum haptoglobin binding capacity and renal threshold for tubular absorption of Hgb).

**URINE HEMOSIDERIN**

*Normal:* absent.

*Present in:* PNH, chronic hemolytic anemia, hemochromatosis, blood transfusion, thalassemias.

**URINE 5-HYDROXYINDOLEACETIC ACID (URINE 5-HIAA)**

*Normal range:* 2-8 mg/24 hr.

*Elevated in:* carcinoid tumors, after ingestion of certain foods (bananas, plums, tomatoes, avocados, pineapples, eggplant, walnuts), drugs (MAOIs, phenacetin, methyldopa, glycerol guaiacolate, acetaminophen, salicylates, phenothiazines, imipramine, methocarbamol, reserpine, methamphetamine).

**URINE INDICAN**

*Normal:* absent.

*Present in:* malabsorption resulting from intestinal bacterial overgrowth.

**URINE KETONES (Semiquantitative)**

*Normal:* absent.

*Present in:* DKA, alcoholic ketoacidosis, starvation, isopropanol ingestion.

**URINE METANEPHRINES**

*Normal range:* 0-2.0 mg/24 hr.

*Elevated in:* pheochromocytoma, neuroblastoma, drugs (caffeine, phenothiazines, MAOIs), stress.

**URINE MYOGLOBIN**

*Normal:* absent.

*Present in:* severe trauma, hyperthermia, polymyositis or dermatomyositis, CO poisoning, drugs (narcotic and amphetamine toxicity), hypothyroidism, muscle ischemia.

**URINE NITRITE**

*Normal:* absent.

*Present in:* UTIs.
URINE OCCULT BLOOD
Normal: negative.
Positive in: trauma to urinary tract, renal disease (GN, pyelonephritis),
renal or ureteral calculi, bladder lesions (carcinoma, cystitis), prostatitis,
prostatic carcinoma, menstrual contamination, hematopoietic disorders
(hemophilia, thrombocytopenia), anticoagulants, ASA.
Note: Hematuria w/o erythrocyte casts or significant albuminuria suggests
the possibility of renal or bladder cancers.

URINE OSMOLALITY
Normal range: 50-1200 mOsm/kg.
Elevated in: SIADH, dehydration, glycosuria, adrenal insufficiency,
high-protein diet.
Decreased in: diabetes insipidus, excessive water intake, IV hydration
w/D3W, acute renal insufficiency, GN.

URINE pH
Normal range: 4.6-8.0 (average 6.0).
Elevated in: bacteriuria, vegetarian diet, renal failure w/inability to form
ammonia, drugs (abx, sodium bicarbonate, acetazolamide).
Decreased in: acidosis (metabolic, respiratory), drugs (ammonium chloride,
methenamine mandelate), DM, starvation, diarrhea.

URINE PHOSPHATE
Normal range: 0.8-2.0 g/24 hr.
Elevated in: ATN (diuretic phase), chronic renal disease, uncontrolled DM,
hyperparathyroidism, hypomagnesemia, metabolic acidosis, metabolic
alkalosis, neurofibromatosis, adult-onset vitamin D–resistant
hypophosphatemic osteomalacia.
Decreased in: acromegaly, ARF, decreased dietary intake,
hipparathyroidism, respiratory acidosis.

URINE POTASSIUM
Normal range: 25-100 mEq/24 hr.
Elevated in: aldosteronism (primary, secondary), glucocorticoids, alkalosis,
renal tubular acidosis, excessive dietary K+ intake.
Decreased in: ARF, potassium-sparing diuretics, diarrhea, hypokalemia.

URINE PROTEIN (Quantitative)
Normal range: <150 mg/24 hr.
Elevated in: renal disease (glomerular, tubular, interstitial), CHF, HTN,
eosplasms of renal pelvis and bladder, MM, Waldenström’s
macroglobulinemia.

URINE SODIUM (Quantitative)
Normal range: 40-220 mEq/day.
Elevated in: diuretic administration, high sodium intake, salt-losing
nephritis, ATN, vomiting, Addison’s disease, SIADH, hypothyroidism, CHF,
hepatic failure, chronic renal failure, Bartter’s syndrome, glucocorticoid
deficiency, interstitial nephritis (caused by analgesic abuse, mannitol,
dextran, or glycerol Rx), milk-alkali syndrome, decreased renin secretion,
postobstructive diuresis.
Decreased in: increased aldosterone, glucocorticoid excess, hyponatremia,
prerenal azotemia, decreased salt intake.

URINE SPECIFIC GRAVITY
Normal range: 1.005-1.03.
Elevated in: dehydration, excessive fluid losses (vomiting, diarrhea, fever),
X-ray contrast media, DM, CHF, SIADH, adrenal insufficiency, decreased
fluid intake.
Decreased in: diabetes insipidus, renal disease (GN, pyelonephritis),
excessive fluid intake or IV hydration.
URINE VANILLYLMANDELIC ACID (VMA)

Normal range: <6.8 mg/24 hr.
Elevated in: pheochromocytoma, neuroblastoma, ganglioblastoma, drugs (isoproterenol, methocarbamol, levodopa, sulfonamides, chlorpromazine), severe stress; after ingestion of bananas, chocolate, vanilla, tea, coffee.
Decreased in: drugs (MAOIs, reserpine, guanethidine, methyldopa).

VASOACTIVE INTESTINAL PEPTIDE (VIP)

Normal: <50 pg/mL.
Elevated in: pancreatic VIPomas, neuroblastoma, pancreatic islet cell hyperplasia, liver disease, multiple endocrine neoplasia type I, ganglioneuroma, ganglioneuroblastoma.

VENEREAL DISEASE RESEARCH LABORATORIES (VDRL)

Normal range: negative.
Positive test: syphilis, other treponemal diseases (yaws, pinta, bejel).
Note: A false-positive test result may be seen in pts w/SLE and other autoimmune diseases, infectious mononucleosis, HIV infection, atypical pneumonia, malaria, leprosy, typhus fever, rat-bite fever, and relapsing fever.

VIP; see VASOACTIVE INTESTINAL PEPTIDE

VISCOITY (Serum)

Normal range: 1.4-1.8 relative to water (1.10-1.22 centipoise).
Elevated in: monoclonal gammopathies (Waldenström’s macroglobulinemia, MM), hyperfibrinogenemia, SLE, RA, polycythemia, leukemia.

VITAMIN B₁₂

Normal range: 190-900 ng/mL.
Decreased in: pernicious anemia, dietary (strict lacto-ovo-vegetarians, food faddists), malabsorption (achlorhydria, gastrectomy, ileal resection, Crohn’s disease of terminal ileum, pancreatic insufficiency, drugs [omeprazole and other PPIs, metformin, cholestyramine]), chronic alcoholism, Helicobacter pylori infection.

VITAMIN D, 1,25-DIHYDROXYCHOLECALCIFEROL

Normal: 16-65 pg/mL.
Elevated in: tumor calcinosis, primary hyperparathyroidism, sarcoidosis, tuberculosis, idiopathic hypercalcioria.
Decreased in: Postmenopausal osteoporosis, chronic renal failure, hypoparathyroidism, tumor-induced osteomalacia, rickets, elevated blood lead levels.

VITAMIN K

Normal: 0.10-2.20 ng/mL.
Decreased in: PBC, anticoagulants, abx, cholestyramine, GI disease, pancreatic disease, cystic fibrosis, obstructive jaundice, hypoprothrombinemia, hemorrhagic disease of the newborn.

VON WILLEBRAND FACTOR

Normal: levels vary according to blood type: 50-150 U/dL (blood type O); 90-200 U/dL (blood type non-O).
Decreased in: vWD (however, in type II vWD, the antigen may be nl but the function is impaired).

WBCS; see COMPLETE BLOOD COUNT

WESTERGREN; see ERYTHROCYTESEDIMENTATION RATE

WHITE BLOOD CELL COUNT; see COMPLETE BLOOD COUNT

D-XYLOSE ABSORPTION

Normal range: 21%-31% excreted in 5 hours.
Decreased in: malabsorption syndrome.
D. Diagnostic Tests: The Basics

1. **The Chest X-ray**

   **Figure 1-7** illustrates the location of various pulmonary and cardiac structures seen on a CXR (PA view). The following is a short guide to reading a CXR.

   1. Check exposure technique for lightness or darkness.
   2. Verify left and right by looking at the heart shape and stomach bubble, respectively.
   3. Check for rotation. Does the thoracic spine shadow align in the center of the sternum between the clavicles?
   4. Make sure the x-ray is taken in full inspiration (10 posterior or 6 anterior ribs should be visible).
   5. Is the film a portable, AP, or PA film? (The heart size cannot be accurately judged from an AP film.)
   6. Check the soft tissues for foreign bodies or SC emphysema.
   7. Check all visible bones and joints for osteoporosis, old fxs, metastatic lesions, rib notching, or presence of cervical ribs.
   8. Look at diaphragm for tenting, free air, and position.
   9. Check hilar and mediastinal areas for the following: size and shape of aorta, presence of hilar nodes, prominence of hilar blood vessels, elevation of vessels (left normally slightly higher), elevation of left main stem bronchus indicating left atrial enlargement.
   10. Look at heart for size, shape, calcified valves, and enlarged atria.
   11. Check costophrenic angles for fluid or pleural scarring.
   12. Check pulmonary parenchyma for infiltrates, increased interstitial markings, masses, absence of nl margins, air bronchograms, or increased vascularity and “silhouette” signs.
   13. Look at lateral film for the following: confirmation and position of questionable masses or infiltrates, size of retrosternal air space, AP chest diameter, vertebral bodies for bony lesions or overlying infiltrates, posterior costophrenic angle for small effusion.

2. **The Electrocardiogram**

   1. Determine the **heart rate (HR)**. If the heart rhythm is regular, the HR can be determined by dividing 300 by the number of boxes in the R-R interval (e.g., if R-R interval contains four large boxes, the HR is 75 bpm.
The heart rhythm can also be calculated by use of the following formula: each large square = 0.2 sec; 5 large squares/sec. For specific rate, measure large squares between R waves as follows:

a. \( 1 = 300 \) bpm
b. \( 2 = 150 \) bpm
c. \( 3 = 100 \) bpm
d. \( 4 = 75 \) bpm
e. \( 5 = 60 \) bpm
f. \( 6 = 50 \) bpm

2. Determine the heart rhythm.
   a. Is the rhythm regular?
   b. Are there P waves (Fig. 1-8)?
   c. Is the P wave related to the QRS (i.e., are P waves “married” to the QRS)?
   d. The P wave should always be upright in lead II if there is sinus rhythm (unless there is reversal of leads or dextrocardia). If the rhythm is irregular, the P wave can help w/the dx (e.g., w/sinus arrhythmia, the P waves will be identical; w/wandering pacemaker, the P waves will have different shapes; w/AF, the P waves are not discernible).
3. Evaluate the intervals.
   a. **PR interval**: if is 0.12 to 0.20 sec (for practical purposes, the PR interval is if does not exceed a large box). The PR interval becomes shorter as the rate increases.
   b. **QRS interval** (Fig. 1-9): if is 0.04 to 0.12 sec (for practical purposes, the QRS interval should not be > half a large box). If the QRS is wide, evaluate for BBB.
      i. **LBBB**: The following may be seen:
         (a) Wide slurred R in V6.
         (b) QRS prolonged ≥0.12 sec, lengthened VAT or intrinsicoid deflection.
         (c) AVL similar to V5-6, lead I similar to aVL and V5-6 (w/depression of the ST segments and inversion of the T waves).
ii. **RBBB:**
   (a) QRS ≥0.12 sec.
   (b) Wide slurred S waves in V5-6, rsR’ complexes in V3R and V1, w/absent Q waves.
   (c) VAT prolonged in V1 and V12; a wide S wave in lead I.

3. **QT interval:** the nl QT interval should be < half the R-R interval (if the HR is <100 bpm). Normal is ≤440 msec.

4. Determine the axis deviation: look at the net QRS deflection in leads I and aVF.
   a. Normal axis: net QRS deflection is positive in both leads I and aVF.
   b. RAD: net QRS deflection negative in lead I, positive in lead aVF.
   c. LAD: net QRS deflection positive in lead I, negative in lead aVF.
   d. Indeterminate axis: net QRS deflection negative in leads I and aVF.

5. **Hypertrophy:** look for signs of enlargement of the four chambers.
   a. LVH: the sum of the deepest S in V1 or V6 and the tallest R in V5 or V6 is >35 mm (in pts ≥35 years of age); R in lead aVL ≥12 mm; “strain” pattern.
   b. Left atrial hypertrophy (P mitrale): the P waves are notched (M shaped) in the mitral leads (I, II, or aVL), or there is a deep terminal negative component to the P in lead V1.
   c. Right atrial hypertrophy (P pulmonale): the P waves are prominent (>2.5 mm tall) and peaked in the pulmonary leads (II, III, and aVF).
   d. RVH: findings suggestive of RVH in adults are right atrial enlargement, RAD, incomplete RBBB, low voltage, tall R wave in V1, persistent precordial S waves, right ventricular strain.

6. **Infarct:** look at all leads (except aVR) for:
   a. Q waves: small (nl septal Q waves) are commonly seen in lateral leads (I, aVL, V4, V5, and V6); moderate- or large-sized Q waves may be nl (as an isolated finding) in leads III, aVF, aVL, and V1.
   b. R-wave progression: transition should occur between V2 and V4.
   c. ST segments: concentrate more on shape (i.e., “smiley” or “frowny”) than on the amount of ST-segment deviation.
   d. T waves: may normally be inverted in leads III, aVF, aVL, and V1.

3. **THE PULMONARY ARTERY CATHETER (SWAN-GANZ)**

1. **Figure 1-10** describes pressure waves.
2. **Table 1-11** describes hemodynamic measurements and their clinical significance.

![Figure 1-10. A Swan-Ganz catheter is introduced into a large vein and advanced in the direction of blood flow. Vena cava pressure and RAP are about 0 to 5 mm Hg. Right ventricular pressure is 25/0 mm Hg; pulmonary artery pressure is 25/15 mm Hg. Inflation of the balloon on the catheter allows recording of the PAWP, about 8 mm Hg, which is a good estimate of pulmonary venous BP.](image-url)
<table>
<thead>
<tr>
<th>Hemodynamic Measurement</th>
<th>Normal Value</th>
<th>Clinical Significance</th>
<th>Abnormalities</th>
</tr>
</thead>
<tbody>
<tr>
<td>Right atrial pressure (RAP)</td>
<td>0-8 mm Hg</td>
<td>Equivalent to CVP</td>
<td>↑: Right ventricular failure, PE, tricuspid valve abnormalities, pericardial tamponade, right ventricular infarction ↓: Hypovolemia</td>
</tr>
<tr>
<td>Pulmonary artery pressure (PAP)</td>
<td>Systolic: 15-30 mm Hg Diastolic: 5-12 mm Hg Mean: 10-20 mm Hg</td>
<td>PAP is equal to RAP during systole while the pulmonary valve is open If the pulmonary vascular resistance is normal, the PADP is 1-4 mm Hg &gt; PCWP and can be substituted for it in following the patient’s hemodynamic measurements</td>
<td>↑: PE, chronic lung disease, VSD, cardiogenic shock, right ventricular infarction ↓: Hypovolemia</td>
</tr>
<tr>
<td>Pulmonary capillary wedge pressure (PCWP)</td>
<td>5-12 mm Hg</td>
<td>PCWP is normally equal to left atrial pressure; it is therefore a sensitive indicator of the presence of pulmonary congestion and left-sided CHF. PCWP is not equal to LVEDP in the following situations: PCWP &gt; LVEDP: Mitral stenosis Patient receiving PEEP Left atrial myxoma Pulmonary venous obstruction PCWP &lt; LVEDP: “Stiff” left ventricle ↑ LVEDP (&gt;25 mm Hg)</td>
<td>↑: Left ventricular failure w/resultant pulmonary congestion, acute mitral insufficiency, tamponade ↓: Left ventricular compliance (hypertrophy, infarction)</td>
</tr>
<tr>
<td>Cardiac output (CO)</td>
<td>3.5-7 L/min</td>
<td>CO = SV × HR</td>
<td>↓: Cardiac dysrhythmias, ↓ contracting muscle mass (myocardial ischemia, MI), mitral insufficiency, VSD</td>
</tr>
<tr>
<td>Cardiac index (CI)</td>
<td>2.5-4 L/m²</td>
<td>CI relates CO to BSA</td>
<td>↑: High-output failure secondary to fluid overload, hepatocellular failure, renal disease, septic shock ↓: Hypovolemia, cardiogenic shock, PE, hypothyroidism, CHF w/failing ventricle</td>
</tr>
<tr>
<td>Systemic vascular resistance (SVR)</td>
<td>900-1300 dyne-sec/cm⁻⁵</td>
<td>Resistance against which the left ventricle must work to eject its SV SVR = ( MAP − RAP) × 80/CO</td>
<td>↑: Hypervolemic vasoconstrictive states (HTN, cardiogenic shock, traumatic shock) ↓: Septic shock, acute renal failure, pregnancy</td>
</tr>
<tr>
<td>Pulmonary vascular resistance (PVR)</td>
<td>155-255 dyne-sec/cm⁻⁵</td>
<td>PVR = ( PAP − PAWP) × 80/CO</td>
<td>↑: Cor pulmonale, PE, valvular heart disease, CHF ↓: Hypervolemic states, pregnancy</td>
</tr>
</tbody>
</table>
3. Box 1-3 describes hemodynamic measurements in specific disease states.

4. Table 1-12 illustrates the effects of therapeutic measures on hemodynamic measurements.

**TABLE 1-12 Effects of Therapeutic Measures on Hemodynamic Measurements**

<table>
<thead>
<tr>
<th>Therapeutic Measure</th>
<th>CO</th>
<th>SVR</th>
<th>PCWP</th>
</tr>
</thead>
<tbody>
<tr>
<td>IV fluids</td>
<td>N↑</td>
<td>N↑</td>
<td>↑</td>
</tr>
<tr>
<td>Diuretics</td>
<td>N/↓</td>
<td>↓/Secondary ↑</td>
<td>↓</td>
</tr>
<tr>
<td>Nitrates</td>
<td>N/↑/↓</td>
<td>↓</td>
<td>↓</td>
</tr>
<tr>
<td>Nitroprusside</td>
<td>↑</td>
<td>↓/↓</td>
<td>N/↓</td>
</tr>
<tr>
<td>Catecholamines</td>
<td>N/↑↑</td>
<td>↑↑</td>
<td>N/↑↑</td>
</tr>
<tr>
<td>Dopamine</td>
<td>↑↑</td>
<td>↓</td>
<td>N/↓</td>
</tr>
<tr>
<td>Dobutamine</td>
<td>↑↑</td>
<td>↓</td>
<td>N/↓</td>
</tr>
</tbody>
</table>

N, no effect.

**Box 1-3 Hemodynamic Measurements in Specific Disease States**

Septic shock
- Early: ↓ PCWP, ↓ SVR, ↑ CO
- Late: ↓ PCWP, ↑ SVR, ↓ CO

Neurogenic shock: ↓ PCWP, ↓ SVR, N/ CO

Cardiac tamponade: ↑ PCWP, ↑ SVR, ↓ CO, ↓ CI

CVP = PADP = PCWP

Pulmonary embolism: normal PCWP, ↑ PADP, ↓ CI

Cardiogenic shock: ↑ PCWP, ↑ PADP, ↓ CO, ↓ CI, ↑ SVR

Hypovolemic shock: ↓ PCWP, ↓ CO, ↑ SVR, ↓ CI

Right ventricular infarct: RAP/PCWP ≥0.8

N, no effect

**FIGURE 1-11.** Basic spirometry. Lung volumes obtained with a bell spirometer.
1. Indications:
   a. Physiologic assessment leading to dx
   b. Establishment of severity
   c. Monitoring of the disease process and response to Rx
   d. Bronchoprovocation
   e. Preoperative risk assessment
   f. Pulmonary disability
   g. Exercise testing
2. PFTs:
   a. Prebronchodilator and postbronchodilator spirometry (Fig. 1-11)
   b. Maximal expiratory flow-volume curve (Fig. 1-12)
   c. Pulse oximetry, resting
3. Interpretation of basic PFTs: Figure 1-13 and Table 1-13.

**Figure 1-12.** Flow-volume curves of restrictive disease and various types of obstructive diseases compared with normal curves. FVC, forced vital capacity.

**Figure 1-13.** Timed vital capacity (or forced expirogram) using bellows or electronic spirometer. FEF, forced expiratory flow; FEV 1.0, forced expiratory volume in 1 sec; FVC, forced vital capacity.
### TABLE 1-13 | Severity Determination

<table>
<thead>
<tr>
<th>Obstruction</th>
<th>FEV₁ % Predicted</th>
<th>Restriction</th>
<th>TLC % Predicted</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mild</td>
<td>65-79</td>
<td>Mild</td>
<td>70-79</td>
</tr>
<tr>
<td>Moderate</td>
<td>50-64</td>
<td>Moderate</td>
<td>60-69</td>
</tr>
<tr>
<td>Moderately severe</td>
<td>35-49</td>
<td>Moderately severe</td>
<td>50-59</td>
</tr>
<tr>
<td>Severe</td>
<td>&lt;35</td>
<td>Severe</td>
<td>&lt;50</td>
</tr>
</tbody>
</table>

FEV₁, forced expiratory volume in 1 sec; TLC, total lung capacity.

## 5 MECHANICAL VENTILATION

### Indications for Mechanical Ventilation

1. Clinical assessment: presence of apnea, tachypnea (>40 bpm), or respiratory failure that cannot be adequately corrected by any other means.
2. Clinical instability, failure to protect the airway—usually from declining mental status.
3. ABGs: severe hypoxemia despite high-flow oxygen or significant CO₂ retention (e.g., oxygen tension [PO₂] <50, carbon dioxide tension [PCO₂] >50).
4. Physiologic parameters are of limited use because many pts w/respiratory insufficiency are unable to perform PFTs and their respiratory failure mandates immediate intervention. Some of the commonly accepted physiologic parameters for intubation and respiratory support are as follows:
   a. VC <10 mL/kg
   b. Inspiratory force 25 cm H₂O or less
   c. FEV₁ <10 mL/kg
   d. Tidal volume <5 mL/kg BW
   e. Minute ventilation >10 L/min
   f. Ratio of RR (breaths/min) to tidal volume (L) >105

Note: The clinical assessment is the most important determinant of the need for mechanical ventilation because neither physiologic parameters nor ABGs distinguish between acute and chronic respiratory insufficiency (e.g., a Pco₂ >60 mm Hg and an RR >30/min may be the “norm” for a patient w/COPD, whereas the same values in a young, otherwise healthy adult are indications for intubation and mechanical ventilation).

### ICU Sedation

Commonly used agents are GABA agonists such as propofol and benzo. These agents can cause respiratory depression and delirium. The α-adrenoreceptor agonist dexmedetomidine (Precedex) is as effective for sedation but significantly better in incidence of delirium.

### Common Modes of Mechanical Ventilation

**Invasive mechanical ventilation** is defined as ventilatory support supplied through endotracheal intubation. The use of devices that apply intermittent negative extrathoracic pressure or furnish intermittent positive pressure through a tight-fitting nasal or face mask w/o an artificial airway in place is known as **noninvasive ventilation**. The delivery of gas under positive pressure into the airways and the lungs is known as **positive-pressure ventilation** (Table 1-14).

1. **IMV**: The patient is allowed to breathe spontaneously, and the ventilator delivers a number of machine breaths at a preset rate and volume.
   a. Advantages and indications:
      i. IMV is indicated in the majority of spontaneously breathing pts because it maintains respiratory muscle tone and results in less depression of cardiac output than with ACV.
      ii. It is useful for weaning because as the IMV rate is decreased, the patient gradually assumes the bulk of the breathing work.
   b. Disadvantages:
      i. The increased work of breathing results in increased oxygen consumption (deleterious to pts w/myocardial insufficiency).
      ii. IMV is not useful in pts w/depressed respiratory drive or impaired neurologic status.
### TABLE 1-14  ■ Modes of Positive-Pressure Ventilation

<table>
<thead>
<tr>
<th>Mode</th>
<th>Description</th>
<th>Advantages and Disadvantages</th>
</tr>
</thead>
<tbody>
<tr>
<td>Controlled mechanical ventilation (CMV)</td>
<td>Ventilator f, inspiratory time, and Vt (and thus Ve) preset</td>
<td>Can be used in patients w/sedation or paralysis; ventilator cannot respond to ventilatory needs</td>
</tr>
<tr>
<td>Assisted mechanical ventilation (AMV) or</td>
<td>Ventilator Vt and inspiratory time preset, but patient can ↑ f (and thus Ve)</td>
<td>Ventilator may respond to ventilatory needs; ventilator may undertrigger or overtrigger, depending on sensitivity</td>
</tr>
<tr>
<td>assist-control ventilation (ACV)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Intermittent mandatory ventilation (IMV)</td>
<td>Ventilator delivers preset Vt, f, and inspiratory time, but patient also can breathe spontaneously</td>
<td>May ↓ asynchronous breathing and sedation requirements; ventilator cannot respond to ventilatory needs</td>
</tr>
<tr>
<td>Synchronized intermittent mandatory ventilation (SIMV)</td>
<td>Same as IMV, but ventilator breaths delivered only after patient finishes inspiration</td>
<td>Same as IMV, and patient not overinflated by receiving spontaneous and ventilator breaths at same time</td>
</tr>
<tr>
<td>High-frequency ventilation (HFV)</td>
<td>Ventilator f is ↑ and Vt may be smaller than Vd</td>
<td>May reduce peak airway pressure; may cause auto-PEEP</td>
</tr>
<tr>
<td>Pressure support ventilation (PSV)</td>
<td>Patient breathes at own f; Vt determined by inspiratory pressure and Crs</td>
<td>↑ comfort and ↓ work of breathing; ventilator cannot respond to ventilatory needs</td>
</tr>
<tr>
<td>Pressure control ventilation (PCV)</td>
<td>Ventilator peak pressure, f, and respiratory time preset</td>
<td>Peak inspiratory pressures may be ↓; hypoventilation may occur</td>
</tr>
<tr>
<td>Inverse ratio ventilation (IRV)</td>
<td>Inspiratory time exceeds expiratory time to facilitate inspiration</td>
<td>May improve gas exchange by ↑ time spent on inspiration; may cause auto-PEEP</td>
</tr>
<tr>
<td>Airway pressure release ventilation (APRV)</td>
<td>Patient receives CPAP at high and low levels to simulate Vt</td>
<td>May improve oxygenation at lower airway pressure; hypoventilation may occur</td>
</tr>
<tr>
<td>Proportional assist ventilation (PAV)</td>
<td>Patient determines own f, Vt, pressures, and flows</td>
<td>May amplify spontaneous breathing; depends entirely on patient’s respiratory drive</td>
</tr>
</tbody>
</table>

Crs, respiratory system compliance; f, respiratory rate; Vd, dead space; Ve, minute ventilation; Vt, tidal volume.

iii. It was previously assumed that the degree of respiratory muscle rest was proportional to the level of machine assistance. However, recent evidence indicates that respiratory-sensor output does not adjust to breath-to-breath changes in respiratory load, and IMV may therefore contribute to the development of respiratory muscle fatigue or prevent recovery from it.

2. **ACV**: The patient breathes at his or her own rate, and the ventilator senses the inspiratory effort and delivers a preset tidal volume (VT) w/each patient effort; if the patient’s RR decreases past a preset rate, the ventilator delivers tidal breaths at the preset rate.
   a. Advantages and indications: useful in pts w/neuromuscular weakness or CNS disturbances.
   b. Disadvantages:
      i. Tachypnea may result in significant hypocapnia and respiratory alkalosis.
      ii. Improper setting of sensitivity to the negative pressure necessary to trigger the ventilator may result in “fighting the ventilator” when the sensitivity is set too low.
      iii. Increased sensitivity may result in hyperventilation; sensitivity is generally set so that an inspiratory effort of 2 to 3 cm will trigger ventilation.
iv. The respiratory muscle tone is not well maintained in pts on ACV, and this may result in difficulty w/weaning.

3. **CMV:** The patient does not breathe spontaneously; the RR is determined by the physician; the ventilator assumes all respiratory work by delivering a preset volume of gas at a preset rate.

a. Advantages and indications:
   i. Useful in pts who are unable to make an inspiratory effort (e.g., severe CNS dysfunction) and in pts w/excessive agitation or breathing effort.
   ii. Pts w/excessive agitation are often sedated w/morphine or benzo and paralyzed w/pancuronium bromide (Pavulon); adequate sedation is necessary to eliminate awareness of paralysis.
   iii. Initial pancuronium dose is 0.08 mg/kg IV in adults.
   iv. Later incremental doses starting at 0.01 mg/kg may be used as necessary to maintain paralysis; pancuronium should be administered only by or under the supervision of experienced clinicians; a combination of neostigmine and atropine may be used to reverse the action of the pancuronium.

b. Disadvantages: paralyzed pts on CMV must be closely monitored because ventilator malfunction or disconnection is rapidly fatal.

4. **SIMV:** A hybrid of ACV and IMV, the ventilator delivers a number of specified breaths/min (as w/IMV). However, at the appropriate interval (e.g., q6sec if machine rate is 10 breaths/min), the machine waits for an ET pressure deflection to signal patient effort and then delivers a positive-pressure breath; ventilator breaths are thus synchronized w/patient respiratory efforts, as w/assist features of ACV.

5. Other useful ventilation modes are as follows:
   a. **Pressure control ventilation (PCV):** A ventilatory mode in which inspiratory pressure, RR, and inspiratory time (Ti) are determined by the ventilator settings. Because inspiratory pressure is the controlled variable, Vt during PCV is influenced by the mechanical properties of the respiratory system (resistance and compliance).
   b. **Pressure support ventilation (PSV):** A ventilatory mode in which the patient’s inspiratory effort is supported by a set level of inspiratory pressure. This pressure is maintained until respiratory flow falls below a threshold value, signaling the onset of expiration. Vt during PSV is determined by patient effort and the mechanical properties of the lung. PSV differs from PCV in that the RR and the Ti are determined by the patient.
   c. **Inverse ratio ventilation (IRV):** A ventilatory strategy in which the inspiratory-to-expiratory ratio is prolonged to 1:1 or greater. In pts w/ARDS, IRV is used to improve oxygenation by increasing mean airway pressure. This modality is used as a salvage Rx when adequate oxygenation cannot be achieved w/conventional ventilation in ARDS. When used, pressure cycled IRV is preferred because of decreased barotrauma risk.
   d. **Noninvasive positive-pressure ventilation (NPPV):** Ventilatory support is delivered by use of a mechanical ventilator connected to a mouthpiece or mask instead of an ETT. It is very useful in pts w/chronic respiratory failure caused by neuromuscular disease or thoracic deformities and in pts w/idiopathic hypoventilation. It improves the patient’s well-being and may eliminate the need for tracheostomies. It is also used in pts as a short-term bridge to avoid intubation and mechanical ventilation, when possible, in conditions that are rapidly reversible, like hypercarbic respiratory failure in COPD and, importantly, acute pulmonary edema in heart failure. It is also sometimes used as salvage Rx in pts w/any of the indications for intubation who do not want to be intubated.

**Selection of Ventilator Settings**
1. Vt: 10 to 15 mL/kg of ideal BW.
2. Rate (number of tidal breaths delivered per minute): 8 to 16, depending on the desired PaCO₂ or pH (increased rate equals decreased PaCO₂).
3. Mode: IMV, ACV, CMV (or PCV or PSV, depending on what is available at one’s institution).
4. Oxygen concentration (FiO₂): the initial FiO₂ should be 100% unless it is evident that a lower FiO₂ will provide adequate oxygenation. The FiO₂ should be calibrated down as quickly as possible to prevent oxygen toxicity.
5. Obtain ABGs 15 to 30 minutes after initiation of mechanical ventilation.
6. Immediate CXR is indicated after intubation to evaluate for correct placement of ETT.
7. Sedation orders (e.g., morphine, diazepam) are necessary in most pts.
8. PEEP.
   a. The application of PEEP may prevent the closure of edematous small airways; it is indicated when arterial oxygenation is inadequate (saturation <90%) despite an FiO₂ >50%; it is useful in pts w/diffuse lung edema and refractory hypoxemia caused by intrapulmonary shunting (e.g., ARDS). Useful to ↓ the needed FiO₂ to ↓ oxygen toxicity. In reality, at least 5 mm PEEP is used on virtually everyone, but it can be ↓ if oxygenation is not a problem but intubation-associated hypotension is.
   b. PEEP is generally started at 5 cm H₂O and ↑ by increments of 2 to 5 cm to maintain the PaO₂ at 60 mm Hg or greater.
   c. The use of PEEP can result in pulmonary barotrauma and hemodynamic compromise (secondary to decreased right ventricular filling).
   d. Pts receiving PEEP should have their cardiac output frequently monitored; the measurement of mixed venous oxygen saturation is useful to evaluate the effect of PEEP on cardiac output. The surrogate of cardiac output (BP) is fine in most pts.
9. Adjust the initial ventilator setting according to results of the ABGs and clinical response.
   a. Use the lowest FiO₂ necessary to maintain a PaO₂ >60 mm Hg (90% Hgb saturation in pts w/nl pH).
   b. Adjust minute ventilation (VT time rate) to normalize the pH and the PaCO₂.
      i. ↑ the VT or the rate will ↓ PaCO₂ and ↑ pH.
      ii. Do not lower the PaCO₂ below the “norm” for that patient (e.g., some pts w/COPD should be allowed to maintain their usual mildly elevated PaCO₂ to avoid alkalosis and to provide stimulus for breathing).
10. Common ventilator machine settings for various disorders are described in Table 1-15.

### Table 1-15: Common Ventilator Machine Settings for Various Disorders

<table>
<thead>
<tr>
<th>Condition</th>
<th>Mode</th>
<th>VT, VE</th>
<th>PEEP (cm H₂O)</th>
<th>Pressure Targets</th>
<th>FiO₂</th>
</tr>
</thead>
<tbody>
<tr>
<td>Depressed CNS drive</td>
<td>Mandatory ACV, SIMV</td>
<td>VT = 10 mL/kg VE = 6-8 L/min</td>
<td>0-5</td>
<td>Peak usually &lt;35 cm H₂O Minimum for SaO₂ &gt;90%</td>
<td></td>
</tr>
<tr>
<td>Neuromuscular insufficiency</td>
<td>Acute: mandatory ACV, SIMV</td>
<td>VT = 8-10 mL/kg VE = 6-8 L/min</td>
<td>0-5</td>
<td>Peak usually &lt;35 cm H₂O As above</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Mild, recovering: SIMV and PSV, PSV alone</td>
<td>Guarantee VT &gt;350 mL w/PSV breaths</td>
<td>0-5</td>
<td></td>
<td></td>
</tr>
<tr>
<td>COPD</td>
<td>Early: ACV, SIMV</td>
<td>VT = 8 mL/kg VE: minimize, usually 8-10 L/min Peak flow ≥60 L/min</td>
<td>0*</td>
<td>Plateau &lt;30 cm H₂O; monitor for intrinsic PEEP (auto-PEEP)</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Late: see text</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

*PEEP added to obstructive disease only in special circumstances.
Major Complications of Mechanical Ventilation
1. Pulmonary barotrauma (e.g., pneumomediastinum, pneumothorax, SC emphysema, pneumoperitoneum): generally secondary to high levels of PEEP, excessive tidal volumes, high peak airway pressures, and coexistence of significant lung disease.
2. Pulmonary thromboemboli can be prevented by vigorous leg care, antiembolic stockings, and use of prophylactic low-dose heparin (i.e., 5000 U SC q8-12h).
3. GI bleeding: prophylaxis w/IV ranitidine 50 mg q8h, PPIs, or sucralfate suspension, 1 g q6h through NG tube, is indicated in most pts on mechanical ventilators.
4. Arrhythmias: avoid the use of arrhythmogenic drugs and prevent rapid acid-base shifts.
5. Accumulation of large amount of secretions: frequent respiratory toilet is necessary in all pts on mechanical ventilators. Consider mouth care with chlorhexadine.
6. Others: nosocomial infections, laryngotraheal injury, malnutrition, hypophosphatemia, oxygen toxicity, psychosis; risk factors for pneumonia are severe illness, old age (>60 years), prior administration of abx, supine head position. Respiratory ICU pts who are managed in the semirecumbent (30- to 45-degree head-up) position have a lower incidence of nosocomial pneumonia. Use of sucralfate rather than H₂ antagonists is also associated w/lower incidence of nosocomial pneumonia. Extubation as rapidly as possible is important to help prevent ventilator-associated pneumonia.

Withdrawal of Mechanical Ventilatory Support
1. Common criteria for ventilator weaning:
   a. Improved clinical status (the patient is alert and hemodynamically stable); process that required mechanical ventilation is reversed.
   b. Adequate oxygenation (Pao₂ >60 mm Hg w/inspired oxygen concentration of 40%).
   c. pH 7.33 to 7.48 w/acceptable Paco₂.
   d. RR of 25 breaths/min or less.
   e. VC of 10 mL/kg or more.
   f. Resting minute ventilation <10 L/min, w/ability to double the resting minute ventilation.
   g. Peak pressure more negative than −25 cm H₂O.
   h. Vt >5 mL/kg.
   i. The ratio of respiratory frequency to Vt during 1 minute of spontaneous breathing, also known as the rapid shallow breathing index (f/Vt), is a good predictor of a patient’s readiness for weaning; a value of fewer than 100 breaths/min/L indicates that weaning probably will be successful, especially if it is confirmed by serial measurements.

   Note: The preceding criteria are only guidelines; significant variation may be present (e.g., an RR of 30 breaths/min may be acceptable in a patient w/COPD). Failure to meet these criteria does not mean that the patient will not be weaned successfully.
2. Methods of weaning:
   a. Weaning by IMV
      i. Gradually decrease the IMV as tolerated (e.g., two breaths q3-4h), monitoring ABGs PRN. Monitoring of clinical signs (RR, patient’s comfort, and tidal volume) is usually sufficient to avoid repeated ABGs.
      ii. Do not change more than one parameter at a time.
      iii. When the patient is tolerating an IMV of 4 to 6, a trial w/T tube can be attempted. The T tube is attached to the ETT and delivers humidified oxygen (FiO₂ 40%).
      iv. If the patient tolerates the T tube well, extubation may be attempted.
         (a) Have adequate equipment and personnel available if reintubation is necessary (start early in the day).
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(b) Suction airway and oropharynx.
(c) Deflate cuff and extubate.
(d) Administer oxygen by face mask ($\text{FiO}_2$ 40%–100%).
(e) Auscultate the lungs for adequate air movement.
(f) Closely monitor VS.
(g) Obtain ABGs approximately 15 to 30 minutes after extubation.

v. Reintubate if extubation is poorly tolerated.

b. Stable pts w/o pulmonary disease and w/good probability of quick extubation (e.g., after uncomplicated cardiac surgery) may be given a direct trial of T tube (bypassing gradual decreases of IMV).

c. PSV
   i. Titrate pressure to achieve a frequency of 25 breaths/min or fewer; allow a CPAP of 5 cm of water or less.
   ii. Set pressure support initially at 18.0 ± 6.1 cm of water and attempt to reduce this level of support by 2 to 4 cm of water at least bid.
   iii. Extubate pts who tolerate a pressure support setting of 5 cm of water for 2 hours w/no apparent ill effects.

d. Intermittent trials of spontaneous breathing
   i. Disconnect stable patient from the ventilator and allow the patient to breathe spontaneously through either a T-tube circuit or a continuous-flow circuit designed to provide a CPAP of 5 cm of water or less.
   ii. Attempt the trial at least bid and gradually increase the duration of the trial.
   iii. Provide ACV for at least 1 hour between the trials.
   iv. Extubate pts who are able to breathe on their own for at least 2 hours w/o signs of distress.

e. Once-daily trial of spontaneous breathing
   i. Disconnect the stable patient from the ventilator and allow him or her to breathe spontaneously through a T-tube circuit for up to 2 hours each day.
   ii. Extubate pts who tolerate a 2-hour trial w/o signs of distress.
   iii. Reinstitute ACV for 24 hours if signs of intolerance develop.

Failure to Wean from Mechanical Ventilator
Failure usually results from premature attempts at weaning (e.g., patient is hemodynamically unstable). Other common, reversible causes of failure to wean are as follows:

1. Hypophosphatemia, hypomagnesemia, hypokalemia.
2. Drug toxicity (e.g., excessive CNS depression from analgesics, sedatives). Continuous infusions of sedative drugs may prolong the duration of mechanical ventilation. Daily interruption of sedative infusions until the patient is awake decreases the duration of mechanical ventilation.
4. Excessive secretions.
5. Significant acid-base disturbances (e.g., metabolic alkalosis depresses respiratory drive).
6. Hypothyroidism.
7. Malnutrition.
8. Small-bore ETT (tube ≥8 mm is preferred).
9. Interference w/chest wall (e.g., chest tube, restraints).

Ventilator-Associated Pneumonia
1. Ventilator-associated pneumonia occurs in 9% to 24% of pts intubated >48 hours.
2. The etiology of ventilator-associated pneumonia varies w/the following factors:
   a. Onset <5 days after hospital admission or intubation.
   b. Presence of risk factors (previous recent abx treatment, corticosteroid use, structural lung disease, and immunosuppression).
3. Pts w/pneumonia diagnosed <5 days after hospital admission or intubation and w/no risk factors can be empirically treated w/one of the following abx:
   a. Second- or third-generation cephalosporin
   b. β-Lactam w/ or w/o β-lactamase inhibitors
   c. Quinolones
4. Pts w/risk factors or those diagnosed 5 days or more after hospital admission or intubation can be empirically treated w/two abx from the following classes:
   a. Antipseudomonal lactam agents (e.g., imipenem, meropenem, cefepime, ceftazidime, piperacillin-tazobactam)
   b. Quinolones with w/reliable antipseudomonal activity
   c. Aminoglycosides
5. Consider addition of vancomycin in institutions w/MRSA.
6. Recommended duration of treatment is 7 days, longer if *Pseudomonas* infection is diagnosed.

6 PACEMAKERS
1. Classification: Table 1-16.
2. Indications for pacemaker in MI: Table 1-17.

<table>
<thead>
<tr>
<th>TABLE 1-16</th>
<th>Commonly Programmed Modes of Pacemaker Function</th>
</tr>
</thead>
<tbody>
<tr>
<td>AAI</td>
<td>Demand atrial pacing; output inhibited by sensed atrial signals</td>
</tr>
<tr>
<td>AAIR</td>
<td>Demand atrial pacing; output inhibited by sensed atrial signals; Atrial pacing rates ↓ and ↑ in response to sensor input up to the programmed sensor-based upper rate</td>
</tr>
<tr>
<td>VVI</td>
<td>Demand ventricular pacing; output inhibited by sensed ventricular signals</td>
</tr>
<tr>
<td>VVIR</td>
<td>Demand ventricular pacing; output inhibited by sensed ventricular signals; Ventricular paced rates ↓ and ↑ in response to sensor input up to the programmed sensor-based upper rate</td>
</tr>
<tr>
<td>VDD</td>
<td>Paces ventricle, senses in both atrium and ventricle; Synchronizes w/atrial activity and paces ventricle after a preset atrioventricular interval up to the programmed upper rate</td>
</tr>
<tr>
<td>VDDR</td>
<td>Paces ventricle, senses in both atrium and ventricle; Synchronizes w/atrial activity and paces ventricle after a preset atrioventricular interval up to the programmed upper rate; in absence of spontaneous atrial activity, functions as VVIR</td>
</tr>
<tr>
<td>DDD</td>
<td>Paces and senses in both atrium and ventricle; Paces ventricle in response to sensed atrial activity up to programmed upper rate</td>
</tr>
<tr>
<td>DDDR</td>
<td>Atrial and ventricular paced rates can both ↑ and ↓ in response to sensor input up to the programmed sensor-based upper rate</td>
</tr>
</tbody>
</table>

A, atrium; V, ventricle; D, dual (both atrium and ventricle); I, inhibition and triggering (pacing in response to another event); R, rate adaptation available.

7 PROSTHETIC HEART VALVES
Artificial valves can be mechanical or biologic.
1. Mechanical prosthetic valves: Preferred valve substitutes in adult pts who are already taking anticoagulants (e.g., for AF). The most important risk linked to these valves is valvular thrombosis requiring lifelong anticoagulation.
   a. Ball-cage prosthesis: Constructed as a ball in a metallic cage (e.g., Starr-Edwards valve). The ball prosthesis partially obstructs blood flow, and flow through the prosthesis is turbulent. Benefit: low cost. Disadvantage: trauma to RBCs can result in hemolytic anemia. Prosthesis is also very bulky.
   b. Tilting disk prosthesis: The mobile element of these valves is a tilting disk held in place by two welded struts. Older models consisted of the Bjork-Shiley valve; a newer model is the Medtronic Hall Omnicarbon prosthesis.
TABLE 1-17  Guidelines of the ACC and the AHA for Temporary or Permanent Implantation of Pacemakers in Patients with Acute MI

<table>
<thead>
<tr>
<th>Class*</th>
<th>Indications for Temporary Pacing</th>
<th>Indications for Permanent Pacing</th>
</tr>
</thead>
<tbody>
<tr>
<td>I</td>
<td>Asystole</td>
<td>Persistent second-degree AV block in the His-Purkinje system, with bilateral BBB or third-degree AV block within or below the His-Purkinje system after MI</td>
</tr>
<tr>
<td></td>
<td>Symptomatic bradycardia (including sinus bradycardia or Mobitz type I block with hypotension)</td>
<td>Transient advanced (second- or third-degree) infranodal AV block and associated BBB† Persistent and symptomatic second- or third-degree AV block</td>
</tr>
<tr>
<td></td>
<td>Bilateral BBB (alternating BBB or RBBB alternating with LAFB or LPFB)</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Bifascicular block that is new or of indeterminate age (RBBB with LAFB or LPFB or LBBB) with a prolonged PR interval</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Mobitz type II second-degree AV block</td>
<td></td>
</tr>
</tbody>
</table>

| Iia     | RBBB and LAFB or LPFB that is new or of indeterminate age | None |
|         | RBBB with a prolonged PR interval | |
|         | LBBB that is new or of indeterminate age | |
|         | Recurring sinus pauses not responsive to atropine | |

| Iib     | Bifascicular block of indeterminate age | Persistent second- or third-degree AV block at the level of the AV node |
|         | Isolated RBBB that is new or of indeterminate age | |

| III     | Prolonged PR interval | Transient AV conduction disturbances in the absence of intraventricular conduction defects Transient, isolated AV block in the presence of isolated LAFB Acquired LAFB in the absence of AV block Persistent first-degree AV block in the presence of BBB that is old or of indeterminate age |
|         | Type I second-degree AV block with normal hemodynamics | |
|         | Accelerated idioventricular rhythm | |
|         | BBB or fascicular block known to exist before acute MI | |

LAFB, left anterior fascicular block; LPFB, left posterior fascicular block.

*Class designations refer to the level of evidence supporting the effectiveness of the procedure or treatment, where class I indicates that the evidence is very strong and class III that it is absent or that the procedure is not useful and may be harmful.

†An electrophysiologic study may be useful to determine the site of the block.

c. **Bileaflet prostheses:** Made of two semicircular pivoting disks constructed from pyrolytic carbons, a material considered to be less thrombogenic. Introduced in 1977, the prototype is the St. Jude valve, the most commonly implanted prosthetic valve. Newer models include the CarboMedics prosthesis.

2. **Biologic valves:** These valves are divided into three groups based on the origin of the biologic material: heterografts (animal origin), homografts (human donor), and autografts (tissues originating from the patient).

a. **Bioprosthesis (heterografts):** Porcine bioprosthetic valves such as the Carpentier-Perimount are derived from pig aortic leaflets mounted on metal-coated stents. A major concern in these valves is degradation over time, usually manifested as a valvular leak caused by a torn and prolapsed cusp or by commissural detachment. As a rule, most pts >75 years of age are offered a bioprosthesis.

b. **Homograft valves:** Valves harvested from human donors. They have an excellent hemodynamic profile and are particularly useful in the management of infectious endocarditis because of the absence of prosthetic material.
c. **Autograft valves:** The main use of autograft valves is the transfer of the pulmonary valve to the aortic position (Ross procedure) w/the subsequent implantation of a pulmonary homograft into the prior position of the pulmonary valve. The Ross procedure is the operation of choice for aortic valve replacement.

### E. Procedures

#### 1 LUMBAR PUNCTURE

**Indications**
1. Suspected meningitis.
2. Suspected encephalitis.
3. Dx of meningeal carcinomatosis and meningeal leukemia.
4. Dx of tertiary syphilis.
5. Follow-up of Rx for meningitis (selected cases).
6. Evaluation for GBS.
7. Evaluation for MS.
8. Staging of lymphomas.
9. Evaluation of dementia (in selected cases).
10. Treatment of pseudotumor cerebri.
11. Suspected subarachnoid hemorrhage (only after nl head CT scan).
12. Introduction of drugs, anesthetics, or radiographic media into the CNS.

**Contraindications**
1. Infection at the site of LP.
2. ↑ ICP.
3. Severe hemorrhagic diathesis (hereditary or acquired).
4. Presence of a CNS mass lesion.
5. Suspected venous sinus occlusion.
6. Uncooperative patient.

**Procedure**
1. Perform a careful ophthalmoscopic examination; if ↑ ICP or a CNS space-occupying lesion is suspected, CT scan of the head should be done before LP.
2. Place the patient in a lateral decubitus position w/spine flexed (draw shoulders forward and bring thighs toward the abd; maximal flexion of the spine helps open up the interspace and improves chances of a successful procedure). If the patient is able to, LP can also be performed w/the patient sitting upright, ideally leaning over a tray table.
3. Identify the L4-5 interspace (imaginary line connecting the iliac crests).
4. Clean area w/povidone-iodine solution.
5. Anesthetize skin and SC tissues w/1% to 2% lidocaine.
6. Gently introduce the spinal needle (w/bevel turned upward) in the L4-5 interspace in a horizontal direction and w/slight cephalad inclination. Point toward the umbilicus. A drop in resistance may be felt as the needle penetrates the dura.
7. Measure opening pressure (nl is 100 to 200 mm Hg [10 to 20 cm Hg]).
   a. If the pressure is elevated, instruct the patient to relax and ensure that there is no abd compression or breath holding (straining and pressure on the abd wall will ↑ CSF pressure).
   b. If the pressure is markedly elevated, remove only 5 mL of spinal fluid and remove the spinal needle immediately.
8. Collect 5 to 10 mL of spinal fluid in four collection tubes (2 mL/tube).
9. Measure closing pressure, then remove manometer and stopcock, and replace stylet before removing the spinal needle; apply pressure to the puncture site w/sterile gauze for a few minutes.
10. Instruct the patient to remain in a horizontal position for approximately 4 hours to minimize post-LP headache (caused by CSF fluid leakage through the puncture site).
11. Process the CSF fluid.
   a. Tube 1: protein, glucose.
   b. Tube 2: Gram stain of the centrifuged specimen.
c. Tube 3: save the fluid until further notice.
d. Tube 4: cell count (total and diff).

12. Consider additional tests (if indicated).
   a. Bacterial cultures in suspected bacterial meningitis.
   b. Assay for cryptococcal antigen in immunocompromised pts.
   c. Countercurrent immunoelectrophoresis or latex agglutination: to detect specific polysaccharide bacterial antigens (Neisseria meningitidis, Haemophilus influenzae, Streptococcus pneumoniae) in the CSF of pts w/inconclusive Gram stain findings (e.g., pts w/partially treated meningitis).
   d. Oligoclonal banding and assay for myelin basic protein are useful to diagnose MS.
   e. VDRL, AFB stain, Wright stain of sediment, India ink preparation, Lyme titer Ab, fungal or viral cultures, and cytologic examination should be ordered only when specifically indicated.
   f. The most sensitive technique for rapid dx of tuberculous meningitis is PCR assay. Bacteriologic methods are inadequate for early dx because there are generally too few organisms in the CSF for identification by direct smear, and identification w/cultures takes 6 to 8 weeks.
   g. Rapid dx of herpes simplex encephalitis (when suspected) can be accomplished by nested PCR assay of CSF.
   h. Enterovirus-specific reverse transcriptase PCR assay of CSF fluid is useful for rapid dx of enteroviral meningitis.

**Interpretation of Results**

1. Appearance of the fluid:
   b. Yellow color (xanthochromia) in the supernatant of centrifuged CSF within 1 hour or less after collection is usually the result of previous bleeding (subarachnoid hemorrhage); it may also be caused by increased CSF protein, melanin from meningeal melanomas, or carotenoids.
   c. Pinkish color is usually the result of a bloody tap; the color generally clears progressively from tubes 1-4 (the supernatant is usually crystal clear in traumatic taps).
   d. Turbidity usually indicates the presence of leukocytes (bleeding introduces approximately 1 white blood cell to 500 RBCs into the CSF).

2. CSF pressure: elevated pressure can be seen in pts w/meningitis, meningoencephalitis, pseudotumor cerebri, mass lesions, and intracerebral bleeding.

3. Cell count: in the adult, the CSF is normally free of cells (although up to 5 mononuclear cells/mm³ is considered nl); the presence of granulocytes is never nl.
   a. Neutrophils: seen in cases of bacterial meningitis, early viral meningoencephalitis, and early tuberculous meningitis.
   b. Increased lymphocytes: tuberculous meningitis, viral meningoencephalitis, syphilitic meningoencephalitis, fungal meningitis, Lyme disease, SLE, Listeria.

4. Protein: serum proteins are generally too large to cross the nl blood-CSF barrier; however, ↑ CSF protein is seen w/meningeal inflammation, traumatic tap, ↑ CNS synthesis, tissue degeneration, obstruction to CSF circulation, and GBS.

5. Glucose:
   a. ↓ glucose is seen w/bacterial meningitis, tuberculous meningitis, fungal meningitis, subarachnoid hemorrhage, and some cases of viral meningitis.
   b. A mild ↑ in CSF glucose level can be seen in pts w/very elevated serum glucose levels.

Note: Table 1-18 describes CSF abnormalities found in various CNS conditions.
THORACENTESIS

Indications
1. Presence of any pleural effusion of unknown cause.
2. Relief of dyspnea caused by large pleural effusion.

Contraindications
1. Clotting abnormalities.
2. Thrombocytopenia.
3. Uncooperative patient or patient w/severe cough or hiccups.

Localization of Pleural Effusion
1. Physical examination: dullness to percussion, loss of tactile fremitus.
2. CXR: PA view is usually sufficient in identifying the fluid collection; but in case of equivocal effusions, a lateral decubitus CXR can demonstrate layering out of the pleural fluid. Effusions >1 cm on a lateral decubitus film are usually sufficiently large to be removed at the bedside w/o additional imaging.
3. Fluoroscopy, ultrasonography, or CT guidance in performing thoracentesis if the fluid collection has the following qualities:
   a. <10 mm thick
   b. Not freely movable on the lateral decubitus x-ray view

Procedure
1. Position patient in a sitting position w/arms and head supported on a bedside adjustable table.
2. Identify the area of effusion by gentle percussion.
3. Clean the area w/povidone-iodine solution and maintain strict aseptic technique.
4. Insert the needle in the posterior chest (approximately 5 to 10 cm lateral to the spine, in the midpoint between the spine and the posterior axillary line) in 1 to 2 interspaces below the point of dullness to percussion.
5. Anesthetize the skin and SC tissues w/1% to 2% lidocaine using a 25-gauge needle.
6. Make sure that the needle is positioned and advanced above the superior margin of the rib (the intercostal nerve and the blood supply are located near the inferior margin). “Walk” the needle over the

<table>
<thead>
<tr>
<th>TABLE 1-18</th>
<th>Cerebrospinal Fluid Abnormalities in Various CNS Conditions</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Appearance</strong></td>
<td><strong>Glucose (mg/dL)</strong></td>
</tr>
<tr>
<td>Normal</td>
<td>Clear</td>
</tr>
<tr>
<td>Acute bacterial meningitis</td>
<td>Cloudy</td>
</tr>
<tr>
<td>Aseptic (viral) meningitis</td>
<td>Clear/cloudy</td>
</tr>
<tr>
<td>Hemorrhage</td>
<td>Bloody/xanthochromic</td>
</tr>
<tr>
<td>Neoplasm</td>
<td>Clear/xanthochromic</td>
</tr>
<tr>
<td>Tuberculous meningitis</td>
<td>Cloudy</td>
</tr>
<tr>
<td>Fungal meningitis</td>
<td>Clear/cloudy</td>
</tr>
<tr>
<td>Neurosyphilis</td>
<td>Clear/cloudy</td>
</tr>
<tr>
<td>Guillain-Barré syndrome</td>
<td>Clear/cloudy</td>
</tr>
</tbody>
</table>
superior margin of the rib and deeper into the interspace, anesthetizing the intercostal muscle layers.

7. Apply negative pressure as the needle is advanced. In thin pts, this needle is often sufficiently long to reach the pleural space. If pleural fluid is withdrawn, anesthetize the pleura adequately and note the depth at which it was reached. If it is not reached, use a longer 20- to 22-gauge syringe w/1% to 2% lidocaine, advance it slowly w/negative pressure along the same track as the prior needle, anesthetize the pleura adequately, and advance the needle into the pleural space. If the purpose of the thoracentesis is for dx only, a 30- to 50-mL syringe may then be attached and pleural fluid withdrawn for diagnostic studies. If the purpose of the thoracentesis is fluid removal, proceed further as below. Place a clamp on the needle at skin level to mark the depth, then remove the needle and note the depth of insertion needed for the thoracentesis needle.

8. In the previous puncture site, insert a 17-gauge needle (flat bevel) attached to a 30-mL syringe via a three-way stopcock connected to a drainage tube.

9. Slowly advance the needle (above the superior margin of the rib) and gently aspirate while advancing.

10. Keep a clamp or a hemostat on the needle at the level previously marked to prevent it from inadvertently advancing forward. Many thoracentesis kits will have a catheter that might be advanced over the needle to remove the risk of having a sharp needle within the pleural space.

11. Remove the necessary amount of pleural fluid (usually 100 mL for diagnostic studies), but do not remove more than 1000 mL of fluid at any one time because of ↑ risk of pulmonary edema or hypotension (pneumothorax from needle laceration of the visceral pleura is also much more likely to occur if an effusion is completely drained).

12. Gently remove the needle.

13. Obtain measurements of serum LDH, alb, glucose, and total protein levels.

14. Process the pleural fluid; the initial laboratory studies should be aimed only at distinguishing an exudate from a transudate (Fig. 1-14).
   a. Tube 1: protein, LDH, alb.
   b. Tubes 2, 3, 4: save the fluid until further notice. In selected pts w/suspected empyema, ascertaining a pH level may be useful (generally <7.0).

Note: Do not order further tests until the presence of an exudate is confirmed on the basis of protein and LDH determinations (see Table 1-19). However, if the results of protein and LDH determinations cannot be obtained within a reasonable time (resulting in unnecessary delay), additional laboratory tests should be ordered at the time of thoracentesis.

15. A serum/effusion alb gradient of 1.2 g/dL or less is indicative of exudative effusions, especially in pts w/CHF treated w/diuretics.

16. Note the appearance of the fluid:
   a. A grossly hemorrhagic effusion can be a result of a traumatic tap, a neoplasm, or an embolus w/infarction.
   b. A milky appearance indicates either of the following:
      i. Chylous effusion: caused by trauma or tumor invasion of the thoracic duct; lipoprotein electrophoresis of the effusion reveals chylomicrons and triglyceride levels >115 mg/dL.
      ii. Pseudochylous effusion: often seen w/chronic inflammation of the pleural space (e.g., tuberculosis, connective tissue diseases).

Complications
1. Pneumothorax.
2. Hemorrhage.
3. Vasovagal episode.
4. Infection.
5. Unilateral pulmonary edema.
6. Puncture of liver or spleen.
7. SC emphysema.
8. Air embolism.

**3 PARACENTESIS**

**Indications**
1. Ascites of undetermined etiology.
2. Evaluation for possible peritonitis.
3. Relief of abd pain and discomfort caused by tense ascites.
4. Relief of dyspnea caused by elevated diaphragm (from ascites).
Chapter 1  Surviving the Wards

5. Evaluation of possible intra-abd hemorrhage in a patient w/blunt abd trauma.
6. Institution of peritoneal dialysis.

Contraindications
1. Bleeding disorders, thrombocytopenia (relative contraindication).
2. Bowel distention.
3. Infection or surgical scars at the site of needle entry.
4. Acute abd.
5. Distended bladder that cannot be emptied w/Foley catheter.

Procedure
1. Have the patient empty the bladder (insertion of a Foley catheter is not recommended but may be necessary in certain pts).
2. To identify the site of paracentesis, first locate the rectus muscle; a good site is approximately 2 to 3 cm lateral to the rectus muscle border in the lower abd quadrants. Avoid the following:
   a. Rectus muscles (increased risk of hemorrhage from epigastric vessels)
   b. Surgical scars (increased risk of perforation caused by adhesion of bowel to the wall of the peritoneum)
   c. Areas of skin infection (increased risk of intraperitoneal infection)
   d. Note: an alternative site is on the linea alba 3 to 4 cm below the umbilicus.
3. Cleanse the area w/povidone-iodine and drape the abd.
4. Anesthetize the puncture site w/1% to 2% lidocaine.
5. Cautiously insert the needle (attached to a syringe) perpendicular to the skin; a small “pop” is felt as the needle advances through the anterior and posterior muscular fascia, and entrance into the peritoneal cavity is evidenced as a sudden “give” (use caution to avoid the sudden thrust forward of the needle). Some physicians use the Z technique to minimize leaks—the needle is inserted through the skin, then moved laterally before entering the peritoneal cavity to avoid a straight shot from skin to peritoneal cavity that is better for leaking fluid.
6. Remove the necessary amount of fluid (generally not more than 1 L, particularly in cirrhotic pts). If it is a therapeutic paracentesis w/plans to remove a significant amount of fluid, one can use an angiocatheter (basically just an IV) to cover the sharp needle during the procedure and to allow the operator to move the catheter around at will (in small increments) to try to restart flow when it stops. Transfusion of alb may be necessary with >4 to 5 L of paracentesis to avoid hemodynamic deterioration.
7. If it is a diagnostic paracentesis, process the fluid as follows:
   a. Tube 1: LDH, glucose, alb levels
   b. Tube 2: protein level, specific gravity
   c. Tube 3: complete blood cell count and diff
   d. Tube 4: save until further notice
9. Gram stain, AFB stain, bacterial and fungal cultures, amylase, and TGs should be ordered only when clearly indicated; bedside inoculation of blood culture bottles w/10 to 20 mL of ascitic fluid improves sensitivity in detecting bacterial growth in suspected cases of bacterial peritonitis.
10. If malignant ascites is suspected, consider ascertaining a carcinoembryonic antigen level on the paracentesis fluid and a cytologic evaluation.

Interpretation of Results
1. Peritoneal effusion, like pleural effusion, can be subdivided into exudative or transudative on the basis of its characteristics (Table 1-19).
2. The serum-ascites albumin gradient (SAAG) (serum alb level–ascitic fluid alb level) correlates directly w/portal pressure and can also be used to classify ascites (Table 1-20). Pts w/gradients of 1.1 g/dL or higher have ascites secondary to portal HTN, and those w/gradients <1.1 g/dL do not; the accuracy of this method is >95%.
3. Table 1-21 describes the characteristics of ascitic fluid in various conditions.
4. An ascitic fluid polymorphonuclear leukocyte count >500/µL is suggestive of SBP.
5. A blood–ascitic fluid alb gradient <1.1 g/dL is suggestive of malignant ascites.

**Complications**
1. Persistent leakage of ascitic fluid.
2. Hypotension and shock.
4. Perforated bowel.
5. Abscess formation in area of puncture site.
6. Peritonitis.
ARTHROCENTESIS

Indications
1. Presence of effusion of unexplained etiology.
2. Steroid injection.
3. Decompression of a hemorrhagic effusion in traumatized joints.
4. Evaluation of abx response in pts w/infectious arthritis.
5. Removal of purulent fluid in distended infected joints.

Contraindications
1. Cellulitis or broken skin over the intended entry site.
2. Coagulopathy.
3. Unstable joint.

Procedure
1. Palpate the joint and identify the extensor surface (vessels and nerves are less commonly found here).
2. With firm pressure, use a ballpoint pen that has the writing portion retracted to mark the specific area of the joint to be aspirated.
3. Clean the skin w/an antiseptic solution.
4. Use a 25-gauge needle to infiltrate the skin w/1% to 2% lidocaine.
5. Gently insert an 18- or 20-gauge needle connected to a 20- to 30-mL syringe; a slight “pop” may be felt as the needle penetrates through the capsule.
6. Apply gentle suction to the syringe to aspirate the fluid.
7. Gently remove the needle and apply slight pressure to the puncture site.
8. Process the aspirated synovial fluid:
   a. Tube 1 (no heparin): viscosity, mucin clot
   b. Tube 2 (containing heparin): glucose level
   c. Tube 3 (containing heparin): Gram stain, C&S, cytology, CBC and diff
   d. Glass slide: place a drop of fluid and examine under polarized light
   e. Plate w/Thayer-Martin medium (used in cases of suspected gonococcal arthritis); assessment for Lyme titer, cultures for anaerobes, Mycobacterium tuberculosis, and fungi should be ordered only when clearly indicated.
9. Draw samples for measurement of serum glucose level.

Interpretation of Results
1. Color: normally it is clear or pale yellow; cloudiness indicates inflammatory process or presence of crystals, cell debris, fibrin, or TGs.
2. Viscosity: normally it has a high viscosity because of hyaluronate; when fluid is placed on a slide, it can be stretched to a string longer than 2 cm before separating (low viscosity indicates breakdown of hyaluronate [lysosomal enzymes from leukocytes] or the presence of edema fluid).
3. Mucin clot: add 1 mL of fluid to 5 mL of a 5% acetic acid solution and allow 1 minute for the clot to form; a firm clot (does not fragment on shaking) is nl and indicates the presence of large molecules of hyaluronic acid (this test is nonspecific and infrequently done).
4. Glucose level: normally it approximately equals serum glucose level; a difference of more than 40 mg/dL is suggestive of infection.
5. Total protein concentration is <2.5 g/dL in the nl synovial fluid; it is elevated in cases of inflammatory and septic arthritis.
6. Microscopic examination for crystals:
   a. Gout: monosodium urate crystals
   b. Pseudogout: calcium pyrophosphate dihydrate crystals

Note: synovial fluid is classified into three major groups on the basis of its characteristics (Table 1-22).

Complications
1. Infection.
2. Hemorrhage.
3. Tendon rupture.
TABLE 1-22 □ Knee Joint Synovial Fluid Findings in Common Forms of Arthritis

<table>
<thead>
<tr>
<th></th>
<th>Normal</th>
<th>Osteoarthritis</th>
<th>Rheumatoid and Other Inflammatory Arthritis</th>
<th>Septic Arthritis</th>
</tr>
</thead>
<tbody>
<tr>
<td>Gross appearance</td>
<td>Clear</td>
<td>Clear</td>
<td>Opaque</td>
<td>Opaque</td>
</tr>
<tr>
<td>Volume (mL)</td>
<td>0-1</td>
<td>0-10</td>
<td>5-50</td>
<td>5-50</td>
</tr>
<tr>
<td>Viscosity</td>
<td>High</td>
<td>High</td>
<td>Low</td>
<td>Low</td>
</tr>
<tr>
<td>Total WBC/mm³</td>
<td>&lt;200</td>
<td>200-10,000</td>
<td>500-75,000</td>
<td>&gt;50,000</td>
</tr>
<tr>
<td>Polymorphonuclear cells (%)</td>
<td>&lt;25</td>
<td>&lt;50</td>
<td>&gt;50</td>
<td>&gt;75</td>
</tr>
</tbody>
</table>

5 RADIAL ARTERY CANNULATION (A-LINE)

Indications
1. Monitoring of BP during use of potent vasoactive agents (e.g., nitroprusside, dopamine).
2. Monitoring of BP in critically ill hypotensive pts (e.g., shock) or during major surgery (e.g., CV).
3. Frequent ABG analysis or other blood tests in pts w/limited vascular access.

Procedure
1. Evaluate patency of the ulnar artery w/the Allen test. Simultaneously compressing the radial and ulnar arteries, have the patient clench and elevate the fist to let blood drain from the hand; keep pressure on both arteries until the hand blanches; then have the patient open the hand while pressure is maintained on both arteries. Release the ulnar artery and observe the hand for blushing. The presence of blushing and return of nl color to the hand indicate patency of the ulnar artery and adequate blood supply if radial occlusion occurs w/the catheter.
2. Hyperextend the hand over a wrist roll and immobilize it and the lower arm.
3. Sterile drape and clean the area w/povidone-iodine solution.
4. Anesthetize the skin and then insert the angiocatheter through the skin at a 30- to 45-degree angle, advancing it parallel to the artery; gently cannulate the artery (as evidenced by the blush of blood within the catheter). Advance the catheter over the needle until it locks into place. It should easily advance over the needle. If it does not easily advance, the artery is probably no longer cannulated.
5. Detach the syringe and connect the catheter to the pressure tubing and functioning irrigation system; an arterial pressure tracing indicates intra-arterial positioning.
6. Secure the catheter line to the skin w/silk ligature; apply sterile dressing and adhesive tape to prevent accidental disconnection.
7. Remove the wrist from its hyperextended position and splint the dorsal aspect to prevent accidental disconnection.

6 CENTRAL VENOUS ACCESS (CVP LINE)

Indications
1. Inadequate peripheral venous access.
2. TPN, use of vasopressor agents that cannot be given through peripheral lines.
3. Chemotherapeutic administration.
4. Central venous and PA pressure monitoring.
5. Frequent blood draws w/difficult IV access.

Anatomy for Central Venous Catheter Placement
1. External jugular vein: formed at the angle of the mandible by the posterior facial veins and the posterior auricular vein; passes caudally over the sternocleidomastoid (SCM) muscle to enter the subclavian vein lateral to the anterior scalene muscle.
2. Internal jugular vein: arises from the base of the skull in the carotid sheath posterior to the internal carotid artery and terminates in the subclavian vein anterior and lateral to the common carotid artery; runs medial to the SCM in its upper part, posterior in triangle between two heads of the SCM and behind the clavicular head in its lower part.

3. Subclavian vein: continuation of axillary vein at the lateral border of the first rib; passes over the first rib anterior to the anterior scalene muscle, continues behind the medial third of the clavicle, where it is fixed to the rib and clavicle; joins the internal jugular to form the innominate vein behind the sternocostoclavicular joint. The subclavian artery and apical pleura lie behind the vein at the medial third of the clavicle.

4. Femoral vein: used as a last resort because of the increased frequency of thrombosis, embolism, and infection. The vein is located medial to the femoral artery in the femoral sheath below the inguinal ligament. The artery may be found at the midpoint of a line connecting the anterior superior iliac spine and the pubic symphysis; the vein is one fingerbreadth medial. A useful mnemonic is NAVEL (Nerve, Artery, Vein, Empty space, Lymphatics).

**Principles of Internal Jugular and Subclavian Vein Catheterization**

1. Check the INR, APTT, and platelet count before puncture attempts to r/o coagulopathy.
2. Equipment needed: pre-packaged sterile kit that contains apparatus for catheterization by the Seldinger technique. The use of bedside U/S to verify the internal jugular location is increasing and is standard of care in many hospitals.
3. Place a rolled towel vertically between the shoulder blades; put the patient in the Trendelenburg position w/the neck extended. If the patient is anxious and hemodynamically stable, consider sedation.
4. Wear gown, mask, and sterile gloves; prepare and drape the patient.
5. Infiltrate local anesthesia at the puncture site w/25-gauge needle, then a 20-gauge needle; infiltrate track toward the vein, aspirating before instilling anesthetic. It is especially important in subclavian venipuncture to anesthetize the clavicle edge.
6. Flush the catheter w/sterile fluid; estimate the length to the sternomanubrial junction to place in the SVC.
7. Mount an 18-gauge thin-walled needle on the syringe.
8. Insert slowly, while aspirating, until blood returns; advance a few millimeters farther until blood return increases. Bright red blood usually means arterial puncture; remove needle and apply pressure for 10 minutes.
9. If no blood returns, withdraw needle slowly under negative pressure; blood may still return into syringe. If still no blood returns, reattempt.
10. After blood returns, stabilize needle, carefully unscrew syringe, and prevent air embolism by occluding the needle w/a finger.
11. Place a guide wire through the needle gently; it should advance easily. Withdraw the needle, holding the wire in position.
12. Nick the skin w/the #11 blade, slide the dilator over the wire to enlarge the skin site and track, remove the dilator, then advance the catheter over the wire into the desired position.
13. Remove the wire, check blood return on each port and flush it w/NS, and attach IV tubing or caps.
14. Suture at skin and place sterile occlusive dressing.

**Specific Sites**

1. Internal jugular—central approach
   a. Locate the triangle formed by the two heads of the SCM and the clavicle.
   b. Insert a 22-gauge localizing needle at the apex of the triangle formed by the two heads of the SCM.
   c. Aim the needle parallel to the clavicular head toward the ipsilateral nipple at a 45- to 60-degree angle until the vein is entered. Keep a finger of the nondominant hand on the pulse of the carotid artery to be cognizant of its location.
d. If the needle is inserted 3 cm w/o blood return, attempt a new puncture in a slightly more lateral position.
e. Do not proceed medially because the carotid artery may be punctured.

2. Internal jugular—posterior approach
   a. Insert the needle under the SCM three fingerbreadths above the clavicle, aiming anteriorly to the suprasternal notch at a 45-degree angle to the sagittal and horizontal planes.
   b. The vein should be entered within 5 to 7 cm of needle penetration.

3. Subclavian vein catheterization (infraclavicular)
   a. Insert the needle 1 to 2 cm below the junction of the medial and middle thirds of clavicle.
   b. Advance the needle parallel to the frontal plane until the clavicle is located.
   c. March the needle down the clavicle until it just passes below it, aiming just above the suprasternal notch and keeping the needle parallel to the frontal plane.
   d. When the vein is entered, carefully rotate the needle 90 degrees to aim the bevel caudally so that the wire will pass into the innominate vein.

Contraindications
1. Thrombosis of central veins.
2. Coagulopathy: a relative contraindication. Many coagulopathies can be temporarily overcome w/transfusion of FFP, cryoprecipitate, or platelets, followed by immediate venipuncture. It is preferable to place deep lines in areas that are compressible in the event of bleeding (i.e., femoral, brachial, internal jugular). Also consider cutdown of antecubital veins.

Complications
1. Catheter misplacement: poor blood return, cardiac irritability, pain in neck or ear. Corrective options include the following:
   a. Reposition under fluoroscopy.
   b. Reattempt entire procedure.
2. Arterial puncture (subclavian, carotid, femoral).
3. Hemorrhage: venous or arterial.
4. Pneumothorax: always check CXR after placement and after failed attempts and before reattempting central venipuncture on the contralateral side.
5. Thoracic duct injury with or w/o chylothorax.
6. Extravasation of fluid, hyperalimentation, and so forth.
7. Neural injury (brachial plexus).
8. Air embolism.
9. Catheter or wire embolization.
10. Hydrothorax
    a. Primary: placement of the catheter into pleural or mediastinal spaces.
    b. Secondary: erosion of the catheter through SVC after successful placement.
11. Infection
    a. Cellulitis at puncture site.
    b. Bacteremia from catheter colonization (catheter sepsis).
    c. Increased incidence w/use of multilumen catheters.
12. Thrombosis (central venous): clinical signs include unilateral upper extremity edema, upper extremity and neck venous distention, and neck pain. Treatment: similar to that of iliofemoral DVT. Remove the catheter, heparinize, and follow w/long-term warfarin administration because there is a well-described incidence of PE after subclavian vein thrombosis.

Reference
F. Facts and Formulas

1 CARDIOVASCULAR
See Box 1-4.

2 PULMONARY
See Box 1-5.

3 RENAL FLUIDS, ELECTROLYTES
See Boxes 1-6 and 1-7 and Tables 1-23 and 1-24.

4 CALCIUM
See Box 1-8.

5 NUTRITION
See Box 1-9.

6 EPIDEMIOLOGY
See Box 1-10.

7 MISCELLANEOUS
See Box 1-11.

Box 1-4 • Cardiovascular Formulas

Output of left ventricle
\[
\text{O}_2 \text{ consumption (mL/min)} = \frac{[\text{CaO}_2 - \text{CvO}_2]}{250 \text{ mL/min}} - 140 \text{ mL/L venous blood in pulmonary artery}
\]
\[
= \frac{190 \text{ mL/L arterial blood}}{250 \text{ mL/min}} - \frac{50 \text{ mL/L}}{250 \text{ mL/min}} = 5 \text{ L/min}
\]
CI = Cardiac output/Body surface area
Normal = 3.0-3.4 L/min/m²
EF = End-diastolic volume – end-systolic volume
Shunt % = (Qs/Qt)
Qs/Qt (%) = \frac{\text{C CO}_2 - \text{CaO}_2}{\text{C CO}_2 - \text{CvO}_2}
\text{C CO}_2 = \text{Hgb in g} \times 1.34 + (\text{alveolar P O}_2 \times 0.003)
Normal = <10%
Considerable disease = 20%-29%
Life-threatening = >30%
SV = (end-diastolic volume) – (end-systolic volume)
Systemic vascular resistance index (SVRI) = 79.92 (MAP – CVP/CI)
Venous blood O₂ content (CvO₂) = (PvO₂ × 0.003) + (1.34 × Hgb in g × venous blood Hgb O₂ sat %)
Normal = 13-16 mL/dL

CI, cardiac index; CVP, central venous pressure; DBP, diastolic blood pressure; DPAP, diastolic pulmonary artery pressure; EF, ejection fraction; MAP, mean arterial pressure; PAOP, pulmonary artery occlusion pressure; PAP, pulmonary artery pressure; SBP, systolic blood pressure; SPAP, systolic pulmonary artery pressure; SV, stroke volume.
## Box 1-5 Pulmonary Formulas

### Lung volumes

Normal values for lung volumes in upright subjects:

<table>
<thead>
<tr>
<th>Volume or Capacity</th>
<th>Approximate Value in Upright Subjects</th>
</tr>
</thead>
<tbody>
<tr>
<td>Total lung capacity (TLC)</td>
<td>6 L</td>
</tr>
<tr>
<td>Vital capacity (VC)</td>
<td>4.5 L</td>
</tr>
<tr>
<td>Residual volume (RV)</td>
<td>1.5 L</td>
</tr>
<tr>
<td>Inspiratory capacity (IC)</td>
<td>3 L</td>
</tr>
<tr>
<td>Functional residual capacity (FRC)</td>
<td>3 L</td>
</tr>
<tr>
<td>Inspiratory reserve volume (IRV)</td>
<td>2.5 L</td>
</tr>
<tr>
<td>Expiratory reserve volume (ERV)</td>
<td>1.5 L</td>
</tr>
<tr>
<td>Tidal volume (Vt)</td>
<td>0.5 L</td>
</tr>
</tbody>
</table>

The VC is calculated as:

\[ \text{VC} = \text{IRV} + \text{ERV} + V_t \]

The RV is calculated as the difference between the FRC and the ERV:

\[ \text{RV} = \text{FRC} - \text{ERV} \]

Alternatively, if the TLC and VC are known, the following formula can be used:

\[ \text{RV} = \text{TLC} - \text{VC} \]

### Alveolar-Arterial Oxygen Gradient (A-a gradient)

\[
\text{A-a gradient} = \left[ 713 (F_{\text{I}O_2}) - \left( \frac{P_{\text{aCO}_2}}{0.8} \right) \right] - P_{\text{aO}_2}
\]

Normal A-a gradient = 5-15 mm

- F\text{I}O_2, fraction of inspired oxygen (normal = 0.21-1.0)
- P\text{aCO}_2, arterial carbon dioxide tension (normal = 35-45 mm Hg)
- P\text{aO}_2, arterial partial pressure of oxygen (normal = 70-100 mm Hg)

Differential dx of A-a gradient:

<table>
<thead>
<tr>
<th>Abnormality</th>
<th>15% O₂</th>
<th>100% O₂</th>
</tr>
</thead>
<tbody>
<tr>
<td>Diffusion defect</td>
<td>Increased gradient</td>
<td>Correction of gradient</td>
</tr>
<tr>
<td>Ventilation-perfusion mismatch</td>
<td>Increased gradient</td>
<td>Partial or complete correction of gradient</td>
</tr>
<tr>
<td>Right-to-left shunt (intracardiac or pulmonary)</td>
<td>Increased gradient</td>
<td>Increased gradient (no correction)</td>
</tr>
</tbody>
</table>
**Box 1.6 • Renal Fluids and Electrolytes Formulas**

**Calculation of Creatinine Clearance (C_{Cr})**

\[
C_{Cr} \text{ (male)} = \frac{\text{(140 - age)} \times \text{wt (in kg)}}{\text{Serum creatinine} \times 72}
\]

\[
C_{Cr} \text{ (female)} = 0.85 \times C_{Cr} \text{ (male)}
\]

**Calculation of Fractional Excretion of Sodium (FE_{Na})**

\[
FE_{Na} \% = \frac{\text{Quantity of Na}^+ \text{ excreted}}{\text{Quantity of Na}^+ \text{ filtered}} \times 100
\]

**or**

\[
FE_{Na} \% = \frac{U/P_{Na} \times 100}{U/P_{Cr}}
\]

**or**

\[
FE_{Na} \% = \frac{U_{Na} \times V}{P_{Na} \times (U_{Cr} \times V/P_{Cr})} \times 100
\]

**or**

\[
FE_{Na} \% = \frac{U_{Na} \times P_{Cr}}{P_{Na} \times U_{Cr}} \times 100
\]

where \( U_{Na} \) is urine sodium concentration, \( V \) is urine flow rate, \( P_{Na} \) is plasma sodium concentration, \( U_{Cr} \) is urine creatinine concentration, and \( P_{Cr} \) is plasma creatinine concentration.

**Sodium Formulas**

- **Serum sodium correction in hyperglycemia**

\[
\text{Na}^+_{\text{euglycemic}} = \text{Measured Na}^+ + 0.028 \times (\text{glucose} - 100)
\]

- **Estimated sodium deficit in hyponatremia**

\[
\text{Na}^+ \text{ deficit (mEq)} = 0.6 \times \text{body weight} \times (\text{desired plasma Na}^+ - \text{current plasma Na}^+)
\]

- **Estimated sodium excess in hypernatremia**

\[
\text{Na}^+ \text{ excess (mEq/L)} = 0.6 \times \text{body weight (kg)} \times (\text{current plasma Na}^+ - 140)
\]

- **Serum sodium correction in hyperlipidemia and hyperproteinemias**

\[
\text{Decrease (mEq/L) serum Na}^+ \text{ in hyperlipidemia} = \text{plasma lipids (mg/dL)} \times 0.002
\]

\[
\text{Decrease (mEq/L) serum Na}^+ \text{ in hyperproteinemias} = \text{increment of total protein} > 8 \text{g/dL} \times 0.25
\]

**Potassium Formulas**

- **Diagnostic equations for hyperkalemia:**

\[
\frac{U_{K}/S_{K}}{U_{Cr}/S_{Cr}} \times 100\%
\]

**or**

\[
\frac{[(U_{K})/(U_{\text{osm}}/S_{\text{osm})}] \times S_{K}}{(U_{K} \times S_{\text{osm}})/(S_{K} \times U_{\text{osm}})}
\]

**Osmolality Formulas**

\[
\text{Calculated osmolality} = 2(\text{Na}^+ + \text{K}^+) + \frac{\text{Glucose}}{18} + \frac{\text{BUN}}{2.8}
\]

\[
\text{Effective osmolality} = 2(\text{Na}^+) + \frac{\text{Glucose}}{18}
\]

\[
\text{Osmolal gap} = \text{Measured osmolality} - \text{calculated osmolality}
\]

\( U_{K} \), urine potassium; \( S_{K} \), serum potassium; \( U_{Cr} \), urine creatinine; \( S_{Cr} \), serum creatinine; \( U_{\text{osm}} \), urine osmolality; \( S_{\text{osm}} \), serum osmolality.
**Box 1-7 Water Balance**

To estimate the amount of total body water (TBW), the following formula is frequently used:

\[
\text{TBW} = \text{Body weight (kg)} \times 60\%
\]

The water deficit of a patient can be estimated by the following equation:

\[
\text{Water deficit} = 0.6 \times \text{body weight in kg} \times \left( \frac{\text{P}_{\text{Na}}}{140} - 1 \right)
\]

where \( \text{P}_{\text{Na}} \) is plasma sodium concentration.

Alternatively, the free water deficit from the osmolality can be calculated as the following:

\[
\text{H}_2\text{O deficit (L)} = \text{Total body weight (kg)} \times 0.6 \left( 1 - \frac{\text{normal osm}}{\text{observed osm}} \right)
\]

To calculate the free water clearance based on the osmolar clearance, the following formula can be used:

\[
\text{Free water clearance} = \frac{\text{Urine volume} - \text{osmolar clearance}}{\text{Plasma osmolality}}
\]

\[
\text{Osmolar clearance} = \frac{\text{Urine osmolarity} \times \text{urine volume}}{\text{Plasma osmolality}}
\]

**TABLE 1-23 Daily Body Fluids**

<table>
<thead>
<tr>
<th>Fluid</th>
<th>Na (mEq/L)</th>
<th>K (mEq/L)</th>
<th>Cl (mEq/L)</th>
<th>HCO₃ (mEq/L)</th>
<th>Volume (mL/d)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Biliary</td>
<td>145</td>
<td>5</td>
<td>100</td>
<td>35</td>
<td>50-800</td>
</tr>
<tr>
<td>Diarrheal</td>
<td>60</td>
<td>35</td>
<td>40</td>
<td>30</td>
<td>Varies</td>
</tr>
<tr>
<td>Gastric</td>
<td>60</td>
<td>10</td>
<td>130</td>
<td>0</td>
<td>100-4000</td>
</tr>
<tr>
<td>Ileal</td>
<td>130</td>
<td>5</td>
<td>100</td>
<td>50</td>
<td>100-9000</td>
</tr>
<tr>
<td>Pancreatic</td>
<td>140</td>
<td>5</td>
<td>75</td>
<td>115</td>
<td>100-800</td>
</tr>
<tr>
<td>Salivary</td>
<td>10</td>
<td>26</td>
<td>10</td>
<td>30</td>
<td>500-2000</td>
</tr>
</tbody>
</table>

**TABLE 1-24 Replacement Fluids**

<table>
<thead>
<tr>
<th>Fluids</th>
<th>Na (mEq/L)</th>
<th>K (mEq/L)</th>
<th>Cl (mEq/L)</th>
<th>HCO₃ (mEq/L)</th>
<th>Ca (mEq/L)</th>
<th>Kcal/L</th>
</tr>
</thead>
<tbody>
<tr>
<td>(\frac{1}{2}) Normal saline</td>
<td>77</td>
<td>—</td>
<td>77</td>
<td>—</td>
<td>—</td>
<td>—</td>
</tr>
<tr>
<td>Normal saline</td>
<td>154</td>
<td>—</td>
<td>154</td>
<td>—</td>
<td>—</td>
<td>—</td>
</tr>
<tr>
<td>D₅W</td>
<td>—</td>
<td>—</td>
<td>—</td>
<td>—</td>
<td>—</td>
<td>170</td>
</tr>
<tr>
<td>D₁₀W</td>
<td>—</td>
<td>—</td>
<td>—</td>
<td>—</td>
<td>—</td>
<td>340</td>
</tr>
<tr>
<td>Lactated Ringer’s solution</td>
<td>130</td>
<td>4</td>
<td>109</td>
<td>28*</td>
<td>3</td>
<td>9</td>
</tr>
<tr>
<td>Extracellular fluid</td>
<td>141</td>
<td>4</td>
<td>—</td>
<td>27</td>
<td>5</td>
<td>—</td>
</tr>
</tbody>
</table>

*Lactate converted to HCO₃ in liver.
Box 1-8 • Calcium Formulas

The correction of Ca based on the serum albumin and globulin levels is calculated as:

\[ \% \text{Ca bound} = 8(\text{albumin}) + 2(\text{globulin}) + 3 \]

Another formula to correct Ca based on total protein is:

**Corrected Ca** = Measured Ca/(0.6 + [total protein/8.5])

A quick bedside formula for calculation of the corrected Ca is:

**Corrected Ca** = Measured Ca – albumin + 4

---

Box 1-9 • Nutrition Formulas

Basal energy expenditure (BEE) can be determined by the Harris-Benedict formulas:

\[ \text{BEE male} = 66.5 + [13.7 \times \text{wt (in kg)}] + [5 \times \text{ht (in cm)}] - [6.8 \times \text{age (in yr)}] \]

\[ \text{BEE female} = 655 + [9.6 \times \text{wt (in kg)}] + [1.7 \times \text{ht (in cm)}] - [4.7 \times \text{age (in yr)}] \]

For states other than basal, the BEE is multiplied by a correction factor:

- Low stress: 1.3 × BEE
- Moderate stress: 1.5 × BEE
- Cancer: 1.6 × BEE
- Sepsis (normotensive): 1.7 × BEE
- Severe stress: 2 × BEE
- Severe burn (>40% of body surface area, normotensive patient): 2.5 × BEE

---

Box 1-10 • Epidemiology Formulas

<table>
<thead>
<tr>
<th>Sensitivity, Specificity</th>
<th>(dz +)</th>
<th>(dz -)</th>
</tr>
</thead>
<tbody>
<tr>
<td>test + test –</td>
<td>a b c d</td>
<td></td>
</tr>
<tr>
<td>Sensitivity = (\frac{a}{a + c}) (screening test)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Specificity = (\frac{d}{b + d}) (confirming test)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Positive predictive value = (\frac{a}{a + b}) (influenced by prevalence)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Negative predictive value = (\frac{d}{b + d}) (influenced by prevalence)</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Odds Ratio, Relative Risk</th>
<th>(dz +)</th>
<th>(dz -)</th>
</tr>
</thead>
<tbody>
<tr>
<td>exposure + exposure –</td>
<td>a b c d</td>
<td></td>
</tr>
</tbody>
</table>

---

Box 1-11 • Miscellaneous Formulas

Parkland formula = 4 mL/kg × % burn
→ fluid given during 24 hr:
- Administer \(\frac{1}{2}\) of total in first 8 hr
- Administer \(\frac{1}{2}\) of total during next 16 hr

Volume of distribution = amount drug
in body/plasma drug concentration

Weight conversion: lb = kg × 2.2

Temperature conversion:
\[^\circ C = \left( ^\circ F - 32 \right) \left( \frac{5}{9} \right)\]

---

G. Formulary

1. IV DRIPS
   See Table 1-25.

2. STEROID CONVERSION TABLE
   See Table 1-26.

3. REGULAR INSULIN (SC) SLIDING SCALE
   See Table 1-27.
<table>
<thead>
<tr>
<th>Medication</th>
<th>Dose</th>
<th>Indication</th>
<th>Comments and Adverse Effects</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Vasopressors</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Dopamine</td>
<td>1-20 µg/kg/min</td>
<td>Cardiogenic, septic shock; low dose can preserve renal blood flow and promote urinary output</td>
<td>May cause tachyarrhythmias, ischemic limb necrosis</td>
</tr>
<tr>
<td>Phenylephrine (Neo-Synephrine [Bayer Corporation, West Haven, CT])</td>
<td>10-200 µg/min</td>
<td>Hypotension</td>
<td>Pure α agonist</td>
</tr>
<tr>
<td>Norepinephrine (Levophed [Abbott Laboratories, Abbott Park, IL])</td>
<td>1-20 µg/min</td>
<td>Septic shock w/hypotension refractory to dopa (low systemic vascular resistance and adequately resuscitated)</td>
<td>Potent α agonist (vasoconstrictor); avoid in cardiogenic shock</td>
</tr>
<tr>
<td>Vasopressin</td>
<td>0.01-0.04 unit/min</td>
<td>Refractory vasodilatory shock (late)</td>
<td>Avoid w/CAD</td>
</tr>
<tr>
<td>Dobutamine</td>
<td>2-20 µg/kg/min</td>
<td>Severe systolic heart failure</td>
<td>Inotrope and systemic vasodilator</td>
</tr>
<tr>
<td>Epinephrine</td>
<td>1-20 µg/min or 30-100 ng/kg/min</td>
<td>Second line for cardiogenic shock</td>
<td>Chronotrope, inotrope, and vasoconstrictor</td>
</tr>
<tr>
<td><strong>Antihypertensives</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Nitroprusside (Nipride [Roche Laboratories, Nutley, NJ])</td>
<td>0.5-5 µg/kg/min</td>
<td>Severe HTN (particularly w/low CO)</td>
<td>Potent vasodilator; caution in renal and hepatic failure (cyanide/thiocyanide toxicity); do not use alone in dissection (reflex tachycardia); can ↓ PaO₂ due to pulmonary shunting</td>
</tr>
<tr>
<td>Nitroglycerin</td>
<td>10-400 µg/min</td>
<td>Augment CO (intermediate dose), angina (low dose, typically 0.5-0.6 mg SL q5min); hypertensive crisis</td>
<td>Predominantly venodilator, mediated by nitric oxide; rapid onset; headache; ↑ ICP; methemoglobinemia; tachyphylaxis</td>
</tr>
<tr>
<td>Nicardipine</td>
<td>5-15 mg/hr</td>
<td>HTN, ↓ cerebral vasoconstriction</td>
<td>Potent CCB, vasodilator; renal clearance</td>
</tr>
<tr>
<td>Diltiazem</td>
<td>5-15 mg/hr</td>
<td>HTN, atrial fibrillation</td>
<td>CCB, monitor HR and BP, especially if also on β-blocker</td>
</tr>
<tr>
<td>Esmolol</td>
<td>50-300 µg/kg/min</td>
<td>HTN, particularly w/aortic dissection; supraventricular tachycardia</td>
<td>β₁-Blocker, short acting</td>
</tr>
<tr>
<td><strong>Paralytics</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Vecuronium</td>
<td>0.05-0.1 mg/kg/hr</td>
<td>Paralysis</td>
<td>Monitor muscle twitch (2/4 train-of-four); nondepolarizing; onset 1-2 min; caution w/renal failure; caution w/steroids (including myopathy)</td>
</tr>
<tr>
<td>Cisatracurium</td>
<td>0.5-10 µg/kg/min</td>
<td>Paralysis w/renal or hepatic failure</td>
<td>Nondepolarizing, Hoffman elimination</td>
</tr>
<tr>
<td><strong>Sedative</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Midazolam (Versed [Roche Laboratories, Nutley, NJ])</td>
<td>1-10 mg/hr</td>
<td>Sedation</td>
<td>Potent, short acting but can result in accumulation</td>
</tr>
</tbody>
</table>
TABLE 1-26  Steroid Conversion Scale

<table>
<thead>
<tr>
<th>Corticosteroids</th>
<th>Approximate Equivalent Dose (mg)</th>
<th>Relative Anti-inflammatory Potency</th>
<th>Relative Mineralocorticoid Potency</th>
<th>Biologic Half-life (hr)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Betamethasone</td>
<td>0.6-0.75</td>
<td>20-30</td>
<td>0</td>
<td>36-54</td>
</tr>
<tr>
<td>Cortisone</td>
<td>25</td>
<td>0.8</td>
<td>2</td>
<td>8-12</td>
</tr>
<tr>
<td>Dexamethasone</td>
<td>0.75</td>
<td>20-30</td>
<td>0</td>
<td>36-54</td>
</tr>
<tr>
<td>Hydrocortisone</td>
<td>20</td>
<td>1</td>
<td>2</td>
<td>8-12</td>
</tr>
<tr>
<td>Methylprednisolone</td>
<td>4</td>
<td>5</td>
<td>0</td>
<td>18-36</td>
</tr>
<tr>
<td>Prednisolone</td>
<td>5</td>
<td>4</td>
<td>1</td>
<td>18-36</td>
</tr>
<tr>
<td>Prednisone</td>
<td>5</td>
<td>4</td>
<td>1</td>
<td>18-36</td>
</tr>
<tr>
<td>Triamcinolone</td>
<td>4</td>
<td>5</td>
<td>0</td>
<td>18-36</td>
</tr>
</tbody>
</table>

TABLE 1-27  Regular Insulin (SC) Sliding Scale

<table>
<thead>
<tr>
<th>Finger Stick Blood Glucose</th>
<th>Mild Scale</th>
<th>Moderate Scale</th>
<th>Aggressive Scale</th>
</tr>
</thead>
<tbody>
<tr>
<td>&lt;60</td>
<td>1 amp (25 g) D50 or orange juice, call MD</td>
<td>1 amp D50 or orange juice, call MD</td>
<td>1 amp D50 or orange juice, call MD</td>
</tr>
<tr>
<td>60-150</td>
<td>No insulin</td>
<td>No insulin</td>
<td>No insulin</td>
</tr>
<tr>
<td>151-200</td>
<td>No insulin</td>
<td>3 units</td>
<td>4 units</td>
</tr>
<tr>
<td>201-250</td>
<td>2 units</td>
<td>5 units</td>
<td>6 units</td>
</tr>
<tr>
<td>251-300</td>
<td>4 units</td>
<td>7 units</td>
<td>10 units</td>
</tr>
<tr>
<td>301-350</td>
<td>6 units</td>
<td>9 units</td>
<td>12 units</td>
</tr>
<tr>
<td>351-400</td>
<td>8 units</td>
<td>11 units</td>
<td>15 units</td>
</tr>
<tr>
<td>&gt;400</td>
<td>10 units, call physician</td>
<td>13 units, call physician</td>
<td>18 units, call physician</td>
</tr>
</tbody>
</table>

4 OPIOID ANALGESICS DOSING TABLE
See Table 1-28.

5 HEPARIN SLIDING SCALE
See Box 1-12.

6 NUTRITION FEEDS
See Table 1-29.

7 THERAPY FOR COMMON SIDE EFFECTS

Nausea/Vomiting

- Metoclopramide (Reglan): 10-20 mg IV/PO q3-6h.
- Promethazine (Phenergan): 12.5-25 mg IV/PO/PR q4-6h.
- Droperidol: 0.625 mg IV q4-6h.
- Ondansetron (Zofran): 4-8 mg IV q4h.

Constipation

- Docusate sodium: 250 mg PO bid.
- MOM: 30 mL PO bid.
- Lactulose: 30 mL PO bid.
- Senokot: 1-4 tabs PO qd.
- Bisacodyl (Dulcolax): 5-10 mg PO or 10 mg PR qd.
- Fleets enema PRN.
- Magnesium citrate: 300 mL PO PRN.

Sedation

- Decrease dose.
- Add adjuvant.
- Change routes to minimize dose (IV to epidural).
- Change opiates.
- Adjust dosing schedule to normalize sleep-wake cycle.
- Avoid drugs w/sedating effects.

(text continues on page 91)
**TABLE 1-28 Opioid Dosing Table**

Equianalgesic dose refers to the amount of other opioid required to produce the same effect as 10 mg IV morphine. To convert between opioids, determine the morphine equivalent of the first drug. Convert the morphine dose to the new drug by use of the following table.

<table>
<thead>
<tr>
<th>Drug</th>
<th>Dose Ranges in Adults</th>
<th>Duration</th>
<th>Equianalgesic Dose to Morphine 10 mg IV</th>
<th>Patient-Controlled Analgesia Starting Doses</th>
<th>Comments</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Potent Opioids</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Morphine [Roxanol [Xanodyne Pharmaceuticals, Inc., Newport, KY], MS Contin [Purdue Pharmaceuticals, Stamford, CT]]</td>
<td>IM, IV, SC 2.5-20 mg q2-6h infusion: 0.5-10 mg/hr Oral prompt release: 10-30 mg q4h Oral extended release: 15-30 mg q8-12h Rectal suppository: 5-10 mg q4-6h</td>
<td>Parenteral: 3-5 hr Oral prompt release: 4 hr Oral extended release: 8-12 hr</td>
<td>Parenteral: 10 mg Oral: 30 mg</td>
<td>Basal: 1-2 mg/hr PCA: 2 mg q10min Range: 0.5-3 mg q10-20min</td>
<td>Potential accumulation of active metabolite morphine-6-glucoronide, which is renally excreted Avoid doses &gt;100 mg/hr Histamine release may cause local reaction</td>
</tr>
<tr>
<td>Fentanyl [Sublimaze [Janssen-Cilag, High Wycombe, UK], Duragesic [Ortho-McNeil Pharmaceutical, Raritan, NJ]]</td>
<td>IM, IV, SC 50-100 µg q30-60min Transdermal dose as µg/hr</td>
<td>Parenteral: 0.5-1 hr</td>
<td>Parenteral: 100 µg</td>
<td>Basal: 10 µg/hr PCA: 10 µg q10min Range: 10-50 µg q10min</td>
<td>Wide range of doses Transdermal system not for acute pain management</td>
</tr>
<tr>
<td>Hydromorphone [Dilaudid [Abbott Laboratories, Abbott Park, IL]]</td>
<td>IM, IV, SC 1-2 mg q4-6h Oral: 2-4 mg q4-6h Rectal suppository: 6 mg q4-6h</td>
<td>Parenteral: 3-4 hr Oral: 4-6 hr</td>
<td>Parenteral: 2 mg Oral: 4 mg</td>
<td>Basal: 0.2 mg/hr PCA: 0.2 mg q10min Range: 0.1-0.5 mg q10-15min</td>
<td>Avoid doses &gt;40 mg/hr Choice over morphine in hepatic impairment</td>
</tr>
<tr>
<td>Meperidine [Demerol [Sanofi-Aventis, Bridgewater, NJ]]</td>
<td>IM, IV 25-150 mg q3-4h</td>
<td>Parenteral: 2-4 hr Oral: 3-6 hr</td>
<td>Parenteral: 75 mg Oral: 300 mg</td>
<td></td>
<td>Oral route not recommended Active metabolite normeperidine accumulates in renal impairment and may cause seizures</td>
</tr>
<tr>
<td><strong>COMMON SIDE EFFECTS</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>-------------------------</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Chapter 1: Surviving the Wards</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

### Weak Opioids

- **Methadone** *(Dolophine [Roxane Laboratories, Inc., Columbus, OH]*)
  - IM, IV, PO
  - 2.5-150 mg q6h
  - Durations:
    - Parenteral: 4-8 hr
    - Oral: 4-12 hr
  - doses:
    - Parenteral: 5-10 mg
    - Oral: 5-10 mg
  - Methadone has variable half-life
  - Slow titration advised

- **Oxycodone** *(Percocet [Endo Pharmaceuticals, Chadds Ford, PA], Tylox [Ortho-McNeil Pharmaceutical, Raritan, NJ], OxyContin [Purdue Pharmaceuticals, Stamford, CT]*)
  - Oral prompt release:
    - 5-10 mg q3-4h
  - Oral extended release:
    - 10 mg q12h
  - Durations:
    - Oral: 4-5 hr
  - doses:
    - Oral: 15-30 mg
  - Note cumulative acetaminophen dosage
  - Adjust acetaminophen dose for liver impairment <2 g/24 hr

### Ultra-weak Opioid

- **Propoxyphene** *(Darvon, Darvocet N 100 [Xanodyne Pharmaceuticals, Inc., Newport, KY]*)
  - PO
  - 15-60 mg q4-6h
  - Max. 360 mg/24 hr
  - Durations:
    - Oral: 4-5 hr
  - doses:
    - Oral: 40 mg
  - Note cumulative acetaminophen dosage
  - Adjust acetaminophen dose for liver impairment <2 g/24 hr

### Miscellaneous

- **Tramadol** *(Ultram [Ortho-McNeil Pharmaceutical, Raritan, NJ]*)
  - PO
  - 50-100 mg q4-6h
  - Max. 400 mg/24 hr
  - Durations:
    - Oral: 4-6 hr
  - doses:
    - Oral: 300 mg
  - Seizure risk >400 mg/24 hr
  - Reduce dose in elderly, cirrhosis = 50 mg q12h
<table>
<thead>
<tr>
<th>Product</th>
<th>Energy</th>
<th>Protein</th>
<th>Fat</th>
<th>Carbohydrate</th>
<th>Ca (mg/L)</th>
<th>Phosphate (mg/L)</th>
<th>Na</th>
<th>K</th>
<th>Osm</th>
<th>Vol</th>
<th>% Free</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Oral Supplements: Intact Protein, Lactose Free</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Resource</td>
<td>1.06</td>
<td>38</td>
<td>0</td>
<td>230</td>
<td>42</td>
<td>680</td>
<td>&lt;358</td>
<td>&lt;84</td>
<td>750</td>
<td>N/A</td>
<td>83</td>
</tr>
<tr>
<td>Boost</td>
<td>1.01</td>
<td>43</td>
<td>18</td>
<td>170</td>
<td>1270</td>
<td>1060</td>
<td>550</td>
<td>1690</td>
<td>640</td>
<td>1180</td>
<td>84</td>
</tr>
<tr>
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<td>670</td>
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<td>39</td>
<td>43</td>
<td>101</td>
<td>1390</td>
<td>1310</td>
<td>850</td>
<td>1820</td>
<td>400</td>
<td>1310</td>
<td>85</td>
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<td><strong>Tube Feeding: Intact Protein, Lactose Free</strong></td>
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<td>44</td>
<td>135</td>
<td>630</td>
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<td>270</td>
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<td><strong>Special Formulations</strong></td>
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<td>570</td>
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<td>Suplena</td>
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<td>96</td>
<td>255</td>
<td>1430</td>
<td>730</td>
<td>790</td>
<td>1120</td>
<td>600</td>
<td>947</td>
<td>71.2</td>
</tr>
</tbody>
</table>

**TABLE 1-29 Nutrition Feeds**
Box 1.12 • Heparin Dosage Regimens

1. Weight-Based Nomogram
The initial dose is a bolus of 80 U/kg body weight, followed by an infusion starting at a rate of 18 U/kg/hr. The APTT is measured every 6 hr, and the heparin dose is adjusted as follows.

<table>
<thead>
<tr>
<th>Measured Value</th>
<th>Adjustment</th>
</tr>
</thead>
<tbody>
<tr>
<td>PTT &lt;35 sec (&lt;1.2 × control value)</td>
<td>80 U/kg as bolus, then ↑ infusion rate by 4 U/kg/hr</td>
</tr>
<tr>
<td>APTT 35-45 sec (1.2-1.5 × control value)</td>
<td>40 U/kg as bolus, then ↑ infusion rate by 2 U/kg/hr</td>
</tr>
<tr>
<td>APTT 46-70 sec (&gt;1.5-2.3 × control value)</td>
<td>No change</td>
</tr>
<tr>
<td>APTT 71-90 sec (&gt;2.3-3 × control value)</td>
<td>↓ Infusion rate by 2 U/kg/hr</td>
</tr>
<tr>
<td>APTT &gt;90 sec (&gt;3 × control value)</td>
<td>Stop infusion for 1 hr, then ↓ infusion rate by 3 U/kg/hr</td>
</tr>
</tbody>
</table>

2. 5000-U Bolus Dose, Followed by 1280 U/hr

<table>
<thead>
<tr>
<th>APTT (sec)</th>
<th>Bolus (U)</th>
<th>Rate of Change (mL/hr)</th>
<th>Repeat APTT</th>
</tr>
</thead>
<tbody>
<tr>
<td>&lt;50*</td>
<td>5000</td>
<td>+3</td>
<td>In 6 hr</td>
</tr>
<tr>
<td>50-59</td>
<td>0</td>
<td>+3</td>
<td>In 6 hr</td>
</tr>
<tr>
<td>60-85</td>
<td>0</td>
<td>0</td>
<td>Next morning</td>
</tr>
<tr>
<td>86-95</td>
<td>0</td>
<td>–2</td>
<td>Next morning</td>
</tr>
<tr>
<td>96-120</td>
<td>30</td>
<td>–2</td>
<td>In 6 hr</td>
</tr>
<tr>
<td>&gt;120</td>
<td>60</td>
<td>–4</td>
<td>In 6 hr</td>
</tr>
</tbody>
</table>

3. Intravenous Dose-Titration Nomogram for APTT
The starting dose is a 5000-U bolus, followed by 40,000 U/24 hr (if the patient has a low risk of bleeding) or 30,000 U/24 hr (if there is a high risk of bleeding).

<table>
<thead>
<tr>
<th>APTT (sec)</th>
<th>Rate of Change (mL/hr)</th>
<th>Change in Dose (U/24 hr)</th>
<th>Additional Action</th>
</tr>
</thead>
<tbody>
<tr>
<td>≤45</td>
<td>+6</td>
<td>+5760</td>
<td>Repeat APTT in 4-6 hr</td>
</tr>
<tr>
<td>46-54</td>
<td>+3</td>
<td>+2880</td>
<td>Repeat APTT in 4-6 hr</td>
</tr>
<tr>
<td>55-85</td>
<td>0</td>
<td>0</td>
<td>None†</td>
</tr>
<tr>
<td>86-110</td>
<td>–3</td>
<td>–2880</td>
<td>Stop heparin for 1 hr; repeat APTT 4-6 hr after restarting heparin Rx</td>
</tr>
<tr>
<td>&gt;110</td>
<td>–6</td>
<td>–5760</td>
<td>Stop heparin for 1 hr; repeat APTT 4-6 hr after restarting heparin Rx</td>
</tr>
</tbody>
</table>

*If the APTT is subtherapeutic despite a heparin dose of at least 1440 U/hr (36 mL/hr) at any time during the first 48 hours of therapy, the response to an APTT of <50 sec is a bolus of 5000 U and a rate increase of 5 mL/hr.
†A heparin sodium concentration of 20,000 U in 500 mL is equal to 40 U/mL.
‡During the first 24 hours, repeat the APTT in 4 to 6 hours. Thereafter, the APTT is determined once daily, unless the value is in the therapeutic range.

Note: 1 mL/hr = 40 U/hr.

Pruritus
- Diphenhydramine (Benadryl): 10-25 mg IV/PO q4-6h.
- Hydroxyzine (Atarax, Vistaril): 25 mg PO/IM q6h.
- Nalbuphine (Nubain): 2.5-5 mg IV q2-4h.

Key Concepts
- Administer on scheduled basis.
- Provide PRN for breakthrough pain.
- Consider adjuvants (NSAIDs, antidepressant sleep agents, anesthetics).

Reference
H. DVT Prophylaxis

1. Risk score for venous thromboembolism in hospitalized pts is shown in Table 1-30 (high risk is ≥4).

2. Options for thromboprophylaxis in hospitalized medical pts:
   a. Unfractionated heparin: (UFH) 5000 U SC tid
   b. Enoxaparin: 40 mg SC qd
   c. Dalteparin: starting dose is 100 to 200 U/kg, then 5000 U SC qd
   d. Fondaparinux: 2.5 mg SC qd
   e. Graduated compression stockings or pneumatic compression device (for pts w/contraindications to anticoagulation)

### TABLE 1-30 Risk Score for Venous Thromboembolism in Hospitalized Patients

<table>
<thead>
<tr>
<th>Risk Factor</th>
<th>Points</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cancer</td>
<td>3</td>
</tr>
<tr>
<td>Prior venous thromboembolism</td>
<td>3</td>
</tr>
<tr>
<td>Hypercoagulability</td>
<td>3</td>
</tr>
<tr>
<td>Major surgery</td>
<td>2</td>
</tr>
<tr>
<td>Advanced age</td>
<td>1</td>
</tr>
<tr>
<td>Obesity</td>
<td>1</td>
</tr>
<tr>
<td>Bed rest</td>
<td>1</td>
</tr>
<tr>
<td>Use of hormone replacement therapy or oral contraceptives</td>
<td>1</td>
</tr>
</tbody>
</table>

References

American College of Cardiology/American Heart Association Task Force on Practice Guidelines (ACC/AHA/NASPE).


I. ACLS ALGORITHMS

1 PULSELESS ARREST

See Figure 1-15.

2 BRADYCARDIA

See Figure 1-16.

3 TACHYCARDIA

See Figure 1-17.
**PULSELESS ARREST**

1. BLS Algorithm: Call for help, give CPR
2. Give oxygen when available
3. Attach monitor/defibrillator when available

**Shockable**

4. Give 1 shock
   - Manual biphasic: device specific (typically 120 to 200 J) Note: If unknown use 200 J
   - AED: device specific
   - Monophasic: 360 J
   - Resume CPR immediately

5. Check rhythm
   - Shockable rhythm?
   - Yes: Go to Box 7
   - No: Give 5 cycles of CPR*

6. Continue CPR while defibrillator is charging
   - Give 1 shock
   - Manual biphasic: device specific (same as first shock or higher dose)
     - Note: If unknown, use 200 J
   - AED: device specific
   - Monophasic: 360 J
   - Resume CPR immediately after the shock
   - When IV/IO available, give vasopressor during CPR (before or after the shock)
   - Epinephrine 1 mg IV/IO
     - Repeat every 3 to 5 min
   - or
   - May give 1 dose of vasopressin 40 U IV/IO to replace first or second dose of epinephrine

7. Check rhythm
   - Shockable rhythm?
   - No: Give 5 cycles of CPR*
   - Yes: Go to Box 10

8. Continue CPR while defibrillator is charging
   - Give 1 shock
   - Manual biphasic: device specific (same as first shock or higher dose) Note: If unknown, use 200 J
   - AED: device specific
   - Monophasic: 360 J
   - Resume CPR immediately after the shock
   - Consider antiarrhythmics: give during CPR (before or after the shock)
     - amiodarone (300 mg IV/IO once, then consider additional 150 mg IV/IO once) or lidocaine
     - (1 to 1.5 mg/kg first dose, then 0.5 to 0.75 mg/kg IV/IO, maximum 3 doses or 3 mg/kg)
   - Consider magnesium, loading dose 1 to 2 g IV/IO for torsades de pointes
   - After 5 cycles of CPR, * go to Box 5 above

9. Asystole/PEA
   - Resume CPR immediately for 5 cycles
   - When IV/IO available, give vasopressor
     - Epinephrine 1 mg IV/IO
     - Repeat every 3 to 5 min
   - or
   - May give 1 dose of vasopressin 40 U IV/IO to replace first or second dose of epinephrine

10. Check rhythm
    - Shockable rhythm?
    - No: Give 5 cycles of CPR*
    - Yes: Go to Box 13

11. Check rhythm
    - Not shockable
    - Shockable
    - Resume CPR immediately for 5 cycles
    - Check rhythm
    - Shockable rhythm?
    - No: Give 5 cycles of CPR*
    - Yes: Go to Box 4

12. Check rhythm
    - Not shockable
    - Shockable
    - If asystole, go to Box 10
    - If electrical activity, check pulse. If no pulse, go to Box 10
    - If pulse present, begin postresuscitation care

13. Consider atropine 1 mg IV/IO for asystole or slow PEA rate
    - Repeat every 3 to 5 min (up to 3 doses)

**During CPR**

- Push hard and hard (100/min)
- Ensure full chest recoil
- Minimize interruptions in chest compressions
- One cycle of CPR: 30 compressions then 2 breaths; 5 cycles = 2 min
- Avoid hyperventilation
- Secure airway and confirm placement
- After an advanced airway is placed, rescuers no longer deliver “cycles” of CPR. Give continuous chest compressions without pauses for breaths. Give 8 to 10 breaths/minute. Check rhythm every 2 minutes
- Rotate compressors every 2 minutes with rhythm checks
- Search for and treat possible contributing factors:
  - Hypovolemia
  - Hypoxia
  - Hydrogen ion (acidosis)
  - Hypo-/hyperkalemia
  - Hypoglycemia
  - Hypothermia
  - Toxins
  - Tamponade, cardiac
  - Tension pneumothorax
  - Thrombosis (coronary or pulmonary)
  - Trauma

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**FIGURE 1-15.** Pulseless arrest algorithm.
1. **BRADYCARDIA**
   - Heart rate < 60 bpm and inadequate for clinical condition

2. • Maintain patient airway; assist breathing as needed
   • Give oxygen
   • Monitor ECG (identify rhythm), blood pressure, oximetry
   • Establish IV access

3. **Signs or symptoms of poor perfusion caused by the bradycardia?**
   (e.g. acute altered mental status, ongoing chest pain, hypotension or other signs of shock)

4A. **Observe/Monitor**

**Adequate perfusion**

**Poor perfusion**

- Prepare for transcutaneous pacing; use without delay for high-degree block (type II second-degree block or third-degree AV block)
- Consider atropine 0.5 mg IV while awaiting pacemaker. May repeat to a total dose of 3 mg. If ineffective, begin pacing
- Consider epinephrine (2 to 10 μg/min) or dopamine (2 to 10 μg/kg per min) infusion while awaiting pacemaker or if pacing ineffective

- Prepare for transvenous pacing
  - Treat contributing causes
  - Consider expert consultation

**Reminders**
- If pulseless arrest develops, go to Pulseless Arrest Algorithm
- Search for and treat possible contributing factors:
  - Hypovolemia
  - Hypoxia
  - Hypoglycemia
  - Hypothermia
  - Hypo-/hyperkalemia
  - Hypo-/hyperkalemia
  - Tension pneumothorax
  - Thrombosis (coronary or pulmonary)
  - Toxicity (e.g. amphetamines, cocaine, heroin)
  - Tamponade, cardiac
  - Trauma (hypovolemia, increased ICP)

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**FIGURE 1-16.** Bradycardia algorithm.
TACHYCARDIA

1. With pulses
   - Assess and support ABCs as needed
   - Give oxygen
   - Monitor ECG (identify rhythm), blood pressure, oximetry
   - Identify and treat reversible causes

2. Symptoms persist
   - Perform immediate synchronized cardioversion
     - Establish IV access and give sedation if patient is conscious; do not delay cardioversion
     - Consider expert consultation
     - If pulseless arrest develops, see Pulseless Arrest Algorithm

3. Is patient stable?
   - Unstable signs include altered mental status, ongoing chest pain, hypotension or other signs of shock
     - Note: rate-related symptoms uncommon if heart rate < 150/min

4. Stable
   - Establish IV access
   - Obtain 12-lead ECG (when available) or rhythm strip

5. Is QRS narrow (< 0.12 sec)?
   - Narrow
     - NARROW ORS*: Is rhythm regular?
       - Regular
         - Attempt vagal maneuvers
         - Give adenosine 6 mg rapid IV push. If no conversion, give 12 mg rapid IV push; may repeat 12 mg dose once

     - Irregular Narrow-Complex Tachycardia
       - Probable atrial fibrillation or possible atrial flutter or MAT (multifocal atrial tachycardia)
       - Consider expert consultation
       - Control rate (eg. diltiazem, β-blockers; use β-blockers with caution in pulmonary disease or CHF)

   - Irregular
     - Irregular Narrow-Complex Tachycardia (reentry supraventricular tachycardia):
       - Observe for recurrence
       - Treat recurrence with adenosine or longer-acting AV nodal blocking agents (eg. diltiazem, β-blockers)

     - If rhythm converts, probable reentry SVT: (go to Box 4)
       - Note: If patient becomes unstable, go to Box 4

     - If rhythm does NOT convert, possible atrial flutter, ectopic atrial tachycardia, or junctional tachycardia:
       - Control rate (eg. diltiazem, β-blockers; use β-blockers with caution in pulmonary disease or CHF)
       - Treat underlying cause
       - Consider expert consultation

6. Does rhythm convert?
   - Regular
     - Irregular
     - Note: Consider expert consultation
     - If rhythm converts, probable reentry SVT (reentry supraventricular tachycardia):
       - See Irregular Narrow-Complex Tachycardia (Box 11)
     - If atrial fibrillation with aberrancy
       - See Irregular Narrow-Complex Tachycardia (Box 11)
     - If pre-excited atrial fibrillation (AF + WPW)
       - Expert consultation advised
       - Avoid AV nodal blocking agents (eg. adenosine, digoxin, diltiazem, verapamil)
       - Consider antiarrhythmics (eg. amiodarone 150 mg IV over 10 min)

8. If ventricular tachycardia or uncertain rhythm
   - Amiodarone 150 mg IV over 10 min Repeat as needed to maximum dose of 2.2 g/24 hours
   - Prepare for elective synchronized cardioversion

9. If SVT with aberrancy
   - Give adenosine (go to Box 7)
   - If atrial fibrillation with aberrancy
     - See Irregular Narrow-Complex Tachycardia (Box 11)
   - If pre-excited atrial fibrillation (AF + WPW)
     - Expert consultation advised
     - Avoid AV nodal blocking agents (eg. adenosine, digoxin, diltiazem, verapamil)
     - Consider antiarrhythmics (eg. amiodarone 150 mg IV over 10 min)
   - If recurrent polymorphic VT, seek expert consultation

10. If torsades de pointes, give magnesium (load with 1-2 g over 5-60 min, then infusion)

12. WIDE QRS*: Is Rhythm regular?
    - Expert consultation advised
    - If ventricular tachycardia or uncertain rhythm
      - Amiodarone 150 mg IV over 10 min Repeat as needed to maximum dose of 2.2 g/24 hours
      - Prepare for elective synchronized cardioversion

14. If torsades de pointes, give magnesium (load with 1-2 g over 5-60 min, then infusion)

During evaluation
- Secure, verify airway and vascular access when possible
- Consider expert consultation
- Prepare for cardioversion

Treat possible contributing factors:
- Hypovolemia
- Hypoxia
- Hydrogen ion (acidosis)
- Hypo/hyperkalemia
- Hypoglycemia
- Hypothermia
- Toxins
- Tamponade, cardiac
- Tension pneumothorax
- Thrombosis (coronary or pulmonary)
- Trauma (hypovolemia)

FIGURE 1-17. Tachycardia algorithm.