REFERENCES & HELPFUL RESOURCES
1. UpToDate online
2. Pocket Medicine, Marc S. Sabatine editor, 2000
3. Internal Medicine Clerkship Guide, Douglas Paauw et al., 2007
4. Harrison’s Principles of Internal Medicine
5. Cecil’s Essentials of Medicine
6. Evidence-Based Physical Diagnosis, Steven McGee, 2007
7. Washington Manual of Internal Medicine
8. Sapira’s Art and Science of Bedside Diagnosis, 2005 (3rd edition)

WARD TIPS
1. Be on time!
2. Preround before morning rounds.
3. If you don’t understand something, ask.
4. Be sure to eat, drink enough fluids, and go to the bathroom. You can’t take good care of others if you don’t take care of yourself.
5. Try to get enough sleep.
6. Make every attempt to go to teaching conferences, including morning report.
7. Keep up on reading, patient write-ups, and studying for the final exam.

SELECTED TOPICS IN INTERNAL MEDICINE
Fluids
Total Body Water and Compartments:
TBW is approximately 60% of weight in males and 50-55% in females
- Value varies with age, sex and lean body mass
- Lowest in the elderly and obese; highest in the lean and young
Divided into two main compartments:
Intracellular = 2/3 of TBW (approximately 40% of body weight)
Extracellular = 1/3 of TBW (approximately 20% of body weight)
  a. Interstitial fluid = 3/4 of ECF (approximately 16% of body weight)
  b. Intravascular fluid = 1/4 of ECF (approximately 4% of body weight)
     Na is the main extracellular cation
     K is main intracellular cation

Signs of volume depletion
- Weight loss, postural hypotension, decreased skin turgor, dry mucous membranes, oliguria, tachycardia, increased BUN/ Cr ration

Signs of volume overload (often iatrogenic):
- Weight gain, jugular venous distension, edema, rales

Volume resuscitation in a volume depleted patient: Assess fluid status often
- If hypotensive: choose fluid that stays in the intravascular space (NS or Ringer’s)
- Ringer’s has K+ so use with caution in renal failure/anuric patients
- Lactate is converted to HCO₃ in body, buffers acid.
- Use LR for large infusions, NS can → non-gap hyperchloremic metabolic acidosis.

**COMPARISON OF ECF TO CRYSTALLOID SOLUTIONS**

<table>
<thead>
<tr>
<th></th>
<th>ECF</th>
<th>NS</th>
<th>1/2NS</th>
<th>LR</th>
<th>D5W</th>
<th>3%NS</th>
</tr>
</thead>
<tbody>
<tr>
<td>Na⁺</td>
<td>142</td>
<td>154</td>
<td>77</td>
<td>130</td>
<td>0</td>
<td>513</td>
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<tr>
<td>Cl⁻</td>
<td>103</td>
<td>154</td>
<td>77</td>
<td>109</td>
<td>0</td>
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<tr>
<td>K⁺</td>
<td>4</td>
<td>0</td>
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<td>4</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Ca++</td>
<td>5</td>
<td>0</td>
<td>0</td>
<td>3</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>HCO₃⁻</td>
<td>27</td>
<td>0</td>
<td>0</td>
<td>28</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>pH</td>
<td>7.4</td>
<td>4</td>
<td>4.9</td>
<td>6.7</td>
<td>5</td>
<td></td>
</tr>
</tbody>
</table>

Avg. Daily Water Losses

<table>
<thead>
<tr>
<th></th>
<th>Avg. Daily Electrolyte losses</th>
</tr>
</thead>
<tbody>
<tr>
<td>Urinary</td>
<td>Na⁺ 100mEq</td>
</tr>
<tr>
<td>Intestinal</td>
<td>K⁺ 100 mEq</td>
</tr>
<tr>
<td>Lungs, skin  600-900</td>
<td>Cl⁻ 150mEq</td>
</tr>
</tbody>
</table>

Maintenance needs for fluids and electrolytes

Water

| Na⁺ | 1 mEq/kg |
| K⁺ | 1 mEq/kg |
| Cl⁻ | 1.5 mEq/kg |

Use D51/2NS for maintenance.

Calculate Maintenance fluids: 4:2:1 rule

For first 10 kg 4 mL/kg/hr
For next 10 kg 2 mL/kg/hr
For each kg over 20 1/mL/kg/hr

70 kg man = 40 + 20 + 50 = 110cc/hr

Electrolyte Abnormalities

**Hypernatremia** (Na > 145 mEq/L, deficit of water relative to Na)

Causes Reduced water intake, hypothalamic dysfunction (reduced thirst), inability to get to water (most common), increased water loss, insensible losses (burns, fever/heat, mechanical ventilation), GI loss (vomiting, NG tube, diarrhea), renal loss (central diabetes insipidus, nephrogenic diabetes insipidus, osmotic diuresis), hypertonic infusions, water shift out of extracellular fluid compartment, seizure, extreme exercise

History/sxs Lethargy, weakness, thirst, restlessness, oliguria/anuria, irritability that can progress to seizures, coma and death

PE Vital signs (BP, orthostatics, temperature), dry mouth and mucous membranes, flushed skin, lack of tears and decreased salivation, hyperreflexia

Work-up ASSESS VOLUME STATUS (vital signs, orthostatics, JVP, skin turgor, mucous membranes, edema, BUN/Cr, uric acid)

- If hypovolemic: get urine Na to determine if cause is extra/intrarenal
  - If intrarenal: urine Na > 20 mEq/L
  - If extrarenal: urine Na < 20 mEq/L
- If euvolemic: determine ADH activity with urine osms
  Uosm <300 and increased urine volume may be complete DI
  Uosm 300-600 and increased urine volume may be secondary to renal losses
  (diuretics, osmotic diuresis), partial DI, or reset osmostat
  Uosm >600 may be extrarenal H2O loss (GI or insensible)
- If hypervolemic: usually exogenous NaCl infusion/resuscitation or mineralocorticoid excess

Rx
If hypovolemic, restore intravascular volume with isotonic fluid first, then replace free water. Calculate free water deficit:
FWD = { 0.6 x ideal body weight x [(Na/140) - 1] } (x 0.85 in women)
Replace about 50% in the first 24 hours (too quickly -> cerebral edema)

If patient is hypervolemic: loop diuretics + D5W
With central DI, use DDAVP
With nephrogenic DI, treat underlying cause, salt restriction, thiazide diuretics

Hyponatremia (Na < 130 mEq/L, excess of water relative to Na)

History/sxs
Lethargy, disorientation, weakness, muscle cramps, anorexia, nausea/vomiting, agitation, stupor, seizures

PE
Vital signs (BP, orthostatics, temperature), edema, ascites, lung crackles, decreased deep tendon reflexes, positive Babinski, Cheyne-Stokes respiration

Work-up/dx Determine tonicity
Hypertonic hyponatremia: Presence of another effective osmole in excess (glucose, mannitol). Rule out pseudohyponatremia first!
For every 100 mg/dL rise in glucose above 100 the Na will decrease by 1.6 mEq/L
Isotonic hyponatremia: Secondary to hyperlipidemia/hyperproteinemia
Hypotonic hyponatremia: True excess of water relative to Na

For hypotonic hyponatremia next determine volume status (vitals, orthostatics, JVP, etc)

If hypovolemic:
Renal if Urine sodium is > 20. Causes include diuresis, hypoaldo, salt-wasting nephropathy
Extrarenal if urine sodium is < 20. Causes include GI losses, third-spacing, insensible losses

If hypervolemic:
CHF, nephrotic syndrome, cirrhosis

If euvolemic:
SIADH, psychogenic polydipsia, reset osmostat. Know the meds that cause hyponatremia- hydrochlorathiazide, SSRI's, carbamezepine.

Rx
Hypovolemic: Correct Na deficit.
Deficit=0.6 x body weight x(140 - measured Na)(x .85 in women)
Overly rapid correction may lead to central pontine myelinosis
Rate of correction should not exceed 0.5 mEq/L/hr
Hypervolemic: sodium and water restriction, diuretics
Euvolemic: water restrict
Hypokalemia (K < 3.5-3.7)

**Causes**
1) Diuretics 2) GI losses (vomiting, diarrhea) 3) Low magnesium (common in alcoholics). Other causes: Increased entry into cells, metabolic acidosis, increased beta-adrenergic activity, increased urinary loss, primary hyperaldosteronism, secondary hyperaldosteronism, renal tubular acidosis types I and II, very low intake

**Signs/Sxs**
Muscle cramps, ileus, weakness, nausea, vomiting, rhabdomyolysis, arrhythmias, hyperglycemia, polyuria, polydipsia

**EKG Δs**
Prominent U wave, flattened T wave, prolonged QT, AV block, ventricular ectopy

**Work-up**
Urine K+ to determine if loss is extra/intrarenal

<table>
<thead>
<tr>
<th>High Urinary K+ (renal loss)</th>
<th>Low Urinary K+</th>
</tr>
</thead>
<tbody>
<tr>
<td>Metabolic acidosis</td>
<td>GI loss</td>
</tr>
<tr>
<td>Renal tubular acidosis</td>
<td>Internal shifts</td>
</tr>
<tr>
<td>Drugs</td>
<td>Insulin, beta2-agonists, alkalosis</td>
</tr>
<tr>
<td>Acetazolamide</td>
<td>Dietary deficiency</td>
</tr>
<tr>
<td>Metabolic alkalosis</td>
<td></td>
</tr>
</tbody>
</table>

**Rx**
Administer K+: orally if possible, IV if necessary
For urinary wasting consider K+ sparing diuretic

### Hyperkalemia (K > 5.0)

**Causes**
Increased intake, metabolic acidosis, insulin deficiency or hyperglycemia, beta adrenergic blockade, rhabdomyolysis, reduced K+ excretion, renal failure, hypoaldosteronism, drugs, (K+ sparing diuretics, ACE-I, TMP-SMX, succ, dig, beta-blockers), pseudohyperkalemia secondary to hemolyzed blood sample

**Signs/Sxs**
Ileus, constipation, weakness, hypotension, arrhythmias

**EKG Δs**
Peaked T waves, flattened P waves, widened QRS that can progress to sine wave pattern that is life-threatening

**Rx**
Administer Ca++ to stabilize membranes
Increase K+ entry into cells
- Insulin and glucose (amp of D50)
- Beta-adrenergic agonists
Sodium bicarb
Increase renal excretion by administering kaliuretic diuretics
Induce diarrhea, use K+-binding resin
Hemodialysis

### Hypocalcemia (Ca < 8.5)

**Causes**
Decreased Mg, sepsis, alkalosis (increased Ca binding to albumin causing decreased ionized Ca), blood transfusion (Ca binds to citrate), renal failure (increased PO4 binds Ca), hypoparathyroidism, pancreatitis

**Signs/Sxs**
Tetany, hyperreflexia, Chvostek's and Trousseau's signs, ventricular ectopy, hypotension

**Rx**
CaCl: centrally for severe hypocalcemia
Calcium gluconate
Monitor for vasoconstrictive ischemia

**Hypercalcemia (Ca > 10.5)**

**Causes**
Hyperparathyroidism, malignancy, thiazides, vitamin D excess, sarcoid, TB, Milk alkali syndrome, Paget’s dz, Addison’s dz, acromegaly, Ca intake

**Signs/Sxs**
Hypovolemia, nausea, vomiting, ileus, shortened QT interval, coma

**Rx**
Correct hypovolemia and promote Ca clearance with NS
Lasix to get UOP >100 cc/hour
Pamidronate
Dialysis

**Hypophosphatemia (PO₄ < 3.0)**

**Causes**
Hormone alterations (hyperparathyroidism), alcohol, intracellular shifts (beta-agonists), decreased nutritional intake, GI disease, Vit D deficiency, glucose loading (PO₄ enters cells with glucose), respiratory alkalosis, sepsis, DKA (leads to osmotic diuresis and PO₄ loss)

**Signs/Sxs**
Reduced myocardial contractility, reduced ATP production, severe hemolytic anemia, impaired leukocyte function, platelet disorders, myopathy, metabolic encephalopathy

**Rx**
Replace with nutritional source (i.e. milk), Fleet enema orally
IV if levels are less than 1mg/dL

**Hyperphosphatemia**

**Causes**
Increased administration orally, intravenously, or rectally, hypoparathyroidism, pseudohyperparathyroidism, acromegaly, tumor cell lysis, rhabdomyolysis, renal insufficiency

**Rx**
Phosphate binders, dialysis

**Hypomagnesemia (Mg < 1.5)**

**Causes**
Decreased intake, GI or renal loss, malabsorption, redistribution out of ECF, chronic thiazide and loop diuretic use, primary hypoaldosteronism, chronic alcoholism or alcohol withdrawal, toxins (amp B, cyclosporine, aminoglycosides, pentamidine), complicated by hypocalcemia and hypokalemia, inherited renal tubular defects, serum levels may be normal despite total body depletion because most of the stores are in bone, muscle and soft tissue

**Signs/Sxs**
Tetany, lethargy, anorexia, convulsions, arrhythmias

**Rx**
Moderate deficiency can be replaced orally but Mg is poorly absorbed by the GI tract and large doses of magnesium can cause diarrhea
Severe deficits require parenteral replacement

**Hypermagnesemia**

**Causes**
Excessive exogenous load (IV infusion, oral salts, magnesium salt enemas), renal insufficiency

**Signs/Sxs**
Diminished deep tendon reflexes that may progress to flaccid paralysis, bradycardia, hypotension, heart block secondary to the calcium channel blocking effects of high magnesium

**Rx**
ECF expansion and loop diuretics, dialysis if severe

**Acid-Base Disturbances**

**Definition**
acidemia – arterial blood pH < 7.36  
akalemia – arterial blood pH > 7.44  
acidosis – process that causes the accumulation of H⁺  
alkalosis – process that causes the accumulation of OH⁻

General Approach
1. Identify the primary process.  
2. Identify the compensatory process.  
3. Calculate the anion gap correcting for low albumin.  
4. If the anion gap is elevated, calculate osmolar gap.  
5. If the anion gap is elevated, use delta-delta to find simultaneous metabolic disorders.  
6. Use clues from the history and physical exam (particularly, assess volume status by checking orthostatics) to determine specific conditions causing alterations.  

(Courtesy of “Internal Medicine Clerkship Guide,” 2007; by Paauw, Burkholder and Migeon.)

History
Ingestion (ethylene glycol, paraldehyde, etc.), vomiting, diarrhea, blurry vision, fever, neurological status, alcohol use, H/O type 1 diabetes mellitus (precipitants include infection, lack of insulin, and new-onset diabetes), medication history

<table>
<thead>
<tr>
<th>PRIMARY DISORDERS*</th>
<th>pH</th>
<th>P_aCO₂</th>
<th>HCO₃⁻</th>
</tr>
</thead>
<tbody>
<tr>
<td>Metabolic acidosis</td>
<td>gain of H⁺ or loss of HCO₃⁻</td>
<td>↓</td>
<td>↓</td>
</tr>
<tr>
<td>Metabolic alkalosis</td>
<td>loss of H⁺ or gain of HCO₃⁻</td>
<td>↑</td>
<td>↑</td>
</tr>
<tr>
<td>Respiratory acidosis</td>
<td>hypoventilation</td>
<td>↓</td>
<td>↑</td>
</tr>
<tr>
<td>Respiratory alkalosis</td>
<td>hyperventilation</td>
<td>↑</td>
<td>↓</td>
</tr>
</tbody>
</table>

(Adapted from “Pocket Medicine,” 2000; edited by Sabatine.)

*Numerous processes may occur simultaneously. (If three primary disorders co-exist, then it is known as the “triple ripple.” Note that there cannot be two co-existent respiratory disorders.)

Compensation
- Occurs when the respiratory or renal system reacts to correct an altered pH  
- It never fully corrects an altered pH; if the pH is normal, consider a mixed disorder  

- Respiratory: Hyper- or hypoventilation to alter the P_aCO₂ to counteract primary metabolic process (respiratory compensation takes minutes)  
- Renal: Excretion or retention of H⁺ /HCO₃⁻ by kidneys to counteract primary respiratory process (renal compensation take hours to days)
RULES OF COMPENSATION

<table>
<thead>
<tr>
<th>Primary disorder</th>
<th>Mechanism</th>
<th>Mixed Disorders</th>
</tr>
</thead>
<tbody>
<tr>
<td>Metabolic acidosis</td>
<td>↓ ( P_a CO_2 = 1.25 \times \Delta HCO_3 ) (( P_a CO_2 ) ~ last two digits of pH)</td>
<td>If ( P_a CO_2 ) is too low → concomitant 1° respiratory alkalosis</td>
</tr>
<tr>
<td>Metabolic alkalosis</td>
<td>↑ ( P_a CO_2 = 0.75 \times \Delta HCO_3 ) (through hypoventilation)</td>
<td>If ( P_a CO_2 ) is too high → concomitant 1° respiratory acidosis</td>
</tr>
<tr>
<td>Acute respiratory acidosis*</td>
<td>↑ ( HCO_3 = 0.1 \times \Delta P_a CO_2 ) (or ↓ ( pH = 0.008 \times \Delta P_a CO_2 ))</td>
<td>If ( HCO_3 ) is too high → concomitant 1° metabolic acidosis</td>
</tr>
<tr>
<td>Chronic respiratory acidosis</td>
<td>↑ ( HCO_3 = 0.4 \times \Delta P_a CO_2 ) (or ↓ ( pH = 0.003 \times \Delta P_a CO_2 ))</td>
<td></td>
</tr>
<tr>
<td>Acute respiratory alkalosis</td>
<td>↓ ( HCO_3 = 0.2 \times \Delta P_a CO_2 )</td>
<td>If ( HCO_3 ) is too low → concomitant 1° metabolic alkalosis</td>
</tr>
<tr>
<td>Chronic respiratory alkalosis</td>
<td>↓ ( HCO_3 = 0.4 \times \Delta P_a CO_2 )</td>
<td></td>
</tr>
</tbody>
</table>

(Adapted from “Pocket Medicine,” 2000; edited by Sabatine.)

*In acute (uncompensated) respiratory acidosis, the pH falls before the kidneys have time to compensate.

Check anion gap
The anion gap is the difference between the measured cations and measured anions
\[ \text{Anion Gap} = \text{Sodium} - (\text{Chloride} + \text{Bicarbonate}) \]
Normal AG = 8-12
Note: for each 1gm/dl decrease in albumin below 4, subtract 2.5 from the nml AG range.

Calculate osmolar gap
Osm gap = (measured serum Osms) – (calculated Osms) where
\[ \text{Calculated Osms} = 2(\text{sodium}) + \text{BUN}/2.8 + \text{glucose}/18. \]
(If the Osm gap is > 10, consider methanol or ethylene glycol ingestion.)

Calculate the delta-delta
In an isolated anion gap metabolic acidosis, the change in anion gap (\( \Delta AG \)) should rise by the same amount that the bicarbonate falls (\( \Delta HCO_3 = 24 - HCO_3 \)). Use the delta-delta when an anion gap is present to determine simultaneous metabolic processes. There are 2 ways of calculating the delta-delta as detailed below.

A. Determine the change in anion gap (\( \Delta AG \)) which = measured anion gap - normal anion gap:
   - If the \( \Delta AG + HCO_3 < 22 \) → AG met. acidosis + non-AG metabolic acidosis
   - If the \( \Delta AG + HCO_3 = 22-30 \) → isolated AG metabolic acidosis
   - If the \( \Delta AG + HCO_3 > 30 \) → AG metabolic acidosis + metabolic alkalosis
B. Divide the change in anion gap by the bicarbonate level ($\Delta AG / \Delta HCO_3$):

- If $\Delta AG / \Delta HCO_3 < 1 = AG$ metabolic acidosis + non-AG metabolic acidosis  
  (there is a loss of $HCO_3$ greater than expected)
- If $\Delta AG / \Delta HCO_3$ is between 1-2 = isolated metabolic acidosis  
  (there is the expected 1:1 relationship with an ↑ AG and ↓ $HCO_3$)
- If $\Delta AG / \Delta HCO_3 > 2 = AG$ metabolic acidosis + metabolic alkalosis  
  (there is a loss of $HCO_3$ less than expected)

(Adapted from “Pocket Medicine,” 2000; edited by Sabatine and “Internal Medicine Clerkship Guide,” 2007; by Paauw, Burkholder, and Migeon.)

### ETIOLOGIES OF RESPIRATORY ACIDOSIS AND ALKALOSIS

<table>
<thead>
<tr>
<th>RESPIRATORY ACIDOSIS</th>
<th>Etiology</th>
<th>RESPIRATORY ALKALOSIS</th>
<th>Etiology</th>
</tr>
</thead>
</table>
| **Upper airway abnormalities** | a. Acute airway obstruction  
  b. Laryngospasm  
  c. Obstructive sleep apnea | Hyoxia                | a. Pneumonia                    |
| **Lower airway abnormalities** | Asthma, COPD                   | Primary hyperventilation | b. Pulmonary edema               |
| **Lung parenchyma abnormalities*** | a. Pneumonia  
  b. Pulmonary edema  
  c. Restrictive lung disease |                        | c. Restrictive lung disease      |
| **Thoracic cage abnormalities** | a. Pneumothorax  
  b. Flail chest  
  c. Kyphoscoliosis | Drugs (causing primary hyperventilation) | a. Salicylates                   |
| **Miscellaneous** | CNS depression, neuromuscular disorders |                        | b. Progesterone (pregnancy)      |

*Lung parenchyma abnormalities often cause hypoxia, leading to respiratory alkalosis and ultimately, respiratory muscle fatigue causing respiratory acidosis

### METABOLIC ACIDOSIS

Divided into anion gap and non-anion gap metabolic acidosis.

**ANION GAP Metabolic Acidosis**
- Methanol
- Uremia
- Lactic Acidosis
- Ethylene Glycol
- Paraldehyde
- Aspirin (metab acidosis + resp alkalosis: hyperventilation due to CNS effect)
Ketoacidosis

**NON-ANION GAP Metabolic Acidosis**
Loss of $\text{HCO}_3^-$ through the gut or kidney (see etiologies below)

## Etiologies of Metabolic Acidosis

<table>
<thead>
<tr>
<th>ANION GAP METABOLIC ACIDOSIS</th>
<th>NON-ANION GAP METABOLIC ACIDOSIS</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Category</strong></td>
<td><strong>Etiology</strong></td>
</tr>
<tr>
<td>Ketoacidosis</td>
<td>Diabetes mellitus, alcoholism, Starvation</td>
</tr>
<tr>
<td>Lactic acidosis</td>
<td>a. Circulatory or respiratory failure, sepsis b. Ischemic bowel or limb, seizure, malignancy, liver failure, diabetes mellitus c. Metformin, carbon monoxide or cyanide poisoning</td>
</tr>
<tr>
<td>Renal failure</td>
<td>Accumulation of organic anions (phosphates, sulfates, etc.)</td>
</tr>
<tr>
<td>Ingestions</td>
<td>a. Methanol (blurred vision) b. Ethylene glycol (oxalate crystals in urine, $\Delta\text{MS}$, renal or cardiopulmonary failure) c. Paraldehyde d. Salicylates</td>
</tr>
<tr>
<td>Medications</td>
<td>Acetazolamide</td>
</tr>
</tbody>
</table>

(Adapted from “Pocket Medicine,” 2000; edited by Sabatine.)

**Work-up of acidosis**
Labs: ABG, electrolytes, CBC, Chem 7, LFTs
If elevated AG – check for ketonuria, assess renal function, uremia, lactate levels, toxin screen, osmolal gap, urinalysis
If normal AG – check urine anion gap ($= [U_{\text{Na}} + U_{\text{K}}] - U_{\text{Cl}}$), which is an indirect assay for renal excretion of $\text{NH}_4^+$ and equals unmeasured anions – unmeasured cations
- Negative UAG – increased renal $\text{NH}_4^+$ secretion indicates GI causes, type I RTA
or exogenous acids
Positive UAG – failure of the kidneys to secrete NH₄ indicated type I or type IV RTA or early renal failure
Also check urine pH, serum K⁺ and FE₃⁻ to further distinguish between types of RTA

Metabolic Alkalosis
Caused by
1. Loss of H⁺ from the GI tract or kidney
2. Exogenous alkali or contraction alkalosis (diuresis causes the excretion of HCO₃-poor fluid and extracellular fluid “contracts” around a relatively fixed amount of HCO₃⁻)
3. Hypercapnia: respiratory acidosis causes renal compensation with HCO₃ retention
4. Volume depletion causes proximal reabsorption of NaHCO₃ and increased aldosterone
5. Hyperaldosteronism causes distal Na⁺ reabsorption in exchange for H⁺ and K⁺ excretion
6. Hypokalemia causes transcellular H⁺/K⁺ shift (hydrogen ions shift into cells as potassium moves from the cell into the extracellular space)

ETIOLOGIES OF METABOLIC ALKALOSIS

<table>
<thead>
<tr>
<th>Category</th>
<th>Etiologies</th>
</tr>
</thead>
<tbody>
<tr>
<td>Saline-responsive</td>
<td>Gl loss of H⁺: vomiting, NGT drainage, villous adenoma</td>
</tr>
<tr>
<td></td>
<td>Diuretics</td>
</tr>
<tr>
<td></td>
<td>Prerenal azotemia (severe)</td>
</tr>
<tr>
<td></td>
<td>Post-hypercapnea</td>
</tr>
<tr>
<td>Saline-resistant</td>
<td>Hypertensive: mineralocorticoid excess – hyperaldosteronism, Cushing’s syndrome</td>
</tr>
<tr>
<td></td>
<td>Normotensive: severe hypokalemia, exogenous alkali load, Bartter’s syndrome, Gitelman’s syndrome</td>
</tr>
</tbody>
</table>

(Adapted from “Pocket Medicine,” 2000; edited by Sabatine.)

Work-Up
Check volume status and urine chloride
U₃⁻ < 20 mEq/L indicates saline-responsive
U₃⁻ > 20 mEq/L indicates saline-resistant (except concurrent diuretic use)

Cardiology
ECG interpretation (Use a systematic approach)

1. Rate
2. Rhythm
3. Axis
4. Intervals
5. Chamber enlargement (voltages)
6. QRST changes

Rate
Each little box = 0.04 seconds, each big box = 0.2 seconds
Rate = 300/x where x is no. of large boxes between each QRS complex

<table>
<thead>
<tr>
<th>Boxes b/t QRS complex</th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>5</th>
</tr>
</thead>
<tbody>
<tr>
<td>Rate</td>
<td>300</td>
<td>150</td>
<td>100</td>
<td>75</td>
<td>60</td>
</tr>
</tbody>
</table>
Rhythm
Normal sinus rhythm exists when “there is a P for every QRS and a QRS for every P” AND the p wave is upright in lead 2

Intervals
PR > 0.2 seconds = AV node block
QRS > 0.12 seconds = interventricular conduction delay (a BBB)
QT prolongation (varies, but > 450ms) can lead to torsades de pointes

?calculate QTc

Axis
Normal axis is between -30 and +90.
If QRS is upward in I and aVF, then axis is normal
LAD: axis > -30, or QRS is up in I and down in II
RAD: axis > +90, or QRS is down in I and up in II

QRS Axis Determination

Chamber
LVH: left axis deviation, S waves in V1-V2, large R waves in aVL, V5, V6
Enlargement
RVH: large R waves in V1-V2
LAE: late negative deflection in biphasic P wave best seen in V1.
Negative portion of P wave should be > 1mm deep and 1 box wide.
RAE: large peaked P wave greater than 2.5mm high best seen in lead II

QRS/ T Δ’s
ST elevation: ACS, coronary spasm, pericarditis, normal early repolarization
ST depression: myocardial ischemia, digitalis, hypokalemia, LBBB or LVH
T-wave inversion: myocardial ischemia or infarct, pericarditis, cardiomyopathy, electrolyte abnormalities

Chest Pain Differential Diagnosis (From “Pocket Medicine,” 2000; edited by Sabatine)
Angina
MI
Esophageal reflux
Esophageal spasm
Pericarditis  Mallory-Weiss tear
**Aortic dissection**  Peptic ulcer disease
Pneumonia  Biliary disease
Pleuritis  Pancreatitis
Pneumothorax  Costochondritis
PE  Herpes Zoster
Pulmonary HTN  Anxiety

**Acute Myocardial Infarction / Unstable Angina**

5 Risk Factors:  
1. Smoking  
2. HTN  
3. hyperlipidemia,  
4. FH of premature CAD (1st degree female < 55, male < 45)  
5. Age (female > 55, male > 45)

Coronary Risk Equivalent (chances = to someone w/previous MI):

**Causes**  
Ruptured atherosclerotic plaque, coronary spasm, cocaine are most common

**Clinical**  
Chest pain: typical is dull, squeezing, >30 min duration, not positional, not pleuritic, may radiate to jaw, neck, L arm. This may be ↓ in DM, women. Also nausea, lightheadedness, SOB.

**PE**  
Diaphoresis, pallor. Severe: new MR murmur, findings of heart failure including ↑JVP, crackles in lungs, S3, S4

**Labs**  
Cardiac enzymes: Troponin, CK-MB, LDH; myoglobin is earliest marker, highly sensitive, but not specific.

**Studies**  
ECG, CXR

**Rx**  
Acuity:  
**Morphine** (for pain management and decrease preload)

**Oxygen** 4L NC or mask

**Nitroglycerin** 0.4 mg SL q 5 min x 3, as limited by BP: (a. dilation ↓preload, v. dil ↓afterload)

**Aspirin**, 325 mg PO (chewed)

**B-Blocker**: metoprolol 25 mg po q 6hr, titrate up as tol.

Consider thrombolytics (Alteplase (tPA), Reteplase) or PCI (preferred)

<table>
<thead>
<tr>
<th>Thrombolytic Therapy</th>
<th>Indications</th>
<th>Contraindications</th>
</tr>
</thead>
</table>
| Sxs c/w MI > 30 min and < 12 hr and ST ↑ ≥1mm in ≥2 contiguous leads or Presumably new LBBB (not on prior ECG, etc) | Absolute:  
Any prior ICH or non-hemorrhagic stroke w/in 1 year  
Intracranial neoplasm, aneurysm, or AVM  
Active internal bleeding  
Suspected aortic dissection | Relative:  
SBP > 180 on presentation  
INR > 2 or known bleeding diathesis  
Trauma or major surgery w/in 2-4 wks  
Prolonged CPR (>10 min)  
Recent internal bleeding w/in 2-4 wks  
Noncompressible vascular punctures  
Prior streptokinase exposure |
| Age limits: in pts > 75, thrombolysis is reasonable, but higher risk of ICH |  |  |
Inpt Mgmt: Admit to CCU/monitored bed
ASA 325 mg PO qd
B-blocker: metoprolol 25 mg PO q6hr, titrate as tolerated for SBP
ACE inhibitor: lisinopril 5 mg qd, start >6hrs post onset
IV heparin 12 U/kg/hr infusion
Stress test and/or Echo after 5 days.
If stress test positive, do cardiac catheterization

D/C Meds: ASA 325 mg PO qd
Continue beta-blockers
Continue ACE inhibitors
Add lipid-lowering agent and modify risk factors (smoking cessation, etc)

Meds that improve mortality post-MI
1. ASA  
2. beta-blockers  
3. Statins  
4. ACEI (< than other 3)

**CONGESTIVE HEART FAILURE**

<table>
<thead>
<tr>
<th>Causes</th>
<th>LV failure</th>
<th>RV failure</th>
</tr>
</thead>
<tbody>
<tr>
<td>HTN and CAD account for 50-75% of LV failures. Other common causes include valvular disease, idiopathic dilated cardiomyopathy. Less common causes include chronic alcohol use, hypothyroidism, and toxins (i.e. chemotx)</td>
<td>Majority of RV failure due to LV failure. Also idiopathic pulm HTN, secondary pulm HTN (COPD, chronic PE, etc.), tricuspid valve disease, cardiomyopathy, RV infarct.</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Symptoms</th>
<th>Pulmonary: orthopnea, dyspnea on exertion, paroxysmal nocturnal dyspnea, cough, frothy hemoptysis</th>
<th>increasing abdominal girth, RUQ pain, anorexia, LE edema</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>With pulm HTN: SOB, exercise intolerance</td>
<td></td>
</tr>
<tr>
<td>Signs</td>
<td>Leg edema, crackles, S3, PMI &gt;3 cm and laterally displaced, cool, mottled LE’s, abnormal abdominojugular reflex</td>
<td>Leg edema, JVP &gt; 8 cm, RV parasternal heave, S3, Ascites, abnormal abdominojugular reflex</td>
</tr>
<tr>
<td></td>
<td>Cephalization of pulmonary blood flow, pulmonary edema, pleural effusion, Kerley B lines</td>
<td>Depends on cause; similar to LV findings if LV is cause; if cor pulmonale, may see flattening of diaphragms, bullae consistent with COPD</td>
</tr>
</tbody>
</table>

(Adapted from “Internal Medicine Clerkship Guide,” Paauw, Burkholder, Migeon, 2007)

Work-up of new left-sided CHF:
- Chemistry panel, cholesterol, ECG, CXR, Echo.
Echocardiogram: <40% EF is considered systolic dysfunction, but >40% does not rule out CHF. Focal wall motion abnormalities suggest ischemic injury.

If unclear cause, consider EtOH, thyroid dz, hemochromatosis, amyloidosis, HIV

**Treatment**: goals are to ↓ symptoms, prevent complications, ↑ survival.

1st-line tx for LV systolic failure: ACEIs.
- Diuretics usually needed for sodium/water overload.
- B-blockers should be added after acute symptoms begin to resolve.
- Add digoxin if pt remains symptomatic on full-dose ACEI and diuretics.
- Sodium restriction.

First line tx for diastolic dysfunction: B-blocker and calcium channel blockers (increase cardiac output in these patients by increasing diastolic filling time)

ACEI second line.

**Meds that improve mortality in CHF**
1. ACEIs
2. Beta-blockers
3. Spironolactone (in class IV HF)


CHF mortality predictor: www.SeattleHeartFailureModel.org

**Valvular Heart Disease**

**Aortic Stenosis**

**Causes**
- Bicuspid aortic valve, calcific stenosis, rheumatic heart disease

**Clinical**
- Angina, exertional syncope, heart failure, a. fib

**PE**
- Systolic crescendo-decrescendo murmur at right upper sternal border, radiates to carotids and apex

**Studies**
- ECG, CXR, Echo, cardiac cath for pressures

**Rx**
- Avoid exertion, diuretics for CHF,
- AVR surgery for symptomatic AS or asymptomatic AS with ↓ LV function

**Aortic Insufficiency**

**Causes**
- Rheumatic heart disease, bicuspid aortic valve, infective endocarditis, root disease (Marfan’s, syphilis, HTN, aortic dissection, RA, SLE)

**Clinical**
- Acute: pulmonary edema and hypotension
- Chronic: LV decompensation leads to CHF

**PE**
- Diastolic decrescendo murmur at left upper sternal border, wide pulse pressure, S3, laterally displaced and diffuse PMI

**Studies**
- ECG: look for LVH, LAD
- CXR: look for cardiomegaly, aortic dilatation
- Echo: assess LV size and function

**Rx**
- Reduce afterload: nifedipine, ACE inhibitors, hydralazine.
- Digoxin, diuretics for CHF.
- Surgery for acute or symptomatic Al

**Mitral Stenosis**

**Causes**
- Rheumatic heart disease, congenital, myxoma, SLE, amyloid, carcinoid

**Clinical**
- Dyspnea, pulm edema, atrial fibrillation, emboli, pulm HTN, hemoptysis
Mitral Regurgitation

Causes
- Myxomatous degeneration, endocarditis, rheumatic heart disease, collagen vascular disease, LV dilatation, ruptured chordae tendinae, papillary muscle dysfunction

Clinical
- Acute: pulmonary edema, hypotension
- Chronic: progressive dyspnea with exertion, fatigue, pulm HTN

PE
- High-pitched, blowing holosystolic murmur at apex, radiates to axilla

Studies
- ECG: look for LAE, LVH, atrial fibrillation
- CXR: look for dilated LA, dilated LV
- Echo to assess degree of MR
- Cardiac cath for pressures

Rx
- Reduce afterload: ACE inhibitors, hydralazine, nitrates
- Reduce preload: diuretics, nitrates
- Inotropy: digoxin
- Surgery for acute or symptomatic MR, or asymptomatic with ↓LV function

Infectious Endocarditis (Infection of endothelium of heart)

Acute (ABE) usu. involves normal valves with virulent organism (S. aureus)
Subacute (SBE) usu. involves abnormal valves with less virulent organism (S. viridans)

Organisms
- Prosthetic valve < 6 months post-op: S. epidermidis, S. aureus
- Prosthetic valve > 6 months post-op: S. viridans, S. epidermidis
- Native valve, IDVU: S. aureus
- Native valve, non-IVDU: S. viridans, S. aureus

Risk Factors
- IVDU, indwelling venous catheters, rheumatic heart disease, prosthetic valve, prior history of IE

Clinical Sx
- Persistent fever, anorexia, weight loss, fatigue

PE
- Fever, weight loss, murmur, Janeway lesions, Osler’s nodes, Roth spots, petechiae, splinter hemorrhages, clubbing

Studies
- Blood cultures (3 sets), CBC w/ diff, ESR, RF, Chem 7, UA, Ucx, ECG – TTE first, then TEE if needed for diagnosis of valvular lesion

<table>
<thead>
<tr>
<th>Major</th>
<th>Minor</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Sustained bacteremia with organism known to cause endocarditis</td>
<td>1. Predisposing condition</td>
</tr>
<tr>
<td>2. Endocardial involvement documented by Echo or clearly established NEW valvular regurgitation</td>
<td>2. Fever</td>
</tr>
<tr>
<td>4. Immune phenomena</td>
<td>5. + blood cultures not meeting major criteria</td>
</tr>
<tr>
<td>6. + echo not meeting major criteria</td>
<td>(Am J Med 96:200; 1994)</td>
</tr>
</tbody>
</table>
Highly probable diagnosis with 2 major, or 1 major plus 3 minor, or 5 minor criteria

Rx  
Get blood cultures first. Abx usually for 6 weeks  
Native valve ABE: nafcillin +gentamicin or vancomycin + gentamicin  
Native valve SBE: PCN/ampicillin + gentamicin  
Prosthetic valve: vancomycin + gentamicin + rifampin

New endocarditis prevention guidelines: no need to prophylax most valvular lesions including AS and MR. Only prophylax artificial valves and previous endocarditis

Cardiac Tamponade
Causes  
Malignancy, uremia, proximal aortic dissection with rupture, myocardial rupture, idiopathic. Also see causes for pericardial effusion
Clinical  
Fatigue, dyspnea
PE  
Beck’s Triad: distant heart sounds, ↑ JVP, hypotension  
Pulsus paradoxus seen in ~75% (↓ SBP >10mmHg during inspiration)
Studies  
ECG shows low voltage, electrical alternans  
Echo will show effusion  
Cardiac catheterization to get pressures
Rx  
Volume resuscitation, pericardiocentesis

Pericarditis / Pericardial Effusion
Causes  
Infection (coxsackie B, echovirus, adenovirus, EBV, VZV, HIV), idiopathic, uremia, neoplasm, collagen vascular disease, trauma, drug-induced, acute post MI
Clinical  
Pleuritic chest pain that decreases when leaning forward, fever
PE  
Pericardial friction rub, distant heart sounds if pericardial effusion present
Studies  
ECG shows diffuse ST elevations, PR depression  
CXR shows cardiomegaly if effusion present  
Pericardiocentesis: do cell counts, TP, LDH, glucose, gram stain, culture
Labs  
BUN, Cr, ANA, RF to rule out non-infection etiologies
Rx  
NSAIDs or ASA. If effusion is infected, may need pericardial drainage and antibiotics. If recurrent, consider pericardial window.

Aortic Dissection (Extravasation of blood into and along aortic media)
Acute < 2wks, Chronic > 2wks
Type A involves proximal aorta  
Type B involves distal aorta only
Risk Factors  
Age, **hypertension**, connective tissue disorder (Marfan’s for type A) congenital aortic anomaly, pregancy, blunt trauma, cocaine cardiac/aortic surgery
Clinical  
Severe tearing chest pain radiating to back, syncope, CHF
Studies  
CT, aortic angiogram, TEE, MRI
Complication  
Aortic rupture, tamponade, obstruction of branching arteries leading to ischemia, aortic regurgitation
Prognosis  
For acute proximal dissection, 1% mortality per hour x 48 hours.
Rx  
Medical: IV B-blockers, then IV vasodilators, morphine for pain.  
For chronic or Type B dissections, aim for long-term control of BP.  
Surgical: for proximal dissection or distal with progression / complications.
Arrhythmias
Tables adapted from Washington Manual of Medical Therapeutics, 30th ed., 2001

<table>
<thead>
<tr>
<th>AV Nodal Block</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>First-degree AV block</td>
<td>Conduction delay within AV node</td>
</tr>
<tr>
<td>Causes</td>
<td>Increased vagal tone, drug effect, electrolyte abnml, ischemia</td>
</tr>
<tr>
<td>Clinical</td>
<td>Usually asymptomatic</td>
</tr>
<tr>
<td>ECG</td>
<td>PR interval &gt; 0.2 seconds</td>
</tr>
<tr>
<td>Rx</td>
<td>No therapy needed usually. If symptomatic, consider pacing</td>
</tr>
</tbody>
</table>

Second-degree AV block: Mobitz Type I (Wenckebach)
| Causes           | Increased vagal tone, antiarrhythmics, electrolyte abnml, myocardial ischemia |
| Clinical         | Usually asymptomatic/benign |
| ECG              | Progressive PR interval prolongation until dropped beat occurs |
| Rx               | Stop drugs or correct cause. If symptomatic, can give atropine 0.5 mg IV q 2min to max of 0.04 mg/kg. If persistently symptomatic, consider pacing |

Second-degree AV block: Mobitz Type II
| Causes           | Antiarrhythmics, myocardial ischemia, increased vagal tone, conduction system disease |
| Clinical         | Fatigue, palpitations, lightheadedness, syncope |
| ECG              | Abrupt AV conduction block with no conduction delay or change in PR interval in preceding impulses. |
| Rx               | Because of potential for progression to complete heart block, treat with permanent pacemaker |

Third-degree AV block | All atrial impulses fail to conduct to ventricles |
| Causes           | Ischemia, infarction, drug toxicity, amyloidosis, sarcoidosis, metastatic disease, polymyositis, scleroderma, Chagas disease |
| Clinical         | Dyspnea, CHF, lightheadedness, angina, syncope |
| ECG              | Ventricular escape rhythm, no relationship between P waves and QRS |
| Rx               | Permanent pacemaker |
Atrial fibrillation
Causes: Cardiac surgery, **hypertension**, acute alcohol ingestion, theophylline toxicity, pericarditis, MI, idiopathic or “lone” AF
Clinical: (sx are poorly correlated) Palpitations, skipped beats, lightheadedness, breathlessness, CHF, angina, syncope
ECG: Irregularly fluctuating baseline with irregular and sometimes rapid ventricular response
Rx: Rate control, cardioversion (electric or pharm) post anticoag if duration >48h

Atrial flutter
Causes: Structural heart disease predisposes to development, CAD, CHF, valvular disease, pericarditis
Clinical: Asymptomatic, or palpitations, lightheadedness, syncope
ECG: Regular rhythm with “Sawtooth” appearance of P waves, atrial rate of 280-350 bpm
Rx: See atrial fibrillation

Multifocal Atrial Tachycardia (MAT)
Causes: COPD w/cor pulmonale, dig toxicity, rheumatic heart disease, ACS
Clinical: Asymptomatic or palpitations, chest pain, lightheadedness, fatigue
ECG: PR variable, 3 or more P wave morphologies
Rx: β-blocker, diltizem, amiodarone. Do NOT cardiovert

Paroxysmal SVT
Causes Accessory conduction pathway; increased frequency in CAD, COPD, CHF
Clinical Palpitations at paryoxysmal onset, anxiety, low exercise tolerance
ECG Rate seldom <150 bpm, regular, seldom see P waves
Rx: Vagal stimulation (carotid massage, Valsalva) AV blockade (β-blocker, diltizem, digoxin), amiodarone, cardioversion
Wide-Complex Tachycardias

Ventricular Tachycardia: a series of 3 or more ventricular complexes that occur at rate of 100-250 bpm where origin of activation is within the ventricle.
Causes: CAD, cardiomyopathy, infiltrative disease, SLE, RA, malignancy that involves the heart, congenital myocardial defects
Clinical: Palpitations, breathlessness, lightheadedness, angina, syncope, hemodynamic collapse, death
ECG: >3 Wide QRSs with T-wave polarity opposite of major QRS deflection.
Rx: DC cardioversion for pulseless VT, antiarrhythmics, ICD implant

Ventricular fibrillation: results from rapid, repetitive activation of ventricles from multiples areas of depolarization.
Causes: Ischemia, infarct, structural abnml, electrolyte abnml, drug toxicity
Clinical: Sudden hemodynamic collapse and death
ECG: Irregular, rapid oscillations, variably amplitudes, no identifiable QRS complexes or T waves
Rx: DC cardioversion, antiarrhythmic therapy. Long-term: implant ICD and prophylactic antiarrhythmics

Others include **SVT with aberrancy**, WPW syndrome, accelerated idioventricular rhythm

<table>
<thead>
<tr>
<th>Antiarrhythmic Agents</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Class I agents</strong>: Inhibit fast sodium channels</td>
</tr>
<tr>
<td><strong>Class Ia</strong>: Can be proarrhythmic and ↑mortality</td>
</tr>
<tr>
<td><strong>Class Ib</strong></td>
</tr>
<tr>
<td><strong>Class Ic</strong>: Can be proarrhythmic and ↑mortality</td>
</tr>
<tr>
<td><strong>Class II</strong>: B-adrenergic antagonists</td>
</tr>
<tr>
<td><strong>Class III</strong>: Prolong action potential duration and repolarization</td>
</tr>
<tr>
<td><strong>Class IV agents</strong>: Calcium-channel antagonists</td>
</tr>
<tr>
<td><strong>Common Meds used in ACLS</strong></td>
</tr>
<tr>
<td>-------------------------------</td>
</tr>
<tr>
<td><strong>Epinephrine:</strong> increases myocardial and cerebral blood flow. Recommended dose is 1 mg (10mL of 1:10,000 solution) every 3-5 minutes</td>
</tr>
<tr>
<td><strong>Vasopressin:</strong> at high doses acts as a peripheral vasoconstrictor. Give single dose of 40 units IV</td>
</tr>
<tr>
<td><strong>Atropine:</strong> used for symptomatic bradycardia and asystole. Give 0.5-1.0 mg IV; repeat every 3-5 minutes as necessary. For asystole or PEA give 1.0 mg every 3-5 minutes</td>
</tr>
<tr>
<td><strong>Amiodarone:</strong> give after defibrillation and vasopressors in persistent VT or VF. 300 mg rapid infusion diluted in 20-30mL of normal saline or dextrose in water. Subsequent doses are 150 mg by rapid infusion for persistent VT/VF. Then give 1mg/minute infusion for 6 hours, then 0.5 mg/minute to a max daily dose of 2 grams.</td>
</tr>
<tr>
<td><strong>Lidocaine:</strong> Used to treat VT/VF that persists after defibrillation and epinephrine. Give 1.0-1.5 mg/kg q5-10 minutes to max of 3 mg/kg</td>
</tr>
<tr>
<td><strong>Procainamide:</strong> used for VT when lidocaine fails or is contraindicated. Infuse 20-50 mg/minute to max of 17 mg/kg</td>
</tr>
<tr>
<td><strong>Magnesium sulfate:</strong> use for VT/VF/torsades de pointes. Give 1-2 grams IV over 1-2 minutes up to 4-6 grams</td>
</tr>
<tr>
<td><strong>Adenosine:</strong> used for SVT. Give 6 mg as rapid IV bolus over 1-3 seconds, followed by 20 cc saline flush.</td>
</tr>
<tr>
<td><strong>Diltiazem / verapamil:</strong> Use for atrial fibrillation, flutter, or multifocal atrial tachycardia. IV diltiazem bolus is 0.25 mg/kg. Second dose can be given after 15 minutes. Maintenance infusion is 5-15 mg/hr, titrated to control ventricular rate. Verapamil initial dose is 2.5-5.0 mg IV, followed by 5-10 mg IV up to max of 20 mg.</td>
</tr>
<tr>
<td><strong>Isoproterenol:</strong> may be useful for refractory torsades de pointes after magnesium and electrical pacing have failed. Give 2-10 microgram/minute</td>
</tr>
<tr>
<td><strong>Sodium bicarbonate:</strong> indicated for hyperkalemia, acidosis, tricyclic anti-depressant overdose, and to alkalinize urine in drug overdoses. Give 1.0 mEq/kg IV initially, then 0.5 mEq/kg q 10 minutes. Not useful for hypoxic lactic acidosis. In ACLS setting, acidosis is likely due to inadequate ventilation and this should be addressed first.</td>
</tr>
</tbody>
</table>
**Gastroenterology**

### COMMON ETIOLOGIES OF ABDOMINAL TENDERNESS

<table>
<thead>
<tr>
<th>Area of pain</th>
<th>Potential etiology</th>
</tr>
</thead>
<tbody>
<tr>
<td>RUQ</td>
<td>Liver, GB: Cholelithiasis, cholecystitis, choledocholithiasis, cholangitis, hepatitis, hepatic carcinoma, liver abscess (remember: pneumonia)</td>
</tr>
<tr>
<td>Midepigastric</td>
<td>Stomach, Pancreas, Aorta: Gastritis, peptic ulcer disease, pancreatitis, leaking AAA</td>
</tr>
<tr>
<td>LUQ</td>
<td>Spleen: Splenic rupture, splenomegaly, splenic infarct, splenic abscess</td>
</tr>
<tr>
<td>Umbilicus</td>
<td>Gastroenteritis, intestinal ischemia or infarct, obstruction or ileus, obstipation</td>
</tr>
<tr>
<td>RLQ</td>
<td>Appendicitis, inflammatory bowel disease (IBD), nephrolithiasis or ureteral stone, ovarian torsion, ectopic pregnancy, pelvic inflammatory disease (PID)</td>
</tr>
<tr>
<td>LLQ</td>
<td>Diverticulitis, IBD, toxic megacolon, nephrolithiasis or ureteral stone, ovarian torsion, ectopic pregnancy, PID</td>
</tr>
</tbody>
</table>

(Adapted from “Pocket Medicine,” Sabatine, 2000.)

Others to consider: Pre-herpetic neuralgia, hypercalcemia, acute intermittent porphyria

### Gastroesophageal Reflux Disease

**Pathophys**  
Excessive transient relaxation of the LES or incompetent sphincter tone  
Esophageal mucosal damage caused by prolonged contact with acid/bile salts  
Hiatal hernia can contribute to decreased LES tone and act as a reservoir for refluxed gastric contents

**Hx**  
Heartburn, atypical “angina,” regurgitation of stomach contents, **cough**, asthma, **hoarseness** and warning symptoms: dysphagia, early satiety, weight loss or bleeding; precipitants: fatty foods, caffeine, colas, alcohol, cigarettes, supine positioning, large meals

**Dx**  
Often diagnosed based upon history and trial of acid suppressive agent. EGD reserved for those with refractory symptoms or warning symptoms to detect Barrett’s esophagus, stricture, ulcer or esophagitis. 24-hour esophageal pH monitoring if the diagnosis is unclear

**Rx**  
**CONSERVATIVE** - include elevating the head of the bed 6 inches, avoiding precipitants, avoiding late meals, avoiding calcium channel blockers, anticholinergics, sedatives and theophylline which can exacerbate symptoms  
**MEDICAL** - Antacids; H₂-blockers; or proton-pump inhibitors which are more effective than standard-dose H₂-blockers (breakthrough nocturnal symptoms can be controlled by adding an H₂-blocker )  
**SURGERY** - Fundoplication is an option for those who require continuous or increasing medical therapy or for whom continuous PPI therapy is undesirable

### Acute Liver Failure

**Definition**  
Acute hepatic disease + coagulopathy + encephalopathy  
Fulminant < 8 weeks; subfulminant between 8 weeks and 6 months

**Etiology**  
Discussed under “ABNORMAL LIVER TESTS.”
Clinical manifestations
Neurologic: asterixis, encephalopathy, cerebral edema (Cushing’s reflex hypertension + bradycardia; papillary dilatation; decerebrate posturing; apnea)
Cardiovascular: hypotension with low SVR
Pulmonary: respiratory alkalosis, impaired peripheral O\textsubscript{2} uptake, ARDS
Gastrointestinal: GI bleeding, pancreatitis
Renal: ATN, hepatorenal syndrome, hyponatremia, hypokalemia, hypophosphatemia
Hematology: coagulopathy (consider DIC)
Endocrine: hypoglycemia
Skin: jaundice, telangiectasias, palmar erythema, caput medusae, Dupuytren’s contractures, Terry’s nails (white proximal nail beds), gynecomastia
GU: testicular atrophy

Diagnostic studies
Labs CBC: anemia, neutropenia, thrombocytopenia; COAGs: increased PT, PTT, BT; decreased albumin, viral serologies, toxicology screen (APAP levels q1-2hr until peak determined) and others, as below
Imaging RUQ U/S, abdominal CT, doppler studies of hepatic and portal veins
Liver Bx CORRECT COAGULOPATHY with fresh frozen plasma prior to procedure

CHILD-TURCOTTE-PUGH Scoring System (severity of liver disease)

<table>
<thead>
<tr>
<th></th>
<th>1</th>
<th>2</th>
<th>3</th>
</tr>
</thead>
<tbody>
<tr>
<td>Albumin (g/dl)</td>
<td>&gt;3.5</td>
<td>2.8-3.5</td>
<td>&lt;2.8</td>
</tr>
<tr>
<td>Bilirubin (mg/dl)</td>
<td>&lt; 2</td>
<td>2-3</td>
<td>&gt;3</td>
</tr>
<tr>
<td>INR</td>
<td>&lt;1.7</td>
<td>1.7-2.3</td>
<td>&gt;2.3</td>
</tr>
<tr>
<td>Ascites</td>
<td>Absent</td>
<td>Slight</td>
<td>Moderate</td>
</tr>
<tr>
<td>Encephalopathy (stage)*</td>
<td>None</td>
<td>Stage 1 or 2</td>
<td>Stage 3 or 4</td>
</tr>
<tr>
<td>Total Points</td>
<td>5-6</td>
<td>7-9</td>
<td>10-15</td>
</tr>
<tr>
<td>Classification</td>
<td>A</td>
<td>B</td>
<td>C</td>
</tr>
<tr>
<td>Survival</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1 year</td>
<td>100%</td>
<td>80%</td>
<td>45%</td>
</tr>
<tr>
<td>2 year</td>
<td>85%</td>
<td>60%</td>
<td>35%</td>
</tr>
</tbody>
</table>

*Stage I - altered mental status (Brit J Surg 60:646;1973)
Stage II - lethargy, confusion (Hepatology 19:1513;1994)
Stage III - stupor
Stage IV - coma
Abnormal Liver Tests

Markers of hepatic functional status

- Albumin: general marker for liver protein synthesis
- Prothrombin time: depends on synthesis of coagulation factors I, II, V, VII and X
- Bilirubin: product of heme metabolism in the liver

Markers of hepatic injury

- Aminotransferases: intracellular enzymes
  - ALT (or SGPT) specific for liver
  - AST (or SGOT) found in liver, heart, skeletal muscle, kidney and brain
- Alkaline phosphatase: enzyme bound in hepatic canalicular membrane
  - Found not only in liver, but also in bone, intestines and placenta
  - CONFIRM liver origin with increased GGT

ABNORMAL LIVER TESTS IN DIFFERENT PATTERNS OF LIVER INJURY

<table>
<thead>
<tr>
<th>TYPE OF LIVER INJURY</th>
<th>Aminotransferase</th>
<th>Bilirubin</th>
<th>Alkaline phosphate</th>
</tr>
</thead>
<tbody>
<tr>
<td>Hepatocellular</td>
<td>↑↑</td>
<td>±↑</td>
<td>±↑</td>
</tr>
<tr>
<td>Cholestasis</td>
<td>±↑</td>
<td>↑↑</td>
<td>↑↑</td>
</tr>
<tr>
<td>Isolated hyperbilirubinemia</td>
<td>Near normal</td>
<td>↑↑</td>
<td>Near normal</td>
</tr>
<tr>
<td>Infiltrative</td>
<td>±↑</td>
<td>±↑</td>
<td>↑</td>
</tr>
</tbody>
</table>

(Adapted from “Pocket Medicine,” 2000; edited by Sabatine.)

Patterns of Liver Injury

1. Hepatocellular injury

- Viral hepatitis (~60%) - HAV, HBV, HCV, HDV, HEV, CMV, EBV, HSV, VSV. Test viral serologies. Aminotransferases significantly elevated (>1000) in acute viral hepatitis, with ALT > AST. Test viral serologies. Very high transaminases are not seen with hepatitis C.
- Autoimmune -
  - a. Type 1: anti-smooth muscle Ab (ASMA), ANA
  - b. Type 2: anti-liver/kidney microsome type 1 (anti-LKM1)
  - c. Type 3: anti-soluble liver antigen (anti-SLA)
- Drugs and toxins (~20%) - Alcohol (AST:ALT > 2:1), medications: acetaminophen, phenytoin, INH, rifampin, sulfonamides, tetracycline, amiodarone, propylthiouracil, toxins (toxicology screen)
- Vascular (hypotensive/CHF) - Ischemic, congestive, Budd-Chiari, veno-occlusive disease
- Hereditary (systemic disease) - Hemochromatosis (elevated transferrin saturation and serum ferritin), α-1-antitrypsin deficiency (also, emphysema), Wilson’s disease (Kayser-Fleischer ring on slit lamp exam, elevated serum free copper and 24-hour urinary copper level; low serum ceruloplasmin)
- Metabolic - Steatohepatitis, hepatic glycogenosis (Mauriac Syndrome in IDDM)
- Idiopathic (20%)

2. Cholestasis - Evaluate with RUQ ultrasound (also, ERCP, cholangiogram, cholescintigraphy)

<table>
<thead>
<tr>
<th>No biliary ductal dilatation on U/S</th>
<th>Biliary ductal dilatation on U/S</th>
</tr>
</thead>
</table>
### HEPATOCELLULAR DYSFUNCTION

<table>
<thead>
<tr>
<th>Biliary epithelial damage:</th>
<th>Intrahepatic cholestasis:</th>
<th>Obstruction</th>
</tr>
</thead>
<tbody>
<tr>
<td>Hepatitis, cirrhosis</td>
<td>Drug-induced, sepsis, post-op, primary biliary cirrhosis (check AMA)</td>
<td>Choledocholithiasis, cholangiocarcinoma, pancreatic cancer, pancreatitis, stricture, primary sclerosing cholangitis (check p-ANCA), primary biliary cirrhosis, cholangitis</td>
</tr>
</tbody>
</table>

Charcot’s triad = RUQ pain, jaundice and fever/chills
Reynaud’s pentad = above plus shock and altered mental status

### 3. Isolated hyperbilirubinemia

Unconjugated (indirect)
- **Overproduction of bilirubin** - hemolysis, ineffective erythropoiesis, hematoma resorption
- **Defect in conjugation** - Gilbert’s (“zhil-bear”—benign) and Crigler-Najjar syndromes

Conjugated (direct)
- **Defect in bile secretion** - Dubin-Johnson and Rotor syndromes

### 4. Infiltration

- **Malignancy**: HCC (↑AFP), metastatic disease (colon = ↑CEA), lymphoma
- **Granulomas**: (TB, sarcoidosis, histoplasmosis)
- **Abscess**: (amoebic, pyogenic)

### Ascites

Abnormal accumulation of fluid (> 25 cc) within the peritoneal cavity

**PE**
- Shifting dullness, fluid wave (positive LR 5.0), edema (negative LR 0.2), bulging flanks

**Dx**
- **IMAGING** - Abdominal U/S (if >100 cc), doppler studies of portal and hepatic veins, echocardiogram (if concerned about right-sided heart disease)

**PARACENTESIS** - Obtain albumin, cell count with differential, total protein, gram stain and culture, LDH and glucose; amylase and triglyceride levels, cytology and mycobacterial smear/culture as indicated.

### SERUM TO ASCITES ALBUMIN GRADIENT (SAAG)

<table>
<thead>
<tr>
<th>Portal hypertension-related (SAAG &gt; 1.1)</th>
<th>Non-portal hypertension-related (SAAG &lt; 1.1)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Intrahepatic: cirrhosis, spontaneous bacterial peritonitis, hepatitis, HCC, liver metastases</td>
<td>Peritonitis: Tuberculosis, ruptured viscus, SBP Vasculitis</td>
</tr>
<tr>
<td>Post-hepatic: constrictive pericarditis, right-sided CHF, Budd-Chiari</td>
<td>Peritoneal carcinomatosis Serositis</td>
</tr>
<tr>
<td>Pre-hepatic: portal or splenic vein thrombosis</td>
<td>Nephrotic syndrome</td>
</tr>
</tbody>
</table>

(Adapted from "Pocket Medicine," 2000; edited by Sabatine.)
In portal HTN, expect ascitic fluid to have less albumin than serum—it has been “pushed” into the abdominal cavity by hydrostatic pressure, rather than leaked out through defects in the vasculature or a fluid derived from another source.

**Ascites fluid total protein (AFTP)**
May be used to distinguish intrahepatic and post-hepatic causes of ascites:
- a. Cardiac ascites: SAAG > 1.1, but AFTP > 2.5
- b. Cirrhotic ascites: SAAG > 1.1, but AFTP < 2.5
- c. Spontaneous bacterial peritonitis: SAAG < 1.1, but AFTB < 2.5; >250 PMNs per µl

Rx  Decrease sodium intake (1-2gm/day), fluid restriction if hyponatremic diuretics: spironolactone (beware of hyperkalemia), loop therapeutic paracentesis-- if patient is dyspneic or uncomfortable (remove 4-6L; ±colloid replacement)
TIPS (Transjugular intrahepatic portosystemic shunt)
Liver transplantation if eligible (calculate MELD score), EtOH abstinence > 6 mos

**Gastrointestinal Bleeding**
Intraluminal blood loss anywhere from the oropharynx to the anus

*Upper = above the ligament of Treitz*
1. Oropharyngeal bleeding and epistaxis (swallowed blood)
2. Erosive esophagitis
   a. Immunocompetent patient: GERD/Barrett’s esophagus, XRT
   b. Immunocompromised patient: HSV, CMV, Candida
3. Varices (10% of cases)
4. Mallory-Weiss tear (7%; GE junction tear due to retching/vomiting against a closed glottis)
5. Gastritis/Gastropathy (23%)
6. Peptic ulcer disease (46%)
7. Vascular malformations (Dieulafoy’s lesion, Osler-Weber-Rendu)
8. Neoplastic disease
9. Other causes: hiatal hernia ulcerations, coagulopathy, amyloidosis, connective tissue disease

*Lower = below the ligament of Treitz*
1. Diverticular disease (more likely to be diverticulosis than diverticulitis; although divertica are more common in the left colon, bleeding diverticula are more common in the right colon)
2. Angiodysplasia
3. Neoplastic disease
4. Colitis: infection, ischemic, radiation, inflammatory bowel disease (ulcerative colitis > Crohn’s disease)
5. Hemorrhoids

Clinical manifestations
UGIB > LGIB: nausea, vomiting, hematemesis, coffee-ground emesis, epigastric pain, vasovagal reactions, syncope, melena (some briskly bleeding ulcers can present as hematochezia)
LGIB > UGIB: diarrhea, tenesmus, BRBPR or maroon stools
Hx Use of aspirin, NSAIDs, anticoagulants; known anticoagulopathy; cirrhosis; alcohol abuse

PE Vital signs: tachycardia -- 10% volume loss
orthostatic hypotension -- 20%
shock -- 30%

HEENT: pale conjunctivae
Abdominal exam: Localized tenderness or peritoneal signs
Rectal exam (mandatory): Appearance of stools, anal fissures, hemorrhoids
Skin: signs of chronic liver disease, pallor, delayed capillary refill

Dx Labs Hct, platelet count, PT, PTT, increased BUN/Cr, LFTs
NG tube can Dx UGIB (except if intermittent or duodenal bleed), remove GI contents (prior to EGD and to prevent aspiration); lavage “until clear” to evaluate rate/presence of continued bleeding

Imaging
UGIB: Esophagoduodenoscopy (EGD); potentially therapeutic.
LGIB: 1. Colonoscopy - if bleeding stops spontaneously; potentially therapeutic
2. Tagged RBC scan - uses $^{99m}$Tc-tagged RBC to detect bleeding rates of ≥0.1-1.0 ml/min in stable patients; localization difficult
3. Arteriography - detects bleeding rates of ≥0.5-1.0 ml/min in unstable patients; potentially therapeutic (intraarterial vasopressin infusion or embolization)
4. Exploratory laparotomy

Rx Acute treatment includes hemodynamic resuscitation:
1. Volume resuscitation with IV fluids (NS or lactated Ringer’s)
2. Transfusion therapy (type and cross; may use O-negative blood if patient is exsanguinating). GI service generally wants a HCT > 25 to scope.
3. Identify and correct coagulopathies (FFP to normalize PT; keep platelets >50,000)
4. Nasogastric tube lavage
5. Airway management as needed
6. CONSULT GI and surgical services

<table>
<thead>
<tr>
<th>ETIOLOGY of GI BLEED</th>
<th>TREATMENT</th>
</tr>
</thead>
</table>
| Varices              | Octreotide ± endoscopic sclerotherapy
|                      | Band ligation
|                      | Balloon tamponade
|                      | Embolization or TIPS if previous strategies fail
|                      | When HD stable - beta-blocker and nitrates |
| Peptic Ulcer Disease | PPIs
|                      | Endoscopic therapy (injection, thermal contact, laser)
|                      | Mesenteric arteriography with infusion of vasopressin or embolization |
| Mallory-Weiss        | Usually stops spontaneously |
| Angiodysplasia       | Arterial vasopressin, endoscopic therapy, surgery |
| Esophagitis, gastritis| PPIs, H$_2$-antagonists |

(Adapted from “Pocket Medicine,” 2000; edited by Sabatine.)
### GASTROPATHY & GASTRITIS

<table>
<thead>
<tr>
<th>Classification</th>
<th>Etiology</th>
<th>Clinical manifestations</th>
</tr>
</thead>
<tbody>
<tr>
<td>Acute gastropathy</td>
<td>NSAIDs, alcohol, stress-related mucosal disease, glucocorticoids</td>
<td>Asymptomatic, anorexia, nausea, vomiting, epigastric pain, UGIB</td>
</tr>
<tr>
<td>Chronic fundal gastritis (“Type A”)</td>
<td>Autoantibodies directed against parietal cells, resulting in a lack of acid and intrinsic factor</td>
<td>Atrophic gastritis, achlorhydria, hypergastrinemia, pernicious anemia, gastric carcinoid tumors and adenoCA</td>
</tr>
<tr>
<td>Chronic antral gastritis (“Type B”)</td>
<td>H. pylori infection</td>
<td>Mostly asymptomatic; can progress to atrophic gastritis with increased risk of gastric adenoCA</td>
</tr>
</tbody>
</table>

### Peptic Ulcer Disease

**Etiologies**
- H. pylori infection, NSAIDs and aspirin, malignant ulcers, Zollinger-Ellison syndrome (gastrinoma) and other hypersecretory states

**Hx**
- Epigastric abdominal pain: 2-5h postprandial in duodenal ulcers,, soon after meals in gastric ulcers. Pain relieved by food, antacids in DU > than GU.

**Dx**
- Tests for H. pylori : serology (not in peds), urea breath test, EGD + rapid urease testing (CLOtest) or biopsy and histology
- EGD or UGI series to detect ulcer

**Rx**
- Discontinue NSAIDs and smoking acid suppression with H$_2$-blockers or PPIs
- H. pylori “triple therapy” (e.g. metronidazole 500 mg bid, clarithromycin 500 mg bid, omeprazole 20 mg bid for 10-14 days)
- Surgery for intractable symptoms, GI bleeding, Zollinger-Ellison syndrome

**Complications**
- GI bleeding, gastric outlet obstruction, perforation, pancreatitis (erosion into the pancreas: seen with ulcers in the posterior wall of the duodenal bulb)

### Diverticular Disease

**Diverticulosis** - Herniations of the colonic mucosa and submucosa through the colonic wall (L > R); may be a consequence of a low-fiber diet; affects 20-50% of patients > 50

**Clinical**
- Usually asymptomatic, but may be complicated by microperforations or bleeding

**Rx**
- Increase fiber content in diet; or as below (if bleeding occurs)

**Diverticulitis** - Undigested food and bacteria are retained within a diverticulum -> fecalith formation, obstruction, ischemia, infection and/or perforation. Abscess formation and/or peritonitis are severe presentations.

**Clinical**
- LLQ pain, fever, nausea, vomiting, constipation

**PE**
- LLQ tenderness, ± palpable mass, ± FOBT, diarrhea, fever, chills, anorexia, nausea, vomiting, dysuria, LLQ mass, **Does not cause big lower GI bleeds**
- Severe – peritonitis, septic shock

**Dx**
- Labs: ↑ WBC
- Imaging 1. Acute abdominal series to r/o obstruction, free air, ileus
  2. Abdominal CT (with contrast for best visualization)
3. Colonoscopy or sigmoidoscopy are CONTRAINDICATED in an acute setting because of increased risk of overt perforation

Rx
Outpt Rx if mild; antibiotics (cipro, metronidazole)
Hospitalize for severe Sx; keep NPO, IV fluids, NGT
Broad-spectrum antibiotics to cover anaerobes and gram-negative rods
Surgery if medical therapy fails, for peritonitis, or to drain an abscess that is inaccessible to percutaneous drainage

Diarrhea
(Stool output > 200cc/day)

Etiologies
1. Infectious
   a. Pre-formed toxins (S. aureus, C. perfringens, B. cereus)
   b. Viruses (Norwalk, Rotavirus)
   c. Non-invasive bacteria
      enterotoxin-producing (no fecal WBC or blood) – ETEC, Vibrio cholera
      cytotoxin-producing (+ fecal WBC or blood) – E.coli O157:H7, C. difficile
   d. Invasive bacteria (+ fecal WBC or blood) – enteroinvasive E. coli, Salmonella, Shigella, Campylobacter, Yersinia, V. parahelolyticus
   e. Parasites (Giardia, E. histolytica)
   f. Opportunistic (Cryptosporidia, Microsporidia)
   g. Chronic (Giardia, E. histolytica, C. difficile, opportunistic organisms)

2. Malabsorption
   Bile salt deficiency
   Pancreatic insufficiency
   Mucosal abnormalities
   Celiac sprue - check anti-tissue transglutaminase (Most Sensitive and Specific), anti-endomysial, anti-gliadin Abs, plus IgA (false neg in peds <2 yrs)
   Whipple’s disease – caused by Trophryema whippelii
   Tropical sprue
   Intestinal lymphoma

3. Osmotic
   Medications or Lactose intolerance

4. Inflammatory
   Inflammatory bowel disease
   Ischemic colitis

5. Secretory
   Hormonal - VIP (VIPoma); serotonin (carcinoid); calcitonin (medullary cancer of the thyroid); gastrin (Zollinger-Ellison);
   glucagons, substance P, thyroxine
   Villous adenoma

6. Motility
   Irritable bowel syndrome
   Scleroderma (pseudo-obstruction)
   Endocrinopathies

Acute diarrhea (< 3 weeks duration)
If severe dehydration, fever, duration > 5 days, mucus or pus in BMs, bloody diarrhea, abdominal pain, recent travel or recent antibiotic use are present consider:
Labs
   fecal leukocytes, FOBT, C. difficile toxin, stool cultures, stool O & P X 3
   Imaging flexible sigmoidoscopy/colonoscopy with biopsy

Chronic diarrhea (> 3 weeks duration)
Labs as for acute + consider 24-hour stool collection with evaluation of fecal fat, Giardia antigen, hormone levels, secretin test (pancreatic insufficiency), $^{14}$C-xylose breath test (bile salt deficiency), D-xylose test or small intestinal biopsy (mucosal abnormality), lactose test, ESR

RESPONSE TO NPO
- If diarrhea decreases with fasting = malabsorptive etiology
- If diarrhea does NOT change with fasting = secretory etiology

STOOL OSMOTIC GAP = \( \text{Osm}_{\text{stool}} (290) - [2 \times (\text{Na}_{\text{stool}} + \text{K}_{\text{stool}})] \):
- If > 50, malabsorptive etiology
- If < 50, secretory etiology

**Inflammatory Bowel Disease**

**Ulcerative Colitis**
Idiopathic inflammation of the *colonic* mucosa; average age of onset 20-25 yo.

**Clinical**
Grossly bloody diarrhea, lower abdominal cramps, urgency, tenesmus, fulminant colitis, toxic megacolon, perforation

EXTRACOLONIC: Erythema nodosum, pyoderma gangrenosum, aphthous ulcers, iritis, episcleritis, thromboembolic events, seronegative arthritis, chronic hepatitis, cirrhosis, sclerosing cholangitis, cholangiocarcinoma

Complications Stricture; colon cancer (after 10 years, risk incr 1% each year)

**Crohn’s Disease**
Idiopathic inflammation; can **occur anywhere in the alimentary tract**, although often focal at terminal ileum. Bimodal age distribution with peaks in the 20s and from 50-70

**Clinical**
Smoldering disease with abdominal pain, mucus-containing, non-grossly bloody diarrhea; fevers, malaise, weight loss

EXTRACOLONIC: same as UC and also, gallstones and kidney stones

**Complications**
Perianal fissures, perirectal abscesses, stricture, fistulas, cancer (small intestinal and colonic: risk similar to that of UC when the entire colon is involved)

**PATHOLOGY OF ULCERATIVE COLITIS VS. CROHN’S DISEASE**

<table>
<thead>
<tr>
<th>Pathology</th>
<th>Ulcerative Colitis</th>
<th>Crohn’s Disease</th>
</tr>
</thead>
<tbody>
<tr>
<td>Extent</td>
<td>involves the rectum/colon and extends contiguously</td>
<td>can affect any portion of the GI tract from the mouth to the anus. lesions with areas of sparing -- “skip lesions”</td>
</tr>
<tr>
<td>Appearance</td>
<td>granular, friable mucosa with small ulcerations; pseudopolyps</td>
<td>≥ 1 cm ulcerations, non-friable mucosa, cobblestoning, deep and lor fissures</td>
</tr>
<tr>
<td>Biopsy</td>
<td>superficial microulcerations, crypt abscesses (PMNs); no granulomas</td>
<td>transmural inflammation with mononuclear cell infiltrate, non-caseating granulomas, fissures</td>
</tr>
</tbody>
</table>
Rx of Inflammatory Bowel Disease
Fiber supplements (unless obstructive symptoms in CD)
No caffeine or gas-producing vegetables
Trial of lactose-free diet in CD
Antidiarrheals and antispasmodics
In acute flare:

MILD - 5-ASA compounds including sulfasalazine, mesalamine or olsalazine
MODERATE - Oral steroids (± azathioprine, methotrexate or 6-mercaptopurine in CD)
SEVERE - Intravenous steroids (± cyclosporine ± Remicade for refractory CD); bowel rest, TPN, antibiotics; serial abdominal exams and radiographs/CT to rule out dilatation, perforation or abscess; decompression in toxic megacolon.
TNF inhibitors: infliximab, etanercept (place PPD + controls prior to administration); risk of granulomatous infection higher with infliximab

Hematology
Anemia (Hematocrit <36/Hgb <13 in females and <41/Hgb <14 in males)
Sx Fatigue, headache, dyspnea, decreased exercise tolerance, chest pain, pica, melena, BRBPR, hematemesis, dizziness; family history of anemia/heme disorders, review meds (look for NSAIDS, ASA, coumadin)
PE Pallor, pale mucous membranes, HSM, jaundice, bone tenderness, Orthostatic hypotension, tachycardia, koilonychia, numbness, paresthesias,
Labs Hgb, Hct, CBC w/ platelets, peripheral smear, retic count, stool guiac
Consider bilirubin, haptoglobin, LDH

Low corrected retic count (<100 billion/L ) & index (<2%) = hypoproliferation
High corrected retic count (>150 billion/L) & index (>2%) = %)=peripheral destruction, blood loss

Low corrected reticulocyte count/index (underproduction) -> look at MCV:
1. Low MCV (<80) = microcytic anemia
   I Iron-deficiency
   - chronic bleed / decreased supply / increased demand
   - special PE findings : angular cheilosis, atrophic glossitis, koilonychia, pica
   - lab findings : low Fe, low ferritin, high TIBC, Fe/TIBC <1/6
   T Thalassemias
   S Sideroblastic anemia
2. Normal MCV (80-100) = normocytic anemia
   A Anemia of chronic disease/ inflammatory block (can also be microcytic)
   - lab findings: low Fe, low TIBC, +/- high ferritin, high ESR
   - tx: Fe supplementation unsuccessful, must tx underlying disorder
   N Nephrogenic - low erythropoietin levels
   E Endocrine - thyroid disease
   M myelophthisis - marrow replacement with tumor, fibrosis; teardrop cells
   I IVF- dilution
   A Aplastic anemia
   S sickle cell anemia
3. High MCV (>100) = macrocytic anemia
B12 deficiency (neuro Sx + hypersegmented PMNs)  
Reticulocytosis (see in blood loss)  
Alcohol  
Nutritional - folate deficiency (no neuro findings, + hyperseg PMNs)  
Drugs - AZT, MTX  
(Thanks to Differential Diagnosis Mnemonics)

**High corrected reticulocyte count/index (destruction or loss):**

1. Blood loss  
2. Hemolysis  
   a. Hereditary spherocytosis  
   b. Glucose-6-phosphate dehydrogenase deficiency  
   c. Sickle cell anemia  
   d. Autoimmune hemolytic anemia (AIHA)  
   e. Drug-induced hemolytic anemia  
   f. Microangiopathic hemolytic anemia (MAHA)  
      - DIC, HUS, TTP, HELLP, malignant HTN  
   g. Paroxysmal nocturnal hemoglobinuria (PNH)

**Thrombocytopenia** (Platelet count < 150,000/ mm$^3$)

- at steady state, platelet production should equal destruction/removal  
- causes include decreased production, increased destruction, or increased sequestration

**RISK OF BLEEDING**

<table>
<thead>
<tr>
<th>Platelet count</th>
<th>Risk of bleeding</th>
</tr>
</thead>
<tbody>
<tr>
<td>&gt;100,000</td>
<td>No increased risk</td>
</tr>
<tr>
<td>50-100,000</td>
<td>Surgery is o.k., some increased risk with major trauma</td>
</tr>
<tr>
<td>20-50,000</td>
<td>Risk with surgery or trauma</td>
</tr>
<tr>
<td>&lt;10,000</td>
<td>Spontaneous bleeding</td>
</tr>
</tbody>
</table>

**History/Sx**  
Mucocutaneous bleeding, epistaxis, small ecchymoses, petechiae, melena, BRBPR, menorrhagia, symptoms of infection. Review medication list, take thorough medical history (ask about HIV, bleeding disorders, etc)

**PE**  
Look for hepatosplenomegaly, ecchymoses, petechiae, + stool guiac  

**Labs**  
CBC with diff and platelets, peripheral smear  
Bone marrow aspirate and biopsy in some cases

**Etiologies**

a. **Decreased production:** aplastic anemia, myelodysplasia, drugs (EtOH, thiazide diuretics, sulfas), megaloblastic anemia, infiltrative marrow process  
b. **Increased destruction:** immune-mediated (see below), drug-induced, infection, DIC, HUS/TTP, vasculitis, pre-eclampsia  
c. **Increased sequestration** by the spleen

**Idiopathic thrombocytopenic purpura (ITP)** - autoimmune mediated  
- Most common cause of immune thrombocytopenia  
- Mediated by an auto-antibody against glycoproteins on platelet surface, platelets then destroyed by the liver, spleen, and marrow
- Often occurs following a viral illness and can be chronic in adults
- See large platelets on smear
- Rx: glucocorticoids, IV IG, platelet transfusion, splenectomy, Vincristine, immunosuppressants, Danazol

**Drug-induced thrombocytopenia**
- More than 100 drugs have been associated with thrombocytopenia
- Syndrome resembling ITP may be seen in those susceptible following ingestion
- Examples are quinine and quinidine derivatives
- Removal of drug is most effective therapy

**Heparin-induced thrombocytopenia (HIT)**
- Production of antibody that leads to destruction of platelets
- Can occur with trace amounts of heparin (IV flush)
- Can also cause platelet aggregation (less common)
- Rx: stop heparin

**Hemolytic-uremic syndrome (HUS) / Thrombotic thrombocytopenic purpura (TTP)**
- Normally von Willebrand factor is cleaved into multimers by a protease; in TTP/HUS an antibody against the protease leads to accumulation of larger multimers; results in platelet aggregation leading to thrombotic microangiopathy
- HUS: thrombocytopenia, renal failure and MAHA; syndrome has been associated with E. Coli O157H7
- TTP: HUS triad plus fever and neurologic abnormalities
- Rx: plasma exchange, immunosuppressants

**Hypercoaguability**

**Risk Factors**

**Virchow’s triad**
1. Endothelial cell injury (trauma, surgery)
2. Stasis (e.g., immobility s/p hip replacement, long airplane ride)
3. Hypercoaguable states
   - Acquired: Pregnancy
     - Surgery/trauma
     - Malignancy
     - Smoking
     - Oral contraceptives
     - Antiphospholipid antibody syndrome
     - DIC
   - Familial: Factor V Leiden
     - Antithrombin III deficiency
     - Protein S deficiency
     - Protein C deficiency

**Complications** DVT, PE, stroke

Rx anticoagulation—duration of treatment determined by etiology

<table>
<thead>
<tr>
<th>Leukemias</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>AML</strong></td>
</tr>
<tr>
<td>Primarily occurs in adults</td>
</tr>
<tr>
<td>Dx: blasts, auer rods</td>
</tr>
</tbody>
</table>
Tx: chemo, BMT in 1st remission
Complications: leukostasis -> ARDS, intracerebral hemorrhage

M3 subtype (Promyelocytic): Tx w/transretinoic acid. DIC may occur w/tumor lysis.

CLL
Elderly patients
Often present w/infection due to hypogammoglobulinemia
Dx: Smudge cells on smear suggestive; CD5 Ag
Tx: palliative chemo

Multiple Myeloma
Proliferation of malignant plasma cells. Peak incidence in 70s.
Sx bone pain, pathologic fx, fever, epistaxis, subQ nodules (plasmacytomas), renal failure sx, peripheral neuropathy
Dx lytic bone lesions on XR, SPEP/UPEP
Tx observation for mild cases
Bisphosphonates
Palliative XRT, chemotherapy
Early autologous BMT may increase disease-free survival

Infectious Disease
Fever of Unknown Origin
Definition = Fever > 38.3C(101F) on multiple occasions, plus
Duration of > 3 weeks, plus
Uncertain diagnosis after 1 week of hospitalization*

Etiology
Infectious (TB, abscess, osteo, endocarditis) ~30%
Malignancy (lymphoma, leukemia, RCC, HCC) ~30%
Collagen vascular disease (JRA, GCA, Stills, Wegener’s) ~30%
Other ~10% - drugs, thyroid, Familial Mediterranean Fever, idiopathic

Work-up
Detailed Hx: travel, pets, immunosuppression, meds, ROS
Labs: ESR, LDH, PPD, HIV, BCx x 3, RF, ANA, Heterophile Abs
Consider Bx bone marrow, liver, lymph node (TB, Bartonella)
Consider CT head/neck to rule out sinus disease, dental abscess, etc.
Consider CT abdomen
No empiric abx or steroids

Catheter-related Bloodstream Infection (Line infection)
Definition = Isolation of same organism from catheter and peripheral blood
No alternative source of infection
Non-contaminated infusate

Etiology
Incidence ~3%; Catheter colonized by flora from patient’s skin or hands of healthcare workers
Occasional hematogenous seeding of catheter, especially if thrombosed

Risk
femoral > internal jugular > subclavian

Prevention
Mask, gown, cap, gloves for insertion; chlorhexidine preferred over betadine
Bugs: Coag negative staph and S. aureus, enterococci (50%), gram negatives (30%), candida (20%)

Work-up:
- CBC, BCx (1 from line, 2 from separate peripheral sticks)
- Examine insertion site for erythema, tenderness, or purulence
- Empiric abx (vanco + [aminoglycoside or ceftaz/cefipime or cipro]) if sick
- If positive BCx: pull line and culture tip
- If non-septic and only coag negative staph are isolated, may change over wire and culture tip; remove if > 15 cfu from line
- Adjust abx when sensitivities return

Duration of abx: S. aureus, 2-3 weeks; others, 10-14 days

Osteomyelitis

Definitions:
- Infection of bone resulting in progressive inflammation, destruction, and reformation. Categories: hematogenous seeding, contiguous spread, vascular insufficiency.
- Acute: Days to weeks; usually painful, febrile; no necrotic bone on bx;
- Chronic: weeks to months; chronic pain, non-healing fx; elevated ESR, nl CBC

Bugs:
- Hematogenous seeding: S. aureus (~70%); GNRs (~30%). Rarely candida, bartonella, C. immitis, P. acnes.
- IVDU: pseudomonas, serratia, candida, TB
- Contiguous spread: Staph, strep, enterococcus (75%); GNRs, anaerobes (25%); often polymicrobial. Rarely, brucella or TB
- Vascular insufficiency/diabetic foot: Polymicrobial staph, strep, enterococcus, proteus, pseudomonas, and/or anaerobes

Sx:
- Fever, bone pain, warmth/swelling are classic presentation

Dx:
- Elevated CBC, ESR; Sed rate >100 in diabetic foot highly specific for osteo.
- Blood cultures positive in 50% of acute osteo
- Plain film -> soft tissue swelling, bone destruction, periosteal reaction specific but not sensitive; poor yield in first 3 weeks of infection; positive culture and suggestive film obviate biopsy; empiric treatment recommended
- CT -> with and w/o contrast very specific
- MR preferred for spine/foot
- Ultrasound in pediatrics to reduce exposure; fluid, periosteal elevation

Open bone biopsy if high suspicion and negative films or culture due to poor sensitivity of radiologic changes in acute infection

Treatment:
- Hematogenous, Non-IVDU adult -> nafcillin, cefazolin, or vancomycin
- Others: see Sanford Guide
- Contiguous: Ceftazidime, Cefipime, or Cipro.
- Post-ORIF -> Nafcillin + cipro.
- Vascular insufficiency: Outpt -> amox/clavulanate or cipro + clindamycin
- Inpt-> pip/taz, tic/clav, or amp/sublactam
- Chronic: based on biopsy. Abx adjunct to surgery only. +rifampin if S. Aureus
**Pneumonia**

- Inflammation of the lung parenchyma. 6th leading cause of death in U.S.
- Organisms reach the lung by aspiration, inhalation, or hematogenous spread
- Contributing factors = Impaired glottic reflex or cough, immunocompromised, impaired ciliary function and smoking

## Pneumonia Etiology

<table>
<thead>
<tr>
<th>Risk Group / Clinical Setting</th>
<th>Likely Organisms</th>
</tr>
</thead>
<tbody>
<tr>
<td>Community-acquired</td>
<td>S. Pneumoniae, H. influenza, Mycoplasma, Chlamydia, Legionella, M. catarrhalis, Klebsiella, virus</td>
</tr>
<tr>
<td>Young healthy adults</td>
<td>Mycoplasma, Chlamydia, S. pneumo</td>
</tr>
<tr>
<td>Alcoholism / Aspiration</td>
<td>S. pneumo, anaerobes, H. flu, Klebsiella, TB</td>
</tr>
<tr>
<td>Hospital-acquired</td>
<td>S. aureus, S. pneumo. GNR including Pseudomonas Klebsiella, Enterobacter, Serratia, Acinetobacter</td>
</tr>
<tr>
<td>Nursing Home</td>
<td>Klebsiella, S. Aureus, TB (Consider same organisms as hospital-acquired pneumonia)</td>
</tr>
<tr>
<td>IDU</td>
<td>S. pneumo, anaerobes, S. aureus, TB</td>
</tr>
<tr>
<td>Smokers</td>
<td>S. pneumo, H. flu, M. catarrhalis, Legionella</td>
</tr>
<tr>
<td>HIV, immunocompromised</td>
<td>All of the above plus PCP, fungi, Nocardia, atypical mycobacteria, CMV, HSV</td>
</tr>
</tbody>
</table>

(Adapted in part from “Pocket Medicine”, 2000, edited by Sabatine)

### Community-acquired Pneumonia

**Symptoms**

- Cough (90%), dyspnea (66%), sputum production (66%), +/- fever, rigors, sweats, myalgias, malaise

**Diagnosis**

- History, PE (vitals, pulse ox)*, CXR (critical), Lab (CBC, ABG, Blood Cx, HIV at discretion), sputum gram stain and culture, consider ABG and blood cultures. Consider bronchoscopy in immunocompromised, critically ill or not responding to treatment.
- Fremitus increased with consolidation, decreased with effusion, PTX, or obstructed bronchus.
- Percussion is dull over consolidation or effusion
- Chest exam is neither sensitive nor specific in diagnosing CAP

**Mgmt**

- Inpatient vs. Outpatient therapy

**Risk of Mortality, Pneumonia PORT prediction rules**

  Step 1: Assess baseline risk predictors—age < 50, normal vitals, no comorbidities, normal mental status
  Step 2: Scoring system of the prediction rule:
## ASSIGNMENT TO RISK CLASSES II–V

<table>
<thead>
<tr>
<th>Patient Characteristics</th>
<th>Points assigned</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Demographic Factors</strong></td>
<td></td>
</tr>
<tr>
<td>Age (male)</td>
<td>No. of years old</td>
</tr>
<tr>
<td>Age (female)</td>
<td>No. of years old – 10</td>
</tr>
<tr>
<td>Nursing home resident</td>
<td>10</td>
</tr>
<tr>
<td><strong>Comorbid Illnesses</strong></td>
<td></td>
</tr>
<tr>
<td>Neoplasm</td>
<td>30</td>
</tr>
<tr>
<td>Liver disease</td>
<td>20</td>
</tr>
<tr>
<td>CHF</td>
<td>10</td>
</tr>
<tr>
<td>Cerebrovascular dz</td>
<td>10</td>
</tr>
<tr>
<td>Renal disease</td>
<td>10</td>
</tr>
<tr>
<td><strong>Physical Findings</strong></td>
<td></td>
</tr>
<tr>
<td>Altered mental status</td>
<td>20</td>
</tr>
<tr>
<td>Respiration &gt;30 breaths/min</td>
<td>20</td>
</tr>
<tr>
<td>Systolic BP &gt;90 mmHg</td>
<td>20</td>
</tr>
<tr>
<td>Temp &lt;35 C or &gt;40 C</td>
<td>15</td>
</tr>
<tr>
<td>Pulse &gt;125 beats/min</td>
<td>10</td>
</tr>
<tr>
<td><strong>Lab or Radiographic Findings</strong></td>
<td></td>
</tr>
<tr>
<td>Arterial pH &lt;7.35</td>
<td>30</td>
</tr>
<tr>
<td>BUN &gt;30 mg/dL</td>
<td>20</td>
</tr>
<tr>
<td>Na &lt;130 mEq/L</td>
<td>20</td>
</tr>
<tr>
<td>Glucose &gt;250 mg/dL</td>
<td>10</td>
</tr>
<tr>
<td>Hct &lt;30</td>
<td>10</td>
</tr>
<tr>
<td>PaO2 &lt;60 mmHg</td>
<td>10</td>
</tr>
<tr>
<td>Pleural effusion</td>
<td>10</td>
</tr>
</tbody>
</table>

A total point score is obtained by adding the patient’s age in years (age - 10, for females) and the points for each applicable patient characteristic.

## RISK MORTALITY RATES

<table>
<thead>
<tr>
<th>Risk Class</th>
<th>No. of points</th>
<th>Recommended site of care</th>
</tr>
</thead>
<tbody>
<tr>
<td>I</td>
<td>No predictors</td>
<td>Outpatient – mortality 0.1%</td>
</tr>
<tr>
<td>II</td>
<td>&lt; 70</td>
<td>Outpatient – mortality 0.6%</td>
</tr>
<tr>
<td>III</td>
<td>71-90</td>
<td>Outpatient vs close observation – mortality 0.9%</td>
</tr>
<tr>
<td>IV</td>
<td>91-130</td>
<td>Inpatient – mortality 9.3%</td>
</tr>
<tr>
<td>V</td>
<td>&gt; 130</td>
<td>Inpatient – mortality 27%</td>
</tr>
</tbody>
</table>

Adapted from Halm et al, NEJM 2002.
ANTIBIOTIC THERAPY

<table>
<thead>
<tr>
<th>PNA Setting</th>
<th>Treatment Guidelines</th>
</tr>
</thead>
</table>
| Outpatient                    | Uncomplicated: macrolide, quinolone*, or doxycycline  
If suspect resistant S.pneumo: quinolone*  
If suspect aspiration: amoxicillin/clavulanate, or clindamycin, or PCN + metronidazole |
| Inpatient                     | Uncomplicated: 3<sup>rd</sup> generation cephalosporin + macrolide. OR quinolone*. OR β-lactam-β-lactamase inhibitor + macrolide.  
ICU 3<sup>rd</sup> generation cephalosporin + macrolide, OR quinolone, OR imipenem OR Zosyn  
Aspiration Clindamycin, Timentin, Zosyn, or cefoxitin  
Hospital-acquired +/- mechanical ventilation Imipenem or meropenem + quinolone, OR Cefepime OR zosyn + tobramycin +/- quinolone* |
| Immunocompromised             | Above plus TMP/Sulfa ± steroids for PCP(if pO2<70 or A-a difference >35mmHg)                              |

*Use anti-pneumococcal quinolone (gati, gemi, levo, moxi, telithro)  

Urinary Tract Infection  
Definitions  
Cystitis Superficial infection of the bladder  
Pyelonephritis Inflammation of the renal parenchyma  
Lower UTI Urethritis, cystitis, prostatitis  
Upper UTI Pyelonephritis, renal abscess  
Uncomplicated Cystitis or pyelonephritis in nonpregnant woman; no underlying structural disease  
Complicated Upper tract infection occurring in the setting of catheters, stones, obstruction; any UTI in a man or pregnant woman; UTI with underlying disease (resistant organisms are more common)  

Etiology  
Uncomplicated Commonly associated with E. coli, Staph saprophyticus  
Complicated Can be catheter-associated. Commonly caused by E. coli, Pseudomonas, S. epi, GNR’s, Enterococcus  
Urethritis Chlamydia trachomatis, Neisseria gonorrhoea  
History/Sxs Dysuria, urgency, increased frequency, change in urine color or smell, suprapubic pain, discharge with urethritis, fever, shaking chills, flank/back pain, vomiting, diarrhea with pyelo, symptoms of outlet obstruction w/ prostatitis  
Work-up/dx UA and dipstick: +LE, nitrite, WBC, RBC  
Urine culture (not for acute uncomplicated cystitis)  
DNA or culture for Neisseria or Chlamydia  
Abdominal CT to rule out abscess if necessary  
Consider IVP/VCG to rule out structural problem in recurrent UTIs
**Type of Infection** | **Treatment Guidelines**
--- | ---
Cystitis | TMP-SMX or quinolone for 3 days if uncomplicated. Rx 10-14 days if complicated.
Pyelonephritis | Quinolone, aminoglycoside, or cephalosporin for 14 d (E. coli resistance to amoxicillin is increasing) for outpatient. For inpatient, use IV x 24-48hr, then switch to Pos.
Urethritis | Ceftriaxone 125 mg IM x 1 (for Neisseria) and doxycycline 100 mg PO x 7 days or azithromycin 1 g PO x 1 (for Chlamydia)
Prostatitis | TMP-SMX or quinolone for 14-28 d if acute, up to 12 wks if chronic
Renal Abscess | Drain + Rx as for pyelonephritis above

(Adapted from "Pocket Medicine", 2000, edited by Sabatine)

**Nephrology**

**Acute Renal Failure**

**Definition**
- Rapid deterioration of renal function: azotemia, elevated BUN and Cr
- Decreased urine output
- Increase in creatinine of > 0.5 mg/dL or increase in creatinine >50% or decrease GFR > 50%
- Nonoliguria = UOP > 400 ml/24 hr
- Oliguria = UOP = 100-400 ml/24 hr
- Anuria = UOP < 100 ml/ 24 hr

**Hx/sxs**
- GI: anorexia, nausea, vomiting
- Cardiopulmonary: chest pain (pericarditis), dyspnea (pulmonary edema)
- Fatigue, confusion
- Ask about recent procedures or hypotensive episodes, review med list, pertinent PMH

**PE**
- Vital signs: may have hypertension from volume overload
- Extra heart sounds
- Ascites, abdominal masses
- Skin changes, pallor, rash, breath odor

**Common Etiologies of ARF:**

1. **Prerenal**

   **Causes**
   - Intravascular volume loss: vomiting, diarrhea, ↓ intake, diuresis, 3rd-spacing
   - Hypotensive episode: surgery, sepsis, drugs, blood loss
   - Decreased cardiac output: MI, CHF, renal artery stenosis, emboli, thrombosis, NSAIDs, ACEIs

   **Work-up/dx**
   - History, PE (vitals, orthostatics, neck veins, CV, Resp) R/O bleeding
   - UA, BUN, creatinine, FeNa
   - BUN/Cr ratio >20 suggests prerenal ARF.
   - Renal ultrasound if RAS suspected

   **UA**
   - Urinalysis is bland: few or no cells, +/- hyaline casts
   - Urine Na <20 mEq/L
   - (FeNa <1 suggests prerenal disease; FeNa >2 suggests intrinsic renal. FeNa >4 suggests post-renal etiology.)
Rx  
Stop offending medications
Optimize volume status
Correct underlying problem. Usually reversible

2. Intrarenal

**Acute tubular necrosis (ATN)**

Causes  
Drugs (aminoglycosides, amphotericin, cisplatin), toxins, ischemia, contrast dye, pigments, crystals, proteins

Work-up/dx  
History, PE, UA, BUN, Creatinine, FeNa

UA  
Renal tubular cells
Muddy brown/pigmented casts
Urine Na >20 mg/dL

Rx  
Stop offending medications or other cause
Support BP
Dialysis PRN

**Acute interstitial nephritis (AIN)**

Causes  
Drugs (beta-lactam antibiotics, sulfas, NSAIDs), infections, toxins, autoimmune, infiltrative

Work-up/dx  
Same as for ATN, consider 24-hr urine, urine eosinophils, UPEP, renal bx

UA  
WBCs and WBC casts, eosinophils
Urine Na usually low

Rx  
Remove cause
Prednisone
Dialysis PRN

**Glomerulonephritis**

Causes  
Berger’s disease (IgA nephropathy), post-strep GN, SLE, RPGN, hep C

Work-up/dx  
Same as above, consider renal bx

UA  
RBCs and RBC casts
Urine Na usually low

Rx  
Post-strep: supportive
If crescenteric (RPGN) then immunosuppression
Dialysis PRN

**Vascular**

Causes  
Wegener’s, HUS/TTP, athero-embolic, scleroderma, hypertensive crisis, renal artery stenosis

Work-up/dx  
Same as above, consider renal bx

UA  
Few cells
Urine Na usually low

Rx  
Immunosuppression
Dialysis PRN

3. Post-renal (obstructive)

Causes  
Stones, retroperitoneal fibrosis, intratubular (uric acid crystals, light chains, methotrexate, acyclovir crystals), prostate enlargement/cancer, bladder/ureteral disease, lymphadenopathy, anticholinergic meds
Work-up/dx  As above with attention to neuro exam, palpate and percuss bladder
   Post-void residual, catheterization
   Ultrasound, CT
UA  ± cells, crystals
Rx  Remove cause
    Dialysis PRN
Recovery is directly related to the amount of time spent obstructed

Chronic renal failure
Etiologies include any cause of intrinsic disease with chronic hypertension and diabetes
being the most common.

Consequences of CRF:
1. Uremia
   - secondary to Na, K, and water retention, metabolic acidosis, excess toxins
   - signs and symptoms: edema, HTN, (activated renin-angiotensin axis), nausea, fatigue,
     anorexia, pericarditis, platelet dysfunction, encephalopathy, fluid volume disorder
     (early, can’t concentrate urine; late, can’t dilute)
   - treatment: diuretics, restrict Na and K, anti-hypertensive drugs, dialysis if severe acid-base or electrolyte disorders

2. Bone disease:
   - secondary to high phosphate levels, low 1,25-vitamin D, low Ca, High PTH
   - signs and sx: bone pain (fractures), pruritus, calcifications, carpal tunnel
   - treatment: lower phosphate levels, raise calcium, lower PTH

3. Anemia:
   - secondary to decreased production of EPO, fewer RBCs made, loss with dialysis
   - signs and symptoms: pallor, fatigue, anorexia
   - treatment: EPO, replace iron loss

Indications for Dialysis:

A  acid-base disturbance (acidemia)
E  electrolyte disorder (hyperkalemia)
I  intoxication (methanol, ethylene glycol)
O  overload of volume
U  uremic symptoms
Pulmonology
Pulmonary Function Testing
Interpretation of spirometry/lung volumes

1. Ensure acceptable and reproducible data
2. FEV1/FVC ratio
   a. Lower limit of normal (LLN) = predicted minus 8% men, 9% women
3. FEV1/FVC ≥ LLN - no airflow obstruction
4. FEV1/FVC < LLN:
   a. FEV1 65-100% predicted - mild airflow obstruction
   b. FEV1 50-64% predicted - moderate airflow obstruction
   c. FEV1 <50% predicted - severe airflow obstruction
5. FEV1/FVC ≥ LLN:
   a. TLC or VC 65-79% predicted - mild restriction
   b. TLC or VC 50-64% predicted - moderate restriction
   c. TLC or VC < 50% predicted - severe restriction
6. Bronchodilator response
   a. Increase ≥ 12% AND ≥ 200ml in FEV1 or FVC following administration of bronchodilator
7. If obstructed: RV > 120% - air trapping, TLC > 120% - hyperinflation
8. Other tests
   a. DLCO - estimates alveolar capillary surface area
      i. Decreased - interstitial lung disease, emphysema
      ii. Increased - erythrocytosis, increased pulmonary blood flow
   b. Maximal inspiratory/expiratory pressures - useful in neuromuscular disorders
   c. ABG (See general medicine section for ABG analysis)

Ventilator Mode Settings
1. AC or AMV: Preset tidal volume (8-12cc/kg) and rate. Patient triggers each breath but machine mandates minimum number of breaths.
2. SIMV: Preset tidal volume and rate. Preset machine breaths provide set tidal volume, and spontaneous breaths are allowed between machine breaths for patient to take spontaneous tidal volumes.
3. PC (pressure control): Set peak pressure, rate and inspiratory time. Tidal volume varies with airway resistance and compliance.
4. CPAP - Uses positive end expiratory pressure (PEEP) during spontaneous breathing through a mask.
5. BiPAP - Bilevel Positive Airway Pressure. Inspiratory and expiratory positive pressures delivered by mask to treat sleep apnea or to try to avoid intubation/mechanical ventilation.
6. Pressure support - Preset amount of pressure during inspiration, and patient controls inspiratory time, tidal volume and rate. Overcomes resistance in the breathing circuit and ETT. Basically, the ventilator does the initial part of the breath, and PS can be used in conjunction with SIMV to overcome resistance of airway/ETT. Caution: Pt. must have intact respiratory drive as tidal volume and minute ventilation are not set!
Pleural Effusions

- Effusions can be either exudative or transudative
- At least 150 mL of fluid is needed to be seen on upright PA films as blunting of costophrenic angle, and 25-50 mL on lateral films
- Obtain decubitus films on all patients prior to thoracentesis to decipher loculations and evaluate underlying parynchema. >1cm of fluid on decub film = tappable.
- Perform thoracentesis on all NEW effusions. Can observe effusions in pts with known CHF that have symmetrical effusions and no evidence of infection or other cause for effusion.
- Send fluid for cell count + differential, LDH, glucose, total protein, cholesterol, amylase, pH, Gram stain and culture. May also consider cytology, ANA, RF, AFB stains/cultures, or HCT depending on likely etiologies.

<table>
<thead>
<tr>
<th>Cause</th>
<th>Transudate</th>
<th>Exudate</th>
</tr>
</thead>
<tbody>
<tr>
<td>Congestive Heart Failure</td>
<td>YES</td>
<td>NO</td>
</tr>
<tr>
<td>Pneumonia</td>
<td>NO</td>
<td>YES</td>
</tr>
<tr>
<td>Cancer</td>
<td>NO</td>
<td>YES</td>
</tr>
<tr>
<td>Pulmonary Embolism</td>
<td>Sometimes</td>
<td>Sometimes</td>
</tr>
<tr>
<td>Viral Disease</td>
<td>NO</td>
<td>YES</td>
</tr>
<tr>
<td>CABG</td>
<td>NO</td>
<td>YES</td>
</tr>
<tr>
<td>Cirrhosis with Ascites</td>
<td>YES</td>
<td>NO</td>
</tr>
</tbody>
</table>

Listed in order of incidence, adapted from Light, NEJM 2002.

LIGHT’S Criteria - must satisfy at least one of the below criteria to be an exudate
- Ratio of pleural protein to serum protein > 0.5 = Exudate
- Ratio of pleural LDH to serum LDH > 0.6 = Exudate
- Pleural LDH > 2/3 upper limit of normal for serum LDH = Exudate

Can also use
- Pleural fluid protein > 2.9 mg/dL
- Pleural fluid cholesterol > 45 mg/dL
- Pleural fluid LDH > 45% upper limit of normal serum value

If an exudate is found, can use other laboratory values to decipher etiology
- Glucose < 60 seen in malignancy, Rheumatoid, TB, Lupus, empyema/parapneumonic
- pH < 7.3 seen in malignancy, Rheumatoid, TB, systemic acidosis, empyema
- If associated with bacterial pneumonia, abscess, or bronchiectasis it is a parapneumonic effusion:
  1. Uncomplicated parapneumonic = free flowing with pH > 7.2, gram stain negative, culture negative
  2. Complicated parapneumonic = loculated OR pH < 7.2 OR gram stain positive OR culture positive

- Needs chest tube if complicated parapneumonic, pH < 7.2, bacteria present, or pus
**Pulmonary Embolism**

- Most common signs/symptoms of PE include: tachycardia, tachypnea, SOB, and pleuritic chest pain
- Laboratory findings include elevated D-dimer (sensitive but not specific), hypoxemia with increased A-a difference. Can see leukocytosis, elevated LDH, and elevated cardiac enzymes due to right heart strain. D Dimer only useful when PE is not your top suspicion in the differential.
- EKG is nonspecific and is most commonly sinus tachycardia. Nonspecific ST-T changes can be seen, and rarely the classic S in I, Q in III, and inverted T in III due to elevated pressures in the right heart.
- CXR: Nonspecific abnormalities. Hampton’s Hump or wedge shaped peripheral opacities. Gold standard is pulmonary angiogram. Typically, use spiral CT with IV contrast or V/Q scan.

Don’t forget that most (up to 90%) of PE’s come from lower extremity DVTs, so venous duplex is often indicated if high suspicion for PE. Treatment includes initiation of a heparin drip with a loading bolus of 80 units/kg followed by 18 units/kg/hr. The aPTT should be checked in 6hr and infusion rate adjusted to maintain the aPTT at 1.5-2.5 x control. (LMWH is as effective as unfractionated heparin) Warfarin should be initiated if no contraindications are found, to achieve an INR of 2-3. Once INR achieved for 24hrs, heparin can be discontinued. Patients with their first DVT/PE should be maintained on warfarin for 3-6 months.

**Lung Cancer** (leading cause of cancer mortality in US)

*Non-small cell 80%*
- Adenocarcinoma 30-40%  
  bronchoalveolar CA subtype  
- SCC 20-30%  
- Large cell 10%

*Small cell 20%*  
- SIADH, ↑ ACTH, Eaton-Lambert

Paraneoplastic syndromes associated:
- Hypercoagulable states
- ↑ PTH, hypercalcemia
- ↑ hCG

**Sx**  
Usually symptomatic at presentation; cough/change in chronic cough, dyspnea, hemoptysis, weight loss, SVC syndrome, pancoast syndrome

**Dx**  
CXR, CT chest, ± thoracentesis, VATS, mediastinoscopy

**Non-small cell – TNM Staging (simplified)**

<table>
<thead>
<tr>
<th>T</th>
<th>tumor &lt; 3 cm</th>
</tr>
</thead>
<tbody>
<tr>
<td>T2</td>
<td>&gt; 3 cm or invades pleura</td>
</tr>
<tr>
<td>T3</td>
<td>any size with chest wall/diaphragm invasion, or within 2cm carina</td>
</tr>
<tr>
<td>T4</td>
<td>any size + mediastinal/heart/tracheal/esophageal invasion or malig pleural effusion</td>
</tr>
<tr>
<td>N0</td>
<td>no node</td>
</tr>
<tr>
<td>N1</td>
<td>ipsilateral hilar nodes</td>
</tr>
<tr>
<td>N2</td>
<td>ipsilateral mediastinal/tracheal nodes</td>
</tr>
<tr>
<td>N3</td>
<td>contralateral nodes</td>
</tr>
<tr>
<td>M0</td>
<td>no mets</td>
</tr>
<tr>
<td>M1</td>
<td>+ mets</td>
</tr>
</tbody>
</table>
### Non-small cell

<table>
<thead>
<tr>
<th>Stage</th>
<th>Treatment</th>
</tr>
</thead>
<tbody>
<tr>
<td>I</td>
<td>T1 or T2N0M0 resection</td>
</tr>
<tr>
<td>II</td>
<td>T1 or T2N1M0 or T3N0M0 resection ± chemo or rads</td>
</tr>
<tr>
<td>IIIA</td>
<td>T3N1M0 or T1-T3N2M0 resection vs chemo/rads</td>
</tr>
<tr>
<td>IIIB</td>
<td>anyTN3M0 or T4anyNM0 palliation vs chemo/rads</td>
</tr>
<tr>
<td>IV</td>
<td>anyTanyNM1 palliation vs chemo</td>
</tr>
</tbody>
</table>

### Small cell

- Limited: disease limited to ipsilateral hemithorax (one radiation port), chemo (largely palliative)
- Extensive: metastatic disease beyond one hemithorax, palliation

### Rheumatology

#### Osteoarthritis (OA)

- Most common joint disorder in US and the world; major cause of disability and pain in the elderly; before age 50 males > females; after 50 females < males
- Overweight people are at greater risk. Injuries may increase risk of development

#### History/Sx

- Pain and stiffness in and around joints (knees, hips, hands esp. DIPS/PIPS, cervical/lumbar spine), characteristic pattern is axial and peripheral joints in an asymmetric pattern, mild to moderate pain often gradual or insidious in onset, relieved by rest, may have AM stiffness but usually less than 30 minutes

#### PE

- Bony enlargement is common and may lead to tenderness at joint margins ± decreased ROM, ± crepitus, locking of joints with ROM
- Heberden's and Bouchard's nodes

#### Labs

- Usually not necessary, may want to R/O inflammatory arthritis

#### XR

- Bony proliferation (osteofyte formation or spurs)
- Joint space narrowing

#### Rx

- Education, weight loss if necessary, acetaminophen, NSAIDs ± glucosamine/chondroitin
- Consider PT/OT, corticosteroid injections, surgery

### Rheumatoid Arthritis (RA)

- Systemic inflammatory disease predominantly in the synovial membrane of diarthrodial joints, may have extra-articular manifestations
- Affects all ethnic groups, 2.5-3.1 to 1 female to male ratio
- Peaks in 4th-6th decades

#### Need 4 out of 7 criteria for diagnosis:

1. AM stiffness for > 1 hour
2. Arthritis of 3+ joint areas
3. Arthritis of hand joints
4. Symmetric joint involvement/arthrits
5. Rheumatoid nodules (common over bony prominences, extensor surfaces)
6. + serum rheumatoid factor (RF)
7. Radiographic changes consistent with RA (erosions, periarticular decalcification)

#### Physical exam/clinical features:

- Symmetric synovitis of joints, esp. PIPs, MCPs, wrists, ankles, knees, MTPs
- Joint deformities: ulnar deviation, swan neck deformity, Boutonniere deformity
- C1-C2 instability (check C-spine films and inform team prior to intubation)
- Nodules (subcutaneous, lung, pericardium, sclera)
- Malaise, fever, weight loss
- Eyes: episcleritis/scleritis
- Lungs: fibrosis, nodules, pleurisy
- Cardiac: pericardial effusion, pericarditis, aortitis, Al
- GI: rarely involved
- Renal: rarely involved
- Neuro: C-spine instability can lead to cervical myelopathy, nerve compressions, mononeuritis multiplex
- Heme: hypochromic microcytic anemia, leukopenia, thrombocytopenia

Labs
- + RF in 85% of people with RA. Higher levels may correlate with extra-articular features although RF is of little prognostic value (don't need to follow)
- anti CCP (citrulline containing peptide) antibodies—more specific but less sensitive than RF, often used on combination with RF for even greater specificity to r/o RA.
- Elevated ESR and CRP (nonspecific)
- Hypergammaglobulinemia, hypocomplementemia, thrombocytosis, eosinophilia

Treatment:
- Accurate dx
- Smoking cessation, immunizations, appropriate tx of infections, management of diabetes, HTN, osteoporosis
- NSAIDs are effective for treatment of pain, swelling and stiffness but don't alter the progression of disease
- DMARDs (disease-modifying antirheumatic drugs) are used to control disease and limit damage
- New class of biologics (e.g., infliximab, entanercept) that target inflammatory mediators (TNF-alpha, IL-20) have revolutionized RA treatment and resulted in 75% improvement of symptoms in many patients.
- Methotrexate and TNF-alpha inhibitors are a common combination therapy.
- Surgery may be needed to modify joint damage.

Systemic Lupus Erythematosus
General:
- Autoimmune disease consisting of multisystemic inflammation with broad spectrum of clinical manifestations
- Cluster of signs and symptoms classified as one entity
- Associated with production of antibodies to components of the cell nucleus (antinuclear antibodies)
- Peak between ages 15-40 with female to male ratio 6-10:1
- HLA linked (DR3)
- 11 diagnostic criteria that reflect the major clinical features (4+ needed for dx)

Clinical manifestations / diagnostic criteria (4+ for dx):
Cutaneous
1. malar rash
2. discoid rash
3. photosensitivity
4. oral/nasopharyngeal ulcers

Musculoskeletal
5. non-erosive arthritis

Cardiopulmonary
6. serositis (pleuritis, pleural effusion, pericarditis, pericardial effusion)

Renal
7. proteinuria ( > 500 mg/dL or urinary cellular casts)

Neurologic
8. seizures or psychosis

Hematologic
9. hemolytic anemia or leukopenia or lymphopenia, thrombocytopenia

Serologies
10. +ANA
11. +anti-dsDNA

Other systems involved:
GI (serositis, vasculitis, abdominal pain, hepatitis, pancreatitis)
Ocular (cotton wool spots, corneal/conjunctival involvement)

Labs
Each cellular element in the blood can be affected by SLE (get CBC and look for “penias”). ESR is commonly elevated but not reliable marker of clinical activity

**AUTOANTIBODIES**

<table>
<thead>
<tr>
<th>Autoantibody</th>
<th>Frequency</th>
<th>Clinical association</th>
</tr>
</thead>
<tbody>
<tr>
<td>ANA</td>
<td>90%</td>
<td>Any or all clinical findings</td>
</tr>
<tr>
<td>Anti-dsDNA</td>
<td>40-60%</td>
<td>Lupus nephritis, vasculitis</td>
</tr>
<tr>
<td>Anti-RNP</td>
<td>30-40%</td>
<td>Raynaud’s, musculoskeletal</td>
</tr>
<tr>
<td>Anti-Sm</td>
<td>30% (very specific)</td>
<td></td>
</tr>
<tr>
<td>Anti-Ro(SSA)</td>
<td>30-45%</td>
<td>Dry eyes/mouth, neonatal lupus</td>
</tr>
<tr>
<td>Anti-La(SSB)</td>
<td>10-15%</td>
<td>Dry eyes/mouth, neonatal lupus</td>
</tr>
<tr>
<td>Antiphospholipid</td>
<td>30%</td>
<td>Clotting diathesis</td>
</tr>
</tbody>
</table>

Treatment
- Education, control fatigue, treat comorbidities (hypothyroidism, depression, etc), avoid sunlight
- NSAIDs: musculoskeletal complaints, pleuritis, pericarditis, HA monior for side effects/contraindications (renal, GI, etc. …)
- Corticosteroids: topical for cutaneous lesions, oral for constitutional symptoms, arthritis, serositis. Be aware of side effects/toxicities
- Hydroxychloroquine/Plaquenil: constitutional symptoms, cutaneous, arthritis, serositis, musculoskeletal (steroid sparing)
- Azathioprine (inhibits nucleic acid synthesis/ affects cellular and humoral immunity): alternative for lupus nephritis, and steroid sparing for other nonrenal manifestations
- Cyclophosphamide (immunosuppressive): mainstay for lupus nephritis/severe organ disease
- Methotrexate: cutaneous and joint disease
Gout
- Disease resulting from monosodium urate (MSU) crystal deposition in tissues
- Predominantly disease of adult men with peak in 5th decade
- Rare in premenopausal women
- Classic gout passes through 3 stages
  1. Asymptomatic hyperuricemia
  2. Acute intermittent gout
  3. Chronic tophaceous gout

Precipitants
- Obesity; hypertriglyceridemia; diabetes; excessive EtOH intake; high purine diet; medications: cyclosporine, HCTZ, low-dose aspirin (high-dose is protective), allopurinol if given during an acute flare

History/sxs
- Intense, sudden onset of pain in joints commonly in 1st MTP (podagra), ankles, knees, typically monoarticular, warmth, swelling, redness of the area, common onset at night, fevers, chills, malaise may be present

PE
- Erythematous, swollen, very tender joints, overlying skin may be warm, tense, dusky, tophi in synovium, Heberden's nodes, Achilles tendon, gross joint deformities

X-rays
- Unremarkable in early stages
- Soft-tissue swelling
- Bony erosions with "overhanging edge"
- Joint space preserved until late

Labs/dx
- Elevated serum urate level
- Definitive diagnosis only by aspiration of synovial fluid and demonstration of characteristic crystals (needle/rod shaped, birefringent that are yellow when parallel to the axis of the polarized light)
- Synovial fluid findings are consistent with inflammation (WBC count 5-80,000, mostly PMNs)

Rx
- Acute attack: NSAIDs, colchicine, corticosteroids,
  DON'T INITIATE ALLOPURINOL DURING AN ACUTE ATTACK
- Prophylaxis: lifestyle modification, prevention of precipitants, weight loss, urate lowering agents (allopurinol, uricosuric agents)