KAPLAN MEDICAL

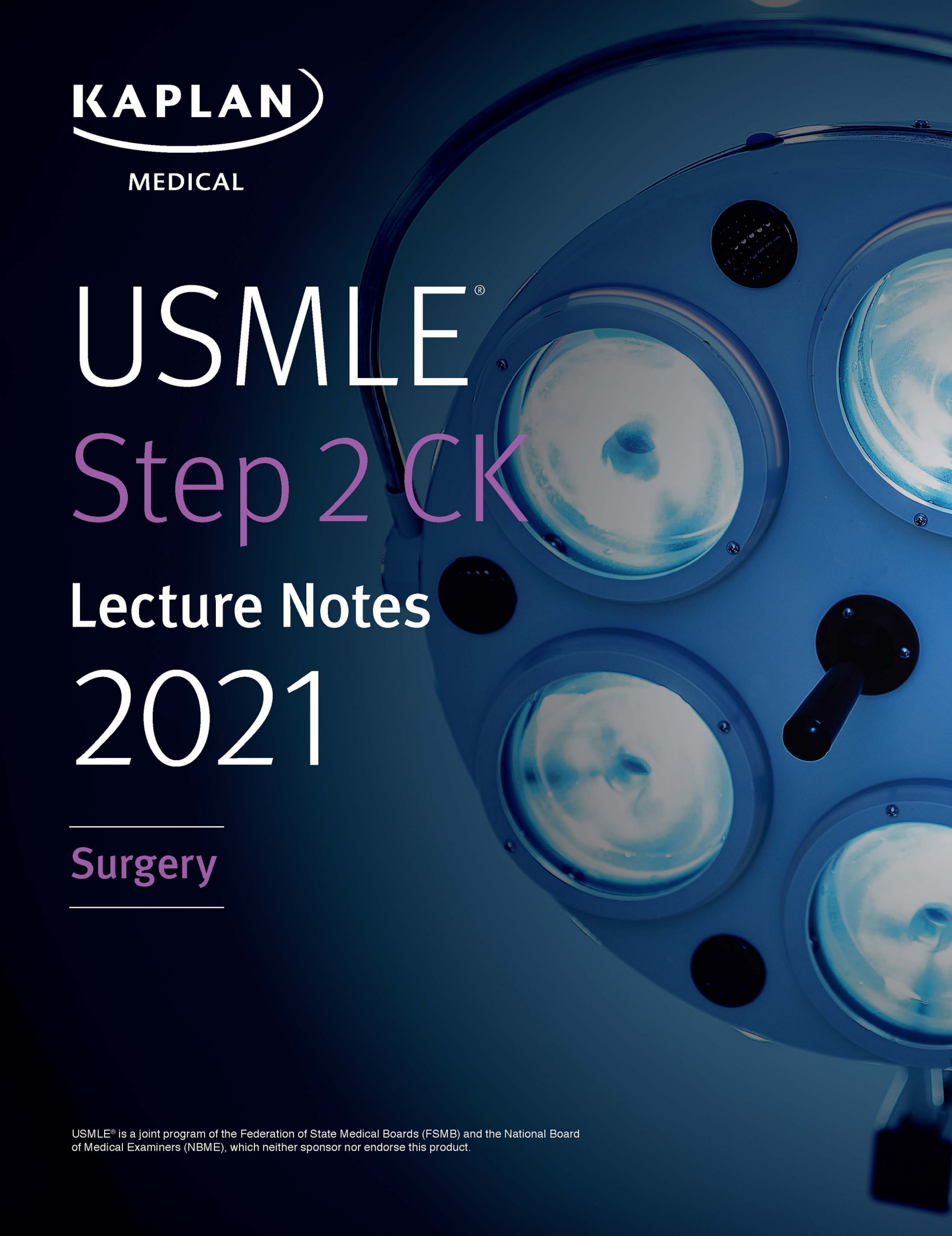
USMLE®

Step 2 CK

Lecture Notes

2021

Surgery



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Preoperative and Postoperative Care 1

Learning Objectives

- ❑ Recognize the factors essential to a preoperative assessment
- ❑ Describe the approach to diagnosis and management of postoperative complications

PREOPERATIVE ASSESSMENT

Prior to **elective** surgery, a patient should be evaluated for potential risks associated with surgery and general anesthesia. These include cardiac, pulmonary, hepatic, nutritional, and metabolic factors that can contribute to intra- and postoperative complications.

Cardiac Risk

The revised cardiac risk index (RCRI) can be used to estimate the risk of cardiac complications for patients undergoing noncardiac operative procedures under general anesthesia. This index is composed of the following variables:

- History of ischemic cardiac disease
- History of congestive heart failure (CHF)
- History of stroke or cerebrovascular accident (CVA)
- Diabetes mellitus
- Chronic kidney disease (CKD, or creatinine >2 mg/dL)
- Planned surgery for thoracic, intra-abdominal, or infrainguinal vascular disease

The risk of cardiac death, cardiac arrest, or nonfatal perioperative myocardial infarction is based on total score.

Score	Risk
0 factors	<0.4% risk
1 factor	0.9% risk
2 factors	6.6% risk
3 or more factors	>11% risk

Note

All general anesthetics **decrease inotropy** and **increase ectopy**.

Pulmonary Risk

Smoking is by far the most common cause of increased pulmonary risk; the problem is compromised ventilation more than compromised oxygenation. Increased pCO_2 and decreased FEV_1 are the most significant predictors of advanced disease.

Smoking history or the presence of chronic obstructive pulmonary disease (COPD) should lead to evaluation with pulmonary function testing.

Smoking cessation and intensive respiratory therapy (physical therapy, expectorants, incentive spirometry, humidified air) should precede elective surgery when possible.

Hepatic Risk

Perioperative risk due to hepatic disease is stratified by several systems, most notably the Child-Pugh classification system and the Model for End-Stage Liver Disease (MELD). The most common disease affecting the liver is alcoholism.

The Child-Pugh system incorporates **A**scites, **B**ilirubin, **C**lotting (prothrombin time), **D**iet (serum albumin), and **E**ncephalopathy (presence/absence). Predicted surgical mortality is as follows:

- Mortality of ~40% is predictable with bilirubin >2 mg/dL, albumin <3 g/dL, prothrombin time >16 sec, or encephalopathy.
- Mortality of ~80–85% is predictable if 3 of the above are present (close to 100% if all 4 exist) or if bilirubin alone is >4 mg/dL, albumin alone is <2 g/dL, or blood ammonia concentration alone is >150 mg/dL.

The MELD score uses the patient's serum bilirubin, creatinine, and INR (normalized prothrombin time) to predict survival and estimate hepatic reserve. Online and app-based calculators are available to calculate the score.

The table shows MELD scores and their associated mortality rates.

MELD score	Mortality rate
<9	1.9%
10–19	6%
20–29	19.6%
30–39	52.6%
≥40	71.3%

Nutritional Risk

Malnutrition results in immunodeficiency and impairs healing, significantly increasing the risk of major surgery. Severe nutritional depletion is identified by one or more of the following:

- Loss of 20% of body weight over 6 months
- Serum albumin <3 g/dL; prealbumin <16 mg/dL
- Serum transferrin level <200 mg/dL

Operative risk is increased significantly in the presence of malnutrition. As few as 4–5 days of preoperative nutritional support (preferably enteral) can make a big difference; 7–10 days is optimal if the surgery can be deferred for that long.

Metabolic Risk

Diabetic ketoacidosis is an absolute contraindication to surgery. Rehydration, return of urinary output, and at least partial correction of the acidosis and hyperglycemia must be achieved before surgery can be undertaken.

Cardiac Risk

> A 72-year-old man with a history of multiple myocardial infarctions is scheduled to have an elective sigmoid resection for diverticular disease. A preoperative echocardiogram shows ejection fraction 35%.

With this ejection fraction, the incidence of perioperative myocardial infarction is ~75%, and the associated mortality rate is 50–90%. In this case, elective surgery is most likely not an option. Continue with medical therapy for the diverticular disease and to optimize cardiac function. If the patient develops an abscess, consider percutaneous drainage to avoid surgical intervention.

> A 72-year-old chronically bedridden man is being considered for emergency cholecystectomy for acute cholecystitis that is not responding to medical management. Four months ago he had a myocardial infarction. Currently he has paroxysmal atrial fibrillation.

This patient has multiple risk factors correlating to a ~20% predicted mortality. Nonsurgical treatment (in this case, percutaneous cholecystostomy tube under local anesthesia) should be pursued.

A 72-year-old man is scheduled to have an elective sigmoid resection for diverticular disease. In the preoperative evaluation it is noted that he has venous jugular distention.

Not a lot of information is provided, but what is given raises suspicion for CHF, which is the worst cardiac risk predictor. Further evaluation starting with echocardiography should be pursued, and the patient should be medically optimized prior to surgery with ACE inhibitors, beta-blockers, and diuretics.

A 61-year-old man with a 20-pack-year smoking history needs elective surgical repair of an abdominal aortic aneurysm. He has cut back on smoking to half a pack per day.

Smoking is by far the most common cause of increased pulmonary risk; smoking cessation and respiratory therapy should precede surgery. Do a complete pulmonary evaluation with pulmonary function testing and optimization with bronchodilators and secretion management. A rapidly growing aneurysm at risk for rupture will need more urgent intervention prior to optimization.

A 49-year-old alcoholic presents with upper gastrointestinal bleeding from a duodenal ulcer. On examination she has bilirubin 3.5 mg/dL, prothrombin time 22 seconds, and serum albumin 2.5 g/dL. Ascites is present.

This patient likely has advanced cirrhosis. Surgical intervention is contraindicated.

- If only one of these conditions is present (bilirubin >2 mg/dL, prothrombin time >16, albumin <3), mortality is predicted at >40%.
- If 3 of these conditions are present, mortality is as high as 85%.

Attempt nonsurgical treatment with blood product resuscitation and consider nonsurgical options such as endoscopic clipping or endovascular embolization.

A 78-year-old man needs palliative surgery for an obstructing cancer of the colon. He has lost 20% of his body weight over the past 2 months. Serum albumin is 2.7.

Any one of these findings indicates severe nutritional depletion. Delaying surgical intervention for several days of preoperative nutrition would decrease some of the risk. This must be taken into consideration when contemplating a palliative procedure.

An older diabetic man presents with a clinical picture of acute cholecystitis that has been present for 3 days. He is profoundly dehydrated and confused, and has blood sugar 550 mg/dL with severe metabolic acidosis.

Diabetic ketoacidosis is a contraindication to surgical intervention. This vignette presents a challenging situation because the patient's hyperglycemia will continue to worsen as long as sepsis is present. Therefore, when the acidosis has resolved, nonsurgical management of the

infection should be pursued—in this case, a percutaneous cholecystostomy tube and definitive source control with cholecystectomy.

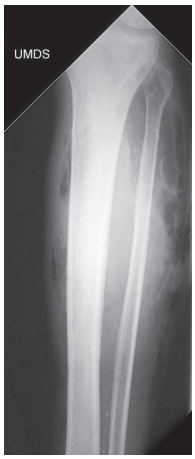
PERIOPERATIVE COMPLICATIONS

Fever

Malignant hyperthermia develops shortly after the onset of the anesthetic (most commonly halothane or succinylcholine). Symptoms include temperature >40 C (104 F), metabolic acidosis, hypercalcemia, and hyperkalemia. A family history may exist; the patient should always be questioned preoperatively. Treatment is **IV dantrolene**, 100% oxygen, correction of the acidosis, and cooling blankets. Monitor postoperatively for the development of myoglobinuria (very uncommon).

Bacteremia is seen within 30–45 minutes of invasive procedures (instrumentation of the urinary tract is a classic example) and presents as chills and a temperature spike as high as 40 C (104 F). Draw multiple sets of blood cultures and start empiric broad-spectrum antibiotics.

Although the condition is rare, severe wound pain and very high fever within hours of surgery should alert you to the possibility of a **necrotizing soft tissue infection**. Immediately remove surgical dressings to examine the wound and promptly return to the OR for wound reopening, debridement, and washout.



Courtesy of SRS-X, Scottish Radiological Society

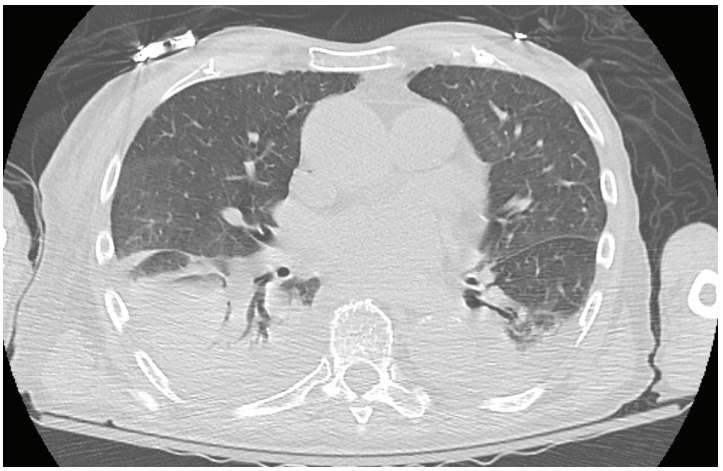
Figure 1-1. Necrotizing Soft Tissue Infection due to *Clostridium Perfringens*

Postoperative fever typically is not as high as in the previous examples, usually 38.3–39.4 C (101–103 F). Fever in the postoperative period is caused (in order of time sequence) by atelectasis, pneumonia, urinary tract infection (UTI), deep vein thrombosis (DVT), wound infection, or deep abscesses.

Atelectasis is the most common source of fever on the first postoperative day. Assess the risk of the other causes already noted, listen to the lungs, do a chest x-ray, and improve ventilation (deep breathing and coughing, postural drainage, incentive spirometry). No need to order a CT or blood cultures in this early postoperative period, as this is generally an empiric diagnosis. Bronchoscopy with clearing of secretions is occasionally necessary.

Clinical Pearl

In post-op patients, fever commonly arises from **W**ind (atelectasis), **W**ater (UTI), and **W**ound (wound infection). (Note that **W**alking [DVT]—historically part of the 4 Ws—is now much less common in the post-op period due to the absolute necessity of DVT prophylaxis.)



Courtesy of Gary Schwartz, MD

Figure 1-2. Atelectasis

Pneumonia will happen in about 3 days if atelectasis is not resolved (atelectasis is a prelude to pneumonia). Fever will persist, leukocytosis will be present, and chest x-ray will demonstrate infiltrate(s). There may be purulent sputum. Obtain sputum cultures and treat with appropriate antibiotics.

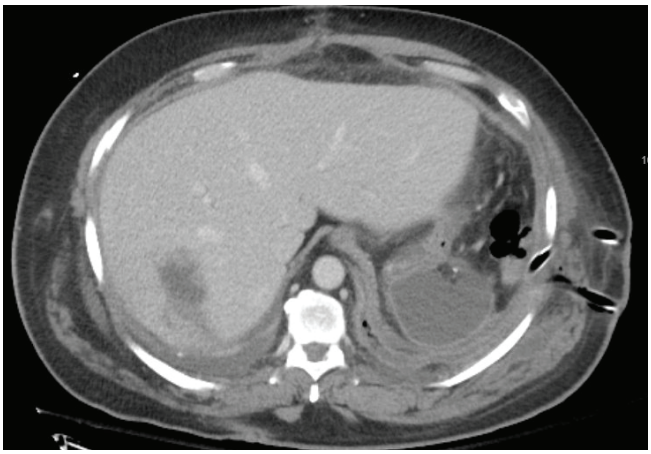
UTI typically produces fever starting on postoperative day 3. Work up with a urinalysis and urinary cultures and treat with appropriate antibiotics. The most common cause is instrumentation (catheterization).

Deep vein thrombosis can result in fever starting around postoperative day 5. Diagnosis requires a high index of suspicion. Physical exam is not very sensitive; U/S is diagnostic. Treatment is systemic anticoagulation, initially with heparin or unfractionated low molecular weight heparin and then transitioned to a long-term anticoagulant. Prophylaxis is mandatory in all surgical patients with early ambulation, compression devices, and/or chemical prophylaxis with low-dose heparin.

Wound infection typically begins to produce fever around postoperative day 7. Physical exam will reveal erythema, warmth, tenderness, and fluctuance. The 7-day delay is because it takes that long from **colonization to infection** (a numbers game).

- If only cellulitis is present, treat with antibiotics.
- If an abscess is present or suspected (most important physical finding is **fluctuance**), the wound must be opened and drained.
- If the case is unclear, use U/S or CT to diagnose.

A **deep abscess** (e.g., intraperitoneal: subphrenic, pelvic, or subhepatic) will start to produce fever around postoperative days 10–15. CT of the appropriate body cavity is diagnostic. Percutaneous image-guided drainage is therapeutic.



Courtesy of Gary Schwartz, MD

Figure 1-3. CT Splenic Bed Abscess

Shortly after the onset of a general anesthetic with inhaled halothane and muscle relaxation with succinylcholine, a patient develops a rapid rise in body temperature, exceeding 40 C (104 F). Metabolic acidosis and hypercalcemia are also noted. A family member died under general anesthesia several years earlier.

This is a classic case of malignant hyperthermia. The history should have been a warning, but once the problem develops, discontinue the anesthetic gas, treat with IV dantrolene, and take the essential support measures:

- 100% oxygen
- Correction of the acidosis
- Cooling blankets

Monitor for myoglobinuria and an acute kidney injury.

Forty-five minutes after completion of a cystoscopy, a patient develops chills and a fever spike to 40 C (104 F).

This is early on after an invasive procedure, and a fever this high means bacteremia. Take blood cultures and start broad-spectrum, empiric IV antibiotic therapy.

On postoperative day 1 after a right hemicolectomy, a patient develops a fever of 38.9 C (102 F).

Fever on day 1 is most commonly due to atelectasis, but all the other potential sources have to be ruled out. Examine the wound and IV sites and take a chest x-ray. Inquire about urinary tract symptoms. Improve the patient's ventilation: deep breathing and coughing, postural drainage, and incentive spirometry. This is all referred to as "pulmonary toilet."

On postoperative day 1 after an abdominal procedure, a patient develops a fever of 38.9 C (102 F). The patient is not compliant with treatment for atelectasis and by postoperative day 3 still has daily fever in the same range.

Bacterial pneumonia has mostly likely developed in the atelectatic lung. Chest x-ray, sputum cultures, and appropriate antibiotics are needed.

A patient who had a right colectomy for colon cancer is afebrile during the first 2 postoperative days, but on day 3 she has a fever spike to 39.4 C (103 F).

A patient who had a right colectomy for colon cancer is afebrile during the first 4 postoperative days, but on day 5 he has a fever spike to 39.4 C (103 F).

A patient who had a right colectomy for colon cancer is afebrile during the first 6 postoperative days, but on day 7 she has a fever spike to 39.4 C (103 F).

Every potential source of post-op fever always has to be investigated, but the timing of the first febrile episode gives a clue as to the most likely source. Remember the "4 Ws": UTI, thromboembolism (now less common because of mandatory prophylaxis), and wound infection are the likely culprits in these vignettes. Urinalysis and urinary culture, lower extremity venous U/S, and physical examination are the respective tests.

A patient who had major abdominal surgery has a normal postoperative course, with no significant episodes of fever until day 10, when his temperature begins to spike up to 39.4 C (103 F) daily.

At this postoperative stage, a deep abscess is the most likely source. CT is diagnostic, and treatment typically is percutaneous drainage.

Chest Pain

Perioperative myocardial infarction (MI) may occur during the operation (most commonly triggered by hypotension), in which case it is detected by the EKG monitor (ST elevation or depression, T-wave flattening). When it happens postoperatively, MI typically presents with chest pain in the first 2–3 days. The most reliable diagnostic test is serum troponin I level. Mortality is 50–90%, greatly exceeding that of MI not associated with surgery. Treatment is directed at the complications. Emergency coronary angiography with percutaneous intervention (angioplasty, stenting) may be lifesaving.

On postoperative day 2 after an abdominoperineal resection for rectal cancer, a 72-year-old man complains of severe retrosternal pain radiating to the left arm. He is short of breath and tachycardic.

During an abdominoperineal resection for rectal cancer, the patient unexpectedly has severe bleeding and is hypotensive on and off for almost 1 hour. The anesthesiologist notes ST depression and T-wave flattening in the EKG monitor.

Perioperative MI happens intraoperatively or within the first 3 days, and the biggest triggering cause is hypovolemic shock and hypotension. The 2 vignettes presented here are typical scenarios, although in practice the classic chest pain picture is often obscured by other ongoing events. Check a 12-lead EKG and serum troponin levels, and contact cardiology.

Pulmonary Embolism

Pulmonary embolism (PE) typically occurs around postoperative day 7 but can occur at any time postoperatively. Elderly patients and those with cancer are at increased risk; postoperative immobilization alone increases the risk. Typical presentation is sudden-onset pleuritic pain accompanied by shortness of breath.

Look for a patient who is anxious, diaphoretic, and tachycardic, with prominent distended veins in the neck and forehead. (Note that a low central venous pressure [CVP] virtually excludes the diagnosis.) Arterial blood gases demonstrate hypoxemia and often hypocapnia due to tachypnea.

CT angiogram (the gold standard) is used for diagnosis. This diagnostic test is a spiral CT with a large IV contrast bolus timed to pulmonary artery filling. **This diagnostic test is not to be delayed.**

Treatment is systemic anticoagulation, initially with heparin, and should be started immediately following diagnosis.

- In decompensating patients with a high index of suspicion, consider starting treatment even before confirming the diagnosis.
- If a PE recurs while the patient is anticoagulated or if anticoagulation is contraindicated, place an inferior vena cava filter to prevent further embolization from lower extremity deep venous thromboses.

Prevention of thromboembolism will also prevent PE.

- Use a sequential compression device on anyone who does not have a lower extremity fracture or significant lower extremity arterial insufficiency.
- In moderate- or high-risk patients, prophylactic anticoagulation is indicated with low-dose heparin (typically 5,000 units subcutaneously/8–12 hours until mobile) or enoxaparin (30–40 mg/24 hours, based on renal function). This is referred to as **chemoprophylaxis**.
- Risk factors for DVT include age >40, pelvic/leg fracture, venous injury, femoral venous catheter, presence of cancer, and anticipated prolonged immobilization.

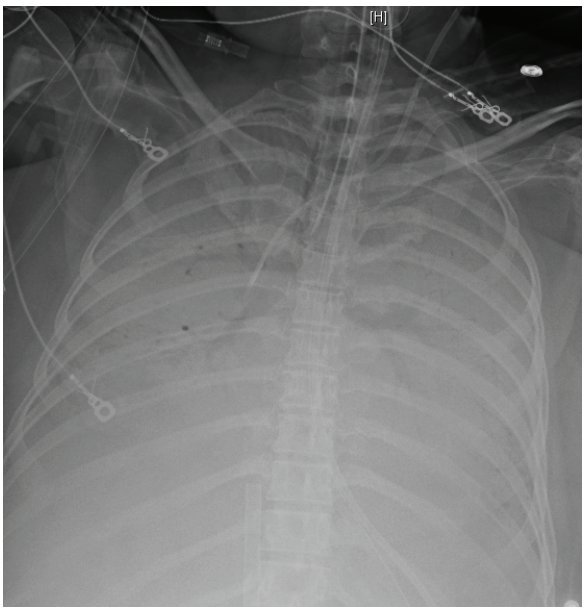
On postoperative day 7 after a broken hip is pinned, a 76-year-old man suddenly develops severe pleuritic chest pain and shortness of breath. When examined, he is found to be anxious, diaphoretic, and tachycardic. He has prominent distended veins in his neck and forehead.

Chest pain this late post-op is most likely due to a pulmonary embolus (PE). This patient is obviously at high risk, and the findings are classic. Arterial blood gas or pulse oximetry is the first test, and hypoxemia and hypocapnia are the expected findings; in their absence, it is not a PE. CT angiogram is the immediate gold standard diagnostic test of choice. Therapy starts with systemic heparinization. Fibrinolysis with tissue plasminogen activator (tPA), either systemic or catheter-directed, is indicated for extreme cases with hemodynamic compromise, as well as consideration of surgical embolectomy. If a PE recurs despite anticoagulation, an inferior vena cava filter is indicated.

Other Pulmonary Complications

Aspiration is a distinct hazard when intubating patients with a full stomach. It can be lethal right away, but more commonly causes a chemical injury of the tracheobronchial tree—pneumonitis—that can progress to pneumonia and respiratory failure. Prevention includes strict restriction of oral intake prior to surgery and antacids before induction. Therapy starts with bronchoscopic lavage and removal of acid and particulate matter, followed by bronchodilators and respiratory support. Steroids have not been demonstrated to improve outcomes and therefore are not usually indicated. Antibiotics are indicated only where there is evidence of the resultant pneumonia—e.g., leukocytosis, sputum production and culture, and focal consolidation on chest x-ray. This typically does not present for several days following the insult.

Adult respiratory distress syndrome (ARDS) is seen in patients with a complicated post-op course, often with sepsis as the precipitating event. These patients demonstrate bilateral pulmonary infiltrates and hypoxia with no evidence of CHF. The centerpiece of therapy is positive end-expiratory pressure (PEEP) with low volume ventilation. (Excessive ventilatory volumes have been demonstrated to result in barotrauma.) A source of sepsis must be sought and corrected.



Courtesy of Gary Schwartz, MD

Figure 1-4. ARDS

Intraoperative tension pneumothorax can develop in patients with traumatized or emphysematous lungs who are subjected to positive-pressure breathing. They become progressively more difficult to ventilate, with rising airway pressure, steadily declining BP, and steadily rising CVP.

- If the abdomen is open, quick decompression can be achieved through the diaphragm (but the risk is contamination of the pleural cavity).
- Alternatively (and better), needle decompression in the midclavicular line followed by formal chest tube is indicated.

> An awake intubation is being attempted in a drunk and combative man who has sustained a gunshot wound to the abdomen. In the struggle, the patient vomits and aspirates a large amount of gastric contents with particulate matter.

This is every anesthesiologist's nightmare. Aspiration results in a chemical injury to the tracheobronchial tree ("aspiration pneumonitis"). This is an inflammatory problem, not an infectious process, so antibiotics are not immediately indicated. However, the irritation results in pulmonary failure and increases the risk of secondary pneumonia. Prevention is best: empty stomach, antacids before induction, rapid sequence induction with manual cricoid pressure. Once aspiration happens, however, bronchoscopic lavage and removal of particulate matter are the first steps, followed by bronchodilators and respiratory support. Steroids are usually not helpful.

> In week 2 of a complicated postoperative period, a young patient with multiple gunshot wounds to the abdomen becomes progressively disoriented and unresponsive. The patient has bilateral pulmonary infiltrates and PaO_2 of 65 mm Hg while breathing 40% oxygen.

The reason for the mental changes is obvious: the patient is not getting enough oxygen in the blood. The rest of the findings, however, specifically identify ARDS. The centerpiece of therapy for ARDS is mechanical ventilation with high PEEP and low tidal volumes. Also consider why this has developed now: in an older patient with preexisting lung disease, an acute illness can exacerbate the problem; in a patient with normal lungs, chest trauma and sepsis are the most common etiologies.

> A trauma patient is undergoing a laparotomy for a seatbelt injury. She also sustained several broken ribs. Halfway through the case it becomes progressively difficult to ventilate the patient, and oxygen saturation and blood pressure steadily decline. There is no evidence of intra-abdominal bleeding.

This patient has an intraoperative tension pneumothorax. Likely, while the patient was receiving positive-pressure ventilation, one of the broken ribs punctured the lung. The best approach is immediate transdiaphragmatic decompression, or better, transthoracic needle decompression followed by formal chest tube placement.

Disorientation/Coma

When a postoperative patient becomes confused and disoriented, **hypoxia** is the first concern and **sepsis** is a close second. If airway protection is threatened, check an arterial blood gas and provide respiratory support.

Delirium tremens (DTs) is very common in the alcoholic whose drinking is suddenly interrupted by hospital admission. During postoperative day 2 or 3, the patient gets confused, has hallucinations, and becomes combative. IV benzodiazepines are the standard therapy, but oral alcohol is sometimes available at hospitals for this indication (not frequently given in today's environment). DTs must be recognized and treated: it can be fatal!

Electrolyte imbalances, particularly alterations in sodium concentration, can have a profound effect on a patient's mental status. Both hypernatremia and hyponatremia can produce confusion, seizures, lethargy, and coma.

Ammonium intoxication is a common source of coma in the cirrhotic patient. In patients with cirrhosis, inability to detoxify absorbed protein from GI bleeding can produce "hepatic coma"; this effect may also be seen after implementation of a portosystemic shunt (e.g., TIPS procedure).

> Eighteen hours after abdominal aortic aneurysm repair, a patient becomes disoriented.

This is a very brief vignette, but of the long list of things that can produce post-op disorientation, the most lethal one if not promptly recognized and treated is hypoxia. Physical examination and vital signs will likely indicate hypoxemia; obtain an arterial blood gas if unsure or to quantify. Alternative etiologies are mostly metabolic: uremia, hyponatremia, hypernatremia, ammonium, hyperglycemia, DTs, or medications.

> A recovered alcoholic undergoes an elective colon resection for recurrent diverticular bleeding. The patient reports that he has not touched a drop of alcohol for the past 6 months. On postoperative day 3 he becomes disoriented and combative, and claims to see elephants crawling up the walls. The spouse then reveals that the patient actually drank heavily up until the day of hospital admission.

This case clearly describes DTs. The standard management relies on benzodiazepines. Some hospitals allow oral intake of alcohol, but that is less common these days.

> Twelve hours after completion of an abdominal hysterectomy, a 42-year-old woman becomes confused and lethargic, complains of severe headache, has a grand mal seizure, and finally goes into a coma. Review of the chart reveals that an order for D5W, to run in at 125 mL/h, was mistakenly implemented as 525 mL/h.

This is a classic example of water intoxication. A very low serum sodium concentration will confirm it. Mortality for this iatrogenic condition is very high, and therapy is quite controversial. Very careful use of hypertonic saline (3%) is a reasonable answer in this extreme scenario. Indications are generally coma or seizures.

> Eight hours after completion of a transsphenoidal hypophysectomy for prolactinoma, a young woman becomes lethargic, confused, and eventually comatose. Review of the record shows that her urinary output since surgery has averaged 600 mL/h, although her IV fluids are going in at 100 mL/h.

This case illustrates the reverse of the previous vignette: large, rapid, unreplaced water loss from surgically induced diabetes insipidus. The labs will show significant hypernatremia. The safest therapy is an infusion of 1/3 or 1/4 normal saline to replace the lost fluid; in this acute setting, D5W would be acceptable.

> A cirrhotic patient goes into coma after receiving an emergency portocaval shunt for bleeding esophageal varices.

This clinical case is brief but unmistakable: the culprit here will be ammonia. If the case also involves hypokalemic alkalosis and high cardiac output combined with low peripheral resistance, overt liver failure has occurred.

Urinary Complications

Postoperative urinary retention is extremely common, particularly after surgery in the lower abdomen, pelvis, perineum, or groin. The patient feels the need to void but cannot. Bladder scanning and catheterization should be performed 6–8 hours postoperatively if no spontaneous voiding has occurred. Indwelling Foley catheter placement is indicated at the second consecutive catheterization.

Zero urinary output typically is caused by a mechanical problem (not a biologic one), as even patients with renal failure will have some output. Look for a plugged or kinked catheter, and flush the tubing to dislodge any clot that may have formed. You need to know this, but likely the nurse will irrigate and replace the catheter if blocked without your definitive order.

Low urinary output (<0.5 mL/kg/hr) in the presence of **normal BP** (i.e., not because of shock) represents either fluid deficit or an acute kidney injury. Always check the BP, as hypotension will cause this (renal blood flow follows cardiac output). The treatment is fluids, not diuretics.

- A low-tech diagnostic test is a fluid challenge: a bolus of 500 mL of IV fluids infused over 10–20 minutes. Patients who are dehydrated will respond with a temporary increase in urinary output; those in renal failure will not.
- A more scientific test is to measure urinary sodium: it will be <10 or 20 mEq/L in the dehydrated patient with normally functioning kidneys; it will exceed 40 mEq/L in cases of renal failure.
- An even more scientific test is to calculate the fractional excretion of sodium, or FeNa. This involves measuring plasma and urinary sodium and creatinine. In acute kidney injury, the ratio >2; in hypovolemia it is <1.

> Six hours after undergoing a hemorrhoidectomy under spinal anesthesia, a 62-year-old man complains of suprapubic discomfort and fullness. He feels the need to void but has been unable to do so since the operation. There is a palpable suprapubic mass that is dull to percussion. Bladder scanning reveals a significant volume of urine.

By far the most common urinary problem post-op is the inability to void, and men are more commonly affected. Treatment is in-and-out bladder catheterization. If bladder catheterization has to be repeated again after another 6–8 hours, a Foley catheter should be left in place for 24–48 hours before removal is attempted.

> A man has had an abdominoperineal resection for cancer of the rectum, and an indwelling Foley catheter was left in place after surgery. The nurses are concerned because even though the patient's vital signs have been stable, urinary output in the last 2 hours has been zero.

In the presence of renal perfusing pressure, urinary output of zero invariably means a mechanical problem: the catheter is plugged or kinked. More ominous possibilities include injury of both ureters or thrombosis of the renal vessels, but these causes are much more rare.

> Several hours after completion of multiple surgery for blunt trauma in an average-sized adult, the patient's urinary output in 3 consecutive hours is reported as 12 mL/h, 17 mL/h, and 9 mL/h. Blood pressure has hovered around 95–130 mm Hg systolic during that time.

The patient's kidneys are perfusing, but she is either behind in fluid replacement or has gone into renal failure. A fluid challenge would suggest which situation exists: a bolus of 500 mL given over 10–20 minutes should produce diuresis in the dehydrated patient but will not do so in renal failure.

The more precise technique—and the preferred exam answer—is to measure urinary sodium (<10–20 mEq/L in dehydration, >40 mEq/L in renal failure). An even more elegant calculation is measurement of FeNa (<2 in renal failure).

Abdominal Distention

Paralytic ileus is to be expected in the first few days after abdominal surgery. Presentation includes:

- Bowel sounds: absent or hypoactive
- No passage of gas
- Mild distention (some cases)
- **No pain**

The condition is prolonged by electrolyte abnormalities, especially hypokalemia and hypomagnesemia. Be patient, as it will usually resolve with time.

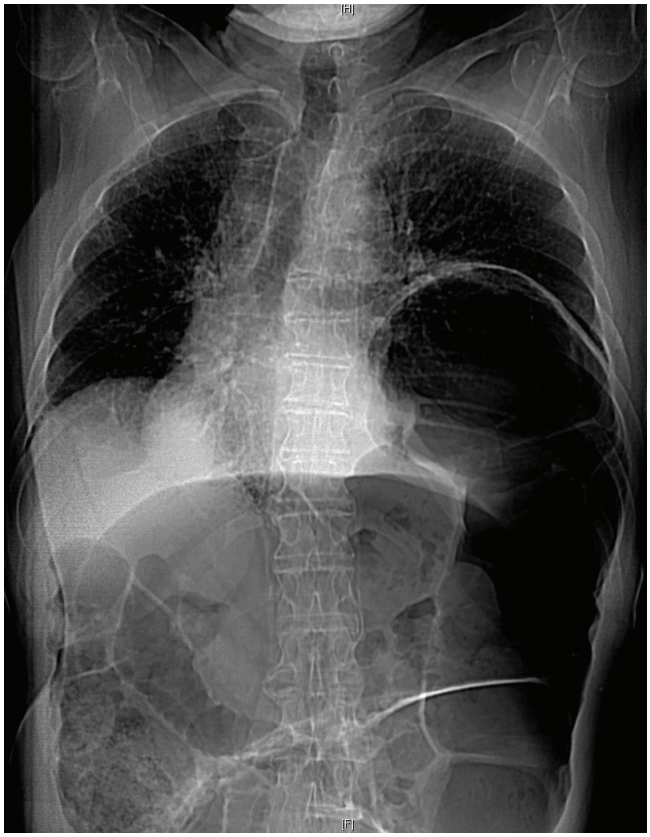
Early mechanical bowel obstruction can happen during the postoperative period because of adhesions. Apparent paralytic ileus that fails to resolve after 5–7 days is most likely an early mechanical bowel obstruction. X-ray will show dilated loops of small bowel and air-fluid levels.

Diagnosis is confirmed with an abdominal CT that demonstrates a transition point between proximal dilated bowel and distal collapsed bowel at the site of the obstruction. Surgical intervention is needed to correct the problem. Remember that with bowel obstruction, **there is pain**.

Ogilvie syndrome (or pseudo-obstruction) is a poorly understood but very common condition that could be described as a paralytic ileus of the colon.

- A functional (physiologic) obstruction, not mechanical obstruction
- Classically seen in elderly, sedentary patients (Alzheimer's, nursing home residents) who have become further immobilized owing to either surgery (broken hip, prostatic surgery) or anticholinergic or psychotropic medications
- Symptoms include abdominal distention without tenderness
- X-ray shows a massively dilated colon
- Treatment
  - Fluid and electrolyte correction first
  - Then, mechanical obstruction must be ruled out radiologically
  - Endoscopy (diagnostic and therapeutic) may include leaving a rectal tube in place
  - IV neostigmine to restore colonic motility, but given the risk of significant bradycardia, can be done only during continuous telemetric monitoring

If this syndrome is not treated, the cecum is the usual point of rupture (law of Laplace).



Courtesy of Gary Schwartz, MD

Figure 1-5. X-Ray Dilated Colon

> Four days after exploratory laparotomy for blunt abdominal trauma with resection and anastomosis of damaged small bowel, a patient has abdominal distention without abdominal pain. She has no bowel sounds and has not passed flatus, and abdominal x-ray shows dilated loops of small bowel without air-fluid levels.

This case is likely a postoperative paralytic ileus, which can be expected under the circumstances. NPO and NG suction should be continued until peristaltic activity resumes. If it does not, CT of the abdomen should be taken to rule out a mechanical obstruction, visible as a transition point between the proximal dilated bowel and the distal collapsed bowel at the site of obstruction. Hypokalemia should also be ruled out. A technical error at the anastomosis site should always be considered. Be patient!

> An 80-year-old man with Alzheimer's disease living in a nursing home undergoes surgery to repair a fractured femoral neck. On postoperative day 5 the patient's abdomen is noted to be grossly distended and tense, but nontender. He has occasional bowel sounds. X-ray shows a very distended colon and a few distended loops of small bowel.

In the elderly, who are not very active to begin with and are now further immobilized, massive colonic dilatation (Ogilvie syndrome) is commonly seen. Correct the fluids and electrolytes first. Neostigmine can dramatically improve colon motility at the cost of **very significant side effects**. Colonoscopy is the most successful treatment should intervention become indicated.

Wound Infections

Wound infections are typically seen around postoperative day 7. Manage with IV antibiotics and, potentially, by reopening the wound partially or completely to allow for drainage.

Wound dehiscence is typically seen around postoperative day 5 after open laparotomy. The wound may look intact, but a **large volume** of pink ("salmon-colored") fluid is noted to be soaking the dressing; this is peritoneal fluid draining through a dehiscence in the fascial closure. Reoperation is indicated to avoid evisceration and peritonitis. In high-risk patients, nonsurgical management with negative pressure wound therapy may suffice.

Evisceration is a catastrophic complication of wound dehiscence where the fascia closure opens and the abdominal contents herniate. It typically happens when the patient (who may not have been recognized as having a dehiscence) coughs, strains, or gets out of bed. The patient must be kept in bed and the bowel covered with large sterile dressings soaked with warm saline. Emergency abdominal closure is mandatory.

Enterocutaneous fistula is a devastating complication that develops between the gastrointestinal tract and the skin, typically through a surgical wound or drain site.

- If the enterocutaneous fistula does not empty completely to the outside ("uncontrolled") but instead leaks into a body cavity, it may precipitate an abscess and lead to sepsis; treatment is complete drainage.
- If it drains freely ("controlled"), sepsis does not usually develop, but fluid and electrolyte loss, nutritional depletion, and erosion of the abdominal wall are potential problems.

Complications associated with GI fistulas depend on the location and volume of the fistula:

- Less problematic in the distal colon
- Present but manageable in low-volume fistula (up to 200–300 mL/day)
- Daunting in high-volume fistulas (several liters per day) arising from upper GI tract

Fluid and electrolyte replacement, nutritional support, and protection of the skin of the abdominal wall are done to keep the patient alive until nature heals the fistula.

Fistulas are a nightmare to both the patients and surgeons, as the healing of even a controlled fistula can take weeks or months.

> On postoperative day 5 after a laparotomy, it is noted that large amounts of salmon-colored clear fluid are soaking the patient's dressings.

This is the classic presentation of a wound dehiscence. Surgical exploration is indicated, with reclosure of the fascia. In a very high-risk patient, consider nonsurgical management with negative pressure wound therapy.

> Nurses report that on postoperative day 5 after a laparotomy, a patient is draining clear pink fluid from his abdominal wound. A medical student removes the dressing and asks the patient to sit up so he can be helped out of bed to the treatment room. When he complies, the wound opens wide and small bowel rushes out.

This variant describes evisceration, a serious problem. Put the patient back in bed, cover the bowel with large, moist dressings soaked in warm saline (moist and warm are the key), and then get him to the OR for reclosure.

> A patient presents to the surgeon's office postoperative day 7 after an open appendectomy. The incision is noted to be red, hot, tender, and fluctuant. She reports fever for the past 2 days.

If there were just a bit of redness, or symptoms occurred earlier in the postoperative course, this could be a case of superficial cellulitis and managed with antibiotics alone. However, this far post-op and with the physical examination findings, this scenario describes a postoperative wound infection. There is likely to be pus; the wound must be opened to allow for drainage, and antibiotics must be administered. If there is doubt as to the presence or absence of a drainable collection, U/S is diagnostic.

> Nine days after a patient undergoes sigmoid resection for cancer, the wound drains a brown fluid that is clearly feculent. The patient is afebrile and otherwise doing quite well.

This scenario describes a fecal fistula. If draining to the outside, it is unruly and inconvenient but not life-threatening. The fistula will close eventually with little or no therapy if there are no limiting factors (FRIENDS mnemonic). If feces were accumulating on the inside ("uncon-

Note

Natural wound healing will take place unless the following **FRIENDS** (mnemonic) are present:

- **F**oreign body
- **R**adiation injury
- **I**nfection or **I**BD
- **E**pithelialization
- **N**eoplasm
- **D**istal obstruction
- **S**teroid use

trolled"), the patient would be febrile and sick and would need drainage and probably a diverting colostomy.

> Eight days after a difficult hemigastrectomy and gastroduodenostomy for gastric ulcer, a patient begins to leak 2–3 L of green fluid per day through the right corner of her bilateral subcostal abdominal wound.

A patient who is febrile and sick, with an acute abdomen, needs to be explored for what is likely an uncontrolled fistula. However, if all the gastric and duodenal contents are leaking to the outside ("controlled"), further immediate surgery can often be avoided:

- Provide fluid/electrolyte replacement
- Deliver elemental nutritional support into the upper jejunum
- Provide local wound care to prevent skin breakdown
- Consider somatostatin or octreotide to diminish the volume of GI fluid loss

Total parenteral nutrition (TPN) is second choice, but it is less effective and carries greater potential risk of bloodstream infections.

Fluid and Electrolyte Imbalance

Hypernatremia means that the patient has lost water (or other hypotonic fluids) and become dehydrated. The condition typically presents as alterations in neurologic function; the extent of brain dysfunction depends on the magnitude and time frame over which the hypernatremia developed. Every 3 mEq/L that serum sodium concentration exceeds 140 represents approximately 1 L of water lost.

- If the problem develops slowly (i.e., over several days), the brain will adapt, and the only clinical manifestations will be those of volume depletion.
- If the problem happens rapidly (e.g., osmotic diuresis, diabetes insipidus), the brain will not be able to adapt, and thus more profound CNS symptoms will develop.

Treatment is volume repletion to correct overall volume rapidly (hours), while tonicity is corrected slowly (days). This is achieved by using 5% dextrose in half-normal saline rather than D5W.

Hyponatremia means the patient has retained a net excess of water and hypotonicity has developed. There are 2 potential scenarios:

- A patient who is losing large amounts of isotonic fluids (typically from the GI tract) is forced to retain water if she has not received appropriate replacement with isotonic fluids. Volume restoration with isotonic fluids (NS or lactated Ringer's [LR]) will correct the hypovolemia and allow the body to unload the retained water slowly and safely and return the tonicity to normal.
- A patient who starts with normal fluid volume adds to it by retaining water in the presence of inappropriate amounts of antidiuretic hormone (ADH) (e.g., post-op water intoxication or inappropriate ADH secreted by tumors). Rapidly developing hyponatremia (water intoxication) produces CNS symptoms because the brain has not had time to adapt; it requires careful use of hypertonic saline (3 or 5%). In hyponatremia that develops slowly in response to inappropriate ADH, the brain has time to adapt; therapy should be water restriction.

Hypokalemia develops slowly, over days, when potassium is lost from the GI tract (all GI fluids have lots of potassium) or in the urine (because of loop diuretics or excess aldosterone) and is not replaced. Hypokalemia develops rapidly, over hours, when potassium moves into the cells—for example, when diabetic ketoacidosis is corrected. Treatment is IV potassium replacement at a rate not faster than 10 mEq/hr.

Hyperkalemia will develop slowly if the kidney cannot excrete potassium (renal failure, aldosterone antagonists), or rapidly if potassium is being released from cells into the blood (crushing injuries, dead tissue, acidosis).

Treatment must take into account whether the kidneys are functioning. Emergent management includes stabilizing cellular membranes with IV calcium and "pushing potassium into the cells" through the use of IV glucose and insulin. Loop diuretics excrete potassium in the urine (if the kidneys are working), and sodium polystyrene sulfonate (oral or rectal) may absorb potassium via the GI tract. Dialysis may be needed in the event of renal failure.

Metabolic acidosis can result from any of the following:

- Excessive production of fixed acids (diabetic ketoacidosis, lactic acidosis, low-flow states)
- Inability of the kidney to eliminate fixed acids (renal failure)
- Loss of buffers (loss of bicarbonate-rich fluids from GI tract)

In all cases, blood pH is low (<7.4), serum bicarbonate is low (<22), and there is a base deficit. When abnormal acids are piling up in the blood, there is also an "anion gap" in which serum sodium exceeds the sum of chloride and bicarbonate by >10 or 15. The anion gap does not exist when the problem is loss of buffers. This can be fatal, as metabolic acidosis increases ectopy and decreases inotropy.

Treatment of metabolic acidosis is aimed at treating the underlying cause. Bicarbonate therapy will correct the pH temporarily but can risk producing a "rebound alkalosis." For chronic acidosis, renal loss of K^+ will cause a deficit that does not become obvious until the acidosis is corrected. Be prepared to replace K^+ as part of the treatment.

Metabolic alkalosis classically occurs in scenarios involving loss of acidic gastric fluid, e.g., prolonged emesis or NG suction. It can also develop if excess bicarbonate is administered. Symptoms include low K+, low Cl−, and high bicarbonate (hypokalemic, hypochloremic metabolic alkalosis).

Treatment of metabolic alkalosis is chloride and potassium replacement, thereby allowing the kidneys to correct the problem.

Respiratory acidosis and alkalosis result from impaired ventilation (acidosis) or abnormal hyperventilation (alkalosis). Symptoms include abnormal PCO_2 (low in alkalosis, high in acidosis) and abnormal blood pH. Treatment is correction of the underlying respiratory problem.

Note that metabolic acid-base derangements may be accompanied by respiratory compensatory changes. For example, acute metabolic acidosis will result in tachypnea with lowering of pCO_2 to mitigate the decrease in pH arising from the primary derangement (in this case, metabolic acid).

Remember that metabolic acidosis has the same effects on the heart that general anesthetics have: **decreased inotropy** and **increased ectopy**.

> Eight hours after completion of a transsphenoidal hypophysectomy for a prolactinoma, a young woman becomes lethargic, confused, and eventually comatose. Review of the record shows that her urinary output since surgery has averaged 600 mL/h, while IV fluids are infusing at 100 mL/h. Serum sodium determination shows concentration 152 mEq/L.

Elevated concentration of serum sodium invariably means that the patient has lost pure water (or hypotonic fluids). Every 3 mEq/L above the normal of 140 represents 1 L lost. This woman is 4 L shy, which fits her history of a diuresis of 500 mL/h more than her intake. She should be given 4L of D5W or possibly D5-1/3NS.

> Several friends go on a weekend camping trip in the desert. On day 2 they get lost and aren't rescued until one week later. One patient is brought to your hospital—awake and alert—with obvious clinical signs of dehydration. Serum sodium concentration is 155 mEq/L.

The patient has also lost water, about 5 L, but has done so slowly by pulmonary and cutaneous evaporation over 5 days. He is hypernatremic, but his brain has adapted to the slowly changing situation. Were he to be given 5 L of D5W, the rapid correction of his hypertonicity would be dangerous. Five liters of D5-1/2NS is a much safer plan.

> Twelve hours after undergoing an abdominal hysterectomy, a 42-year-old woman becomes confused and lethargic, complains of severe headache, has a grand mal seizure, and finally goes into coma. Review of the chart reveals that an order for D5W to run in at 125 mL/h was mistakenly implemented as 525 mL/h. Her serum sodium concentration is 122 mEq/L.

In the surgical patient with normal kidneys, hyponatremia invariably means that water (without sodium) has been retained, so the body fluids have been diluted. In this case a lot of IV water was given, and the ADH produced as part of the metabolic response to trauma has held onto it. Rapidly developing hyponatremia (water intoxication) is a big problem, as the brain has no time to adapt; once it has occurred, therapy is controversial. For the sake of the exam, replete with hypertonic saline (3 or 5%) given 100 mL at a time and reassess (clinically and with bloodwork) before each subsequent dose.

> A 62-year-old woman comes in for her scheduled chemotherapy administration for metastatic cancer of the breast. Although she is quite asymptomatic, the lab reports serum sodium concentration of 122 mEq/L.

In this setting, water has also been retained (by ADH produced by the tumor), but so slowly that the brain has kept up with the developing hypotonicity. Rapid correction would be ill-advised at best and lethal at worst. Water restriction, on the other hand, will slowly allow the abnormality to reverse itself.

A 68-year-old woman comes in with an obvious incarcerated umbilical hernia. She has gross abdominal distention, is clinically dehydrated, and reports persistent fecaloid vomiting for the past 5 days. She is awake and alert. Serum sodium concentration is 118 mEq/L.

Hyponatremia means water retention, but in this case the problem began with loss of isotonic (sodium-containing) fluid from her gut. As the patient's extracellular fluid became depleted, her body retained whatever water it could: exogenous from oral intake and endogenous from catabolism. Consequently, she is now simultaneously volume-depleted and hyponatremic (hypotonic).

This patient desperately needs volume replacement, but it must not be corrected too quickly. Administer isotonic fluids in quantity: Start with 1 or 2 L/h of normal saline or Ringer's lactate, depending on the acid-base status (use clinical variables to fine tune the rate). Once fluid volume is replenished, the patient's body will unload the retained water and correct its own tonicity.

A patient with severe diabetic ketoacidosis comes in with profound dehydration and a serum potassium concentration of 5.2 mEq/L. After several hours of vigorous therapy with insulin and IV fluids (saline, without potassium), the patient's serum potassium concentration is 2.9 mEq/L.

Severe acidosis precipitates a loss of potassium in the urine. While the acidosis is present, however, the serum concentration is high because potassium ions have come out of the cells in exchange for hydrogen ions. Once the acidosis is corrected, that potassium rushes back into the cells, and the true magnitude of the potassium loss becomes evident.

The patient obviously needs potassium. Under most circumstances, 10 mEq/h is a safe limit for a peripheral IV line. In extreme settings, 20 mEq/h can be justified, but central venous catheter placement is indicated.

An 18-year-old woman slips and falls under a bus, and her right leg is crushed. On arrival at the ED she is hypotensive, and she receives several units of blood. Over the next several hours the patient is in and out of hypovolemic shock and develops acidosis. Serum potassium concentration, which was 4.8 mEq/L at the time of admission, is reported at 6.1 a few hours later.

The elevated serum potassium could have multiple etiologies: rhabdomyolysis from the crushed leg, hemolysis from multiple blood transfusions, and/or transcellular migration from acidosis. With low perfusing pressure (in and out of shock), the kidneys have failed to eliminate it.

This patient needs multiple treatment strategies: BP improvement to allow for urinary clearance, intracellular transport using D50 and insulin, GI elimination with exchange resins, and an NG tube. If those are not successful, urgent hemodialysis is indicated. During the stabilization period, IV calcium should be administered to stabilize the cellular membrane.

Clinical Pearl

The definitive compensatory mechanism in acid-base balance is the kidney: "**urine follows serum**," i.e., if acidotic, the kidney will excrete acid (retain bicarb), and vice versa.

An elderly man with alcoholism, diabetes, and marginal renal function sustains multiple traumas while driving under the influence of alcohol. In the course of his resuscitation and multiple surgeries, he is in and out of shock for prolonged periods of time. Blood gases show pH 7.1 and PCO_2 32 mm Hg. Serum electrolytes are sodium 138 mEq/L, chloride 98 mEq/L, and bicarbonate 15 mEq/L.

This man has every risk factor for developing metabolic acidosis through retention of fixed acids (rather than by loss of bicarbonate). The driving force in this case is the state of shock, with lactic acid production; the diabetes, alcohol, and bad kidney are also contributing.

Labs confirm metabolic acidosis here (low pH and low bicarbonate). His body is trying to compensate by hyperventilating (low PCO_2), and he exhibits the classic anion gap: the sum of chloride and bicarbonate is 25 mEq/L less than the serum sodium concentration, instead of the normal 10–15 mEq/L.

The classic treatment for metabolic acidosis is bicarbonate or a bicarbonate precursor such as lactate or acetate. However, in a case like this, this tends to result in alkalosis once the low-flow state is corrected. Thus the emphasis here should be on fluid resuscitation with Ringer's lactate. Avoid large volumes of saline, which would deliver too much chloride.

A patient who has undergone a subtotal gastrectomy for cancer with a Billroth II reconstruction develops a blowout of the duodenal stump and, subsequently, a duodenal fistula. For the past 10 days, 750–1,500 mL/day of green fluid has been draining from the incision. Serum electrolytes are sodium 132 mEq/L, chloride 104 mEq/L, and bicarbonate 15 mEq/L. Blood pH is 7.2 and PCO_2 is 35 mm Hg.

This is another case of metabolic acidosis, but with a normal anion gap. The patient has been losing lots of bicarbonate out of the fistula. The problem would not have developed if his IV fluid replacement had contained lots of bicarbonate (or lactate, or acetate). The use of those agents is now indicated.

Clinical Pearl

Pyloric stenosis in children presents with the same electrolyte abnormality as in adults. Treatment for both populations is surgical (pyloromyotomy). In preparation for surgery, children should be resuscitated with only 1/2 NS to avoid hypernatremia, which can be a consequence.

A patient with severe peptic ulcer disease develops pyloric obstruction and has protracted vomiting of clear gastric contents (i.e., without bile) for several days. Serum electrolytes show sodium 134 mEq/L, chloride 82 mEq/L, potassium 2.9 mEq/L, and bicarbonate 34 mEq/L.

This is a classic case of hypochloremic, hypokalemic, metabolic alkalosis secondary to loss of acidic gastric juice. The patient needs to be rehydrated (choose saline rather than Ringer's lactate) and infused with a lot of potassium chloride ($\geq$10 mEq/hr).

Trauma 2

Learning Objectives

- ❑ Describe the algorithm for evaluating a trauma patient
- ❑ Recognize management of burns, bites, and stings

The initial evaluation of a trauma patient requires a systematic approach to identify life-threatening injuries. This involves 2 parts:

- **Primary survey** to evaluate for all potential injuries; necessary interventions are performed during this time
- After the primary survey is complete and the patient is deemed to be stable, **secondary survey** to do a head-to-toe examination and evaluate all organ systems

PRIMARY SURVEY

The primary survey uses a systematic ABCDE approach to assess a rapidly deteriorating patient: **A**irway, **B**reathing, **C**irculation, **D**isability (neurological exam), and **E**xposure. This is also the **order of priority**.

Airway (A)

An airway should be secured before the situation becomes critical. The first step in the evaluation of trauma is airway assessment and protection.

- If the patient is conscious and speaking in a normal tone of voice, the airway is considered intact.
- If the patient has facial or neck trauma, an expanding hematoma or subcutaneous emphysema in the neck, noisy or "gurgly" breathing, or neurologic deficit with Glasgow coma score ≤8, the airway is considered unprotected.

In the field, an airway can be secured via laryngeal mask airway or orotracheal intubation.

In the ED, an airway can be established by orotracheal intubation or cricothyroidotomy. If the use of intubation is precluded or unsuccessful, surgical cricothyroidotomy may be needed.

Clinical Pearl

If an airway is secured via cricothyroidotomy, formal tracheostomy must be performed later to prevent airway stenosis.

Clinical Pearl

In patients age <8, tracheostomy is preferred over cricothyroidotomy, which can cause airway stenosis (the cricoid is much smaller in children than it is in adults).

Emergent intubation is best done by rapid sequence induction, with continuous hemodynamic and pulse oximetry monitoring. In the presence of a cervical spine injury, orotracheal intubation can still be done if the head is secured and inline stabilization is maintained during the procedure, or via a nasotracheal route.

> A patient with multiple stab wounds arrives at the ED. He is conscious. phonating with a normal voice in full sentences, and hemodynamically stable. Upon removal of the dressing he is noted to have an expanding hematoma in the neck.

Although the patient's vital signs and neurological exam are normal, the expanding hematoma is at risk for compromising his airway. This is considered an unprotected airway and requires orotracheal intubation before it becomes an emergency.

Another similar scenario is with a stable patient, but with subcutaneous emphysema in the neck; that would be a marker for impending loss of airway and should be considered unprotected.

> An elderly patient involved in a severe car accident presents with multiple injuries. He is breathing spontaneously, but is not arousable and is not moving his extremities.

Altered mental status is the most common indication for intubation in the trauma patient. Unconscious patients with Glasgow coma score ≤8 may not be able to maintain or protect their airway. Orotracheal intubation is indicated.

> An unconscious man arrives at the ED with spontaneous but noisy and labored breathing. The paramedics explain that at the accident site, the patient was conscious but complaining of neck pain and unable to move his lower extremities. He lost consciousness during the ambulance ride, and efforts to secure a nasotracheal airway were unsuccessful.

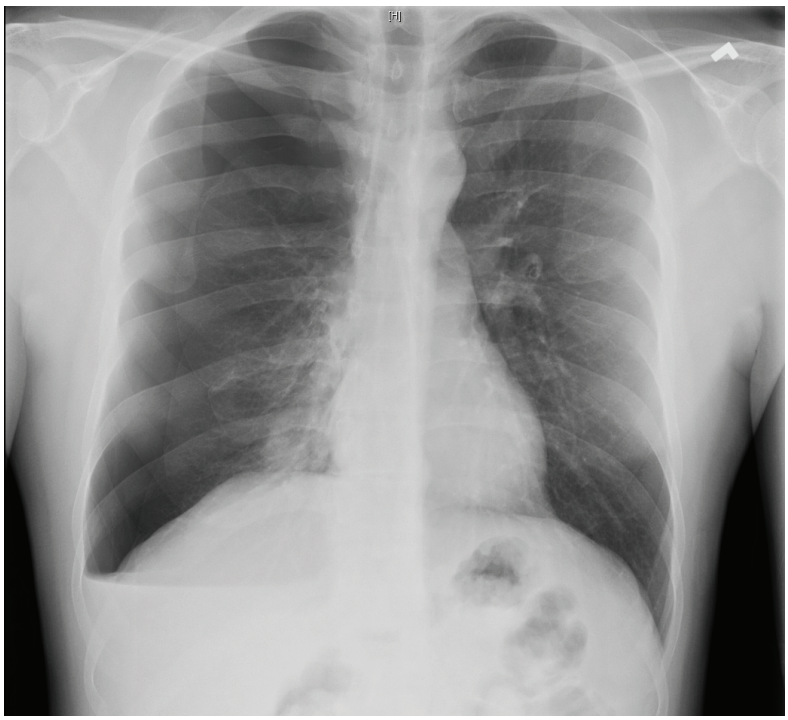
This scenario is intended to convey an unprotected airway with a cervical spinal injury. Orotracheal intubation can still be performed with manual inline cervical immobilization or utilizing a fiberoptic bronchoscope. Nasotracheal intubation is another option if facial injuries do not preclude it.

> A teenager involved in a severe car crash presents with extensive facial fractures and ongoing bleeding from his oropharynx. He is fully awake and alert, but with audible gurgling.

Securing an airway is mandatory here, but orotracheal route may not be possible. Surgical cricothyroidotomy is the best option, with formal tracheostomy later. In a smaller child, tracheostomy should be performed at presentation.

Breathing (B)

The presence of symmetrical breath sounds indicates satisfactory ventilation, while an absence or decrease of breath sounds may indicate a pneumothorax and/or hemothorax (necessitating placement of a chest tube). Pulse oximetry indicates if oxygenation is satisfactory; hypoxia may be secondary to airway compromise, pulmonary contusion, or neurological injury impairing respiratory drive and necessitating intubation. Measurement of end-tidal CO_2 (capnography) is also very useful.



Courtesy of Gary Schwartz, MD

Figure 2-1. Chest X-ray Right Pneumothorax

> An unconscious blunt trauma patient has been rapidly intubated in the ED. He has bilateral breath sounds, and his oxygen saturation by pulse oximetry is 95%.

As far as breathing is concerned, he is moving air and getting oxygen into his blood (oximetry). Deterioration could occur later, but right now we are ready to move to C in the ABCs.

> An unconscious blunt trauma patient has been rapidly intubated in the ED. He has absent breath sounds on the left and his oxygen saturation by pulse oximetry is 86%.

The absence of breath sounds means lack of ventilation of the left lung with subsequent hypoxia. This can be due to inadvertent intubation of the right mainstem bronchus or, alternatively, to a traumatic left pneumothorax. Chest x-ray can confirm the etiology and guide management.

If oxygen saturation were rapidly dropping or hypotension were present, this scenario would be more consistent with a pneumothorax and possibly a tension component. In that case, a left-sided needle decompression followed by chest tube placement would be indicated without a chest x-ray.

Circulation (C)

Shock is the constellation of hypotension, tachycardia, and oliguria representing inadequate organ perfusion. Patients are pale, cold/shivering, sweating, thirsty, and apprehensive. In the most severe cases, impaired perfusion of the brain may lead to unconsciousness. In the trauma setting, this is most often due to **hypovolemia** from hemorrhage (>1,500 mL blood loss), although **cardiogenic** shock can occur due to pericardial tamponade or tension pneumothorax and **neurogenic** shock can occur due to spinal injury.

- **Hemorrhagic shock** is accompanied by collapsed neck veins due to low central venous pressure (CVP), while **cardiogenic shock** causes elevated CVP with jugular venous distention.
- Both processes may occur simultaneously, e.g., a patient could be hemorrhaging and also have a tension pneumothorax.

In pericardial tamponade, there is shock without respiratory distress. With tension pneumothorax, there is significant dyspnea, absent breath sounds and hyperresonance on the side of the tension pneumothorax, and diminished breath sounds on the opposite side (due to mediastinal shift and compression of the lung). Tension pneumothorax can be accompanied by tracheal deviation.

Treatment of hemorrhagic shock includes the following steps (undertaken in the OR or ED depending on the injury and available resources):

- Fluid resuscitation
  - Initial administration is 2 L of lactated Ringer's solution or normal saline unless blood products are immediately available.
  - Resuscitation should be continued until BP and pulse normalize and urine output reaches 0.5–1.0 mL/kg/hr.
  - In the setting of uncontrolled hemorrhage, "permissive hypotension" is recommended to prevent further blood loss while awaiting definitive surgical repair, but a mean arterial pressure >60 mm Hg should be maintained to ensure adequate cerebral perfusion.
  - In the trauma setting, the preferred route is 2 large-bore peripheral IV lines, 16-gauge or greater ("short & fat"); if not possible, insert a central venous catheter. Saphenous vein cutdown is an acceptable alternative. In children <6 years old, intraosseous cannulation of the proximal tibia or femur is the preferred alternative.
- Control of bleeding
  - Transfusion of blood products should be in a 1:1:1 ratio between packed RBCs, fresh frozen plasma, and platelets.

Clinical Pearl

When placing lines for volume resuscitation during hemorrhage, be mindful of the potential location(s) of the traumatic injury. For instance, a femoral venous line with penetrating abdominal trauma may not be very useful in the presence of an IVC or iliac vein injury.

The unstable trauma patient should be rapidly prepared for surgical exploration. This assessment should be underway and appropriate measures taken to head to the operating room during the primary survey—specifically the assessment of circulation.

Pericardial tamponade is a clinical diagnosis that can be confirmed with U/S.

- Management is evacuation of the pericardial space by pericardiocentesis, subxiphoid pericardial window, or thoracotomy. While evacuation is being set up, continue fluid and blood administration to maintain adequate cardiac output.
- In cases of extreme hemodynamic instability or cardiac arrest, emergency left thoracotomy with pericardiotomy is performed in the ED.

Tension pneumothorax is a clinical diagnosis based on physical exam: absent breath sounds, tracheal deviation, "hyperresonance," and distended neck veins. Hypotension and shock will ensue due to decreased venous return to the heart, secondary to elevated intrathoracic pressure. Management requires immediate decompression of the pleural space, initially with a large-bore needle (needle thoracostomy), which converts the tension to a simple pneumothorax. Then place a chest tube.

The fact that a trauma has occurred does not rule out nontraumatic problems causes of shock. Also consider nontraumatic etiologies in the trauma patient. Cardiogenic shock from a myocardial infarction that causes a car accident is a classic example.

Neurogenic/spinal shock is often associated with low BP and bradycardia. It can also result in circulatory collapse. Patients are flushed, "pink and warm," with a low CVP. Treatment is phenylephrine, and fluids aimed at filling dilated veins and restoring peripheral resistance.

> A 22-year-old man arrives at the ED with multiple gunshot wounds to the chest and abdomen. The patient is diaphoretic, pale, cold, shivering, and anxious. He asks for a blanket and a drink of water. Blood pressure is 60/40 mm Hg, while pulse is 150/min and thready.

This is the classic presentation of shock due to penetrating trauma. Although hemorrhage resulting in hypovolemic shock is the most probable etiology, cardiogenic shock due to pericardial tamponade or tension pneumothorax is also possible. Steps in management, done simultaneously, are as follows:

- Large-bore IV lines
- Foley catheter
- Fluid and blood administration
- Preparation for immediate exploratory laparotomy for control of bleeding

Historically, the emphasis in cases of shock was on fluid resuscitation to elevate BP and maintain perfusion. More recently, the focus is on control of the bleeding. This is done manually with rapid assessment of whether there are internal injuries that need surgical exploration for control of hemorrhage, and where these might be.

> A 22-year-old man arrives at the ED with multiple gunshot wounds to the chest and abdomen. The patient is diaphoretic, pale, cold, shivering, anxious, and asking for a blanket and a drink of water. Blood pressure is 60/40 mm Hg and pulse 150/min and thready. Distended veins are visible in his neck and forehead. He has bilateral breath sounds and no tracheal deviation.

This similar scenario now has evidence of pericardial tamponade. A focused abdominal sonography for trauma (FAST exam) could confirm the diagnosis, but time is of the essence. Next steps:

- Evacuate the blood in the pericardial space via pericardiocentesis or surgical exploration (depending on the patient's stability and availability of an OR).
- Left thoracotomy (most rapid technique) can be done in ED if necessary.
- Alternatives include median sternotomy or transdiaphragmatic window at the time of laparotomy.

Clinical Pearl

When assessing the location of a hemorrhage, consider the compartments that might need to be explored–chest, abdomen, retroperitoneum, pelvis, extremities–based on the mechanism of injury. And don't forget "the street," i.e., blood loss that occurred in the field and has now been controlled. The patient may no longer be hemorrhaging, but could still be in shock and require volume resuscitation and/or surgical exploration.

CARPET:

Chest
Abdomen
Retroperitoneum
Pelvis
External
Thigh

- If the chest has been opened, this patient still needs a laparotomy to assess for abdominal damage given the injury pattern.
- Fluid administration and/or blood transfusion would also help with pericardial tamponade, but only until pericardial sac is evaluated.

> A 22-year-old man arrives at the ED with multiple gunshot wounds to the chest and abdomen. The patient has labored breathing and is diaphoretic, cold, shivering, and cyanotic. Blood pressure is 60/40 mm Hg and pulse 150/min and thready. He is in respiratory distress, with no right-sided breath sounds and left-sided tracheal deviation; distended veins are visible in his neck.

This similar scenario describes a tension pneumothorax. Treatment is immediate decompression using a large-bore needle or IV catheter placed into the right pleural space (second intercostal space, midclavicular line), followed by chest tube placement on the right side.

Watch out for chest x-ray as an answer choice—it is a trap. Although it would confirm the diagnosis, pneumothorax is clinically apparent, and time is of the essence. The patient will die while awaiting an x-ray. Exploratory laparotomy will still be needed given the injury pattern.

> A 19-year-old man is shot in the right groin during a drug deal. He staggers to the hospital on his own and arrives at the ED with blood pressure 90/70 mm Hg and pulse 105/min. Bright red blood is squirting from the groin wound.

Control of the bleeding by direct local pressure is the first order of business before volume resuscitation is started. This is done with manual compression or a tourniquet, depending on the scenario. A hemostat (clamp) is not used because it could make the injury worse in that placement is "blind."

> A 4-year-old child has been shot in the arm in a drive-by shooting. The site of bleeding has been controlled by local pressure, but the patient is hypotensive and tachycardic. Two attempts at starting peripheral IVs have been unsuccessful.

Up to age 6, intraosseous cannulation in the proximal tibia or femur is an acceptable route of rapid fluid administration. The initial bolus of Ringer's lactate would be 20 mL/kg of body weight.

A 22-year-old man is involved in a high-speed, head-on motorcycle accident. He arrives at the ED unconscious, with fixed and dilated pupils. He has multiple open fractures in both upper extremities and in the right lower leg. Blood pressure is 70/50 mm Hg, with pulse 140/min.

Shock in the trauma setting is most commonly caused by bleeding, pericardial tamponade, or tension pneumothorax. This case fits right in, but the presence of an obvious head injury might be tricky. On the exam you might be offered various types of intracranial bleeding (epidural or subdural hematoma, subarachnoid hemorrhage) as a source of shock—all would be incorrect. Intracranial bleeding can indeed kill you, but not by blood loss, as there isn't enough room in the head to accommodate the amount of blood needed to go into shock. Appropriate treatment is locating and controlling the source of the bleed prior to evaluating the neurologic injury.

A 72-year-old man who lives alone calls 911 saying that he has severe chest pain. When EMS arrives he is found unresponsive on the living room floor with a laceration to the scalp that is actively bleeding. On arrival at the ED this patient is cold and diaphoretic. Blood pressure is 80/65 mm Hg, and pulse is irregular at 130/min. His neck and forehead veins are distended, and he is tachypneic.

Many findings in this scenario are similar to the previous cases, but the mechanism of trauma seems minimal for such profound hemodynamic instability, and chest pain appears to have preceded the fall. Think of nontraumatic etiologies of similar presentation: cardiogenic shock from a massive MI is most likely.

The next step is EKG. Check coronary enzymes and admit to the coronary care unit. Be careful not to over-resuscitate during the initial trauma evaluation.

A 17-year-old girl is stung several times by a swarm of bees. On arrival at the ED, blood pressure is 75/20 mm Hg and pulse 150/min, but she looks warm and flushed.

Twenty minutes after receiving a penicillin injection, a man breaks into hives and develops wheezing. On arrival at the ED his blood pressure is 75/20 mm Hg and pulse 150/min, but he looks warm and flushed.

In preparation for an inguinal hernia repair, a patient has a spinal anesthetic placed. His level of sensory block is much higher than anticipated. A short while later, blood pressure is 75/20 mm Hg, but he looks warm and flushed.

All of these vignettes describe vasomotor shock due to anaphylaxis or inhibition of the sympathetic nervous system. Treatment is vasoconstrictors and volume replacement.

Disability (D)

Neurologic evaluation (disability) is an important component of the primary survey. Key points include assessing the patient's level of consciousness and ability to move all extremities and open eyes, and as scored by the Glasgow coma scale:

- **Eye**
  1. Does not open eyes
  2. Opens eyes to pain
  3. Opens eyes to voice
  4. Opens eyes spontaneously

- **Verbal**
  1. No sounds
  2. Sounds
  3. Words
  4. Disoriented
  5. Oriented, normal conversation

- **Motor**
  1. No movements
  2. Decerebrate
  3. Decorticate
  4. Flexion/withdrawal to painful stimulus
  5. Localizes pain
  6. Obeys commands

Exposure (E)

Remove the patient's clothing to allow for a thorough physical examination. Check for signs of trauma, bleeding, skin irritations, needle marks, and warm body temperature.

SECONDARY SURVEY

After the primary survey has been completed and any immediate life-threatening emergencies addressed, the trauma evaluation continues with the secondary survey.

- Complete physical exam to evaluate for occult injuries
- Chest x-ray, pelvic x-ray
- Focused abdominal sonography for trauma (FAST exam)
- Foley catheter and gastric tube placement if needed

Note

In real life, the primary and secondary surveys overlap.

Any change in the ABCDEs during the secondary survey requires complete reevaluation.

FAST is a reliable and readily available adjunct to identify intra-abdominal and pericardial fluid. It consists of a bedside U/S that evaluates the perihepatic space, perisplenic space, pelvis, and

pericardium for free fluid. Fluid is not typically present in these locations, so if there is a clinical suspicion such as hypotension following blunt trauma, consider an internal injury.

- An unstable patient with a positive FAST exam needs immediate surgical exploration in the OR.
- A stable patient with a positive FAST exam needs a CT, which is more reliable and may demonstrate the source of the bleeding—typically the liver or spleen.

PHYSICAL EXAM: HEAD TO TOE

Head Trauma

As a rule, **penetrating** head trauma requires surgical intervention and repair of the damage (although a transcranial gunshot wound is often lethal).

- Linear skull fracture with no overlying wounds is left alone.
- Open fracture requires wound closure; if comminuted or depressed, treat in the OR.
- Threshold for obtaining a brain CT should be very low, i.e., do a CT on almost anyone who has lost consciousness or has Glasgow coma score <13.
  - Positive findings need a neurosurgical consult.
  - Normal findings and neurologically intact (Glasgow coma score 15) can be discharged if someone can accompany the patient at home for 24 hours; alternatively, admit for 24 hours of observation and repeat head CT.
  - Normal findings and neurological deficits need further imaging with MRI.
- Basilar skull fracture can be difficult to diagnose. Signs of a fracture affecting the base of the skull include raccoon eyes, rhinorrhea, otorrhea, or ecchymosis behind the ear (Battle sign). CT of the head is required to rule out intracranial bleed and should be extended to include the cervical spine.

Traumatic brain injury (TBI) from trauma has 3 potential etiologies:

- Initial blow/direct cerebral injury; no treatment (other than prevention)
- Intracranial hemorrhage that results in hematoma displacing the brain structures (can relieve with surgery)
- Development of increased intracranial pressure (ICP) due to cerebral edema (can prevent or minimize with medical measures)

Acute epidural hematoma occurs with modest trauma to the side of the head. It has a classic sequence of trauma, unconsciousness, a lucid interval (completely asymptomatic patient), gradual relapse into coma, fixed dilated pupil (90% of the time on the side of the hematoma), and contralateral hemiparesis with decerebrate posturing. CT shows a biconvex, lens-shaped hematoma, typically in the frontotemporal area. Emergency craniotomy produces a dramatic cure.

Acute subdural hematoma also arises from a blow to the head, but the force of the trauma is typically much larger and the patient is usually much sicker, rarely with a period of full consciousness. CT will show a semilunar, crescent-shaped hematoma. If midline structures are deviated, craniotomy to evacuate the blood is indicated, but the prognosis is frequently poor. If there is no deviation, the goal of therapy is to reduce ICP to prevent further damage: invasive ICP monitoring, head elevation, modest hyperventilation, gentle diuresis, and avoidance of fluid overload.

Diffuse axonal injury occurs in more severe trauma, secondary to anoxia or decreased cerebral perfusion. CT shows diffuse blurring of the gray-white matter interface and multiple

Clinical Pearl

Because almost all patients with a history of trauma and unconsciousness (of any length) get a CT scan, the extreme presentation of a fixed pupil and contralateral hemiparesis is seldom seen.

Clinical Pearl

- Cerebral perfusion pressure = mean arterial pressure – intracranial pressure. Accordingly, do not over-diurese to the point of systemic hypotension.
- Hyperventilation is recommended when there are signs of herniation, with goal PCO_2 35 mm Hg.
- Sedation is used to decrease brain activity and oxygen demand. Moderate hypothermia is recommended to further reduce cerebral oxygen demand.

small punctate hemorrhages. Since there is not a discrete hematoma, there is no role for surgery. Therapy is directed at preventing further damage from increased ICP.

Chronic subdural hematoma typically presents in a delayed fashion due to an unrecognized subdural hematoma or expansion of acute subdural hematoma that was not drained. Chronic subdural hematoma may develop from minor trauma, often in older individuals with underlying brain atrophy, from a tearing of the bridging veins. Over several days or weeks, mental function deteriorates as hematoma forms. CT is diagnostic. Treatment is surgical evacuation, which provides dramatic improvement.

> An 18-year-old man arrives at the ED with an ax firmly implanted into his head. Although it is clear from the size of the blade that he has sustained an intracranial wound, he is awake, alert, and hemodynamically stable.

Management of penetrating wound is fairly straightforward, with a few exceptions. As a rule, the damage done to the internal organs (the brain, in this case) will need to be repaired surgically. This man must have the ax removed under anesthesia and with full control in the OR. When a weapon is embedded in the patient with part of it sticking out, do not remove it in the ED or in the field, where uncontrollable bleeding could occur.

> A 48-year-old man is hit over the head with a beer bottle during an assault in a park. He has a scalp laceration, and CT shows an underlying linear skull fracture. He is neurologically intact and gives no history of having lost consciousness.

Clinical Pearl

Hypovolemic shock cannot result from intracranial bleeding, as there simply isn't enough space inside the head for the amount of blood loss needed to produce shock. Look for another source. This is a **classic exam question**.

The rule in skull fracture is that if it is closed (no overlying wound) and asymptomatic, no treatment is required. If it is open (as this one is), the laceration must be cleaned and closed. If it is not comminuted or depressed, the procedure can be done in the ED.

> A 48-year-old man is hit over the head with a beer bottle during an assault in a park. He has a scalp laceration, and CT shows an underlying comminuted, depressed skull fracture. He is neurologically intact and gives no history of having lost consciousness.

The addition to this scenario is a comminuted skull fracture. This requires surgical repair in the OR.

> A 72-year-old pedestrian is struck by a car at an unknown speed. She arrives at the ED with minor bruises and lacerations but is otherwise asymptomatic. She is found to be neurologically intact, although she does not remember the accident. The paramedic reports that she was unconscious at the scene but awoke during the ambulance ride.

Anyone with blunt head trauma who has become unconscious needs a neurologic exam plus CT to assess for intracranial hemorrhage. If both are normal, discharge under supervision is reasonable. If not, admit inpatient and repeat the CT. This scenario is particularly worrisome for an intracranial bleed, given the period of unconsciousness followed by amnesia.

A 72-year-old pedestrian is struck by a car at an unknown speed. She arrives at the ED unconscious. She has ecchymosis around both eyes.

"Raccoon eyes" following blunt head trauma is suspicious for a basilar skull fracture. A CT must be performed, but surgical fixation is rarely necessary. Other potential scenarios include ecchymosis behind the ear, rhinorrhea, and otorrhea, which suggest a CSF leak. These scenarios are typically self-limited but do increase the risk of meningitis. For this reason, systemic antibiotics are indicated.

A 14-year-old boy is hit on the side of the head with a baseball bat. He loses consciousness for a few minutes but recovers promptly and continues to play. An hour later he is found unconscious in the locker room; his right pupil is noted to be fixed and dilated.

This vignette describes an acute epidural hematoma, most likely on the right side. Diagnosis is made with CT scan, which will show a lens-shaped hematoma and deviation of the midline structures to the opposite side. Management is emergency surgical decompression via craniotomy. This condition has a good prognosis if treated but is fatal within hours if it is not.

A 32-year-old man is involved in a head-on, high-speed car crash. He is unconscious at the site, regains consciousness briefly during the ambulance ride, and arrives at the ED in deep coma with a fixed, dilated right pupil and contralateral hemiparesis.

This could also be an acute epidural hematoma, but the high impact mechanism more frequently produces an acute subdural hematoma. Diagnosis is again made with CT scan, which will show a semilunar, crescent-shaped hematoma. Given the lateralizing signs, it will likely demonstrate contralateral midline deviation. Be sure to check the cervical spine! Management requires an emergency craniotomy with evacuation of the clot; this step often leads to significant improvement, particularly when the brain is being pushed to the side, but ultimate prognosis is typically poor due to the accompanying parenchymal injury.

A 32-year-old man is involved in a head-on, high-speed car crash. He is unconscious at the site and arrives at the ED with bilateral fixed dilated pupils. CT of the head shows diffuse blurring of the gray-white mass interface and multiple small punctate hemorrhages. There is no hematoma or displacement of the midline structures.

The CT findings here are classic for diffuse axonal injury. The prognosis is terrible, and there is no role for surgical intervention. Treatment will be directed at preventing further injury from increased ICP, including ICP monitoring, head elevation, hyperventilation, avoidance of fluid overload, gentle administration of mannitol and/or furosemide, and IV sedation and hypothermia to decrease cerebral oxygen demand.

> A 32-year-old man is involved in a head-on, high-speed car crash. He is unconscious at the site and arrives at the ED with bilateral fixed dilated pupils. He has multiple other injuries, including fractures of the lower extremities. Blood pressure is 70/50 mm Hg and pulse 130/min.

Same presentation but with hemodynamic instability. Ignore the neurological deficit for now and focus on identifying a source of bleeding, either external (extremity, scalp, street) or internal (chest, abdomen, pelvis).

> A 77-year-old man is noted by his neighbors to have become progressively forgetful over 3–4 weeks. He used to be active and managed all of his financial affairs. Now he stares at the wall, barely talks, and sleeps most of the day. His daughter recalls that he tripped on his apartment steps and fell about a week prior to the development of symptoms.

This vignette is suspicious for a chronic subdural hematoma. Diagnosis is made with CT; management is surgical decompression via craniotomy. Complete recovery is expected if the condition is recognized and treated appropriately.

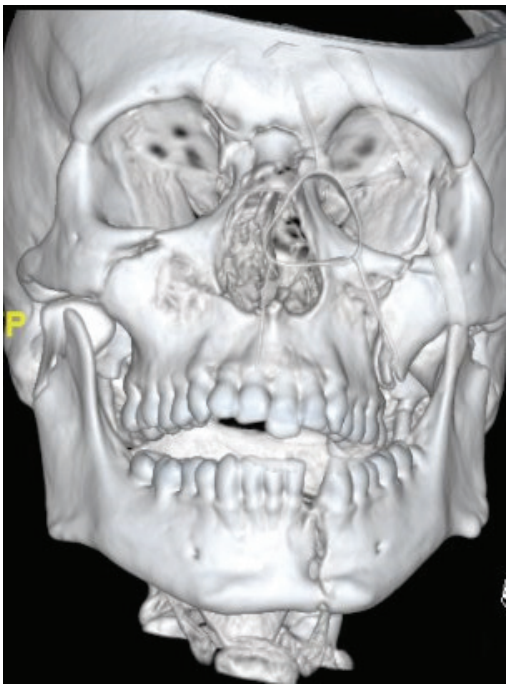
Generally speaking, the indications for surgical intervention in blunt head trauma are **neurologic signs** or **shift of the midline**.

Facial Trauma

The primary concern related to facial fractures in trauma is securing an airway. In the setting of severe facial trauma, orotracheal intubation may be difficult or impossible. In reality, injuries limited to the oropharynx may be managed with nasotracheal intubation, but the safest answer on the exam is a surgical airway: cricothyroidotomy in adults, tracheostomy in children <6 years old.

Severe facial fractures are classified according to the Le Fort system:

- **Le Fort I fracture** is a horizontal fracture pattern resulting in a "floating palate," usually secondary to blunt trauma to the lower maxilla in a downward direction.
- **Le Fort II fracture** is a pyramidal fracture pattern also secondary to blunt trauma to the maxilla, but either directly anterior-posterior or in an upward direction, resulting in fracture of the inferior orbit as well.
- **Le Fort III fracture** includes the above injuries as well as the zygomatic arch, resulting in "craniofacial dissociation."



Courtesy of Gary Schwartz, MD

Figure 2-2. CT Le Fort Fracture

Neck Trauma

To evaluate penetrating neck trauma, the neck is divided into 3 zones from caudad to cephalad:

- **Zone 1** begins at the clavicles and extends up to the level of the cricoid cartilage.
- **Zone 2** is located between the cricoid cartilage and the angle of the mandible.
- **Zone 3** runs from the angle of the mandible to the base of the skull.

Surgical exploration is indicated for an expanding hematoma, deteriorating vital signs, and signs of esophageal or tracheal injury such as coughing or spitting up blood, voice change, or subcutaneous emphysema.

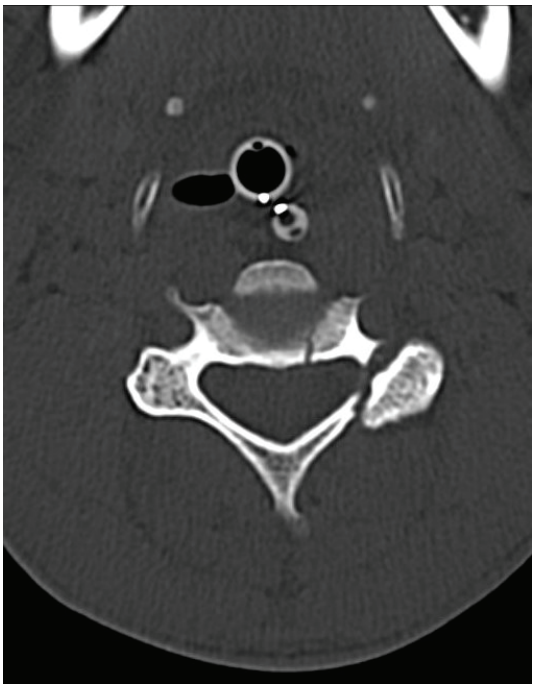
- For injuries to zone 1, evaluate with CT angiogram. If there is radiographic evidence of vascular, airway, or GI tract injury, proceed to the operating room for surgical exploration, bronchoscopy, and esophagoscopy. If CT is negative, further nonsurgical evaluation with esophagram should be considered based on trajectory and CT findings. Bronchoscopy and esophagoscopy may still be necessary, even if a major injury has not been identified on CT.
- Historically, all penetrating injuries to zone 2 mandated surgical exploration. The more recent trend is toward selective exploration based on physical exam and the same imaging studies: CT angiogram to start, esophagram if necessary, and endoscopy as indicated.
- For injuries to zone 3, evaluate with CT angiogram to assess for vascular injury and potential need for angiography and embolization; surgical access to this zone is quite invasive and therefore avoided if possible.

Clinical Pearl

If the patient's condition changes or deteriorates, proceed with urgent surgical exploration—regardless of CT findings.

In all patients with severe blunt trauma to the neck, the integrity of the cervical spine must be ascertained.

- Unconscious patients and conscious patients with midline tenderness to palpation: initially evaluate with CT; depending on findings, possibly follow with MRI
- Conscious patients with no symptoms (i.e., are not intoxicated, have not used drugs, have no "distracting" injury): examine clinically and clear for a cervical spinal injury; if CT of the head is being done, extend the study to include the cervical spine



Courtesy of Gary Schwartz, MD

Figure 2-3. CT C-Spine Fracture

A man has been shot in the neck, and his blood pressure is rapidly deteriorating.

There is not much detail here, but the idea is that penetrating wounds anywhere in the neck need immediate surgical exploration if the patient is unstable. Do not get distracted by the zone of injury. If the patient is unstable, proceed directly to surgical exploration.

A 42-year-old man arrives at the ED after being shot in the neck. A wound is identified in the anterior left side of the neck at the level of the thyroid cartilage. The patient is spitting and coughing blood and has an expanding hematoma under the entrance wound. Blood pressure responded promptly to fluid administration, and he has remained stable.

This is a clear-cut case of a penetrating wound in zone 2 of the neck. The presence of a hematoma and hemoptysis are both highly concerning and are indications for immediate surgical exploration.

A 22-year-old man arrives at the ED after being shot in the neck. A wound is identified above the angle of the mandible with a steady trickle of blood. The patient is drunk and combative but is otherwise stable.

In zone 3 penetrating injuries, there is less concern for a tracheal or esophageal injury—most traumatic injuries are vascular. Given the stability of the patient and difficulty surgically accessing this zone (as it is most difficult to take apart the skull), CT angiogram is still the test of choice. If contrast extravasation is identified, pursue angiography with embolization.

A 22-year-old man arrives at the ED after being shot in the neck. A wound is identified just above the clavicle. The patient is drunk and combative but is otherwise stable.

Unlike zone 3 injuries, zone 1 injuries are very accessible; however, the exact injury will define the surgical approach. Accordingly, in a stable patient, first obtain a CT angiogram to evaluate the need for open surgical exploration. Also evaluate endoscopically with bronchoscopy and esophagoscopy.

Clinical Pearl

Zone 1 injuries can also enter the chest. Make sure to perform a chest x-ray prior to CT angiogram of the neck to rule out pneumothorax or hemothorax.

A 45-year-old woman, an unbelted front passenger during a car crash, was thrown through the windshield at approximately 30 mph. She arrives at the ED strapped to a headboard with multiple facial lacerations but is otherwise hemodynamically stable. Physical examination reveals tenderness to palpation of the posterior cervical midline. Neurological exam is normal.

Every patient with a head injury from blunt trauma is at risk for a cervical spine injury. Pain on palpation raises concern for a serious injury, even in the absence of neurological deficits. Proceed to CT of the neck (and head, given the mechanism of injury). Most likely, an MRI will also be necessary if CT is abnormal or pain persists.

Spinal Cord Injury

The level and mechanism of injury to the spinal cord determines the potential for recovery and therefore the impact on quality of life. Transection of the spinal cord results in irreversible complete loss of motor and sensory neurologic function below the level of the injury. With high spinal cord injury, loss of sympathetic innervation and the resulting vasodilation (and in many cases, loss of sympathetic cardiac drive) can result in neurogenic/spinal shock.

Spinal shock should be considered in the acute trauma setting if there is hypotension and paralysis, which is often accompanied by bradycardia. IV fluids and vasoconstrictors are indicated.

Complete transection results in no function—sensory or motor—below the level of the injury.

Hemisection (Brown-Séquard syndrome), typically caused by a clean-cut injury such as a knife blade, results in ipsilateral paralysis and loss of proprioception along with contralateral loss of pain perception below the level of the injury.

Anterior cord syndrome is typically seen with "burst" fractures of the vertebral bodies. There is loss of motor function, pain sensation, and temperature sensation bilaterally below the injury; vibratory and positional sense are preserved, as the posterior columns are intact.

Central cord syndrome ("whiplash") occurs in the elderly with forced hyperextension of the neck, such as from a rear-end car crash. There is paralysis and burning pain in the upper extremities, but most functions in the lower extremities are preserved.

Management necessitates precise diagnosis of a cord injury, best done with MRI. There is some evidence that high-dose corticosteroids immediately after the injury may help, but that concept is *still controversial.* Further surgical management is too specialized for the exam.

> An 18-year-old man is stabbed in the back, just to the right of the midline, during a bar fight. He has paralysis and loss of proprioception distal to the injury on the right side, and loss of pain perception distal to the injury on the left side.

> A 72-year-old woman is involved in a car crash and sustains T9 and T10 vertebral body fractures. She develops loss of motor function and loss of pain and temperature sensation on both sides distal to the injury, but can feel vibrations and sense position in those areas.

> A 72-year-old woman is rear-ended in a car crash. She subsequently develops paralysis and burning pain on both upper extremities but maintains good motor function in both legs.

These scenarios describe Brown-Séquard syndrome, anterior cord syndrome, and central cord syndrome, respectively. Management depends on an accurate diagnosis. Start with CT to evaluate the bony structures; follow with MRI to evaluate the cord and tendinous structures. Consult neurosurgery for further management.

Chest Trauma

Rib fracture can be deadly in the elderly because the pain impairs respiratory effort, leading to hypoventilation, atelectasis, and ultimately pneumonia. To avoid this cycle, treat pain from rib fractures with a local nerve block or epidural catheter in addition to oral and IV analgesics. Multiple rib fractures have a significant mortality, especially in the older population.

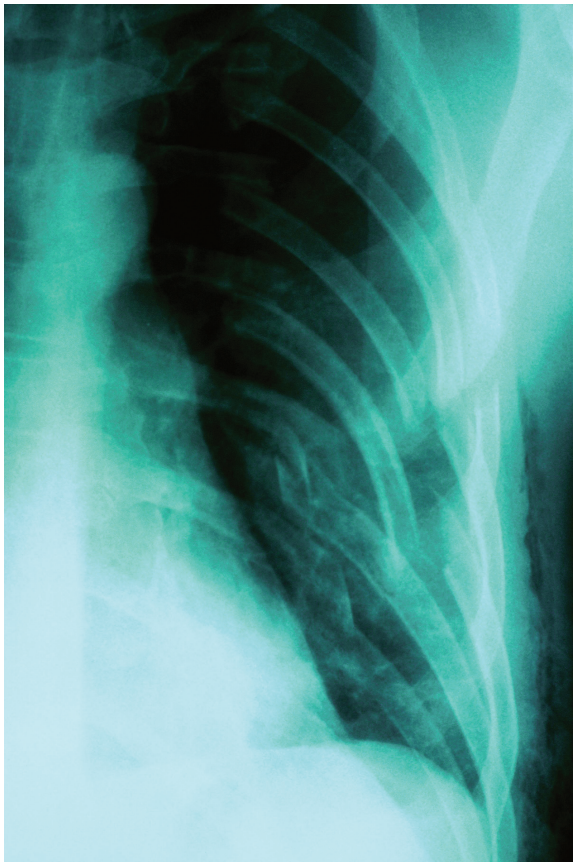


Figure 2-4. X-ray of Multiple Rib Fractures Due to Trauma

Simple pneumothorax is collapse of the lung. It can occur spontaneously but in the setting of trauma can be due to a penetrating injury, rib fracture with puncture of lung, or secondary iatrogenic causes (e.g., central line placement). There is typically moderate shortness of breath with absence of unilateral breath sounds and hyperresonance to percussion. Diagnosis is confirmed with chest x-ray; treatment is chest tube placement.

Hemothorax occurs when a blunt or penetrating injury results in bleeding into the chest cavity. The blood can originate directly from the lung parenchyma or from the chest wall, such as an intercostal artery. Physical examination reveals decreased breath sounds on the affected side accompanied by dullness to percussion.

- Diagnosis is confirmed with chest x-ray, but CT typically aids in diagnosis and surgical planning.
- Treatment is chest tube placement to allow evacuation of the accumulated blood and prevent late development of a restrictive fibrothorax or empyema.
- Surgery to stop the bleeding is sometimes required.
  - If the lung is the source of bleeding, it usually stops spontaneously because it is a low-pressure system.
  - If a systemic vessel, e.g., an intercostal artery, is the source of bleeding, surgical exploration may be necessary to control the hemorrhage. Indications for exploration include:
    - Evacuation of >1,500 mL upon insertion of a chest tube
    - Drainage of >1 L of blood over 4 hours, i.e., >250 mL/hr
    - Hemodynamic instability

Severe blunt trauma to the chest may cause obvious injuries such as rib fractures with a flail chest or sucking chest wound, as well as less apparent injuries such as pulmonary contusion, blunt cardiac injury, diaphragmatic injury, and aortic injury.

Flail chest involves fracture of ≥3 ribs with >2 segments broken per rib. This allows a segment of the chest wall to retract during inspiration and bulge out during expiration ("paradoxical breathing"). The real problem is the underlying pulmonary contusion. A contused lung is very sensitive to fluid overload; thus, treatment includes fluid restriction and aggressive pain management. Pulmonary dysfunction may develop, so serial chest x-rays and arterial blood gases must be monitored. Intubation and mechanical ventilation may become necessary.

Pulmonary contusion may be detected immediately after chest trauma or can be delayed up to 48 hours. It presents with shortness of breath with parenchymal consolidation, which appears as a "white-out" of the affected lung(s) on x-ray. It takes significant force to result in a pulmonary contusion, so also evaluate the patient for traumatic dissection or transection of the aorta using a CT angiogram. ARDS may develop in this scenario.

Blunt cardiac injury should be suspected with the presence of sternal fractures; **it takes great force to fracture the sternum.** EKG monitoring will detect any abnormalities. Historically a serum troponin level was obtained; however, elevations do not generally change management, so this test is not indicated. Treatment is focused on complications of the injury, such as arrhythmias. Obtain an echocardiogram to assess for any structural damage or evidence of a pericardial effusion.

Traumatic rupture of the diaphragm presents with the bowel in the chest on physical exam and x-ray; it is almost always on the left side, as the liver protects the right hemidiaphragm. If diaphragmatic injury is suspected, do laparoscopy to evaluate (although gas insufflation of the peritoneum may complicate anesthetic care). Surgical repair is typically done from the abdomen.

Traumatic rupture of the aorta is the ultimate "hidden injury." It most commonly is due to a significant deceleration injury, and it is located at the junction of the aortic arch and the descending aorta, where the relatively mobile aorta is tethered by the ligamentum arteriosum. This injury may be totally asymptomatic until the hematoma contained by the adventitia ruptures, resulting in rapid death. Suspect aortic injury under the following circumstances:

- There is a high-energy deceleration mechanism
- Widened mediastinum on chest x-ray or mediastinal hematoma on chest CT
- Presence of atypical fractures such as the first or second rib, scapula, or sternum—all require great force to fracture

Diagnosis is made with CT angiogram. As these injuries tend to be delayed, management is deferred until the patient has been stabilized and more immediate life-threatening injuries have been addressed. Repair of aortic injury can then be performed in an open or endovascular route.

Traumatic rupture of the trachea or major bronchus is suggested by the presence of subcutaneous emphysema in the upper chest and lower neck, or by a large "air leak" from a chest tube. Chest x-ray and CT confirm the presence of air outside the bronchopulmonary tree, and fiberoptic bronchoscopy may identify the injury and allow intubation past the injury to secure an airway. Surgical repair is mandatory.

Clinical Pearl

The differential diagnosis of subcutaneous emphysema also includes rupture of the esophagus. Although the pressure of air escaping from the GI tract is typically not enough to cause subcutaneous air tracking, it is possible and so must be ruled out with an esophagram.

Air embolism can produce sudden cardiovascular collapse and cardiac arrest. It should be suspected when sudden death occurs in a chest trauma patient who is intubated and on a respirator. It also can occur in a spontaneously breathing patient if the subclavian vein is opened to the air (e.g., supraclavicular lymph node biopsies, central venous line placement, or lines that become disconnected). Immediate management includes cardiac massage, with the patient positioned in Trendelenburg position with the left side down to "trap" air in the right atrium until it can be absorbed or aspirated.

Fat embolism may also produce respiratory distress in a trauma patient who is without direct chest trauma. The typical setting is the trauma patient with multiple long bone fractures who develops petechial rashes in the axillae and neck; fever, tachycardia, and low platelet count may also be present. Respiratory distress is followed by hypoxemia, with patchy bilateral infiltrates visible on chest x-ray. Management is respiratory support. Adjunctive therapies have been discredited (including heparin, steroids, alcohol, or low-molecular-weight dextran).

> A 75-year-old man slips and falls at home, hitting his right chest wall against the kitchen counter. He has an area of exquisite pain to direct palpation over the seventh rib at the level of the anterior axillary line. Chest x-ray confirms the presence of a rib fracture with hemothorax or pneumothorax.

Rib fracture is the most common chest injury. It is bothersome but manageable in most people. In the elderly, however, it can be hazardous because splinting and hypoventilation lead to atelectasis, which can lead to pneumonia. Treatment is local pain relief with nerve block or epidural catheter and respiratory optimization (supplemental oxygen, incentive spirometry, chest physiotherapy). On the exam, beware of wrong answer choices that might include strapping, binding, or rib plating (rarely indicated as a primary therapy).

> A 25-year-old man is stabbed in the right chest. He is moderately short of breath and has stable vital signs. There are no breath sounds on the right side, which is hyperresonant to percussion.

This vignette describes an uncomplicated pneumothorax. Diagnosis is made with chest x-ray. In this case, unlike a tension pneumothorax, there is time to get an x-ray if the option is offered. Ultimately, management is with insertion of a chest tube. If given an option for location, it should be placed at the fifth intercostal space in the midaxillary line, above the rib.

> A 25-year-old man is stabbed in the right chest. He is moderately short of breath and has stable vital signs. The base of the right chest has no breath sounds and is dull to percussion. Faint breath sounds are auscultated at the apex.

This presentation is consistent with a hemothorax. Diagnosis is made with chest x-ray; if confirmed, treatment is still with a chest tube. This allows drainage to enable ventilation, assess quantity of bleeding, and prevent future empyema or fibrothorax.

A 25-year-old man is stabbed in the right chest. He is moderately short of breath and has stable vital signs. There are no breath sounds at the right base and only faint distant breath sounds at the apex. The right base is dull to percussion. Chest x-ray confirms the presence of a hemothorax. A chest tube placed in the right pleural space drains 400 mL of blood. Over the subsequent 4 hours he continues to drain 200–300 mL of blood/hr, but remains hemodynamically stable.

Hemodynamic instability and volume of chest tube drainage for hemothorax dictate the need for surgical exploration. This scenario qualifies as significant bleeding, probably from a systemic source (e.g., intercostal vessel) rather than the pulmonary parenchyma, which is more likely to resolve spontaneously.

A 54-year-old woman crashes her car against a telephone pole at high speed. On arrival at the ED she is in moderate respiratory distress. She has multiple bruises on the chest and multiple sites of point tenderness over the ribs. X-ray shows multiple rib fractures on both sides, but no hemothorax or pneumothorax.

Clinical Pearl

In cases of blunt trauma with extensive thoracic injuries, don't forget the silent killer: aortic transection. Rule it out with a CT angiogram of the chest.

This common scenario puts the patient at risk for flail chest, as well as pulmonary contusions. Examine for evidence of a flail segment and manage respiratory failure if and when it progresses.

A 54-year-old woman crashes her car against a telephone pole at high speed. On arrival at the ED she is in moderate respiratory distress. She has multiple bruises on the chest and multiple sites of point tenderness over the ribs. X-ray shows multiple rib fractures on both sides, but no hemothorax or pneumothorax. She is admitted to the hospital for pain control. Overnight, she develops severe shortness of breath and is found to have an oxygen saturation of 84%. Chest x-ray shows bilateral infiltrates.

Pulmonary contusions can present in a delayed fashion. Given this patient's trajectory, she is in trouble. She will likely need intubation and mechanical ventilation, ideally with high PEEP. Fluid restriction and diuresis will be helpful if her hemodynamics can tolerate.

A 54-year-old woman crashes her car against a telephone pole at high speed. On arrival at the ED she is in moderate respiratory distress. She has multiple bruises on the chest and multiple sites of point tenderness over the ribs and sternum. X-ray shows multiple rib fractures on both sides and a sternal fracture, but no hemothorax, pneumothorax, or mediastinal hematoma.

This is a variation on the previous scenario with the addition of a sternal fracture, which can be associated with myocardial contusion. Get a 12-lead EKG, but don't check serum troponin levels, as elevation will not affect management. The patient will need continuous monitoring for the development of arrhythmias and a transthoracic echocardiogram to evaluate for a pericardial effusion and to assess ventricular function. Given the force necessary to fracture the sternum, a CT angiogram of the chest to evaluate for aortic transection is again indicated.

A 53-year-old man is involved in a high-speed car crash. He has moderate respiratory distress. Physical examination shows no breath sounds over the entire left chest. Percussion is unremarkable. Chest x-ray shows multiple air-fluid levels in the left chest.

This is a classic presentation of traumatic diaphragmatic rupture with consequent migration of intra-abdominal contents into the left chest; the right side is protected by the liver, so diaphragmatic rupture almost always occurs on the left. A nasogastric (NG) tube curling up into the left chest might be an added clue. In suspicious cases, laparoscopic evaluation is indicated. Management is surgical repair through either the abdomen or the chest, depending on the presence of other injuries and surgeon preference.

A motorcycle daredevil attempts to jump over the 12 fountains in front of Caesars Palace Hotel in Las Vegas. As he leaves the ramp at very high speed, his motorcycle turns sideways and he hits the retaining wall at the other end. In the ED he is found to be remarkably stable, although he has multiple extremity fractures. Chest x-ray shows fracture of the left first rib and a widened mediastinum without pneumothorax or hemothorax.

This is a real case and a classic presentation of trauma aortic transection: significant force, with multiple rib fractures including the first rib. A widened mediastinum is concerning for a major vascular injury and requires a CT angiogram for further evaluation. Management is surgical—either open or endovascular.

A 34-year-old woman presents to the ED following a car crash. She has multiple injuries to her extremities and a scalp laceration. During the course of the evaluation she is noted to have progressive subcutaneous emphysema of her upper chest and lower neck.

There are 3 etiologies of subcutaneous emphysema: pneumothorax, esophageal injury, and a major airway injury. Diagnosis begins with chest x-ray.

- If a pneumothorax is present, place a chest tube.
- If a large continuous air leak is present, suspect a major airway injury and proceed with flexible bronchoscopy.
- If an airway injury is identified, proceed to the OR for surgical repair.
- If no airway injury is identified, rule out an esophageal injury with an esophagram.

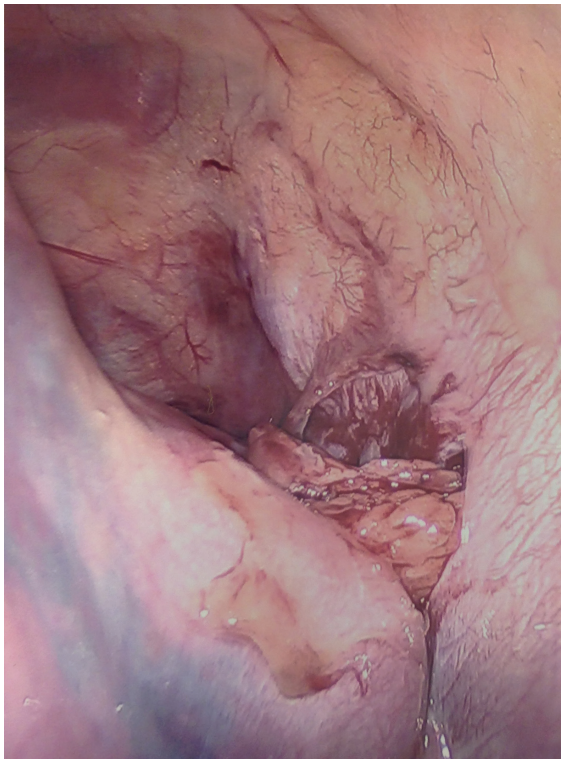
Abdominal Trauma

For the sake of evaluation and management abdominal trauma is divided into penetrating and blunt traumas, based on the mechanism of injury.

Penetrating trauma is further differentiated into gunshot wounds and stab wounds, as the pattern of injury based on these mechanisms is quite different.

Clinical Pearl

The diaphragm separates the thorax and the abdomen, but injuries can occur cross multiple fields. Be aware of potential abdominal injuries with chest wounds and, conversely, chest injuries with abdominal wounds.



Courtesy of Gary Schwartz, MD

Figure 2-5. Transthoracic Transdiaphragmatic Stab Wound

- Gunshot wounds to the abdomen require exploratory laparotomy for evaluation and possible repair of intra-abdominal injuries. Any entrance or exit wound below the nipple line is considered to involve the abdomen.
- Stab wounds allow a more individualized approach. In the presence of protruding viscera or peritoneal signs, proceed to the OR for exploratory laparotomy. In the absence of these signs, some still advocate exploration of the wound in the ED.
  - If the anterior rectus fascia is not violated, no further intervention is necessary.
  - If the anterior rectus fascia is violated, surgical exploration is indicated to evaluate for bowel or vascular injury, even in the setting of hemodynamic stability and lack of peritoneal findings on physical examination. However, this technique is frequently misleading.
- CT scan is most helpful. Safety is the overall primary concern.

Blunt trauma to the abdomen with obvious signs of peritonitis or hemodynamic instability suggesting intra-abdominal hemorrhage requires emergent surgical evaluation via exploratory laparotomy. Signs of internal injury include abdominal distention and significant abdominal pain with guarding or rigidity on palpation.

Even without obvious signs of internal injury, blunt trauma requires further evaluation because intra-abdominal hemorrhage or bowel injury can develop slowly and present in a delayed fashion.

- The unstable trauma patient who has been ruled out for chest and pelvic injuries by physical exam and x-rays needs abdominal exploration.
- The stable blunt trauma patient also needs further evaluation for occult injuries, starting with FAST and progressing to CT scan.

Additionally, CT is helpful in grading the degree of injury and guiding the need for surgical intervention versus observation. In general, intra-abdominal bleeding from the liver or spleen can be observed as long as the patient is hemodynamically stable or responds to fluid and limited blood product administration; the moment instability is mentioned in a vignette, surgical exploration is indicated.

If surgical exploration is performed for penetrating or blunt abdominal trauma, certain principles must be employed.

- Prolonged surgical time and ongoing bleeding can lead to the "triad of death": hypothermia, coagulopathy, and acidosis. The longer a patient is open the worse these components get, and they can interact in a vicious cycle ultimately leading to death. Accordingly, the "damage control" approach has been adopted:
  - Immediate life-threatening injuries are addressed; less urgent injuries are temporized to be addressed later.
  - Immediate life-threatening injuries include hemorrhage and contamination from a GI tract injury. If a bowel resection is necessary, reconstruction can be delayed because only the contamination is life-threatening, not the inability to digest food. Accordingly, resecting the unsalvageable bowel is performed; the GI tract is left in discontinuity requiring future reoperation.
- If hypothermia, coagulopathy, or acidosis is setting in and injuries have been controlled, the operation is terminated and the abdomen is closed in a temporary fashion. The patient is resuscitated in the ICU and returns to the OR at a later date for definitive reconstruction and abdominal closure when warm, not coagulopathic, and not acidotic.
- If coagulopathy does develop during surgical exploration, it is best treated with transfusion of RBCs, fresh frozen plasma, and platelets in equal quantities (**1:1:1 ratio**). This most realistically mimics the replacement of whole blood and provides not only hemoglobin, but also adequate clotting factors to reverse the developing coagulopathy and enable control of hemorrhage.

Clinical Pearl

Whole blood transfusions are now available at major trauma centers.

The abdomen is left open to avoid increasing intra-abdominal pressure due to volume resuscitation and bowel edema, which would otherwise result in **abdominal compartment syndrome**. The elevated pressure leads to decreased perfusion pressure to the viscera, contributing to acute kidney injury and possibly bowel and hepatic ischemia. The diaphragm is displaced cranially, inhibiting efficient ventilation and contributing to respiratory failure. Leaving the abdomen open at the end of a damage-control operation prevents this feared complication and allows for easy access for re-exploration.

Clinical Pearl

Abdominal compartment syndrome can occur in the absence of trauma, when volume resuscitation is significant over a short period of time. This classically occurs in severe pancreatitis. Management is conceptually the same: a decompressive laparotomy to decrease intra-abdominal pressure.

A **ruptured spleen** is the most common source of significant intra-abdominal bleeding in blunt abdominal trauma. Often there are additional diagnostic hints, such as fracture of lower ribs on the left side. Given the limited function of the spleen in the adult, a splenic injury resulting in hemodynamic instability or requiring significant blood product transfusion is an indication for splenectomy. Postoperative immunization against encapsulated bacteria is mandatory (pneumococcus, *Haemophilus influenzae* B, and meningococcus). Lesser injuries to the spleen can be repaired, but for the sake of the examination, perform a splenectomy for unstable patients and manage stable patients nonsurgically.

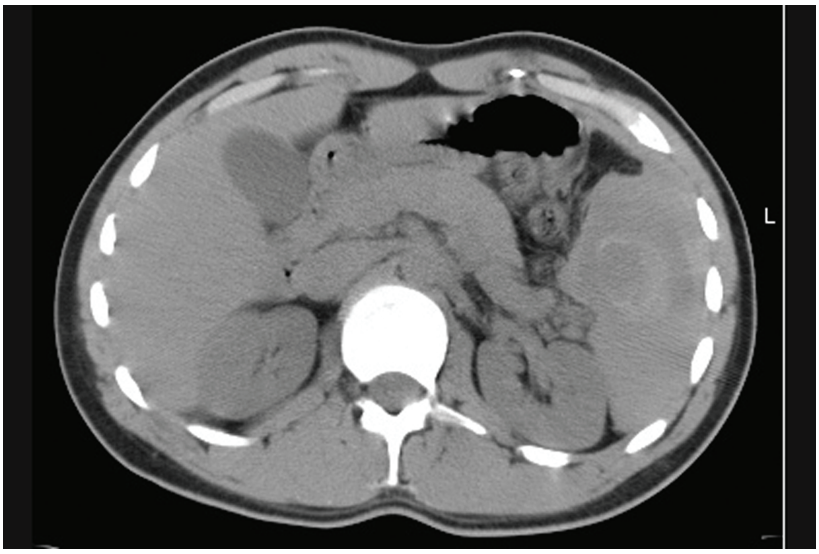


Figure 2-6. CT Ruptured Spleen and Hemoperitoneum

A 19-year-old gang member sustains a gunshot wound to the abdomen. The wound is in the epigastrium to the left of the midline. The patient is hemodynamically stable with minimal abdominal tenderness.

Exploratory laparotomy is needed. Don't be fooled by hemodynamic stability or lack of tenderness; a gunshot wound to the abdomen needs surgical exploration every time. Preparations before surgery include an indwelling bladder catheter, a large-bore venous line for fluid administration, and a dose of broad-spectrum antibiotics.

A 19-year-old gang member sustains a gunshot wound to the abdomen. The wound is in the epigastrium to the left of the midline. The patient is hemodynamically stable with minimal abdominal tenderness. He is taken to the OR for exploratory laparotomy, where a through-and-through injury to the transverse colon is identified.

With minimal contamination, primary repair may be sufficient. If there is a more significant injury or gross contamination is present, bowel resection may be necessary. Historically patients were resected and diverted with an ileostomy or colostomy depending on the location, but there is more recent data to support a primary anastomosis. For the sake of the examination, remain conservative and divert.

A 19-year-old gang member sustains a gunshot wound. On examination a wound is identified just below the right nipple in the midclavicular line. Chest x-ray does not demonstrate a pneumothorax or hemothorax. The patient is hemodynamically stable.

The abdominal cavity extends well into the thoracic cage; consider any penetrating trauma below the level of the nipple to be intra-abdominal. Although no intrathoracic injury is identified on x-ray, this patient needs abdominal exploration.

A 42-year-old man is stabbed in the abdomen in a bar fight. He is hemodynamically stable. On physical exam he elicits no tenderness to palpation. There is a wound to the left of the umbilicus that is not actively bleeding.

A stab wound to the abdomen may not violate the anterior abdominal wall, limiting the possibility of an intra-abdominal injury. Some may explore the wound in the ED, but this can be unreliable. If it does not traverse the anterior rectus fascia, no further workup may be necessary. CT scan is always the safest approach.

A 42-year-old man is stabbed in the abdomen in a bar fight. He is hemodynamically stable. On physical exam he elicits no tenderness to palpation. There is a wound to the left of the umbilicus with protruding omentum.

Stab wounds to the abdomen with clear evidence of fascial penetration require exploratory laparotomy.

A 31-year-old woman is involved in a car accident. Blood pressure is 75/55 mm Hg and pulse 110/min. On physical examination a tender abdomen, with guarding and rebound on all quadrants, is noted.

A 31-year-old woman is involved in a car accident. Blood pressure is 130/80 mm Hg and pulse 80/min. On physical examination a tender abdomen, with guarding and rebound on all quadrants, is noted.

Mechanism of blunt trauma and physical exam suggest an intra-abdominal injury. The point here is that patients can be hemodynamically unstable due to active hemorrhage, but can also be completely stable. The presence of peritoneal signs warrants further evaluation with CT, even in the absence of hemodynamic instability.

A 27-year-old man arrives at the ED having been in a car accident. Blood pressure is 85/68 mm Hg and pulse 128/min. He is tender over the left lower chest wall. Chest x-ray demonstrates fracture of the left 8th, 9th, and 10th ribs without a hemothorax or pneumothorax. CT demonstrates a grade III splenic laceration. He is given 2L of normal saline. Repeat exam reveals blood pressure 78/42 mm Hg and pulse 135/min.

Note

On the exam, you will not be asked about the specific steps of an operation. However, you will need to know the steps for your clinical rotations and your oral examinations, so brush up.

Although this is "only" a grade III laceration, worsening hemodynamics despite volume resuscitation in the presence of a blunt splenic injury is an indication for splenectomy. Proceed to the OR for exploration. Prior to discharge administer Pneumovax and immunize for *Haemophilus influenzae* B and meningococcus.

During an exploratory laparotomy for multiple gunshot wounds to the abdomen, the patient is noted to be 34 C (93.2 F) with oozing from all sites, including IV lines. A ruptured spleen has been removed and a gastric perforation has been repaired.

If the immediate life-threatening bleeding and contamination have been repaired, get out of there. Hypothermia and coagulopathy have already set in; acidosis is not far behind. This "triad of death" is unforgiving. Pack the abdomen, apply a temporary closure, and continue resuscitation in the ICU.

On postoperative day 1 following exploratory laparotomy for blunt trauma with bowel resection and splenectomy, a 27-year-old man complains of worsening abdominal pain. The patient is found to be tachypneic, with abdominal distention and diminishing urine output.

Abdominal compartment syndrome can present in a delayed fashion due to excessive volume resuscitation. Returning the patient to OR for decompressive laparotomy will prevent impending respiratory and renal failure, as well as worsening hemodynamic instability.

Pelvic Fracture

The pelvis is a complete bony ring and therefore cannot be fractured in only one location; multiple fractures are typically present. (Imagine trying to break a pretzel in just one location.) These can range from minor to life-threatening.

Clinical Pearl

With any pelvic fracture, associated injuries must be ruled out:

- Injury to the rectum (evaluate with rectal exam and rigid proctoscopy)
- Injury to the vagina (evaluate with a manual vaginal exam) and urethra (evaluate with a retrograde urethrogram)
- Injury to the bladder

Minor fractures with small pelvic hematomas incidentally identified on CT are typically monitored. In pelvic fractures with ongoing significant bleeding causing hemodynamic instability, management is complex:

- The first step for an obvious pelvic fracture in an unstable patient is external pelvic wrapping to provide some stabilization of the pelvis, thereby limiting the potential space for ongoing blood loss.
- It is difficult to identify and control the source of bleeding in the pelvis, where a deep cavity contains significant organs and vessels including the complex sacral venous plexus. Therefore, angiography is the next step in managing hemorrhage from serious pelvic fracture—not surgical exploration.
- If angiography localizes arterial extravasation, embolization can be hemostatic. If no arterial bleeding is identified, the source is presumed to be venous, and the bilateral internal iliac arteries are prophylactically embolized to proximally control the bleeding.

A 42-year-old woman is thrown from a car during a crash and is crushed underneath the vehicle. Extended extrication is required to get her out. Blood pressure is 92/58 mm Hg and pulse 130/min at the ED, but after administration of 2 L of normal saline, blood pressure 118/68 mm Hg and pulse 110/min. Pelvic x-ray demonstrates a left superior pubic ramus fracture. Focused abdominal sonography for trauma (FAST exam) reveals no intra-abdominal free fluid. CT of the abdomen and pelvis demonstrates no intra-abdominal bleeding, but a hematoma around the fracture.

Nonexpanding pelvic hematomas in a hemodynamically stable patient are initially managed nonsurgically. Blood transfusion may be necessary, and depending on the type of fracture, the orthopedic surgeons may eventually need to stabilize the pelvis. At this time, however, the main issue is to rule out the potential associated pelvic injuries: rectum, bladder, and vagina.

A 42-year-old woman is thrown from a car during a crash and is crushed underneath the vehicle. Extended extrication is required to get her out. Blood pressure is 92/58 mm Hg and pulse 130/min at the ED, but after administration of 2L of normal saline, blood pressure is 88/48 mm Hg and pulse 126/min. Pelvic x-ray demonstrates a left superior pubic ramus fracture. FAST exam reveals no intra-abdominal free fluid. CT of the abdomen and pelvis demonstrates no intra-abdominal bleeding, but a hematoma around the fracture.

This is a similar scenario to the earlier vignette, but the patient is now hemodynamically unstable and not responsive to fluid administration. External pelvic binding to stabilize and transfusion of blood would be the next steps. The big issue will likely be ongoing pelvic hemorrhage. Proceed to interventional radiology for angiography with possible coil embolization.

Urological Injury

The hallmark of traumatic urological injuries is gross hematuria following penetrating or blunt abdominal trauma. Gross hematuria in that setting must be investigated with appropriate studies.

Penetrating urologic injuries as a rule are surgically explored and repaired. Management of **blunt injuries** depends on site:

- Most blunt renal injuries are managed nonsurgically. Hemodynamic instability or contrast extravasation on CT would be an indication for surgical exploration and possible nephrectomy. Renal injuries are secondary to blunt force impacting the flank and are therefore associated with rib fractures.
- Urethral injuries occur almost exclusively in men, as the female urethra is quite short. They are typically associated with a pelvic fracture and typically present with blood at the meatus. Other clinical findings include a scrotal hematoma, the sensation of wanting to void but inability to do so, and a "high-riding" prostate on rectal exam (i.e., it is not palpable on rectal exam). A Foley catheter should not be attempted, as this can compound an existing injury. If it is attempted and meets resistance, attempt should be aborted. A retrograde urethrogram is indicated.
- Bladder injuries can occur in either sex. They are usually associated with pelvic fracture and are diagnosed by retrograde or CT cystogram, including post-void films to enable visualization of extraperitoneal leak that might be obscured by a

Clinical Pearl

Late sequelae for nonsurgical management of blunt renal injury include development of an arteriovenous fistula (leading to high-output heart failure) and renal artery stenosis (leading to hypertension).

bladder full of dye. Management of intraperitoneal bladder injury requires surgical repair with protection by a decompressive suprapubic cystostomy or indwelling Foley catheter.

- Penile fracture (disruption of the corpora cavernosa or the tunica albuginea) occurs to an erect penis, typically during vigorous intercourse. There is sudden pain and development of a penile shaft hematoma, with a normal appearing glans. Frequently, the true history will be concealed by an embarrassed patient. Emergency surgical repair is required. If not done, painful erections and possibly impotence may ensue.

A 22-year-old man is shot in the lower abdomen, just above the pubis. Blood is found in the urine, but on rectal examination there is no evidence of rectal injury.

The hallmark of traumatic urologic injury is hematuria. Penetrating urologic injury is like most penetrating injury elsewhere: it requires surgical repair.

A 22-year-old man is injured in a high-speed car crash and presents to the ED with multiple injuries, including a pelvic fracture. On physical examination there is blood at the meatus.

The vignette on the exam is likely to be longer, but the point is that pelvic fracture plus blood at the meatus in a male means either a bladder injury or (more likely) a urethral injury. Evaluation starts with a retrograde urethrogram. Do not place a Foley catheter, which could compound the injury.

A 22-year-old woman is injured in a high-speed car crash and presents to the ED with multiple injuries, including a pelvic fracture. Insertion of a Foley catheter reveals gross hematuria.

Hematuria in a woman following blunt trauma is most likely to originate in the bladder, given the relatively short urethra. Evaluate with retrograde cystogram. Intraperitoneal extravasation may be seen due to rupture at the dome, but if not visualized, repeat an x-ray after the bladder is empty to potentially visualize retroperitoneal extravasation.

A 22-year-old man is injured in a high-speed car crash and presents to the ED with multiple injuries, including rib fractures and a pneumothorax. Insertion of a Foley catheter results in gross hematuria.

In this case of hematuria following blunt trauma there is no pelvic fracture but there are rib fractures, which are associated with renal injuries. Diagnose with CT scan. Blunt renal injuries can usually be managed nonsurgically; however if hemodynamically unstable, patient may need surgical exploration and possibly nephrectomy.

A 22-year-old man is injured in a high-speed car crash and presents to the ED with multiple injuries, including rib fractures and a pneumothorax. Insertion of a Foley catheter results in gross hematuria, but retrograde cystogram is normal. CT demonstrates a grade II renal injury that is managed nonsurgically. Six weeks later the patient develops acute shortness of breath. Physical examination is significant for normal breath sounds, but a bruit can be auscultated along the flank.

This is a "zebra," but so fascinating that some medical school professors may not be able to resist the temptation to test it. The patient developed a traumatic arteriovenous fistula at the renal pedicle and subsequently developed high-output heart failure. Management is diagnostic arteriogram followed by surgical repair.

In traumatic gross hematuria, both the kidneys and bladder must be evaluated.

Injury to the Extremities

Injury to the extremities can arise from blunt or penetrating mechanisms and can result in orthopedic, soft tissue, vascular, or neurological injuries. Vascular injury has the potential to be immediately life-threatening and should be the initial focus in evaluation. In penetrating injuries of the extremities, the main issue is whether a vascular injury has occurred or not. Anatomic location provides the first clue:

- If there are no major vessels in the vicinity of the injury, only tetanus prophylaxis and irrigation of the wound are required.
- If the penetration is near a major vessel and the patient is asymptomatic, CT angiogram is performed and will guide the need for a surgical intervention.
- If there is an obvious vascular injury (absent distal pulses, expanding hematoma), surgical exploration and repair are required.

Simultaneous vascular and orthopedic injuries pose the challenge of the sequence of operative repair. One perspective is to stabilize the bone first, then do the delicate vascular repair that could otherwise be disrupted by the bony reduction and fixation. However, during the orthopedic repair ongoing ischemia is occurring as the arterial flow is disrupted. A good solution, if proposed on the exam, is to place a vascular shunt, which allows temporary revascularization during the bony repair with subsequent definitive vascular repair. A fasciotomy is usually indicated, as prolonged ischemia could lead to compartment syndrome with irreversible injury.

High-velocity gunshot wounds (e.g. military or big-game hunting rifles) produce a large cone of tissue destruction that requires extensive debridements and potential amputations.

Crushing injuries of the extremities resulting in myonecrosis pose the hazard of hyperkalemia, acidosis, and renal failure, as well as potential development of compartment syndrome. Aggressive fluid administration, osmotic diuretics, and alkalinization of the urine with sodium bicarbonate are good preventive measures for the acute kidney injury. A fasciotomy may be required to prevent or treat compartment syndrome.

Note

A crush injury can result from prolonged lying on a hard floor, where normal movement is prevented by neurologic injury or drugs/alcohol.

A 25-year-old man is shot with a .22-caliber revolver. There is a wound in the anterolateral aspect of his thigh, and the bullet is seen by x-rays to be embedded in the quadriceps posterolateral to the femur.

A 25-year-old man is shot with a .22-caliber revolver. There is a wound in the anteromedial aspect of his upper thigh, and another in the posterolateral aspect of the thigh. There are normal pulses in the leg, and there is no hematoma at the entrance site. X-ray reveals the femur to be intact.

A 25-year-old man is shot with a .22-caliber revolver. There is a wound in the anteromedial aspect of his upper thigh, and another in the posterolateral aspect of the thigh. He has an expanding hematoma in the upper, inner thigh. X-ray reveals the femur to be intact.

Proximity to a major vascular structure is the first thing to assess when assessing penetrating injuries to the extremities. In the first vignette, clearly the trajectory is nowhere near the femoral vessels; therefore no further intervention is warranted (other than tetanus). The second and third vignettes demonstrate that even when you cannot assess what is an entry vs. an exit wound, the proximity to the femoral vessels raises concern for a vascular injury. In the third vignette, there is clear evidence of an arterial injury (expanding hematoma), and this patient should be urgently explored. Although the second vignette does not detail signs of a vascular injury, further investigation with CT angiogram should be performed due to proximity.

A 25-year-old man young man is shot through the arm with a .38-caliber revolver. There are wounds on both the lateral and medial aspect of the extremity, with no radial pulse palpable distally. X-ray demonstrates a shattered humerus.

The lack of a distal pulse is clearly an indication for surgical exploration; the question here is whether to manage the shattered humerus or the vascular injury first. Begin with fracture stabilization, then vascular repair (both artery and vein if possible). The unavoidable delay in restoring circulation will make a fasciotomy mandatory. Temporary shunting the arterial injury to allow distal perfusion is a good solution if offered as a choice, but is easier said than done.

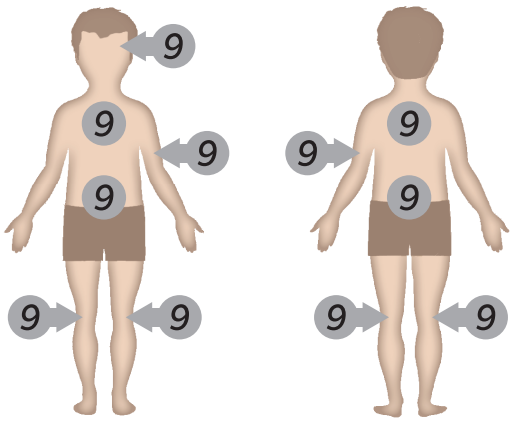
A 6-year-old girl has her hand, forearm, and lower part of the arm crushed in a car accident. The entire upper extremity looks bruised and battered. Pulses are intact, and x-ray demonstrates no fractures.

Crushing injuries lead to 2 concerns in addition to bony or vascular injuries: myoglobulinemia leading to an acute kidney injury, hyperkalemia, and metabolic acidosis; and delayed swelling that may lead to compartment syndrome. For the first, resuscitate with IV fluids, osmotic diuretics (mannitol), and alkalinization of the urine to help protect the kidney. For the latter, perform a fasciotomy.

BURNS

With burns, the loss of skin integrity increases insensible fluid loss, which leads to profound hypovolemia and loss of temperature control. Treatment is as follows:

- In first 24 hours of partial and full thickness burns, fluid resuscitation is guided by the extent of body surface area (BSA) involved; after 24 hours, urine output is main guide for ongoing resuscitation.
- The size of a burn can be estimated by using the tool "**rule of nines**," which divides the BSA into percentages.
  - The head and each upper and lower extremity are each assigned 9% of BSA.
  - Each lower extremity is assigned two 9% units for anterior and posterior.
  - Trunk is assigned 4 units of 9% each: 2 anterior and 2 posterior.
  - Perineum/genitalia is remaining 1% total BSA.
- The Parkland formula is used to estimate the LR replacement fluid needs for burn patients in the first 24 hours (24-hour calculation begins at time of burn injury, not time of presentation).
  - Importance of fluid replacement is to restore circulating volume, enhance tissue perfusion, and preserve vital organs
  - Modified Parkland formula takes body weight (in kilograms) multiplied by the percentage of burn (as a whole number), and multiplied by 4 mL/%TBSA
  - Half of this volume to be infused in first 8 hours
  - Half of this volume to be infused in next 16 hours
- Clean the burn, give tetanus prophylaxis, and use a topical agent (commonly silver sulfadiazine).
  - If deeper penetration is needed, e.g. a thick eschar or a burn over cartilage, mafenide acetate cream is commonly used
  - Burns near the eyes are covered with bacitracin or triple antibiotic ointment (silver sulfadiazine is irritating to eyes)
- After 1–2 days of NG suction, intensive nutritional support is provided, preferably via the gut, with high calorie, high nitrogen diets. Analgesia is initially given IV due to unpredictable GI absorption, but once enteral feeds are started all medications can be given via this route.
- Early excision and skin grafting are recommended to save costs and minimize pain, suffering, and complications.
- Rehabilitation should be started as soon as possible.



Management of burns in infants has several special considerations and therefore warrants transfer to a specialized center.

- Infants have proportionately larger heads and smaller legs than adults (**rule of nines** for infants assigns two 9s to the head and three 9s [not four] for both legs).
- In infants, third-degree burns look deep red, while in adults they have a leathery, dry, gray appearance.
- Infants need proportionally more fluid than adults, so formulas and calculations for them use 4–6 mL/kg/%.

Clinical Pearl

A 70 kg patient with 45% burns would need about 12.6 L of Ringer's lactate solution in the first 24 hours:

- Over first 8 hours: 6.3 L (788 mL/hr)
- Over next 16 hours: 6.3 L (393 mL/hr)

Circumferential full-thickness burns of the extremities can lead to tissue edema and restriction of arterial inflow, resulting in ischemia and compartment syndrome secondary to eschar. This can also occur in circumferential burns to the chest, with resultant limitations in ventilation. Escharotomies of insensate full-thickness burns can be done at the bedside, with no need for anesthesia to provide immediate relief.

Scalding burns in children should always raise the suspicion of child abuse, particularly if the pattern of the burn does not fit the description of the event given by the parents.

Inhalation injuries are caused by flame burns in an enclosed space (e.g., a burning building or car), causing a chemical burn of the tracheobronchial mucosa. Burns around the mouth or soot inside the throat are suggestive clues. Diagnosis is confirmed with fiberoptic bronchoscopy. Treatment is as follows:

- Assess whether respiratory support is necessary and evaluate clinical status
- Get serial arterial blood gases
- Intubate if there is any concern about adequacy of airway
- Monitor carboxyhemoglobin levels

Chemical burns require extensive irrigation to remove the offending agent. Alkaline burns (e.g., from clog remover) are worse than acid burns (e.g., battery acid). Irrigation must begin as soon as possible at the site where the injury occurred (tap water, shower). Do not attempt to neutralize the agent with any chemical reagents.

High-voltage electrical burns are always deeper and worse than they appear. Massive debridement or even amputation may be required. Additional concerns include myonecrosis-induced acute kidney injury, orthopedic injuries secondary to massive muscle contractions (e.g., posterior dislocation of the shoulder, compression fractures of vertebral bodies), and late development of cataracts and demyelination syndromes. Associated arrhythmias can be life-threatening.

> After suitable calculations have been made, a 70 kg adult with extensive third-degree burns is receiving Ringer's lactate at the calculated rate. In the first 3 hours his urinary output is 15, 22, and 18 ml.

The Parkland formula is the classic management of fluid resuscitation in burns and may show up on the exam. However, urine output is the best marker for adequate volume status, and if oliguric (<0.5–1 mL/kg/hr), more fluid is indicated regardless of the Parkland-based calculation.

Adjunctive treatment for burns includes tetanus prophylaxis; topical wound area analgesia; nutritional support; physical therapy; and skin grafting.

> A 42-year-old woman drops her hot iron on her lap while doing the laundry. She comes in with the shape of the iron clearly delineated on her upper thigh. The area is white, dry, leathery, anesthetic.

The description of this burn describes a third-degree burn, but in a limited area. Unlike with extensive burns (even of partial thickness), this patient will not need protracted support. Indeed, with a focal burn, the best management is early excision and grafting.

> A 53-year-old man is brought to the ED after being rescued from a house fire. Burns around the mouth and nose are noted. His pharyngeal mucous membranes are blackened.

There are 2 issues here: carbon monoxide poisoning and respiratory burns due to smoke inhalation from a fire in an enclosed space.

Determine carboxyhemoglobin levels and put the patient on 100% oxygen to shorten its half-life. Serial arterial blood gases will demonstrate the extent of the injury and guide treatment. Bronchoscopy may be helpful for diagnosis, as well as clearance of secretions.

> A 52-year-old man suffers third-degree burns to both arms after his shirt caught fire while lighting a barbecue. The burned areas are dry, white, leathery, anesthetic, and are circumferential around both forearms.

Circumferential burns of the extremities and trunk pose an additional problem: edematous tissue without the ability to expand, leading to increased compartment pressure and ultimately ischemia. Compulsive monitoring of Doppler signals of the peripheral pulses and capillary filling is needed. Emergent escharotomies are indicated if there are signs of ischemia. Chest wall escharotomy is indicated if the burn is limiting ventilation.

> A toddler is brought to the ED with burns on both buttocks. The areas are moist, have blisters, and are exquisitely painful to touch. The parents report that the child accidentally pulled a pot of boiling water over himself.

This vignette describes second-degree burns (in children third-degree burn is deep bright red, rather than white leathery as in the adult.) The same management principles apply, but be on alert for signs of child abuse and appropriate management.

> A frantic mother calls her primary care doctor's office after her 7-year-old girl spilled Drano all over her arms and legs. You can hear the girl screaming in pain in the background.

Chemical injuries, particularly alkali formulas, need immediate copious irrigation. Instruct the mother to do so right at home with tap water, for at least 30 minutes before rushing the girl to the ED. Do not pick an option where you would administer an acidic solution to "neutralize" the chemical burn.

A 42-year-old construction worker accidentally contacts an electrical power line while working on a roof. On physical exam burn wounds are noted on the upper outer thigh and the lower leg on the same side.

Electrical burns are much more significant than they appear. There will be deep tissue myonecrosis, even if it is not apparent on the initial exam. The patient will likely require fasciotomies and surgical debridement. The exam typically focuses on the downstream effects of myonecrosis: myoglobinuria, hyperkalemia, and renal failure. Significant volume resuscitation will be needed, followed by diuresis and alkalinization of the urine.

- Rule out other high-force injuries including posterior dislocation of the shoulder and compression fractures of vertebral bodies (from violent muscle contractions)
- Be aware of the potential for the late development of cataracts and demyelination syndromes

BITES AND STINGS

Tetanus prophylaxis and wound care are required for all bites. Unprovoked bites from dogs or wild animals raise the issue of potential rabies; provoked bites from domesticated dogs are less suspect. If the wild animal can be euthanized, it can be autopsied for signs of rabies; otherwise, rabies prophylaxis with immunoglobulin plus vaccine is mandatory.

Bites

Snakebites do not necessarily result in envenomation, even if the snake is poisonous (up to 30% of bitten patients are not envenomated). The most reliable signs of envenomation are severe local pain, swelling, and discoloration developing within 30 minutes of the bite. If such signs are present, draw blood for typing and crossmatch (cannot be done later if needed), coagulation studies, and liver and renal function.

Treatment is based on antivenin.

- CroFab is preferred agent currently for crotalids (several vials usually needed)
- Antivenin dosage relates to the size of the envenomation, not the size of the patient (children get the same dose as adults).
- Surgical excision of the bite site or fasciotomy is very rarely needed.
- The only valid first aid is to splint the extremity during transportation—**do not make cruciate incisions, suck out venom, wrap with ice, or apply a tourniquet.**

Black widow spiders have a characteristic red hourglass on the belly. Patients with bites experience nausea, vomiting, and severe generalized muscle cramps. Treatment is IV calcium gluconate and muscle relaxants.

Brown recluse spider bites are common, and often not recognized at the time of the bite. These spiders are found in gardens, garages, and basements. In the next several days, a skin ulcer develops with a necrotic center and a surrounding halo of erythema. Surgical debridement of all necrotic tissue is needed, as the venom contains a powerful proteolytic enzyme. Skin grafting may be needed subsequently.

Human bites are the most contaminated and therefore need antibiotic treatment and may require debridement and irrigation in the OR.

Stings

Bee stings kill many more people in the United States than snakebites because of an anaphylactic reaction. Wheezing and rash may occur and rarely may lead to anaphylactic shock. Epinephrine is the drug of choice. The stingers should be removed without squeezing them.

> A 6-year-old child tries to pet a domestic dog while the dog is eating, and the child's hand is bitten by the dog.

This is considered a provoked attack, with a low risk for rabies. Tetanus prophylaxis and standard wound care is all that is necessary.

> While exploring caves in the Texas hill country, a 16-year-old boy is bitten by a bat.

Bats are high risk for rabies transmission; treat with immunoglobulin plus vaccine.

> During a hunting trip, a hunter is bitten in the leg by a snake. The patient arrives at the hospital 1 hour later. Physical examination shows 2 fang marks about 2 cm apart, as well as local edema and ecchymotic discoloration. The area is very painful and tender to palpation.

The local reaction is suspect for envenomation. Blood should be drawn for typing and crossmatch, coagulation studies, and renal and liver function. Treat with antivenin. Surgical excision of the bite site and fasciotomy are only needed in extremely severe cases.

> During a picnic outing, a 6-year-old girl inadvertently bumps into a beehive and is stung repeatedly. Upon arrival to the ED 20 minutes later she is found to be wheezing, hypotensive, and madly scratching an urticarial rash.

This reaction sounds out of proportion to the stings, and likely represents an anaphylactic reaction. Treat with epinephrine.

> A 17-year-old gang member comes to the ED with a 1 cm deep sharp cut over the knuckle of the right middle finger. He says he cut himself with a screwdriver while fixing his car.

The description is classic for a human bite incurred by punching someone in the mouth. Human bites are quite contaminated; start on antibiotics and have a low threshold for surgical exploration.

General Surgery 3

Learning Objectives

- ❑ Understand surgical diseases of the gastrointestinal tract and endocrine systems
- ❑ Recognize surgical etiologies of hypertension
- ❑ List the indications, complications, and alternatives to dermatological procedures

GASTROINTESTINAL

Upper Gastrointestinal Disease

Esophagus

Gastroesophageal reflux disease (GERD) may produce vague symptoms that can be difficult to distinguish from other sources of epigastric distress. Typically, an overweight individual complains of burning retrosternal pain and "heartburn" that is brought on by bending over, wearing tight clothing, and lying flat in bed at night. Patients find relief with antacids and over-the-counter H2 blockers.

- If the diagnosis is uncertain, pH monitoring establishes the presence of reflux and its correlation with symptoms.
- If there is a longstanding history, the concern is that damage might have been done to the lower esophagus (peptic esophagitis) and that Barrett esophagus could develop. In that setting, endoscopy and biopsy are the indicated tests, as Barrett is a precursor to malignancy.

Treatment is as follows:

- H2 blockers or proton pump inhibitors (PPIs) plus lifestyle modification (diet, smoking cessation), which works for most patients
- Surgery may be indicated for symptomatic disease refractory to medical management, intolerance of medication (laparoscopic Nissen fundoplication), and local complications such as ulceration or stenosis (esophagectomy)

Motility problems have recognizable clinical patterns such as crushing pain with swallowing in uncoordinated contraction or dysphagia to solids (but not liquids, as seen in achalasia). Barium swallow is the first step in treatment, to assess for an obstructing lesion, but a definitive diagnosis requires manometry.

Achalasia (women > men) is a functional physiologic obstruction where swallowing becomes difficult and undigested food is occasionally regurgitated. Patients learn that sitting up straight and waiting allows the weight of the column of liquid to overcome the sphincter.

Workup begins with barium esophagram, followed by endoscopy to rule out a mechanical obstruction (e.g., cancer). If not found, manometry is diagnostic. In end-stage achalasia, x-ray demonstrates a severely dilated esophagus ("megaesophagus").

Treatment is endoscopy with dilation and injection of Botox into the lower esophageal sphincter. Because recurrence is high, laparoscopic Heller esophagomyotomy may be required.

Clinical Pearl

Per-oral endoscopic myotomy (POEM) is a new procedure whereby the lower esophageal sphincter is incised endoscopically. Long-term data is still lacking.

Cancer of the esophagus is an obstructive problem that classically presents with progressive dysphagia starting with meat, then other solids, then soft foods, then eventually liquids, and finally (after several months) saliva. Significant weight loss is always seen.

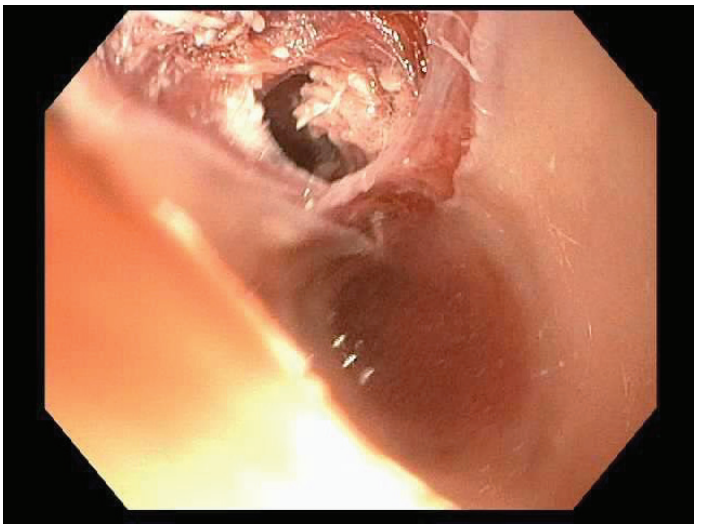
- Squamous cell carcinoma (SCC) is seen in men with a history of smoking and drinking.
- Adenocarcinoma is the more common form of cancer in those with longstanding GERD.

Diagnosis begins with barium esophagram and is confirmed with endoscopy and biopsy. Endoscopic ultrasound (EUS) and CT/PET scan are used to assess local and lymph node involvement, and thus the stage of the cancer. Treatment for early stage lesions is trimodal: chemotherapy, radiation, and surgical resection. Treatment for late stage lesions is chemoradiotherapy (since most are inoperable), but the prognosis is poor.

A **Mallory-Weiss tear** is a mucosal laceration at the junction of the esophagus and stomach. It occurs after prolonged, forceful vomiting and is associated with bright red hematemesis. Endoscopy establishes diagnosis and occasionally allows for treatment with endoscopic clipping or coagulation.

Boerhaave syndrome is rupture (perforation) of the distal esophagus that results from prolonged, forceful vomiting. There is sudden onset of continuous, severe, wrenching epigastric and low sternal pain, followed by fever, leukocytosis, and a very sick-looking patient. A delay in diagnosis and treatment has grave consequences due to the morbidity of mediastinitis.

- Water-soluble contrast esophagram is diagnostic; emergency surgical repair should follow.
- Earlier recognition or limited perforation can be managed endoscopically with esophageal stent placement.
- NPO and nutrition are mandatory; distal enteral feeding (e.g., PEG or jejunostomy) is preferred over TPN.

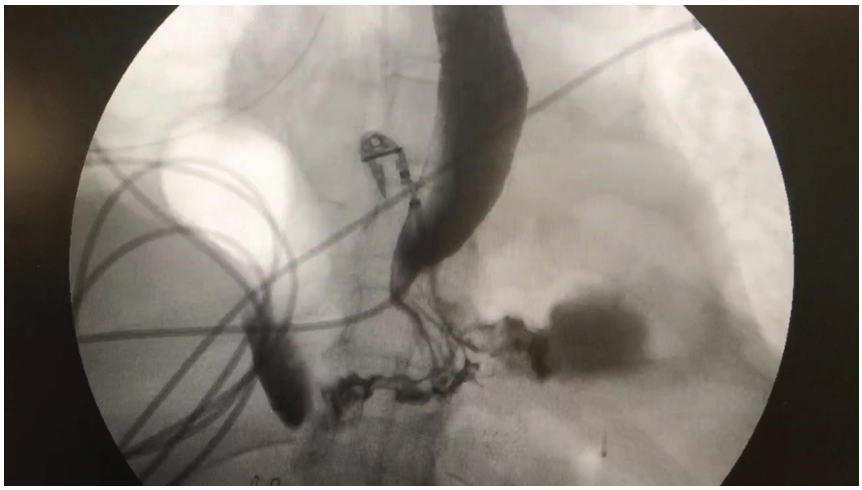


Courtesy of Gary Schwartz, MD

Figure 3-1. Boerhaave's Syndrome

Instrumental perforation is the most common etiology of cervical esophageal perforation. This is most commonly secondary to upper endoscopy but can also occur during cervical spinal instrumentation. Shortly after completion of the procedure, symptoms will develop; immediate post-procedural pain is a perforation until proven otherwise. There may be emphysema in the lower neck (virtually diagnostic in this setting).

- Diagnose with esophagram.
- Treatment is prompt surgical repair (left neck exploration with distal enteral access [e.g. PEG]), which is effective and lifesaving.



Courtesy of Gary Schwartz, MD

Figure 3-2. Upper GI Distal Esophageal Perforation

Stomach

In the past, peptic ulcer disease (PUD) was the most common indication for gastric surgery. In more recent times, the recognition that PUD is caused by *Helicobacter pylori* and the development of highly effective acid-suppressing medications (H2 blockers and PPIs) has dramatically decreased the need for surgical treatment of this condition. Indications for surgery include complications such as perforation.

Gastric adenocarcinoma (elderly > younger) has the following symptoms: anorexia, weight loss, vague epigastric discomfort, early satiety, and occasional hematemesis.

- Diagnose with endoscopy and biopsy; CT helps assess operability.
- Treatment is surgery. Reconstruction depends on the degree of resection, ranging from:
  - No reconstruction (wedge resection)
  - Roux-en-Y gastrojejunal reconstruction (distal resection)
  - Roux-en-Y esophagojejunal reconstruction (proximal or total gastrectomy)

Gastric lymphoma is almost as common as gastric adenocarcinoma. Presentation and diagnosis are similar, but treatment is chemotherapy. Surgery is indicated only if perforation develops as a complication of rapid shrinkage of gastric lymphoma in response to effective chemotherapy.

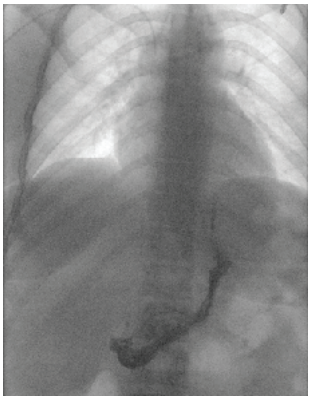
Clinical Pearl

Esophagram utilizing water-soluble contrast (e.g., gastrografin) vs. barium is a classic debate. Barium is much more sensitive, but also more toxic if it aspirates into the tracheobronchial tree or contaminates the mediastinum.

- For the exam, choose *gastrografin*; if the result is negative but you still suspect perforation, repeat with barium.
- In the real world, if the patient is awake and protecting his airway, don't waste time–go with the more sensitive test.

Mucosa-associated lymphoid tissue (MALT) is a low-grade B-cell neoplasm that is associated with *H. pylori* infection. If identified early, MALT neoplasms can be reversed by eradication of *H. pylori*.

Bariatric surgery has gained significant momentum over the past decade for weight loss and reversal of metabolic syndrome. Laparoscopic gastric banding, in which the stomach is externally restricted, resulted in only transient weight loss; with risk of device erosion, it is therefore now rarely performed. Laparoscopic gastric bypass and sleeve gastrectomy are now the preferred techniques, with strict regimens necessary for preserved weight loss and vitamin supplementation. Immediate postoperative risks include staple line and anastomotic leaks, intra-abdominal abscess, and splenic injury.



Courtesy of Gary Schwartz, MD

Figure 3-3. Upper GI Sleeve Gastrectomy

> A 62-year-old man describes epigastric and substernal pain that he cannot characterize well. At times his description sounds like gastroesophageal reflux; at times it does not. Sonogram of the gallbladder, EKG, and cardiac enzymes are negative.

This sounds like GERD, and other etiologies have been ruled out. Perform pH monitoring, which is diagnostic.

> A 54-year-old obese man gives a history of burning retrosternal pain and heartburn that is brought about by bending over, wearing tight clothing, or lying flat in bed at night. He gets symptomatic relief from antacids but has never been formally treated. The problem has been present for many years but seems to be progressing.

The description is classic for GERD. Although symptomatic relief is obtained with antacids, further evaluation should be performed given the chronic nature. This includes *H. pylori* testing and treatment, if indicated, and endoscopy with biopsy to rule out malignant transformation. If any epithelial dysplasia is identified, serial endoscopy is mandatory to evaluate for progression and possible early surgical intervention.

A 54-year-old obese man gives a history of burning retrosternal pain and heartburn that is brought about by bending over, wearing tight clothing, or lying flat in bed at night. He gets symptomatic relief from antacids but has never been formally treated. The problem has been present for many years and seems to be progressing. Endoscopy shows severe peptic esophagitis and Barrett esophagus.

This patient has not had formal medical treatment, so that should be the first step. Continued symptoms or endoscopic evidence of progression despite medical management would warrant fundoplication; the presence of severe dysplastic changes would be an indication for resection.

A 54-year-old obese man gives a history of many years of burning retrosternal pain and heartburn that is brought about by bending over, wearing tight clothing, or lying flat in bed at night. He gets brief symptomatic relief from antacids, but despite adherence to a strict program of medical therapy, the process seems to be progressing. Endoscopy shows severe peptic esophagitis with no dysplastic changes.

The patient is not responding to medical management but has no dysplastic changes. This is an indication for surgical fundoplication. Whether or not it is performed, he needs endoscopy surveillance with biopsies to follow progression of the esophagitis.

A 47-year-old woman describes difficulty swallowing, which she has had for many years. Liquids are more difficult to swallow than solids, and she has learned to sit up straight and wait for the fluids to "make it through." Occasionally she regurgitates undigested food.

This is a classic description of achalasia (a functional physiologic obstruction). Diagnostic testing starts with a barium swallow and is confirmed with manometry. Treatment is endoscopic balloon dilation and Botox injection, but surgical myotomy is often necessary.

A 54-year-old African American man with a history of smoking and drinking describes progressive dysphagia of 3 months' duration. It began with difficulty swallowing meat, progressed to other solid foods and then soft foods, and is now evident for liquids as well. He locates the place where the food "sticks" at the lower end of the sternum. He has lost 30 pounds of weight.

This scenario is highly worrisome for carcinoma of the esophagus. Given the detail of race, age, sex, and habits, it is probably SCC. Had the history been longstanding reflux, it would suggest adenocarcinoma. Diagnosis and staging include barium esophagram, endoscopy with biopsy and endoscopic U/S, and PET/CT to evaluate for distant disease and determine resectability.

A 24-year-old man spends the night going to bars and drinking heavily. By morning he starts vomiting repeatedly. He initially brings up gastric contents only, but eventually he vomits bright red blood.

A 24-year-old man spends the night going to bars and drinking heavily. By morning he starts vomiting repeatedly. Eventually he has a particularly violent episode of vomiting, and he feels a severe, wrenching epigastric pain and low sternal pain of sudden onset. On arrival at the ED an hour later he still has the pain, is diaphoretic, has fever and leukocytosis, and looks quite ill.

Both of these vignettes have the same beginnings, but one leads to a Mallory-Weiss tear and the other to perforation (Boerhaave syndrome).

- For esophageal bleeding, endoscopy is used to ascertain the diagnosis and occasionally to treat. Bleeding will typically be arterial and brisk, but self-limiting. Photocoagulation can be used if needed, and rarely a discrete mucosal tear is identified that can be clipped.
- For esophageal perforation, the patient is facing a potentially lethal problem. Water-soluble contrast esophagram will confirm the diagnosis, and emergency surgical repair versus endoscopic management will follow. Prognosis depends on the length of time elapsed between perforation and treatment and the degree of mediastinal contamination that has occurred.

A 66-year-old man has an upper gastrointestinal endoscopy done to check on the progress of medical therapy for gastric ulcer. Six hours post-procedure, he returns with complaints of severe, constant retrosternal pain that began shortly after he went home. He looks prostrate and very ill, and is diaphoretic. His temperature is 40 C (104 F) and respiratory rate 30/min. There is a hint of subcutaneous emphysema at the base of the neck.

This is an iatrogenic perforation of the esophagus. The setting plus the air in the tissues are virtually diagnostic. Perform an esophagram, likely to be followed by emergency surgical repair. Severe pain after endoscopy is a perforation until proven otherwise.

Mid and Lower Gastrointestinal Disease

Small bowel

Clinical Pearl

Intestinal obstruction is caused by **A**dhesions, **B**lockage (hernia), or **C**ancer.

Mechanical intestinal obstruction of the small bowel is most often caused by adhesions in those who have had a prior surgery; incarcerated hernias and cancer are the other most common etiologies. Typical symptoms include colicky abdominal pain and protracted vomiting, progressive abdominal distention (if it is a low obstruction), and no passage of gas or feces. Early on, high-pitched bowel sounds coincide with the colicky pain; after a few days, there is silence. X-ray shows distended loops of small bowel with air-fluid levels.

Treatment starts with NPO, NG suction, and IV fluids, watching for either spontaneous resolution or early signs of strangulation or peritonitis. Surgery is done within 24 hours if nonsurgical management is unsuccessful. This typically involves lysis of adhesions but may require bowel resection and anastomosis depending on intraoperative findings.

Strangulation of the intestine occurs when compromised blood supply leads to bowel ischemia. It can result from internal obstruction due to adhesions or external obstruction due to an incarcerated hernia. Either etiology starts as described earlier, but eventually the patient develops fever, leukocytosis, constant pain, signs of peritoneal irritation, and ultimately full-blown peritonitis and sepsis. Emergency surgery is required. A thorough physical exam should demonstrate a hernia if this is etiology. If the hernia is reducible, surgery may be avoided, but the patient still requires observation to rule out ischemia in the now-reduced bowel.

Carcinoid syndrome is seen in patients with a small bowel carcinoid tumor with liver metastases. It includes diarrhea, flushing of the face, wheezing, and right-sided heart valvular damage (look for prominent jugular venous pulse). Diagnose with 24-hour urinary collection for 5-hydroxyindolacetic acid (5-HIAA). Also evaluate the chest for lung and heart lesions—a necessary step.

Treatment depends on the extent of disease, but a typical course is surgical resection and, possibly, adjuvant octreotide.

> A 54-year-old man has had colicky abdominal pain and protracted vomiting for several days. He has developed progressive abdominal distention and has not had a bowel movement or passed any gas for 5 days. High-pitched, loud bowel sounds coincide with the colicky pain. X-ray shows distended loops of small bowel and air-fluid levels. Five years ago he had an exploratory laparotomy for a gunshot wound to the abdomen.

This scenario describes a mechanical intestinal obstruction, most likely caused by adhesions. Manage initially with NG suction, IV fluids, and careful observation.

> A 54-year-old man has had colicky abdominal pain and protracted vomiting for several days. He has developed progressive abdominal distention and has not had a bowel movement or passed any gas for 5 days. High-pitched, loud bowel sounds coincide with the colicky pain. X-ray shows distended loops of small bowel and air-fluid levels. Five years ago he had an exploratory laparotomy for a gunshot wound of the abdomen. A nasogastric tube is placed to low suction and he receives IV fluids. Six hours later he develops fever, leukocytosis, abdominal tenderness, and rebound tenderness.

This scenario has now progressed to strangulation, i.e., a loop of bowel that was incarcerated is now ischemic. Emergency surgical exploration is now necessary.

> A 54-year-old man has had colicky abdominal pain and protracted vomiting for several days. He has developed progressive abdominal distention and has not had a bowel movement or passed any gas for 5 days. High-pitched, loud bowel sounds coincide with the colicky pain. X-ray shows distended loops of small bowel and air-fluid levels. On physical examination a groin mass is noted. The patient explains that he used to be able to "push it back" at will, but for the past 5 days has been unable to do so.

This is mechanical intestinal obstruction caused by an incarcerated hernia. Fluid resuscitation should be initiated and gentle reduction attempted. If the hernia is irreducible or there is evidence of bowel ischemia (i.e., it is strangulated), then urgent surgical exploration is indicated.

Clinical Pearl

Whenever hormone-driven or paraneoplastic syndromes produce episodic attacks, the offending agent will be at high serum concentrations only at the time of the attack—not continuously. Accordingly, a blood sample taken after the episode will often be normal. A 24-hour urine collection is much more sensitive.

A 55-year-old woman is being evaluated for protracted diarrhea. On further questioning she gives a history of episodes of flushing of the face, with expiratory wheezing. A prominent jugular venous pulse is noted on her neck.

This is carcinoid syndrome. Diagnosis is made with 24-hour urinary collection for 5-hydroxyindolacetic acid, CT of the chest and abdomen to assess for lung or liver lesions, and transthoracic echocardiogram to assess for cardiac involvement. Octreotide scan is a nuclear medicine scan that can localize a lesion if not found. Management will likely include surgical resection depending on imaging findings.

Clinical Pearl

Patients with acute appendicitis do not always present with classic findings, especially women of childbearing age where ovarian pathology or a retrocecal appendix may present similarly. CT has become the standard diagnostic modality for those cases, but U/S is preferred for children because of the proven negative effects of radiation in children.

Note

Once a colonic malignancy is discovered, the entire colon must be evaluated to look for synchronous cancers.

Colon

Acute appendicitis is one of the most common GI conditions requiring emergency surgery. The clinical presentation provides important diagnostic clues. The classic picture begins with anorexia followed by periumbilical crampy pain that progresses to sharp, severe pain localizing to the right lower quadrant (RLQ). On physical exam, localized tenderness, guarding, and rebound are found in the RLQ. Fever is typically low-grade. Leukocytosis is present in the 10–20K range, with neutrophilia and bandemia. Urgent appendectomy is curative.

Cancer of the right colon typically presents with anemia (hypochromic, iron deficiency) in the right age group (age 50–70). Stools will be 4+ for occult blood.

- Diagnose with colonoscopy and biopsies
- Treatment is surgical resection via right hemicolectomy

Cancer of the left colon typically presents with bloody bowel movements and obstruction. Blood coats the outside of the stools, which may have narrow caliber, and there may be constipation.

- Diagnose first with flexible proctosigmoidoscopy exam and biopsies
- Before surgery is done, full colonoscopy is needed to rule out a synchronous second primary lesion that is more proximal
- CT helps assess operability and extent
- Treatment
  - Nonobstructing lesions: elective surgical resection (sigmoidectomy or left hemicolectomy) and primary anastomosis
  - Acute obstructing lesions: resection with a diverting colostomy

Colonic polyps may be premalignant. In descending order of probability for malignant degeneration, these are familial polyposis (and variants such as Gardner syndrome), familial multiple inflammatory polyps, villous adenoma, and adenomatous polyp. Polyps that are not premalignant include juvenile, Peutz-Jeghers, isolated inflammatory, and hyperplastic.

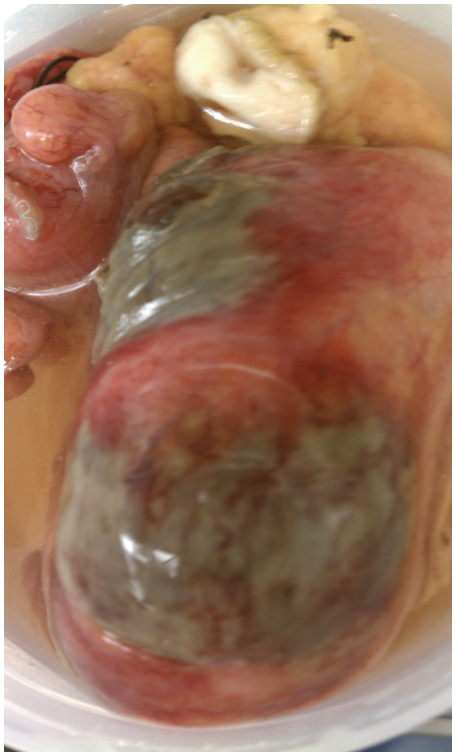
Inflammatory bowel disease (IBD) is divided into **Crohn's disease** and **ulcerative colitis (UC)**. Diagnosis is made with colonoscopy with biopsy. Treatment is primarily medical.

- Crohn's disease can affect the entire length of the GI tract, while UC is limited to the colon.

- UC can be cured with surgical resection (total colectomy with ileoanal anastomosis, often with a temporary diverting ileostomy). Indications for surgery include the following:
  - Disease present >20 years (due to very high incidence of malignant degeneration)
  - Severe interference with nutritional status
  - Multiple hospitalizations
  - Need for high-dose steroids or immunosuppressants
  - Development of toxic megacolon (abdominal pain, fever, leukocytosis, epigastric tenderness, massively distended transverse colon on x-rays with gas within the wall of the colon)

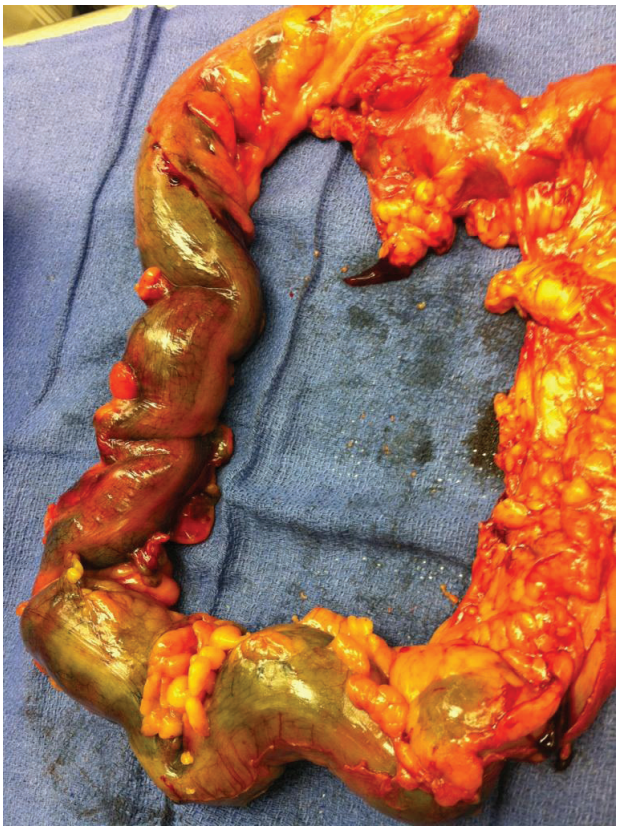
Clostridium difficile overgrowth due to the use of antibiotics and interruption of the normal intestinal flora can result in severe colitis ("pseudomembranous colitis"). Clindamycin was the first antibiotic identified as a culprit; however, any antibiotic and any dose can cause this syndrome of profuse, watery diarrhea, crampy abdominal pain, fever, and leukocytosis.

- Diagnosis is identification of the toxin in the stool. Stool culture takes several days, and the pseudomembranes are not always seen on endoscopy.
- Treatment is immediate discontinuation of the culprit antibiotic (do not use antidiarrheals) and metronidazole (preferred) or vancomycin once the diagnosis is definitively made.
  - A virulent form of the disease, unresponsive to treatment, with WBC >50,000/μL and serum lactate >5 mg/dL, requires emergency colectomy.
  - Fecal transplantation to restore normal gut flora may be needed for those with recurrent infections.



Courtesy of Gary Schwartz, MD

Figure 3-4. Colonoscopy of Pseudomembranous Colitis



Courtesy of Gary Schwartz, MD

Figure 3-5. Toxic Megacolon

A 22-year-old man develops anorexia followed by vague periumbilical pain that several hours later becomes sharp, severe, constant, and well localized to the right lower quadrant of the abdomen. He has abdominal tenderness, guarding, and rebound to the right and below the umbilicus, temperature 37.55 C (99.6 F), and white blood cell count 12,500 with neutrophilia.

This is a classic description of acute appendicitis. Management is emergency appendectomy. CT would not be indicated in this case, but in atypical cases it is diagnostic. In children, U/S is preferred.

A 59-year-old man is referred for evaluation because he has been fainting at his job where he operates heavy machinery. He is pale, but otherwise his physical examination is remarkable only for 4+ occult blood in the stool. Lab shows hemoglobin level 5 g/dL.

This scenario is cancer of the right colon until proven otherwise. Diagnosis is made with colonoscopy and biopsy. Treatment is blood transfusion and eventual right hemicolectomy.

A 56-year-old man has bloody bowel movements. The blood coats the outside of the stools and has been present on and off for several weeks. For the past 2 months he has been constipated, and his stools have become of narrow caliber.

This is cancer of the distal, left side of the colon. Diagnosis is made with endoscopy and biopsy. Treatment is flexible proctosigmoidoscopy first, but a full colonoscopy and surgical resection will likely be needed.

A 42-year-old man with a 20-year history of chronic ulcerative colitis has had at least 40 hospital admissions for exacerbation of the disease. Because of a recent relapse, he has been placed on high-dose steroids and azathioprine. For the past 12 hours he has had severe abdominal pain, temperature 40 C (104 F), and leukocytosis. He looks ill and "toxic." He weighs 90 pounds. His abdomen is tender, particularly in the epigastric area, and there is muscle guarding and rebound. X-ray shows a massively distended transverse colon and gas within the wall of the colon.

This is toxic megacolon. Treatment is emergency total colectomy. Rectal mucosa can harbor residual colitis, so the entire colon must be removed.

- In the elective setting for chronic UC, reconstruction with an ileoanal anastomosis (with or without a temporary diverting ileostomy) can be performed.
- In the setting of toxic megacolon in a sick patient, resection with end ileostomy is the most rapid and lifesaving procedure. If and when the patient recovers, he may be able to have reconstruction with an ileoanal anastomosis.

A 27-year-old man is recovering from an appendectomy for gangrenous acute appendicitis with perforation and periappendiceal abscess. He has been receiving clindamycin and tobramycin for 7 days. Eight hours ago he developed watery diarrhea, crampy abdominal pain, fever, and leukocytosis.

This is worrisome for *Clostridium difficile* colitis. The diagnosis relies primarily on identification of toxin in the stools. Cultures take too long, and a proctosigmoidoscopy exam does not always find typical changes.

Treatment is to stop the clindamycin, stay away from antidiarrheal medications, and treat with metronidazole (oral or IV) or oral vancomycin once the diagnosis is definitively made. Failure of medical management, with development of marked leukocytosis and lactic acidosis, is an indication for emergency colectomy.

Anorectal Disease

Cancer should always be considered in anorectal disease, even if a clinical presentation suggests a benign process. This requires at minimum a thorough physical exam, and a possible colonoscopy depending on the degree of suspicion.

Hemorrhoids typically bleed when they are internal and hurt when they are external; internal hemorrhoids can become painful and produce itching if they prolapse. Internal hemorrhoids can be treated with rubber band ligation, whereas external hemorrhoids

(especially thrombosed external hemorrhoids) may require surgery after failure of conservative measures (e.g., dietary adjustments, increased fiber, sitz baths).

Anal fissures produce exquisite pain, with defecation and blood streaks in stools. The fear of pain is so intense that patients avoid bowel movements and may even refuse proper physical examination of the area. A tight sphincter or a very large, hard bowel movement with straining is believed to both cause and perpetuate the problem.

- Examination may need to be done under anesthesia (the fissure is usually posterior, in the midline).
- Treatment is directed at relaxing the sphincter: stool softeners, topical nitroglycerin, topical CCBs (diltiazem 2% ointment), local injection of botulinum toxin, steroid suppositories, or lateral internal sphincterotomy if there is no improvement.

Crohn's disease can involve the anal area. It starts with a fissure, fistula, or small ulceration. Suspect this diagnosis when the area fails to heal or gets worse after surgical intervention (in general, the anal region heals quickly due to its extensive vascularity). For this reason, surgical intervention for perianal diseases in patients with Crohn's disease should be avoided. A fistula, if present, could be drained with setons while medical therapy is underway. Remicade helps healing.

Ischiorectal abscess (perirectal abscess) is a very common problem. Patients typically present with fever and exquisite perirectal pain that does not let them sit down or move their bowels. Physical exam shows all the classic findings of an abscess (rubor, dolor, calor, and fluctuance) lateral to the anus, between the rectum and the ischial tuberosity. Incision and drainage are needed, and cancer should be ruled out by proper examination during the procedure. If patient is a poorly controlled diabetic, necrotizing soft tissue infection may follow. Significant monitoring is mandatory.

Fistula-in-ano develops in some patients who have had an ischiorectal abscess drained. Epithelial migration from the anal crypts (where the abscess originated) and from the perineal skin (where the drainage was done) form a permanent tract. Patient reports fecal soiling and occasional perineal discomfort. Physical exam shows an opening lateral to the anus or a cordlike tract, and discharge may be expressed. Rule out a necrotic and draining tumor, and treat with fistulotomy.

SCC of the anus is rare, but more common in patients with HIV or who have anoreceptive intercourse. A fungating mass grows out of the anus, and metastasis to inguinal nodes are often palpable. Diagnose with biopsy. Treatment starts with the Nigro protocol of chemoradiation (5-fluorouracil, mitomycin, and external beam radiation), followed by surgery if there is residual tumor. Chemoradiation has a 90% success rate, so surgery is not often required.

> A 60-year-old man known to have hemorrhoids reports bright red blood on toilet paper after evacuation.

> A 60-year-old man known to have hemorrhoids complains of anal itching and discomfort, particularly toward the end of the day. He has mild perianal pain when sitting down and finds himself sitting sideways to avoid the discomfort.

On the exam, reassurance and over-the-counter remedies will be provided as distractors, but in all anorectal problems cancer must be ruled out first.

- Diagnose with proctosigmoidoscopy examination and rule out cancer: digital rectal exam, anoscopy, and consideration of flexible sigmoidoscopy versus complete colonoscopy

- Treatment
  - Internal hemorrhoids: rubber-band ligation
  - External hemorrhoids or prolapsed internal hemorrhoids: surgery

> A 23-year-old woman describes exquisite pain with defecation and blood streaks on the outside of the stools. Because of the pain she avoids having bowel movements. When she finally does, the stools are hard and even more painful. Physical examination cannot be done, as she refuses to allow anyone to even draw apart her buttocks to look at the anus for fear of precipitating the pain.

This is a classic description of anal fissure. Nonetheless, cancer still must be ruled out. Examination under anesthesia is the correct answer. Medical management includes stool softeners and topical agents. A tight sphincter is believed to cause and perpetuate the problem; it can be treated with topical diltiazem, botulin injections, or steroid suppositories. If these fail, lateral internal sphincterotomy is the operation of choice.

> A 28-year-old man is brought to the office accompanied by his mother. In the last 4 months he has had 3 operations—done elsewhere—for a perianal fistula, though after each one the area has failed to heal; in fact, the surgical wounds have become bigger. The patient now has multiple nonhealing ulcers, fissures, and fistulas all around the anus, with purulent discharge. There are no palpable masses.

The perianal area has a fantastic blood supply and heals beautifully even though feces bathe the wounds. When it does not heal rapidly, immediately think of Crohn's disease. You must still rule out malignancy (anal cancer also does not heal if incompletely excised); a proper examination with biopsies is needed. Fistulotomy is not recommended in this setting. Most fistulae will eventually resolve with draining setons, which will ensure adequate drainage of infection while medical management controls the disease. Remicade in particular has shown to help heal these fistulae.

> A 44-year-old man shows up in the ED at 11 p.m. with exquisite perianal pain. He cannot sit down, reports that bowel movements are very painful, and is experiencing chills and fever. Physical examination shows a hot, tender, red, fluctuant mass between the anus and the ischial tuberosity.

This case describes another very common problem: ischiorectal abscess. The treatment for any abscess is drainage, and this one is no exception. However, cancer must also be ruled out, so the best option is examination under anesthesia and incision and drainage. If the patient is diabetic, incision and drainage would have to be followed by minute in-hospital follow-up.

A 62-year-old man complains of perianal discomfort and reports that there are fecal streaks soiling his underwear. Four months ago he had a perirectal abscess drained surgically. Physical examination shows a perianal opening in the skin, and a cordlike tract can be palpated going from the opening toward the inside of the anal canal. Brownish purulent discharge can be expressed from the tract.

This scenario describes fistula-in-ano. Management is to first rule out cancer with proctosigmoidoscopy (necrotic tumors can drain), then schedule an elective fistulotomy.

A 55-year-old HIV-positive man has a fungating mass growing out of the anus, and rock-hard, enlarged lymph nodes in both groins. He has lost a lot of weight and looks emaciated and ill.

This clinical picture is most consistent with SCC of the anus. Diagnosis is made with biopsy of the fungating mass. **Nigro protocol** is combined preoperative chemotherapy and radiation for 5 weeks, and cure rate is 90%. Surgery is done only if this regimen fails to cure the cancer.

Gastrointestinal Bleeding

In 75% of cases, gastrointestinal (GI) bleed originates in the upper GI tract (from tip of the nose to ligament of Treitz), and in 25% of cases it originates in the colon or rectum. Very few cases arise from the jejunum and ileum.

GI bleed in young patients most commonly originates in the upper GI tract (gastritis or PUD), whereas GI bleed in older patients originates from upper or lower sources. Note that GI bleed in lower sources increases with age: angiodysplasia, polyps, diverticulosis, and cancer.

Vomiting blood (hematemesis) always denotes a source in the upper GI tract. The same is true when blood is recovered by an NG tube in a patient who presents with bleeding per rectum. The best next diagnostic test in that setting is upper GI endoscopy. Be sure to look at the mouth and nose first.

Similarly, **melena** (black, tarry stool) always indicates digested blood, thus it must originate high enough to undergo digestion. Start the workup with upper GI endoscopy.

Bright red blood per rectum (hematochezia) could come from anywhere in the GI tract, including upper GI, as it may have transited too fast to be digested.

If the patient is actively bleeding at the time of arrival, the first diagnostic step is to pass an NG tube and aspirate gastric contents to assess if the bleeding is from the upper GI tract and, of course, to prevent aspiration.

- Retrieval of blood establishes an upper source; follow with upper endoscopy as previously described.
- Fluid with no blood and no bile excludes the territory from the tip of the nose to the pylorus, but the duodenum is still a potential source; upper endoscopy is still necessary.
- If no blood is recovered and the fluid is green (bile tinged), the entire upper GI (tip of nose to ligament of Treitz) has been excluded; upper endoscopy is not necessary.

Note

The challenge with the tagged red-cell study is that it is a slow test. By the time it is finished patients have often stopped bleeding, so a subsequent angiogram is useless. However, at least the localization of bleeding helps to identify which side of the colon to resect should the patient rebleed or emergently begin to exsanguinate.

Active bleeding per rectum, when upper GI has been excluded, is more difficult to work up. Bleeding hemorrhoids should always be excluded first by physical exam and anoscopy. Colonoscopy is not helpful during an active bleed, as blood obscures the field. Once hemorrhoids have been excluded, further diagnosis is based on the rate of bleeding.

- If bleeding exceeds 2 mL/min (1 unit of blood every 4 hours), do an angiogram, which is likely to find the source and may allow for angiographic embolization.
- If bleeding is slower, i.e., <0.5 mL/min, wait until it stops; then do a colonoscopy.
- For bleeding in between these rates, do a tagged red-cell study:
  - If the tagged blood collects somewhere, indicating a site of bleeding, do an angiogram.
  - If the tagged red cells do not show up on the scan, plan a colonoscopy. Some practitioners always begin with the tagged red-cell study regardless of the estimated rate of bleeding.

When bleeding is not found to be in the colon, capsule endoscopy is done increasingly often in clinical practice to localize the spot in the small bowel. Obviously, this is done only when the patient is stable and upper/lower GI sources have been ruled out.

Patients with a recent history of blood per rectum but no active bleed at the time of presentation should start workup with upper GI endoscopy if they are young (overwhelming odds). Patients who are old need both an upper and a lower GI endoscopy (typically performed during the same session).

Blood per rectum in a child is most commonly a **Meckel's diverticulum**. Diagnose with a technetium scan, looking for the ectopic gastric mucosa in the distal ileum.

Massive upper GI bleeding in the stressed, multiple-trauma, or complicated post-op patient is probably from stress ulcers in the stomach or duodenum. This is much less common now with routine pharmacological prophylaxis. Endoscopy will confirm the diagnosis.

Treatment is angiographic embolization, with surgery a "salvage" option. But best is to prevent stress ulcer with prophylactic H2 blockers or PPIs, which is now common practice in the ICU setting.

> A 33-year-old man vomits a large amount of bright red blood.

There is not a lot of information here, but you can already define the territory where the bleeding is taking place: from the tip of the nose to the ligament of Treitz. To diagnose, don't forget to look at the mouth and nose, and then proceed with upper GI endoscopy.

> A 33-year-old man has had 3 large bowel movements that he explains all contained a lot of dark red blood. The last one was 20 minutes ago. He is diaphoretic and pale. Blood pressure is 90/70 mm Hg, and pulse is 110/min.

This is a challenging scenario, as the bleeding can be from anywhere in the GI tract. This patient seems to be actively bleeding, so the first diagnostic step is to examine the nose and mouth, then place an NG tube and aspirate.

Clinical Pearl

Rule of 2s in Meckel's diverticulum:

- Presents in 2% of the population
- Typically presents before age 2 years
- Occurs within 2 feet of the ileocecal valve
- Often has 2 types of mucosa (heterotopic gastric mucosa results in bleeding)

A 33-year-old man has had 3 large bowel movements that he explains all contained a lot of dark red blood. The last one was 20 minutes ago. He is diaphoretic and pale. Blood pressure is 90/70 mm Hg, and pulse is 110/min. A nasogastric tube returns copious amounts of bright red blood.

In this clinical case, diagnostic NG lavage has identified the source of bleeding as upper GI. Proceed with urgent endoscopy.

A 65-year-old man has had 3 large bowel movements that he explains all contained a lot of dark red blood. The last one was 20 minutes ago. He is diaphoretic and pale. Blood pressure is 90/70 mm Hg and pulse is 110/min. A nasogastric tube returns clear green fluid without blood.

If the NG tube had returned blood, the boundaries of bleeding would have been tip of the nose to ligament of Treitz. Clear fluid, without bile, would have excluded the area down to the pylorus, while aspirate with bile excludes down to the ligament of Treitz—provided you are sure the patient is bleeding now. That is the case here, so this patient is bleeding from somewhere distal to the ligament of Treitz. Further definition of the actual site is no longer within reach of upper endoscopy, and except for anoscopy looking for bleeding hemorrhoids, lower endoscopy is notoriously unrewarding during massive bleeding. If the bleeding is brisk (1 unit/4 hours), proceed with emergent angiogram for diagnosis and possible embolization; for slower bleeds, proceed with a tagged RBC scan.

A 72-year-old man has had 3 large bowel movements that he explains all contained a lot of dark red blood. The last one was 2 days ago. He is pale but has normal vital signs. A nasogastric tube returns clear green fluid without blood.

Note

Overall, 75% of all GI bleeding is upper, and virtually all causes of lower GI bleed are diseases of the elderly: diverticulosis, polyps, cancer, and angiodysplasias.

The clear aspirate is meaningless because the patient isn't bleeding right now. Thus, the guilty territory can still be anywhere from the tip of the nose to the anal canal.

- Diagnosis of a slow bleed or bleeding that has stopped is endoscopy (both upper and lower).
- Angiography is not the first choice. Even proponents of radionuclide studies don't have much hope of diagnosing if the patient last bled 3 days ago.

A 7-year-old boy passes a large bloody bowel movement.

In this age group, Meckel's diverticulum is the most likely etiology. Diagnose with radioactively labeled technetium scan.

A 41-year-old man has been in the ICU for 2 weeks with idiopathic hemorrhagic pancreatitis. He has had several percutaneous drainage procedures for pancreatic abscesses, chest tubes for pleural effusions, and bronchoscopies for atelectasis. He has been in and out of septic shock and respiratory failure several times. Ten minutes ago he vomited a large amount of bright red blood, and as you approach the bed he vomits another large amount of blood.

In the critical care setting, GI bleed is most likely due to a stress ulcer. This should have been prevented with H2 blockers and/or antacids, but once the bleeding occurs the diagnosis is made as usual with endoscopy. Treatment will be difficult. Start with endoscopic attempts (clipping, cautery), and consider angiographic embolization.

Acute Abdomen

Acute abdominal pain can be caused by perforation, obstruction, or inflammatory/ischemic processes. Physical exam reveals involuntary guarding, rigidity, or rebound tenderness.

- Acute abdominal pain caused by **perforation** has sudden onset and is constant, generalized, and very severe. The patient is reluctant to move and very protective of his abdomen. Except in the very old or very sick, impressive generalized signs of peritoneal irritation are found: tenderness, muscle guarding, rebound, and lack of bowel sounds. Free air under the diaphragm on upright x-rays confirms the diagnosis. Perforated peptic ulcer is the most common example. Emergency surgery is indicated.
- Acute abdominal pain caused by **obstruction** of a narrow duct (ureter, cystic, or common bile) has sudden onset of colicky pain, with typical location and radiation according to source. The patient moves constantly, seeking a position of comfort. There are few physical findings; they are limited to the area where the process is occurring.
- Acute abdominal pain caused by **inflammatory process** has gradual onset and slow buildup (at the very least a couple of hours; more commonly 6–12 hours). It is constant, starts as ill-defined and eventually localizes to the site of pathology, and often has typical radiation patterns. There are physical findings of peritoneal irritation in the affected area and (except for pancreatitis) systemic signs such as fever and leukocytosis. Ischemic processes affecting the bowel are the only ones that combine severe abdominal pain with blood in the lumen of the gut.

An acute abdomen mandates surgical exploration, with the exception of acute pancreatitis. Accordingly, etiologies that mimic an acute abdomen must always be considered prior to proceeding to surgery. These include myocardial ischemia (obtain an EKG), lower lobe pneumonia (perform a chest x-ray), and PE (suspect in an immobilized patient). Nonsurgical processes that mimic an acute abdomen should also be considered: pancreatitis (check serum amylase and lipase), urinary stones (perform a noncontrast CT of abdomen), and spontaneous bacterial peritonitis (SBP).

Acute pancreatitis should be suspected in the alcoholic who develops symptoms of an acute abdomen with epigastric pain. The classic presentation is progressive pain over a few hours (more rapid than other inflammatory processes) that is constant, epigastric, and radiates straight through to the back, with nausea, vomiting, and retching. Physical findings are relatively modest, but there may be vaguely localized discomfort in the epigastrium. Diagnose with serum amylase and lipase, and CT if the diagnosis is uncertain. Treatment is supportive therapy: NPO, NG suction, and IV fluids.

Biliary tract disease should be suspected in obese, multiparous women age 30–50 who present with right upper quadrant (RUQ) abdominal pain. While gallstones are more common in women than men, acute cholecystitis occurs with equal frequency. Acalculous acute cholecystitis is more common in older men and the critically ill.

Clinical Pearl

Exam questions (and real life) will use many descriptors to qualify the pain. These are essential in differentiating disease processes and should aid in selection of further diagnostic testing.

Clinical Pearl

Spontaneous bacterial peritonitis is a medical problem, not a surgical one. It should be considered in patients with ascites with mild generalized abdominal pain and fever. Diagnosis is made with paracentesis with fluid culture but is often empiric. Treatment is IV antibiotics.

Clinical Pearl

"Fat, female, forty, fertile" signifies the biliary etiology of abdominal pain.

Ureteral stones produce sudden onset colicky flank pain radiating to the inner thigh and scrotum or labia, sometimes with urinary symptoms like urgency and frequency, and with microhematuria discovered on urinalysis. Noncontrast CT is the best diagnostic test. Treatment most often involves analgesics and vigorous hydration to facilitate stone passage.

Acute diverticulitis is one of the few inflammatory processes that produces recurrent acute abdominal pain in the left lower quadrant (LLQ) (in women, the fallopian tube and ovary are other potential sources). Patients are typically middle-aged. Symptoms include fever and leukocytosis, with physical findings of peritoneal irritation in the LLQ and occasionally a palpable tender mass.

- CT with oral and IV contrast is diagnostic.
- Treatment is as follows:
  - NPO, IV fluids, and IV antibiotics
  - If there is evidence of perforation: emergency surgical exploration, with colectomy and diverting colostomy
  - If there is evidence of fistulization (most commonly to the bladder, presenting with **pneumaturia**): emergency surgical exploration with colectomy, fistula repair, and diverting colostomy
  - If there is no evidence of perforation or fistulization, but an abscess is identified: percutaneous drainage can often prevent the need for emergency surgical exploration and diverting colostomy
  - Whether or not emergency surgery is performed, colonoscopy is indicated ~6 weeks after an episode of diverticulitis to rule out underlying malignancy. The entire colon must be monitored for malignancy, so if a colectomy/colostomy is performed, endoscopy must evaluate the distal rectal stump as well as the intact colon.
  - Elective colon resection with primary anastomosis is indicated for patients who have had complications, multiple attacks, or continuing discomfort.

Note

If endoscopy is done in the presence of active inflammation, it increases the likelihood of iatrogenic perforation and decreases diagnostic sensitivity.

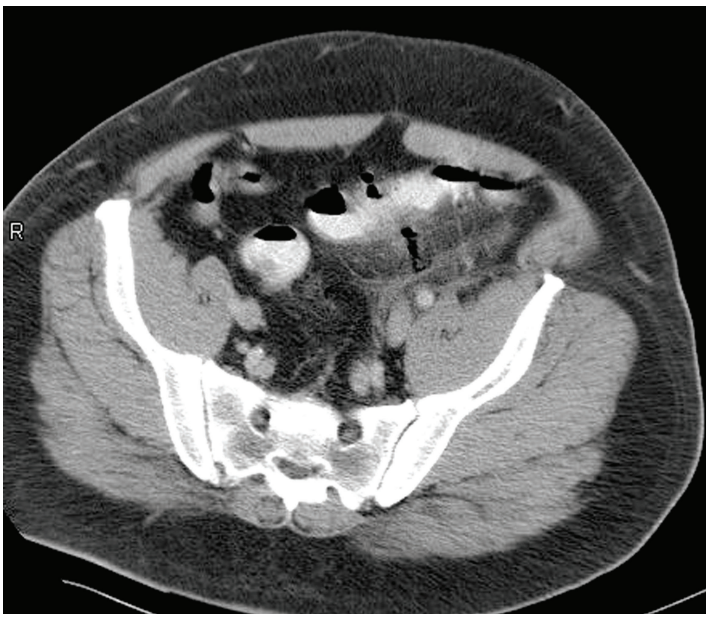


Figure 3-6. CT Scan Diverticulitis of Sigmoid Colon

Volvulus of the sigmoid (second most common cause of large bowel obstruction) is seen in the elderly. It presents with signs of intestinal obstruction and severe abdominal distention. X-ray is diagnostic, as it will show air-fluid levels in the small bowel, very distended colon, and a huge air-filled loop in the RUQ that tapers down toward the LLQ with the shape of a "bird's beak."

Treatment for an acute problem is proctosigmoidoscopy exam, which assesses for mucosal ischemia. Leaving a rectal tube in place allows for complete decompression and prevents immediate recurrence. Recurrent cases require elective sigmoid resection.

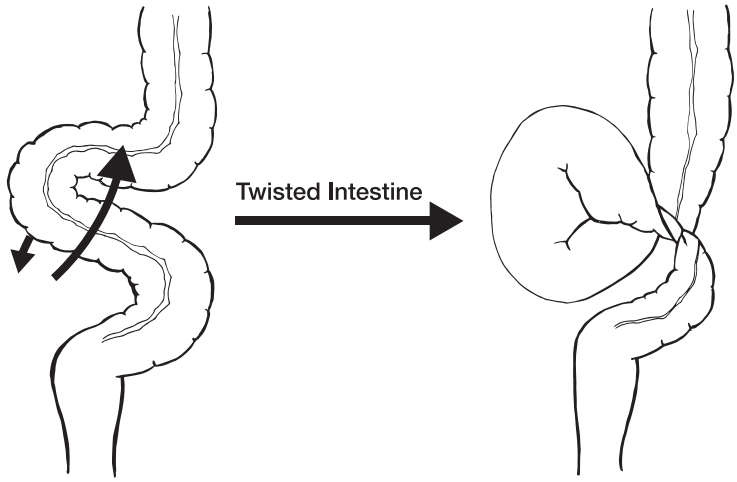


Figure 3-7. Volvulus of Sigmoid Colon

Mesenteric ischemia is seen in the elderly. The classic presentation (and examination scenario) is the development of an acute abdomen in someone with atrial fibrillation or recent MI: the source of the clot that breaks off and lodges in the superior mesenteric artery. Because the elderly do not mount impressive acute abdomens, the diagnosis often is made late, when there is blood in the bowel lumen (the only condition that mixes acute pain with GI bleeding) and lactic acidosis and sepsis have developed. In very early cases, arteriogram and embolectomy might save the situation, but once bowel ischemia is present surgical resection is mandatory. Early presentation will be pain out-of-proportion to the physical exam.

> A 59-year-old man arrives at the ED late at night with abdominal pain that began suddenly about an hour ago. The pain is now generalized, constant, and extremely severe. He lies motionless on the stretcher, is diaphoretic, and has shallow, rapid breathing. The abdomen is rigid, very tender to deep palpation, and has guarding and rebound tenderness in all quadrants.

This is clearly an acute abdomen. The short time elapsed and the circumstances attest to the severity and rapid onset of the problem, and the physical findings are impressive. This patient has generalized acute peritonitis. The best bet regarding its etiology is perforated peptic ulcer, but we do not need to prove that.

An acute abdomen does not need a precise diagnosis to proceed with surgical exploration. Myocardial infarction and pneumonia must be ruled out with EKG and chest x-ray, and it would be nice to have a plain x-ray or CT of the abdomen and a normal lipase. But the safest approach here is prompt emergency exploratory laparotomy.

Note

If a patient with a volvulus has an acute abdomen, he has a dead bowel.

> A 62-year-old man with cirrhosis and ascites presents with generalized abdominal pain that started 12 hours ago. He now has moderate tenderness over the entire abdomen, with some guarding and equivocal rebound. He has mild fever and leukocytosis.

Scenarios describing an acute abdomen in a cirrhotic patient should always raise concern for spontaneous bacterial peritonitis. A thorough evaluation for a surgical problem must be considered, but diagnosis is made via paracentesis.

> A 43-year-old man arrives at the ED with excruciating abdominal pain. He has a rigid abdomen, lies motionless on the examining table, has no bowel sounds, and is obviously in great pain, which he describes as constant. X-ray shows free air under the diaphragm.

An acute abdomen with pneumoperitoneum equals a perforated viscus. Emergency exploratory laparotomy is mandatory.

> A 44-year-old alcoholic presents with severe epigastric pain that began shortly after a heavy drinking episode. The patient reports the pain at 10/10 over a period of 2 hours. It is constant, radiates straight through to the back, and is accompanied by nausea, vomiting, and retching. Two years ago the patient had a similar episode that required hospitalization.

Abdominal pain in an alcoholic is suspicious for acute pancreatitis, especially when recurrent. Diagnosis is made with serum amylase and lipase. If the diagnosis is unclear or there is no improvement in a few days, CT may be necessary. Use caution with IV contrast, however, as alcoholic patients can be hypovolemic and prone to an acute kidney injury. Management is supportive therapy: NPO, NG suction, and IV fluids.

> A 43-year-old obese mother of 6 has severe right upper quadrant abdominal pain that began 6 hours ago. The pain was colicky at first, radiated to the right shoulder and around toward the back, and was accompanied by nausea and vomiting. For the past 2 hours the pain has been constant. Physical exam reveals tenderness to deep palpation, muscle guarding, and rebound in the right upper quadrant. Temperature is 38.3 C (101 F), and white blood cell count 16,000. The patient has a history of similar episodes of pain after eating fatty food, but they were all brief and resolved spontaneously or with anticholinergics.

The demographics should already raise suspicion of a biliary source of pain, and the remainder of the scenario is consistent with acute cholecystitis. Sonogram is the first choice for diagnosis. If equivocal, order a HIDA scan (radionuclide excretion scan). Medical management is first (antibiotics, NPO, IV fluids), but plan to do laparoscopic cholecystectomy during the same hospital admission to prevent recurrence or complications such as biliary pancreatitis.

> A 52-year-old man has right flank colicky pain of sudden onset that radiates to the inner thigh and scrotum. There is microscopic hematuria.

This scenario suggests ureteral colic; diagnosis is sometimes made with abdominal x-ray but typically requires a noncontrast CT.

> A 59-year-old woman has a history of 3 prior episodes of left lower quadrant abdominal pain, for which she was briefly hospitalized and treated with antibiotics. This patient began to feel discomfort 12 hours ago and now has constant left lower quadrant pain, tenderness, and a vaguely palpable mass. She has fever and leukocytosis.

LLQ pain suggests acute diverticulitis, especially when recurrent. Initial diagnosis is with CT scan, but a colonoscopy must be performed later to rule out an underlying colon cancer. Treat the acute attack medically (antibiotics, NPO), but elective sigmoid resection is advisable for recurrent disease. Percutaneous drainage is indicated if there is an abscess. If sepsis is present, emergency surgery (resection or colostomy) may be needed.

> An 82-year-old man develops severe abdominal distention, nausea, vomiting, and colicky abdominal pain. He has not passed any gas or stool for 12 hours and has a tympanitic abdomen with hyperactive bowel sounds. X-ray shows distended loops of small and large bowel. A very large gas shadow is located in the right upper quadrant and tapers toward the left lower quadrant with the shape of a bird's beak.

Clinical presentation and radiographic findings are diagnostic of sigmoid volvulus. Endoscopic intervention will relieve the obstruction. In recurrent cases, consider surgery. If the patient has an acute abdomen, it means the volvulus has progressed to bowel ischemia, and laparotomy is mandated.

> A 79-year-old man with atrial fibrillation develops an acute abdomen. No bowel sounds are audible. There is diffuse tenderness and mild rebound, with a trace of blood on rectal exam. He has acidosis and looks quite sick. X-ray shows a distended small bowel and distended colon up to the middle of the transverse colon.

An acute abdomen in an elderly person who has atrial fibrillation suggests embolic occlusion of the mesenteric vessels. Acidosis frequently ensues, and blood in the stool is often seen. Unfortunately, these signs usually mean significant ischemia is already present; however, if identified early, emergency embolectomy may prevent bowel infarction.

Hepatobiliary Disease

Liver

Primary hepatoma (hepatocellular carcinoma) is seen in patients with cirrhosis in the United States. Patients develop vague RUQ discomfort and weight loss. The specific blood marker is α-fetoprotein (AFP). CT will show location and extent. Resection is done if technically possible.

Metastatic cancer of the liver outnumbers primary cancer of the liver in the United States by 20:1. It is found by CT if follow-up for the treated primary tumor is underway or suspected due to rising carcinoembryonic antigen (CEA) in a patient with a history of colon cancer. If the primary is slow-growing and the metastases are confined to one lobe, resection can be done. Other treatment modes include radiofrequency ablation.

Hepatic adenoma may arise as a complication of birth control pills and is important because it can rupture and bleed massively inside the abdomen, presenting with diffuse abdominal pain, hypotension, and tachycardia. CT is diagnostic. Treatment if patients are symptomatic is to stop the oral contraceptives. Patients who present with hemorrhage should undergo transcatheter embolization, whereas signs of shock or evidence of rupture should be managed with emergency surgical exploration.

> A 53-year-old man with cirrhosis of the liver develops malaise, vague right upper quadrant abdominal discomfort, and a 20-pound weight loss. Physical examination shows a palpable mass that seems to arise from the left lobe of the liver. Alpha-fetoprotein is significantly elevated.

> A 53-year-old man develops vague right upper quadrant abdominal discomfort and a 20-pound weight loss. Physical examination shows a palpable liver with nodularity. Two years ago the patient had a right hemicolectomy for cancer of the ascending colon. His CEA had been within normal limits right after his hemicolectomy, but is now 10x the upper limit of normal.

Both vignettes are good descriptions of cancer in the liver, included to remind you that α-fetoprotein goes with primary hepatoma, whereas CEA goes with metastatic tumor from the colon.

- Management of both patients would start with a CT with contrast to define location and extent of the tumor.
- In the primary hepatoma, resection is done if a tumor-free anatomic segment can be left behind.
- In the metastatic tumor, resection is done if there are no other metastases, it is surgically possible, and the primary is relatively slow growing.

> A 24-year-old woman develops moderate, generalized abdominal pain of sudden onset, and shortly thereafter she faints. At the time of evaluation in the ED the patient is pale, tachycardic, and hypotensive. The abdomen is mildly distended and tender, and hemoglobin 7 g/dL. There is no history of trauma. She denies the possibility of being pregnant because she has been on birth control pills since age 14 and has never missed a dose.

This clinical picture is suspicious for bleeding from a ruptured hepatic adenoma secondary to birth control pills. It is pretty clear that the patient is bleeding into the abdomen, but CT will confirm this and probably show the liver adenoma as well. Surgery will follow. The patient must not take birth control pills in the future.

Pyogenic liver abscess is seen most often as a complication of biliary tract disease, particularly choledocholithiasis and acute ascending cholangitis. Patients develop fever, leukocytosis, and tenderness to palpation in the RUQ. U/S or CT is diagnostic. Percutaneous drainage is required.

Amoebic abscess of the liver (men > women 10:1) is generally seen in travelers from countries with endemic *Entamoeba histolytica* infection. Presentation and imaging diagnosis are similar to those for pyogenic liver abscesses, but amoebic abscess can be treated with metronidazole and rarely requires drainage. Definitive diagnosis is made by serology; because that test takes weeks to be reported, start empiric treatment immediately if amoebic liver abscess is clinically suspected. If improvement is seen, continue treatment; if not, drainage is indicated.

> A 29-year-old migrant worker from Mexico develops fever and leukocytosis, as well as tenderness over the liver when the area is percussed. He has mild jaundice and an elevated alkaline phosphatase. Sonogram of the right upper abdominal area shows a normal biliary tree and an abscess in the liver.

This scenario is suggestive of an amebic abscess, which is very common in Mexico. Alone among abscesses, these do not have to be drained, but can instead be effectively treated with metronidazole. Draw serology for amebic titers, but treat in the meantime as the results can take weeks.

> A 44-year-old woman is recovering from an episode of acute ascending cholangitis secondary to choledocholithiasis. She develops fever and leukocytosis and some tenderness in the right upper quadrant. A sonogram reveals a liver abscess.

This is fairly straightforward from a diagnosis perspective, but the issue is management: this is a pyogenic abscess and needs to be drained immediately. Drainage is typically done percutaneously by an interventional radiologist; otherwise laparoscopic or open drainage must be performed.

Clinical Pearl

If social history suggests an amebic abscess on the exam, don't be tempted by an answer choice that suggests aspirating the pus and sending it for culture. You cannot grow the ameba from the pus.

Jaundice

Jaundice is caused by elevated serum bilirubin (>5 mg/dL to cause clinically detectable changes in sclera or skin). It has 3 main etiologies:

- **Hemolytic jaundice**
  - Usually low level (bilirubin 6–8 mg/dL, but not 35–40)
  - All the elevated bilirubin is unconjugated (indirect)
  - No elevation of conjugated (direct) fraction
  - No bile in urine
  - Workup with peripheral blood smear, medication review, and possible bone marrow biopsy to determine etiology of hemolysis
- **Hepatocellular jaundice** (most common example: hepatitis)
  - Elevations of both fractions of bilirubin
  - High elevation of transaminases
  - Modest elevation of alkaline phosphatase
  - Workup with serologies to determine specific subtype

- **Obstructive jaundice**
  - Elevation of both fractions of bilirubin
  - Modest elevation of transaminases
  - High elevation of alkaline phosphatase
  - Workup with U/S looking for dilatation of the biliary ducts and for other clues about the nature of the obstructive process
  - In obstruction caused by **stones**, the stone that is obstructing the common duct may be seen, but stones are seen in the gallbladder, which cannot dilate because of chronic irritation.
    - Suspect obstructive jaundice caused by stones in obese, multiparous women age ≥45 who have high alkaline phosphatase, dilated ducts on sonogram, and non-dilated gallbladder full of stones.
    - The next step in that case is an endoscopic retrograde cholangiopancreatography (ERCP) to confirm the diagnosis. Then perform a sphincterotomy and remove the common duct stone. Cholecystectomy should usually follow during the same hospitalization. Also consider an intraoperative cholangiogram and a common bile duct exploration if not entirely cleared of residual stone.
  - In obstruction caused by a **tumor** (most commonly adenocarcinoma of the head of the pancreas, adenocarcinoma of the ampulla of Vater, or cholangiocarcinoma arising in the common duct itself):
    - Once the sonogram reveals a dilated gallbladder, thus raising suspicion of a tumor, the next diagnostic test should be CT scan. Pancreatic cancers that have produced obstructive jaundice are often big enough to be seen on CT. If CT is negative, ERCP is the next step.
    - Ampullary cancers or cancers of the common duct produce obstruction when they are very small, due to their location. Given their small size, they may not be seen on CT. Suspect ampullary cancer when jaundice coincides with anemia and positive blood in the stool. Endoscopy will show ampullary cancers, and cholangiography will show intrinsic tumors arising from the duct ("apple core") or small pancreatic cancers.
  - Workup with endoscopic U/S to identify and diagnose tumors in this region. Percutaneous biopsy is not indicated, as it could seed the abdominal wall with tumor. If cancer is suspected and a tumor is identified on CT or ERCP, it should be resected in patients without contraindications (i.e., evidence of metastatic disease).

Clinical Pearl

In malignant obstruction, a large, thin-walled, distended gallbladder may be palpable = Courvoisier-Terrier sign

Pancreatic cancer is aggressive and typically diagnosed at a relatively late stage. Early stage lesions are resectable by the Whipple procedure (pancreaticoduodenectomy). Ampullary cancer and cancer of the lower end of the common duct have a much better prognosis (about 40% cure).

> A 42-year-old woman presents with jaundice recently noted by her husband. She has total bilirubin 6 mg/dL, and labs report unconjugated, indirect bilirubin as 6 mg/dL and direct, conjugated bilirubin as 0. There is no bile in the urine, and she is otherwise asymptomatic.

On the exam, this vignette may have other features of hemolysis, but the lab studies alone are diagnostic of hemolytic jaundice. The challenge is figuring out why. Start with a complete medical history and physical exam.

A 19-year-old college student returns from a trip to Mexico and 2 weeks later develops malaise, weakness, and anorexia. On physical exam, he is notably jaundiced. Lab studies reveal total bilirubin 12 mg/dL, with 7 indirect and 5 direct. Alkaline phosphatase is mildly elevated, and transaminases are very high.

This scenario is consistent with hepatocellular jaundice, most likely infectious in nature. Obtain serologies to confirm diagnosis and type of hepatitis.

A 40-year-old obese mother of 5 presents with progressive jaundice, which she first noticed 4 weeks ago. She has total bilirubin 22 mg/dL, with 16 direct and 6 indirect, and minimally elevated transaminases. The alkaline phosphatase is 6 times the upper limit of normal. The patient gives a history of multiple episodes of colicky right upper quadrant abdominal pain brought about by ingestion of fatty food.

A classic history for gallstone disease, but now with jaundice. The elevated alkaline phosphatase is consistent with obstructive jaundice. Start with an U/S, which will likely show dilated intra- and possibly extrahepatic bile ducts and possibly visualize the culprit stone. ERCP is the next intervention to relieve the obstruction, and cholecystectomy will eventually have to be performed.

A 66-year-old man presents with progressive jaundice that he first noticed 6 weeks ago. He has total bilirubin 22 mg/dL, with 16 direct and 6 indirect, and minimally elevated transaminases. The alkaline phosphatase is about 6 times the upper limit of normal. He has lost 10 pounds in 2 months but is otherwise asymptomatic. Sonogram shows dilated intrahepatic ducts, dilated extrahepatic ducts, and a very distended, thin-walled gallbladder.

With similar lab findings to the previous case but with weight loss and a thin-walled gallbladder, this is worrisome for malignant obstructive jaundice. "Silent" obstructive jaundice is more likely to be caused by tumor, and a distended gallbladder is an ominous sign: when stones are the source of the problem, the gallbladder is thick-walled and nonpliable. The next step is CT of the abdomen to assess for a mass; if nondiagnostic, an ERCP would be indicated.

A 66-year-old man presents with progressive jaundice that he first noticed 6 weeks ago. He has a total bilirubin 22 mg/dL, with 16 direct and 6 indirect, and minimally elevated transaminases. Alkaline phosphatase is about 6 times the upper limit of normal. He is otherwise asymptomatic. Sonogram shows dilated intrahepatic ducts, dilated extrahepatic ducts, and a very distended, thin-walled gallbladder. CT shows dilated hepatic ducts but no mass. Endoscopic retrograde cholangiopancreatography reveals a narrow area in the distal common duct and a normal pancreatic duct.

Malignant obstruction of the biliary tree can be extrinsic (e.g., a mass of the head of the pancreas) or intrinsic, due to cholangiocarcinoma of the common bile duct, which this appears to be. This location is less likely to have a discrete mass visualized on CT scan. Brushings performed at the time of ERCP are diagnostic. Depending on the extent, malignant obstruction may be curable by pancreaticoduodenectomy (Whipple procedure).

A 64-year-old woman presents with progressive jaundice that she first noticed 2 weeks ago. Total bilirubin is 12 mg/dL, with 8 direct and 4 indirect, and minimally elevated transaminases. Alkaline phosphatase is about 10 times the upper limit of normal. She is otherwise asymptomatic but is found to be slightly anemic, with positive occult blood in the stool. Sonogram shows dilated intrahepatic ducts, dilated extrahepatic ducts, and a very distended, thin-walled gallbladder.

Another similar scenario with a subtle but important detail: GI bleeding. This again is suspicious for malignancy but suggests an ampullary carcinoma, which would bleed into the GI tract as well as obstructing the biliary tree. Endoscopic biopsy is diagnostic. If limited stage, ampullary carcinoma is also potentially curable via pancreaticoduodenectomy.

Gallbladder

Gallstones are responsible for the **vast majority of biliary tract pathology** (gallbladder and common duct). There is a spectrum of biliary disease caused by gallstones:

- The obese woman age 45 is the "textbook" victim.
- Incidence increases with age so that eventually rates are common across all ethnic groups.
- Asymptomatic gallstones are left alone. Historically, if another intra-abdominal operation were being performed, the gallbladder might have been simultaneously removed; these days, it is less commonly performed.

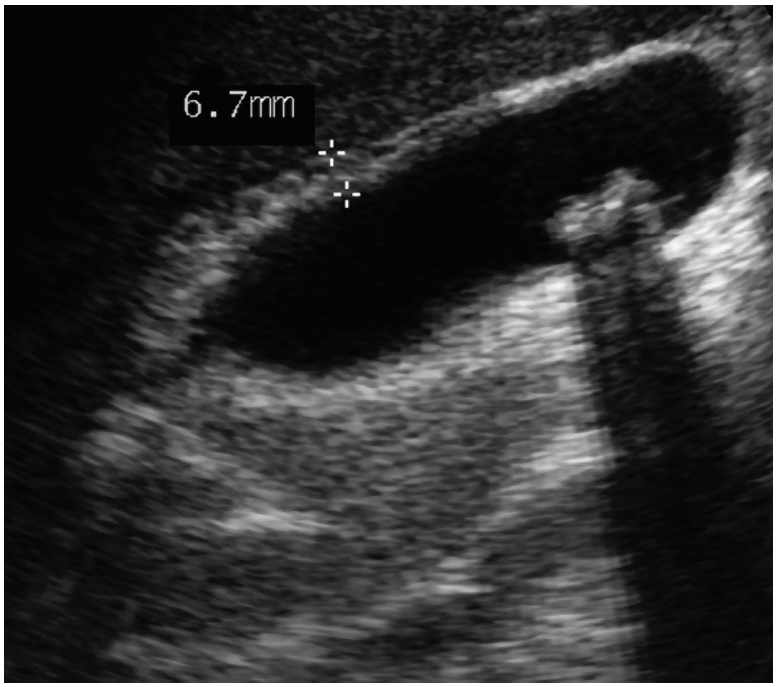


Figure 3-8. U/S Gallstones and Thickened Gallbladder Wall

Biliary colic is a typical pain pattern associated with cholelithiasis and/or chronic cholecystitis. It occurs when a stone temporarily occludes the cystic duct. The pain is described as colicky ("waves") in the RUQ radiating to the right shoulder and back, often triggered by ingestion of fatty food and accompanied by nausea and vomiting, but without signs of peritoneal irritation or systemic signs of inflammatory process. The episode is self-limited (typically <30 minutes) or is easily aborted by anticholinergics. RUQ U/S establishes diagnosis of gallstones, and elective laparoscopic cholecystectomy is indicated.

Acute cholecystitis starts as a biliary colic, but the stone remains at the cystic duct until an inflammatory process develops in the obstructed gallbladder.

- Pain becomes constant, modest fever and leukocytosis are present, and there are physical findings of peritoneal irritation in the RUQ.
- Liver function tests are minimally affected.
- U/S is diagnostic in most cases: gallstones, thick-walled gallbladder, and pericholecystic fluid.
- In equivocal cases, a radionuclide scan (HIDA) would show tracer uptake in the liver, common duct, and duodenum, but not in the occluded gallbladder.
- Management is initially with NPO, IV fluid, and antibiotics.
- Cholecystectomy is usually performed during the same hospital admission as an urgent case, though it is rarely a true emergency.
- Percutaneous cholecystostomy may be the best temporizing option in the very sick patient with a prohibitive surgical risk.

Acute ascending cholangitis is a far more morbid disease in which stones have reached the common duct, producing partial obstruction and ascending infection.

- Patients are often older and much sicker.
- Temperature spikes to 40.6 C (105 F), with chills and very high WBCs.
- There is typically mild hyperbilirubinemia, but the key finding is extremely high levels of alkaline phosphatase.
- **Charcot's triad**: fever, jaundice, and RUQ pain
- **Reynolds pentad**: Charcot's triad plus altered mental status and hypotension
- U/S demonstrates dilated ducts, but diagnosis is primarily clinical.
- IV antibiotics and emergency decompression of the common duct is lifesaving; this is performed ideally by ERCP, alternatively through the liver by percutaneous transhepatic cholangiogram (PTC), or rarely by surgery (common bile duct exploration).
- Eventually, cholecystectomy must be performed.

Biliary pancreatitis occurs when stones become impacted distally in the ampulla, temporarily obstructing both the pancreatic and biliary ducts. The stones often pass spontaneously, producing a mild and transitory episode of cholangitis along with the classic manifestations of pancreatitis (elevated amylase or lipase). U/S confirms gallstones in the gallbladder. Medical management (NPO, NG suction, IV fluids) usually leads to improvement, allowing elective cholecystectomy to be done later. If not, ERCP and sphincterotomy may be required to dislodge the impacted stone.

> A white, obese 40-year-old mother of 5 gives a history of repeated episodes of right upper quadrant abdominal pain brought about by the ingestion of fatty foods and relieved by the administration of anticholinergic medications. The pain is colicky, radiates to the right shoulder and around to the back, and is accompanied by nausea and occasional vomiting. Physical examination is unremarkable.

This is a classic scenario of gallstones causing biliary colic. Diagnose with U/S and treat with elective cholecystectomy.

> A 43-year-old obese mother of 6 has severe right upper quadrant abdominal pain that began 6 hours ago. The pain was colicky at first, radiated to the right shoulder and around toward the back, and was accompanied by nausea and vomiting. For the past 2 hours the pain has been constant. She has tenderness to deep palpation, muscle guarding, and rebound in the right upper quadrant. Her temperature is 38.3 C (101 F), and WBC count is 12,000. Liver function tests are normal.

Similar scenario, but now with pain, fever, and leukocytosis consistent with acute cholecystitis. Perform an U/S to confirm. The patient will need IV antibiotics followed by cholecystectomy.

> A 73-year-old obese mother of 6 has severe right upper quadrant abdominal pain that began 3 days ago. The pain was colicky at first but has been constant for the past 2.5 days. The patient has tenderness to deep palpation, muscle guarding, and rebound in the right upper quadrant. She has temperature spikes of 40–40.55 C (104–105 F), with chills. WBC count is 22,000, with a shift to the left. Labs include bilirubin 5 mg/dL and alkaline phosphatase 2,000 (~20 times normal).

This patient is much sicker than the previous one, with a higher fever and WBCs, along with abnormal liver function tests that appear concerning for acute ascending cholangitis. U/S will likely confirm dilated hepatic ducts, but this is a septic patient who needs several interventions: fluid resuscitation, IV antibiotics, and most importantly, emergency decompression of the biliary tract. This is accomplished preferentially with ERCP, but if unavailable or the patient is too sick, percutaneous transhepatic cholangiogram (PTC) is another option. Surgical decompression via exploration of the common bile duct is the last resort and rarely needed.

Pancreatic Disease

Acute pancreatitis is caused most commonly by alcohol abuse or gallstone obstruction. Epigastric and midabdominal pain starts after a heavy meal or bout of alcoholic intake, is constant, radiates straight through to the back, and is accompanied by nausea, vomiting, and continued retching even after the stomach is empty. There is tenderness and mild rebound in the upper abdomen. Serum amylase and lipase are elevated, and often serum hematocrit levels are high due to hypovolemia. Treatment is a few days of pancreatic rest (NPO, NG suction, IV fluids) and IV narcotics for severe pain, which is a common feature.

Acute severe pancreatitis is a much more morbid disease. It typically begins as an episode of acute pancreatitis but progresses to include pancreatic necrosis. The condition is accompanied by severe hypovolemia, marked leukocytosis, hyperglycemia, and hypocalcemia. Patients are quite ill and frequently require ICU admission and close monitoring, volume resuscitation, and mechanical ventilation. Nutrition is critical, ideally with post-pancreatic enteral access; TPN is a viable alternative.

Mortality is high and can be predicted by the Ranson criteria (the "prognosticators"):

- At admission:
  - Age >55
  - Glucose >200 mg/dL
  - WBC >16,000/dL
  - LDH >350
  - AST >250
- At 48 hours:
  - Hct drop >10% from admission
  - BUN increase >5 mg/dL from admission
  - Calcium <8 mg/dL
  - PaO_2 <60 mm Hg
  - Base deficit >4 mg/dL
  - Fluid resuscitation >6 L over 48 hours

Additional useful scoring systems include the APACHE (Acute Physiologic Assessment and Chronic Health Evaluation) and SOFA (Sequential Organ Failure Assessment) scores.

Pancreatic abscess (acute suppurative pancreatitis) may develop ~10 days after the onset of pancreatitis. Sepsis often ensues with fever and leukocytosis. CT will reveal fluid collection(s); management includes percutaneous drainage and imipenem or meropenem for the typical gram-negative bacterial infection. Open surgical drainage and debridement is often necessary for extensive abscess formation.

Pancreatic necrosis is another sequela of severe pancreatitis, and it can be notoriously difficult to manage. Although surgical necrosectomy is the best way to deal with necrotic pancreas, timing is crucial. Patients do far better by waiting at least 4 weeks before debridement of the dead pancreatic tissue if sepsis is not present. Hemorrhagic pancreatitis results when severe pancreatitis erodes into a vessel, resulting in anemia in addition to the above-mentioned problems. This is clinically recognized by Grey-Turner sign and Cullen sign, and diagnosed with CT scan.

Pancreatic pseudocyst can be a late sequela of acute pancreatitis or secondary to pancreatic trauma with unrecognized ductal injury. In either case, 4–6 weeks elapse between the original problem and the development of a pseudocyst. There is a collection of pancreatic fluid outside the pancreatic ducts, most commonly in the lesser sac, which can cause compressive symptoms on the stomach presenting as early satiety, vague discomfort, and occasionally a palpable mass. CT is diagnostic. Treatment is dictated by the size and age of the pseudocyst:

- Smaller cysts ≤6 cm or those present <6 weeks are not likely to have complications and can be observed for spontaneous resolution.
- Larger cysts (>6 cm) or those present >6 weeks are more likely to cause obstruction, bleed, or become infected. Treatment is required: internal drainage into the stomach via endoscopy or surgical cystogastrostomy, cystoduodenostomy, or cystojejunostomy.

Clinical Pearl

At admission, recall the Ranson criteria as **A**ge, **B**lood glucose, **C**ells (WBC), **D**ehydrogenase (LDH), and **E**nzymes (AST). At 48 hours, recall them as **A**rterial O_2, **B**ase deficit, **C**alcium, **D**rop in Hct, **E**levated BUN, **F**luids.

Chronic pancreatitis results from repeated episodes of pancreatitis (usually in alcoholics). Patients eventually develop calcified burned-out pancreas, steatorrhea, diabetes, and constant epigastric pain. The diabetes and steatorrhea can be controlled with insulin and pancreatic enzymes, but the pain is resistant to most modalities of therapy and can be incredibly debilitating. If ERCP shows specific points of obstruction and dilatation, operations that drain the pancreatic duct may help (e.g., Puestow procedure or lateral pancreaticojejunostomy).

> A 33-year-old alcoholic man presents in the ED with epigastric and midabdominal pain that began after eating a large meal 12 hours ago. The pain is constant and very severe and radiates straight through to the back. He vomited twice early on and continues to have episodes retching. He has tenderness and some muscle guarding in the upper abdomen, is afebrile, and has mild tachycardia. Serum lipase is 1,200 and hematocrit is 52%.

This is the classic presentation of alcohol-induced acute pancreatitis. Treatment is pancreatic rest: NPO, NG suction, IV fluids, analgesia.

> A 56-year-old alcoholic man presents with acute upper abdominal pain. The pain is constant, radiates straight through the back, and is extremely severe. He has serum amylase 800, hematocrit 40%, white blood cell count 18,000, blood glucose 150 mg/dL, and serum calcium 6.5. He is given IV fluids and kept NPO with nasogastric suction. By the next morning his hematocrit has dropped to 30%, serum calcium has remained below 7 despite calcium administration, and blood urea nitrogen (BUN) has gone up to 32. He has developed metabolic acidosis and a low arterial PaO_2.

Another scenario of acute alcoholic pancreatitis, but more severe than the previous one. At least 8 of the Ranson criteria are present in this patient, so predicted mortality is ~80%. Very intensive support will be needed. The common pathway to death is sepsis due to pancreatic abscess formation. Broad-spectrum antibiotics are mandatory; serial CT and early percutaneous drainage may be lifesaving. If there is radiographic evidence of pancreatic necrosis, surgical necrosectomy is indicated.

> A 57-year-old alcoholic is being treated for acute hemorrhagic pancreatitis. He was in the ICU for 1 week, requiring a chest tube for a pleural effusion and a respirator for several days, but eventually improved enough to be transferred to the floor. Two weeks after the onset of the disease he develops a fever spike and leukocytosis.

Even in the recovery phase of pancreatitis, an abscess can develop. Diagnose with CT scan, and treat with antibiotics and percutaneous drainage to start.

A 49-year-old alcoholic presents with acute pancreatitis but recovers and is discharged to rehabilitation. A month later he presents with upper abdominal discomfort and early satiety. On physical examination a large epigastric mass is identified deep within the abdomen.

A 55-year-old woman presents with vague upper abdominal discomfort, early satiety, and a palpable epigastric mass. Five weeks ago she was involved in a car accident in which she hit the upper abdomen against the steering wheel.

These are 2 presentations of pancreatic pseudocyst. You could diagnose it with a sonogram, but CT is probably the best choice.

- Small cysts (<6 cm) of brief duration (<6 weeks) can be watched for spontaneous resolution.
- Larger or older cysts could have serious complications (e.g., obstruction, infection, bleeding) and so require intervention.

Internal drainage via cystogastrostomy (surgical or endoscopic), cystoduodenostomy, or cystojejunostomy is the standard surgical treatment.

A disheveled, malnourished 62-year-old man presents to the ED requesting medication for pain. He smells of alcohol and complains bitterly of constant epigastric pain radiating straight through to the back, which he says he has had for several years. He has diabetes and steatorrhea. Abdominal x-ray demonstrates calcifications in the upper abdomen.

This scenario points to chronic pancreatitis, a very difficult problem to treat. Alcohol cessation is the first step, but diabetes management and pancreatic enzyme repletion are necessary. Pain control can be very challenging. Various operations can be performed to decompress the pancreatic duct depending on its anatomy, so if forced to select a diagnostic study, go with ERCP.

Hernias

All abdominal hernias should be electively repaired to avoid the risk of intestinal obstruction and strangulation. Exceptions include:

- Asymptomatic umbilical hernia in patients age <5 (they typically close spontaneously)
- Esophageal sliding hiatal hernias (not "true" hernias)

A hernia that becomes irreducible needs emergency surgery to prevent strangulation. If it has been irreducible for years, elective repair should be done.

Clinical Pearl

Not all incarcerated hernias are strangulated, but all strangulated hernias are incarcerated.

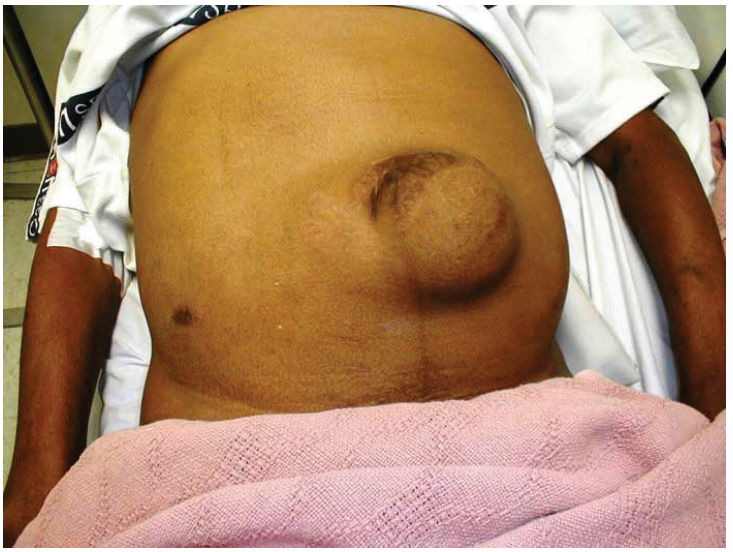


Figure 3-9. Large Umbilical Hernia (Gross Appearance)

A 9-month-old baby girl is brought in because she has an umbilical hernia. The defect is 1 cm in diameter, and the contents are freely reducible.

Elective surgical repair of hernias is generally recommended to prevent strangulation, but there are a few exceptions:

- Umbilical hernia in children age <5 may still close spontaneously, so observation alone is done if asymptomatic.
- Umbilical hernia in children at age 5 usually requires primary repair.

An 18-year-old man has a routine physical examination during college registration, during which time a right inguinal hernia is revealed. The external inguinal ring is about 2.5 cm in diameter, and a hernial bulge can be easily seen and felt going down into his scrotum when he is asked to strain. He is completely asymptomatic and was not even aware of the presence of the hernia.

Elective surgical repair is indicated. Even though the patient is asymptomatic, he should not be exposed to the risk of bowel incarceration or strangulation. The exam will not ask you about specific technical details, but this hernia is probably indirect. All routine unilateral first-time hernias can be repaired by an open or laparoscopic approach with a synthetic mesh. Laparoscopy is often favored for repair of recurrent inguinal, bilateral inguinal, and incisional hernias.

A 72-year-old farmer undergoes a physical examination required by his insurance company to be issued a life insurance policy. He has been healthy all his life and has "never been to the doctor." At the examination it is found that he has a large, left inguinal hernia that reaches down into the scrotum. Bowel sounds can be easily heard over it. The hernia is not reducible. He says that many years ago he used to be able to "push it back," but for the last 10–20 years he has not been able to do so.

This scenario describes a chronically incarcerated hernia: It cannot be reduced. An acutely incarcerated hernia and a strangulated hernia (i.e., blood flow has been compromised with evidence of bowel ischemia) are surgical emergencies. A chronically incarcerated hernia is less likely to progress to strangulation, and is therefore not an emergency; it should be repaired on a nonemergent basis.

BREAST

In all breast disease, cancer must be ruled out **even if the presentation initially suggests benign disease**. The only sure way to rule out cancer is to get tissue.

Risk factors for breast cancer include:

- Age
- Family history (a significant family history should raise concern for a BRCA genetic mutation and trigger appropriate testing)
- Early-age onset of menstruation
- Radiation exposure
- Later menopause
- Never having been pregnant

Diagnosis begins with physical exam followed by mammogram. Screening recommendations are as follows:

- Begin at age 50 or as early as age 40 if high risk.
- Women age <40 with significant risk factors should be screened with U/S and MRI if necessary. Stereotactic or U/S-guided core biopsy is the most convenient, effective, and inexpensive way to biopsy breast mass, whether it is palpable or is discovered by screening mammogram.

Fibroadenoma is primarily seen in young women (late teens to 30s) as a firm, rubbery mass that moves easily with palpation. Core biopsy is performed to establish diagnosis. Removal is optional in uncomplicated cases. Giant juvenile fibroadenoma is seen in very young adolescents, where it has very rapid growth; resection is indicated.

Cystosarcoma phyllodes tumor is most common in women in their 30s and 40s, but is seen in women of all ages. It can become very large and distort the entire breast, yet without invading or becoming fixed. Most tumors are benign, but a malignant variant is possible. Core biopsy is needed (FNA is not sufficient), and resection is mandatory due to the potential for malignant transformation.

Mammary dysplasia (fibrocystic disease, cystic mastitis) is most common in women of childbearing age but can affect women of any age. It often presents with bilateral tenderness related to the menstrual cycle and multiple lumps (cysts) that seem to come and go relative to the menstrual cycle. U/S can be used to evaluate breast complaints and is also diagnostic for simple cysts. Any dominant or persistent mass of concern should be worked up, including a mammogram and biopsy if appropriate.

Intraductal papilloma is the main etiology of bloody nipple discharge; however, do the following:

- Biopsy to rule out cancer
- Mammogram to exclude malignancy (but it may not demonstrate a papilloma, as it is small)
- Galactogram can help guide surgical resection
- Ultrasound to help diagnose; typically included in the routine evaluation of pathologic nipple discharge

Mastitis and **breast abscess** are commonly seen in lactating women; in nonlactating women, what appears to be a breast abscess is more likely cancer or hematoma due to trauma. Treatment for mastitis is oral antibiotics; treatment for true abscess is drainage via U/S-guided fine needle aspiration or incision and drainage.

Breast cancer should be suspected in any woman with a palpable breast mass. The index of suspicion increases with the patient's age. Other strong indicators of cancer include:

- Ill-defined fixed mass
- Retraction of overlying skin or recent retraction of the nipple
- Eczematoid lesions of the areola
- Reddish "orange peel" skin over the mass (peau d'orange), which is associated with inflammatory cancer caused by lymphatic involvement and resultant skin edema
- Palpable axillary nodes

A history of trauma does not rule out cancer.

Note

Breast cancer in pregnancy is diagnosed and treated in the same way as non-pregnancy, except that there is **no radiotherapy during the pregnancy** and **no chemotherapy during the first trimester**. Termination of the pregnancy is not necessary.

The radiologic appearance of breast cancer on mammogram includes an irregular, spiculated mass; asymmetric density; architectural distortion; or new microcalcifications.

Treatment of resectable breast cancer is as follows:

- Lumpectomy (partial mastectomy) plus post-op radiation **or** total mastectomy
- Either way, add simultaneous axillary sentinel lymph node sampling
  - Perform sentinel node biopsy only when nodes are not palpable on physical exam
  - If palpable, do a complete axillary lymphadenectomy
- Lumpectomy is ideal when tumor is small, not multicentric, and not associated with extensive DCIS

Infiltrating (or invasive) ductal carcinoma is the common, standard form of breast cancer. Other variants (lobular, medullary, tubular, mucinous) tend to have slightly better prognosis and are treated the same way as the standard infiltrating ductal. Lobular carcinoma has a higher incidence of bilaterality.

Inflammatory breast cancer is a clinical presentation of advanced breast cancer. It has a worse prognosis and is treated with chemotherapy prior to surgery. The surgery for inflammatory breast cancer is almost always a modified radical mastectomy. Inflammatory breast cancer is also one of the few instances where radiation is added following a total mastectomy.

Ductal carcinoma in situ (DCIS) may be a precursor to invasive breast cancer. Since it is confined to the ducts, it cannot metastasize (thus no axillary sampling is needed). Total mastectomy is recommended for multicentric lesions throughout the breast; many practitioners add a sentinel node biopsy in those patients in the event that invasive cancer is found following the mastectomy, as a sentinel node cannot be identified after the breast has been removed. Lumpectomy with or without radiation is used if the lesion(s) are confined to a limited portion of the breast.

Inoperable cancer of the breast is breast cancer that is not amenable to surgical resection. Inoperability is based primarily on local extent, not metastases. Treatment for inoperable breast cancer can include any combination of chemotherapy, hormonal therapy (if hormone-receptor positive), or radiation, and is often considered palliative. In some cases, chemotherapy may shrink the cancer, making surgical resection feasible.

Treatment after surgery is as follows:

- For tumors >1 cm, high-grade, HER2 positive, or positive axillary lymph nodes: adjuvant systemic therapy
- For tumors that are estrogen receptor-positive: antiestrogen hormonal therapy is an option
- For small, low-risk tumors: hormonal therapy without chemotherapy if tumors are estrogen-receptor positive; many decisions about adjuvant chemotherapy now also involve genomic analysis of the cancer

Premenopausal women receive tamoxifen, while postmenopausal women receive an aromatase inhibitor (e.g., anastrozole).

Persistent headache or back pain in women with a history of breast cancer suggests metastasis. MRI is diagnostic. Other tests for spine metastasis may include bone scan, CT scan, and PET scan. Brain metastases can be radiated or resected. The vertebral body and pedicles are the most common location in the spine. Recurrent metastatic breast cancer can also present with malignant pleural effusion; thoracentesis with cytological examination is indicated.

> An 18-year-old woman has a firm, rubbery mass in the left breast that moves easily with palpation.

This is most likely a fibroadenoma. The underlying concern for all breast masses is cancer, and the **best predictor of the likelihood of malignancy is age**.

- At age 18, the chances of malignancy are remote; begin with an U/S, which is diagnostic for fibroadenoma.
- At age 18 mammogram is not helpful.
- If a fibroadenoma is diagnosed, no intervention is necessary. For a lesion that appears more suspicious, a needle biopsy is necessary.

> A 14-year-old girl has a firm, movable, rubbery mass in her left breast that was first noticed 1 year ago and has since grown to be about 6 cm in diameter.

A breast mass this large in a young patient is characteristic of giant juvenile fibroadenoma. At age 14, chances of cancer are virtually zero. That avenue does not have to be explored, but the rapid growth requires resection to avoid cosmetic deformity.

> A 37-year-old woman has a 12×10×7 cm mass in her left breast. It has been present for 7 years and has slowly grown to its present size. The mass–firm, rubbery, completely movable–is not attached to chest wall or to overlying skin. There are no palpable axillary nodes.

The slow growth of this lesion suggests cystosarcoma phyllodes, a benign condition with the potential to transform into malignant sarcoma. After tissue diagnosis, proceed with resection.

A 35-year-old woman has a 10-year history of tenderness in both breasts related to her menstrual cycle, with multiple lumps on both breasts that seem to "come and go" at different times in the menstrual cycle. She now has a firm, round 2-cm mass that has not gone away for 6 weeks.

Note

Aspiration of fluid for symptom relief is not the same as fine needle aspiration (FNA) biopsy, which is aspiration of a solid mass to retrieve cells for diagnosis.

This presentation suggests a palpable cyst in fibrocystic disease (cystic mastitis, mammary dysplasia).

- Start with a mammogram to evaluate for any lesions suspicious for malignancy.
- U/S is also helpful in evaluating the persistent mass. Once U/S confirms the mass as a cyst, it can be aspirated for symptom relief. Otherwise, a simple cyst can be left alone.
  - If the mass goes away and the fluid aspirated is clear, no further testing is required.
  - If the fluid is bloody, it goes to cytology.
  - If the mass does not go away or recurs, a biopsy is required.

A 34-year-old woman has been experiencing bloody discharge from the right nipple intermittently for several months. There are no palpable masses and there is no family history of breast cancer.

This scenario is classic for an intraductal papilloma. Although cancer is a concern with bloody nipple discharge, benign intraductal papilloma is the most common cause of this complaint. First, cancer must be ruled out. Start with ultrasound, but mammogram is often also needed. Any intraductal mass should undergo core needle biopsy for diagnosis. Resect the duct and any identified intraductal lesion for symptomatic relief and definitive exclusion of a malignant etiology.

A 26-year-old lactating mother has cracks in the nipple and develops a fluctuating, red, hot, tender mass in the breast, along with fever and leukocytosis.

This is a typical example of a breast abscess, most likely to occur in breastfeeding women. Mammogram would be a low-yield diagnostic test: the patient's age and the presence of lactation put her at low risk for cancer. Drainage is the treatment for abscesses anywhere in the body, including the breast. U/S-guided percutaneous drainage is preferred in lactating women, since a formal incision and drainage carries a higher risk of developing a persistent milk fistula in the lactating breast.

A 49-year-old woman has a firm, 2-cm mass in the right breast that has been present for 3 months.

This could be anything and needs formal workup. Age is a strong determinant for risk of breast cancer. Suspect breast cancer on the exam if the patient is older; favor benign in a younger patient. Proceed with mammogram and often ultrasound to assess the palpable mass and to explore for other nonpalpable lesions; follow with a core needle biopsy.

A 34-year-old woman in month 5 of pregnancy reports a 3-cm firm, ill-defined mass in her right breast that has been present and growing for 3 months.

The diagnosis of possible breast cancer in the pregnant patient is done the same way as if she had not been pregnant. Mammogram is performed with fetal shielding, but more often it can be avoided with U/S-guided biopsy. Treatment is the same, except for no radiation during the pregnancy and no chemotherapy during the first trimester.

> A 69-year-old woman has a 4-cm hard mass with ill-defined borders in the right breast, movable from the chest wall but not movable within the breast. The skin overlying the mass is retracted and has an "orange peel" appearance.

> A 69-year-old woman has a 4-cm hard mass in the right breast under the nipple and areola with ill-defined borders, movable from the chest wall but not movable within the breast. The nipple became retracted 6 months ago.

> A 72-year-old woman has a red, swollen breast. The skin over the area looks like an orange peel. The area is not particularly tender, and it is debatable whether the area is hot or not. She has no fever or leukocytosis.

> A 62-year-old woman has an eczematoid lesion in the areola. It has been present for 3 months and looks to her like "some kind of skin condition" that has not improved or gone away with a variety of lotions and ointments.

These are all various presentations of breast cancer. The hard masses are likely invasive breast adenocarcinoma. The red, orange-peel skin is likely inflammatory breast cancer, and the eczematoid areolar lesion is likely Paget disease of the breast, a rare form of breast cancer. They all need mammograms and often ultrasound for further evaluation and multiple core biopsies of suspicious breast lesions, including biopsy of abnormal skin lesions when present.

> A 42-year-old woman hits her breast with a broom handle while doing housework. She noticed a lump in that area at the time, and 1 week later the lump is still there. She has a 3-cm, hard mass deep inside the affected breast and some superficial ecchymosis over the area.

This is a classic trap. It is cancer until proven otherwise. Trauma often brings the mass to the attention of the patient, but is not necessarily the cause of the lump. Proceed as with any other breast mass workup!

> A 58-year-old woman discovers a mass in her right axilla. She has a discrete, hard, movable, 2-cm mass. Physical examination of the breast is negative, and the patient has no enlarged lymph nodes elsewhere.

This is challenging, but it is another potential presentation for cancer of the breast. It could be lymphoma, but it could also be lymph node metastasis from another unrecognized primary cancer. A mammogram and ultrasound are needed to look for an occult primary

cancer in the breast, and the node must be biopsied (core needle biopsy or at least FNA may suffice). MRI of the breast is now in the workup for occult primary breast cancer, as well as for lobular cancers that cannot be fully visualized by mammogram or even U/S.

> A 60-year-old woman has a routine screening mammogram. The radiologist reports an irregular area of increased density, with fine microcalcifications that was not present 2 years ago on a previous mammogram.

On the exam, it is unlikely that you will be asked to read difficult x-rays, particularly mammograms, but you should recognize the description of a malignant radiologic image, which matches this description. Stick with the same algorithm and obtain tissue.

> A 44-year-old woman has a 2-cm palpable mass in the upper outer quadrant of her right breast. A core biopsy shows infiltrating ductal carcinoma. The mass is freely movable, and the breast is normal size. There are no other palpable lesions and no palpable axillary lymph nodes.

With a small tumor far away from the nipple, the standard option is partial mastectomy (lumpectomy) and sentinel lymph node biopsy. Even though no nodes are palpable, axillary sampling is necessary to assess for occult lymph node involvement, and possibly the need for adjuvant chemotherapy. Either way, adjuvant radiotherapy is indicated to augment the partial mastectomy and to prevent a local recurrence. If a total mastectomy is performed, radiotherapy is not typically necessary, except for large tumors (>5 cm) or axillary lymph node involvement.

> A 62-year-old woman has a 4-cm hard mass under the nipple and areola of her relatively small left breast. A core biopsy has diagnosed infiltrating ductal carcinoma. There are no palpable axillary nodes. The mammogram shows extensive associated branching calcifications thought to represent ductal carcinoma in situ (DCIS).

Lumpectomy is an ideal option when the tumor is small (in relation to the size of the breast), is located where most of the breast can be spared, and can be performed in a way that maintains the cosmetic appearance of the breast. A total mastectomy (also called simple mastectomy) is the choice here given the extent of disease. If necessary, a biopsy can be performed of the suspicious calcifications to confirm malignancy if there is any doubt. Axillary sampling of sentinel nodes at the time of breast surgery is also required (i.e., sentinel node biopsy if no palpable nodes).

> A 44-year-old woman has a 2-cm palpable mass in the upper outer quadrant of her right breast. A core biopsy shows lobular cancer.

> A 44-year-old woman has a 2-cm palpable mass in the upper outer quadrant of her right breast. A core biopsy shows medullary cancer of the breast.

Lobular cancer has a higher incidence of bilaterality; oftentimes, the extent of disease is not fully appreciated on mammogram and ultrasound (MRI may be helpful). It is treated much

in the same way as invasive ductal carcinoma. Many other variants of invasive cancer, e.g., medullary, tubular, have a somewhat better prognosis than infiltrating ductal, and they are all diagnosed and treated the same way.

> A 52-year-old woman has a suspicious area on mammogram. Multiple radiologically guided core biopsies show ductal carcinoma in situ.

Lumpectomy and radiation should be offered in cases of limited DCIS without the need for axillary sampling. If there are multicentric lesions all over the breast, total mastectomy (without radiation) is necessary. Sentinel node biopsy should be done at the time of mastectomy in the event that invasive carcinoma is found on the mastectomy pathology, since it is difficult to go back to do a sentinel node biopsy once the breast has been removed.

> A 44-year-old woman arrives at the ED because she is "bleeding from the breast." Physical examination shows a large ulcerated mass occupying the entire right breast and firmly attached to the chest wall. The patient maintains that the mass has been present for only "a few weeks," but a relative indicates that it has been there at least 2 years, maybe longer.

An all-too-frequent tragic case of neglect and denial, and perhaps psychiatric disorder. This is obviously an advanced breast cancer. Tissue diagnosis is still needed, along with either a core or incisional biopsy, but the main question here is what to do next. This cancer is inoperable, but palliation can be offered. Chemotherapy may be considered in the first line of treatment (or hormone therapy if the tumor is hormone-receptor positive), perhaps also radiation. In some cases the chemo- or hormone therapy will shrink the tumor enough to become operable for palliative surgery.

> A 37-year-old woman has a lumpectomy and axillary sentinel node biopsy for a 3-cm infiltrating ductal carcinoma. The pathologist reports clear surgical margins and metastatic cancer in 3 of the sentinel nodes that were removed. The tumor is positive for estrogen and progesterone receptors.

Very rarely is surgery alone sufficient to cure breast cancer. Most patients require subsequent adjuvant systemic therapy. The need for it is underscored by the finding of multiple involved axillary nodes. Chemotherapy is indicated here, followed by radiation (because she had a lumpectomy), and finally hormonal therapy, which, given her age, should be tamoxifen.

> A 66-year-old woman has a total mastectomy with sentinel lymph node biopsy for infiltrating ductal carcinoma of the breast. The pathologist reports that the tumor measures 1 cm in diameter and is estrogen receptor positive, with no lymph node involvement.

The adjuvant hormonal therapy of choice for postmenopausal women is an aromatase inhibitor (e.g., anastrozole), with chemotherapy as indicated. For very small, low-risk breast cancers like this one, typically in elderly women, hormone therapy without chemotherapy should be considered.

A 44-year-old woman presents with severe headaches for several weeks that have not responded to over-the-counter headache medication. She is 2 years post-op from modified radical mastectomy for T3N2M0 cancer of the breast, and she had several courses of post-op chemotherapy that she eventually discontinued because of the side effects.

This case is quite worrisome for recurrent metastatic disease. Despite the lack of metastases at initial presentation and adjuvant chemotherapy, this patient needs an immediate MRI of the brain and treatment as indicated.

A 39-year-old woman completed her last course of postoperative adjuvant chemotherapy for breast cancer 6 months ago. She comes to the clinic complaining of constant back pain for about 3 weeks. The patient is tender to palpation over 2 well-circumscribed areas in the thoracic and lumbar spine.

Clinical Pearl

Patients with metastatic bone lesions are at risk for pathological vertebral body fracture. If it occurs, treatment is orthopedic fixation.

Another presentation of metastatic breast cancer. These are bone metastases until proven otherwise. Again, use MRI or bone scan for diagnosis and treat with radiation and systemic therapy as indicated.

ENDOCRINE

Workup of thyroid nodules begins with thyroid function testing.

In **euthyroid patients**, nodules could be cancer, but the incidence is low and indiscriminate thyroidectomy is not justified. FNA is the diagnostic test of choice, especially with solitary nodule.

- If FNA reads as benign, continue to follow the patient but do not intervene.
- If FNA reads as malignant or indeterminate, follow with a thyroid lobectomy. In indeterminate cases, intraoperative frozen section is necessary to guide extent of resection.
- A total thyroidectomy should be performed in follicular cancers so radioactive iodine can be used in the future if needed to treat blood-borne metastases.

In **hyperthyroid patients**, nodules are almost never cancer, but they may be the source of the hyperfunction ("hot adenomas").

- Clinical signs of hyperthyroidism include weight loss, palpitations, heat intolerance, moist skin, hyperactive behavior, and tachycardia including atrial fibrillation or flutter.
- Lab confirmation includes a high T4 and low TSH.
- Nuclear scan will show whether the nodule is the source.
- Treatment is usually radioactive iodine, but those with a "hot adenoma" have the option of surgical excision of the affected lobe.

Hyperparathyroidism classically presents with "stones, bones, abdominal groans, and psychiatric moans," but in reality it is most commonly discovered incidentally when routine bloodwork turns up high serum calcium.

- Step 1 is to repeat the calcium level, check phosphorus, and rule out cancer with bone metastases.
- If findings persist, do parathyroid hormone (PTH) determination and interpret in light of serum calcium.

- Around 20% of asymptomatic patients become symptomatic, so elective intervention is justified.
- Around 90% of patients with hyperparathyroidism have a single adenoma. Resection is curative, and preoperative localization with a sestamibi radionuclide scan is crucial to localize the culprit gland.
- Pre- and intraoperative hormone testing confirms successful resection.
- Glandular hyperplasia is the second most common etiology.

Cushing syndrome is the constellation of clinical signs that accompany elevated cortisol: fat deposits in the face, a ruddy complexion, hirsutism, interscapular fat ("buffalo hump"), truncal obesity with abdominal striae, and thin weak extremities, classically in a patient with a previously normal appearance. Osteoporosis, diabetes, hypertension, and mood changes may be present. Workup starts with an overnight low-dose dexamethasone suppression test.

- Cortisol suppression at low dosage will rule out the disease.
- If no suppression, measure 24-hour urine-free cortisol; if elevated, move to a high-dose suppression test.
  - Suppression at a higher dose identifies pituitary microadenoma (Cushing disease).
  - No suppression at higher dose identifies adrenal adenoma (or a paraneoplastic syndrome).
- Do appropriate imaging studies (MRI for pituitary, CT for adrenal), and surgically remove the offending adenoma.
- Don't forget the most common etiology: iatrogenic, from exogenous steroid administration.

Zollinger-Ellison syndrome (gastrinoma) presents as virulent PUD, resistant to usual therapy (acid suppression, *H. pylori* eradication) and more extensive than usual (multiple and more extensive ulcers). Some patients also have watery diarrhea. Measure gastrin and do a secretin test; if values are equivocal, locate the tumor with CT (with contrast) of the pancreas and treat with surgical resection. Omeprazole helps those with metastatic disease.

Insulinoma produces CNS symptoms because of low blood sugar, always when the patient is fasting. Differential diagnosis is with reactive hypoglycemia (attacks occur after eating) and self-administration of insulin. In the latter, the patient has reason to be familiar with insulin (some connection with the medical profession or with a diabetic patient), and in plasma assays the patient has high insulin but low C-peptide. In insulinoma, both are high. Do a CT with contrast of the abdomen to locate the tumor and then surgically resect.

Glucagonoma produces severe migratory necrolytic dermatitis, resistant to all forms of therapy, in a patient with mild diabetes, mild anemia, glossitis, and stomatitis. Glucagon assay is diagnostic; CT is used to locate the tumor. Surgical resection is curative. Somatostatin and streptozocin have a modest response for patients with metastatic or inoperable disease.

> A 62-year-old woman is applying her makeup when she notices a lump in the lower part of the neck, visible when she swallows. Physical examination identifies a prominent, 2-cm mass on the left lobe of the thyroid plus 2 small masses on the right lobe. They are all soft, and she has no palpable lymph nodes in the neck.

Most thyroid nodules are benign. Surgical removal to ascertain the diagnosis is not recommended, but evaluation is necessary. Worrisome features: young patient, male gender, single

nodule, history of radiation to the neck, solid mass on sonogram, and cold nodule on scan. FNA is diagnostic.

> A 21-year-old man is found on a routine physical examination to have a single, 2-cm nodule in the thyroid gland. His thyroid function tests are normal. A fine needle aspiration is read as indeterminate.

Surgery is indicated for a thyroid mass with a malignant FNA and those that are indeterminate.

> A 32-year-old woman is undergoing a thyroid lobectomy for a 2-cm mass that had been reported on fine needle aspiration as a "follicular neoplasm, not otherwise specified." Frozen section in the operating room is consistent with follicular cancer.

This is a commonly tested scenario. Complete total thyroidectomy should be performed.

> Blood chemistry done during a routine examination indicates that an asymptomatic patient has a serum calcium 12 mg/dL. Repeat testing is 11.6 mg/dL. Serum phosphorus is low.

Hypercalcemia with hypophosphatemia raises suspicion for a parathyroid adenoma.

- Classically, hypercalcemia presents with kidney stones, abdominal pain, or psychiatric symptoms that prompt checking serum calcium level.
- In reality, hypercalcemia is usually noted incidentally on routine labs.
- Although most cases of hypercalcemia are caused by metastatic cancer, that scenario is less likely in an asymptomatic patient who would also likely have a normal phosphorus level.
- The next diagnostic test is serum parathyroid hormone level, then a sestamibi nuclear scan to localize the adenoma. Once localized, surgical resection is indicated.

> A 32-year-old woman is admitted to the psychiatry unit after being found wandering around the park in her underwear. Vital signs are significant for blood pressure 180/110 mm Hg and blood glucose 225 mg/dL. On physical exam, facial hair and central obesity are noted. Her driver's license photo from 2 years ago shows a much thinner face without hair.

This scenario describes a case of Cushing syndrome. On the exam you may be shown photos. Start with the overnight low-dose dexamethasone suppression test:

- If the patient suppresses at a low dose, she does not have the disease.
- If she does not suppress at a low dose, verify that 24-hour urine-free cortisol is elevated; then go to high-dose suppression testing.
  - If the patient suppresses at a high dose, get an MRI of the head looking for the pituitary microadenoma, which should be removed by the transnasal, transsphenoidal route.
  - If she does not suppress at a high dose, do a CT or MRI of the adrenal glands looking for an adenoma there.

A 28-year-old woman has virulent peptic ulcer disease. Extensive medical management including eradication of *H. pylori* fails to heal her ulcers, which on endoscopy are present in the first and second portions of the duodenum.

Uncontrollable and extensive PUD is suspicious for gastrinoma (Zollinger-Ellison syndrome). Start by measuring serum gastrin. If the value is not clearly normal or abnormal, a secretin stimulation test is helpful. CT of the abdomen with IV and oral contrast will help localize for surgical planning.

A second-year medical student is hospitalized after collapsing on the ward with a seizure. Blood glucose is markedly low. Serum testing reveals a low level of C-peptide.

High insulin with low C-peptide is diagnostic of exogenous insulin administration, especially when the patient is a healthcare provider. Proceed with psychiatric evaluation and counseling. If C-peptide was normal, work up for an insulinoma with CT of the abdomen with IV and oral contrast followed by surgical resection.

A 48-year-old woman has had severe, migratory dermatitis for several years, unresponsive to multiple topical creams. She is thin and has mild diabetes mellitus.

Diabetes with severe dermatitis is suspicious for a glucagonoma. To diagnose, measure serum glucagon level. CT of the abdomen with IV and oral contrast will help localize and plan surgical resection. If inoperable, use somatostatin to control symptoms and streptozocin as the indicated chemotherapeutic agent.

Primary hyperaldosteronism can be caused by an adenoma or by hyperplasia of the adrenal cortex. In either case, the key finding is hypokalemia in a hypertensive patient (usually female) who is not on diuretics.

- Sustained hypertension
- Modest hypernatremia
- Metabolic alkalosis
- High aldosterone
- Low renin

Appropriate response to postural changes (more aldosterone when upright than when lying down) suggests glandular hyperplasia (idiopathic form, which is treated medically), whereas lack of response or inappropriate response is likely secondary to an adrenal adenoma. Adrenal CT scan will localize the lesion, and surgical excision is curative. This is **sustained surgical hypertension**.

Pheochromocytoma is seen in thin, hyperactive women who have attacks of pounding headache, perspiration, palpitations, and pallor, due to extremely high but paroxysmal BP elevations. By the time patients are seen, the attack has subsided and BP may be normal, leading to a frustrating lack of diagnosis.

Clinical Pearl

- Pheochromocytoma is known as a "10% tumor": 10% are familial, 10% are extra-adrenal, 10% are bilateral, 10% are malignant, and 10% occur in children.
- Recent literature has revealed lower rates of these findings, but this is still a testable principle on the exam.

Start the workup with a 24-hour urinary metanephrines level (previously utilized urinary VMA is less sensitive). Follow with a CT of the abdomen and pelvis; if CT is negative, a radionuclide study may be necessary to identify an extra-adrenal tumor.

Treatment is surgical resection following preoperative alpha blockade. Meticulous anesthesia management and hemodynamic monitoring are needed to avoid a hypertensive crisis. This is **paroxysmal hypertension**.

Renovascular hypertension (secondary hyperaldosteronism) is seen in 2 populations:

- Young women with fibromuscular dysplasia
- Old men with atherosclerotic disease

Clinical Pearl

The organ of Zuckerkandl is the location of the chromaffin cells at the bifurcation of the abdominal aorta. It is a commonly quizzed site of extra-adrenal pheochromocytoma.

This is sustained surgical hypertension and secondary hyperaldosteronism. In both groups, hypertension is resistant to the usual medications, and a telltale faint bruit over the flank or upper abdomen suggests the diagnosis. Diagnostic testing begins with duplex U/S of the renal vessels followed by CT angiogram for anatomical characterization and intervention planning. Treatment is endovascular balloon dilation and stenting.

> A 45-year-old woman presents for an annual checkup. She is found to be hypertensive, although her blood pressure was normal on her previous exam. Lab studies show serum sodium 144 mEq/L, serum bicarbonate 28 mEq/L, and serum potassium concentration 2.1 mEq/L. She takes no medications.

This constellation is typical for hyperaldosteronism, possibly due to an adenoma. Measure serum aldosterone and renin levels, and if confirmatory (aldosterone high, renin low), proceed with determinations lying down and sitting up. Adrenal hyperplasia (appropriate response to postural changes) is managed medically with spironolactone, whereas adrenal adenoma (no response or minimal response to postural changes) is managed by surgical resection.

> A thin, 38-year-old woman presents with complaints of intermittent, severe headaches associated with palpitations and perspiration. Upon examination she is in no distress. Vital signs are normal, and she has no headache currently. Routine bloodwork is normal.

Not a lot of information is given, but the case is suspicious for pheochromocytoma. Start with a 24-hour urinary metanephrine exam. If elevated, proceed with CT of the abdomen and pelvis. Surgery following alpha blockade is curative. Ask about family members with similar symptoms. If CT is not diagnostic but clinical suspicion is high, consider an extra-adrenal site.

> A 33-year-old woman presents for a checkup and is found to have blood pressure 160/90 mm Hg. Six months ago she was found to be hypertensive and was started on 2 antihypertensive medications. On physical exam today a bruit is audible during auscultation of the abdomen.

Even with the physical exam findings alone, this scenario is suspicious for renovascular hypertension due to fibromuscular dysplasia. Start with a duplex U/S followed by CT angiogram, and treat endovascularly with dilation and stenting. Most patients can be taken off their antihypertensive medications.

SKIN

Cancer of the skin is typically seen in fair-skinned people with significant sun exposure. The 3 most common types of skin cancer are basal cell carcinoma (BCC), squamous cell carcinoma (SCC), and melanoma.

Initial diagnosis is made by biopsy (shave, punch, or excisional). Skin cancers are notorious for having multiple locations over the course of a lifetime.

BCC (>50% of cases) presents as a raised waxy lesion or a nonhealing ulcer, often in the upper part of the face (above the lips). BCC does not metastasize, but it can continue to grow with relentless local invasion ("rodent ulcer"). Treatment is excision with negative margins (1 mm is enough).

SCC (>25% of cases) presents as a nonhealing ulcer, often in the lower part of the face. It does metastasize to local lymph nodes. Excision with wider margins is necessary (4–6 cm), and lymph node dissection may be indicated for very large/deep lesions or for those with enlarged/palpable nodes. Radiation is an option for unresectable lesions, as well adjuvant therapy for advanced lesions.

Melanoma is an aggressive malignancy that usually originates in a pigmented lesion. Suspect any lesion with the ABCD characteristics:

- Asymmetric (A)
- Has irregular borders (B)
- Contains different colors (C)
- Diameter (D) >0.5 cm

Also suspect melanoma in a pigmented lesion (dysplastic nevus) that has changed in any way (grows, ulcerates/bleeds, changes color/shape). Biopsy reports for melanoma must report both the diagnosis and thickness and depth of invasion, as the diagnosis/management are directly related to those factors.

If palpable nodes are present, treatment is surgical excision with lymphadenectomy. If nodes are not palpable, treatment is sentinel lymph node biopsy. Margins and prognosis are as follows:

- **Melanoma in situ (noninvasive melanoma)**: excellent prognosis and requires local excision with 5 mm margins
- **Lesions <1 mm**: require local excision with 1 cm margins; good prognosis
- **Lesions 1–2 mm**: require resection with 1–2 cm margins; worse prognosis
- **Lesions >2 mm**: require excision with wide margins 2 cm; poor prognosis

Melanoma can metastasize anywhere in the body and at any time from a previous occurrence. Ipilimumab (a monoclonal antibody) and other newer agents have emerged as standard options for adjuvant therapy for high-risk melanoma.

> A 65-year-old farmer presents with an indolent, raised 1.2-cm skin mass over the bridge of the nose that has been slowly growing over the past 3 years. There are no enlarged lymph nodes in the head and neck.

BCC can present as a waxy raised lesion or a "punched-out" ulcer. Both, however, have a preference for the upper part of the face. Diagnosis is made with full-thickness biopsy at the edge of the lesion (shave or punch) or complete excision with a narrow margin of uninvolved skin. Treatment is surgical excision with negative margins but conservative width.

Clinical Pearl

Melanoma is highly unpredictable. If the patient has a history of melanoma, any new tumor regardless of location should raise suspicion for recurrent metastatic melanoma.

A blond 69-year-old retired Navy sailor has a nonhealing 1.5-cm ulcer on the lower lip that has been slowly enlarging for the past 8 months. He is a pipe smoker, and he has no other lesions or physical findings.

This scenario is more suspicious for SCC based on location, but diagnosis is similarly made with a shave or punch biopsy. Manage with surgical resection with a wider (1 cm) margin (≥1 cm). Complex surgical reconstruction may be needed based on location and extent of resection.

A redheaded, freckled, 23-year-old woman who routinely tans presents to her physician after noticing a skin lesion on her shoulder. It is 1.8 cm, pigmented, and asymmetric, with irregular borders.

Although this patient is young, her complexion and habits put her at higher risk for skin cancer, and the characteristics are highly concerning for malignancy. Diagnosis is made by excisional biopsy, and a narrow margin is preferred. Once diagnosis is confirmed, definitive treatment is wide local excision with margins based on depth of invasion. Sentinel lymph node biopsy is indicated for lesions >1 mm thickness or lesions >0.75 mm with high risk features such as ulceration or high-mitotic rates.

A 44-year-old man presents with abdominal pain and is sent for CT scan. He is found to have multiple hepatic masses, but no other abdominal masses are identified. His medical history includes a toe amputation at age 18 for a "black tumor" under the toenail.

A 66-year-old man presents with an upper gastrointestinal bleed and is found to have a duodenal mass. His past medical history includes right eye enucleation for a "tumor" several years ago.

Melanoma is notorious for recurring at unpredictable intervals and in unusual locations. Suspect metastatic melanoma in these scenarios. An isolated tumor (e.g., duodenal) can be treated with surgical resection, whereas multiple sites or unresectable lesions should be treated medically with systemic therapy, e.g., immunotherapy.

UROLOGIC

Urologic Emergencies

Testicular torsion is seen in adolescent boys. This is one of the few urologic emergencies.

- There is very severe testicular pain of sudden onset, but no fever, pyuria, or history of recent mumps.
- The testis is swollen, exquisitely tender, "high riding," and with a "horizontal lie."
- The cord is not tender (differs from acute epididymitis).

- U/S may be performed at the bedside, but time is critical and care should not be delayed to obtain a formal U/S. Immediate surgical intervention is indicated: detorsion and bilateral orchiopexy.

Acute epididymitis can be confused with testicular torsion. It is seen in young men old enough to be sexually active.

- There is severe testicular pain of sudden onset, fever, and pyuria.
- The testis is swollen and very tender, but in a normal position.
- The cord is very tender.
- Treatment is antibiotics, but U/S is typically performed to avoid missing a possible diagnosis of testicular torsion.

The combination of **obstruction and infection of the urinary tract** is the other condition that is a urologic emergency. Any situation in which these two conditions coexist can lead to destruction of the kidney in a few hours, and potentially to death from sepsis. A typical scenario is a patient who is being allowed to pass a ureteral stone spontaneously, and who suddenly develops fever, chills, and flank pain. In addition to IV antibiotics, immediate decompression of the urinary tract above the obstruction is required. This should be accomplished by the quickest and simplest means, i.e. ureteral stent or percutaneous nephrostomy.

UTI (cystitis) is very common in women of reproductive age and requires no elaborate workup. Patients have frequent, painful urination, with small volumes of cloudy and malodorous urine. Empiric antimicrobial therapy is used. More serious infections such as pyelonephritis, as well as a UTI in children or young men, require urinary cultures and a urologic workup to rule out concomitant obstruction as the reason for the serious infection. Urinary cultures are also indicated in women with frequent/recurrent UTI.

Pyelonephritis, an infection involving the kidney, produces chills, high fever, nausea and vomiting, and flank pain. IV antibiotics (guided by cultures) and urologic workup (intravenous pyelogram [IVP] or sonogram to assess for anatomic abnormalities) are required.

Acute bacterial prostatitis is seen in older men who have chills, fever, dysuria, urinary frequency, diffuse low back pain, and an exquisitely tender prostate on rectal exam. IV antibiotics are indicated. Further rectal examination should not be performed.

> A 14-year-old boy presents in the ED with very severe pain of sudden onset in his right testicle. There is no fever, pyuria, or history of recent mumps. The testis is swollen and exquisitely painful, but the cord is not tender.

This is testicular torsion—a urological emergency. Do not waste time on imaging, proceed to the OR for surgical detorsion and bilateral orchiopexy.

> A 24-year-old man presents in the ED with very severe pain of recent onset in his right scrotum. He is febrile to 39.4 C (103 F), with pyuria. The testis is in the normal position, but it is swollen and exquisitely painful. The cord is also very tender.

This describes an infectious problem, and with a tender cord this is most concerning for acute epididymitis. This is not a surgical emergency like testicular torsion, but is managed medically with antibiotics. Get an U/S to confirm no torsion is present.

A 72-year-old man is being observed with a ureteral stone that is expected to pass spontaneously. He develops fever to 40 C (104 F) and flank pain.

Obstruction and infection of the urinary tract is a dangerous combination. IV antibiotics are required, but the obstruction must also be relieved immediately. Stone extraction would be hazardous, so the option in addition to antibiotics would be decompression by ureteral stent or percutaneous nephrostomy.

A 49-year-old woman presents with 5 days of frequent, painful urination, with small volumes of cloudy and malodorous urine. For the first 3 days she had no fever, but for the past 2 days she has been having chills, high fever, nausea, and vomiting. She has also had pain in the right flank in the past 2 days.

The natural history of infections of the urinary tract is ascending, ultimately leading to pyelonephritis. UTI should not occur in men or in children, and thus should trigger a workup looking for a cause. Women of reproductive age, on the other hand, get cystitis all the time, and they are treated with appropriate antibiotics without great fuss. However, when they get flank pain and septic signs it's much more serious. This woman needs hospitalization, IV antibiotics, and at least a sonogram to make sure that there is no evidence of urinary tract obstruction.

A 72-year-old man presents with chills, fever, dysuria, urinary frequency, diffuse low back pain, and an exquisitely tender prostate on rectal exam.

Acute bacterial prostatitis presents in this manner, and is treated with IV antibiotics. Do not perform any more rectal exams or any vigorous prostatic massage, as this could lead to septic shock.

A 33-year-old man has urgency, frequency, and burning pain with urination. The urine is cloudy and malodorous. He has mild fever. On physical examination the prostate is not warm, boggy, or tender.

The first part of this vignette sounds like prostatitis, which would be common and not particularly challenging; however, if the prostate is normal on examination, things become less clear. The point of the vignette is that men—particularly young men—rarely get UTI.

This infection needs to be treated, so check urinary cultures and start antibiotics, but also start a urologic workup. Do not start with cystoscopy (as to not instrument an infected bladder; you could trigger septic shock); start with an U/S.

Retention and Incontinence

Urinary retention is a common problem and often tested on the exam. Take into consideration the patient and circumstances when evaluating and managing.

Acute urinary retention is very common in men, secondary to benign prostatic hypertrophy. It is often precipitated during a viral illness, use of antihistamines, and abundant fluid intake. The

patient wants to void but cannot, and the markedly distended bladder is palpable. Treatment is an indwelling catheter for ≥3 days, with alpha-blockers and 5-alpha-reductase inhibitors.

Postoperative urinary retention is common and sometimes masquerades as incontinence. The patient may not feel the need to void because of post-op pain and medications, but will report that every few minutes there is involuntary release of small amounts of urine. A distended bladder is palpable on exam and visible on bladder scanning, confirming that the problem is overflow incontinence from retention. Manage with an indwelling bladder catheter.

Stress incontinence is common in middle-aged women who have had many pregnancies and vaginal deliveries. They leak small amounts of urine whenever intra-abdominal pressure suddenly increases, as with sneezing, laughing, or lifting a heavy object. They do not have any incontinence during the night. Examination will show a weak pelvic floor, with the prolapsed bladder neck outside of the "high-pressure" abdominal area.

For early cases, pelvic floor exercises (Kegel) may be sufficient; for more advanced cases or those with cystoceles, surgical reconstruction of the pelvic floor may be necessary.

> A 60-year-old man arrives at the ED because he has not been able to void for the past 12 hours. He reports that prior to this presentation he has had several months of increased need to urinate at night, and he has been drinking a lot of fluids for "the flu." On physical examination his bladder is palpable between the pubis and the umbilicus, and he has an enlarged prostate gland without nodules.

This is acute urinary retention with underlying benign prostatic hypertrophy. Place an indwelling bladder catheter to be left for at least 3 days. Long-term management will be based on the use of alpha-blockers and 5-alpha-reductase inhibitors.

> On postoperative day 2 after inguinal hernia repair, a patient presents to the surgeon's office complaining that he "cannot hold his urine." Further questioning reveals that every few minutes he urinates a few drops of urine. On physical examination there is a large palpable mass arising from the pelvis and reaching almost to the umbilicus. The surgical wound is well healed, with no erythema or fluctuance.

This is a common presentation of acute urinary retention with overflow incontinence that can also occur immediately postoperatively in the recovery room, especially in patients whose surgery was performed utilizing spinal anesthesia. Manage with an indwelling bladder catheter.

> A 42-year-old woman complains to her primary care doctor that whenever she sneezes or laughs, she leaks a small amount of urine. Her past medical history is significant for hypothyroidism and 4 vaginal deliveries. She can tolerate the problem but inquires about surgical options.

This is a case of stress incontinence; the pelvic floor has been weakened by her vaginal deliveries. If she has no physical exam abnormalities, she should be taught exercises that strengthen the pelvic floor; if she has a large cystocele, she will need surgical reconstruction.

Stones

Passage of **ureteral stones** produces the classic colicky flank pain, with radiation to the inner thigh and labia or scrotum; it is sometimes associated with nausea and vomiting. Most stones are visible on noncontrast CT scan. Although there are a variety of endoscopic and other modalities to address retained urinary stones, intervention is not always needed.

- Small stones (≤3 mm) at the ureterovesical junction have a high likelihood of passing spontaneously and can be handled with analgesics, fluids, and watchful waiting.
- Large stones are less likely to pass spontaneously and require intervention. The most common tool used is extracorporeal shock wave lithotripsy (ESWL). Sometimes ESWL cannot be used (e.g., pregnant women, bleeding diathesis, stones that are several centimeters large). Other options include endoscopic basket extraction, laser, and open surgery.

Miscellaneous

Pneumaturia is almost always caused by fistulization between the bladder and the GI tract, most commonly the sigmoid colon, and most commonly from diverticulitis (second possibility is cancer of the sigmoid; cancer of the bladder is a very distant third). Men > women, as the uterus buffers the bladder from the GI tract. Workup starts with CT scan, which will show the inflammatory diverticular mass. Colonoscopy is needed later to rule out cancer. Surgical treatment is required.

Erectile dysfunction (ED), or impotence, is defined as an inability to get or maintain an erection. The etiology can be organic or psychogenic.

- **Psychogenic impotence** has sudden onset, is partner- or situation-specific, and usually does not interfere with nocturnal erections. Psycho- or behavioral therapy may be beneficial, or the condition may be self-limited.
- **Organic impotence** has a physiological etiology: most commonly nerve damage (trauma, pelvic surgery) or vascular (arteriosclerosis, diabetes). Neurological etiologies are acute (i.e., immediately following the event there is impotence), as opposed to vascular etiologies which tend to be gradual, progressing from erections not lasting long enough, to being of poor quality, to not happening at all.

Sildenafil, tadalafil, and vardenafil have become first choice treatment in many cases, but there are many options, such as prosthetic implants and vascular reconstruction, for traumatic arterial injury (rare).

> A 72-year-old man who in previous years passed 3 urinary stones is again having symptoms of ureteral colic. He has relatively mild pain that began 6 hours ago but has no real nausea or vomiting. CT shows a 3-mm ureteral stone just proximal to the ureterovesical junction.

Although many tools exist for the management of ureteral stones, small stones will ultimately pass on their own and do not require invasive procedures. Hydrate and manage pain.

> A 54-year-old woman has a severe ureteral colic. CT shows a 9-mm ureteral stone at the ureteropelvic junction.

Larger stone that the previous scenario, therefore less likely to pass spontaneously. The best option is lithotripsy, with endoscopic extraction the next best (more invasive).

A 72-year-old man has for the past several days noticed bubbles of air coming out with the urine when he urinates. He has mild abdominal pain and a low-grade fever.

Pneumaturia is caused by a fistula between the bowel and the bladder, most commonly from sigmoid colon to dome of the bladder caused by diverticulitis. Cancer (also originating in the sigmoid) is the second possibility.

Intuitively you would think that cystoscopy or sigmoidoscopy would verify the diagnosis, but in reality these are low-yield, as are contrast studies (cystogram, barium enema). CT is the most sensitive diagnostic tool. Because ruling out cancer of the sigmoid is important, the sigmoidoscopic examination would be done at some point, but not as the first test. Eventually surgery will be needed.

A 32-year-old man has sudden onset of impotence. One month ago he was unexpectedly unable to perform with his wife after an evening of heavy eating and heavier drinking. Ever since then he has not been able to achieve an erection when attempting to have intercourse with his wife, but he still gets nocturnal erections and can masturbate normally.

A classic case of psychogenic impotence: young man, sudden onset, partner-specific. Typically this is reversible with psychotherapy.

A 66-year-old diabetic man with generalized arteriosclerotic occlusive disease notices gradual loss of erectile function. At first he could get erections, but they did not last long; later the quality of the erection was poor, and eventually he developed complete impotence. He does not get nocturnal erections.

This vignette describes the classic pattern of organic impotence not related to trauma. A wide range of therapeutic options exists, but probably the first choice now is sildenafil.

Pediatric Urology

A **posterior urethral valve** is the most common reason a newborn boy doesn't urinate during day 1 of life (also look for meatal stenosis). Gentle catheterization can be done to empty the bladder (the valves will not present an obstacle to the catheter). Voiding cystourethrogram is the diagnostic test, and endoscopic fulguration or resection is curative.

Hypospadias is easily noted on the neonatal physical exam. The urethral opening is on the ventral side of the penis, somewhere between the tip and the base of the shaft.

UTI in children should always lead to a urologic workup. The cause may be vesicoureteral reflux, or some other congenital anomaly. **Vesicoureteral reflux** and infection produce burning on urination, frequency, low abdominal and perineal pain, flank pain, and fever and chills in a child. Start treatment of the infection (empiric antibiotics first, followed by culture-guided choice), and do an IVP and voiding cystogram looking for the reflux. If found, use long-term antibiotics until the child "grows out of the problem."

Note

Circumcision should never be done on a child with hypospadias, as the skin of the prepuce will be needed for the plastic reconstruction that will eventually be done.

Low implantation of a ureter is usually asymptomatic in men but can be symptomatic in women: the patient feels normally the need to void and voids normally at appropriate intervals (urine deposited into the bladder by the normal ureter), but is also wet with urine all the time (urine that drips into the vagina from the low implanted ureter). If physical examination does not find the abnormal ureteral opening, IVP is diagnostic. Surgery is corrective.

Ureteropelvic junction obstruction allows normal urinary output without difficulty, but if a large diuresis occurs, the narrow area cannot handle it. The classic presentation is an adolescent who goes on a beer-drinking binge for the first time and develops colicky flank pain.

> You are called to the nursery to see an otherwise healthy-looking newborn because he has not urinated in the first 24 hours of life. Physical examination shows a big distended urinary bladder and a normal meatus.

Infants are not born alive if they have no kidneys (without kidneys, lungs do not develop), so this represents some form of obstruction. First look at the meatus: it could be simple meatal stenosis. If it is not, a posterior urethral valve is the most likely diagnosis. Drain the bladder with a catheter, perform a voiding cystourethrogram, and treat with endoscopic fulguration or resection.

> A 9-year-old boy presents with 3 days of burning on urination, increased frequency, low abdominal and perineal pain, left flank pain, and fever and chills.

Boys rarely get UTI. Treat the infection, of course, but do an IVP and voiding cystogram looking for reflux. If found, long-term antibiotics are indicated.

> A mother brings her 6-year-old girl to you because "she has failed miserably to get proper toilet training." On questioning you find out that the little girl perceives normally the sensation of having to void and voids normally and at appropriate intervals, but also happens to be wet with urine all the time.

A classic vignette: low implantation of one ureter. In boys there would be no symptoms because low implantation is still above the sphincter, but in girls the low ureter empties into the vagina and has no sphincter. The other ureter is normally implanted and accounts for her normal voiding pattern. If the vignette did not include physical exam, that would be the next step, which might show the abnormal ureteral opening. Often physical examination does not reveal the anomaly, and imaging with IVP is necessary. Surgery is curative.

> A 16-year-old boy goes on a beer-drinking binge at the end of the school year. Shortly thereafter he develops colicky flank pain.

Another classic vignette: ureteropelvic junction obstruction. Diagnose with U/S and correct surgically.

Oncology

Hematuria is the most common presentation for cancers of the kidney, ureter, or bladder. Most cases of hematuria are caused by benign disease, but any patient presenting with this condition should get a workup to rule out cancer. Workup should begin with CT and continue with cystoscopy, which is the only reliable way to rule out cancer of the bladder.

Renal cell carcinoma in its full-blown picture produces hematuria, flank pain, and a flank mass. It can also produce hypercalcemia, erythrocytosis, and elevated liver enzymes. That full-blown picture is rarely seen today, since most patients are worked up as soon as they have hematuria.

CT typically demonstrates a mass to be a heterogenic solid tumor and needs to be assessed for renal vein and IVC involvement. Surgery is curative, and may include partial nephrectomy, radical nephrectomy, and even en bloc inferior vena cava resection and reconstruction.

Cancer of the bladder (transitional cell cancer in most cases) has a very close correlation with smoking and usually presents with hematuria. Sometimes there are irritative voiding symptoms, and patients may have been treated for UTI in the past. Diagnosis is made by CT and followed by cystoscopy. Both surgery and intravesicular BCG have therapeutic roles, but a very high rate of local recurrence makes lifelong close follow-up a necessity.

Prostatic cancer incidence increases with age. Most are asymptomatic and are discovered by screening rectal exam (hard, nodular gland) or serum prostatic specific antigen (PSA). Transrectal needle biopsy establishes diagnosis. CT helps assess extent and type of therapy. Surgery and/or radiation are choices. Bone metastases occur, but typically respond to androgen ablation (medical utilizing luteinizing hormone-releasing hormone agonists or antiandrogens like flutamide or surgical via orchiectomy).

Testicular cancer affects young men, in whom it presents as a painless testicular mass.

- Because benign testicular tumors are virtually nonexistent, biopsy is not done, and a radical orchiectomy is performed by the inguinal route.
- Blood samples are taken pre-op for serum markers (α-fetoprotein [AFP] and β-human chorionic gonadotropin [β-HCG]), which will be useful for follow-up to identify recurrent disease if elevated initially.
- Most testicular cancer is exquisitely radiosensitive and chemosensitive (platinum-based chemotherapy), offering many options for successful treatment even in cases of clinically advanced, metastatic disease.

> A 70-year-old man presents to his primary care physician with hematuria. On exam he has tenderness over the left flank, and a mass is palpable.

This is most suspicious for renal cell carcinoma. Start the workup with a CT of the abdomen and pelvis with IV contrast.

> A 55-year-old smoker with hypertension and diabetes reports 3 instances of painless hematuria over the past 2 weeks. In the past 2 months he has been treated twice for UTI, although cultures were negative. He does not recall having fever.

Bladder cancer can be irritative, present with symptoms misdiagnosed as a UTI, and treated with antibiotics. In retrospect there is usually no fever, and cultures are negative as the culprit is cancer and not infection. Start with a CT to rule out a renal source; then proceed with cystoscopy.

Clinical Pearl

On the exam, beware of an answer choice with "transscrotal biopsy" to evaluate a testicular mass. It seems reasonable, but is absolutely contraindicated and thus a common exam distractor. Serum tumor markers are drawn preoperatively but do not impact the need for resection, i.e., orchiectomy is still indicated even if negative.

A 59-year-old black man is told by his primary care physician that his prostatic-specific antigen (PSA) has increased significantly since his last visit. He has no palpable abnormalities in his prostate by rectal exam.

In the current era of prostate cancer screening, this is the most common presentation. Start with a transrectal needle biopsy. Management is surgical prostatectomy or radiation, depending on the extent of disease and patient preference.

A 62-year-old man had a radical prostatectomy for cancer of the prostate 3 years ago. He presents today with low back pain. Bone scan shows metastases throughout the entire skeleton.

Prostate cancer, unfortunately, has a tendency to metastasize to bone. It can be quite painful initially. Treatment is as follows:

- Androgen ablation: short-term (1–2 years), but can provide dramatic palliation
- Medical ablation: luteinizing hormone-releasing hormone agonists and antiandrogens (flutamide) (**preferred method**)
- Surgical orchiectomy

A 25-year-old man presents with a painless, hard testicular mass.

There are no benign solid masses of the testicle. Physical exam must be certain to rule out epididymal origin, and if it feels cystic an U/S is indicated. Otherwise no imaging is necessary: proceed directly to radical orchiectomy by the inguinal route for both diagnosis and treatment. Serum tumor markers should be checked prior to surgery for long-term surveillance. Administer adjuvant platinum-based chemotherapy postoperatively.

A 25-year-old man is found on a pre-employment chest x-ray to have multiple bilateral pulmonary nodules. On physical examination a hard testicular mass is found. He reports several months of unintentional weight loss.

Similar presentation to the previous case, although now with metastatic disease. Despite this fact, testicular cancer is very chemosensitive, so the treatment is the same: platinum-based chemotherapy and surgical orchiectomy.

Orthopedics 4

Learning Objectives

- ❑ Understand the different types of fracture and their treatments
- ❑ Know the syndromes that affect various nerves and tendons
- ❑ Know the bone tumors seen in adults versus children

ADULT ORTHOPEDICS

X-rays for suspected fracture in adults should always include the following:

- Two views at 90° to one another
- Joints above and below the broken bone
- Bones that are in "the line of force" of the injury (e.g., lumbar spine following a vertical fall)

Generally, broken bones that are not badly displaced or angulated or that can be satisfactorily aligned by external manipulation can be immobilized in a cast ("**closed reduction**"). Broken bones that are severely displaced or angulated or that cannot be aligned easily require surgical intervention to reduce and fix the fracture ("**open reduction and internal fixation**").

Upper Extremities

Clavicular fracture typically occurs at the junction of middle and distal thirds. It is treated by placing the arm in a sling. The historical "figure-of-8" bandage is no longer used.

Humerus fracture is typically managed with casting. The **radial nerve** can be injured in oblique fractures of the middle to distal thirds of the humerus. If a patient is unable to dorsiflex (extend) the wrist but regains function when the fracture is reduced and the arm is placed on a hanging cast or coaptation sling, no surgical exploration is needed. However, if nerve paralysis develops or remains after reduction, the nerve is entrapped and surgical exploration is mandatory.

Anterior dislocation of the shoulder is the more common direction of shoulder dislocation. Patients hold the arm close to their body, but rotated outward as if they were going to shake hands. There may be numbness in a small area over the deltoid from stretching of the axillary nerve. Anteroposterior (AP) and lateral x-rays are diagnostic. Some patients develop recurrent dislocations with minimal trauma.

Posterior shoulder dislocation is rare and occurs after massive uncoordinated muscle contractions, such as an epileptic seizure or an electrical burn. The arm is held in the protective position: close to the body and internally rotated. Regular x-rays can easily miss it; axillary views or scapular lateral views are needed.

Colles fracture is a fairly common fracture of the distal radius and styloid process of the ulna that results from a fall on an outstretched hand, often in older patients with osteoporosis. The deformed and painful wrist looks like a "dinner fork." The main abnormality seen on x-ray is a dorsally displaced, dorsally angulated fracture of the distal radius. Treatment is with close reduction and long arm cast.

Monteggia fracture results from a direct blow to the ulna resulting in a diaphyseal fracture of the proximal ulna with anterior dislocation of the radial head. The classic scenario of a Monteggia fracture is a raised protective arm hit by police baton.

Galeazzi fracture is the mirror image: the distal third of the radius gets the direct blow and has the fracture, and there is dorsal dislocation of the distal radioulnar joint. In both, the broken bone requires open reduction and internal fixation, and the dislocated one is managed with closed reduction.

Fracture of the scaphoid (carpal navicular fracture) tends to occur in a young adult who falls on an outstretched hand. The chief complaint is typically wrist pain, with physical exam revealing localized tenderness to palpation over the anatomic snuff box. In nondisplaced fractures, x-rays are usually negative, but thumb spica cast is indicated just with the history and physical findings, as x-rays will not demonstrate the fracture for 2–3 weeks. If original x-ray shows displaced and angulated fracture, open reduction and internal fixation are needed.

Metacarpal neck fracture (typically the fourth or fifth, or both) happens when a closed fist hits a hard surface (like a wall). The hand is swollen and tender, and x-rays are diagnostic. Treatment depends on the degree of angulation, displacement, or rotary malalignment: closed reduction and ulnar gutter splint for the mild fractures vs. wire or plate fixation for markedly displaced fractures.

Carpal tunnel syndrome occurs following repetitive hand work such as typing and presents with numbness and tingling in both hands in the distribution of the median nerve (radial 3½ fingers). The symptoms can be reproduced by hanging the hand limply for a few minutes, or by tapping, percussing, or pressing the median nerve over the carpal tunnel (Tinel sign). The diagnosis is clinical, but x-rays should be performed to rule out other pathology. Initial treatment is splinting and anti-inflammatory agents. If these conservative measures fail, perform electromyography and nerve conduction velocity testing and surgically release.

Stenosing tenosynovitis ("**trigger finger**") is more common in women than men and presents with acute finger flexion and the inability to extend it unless pulled with the other hand, which results in a painful "snap." Steroid injection is the first line of treatment; surgery is the treatment of last resort.

De Quervain tenosynovitis is more common in women than men and is often seen after pregnancy. Repetitive activities with the thumb in extension and abduction (pinching, grasping) result in irritation and inflammation of the thumb extensor tendons. Patients complain of pain along the radial side of the wrist and the first dorsal compartment. On physical exam the pain can be reproduced by asking her to hold the thumb inside her closed fist, then forcing the wrist into ulnar deviation. Splint and anti-inflammatory agents can help, but steroid injection is most effective. Surgery is rarely needed.

Clinical Pearl

Scaphoid fracture is notorious for a very high rate of nonunion, secondary to avascular necrosis.

Dupuytren contracture occurs in older men of Norwegian ancestry and in alcoholics. There is contracture of the palm of the hand, and palmar fascial nodules can be felt. Urgent surgery may be necessary but is usually not required.

A **felon** is an abscess in the pulp of a fingertip, often secondary to a neglected penetrating injury. Patients complain of throbbing pain and have all the classic findings of an abscess, including fever. Because the pulp is a closed space with multiple fascial trabecula, pressure can build up and lead to tissue necrosis; urgent surgical drainage is necessary. **Do not confuse this with a paronychial infection**.

Gamekeeper's thumb (or skier's thumb) is an injury of the ulnar collateral ligament sustained by forced hyperextension of the thumb. On physical exam there is collateral laxity at the thumb-metacarpophalangeal joint. If untreated, it can be dysfunctional and painful and lead to arthritis. Manage with casting.

Jersey finger is an avulsion injury to the flexor digitorum profundus tendon sustained when the flexed finger is forcefully extended (as in someone unsuccessfully grabbing a running person by the jersey). When making a fist, the distal phalanx of the injured finger does not flex with the others.

Mallet finger is the opposite: the extended finger is forcefully flexed (a common volleyball injury), and the extensor tendon is ruptured. The tip of the affected finger remains flexed when the hand is extended, resembling a mallet. For both injuries, **splinting** is the first line of treatment.

Traumatically amputated digits are surgically reattached whenever possible. The amputated digit should be cleaned with sterile saline, wrapped in a saline-moistened gauze, placed in a sealed plastic bag, and the bag placed on a bed of ice. The digit should not be placed in antiseptic solutions or alcohol, should not be put on dry ice, and should not be allowed to freeze.

> A 55-year-old woman falls in the shower and injures her right shoulder. She presents to the ED with her arm held close to her body and rotated outward. She is in pain and will not move the arm from that position. There is numbness in a small area of her shoulder over the deltoid muscle.

This is a typical description of an anterior dislocation of the shoulder with axillary nerve damage. Diagnose with AP and lateral x-rays and reduce.

> A 22-year-old woman with epilepsy presents to the ED following a grand mal seizure. She has recovered her mental status and complains of pain in her right shoulder, which she cannot move. AP and lateral x-rays do not demonstrate any abnormality.

Despite the normal x-ray, this is a common presentation of a posterior dislocation of the shoulder. Perform axillary view or scapular lateral view x-rays to confirm and then reduce.

Clinical Pearl

Historically, gamekeeper's thumb was suffered by gamekeepers when they killed rabbits by dislocating their necks with an extended thumb. On the exam, this is more likely to present as a skiing-related injury, as the thumb gets stuck in the ski strap during a fall.

A 19-year-old woman falls on an outstretched hand and presents to the ED complaining of wrist pain. On physical examination there is tenderness to palpation over the snuff box; AP and lateral x-rays demonstrate no abnormality.

Another classic scenario, this is a fracture of the scaphoid bone (carpal navicular). These are notorious because x-rays will not show them for 2–3 weeks, and they have a high rate of non-union due to avascular necrosis. The history and physical findings are sufficient to justify the use of a thumb spica cast, with repeat x-rays 2–3 weeks later.

A 19-year-old woman falls on an outstretched hand and presents to the ED complaining of wrist pain. On physical examination there is tenderness to palpation over the snuff box; AP and lateral x-rays demonstrate displaced scaphoid fracture.

Displaced and angulated scaphoid fractures require open reduction and internal fixation.

During a barroom fight, a 22-year-old man punches a bystander and ends up in the ED with a swollen and tender right hand. X-ray shows fractures of the fourth and fifth metacarpal necks.

A common cause of this fracture pattern. Treatment depends on the degree of angulation, displacement, and malalignment: closed reduction and splint for mild fractures, wire/plate fixation for more severe fractures.

A 48-year-old man breaks his arm when he falls down the stairs. X-rays demonstrate an oblique fracture of the middle to distal thirds of the humerus. Physical examination shows that he cannot dorsiflex his wrist.

Fractures of the humeral shaft can injure the radial nerve, which courses in a spiral groove right around the posterior aspect of that bone. However, surgical exploration is not usually needed. A hanging arm cast or coaptation splint are used, and the nerve function returns eventually. However, if the nerve was okay when the patient came in and becomes paralyzed after closed reduction of the bone, the nerve has been trapped; surgical exploration is necessary.

A 33-year-old carpenter accidentally drives a small nail into his index finger, but it stops bleeding and he applies a bandage. Two days later he shows up in the ER with throbbing pain, fever, and redness.

This kind of abscess is called a felon, and like all abscesses it must be drained. This should be done urgently, as it is a tight space and delay can lead to compartment syndrome and necrosis. **Do not confuse this with a paronychial infection**.

As a young man falls while skiing, he jams his thumb into the snow. Physical examination shows collateral laxity at the thumb metacarpophalangeal joint.

Historically called "gamekeeper's thumb," this is an injury to the ulnar collateral ligament of the thumb. It should be casted; otherwise dysfunctional joint and long-term arthritis may occur.

Emergency medical services arrives at the scene of a factory accident where a 32-year-old man has severed his right index finger.

Clean the digit with sterile saline, wrap it in saline-moistened gauze, and place it in a plastic bag on a bed of ice. Transport to the nearest center that performs reimplantation.

Lower Extremities

Hip fracture is a misnomer for fractures that involve the proximal femur. These fractures typically occur in the elderly following a fall; the hip hurts and the patient's position in the stretcher is one in which the affected leg is shortened and externally rotated. Treatment depends on precise location.

Femoral neck fracture, particularly if displaced, compromises the tenuous blood supply of the femoral head. To achieve faster healing and earlier mobilization, replace the femoral head with a prosthesis.

Intertrochanteric fracture is less likely to lead to avascular necrosis and is usually treated with open reduction and pinning. The unavoidable immobilization increases risk for DVT/PE, mandating chemical and mechanical prophylaxis.

Femoral shaft fracture (common) often requires operative management in adults with intramedullary rod fixation.

- If bilateral or comminuted, may result in significant blood loss and hemodynamic instability; external fixation may control some degree of hemorrhage
- If open, it is an orthopedic emergency requiring irrigation and closure in the OR within 6 hours

Posterior dislocation of the hip occurs when the femur is driven backward, such as in a head-on car crash where the knees hit the dashboard. The patient has hip pain and lies in the stretcher with the leg shortened, adducted, and internally rotated. Because of the tenuous blood supply of the femoral head, emergency reduction is needed to avoid avascular necrosis.

Knee injury typically produces swelling of the knee; any knee pain without swelling is unlikely to be a serious knee injury. Collateral ligament injury is usually sustained when the force of impact is at the side of the knee, a common sports injury. Medial forces to the knee generally result in disruption of the lateral ligament, and vice versa.

- The knee will be swollen, and there is localized pain by direct palpation on the affected side.
- With the knee flexed 30°, passive abduction or adduction will produce pain on the torn ligaments and allow further displacement than the normal leg.

Clinical Pearl

With femoral fracture, be alert for fat embolism leading to severe respiratory distress, which typically requires mechanical ventilation. This is rare occurrence, but is a concept often seen on the exam.

Clinical Pearl

The leg is also shortened due to a hip fracture, but then it tends to be externally rotated, as opposed to in a posterior dislocation where it is internally rotated.

- Abduction demonstrates the medial injuries (valgus stress test), whereas adduction diagnoses the lateral injuries (varus stress test).
- Diagnosis is made with MRI.
- Isolated injuries are treated with a hinged cast.
- When several ligaments are torn, surgical repair is preferred.

Anterior cruciate ligament (ACL) injury is more common than posterior injury.

- There is severe knee swelling and pain.
- With the knee flexed 90°, the lower leg can be pulled anteriorly, like a drawer being opened ("anterior drawer test").
- A similar finding can be elicited with the knee flexed at 20° by grasping the thigh with one hand and pulling the leg with the other (Lachman test).

Posterior cruciate ligament (PCL) injury produces the opposite findings on physical exam. MRI is diagnostic. Sedentary patients may be treated with immobilization and rehabilitation, whereas athletes require arthroscopic reconstruction.

Clinical Pearl

Injuries to the medial meniscus, medial collateral, and anterior cruciate often occur simultaneously.

Meniscal tear is difficult to diagnose clinically and on x-rays but is clearly demonstrated on MRI.

- Protracted pain and swelling after a knee injury with tenderness on exam
- Possible "catching and locking," which limits knee motion, and a "click" when the knee is forcefully extended
- Treatment is arthroscopic repair with attempt to preserve as much meniscus as possible; complete meniscectomy leads to the late development of degenerative arthritis

Posterior dislocation of the knee can result in an injury to the popliteal artery. Following reduction of the dislocation, the popliteal artery must be evaluated with U/S. If distal pulses were absent and returned following reduction, U/S may identify an intimal flap or local dissection. This would mandate further evaluation with CT angiogram. If pulses remain absent or U/S demonstrates a significant injury, surgical exploration is indicated. Delayed restoration of flow may require a prophylactic fasciotomy.

Tibial stress fractures ("shin splints") are most commonly seen in athletes and military trainees. There is tenderness to palpation over a very specific point on the bone, but x-ray is initially normal. Treat with a cast or non-weight bearing on crutches, and repeat the x-ray in 2 weeks.

Clinical Pearl

Because of the superficial location of the tibia, many fractures are open. These require surgical exploration for debridement, irrigation, and internal fixation.

Leg fracture involving the tibia and fibula is often seen when a pedestrian is hit by a car. Physical exam shows angulation; x-rays are diagnostic. Treatment is casting for fracture that is easily reduced and intramedullary nailing for fracture that is not easily reduced.

Compartment syndrome is an emergency that may be missed in the absence of a high index of suspicion. It occurs most frequently in the forearm or lower leg.

- Precipitating events include prolonged ischemia followed by reperfusion, crushing injuries, or other types of trauma; in the lower leg, by far the most common cause is a tibia/fibula fracture with closed reduction.
- The patient has pain and limited use of the extremity; palpation of soft tissue within the compartment feels very tight and tender to palpation. The most reliable physical finding is pain with passive extension.

- Pulses may be normal because tissue ischemia will result if compartment pressure exceeds the capillary perfusion pressure (~20–25 mm Hg), but distal pulses will remain until compartment pressure is greater than the mean arterial pressure (typically 50–60 mm Hg).
- Emergency fasciotomy is required for treatment.

Rupture of the Achilles tendon is often seen in middle-aged recreational athletes who subject themselves to severe strain (e.g., tennis). As they plant the foot and change direction, a loud popping noise is heard (like a rifle shot), and they fall clutching the ankle. Limited plantarflexion is still possible, but pain, swelling, and limping bring them to seek medical attention. Palpation of the tendon reveals a gap. Historically these injuries were treated with casting in equinus position; surgical repair is now the treatment of choice.

Fracture of the ankle occurs when falling on an inverted or everted foot. In either case, both malleoli break. AP, lateral, and mortise (angled) x-rays are diagnostic. If the fragments are displaced, open reduction and internal fixation are indicated.

Plantar fasciitis is a very common but poorly understood problem presenting with disabling, sharp pain on the sole of the foot or heel every time the foot contacts the ground. It tends to be worse in the morning. Physical exam is significant for exquisite tenderness to palpation, and X-ray may demonstrate a bone spur (although this may be incidental, as many patients have asymptomatic bone spurs). Management is symptomatic relief with eventual self-resolution.

Morton neuroma is an inflammation of the common digital nerve at the third interspace, between toes 3 and 4. The neuroma is palpable and exquisitely tender to palpation. The cause is typically the use of pointed, high heel shoes (or pointed cowboy boots) that force the toes to be bunched together. Management includes analgesics and more sensible shoes, but surgical excision can be performed if conservative management fails.

Gout typically produces swelling, redness, and exquisite pain of sudden onset at the first metatarsophalangeal joint in middle-aged obese men with high serum uric acid. Uric acid crystals are identified in fluid from the joint. Treatment for the acute attack is indomethacin and colchicine; treatment for chronic control is allopurinol and probenecid.

> A 77-year-old man falls in the nursing home and hurts his hip. He presents with the affected leg shortened and externally rotated. X-ray demonstrates a displaced femoral neck fracture.

The blood supply to the femoral head is compromised with femoral neck fractures; the patient is better off with a metal prosthesis rather than pinning the fracture.

> A 77-year-old man falls in the nursing home and hurts his hip. He presents with the affected leg shortened and externally rotated. X-ray demonstrates an intertrochanteric fracture.

There is less concern for avascular necrosis, and therefore these are repaired by open reduction and pinning. This is a prime setting for DVT, so the exam question may be geared toward prophylaxis.

Clinical Pearl

Falls from a significant height landing on the feet may have obvious leg or ankle fractures, but fractures of the lumbar or thoracic spine may be less obvious and must be assessed.

> An unrestrained woman in the front seat of a car crashes and sustains closed comminuted fractures of both femoral shafts. Shortly after presentation to the ED, she develops blood pressure 80/50 mm Hg and pulse 120/min. Abdominal and chest exam are normal. Focused abdominal sonography for trauma (FAST), chest x-ray, and pelvic x-ray are normal.

This is a throwback to the trauma vignettes to remind you that femur fractures can bleed significantly, and even cause hypovolemic shock. A full trauma evaluation is necessary to rule out other sources of bleeding, but manage these with external fixation and blood and fluid resuscitation until stable enough for definitive open reduction and internal fixation.

> An unrestrained woman in the front seat of a car crashes and sustains closed comminuted fractures of both femoral shafts. The fractures are externally fixated, and she is resuscitated. After remaining hemodynamically stable, she is transferred to the surgical ICU with plans for open fixation in the morning. Four hours after admission, she develops dyspnea, disorientation, and fever. Oxygen saturation is 84% on 4 L via nasal cannula.

Femoral fractures can lead to fat embolism presenting as respiratory distress or as severe as hypoxemic respiratory failure. Although rare, this is often tested. Support with supplemental oxygen and mechanical ventilation if necessary.

> The unrestrained front seat passenger in a car that crashes presents with pain in the right hip. He is hemodynamically stable and neurologically intact. On exam he is found to have a shortened right lower extremity that is adducted and internally rotated.

This is an orthopedic emergency: posterior dislocation of the hip. The blood supply of the femoral head is tenuous, and delay in reduction could lead to avascular necrosis. Confirm with x-ray and urgently reduce once other traumatic injuries have been ruled out.

> A college student tackled from the right side while playing football develops severe right knee pain. When examined shortly thereafter the knee is swollen, and he has pain on direct palpation over the medial aspect of the knee.

This is most likely an injury to the medial collateral ligament. Physical examination findings will likely include pain with passive abduction and an inability to abduct as far as the contralateral leg. MRI is diagnostic. A hinged cast is typically enough, but if multiple ligaments are injured surgical repair may be required.

A college student tackled while playing football develops severe knee swelling and pain. On physical examination with the knee flexed at 90°, the leg can be pulled anteriorly.

This is more likely an injury to the anterior cruciate ligament, with physical exam describing a positive anterior drawer test. Confirm with MRI. Sedentary patients may be treated just with immobilization and rehabilitation, but this patient is young and athletic and will require surgical repair.

A 19-year-old Army private presents to the base physician complaining of localized pain in his anterior leg. He is tender to palpation over the mid-tibia. X-ray is normal.

This is likely a tibial stress fracture, common in athletes and soldiers from overuse. They are not apparent on x-ray for up to several weeks. Presume there is a fracture and either cast or prescribe non-weight bearing with crutches for 2 weeks; then repeat the x-ray.

A pedestrian is hit by a car. Physical examination shows the leg to be angulated midway between the knee and the ankle. X-ray confirms fractures to the shaft of the tibia and fibula.

Leg fractures that are closed and can be easily reduced are managed with a cast; those that are open or cannot be aligned need open reduction and internal fixation, typically with an intramedullary nail.

A pedestrian is hit by a car. Physical examination shows the leg to be angulated midway between the knee and the ankle. X-rays confirm fractures of the shaft of the tibia and fibula. Satisfactory alignment is achieved, and a leg cast applied. In the ensuing 8 hours, the patient complains of increasing pain. When the cast is removed, the pain persists, the muscle compartments feel tight, and there is significant pain with passive extension of the toes. A dorsalis pedis pulse is palpable.

Compartment syndrome is a distinct hazard after fractures of the leg (and forearm). Urgent fasciotomy is indicated, as the symptoms did not improve with cast removal alone. Note that the presence of a pedis pulse does not rule out compartment syndrome.

A 49-year-old surgeon is playing a vigorous game of tennis when a loud "pop" is heard and he falls to the ground clutching his ankle. He limps off the courts, with pain and swelling in the back of the lower leg. He is still able to dorsiflex his foot.

This is a classic presentation for rupture of the Achilles tendon. Open surgical repair is the fastest option, although reasonable healing will eventually occur if casted in equinus position.

While running to catch a bus, an old man twists his ankle and falls on his inverted foot. X-rays demonstrate displaced fractures of both malleoli.

A very common injury. When the foot is forcefully rotated (in either direction), the talus pushes and breaks one malleolus and pulls off the other one. Open reduction and internal fixation are needed in this case because the fragments are displaced.

A window cleaner falls from a third story scaffold and lands on his feet. Physical examination and x-ray show comminuted fractures of both calcanei.

Obviously, the ankle fractures must be managed, but don't forget to evaluate for associated injuries based on the mechanism: compression fractures of the thoracic or lumbar spine. Start with x-ray. MRI may be necessary.

A 55-year-old obese man with diabetes and hypertension develops acute swelling, redness, and exquisite pain at the first metatarsophalangeal joints. He reports no history of trauma.

This presentation is consistent with an acute attack of gout. The joint is aspirated, and fluid analysis will demonstrate uric acid crystals. Treatment of the acute attack is indomethacin and colchicine. Long-term control of serum uric acid is done with allopurinol or probenecid.

Back

Clinical Pearl

If the "lightning" exits the foot by the big toe, it is L4–L5; if exits by the little toe, it is L5–S1.

Lumbar disk herniation occurs most commonly around age 45 at L4–L5 or L5–S1.

- Symptoms include several months of vague aching pain ("discogenic pain" produced by pressure on the anterior spinal ligament) before a sudden onset of "neurogenic pain" precipitated by a forced movement (patients cannot ambulate and they hold the affected leg flexed).
  - Neurogenic pain is often severe and characterized as "an electrical shock shooting down the leg"; it is exacerbated by coughing, sneezing, or defecating.
  - If the pain is not exacerbated by these activities, the problem is not a herniated disk.
- Straight leg-raising test reproduces excruciating pain and MRI confirms the diagnosis.
- Treatment for most patients is bed rest, physical therapy, and pain control, often enhanced by a regional nerve block. Surgical intervention is needed if neurologic deficits are progressing; emergency intervention is needed in the presence of cauda equina syndrome (distended bladder, flaccid rectal sphincter, or perineal saddle anesthesia).

Clinical Pearl

Many patients with ankylosing spondylitis have the HLA B-27 antigen, which is associated with other autoimmune disorders including inflammatory bowel disease and uveitis.

Ankylosing spondylitis is seen in men in decades 3–4 of life and presents with chronic back pain and morning stiffness. The pain is worse at rest and improves with activity. Symptoms are progressive, and x-rays reveal a "bamboo spine." Anti-inflammatory agents and physical therapy are effective.

Metastatic malignancy should be suspected in patients who have progressive back pain that is worse at night and unrelieved by rest or positional changes. It is often associated with weight

loss. The most common pathology is breast cancer metastases in women (lytic lesions) and prostate metastases in men (blastic lesions). Most are identifiable on x-ray, but CT and MRI are more sensitive. Pathological fractures are managed like any nonmalignant fractures.

> A 46-year-old man has sudden onset of severe back pain as he tries to lift a heavy object. The pain is like an electrical shock that shoots down his leg, and it prevents him from ambulating. On physical exam a straight leg-raise causes excruciating pain, and a flaccid rectal sphincter is noted.

Although likely caused by an acutely herniated disc, the presence of cauda equina syndrome is a surgical emergency.

> A 42-year-old man presents for further evaluation of back pain. He reports it has been present for 5–6 years but is intermittent. It manifests as morning stiffness and is worse at rest, but improves with activity. Two years ago he was treated for uveitis.

Think ankylosing spondylitis with progressive back pain and signs of autoimmune disorders. X-ray will eventually show "bamboo spine." Treatment is anti-inflammatory agents and physical therapy.

> A 72-year-old man presents with low back pain that is worse at night and not relieved by positional changes or over-the-counter analgesics. He is noted to have a 20-pound weight loss since his last visit, with no change in appetite.

Although back pain is common and often benign, weight loss is a red flag for possible malignancy. In this demographic, metastatic prostate cancer is a serious consideration. Include a prostate exam in your physical examination, and perform an x-ray and then likely an MRI.

Oncology

Most malignant bone tumors in adults are metastatic, from breast cancer in women (lytic lesions) and from prostate cancer in men (blastic lesions). Localized pain is an early finding. X-rays can be diagnostic, CT scans give more information, and MRI is even more sensitive. Lytic lesions commonly present as pathologic fractures.

Multiple myeloma is seen in older men and presents with fatigue, anemia, and localized pain at specific places on several bones. X-rays are diagnostic, showing multiple, "punched-out" lytic lesions. Urine protein electrophoresis (UPEP) demonstrates Bence-Jones protein, and abnormal immunoglobulins are seen in the blood on serum protein electrophoresis (SPEP). Treatment is chemotherapy.

Soft tissue sarcoma has relentless growth of soft tissue mass over several months. It is firm and typically fixed to surrounding structures. They can metastasize hematogenously to the lungs but do not invade the lymphatic system. MRI delineates the extent of the mass and degree of local invasion. Incisional biopsy to obtain tissue is diagnostic. Treatment includes wide local excision, radiation, and chemotherapy. Vascular reconstruction should be considered to enable limb-salvage surgeries.

Clinical Pearl

- In women, bone metastases are commonly due to lytic bone lesions from breast cancer (first) and lung cancer (second).
- In men, the most common etiology is prostate cancer, but metastatic lung cancer lesions more commonly result in pathological fractures.

Clinical Pearl

For metastatic malignancy, consider systemic treatment with chemotherapy, hormone therapy, or immunotherapy. Bone lesions have a better response compared with other sites of metastatic cancer.

> A 66-year-old woman picks up a bag of groceries and hears a snap. She presents to the ED in severe pain and is found to have a humerus fracture.

A pathologic fracture (i.e., for trivial reasons) is highly concerning for metastatic cancer. In older women, as in this case, this is most likely metastatic breast or lung cancer. Manage the fracture and workup for a primary cancer.

> A 60-year-old man complains of fatigue and pain at specific places on several bones. He is found to be anemic. X-ray shows multiple punched out lytic lesions throughout the skeleton.

Multiple lytic lesions in an older anemic man suggest multiple myeloma. X-rays are diagnostic, and additional tests include UPEP and SPEP. Treatment is chemotherapy.

> A 58-year-old woman has a soft tissue tumor in her thigh. It has been growing steadily for 6 months. It is located deep into the thigh, is firm and fixed to surrounding structures, and measures 8 cm in diameter.

Soft tissue sarcoma is the concern. Start with MRI to assess extent and neurovascular involvement, followed by incisional biopsy for tissue diagnosis. Management is multimodal consisting of surgery, radiation, and chemotherapy.

PEDIATRIC ORTHOPEDICS

Congenital dysplasia of the hip is familial and ideally should be diagnosed right after birth.

- Physical examination of the hips reveals uneven gluteal folds, and hips that can be easily dislocated posteriorly with a jerk and a "click" and returned to normal with a "snapping."
- If signs are equivocal, U/S is diagnostic. X-ray is not helpful, as the hip is not calcified in the newborn.
- Treatment is abduction splinting with a Pavlik harness for ~6 months.

Legg-Calve-Perthes disease is avascular necrosis of the capital femoral epiphysis and occurs around age 6, with insidious development of limping, decreased hip motion, and hip or knee pain.

- Patients walk with guarded passive motion of the hip and an antalgic gait (i.e., a gait that minimizes pain symptoms, from *anti-*, meaning "against," and *algo-*, meaning "pain").
- Diagnosis is confirmed with AP and lateral hip x-ray.
- Treatment is controversial, usually containing the femoral head within the acetabulum by casting and crutches.

Slipped capital femoral epiphysis (SCFE) (most common hip disorder in adolescents) is an orthopedic emergency because further slippage may compromise the blood supply and result in avascular necrosis of the femoral head. Patients are commonly overweight boys around age 13 who complain of groin or knee pain and ambulate with a limp.

- On physical exam there is limited hip motion, and as the hip is flexed the thigh goes into external rotation and cannot be rotated internally.
- Diagnostic testing is with x-ray.
- Treatment is surgical, e.g., pins to hold the femoral head back in place.

Septic hip (orthopedic emergency) is seen in toddlers who have had a febrile illness and then refuse to move the hip, i.e., they hold in flexed position with slight abduction and external rotation and experience pain with passive movement of the joint such as a diaper change.

- WBC count and erythrocyte sedimentation rate are elevated.
- Diagnosis is made by aspiration of the hip under general anesthesia, and surgical irrigation and open drainage are performed if pus is obtained.

Acute hematogenous osteomyelitis occurs in children who have had a febrile illness and presents as severe localized pain in a bone with no history of trauma.

- Diagnosis is with MRI, as x-ray will not be revealing for several weeks.
- Treatment is IV antibiotics.

Genu varum (bow-legs) is normal up to age 3; no treatment is needed. Persistent varus >3 years old is most commonly Blount disease, a disturbance of the medial proximal tibial growth plate for which surgery is corrective. **Genu valgus (knock-knee)** is normal age 4–8; no treatment is needed.

Osgood-Schlatter disease (osteochondrosis of the tibial tubercle) is seen in teenagers with persistent pain right over the tibial tubercle, which is aggravated by contraction of the quadriceps.

- Physical exam shows localized pain right over the tibial tubercle in the absence of knee swelling.
- Treatment is rest, ice, compression, and elevation. If there is no response, immobilize the knee in an extension or cylinder cast for 4–6 weeks.

Clubfoot (talipes equinovarus) presents at birth: both feet are turned inward and there is plantar flexion of the ankle, inversion of the foot, adduction of the forefoot, and internal rotation of the tibia. Serial plaster casts started in the neonatal period provide sequential correction starting with the adducted forefoot, then the hindfoot varus, and last the equinus. About 50% of patients with clubfoot are fully corrected this way. The other 50% require surgery after age 6–8 months, but before age 1–2 years.

Scoliosis is seen in adolescents and occurs when the thoracic spine is curved >10° to the right or left. The deformity progresses until skeletal maturity is reached (at the onset of menses, skeletal maturity is ~80%). In addition to the cosmetic deformity, severe cases develop decreased pulmonary function.

- Diagnosis is with physical exam from behind, with the patient bending forward.
- Treatment is bracing, which can arrest progression and surgery for severe cases.

> In the newborn nursery of a hospital, a child is noted to have uneven gluteal folds. Physical examination reveals that the right hip can be palpably dislocated posteriorly.

This is a straightforward description of developmental dysplasia of the hip (congenital dislocation of the hip). Physical examination should suffice, but if there is any doubt do an U/S. Treatment is abduction splinting using a Pavlik harness.

> A 6-year-old boy has progressive limping with decreased hip motion. He complains occasionally of knee pain on that side. Passive motion of the hip is guarded.

In this age group, the most likely diagnosis is Legg-Calve-Perthes disease (avascular necrosis of the capital femoral epiphysis). Remember that hip pathology can show up with knee pain. Diagnose with AP and lateral x-ray. Management is containment of the femoral head within the acetabulum by casting and crutches.

> A 13-year-old obese boy complains of pain in the thigh and knee and his mother reports progressive limping. Physical examination is normal for the knee but shows limited hip motion. As the hip is flexed, the leg rotates externally and cannot be rotated internally.

Although the physical exam findings are classic, the age group and chief complaint are enough to make the most likely diagnosis slipped capital femoral epiphysis, an orthopedic emergency. Confirm with anteroposterior and lateral x-rays, and manage surgically with femoral head fixation.

> A 3-year-old boy demonstrates limited mobility. His mother carries him into the ED and reports the symptoms started a few days after he had a "cold" that was going around the house. He appears to be in pain and holds the leg with the hip flexed, in slight abduction and external rotation. You cannot examine that hip with eliciting pain.

This presentation is very concerning for a septic hip, another orthopedic emergency. Check bloodwork, including a CBC and ESR, and aspirate the hip to confirm the diagnosis. Treatment is drainage via open arthrotomy.

> An 8-year-old boy is brought to the pediatrician due to unrelenting mid-tibial pain. His mother reports no trauma, but he did have a "cold" that went around the house the previous week, including high fever.

The "cold" was likely a bacterial infection that has now seeded the bone and caused acute hematogenous osteomyelitis. MRI is diagnostic (x-ray will not be revealing for several weeks). Administer IV antibiotics.

A 14-year-old boy says he injured his knee while playing football. Although there is no swelling of the knee joint, he complains of persistent pain right over the tibial tubercle, which is acutely tender to palpation.

Osteochondrosis of the tibial tubercle (Osgood-Schlatter disease) is often mistaken for a sports-related injury, but there is no joint swelling and the tenderness is focal at the tibial tuberosity. Treatment is conservative: rest, ice, compression, and mobilization. If symptoms progress, immobilize the knee in a cast for 4–6 weeks.

Fracture

Pediatric fractures are different from adult fractures in 2 ways:

- The rate of healing is much faster in children.
- Remodeling occurs to a greater degree in children, allowing for tolerance of angulation that would be acceptable in adults.

There are 2 exceptions to note: supracondylar fractures of the humerus and fractures of any bones that involve the growth plate or epiphysis.

- Supracondylar fractures of the humerus (after hyperextension of the elbow in a child who falls on the hand with arm extended)
  - These injuries are particularly dangerous due to the proximity of the brachial artery and ulnar nerve.
  - Although treatment is standard casting or traction, it requires careful monitoring of vascular and nerve integrity and vigilance regarding the development of compartment syndrome.
- Fractures that involve the growth plate or epiphysis
  - Salter-Harris (SH) classification is used to grade epiphyseal fractures; SH I and II fractures can often be managed without surgery, but ≥III typically require operative management.
  - Treatment is closed reduction if the fracture does not cross the growth plate or involve the joint.
  - Treatment is open reduction and internal fixation if the growth plate is fractured into 2 pieces; this will ensure precise alignment and even growth to avoid chronic deformity of the extremity.

A 4-year-old boy falls down the stairs and fractures his humerus. He is placed in a cast at the nearby urgent care center and seen by his regular pediatrician 2 days later. He does not appear to be in pain; however, the x-ray demonstrates significant angulation of the broken bone.

No intervention is indicated. Except for rotational deformities, children have such tremendous ability to heal and remodel broken bones that almost any reasonable alignment and immobilization will end up with a good result.

An 8-year-old boy falls on his right hand with the arm extended and presents to the ED in significant pain. X-ray reveals a supracondylar fracture of the humerus. The distal fragment is displaced posteriorly.

This type of fracture is common in children, but it is significant because it may produce vascular or nerve injury (or both) and thus result in a Volkmann contracture. Although it can usually be treated with appropriate casting or traction, a careful vascular and neurological exam is mandatory to rule out traumatic injury, as well as to assess continuously for compartment syndrome.

Pediatric Orthopedic Oncology

Primary malignant bone tumors are diseases of young people. They present with persistent low-grade pain for several months.

Osteogenic sarcoma (most common primary malignant bone tumor):

- Seen age 10–25, usually around the knee (lower femur or upper tibia)
- Typical "sunburst" pattern often described on x-ray

Ewing sarcoma (second most common malignant bone tumor):

- Seen in younger children (age 5–15)
- Grows in the diaphyses of long bones
- Typical "onion skinning" pattern often described on x-ray

A 16-year-old boy complains of low-grade but constant pain in the distal femur present for several months. He has local tenderness in the area but is otherwise asymptomatic. X-ray shows a large bone tumor breaking through the cortex into the adjacent soft tissues and exhibiting a "sunburst" pattern.

A 10-year-old complains of persistent pain deep in the middle of the thigh. X-ray shows a large, fusiform bone tumor pushing the cortex out and producing periosteal "onion skinning."

Primary malignant bone tumors are also diseases of young people. The extent of the exam is diagnosis and recognition of the x-ray patterns of each; management is highly specialized and unlikely to be tested.

Cardiovascular Surgery 5

Learning Objectives

- ❑ Recognize presentation, diagnosis, and management of pediatric and adult heart problems
- ❑ Describe surgical issues related to diseases of the lung
- ❑ Recognize the common etiologies of mediastinal masses
- ❑ Comprehend the common procedures in vascular surgery, including indications, complications, and alternatives

CONGENITAL HEART DISEASE

Vascular ring is an aberrant formation of the aorta and great vessels that creates extrinsic compression of the trachea and/or esophagus.

- Initial symptoms include stridor and episodes of respiratory distress with "crowing" respiration, during which the baby assumes a position with an extended neck (relieves the compression).
- Later symptoms revolve around difficulty with feeding or swallowing.
- If only the respiratory symptoms are present, consider tracheomalacia.

Barium swallow demonstrates extrinsic compression from the abnormal vessel. Bronchoscopy shows segmental tracheal compression and rules out diffuse tracheomalacia. CT or MRI will help to reveal details of the vascular anatomy and help plan for surgical repair. Surgery divides the smaller of the two aortic arches.

Cardiac anomalies (congenital or acquired) are best diagnosed with an echocardiogram.

Left-to-right shunts share the presence of a loud, holosystolic (pansystolic) murmur and overloading of the pulmonary circulation, with resultant long-term damage to the pulmonary vasculature. The volume and consequences of the shunt vary depending upon their location.

- **Atrial septal defect** (ASD) has a very minor, low-pressure, low-volume shunt. Patients typically grow into late infancy before it is recognized. A faint pulmonary flow systolic murmur and fixed split second heart sound are characteristic. A history of frequent colds is elicited. Echocardiogram is diagnostic. Treatment is surgical or percutaneous closure.

- **Ventricular septal defect** (VSD) can range from minor to significant:
  - Small, restrictive defects low in the muscular septum have minimal pathophysiological effect and typically close spontaneously by age 3.
  - Defects high in the membranous septum (more common) can be more problematic, resulting in "failure to thrive," a loud pansystolic murmur best heard at the left sternal border, and increased pulmonary vascular markings on chest x-ray. Diagnose with an echocardiogram and close surgically.
- **Patent ductus arteriosus** becomes symptomatic in the first few days of life if it does not close spontaneously. There are bounding peripheral pulses and a continuous "machinery-like" heart murmur. Echocardiogram is diagnostic.
  - In premature infants who have not gone into heart failure, closure can be achieved with indomethacin.
  - In those that do not close, infants who are in heart failure, and full-term babies, surgical ligation via left thoracotomy or percutaneous endovascular closure is needed.

Clinical Pearl

If a baby goes home after birth and later develops cyanosis, the most likely diagnosis is tetralogy. If a baby is blue from infancy, the most likely diagnosis is transposition.

Right-to-left shunts share the presence of a murmur, diminished lung vascular markings in the lung, and cyanosis. Although 5 are always described (all beginning with the letter T), only the most common are typically are tested:

- **Tetralogy of Fallot** (4 abnormalities): VSD, pulmonary stenosis, overriding aorta, and right ventricular hypertrophy.
  - Although crippling, children do grow into infancy.
  - Children are small for their age, have a bluish hue in the lips and tips of their fingers, clubbing, and spells of cyanosis relieved by squatting ("Tet spells").
  - There is a systolic ejection murmur in the left third intercostal space, a small heart, diminished pulmonary vascular markings on chest x-ray, and EKG signs of right ventricular hypertrophy.
  - Echocardiogram is diagnostic; treatment is surgical repair.
- **Transposition of the great vessels** diagnosis is often made prenatally, and if not it becomes apparent shortly after birth due to severe cyanosis and failure to thrive. Children are kept alive by an ASD, VSD, or patent ductus (or a combination), but die very soon if not corrected. Suspect this diagnosis in a child age 1–2 days with cyanosis who is quite ill; perform an echocardiogram and proceed with urgent surgical repair.

Note

Tetralogy of Fallot is the most common cyanotic anomaly. On the exam, this is likely to be the answer for any question that asks about a cyanotic child age 5–6.

A 6-month-old girl has episodes of respiratory distress and audible stridor. She appears to be relieved when assuming a hyperextended position. The family has also noted mild difficulty in swallowing.

The combination of pressure on the esophagus and pressure on the trachea identifies a vascular ring. Barium swallow will show a typical extrinsic compression from the abnormal vessel. Bronchoscopy confirms the segmental tracheal compression and rules out diffuse tracheomalacia. Surgical repair is done by dividing the smaller of the double aortic arches.

During a school physical exam, a 12-year-old girl is found to have a heart murmur. She is referred for further evaluation. An alert cardiology fellow recognizes that she indeed has a pulmonary flow systolic murmur, but he also notices that she has a fixed split second heart sound. A history of frequent colds and upper respiratory infections is elicited.

This is a case of ASD. Echocardiography will establish the diagnosis. Close the defect percutaneously or with open surgery depending on size.

A 3-month-old boy is hospitalized for "failure to thrive." He has a loud, pansystolic heart murmur best heard at the left sternal border. Chest x-ray shows increased pulmonary vascular markings.

This is a classic description of a ventricular septal defect. Echocardiography is diagnostic, and surgical repair is indicated.

A 3-day-old premature baby has trouble feeding and pulmonary congestion. Physical examination shows bounding peripheral pulses and a continuous, machinery-like heart murmur. Shortly thereafter, the baby develops hypotension and tachycardia.

This vignette describes a child with a patent ductus arteriosus who has now progressed to heart failure. Echocardiography is diagnostic, and since he is progressing, surgical ligation is indicated (over pharmacological or catheter-directed closure).

A 3-day-old premature baby girl has mild pulmonary congestion, signs of increased pulmonary blood flow on x-ray, a wide pulse pressure, and a precordial machinery-like murmur. She is not in distress.

This vignette presents the same diagnosis of patent ductus arteriosus but without heart failure, and therefore less urgency. Being premature, this may be amenable to pharmacological closure with indomethacin.

A 6-year-old boy is brought to the United States by his new adoptive parents from an orphanage in Eastern Europe. The boy is small for his age and has a bluish hue in the lips and tips of his fingers. He has clubbing and spells of cyanosis relieved with squatting. He has a systolic ejection murmur in the left third intercostal space. Chest x-ray shows a small heart and diminished pulmonary vascular markings. EKG shows right ventricular hypertrophy.

Various scenarios are used to test tetralogy of Fallot, and this is a common variant where it is not recognized in infancy and progresses. The late presentation rules out Transposition, the next most common cyanotic defect. Confirm with an echocardiogram and repair surgically.

ACQUIRED HEART DISEASE

Aortic stenosis produces angina, syncope, and dyspnea. There is a harsh mid-systolic heart murmur best heard at the right second intercostal space and along the left sternal border. This is typically due to a congenitally bicuspid valve or progressive calcification of a tricuspid valve.

Clinical Pearl

Transcatheter aortic valve replacement (TAVR) is approved for high surgical risk patients, but otherwise standard open surgical valve replacement is the treatment of choice.

Start the workup with an echocardiogram. Surgical valvular replacement is indicated if there is a gradient >50 mm Hg, or at the first indication of CHF, angina, or syncope.

Chronic aortic insufficiency produces a wide pulse pressure ("water hammer pulse") and a blowing, high-pitched, diastolic heart murmur best heard at the second intercostal space and along the left lower sternal border. Patients are often followed with medical therapy for many years but should undergo valvular replacement at the first evidence of left ventricular dilatation on echocardiogram.

Acute aortic insufficiency due to endocarditis is seen in young drug addicts who suddenly develop heart failure and a new, loud diastolic murmur at the right second intercostal space. Emergency valve replacement and long-term antibiotics are needed.

Mitral stenosis is caused by a remote history of rheumatic fever. It presents with dyspnea on exertion, orthopnea, paroxysmal nocturnal dyspnea, cough, and hemoptysis. There is a low-pitched, rumbling diastolic apical heart murmur. As it progresses, patients become thin and cachectic and develop atrial fibrillation. Workup starts with echocardiogram. As symptoms become more disabling, mitral valve repair becomes necessary with a surgical commissurotomy or mitral valve replacement.

Clinical Pearl

MR is typically an indolent, progressive disease. However, a myocardial infarction can cause acute papillary muscle ischemia and acute MR, which is a cardiac surgical emergency.

Mitral regurgitation (MR) is most commonly caused by valvular prolapse but also can be caused by rupture of the chordae tendineae from a myocardial infarction. Patients develop exertional dyspnea, orthopnea, and atrial fibrillation. There is an apical, high-pitched, holosystolic heart murmur that radiates to the axilla and back. Workup and surgical indications are as above, with repair of the valve (annuloplasty) are preferred over prosthetic replacement.

Coronary artery disease (CAD) (**most common type of acquired heart disease in adults**) has a particularly high incidence in men age >45 and post-menopausal women. Risk factors include a history of smoking, sedentary lifestyle, hyperlipidemia, and type II diabetes.

Diagnosis is made with cardiac catheterization if there are indications of progressive, unstable, disabling angina. Percutaneous intervention (angioplasty, stent) is indicated for ≥70% stenosis; the presence of multivessel disease or single vessel disease involving the left main coronary artery are indications for surgical revascularization via coronary artery bypass grafting (CABG). Preferably, the patient should still have good ventricular function, as you cannot resuscitate dead myocardium. The left internal mammary artery is the primary conduit.

Postoperative care of heart surgery often requires that cardiac output be optimized. If cardiac output is considerably under normal (5 liters/min, or cardiac index 3), the pulmonary wedge pressure (or left atrial pressure, or left end-diastolic pressure) should be measured. Low numbers (0–3) suggest hypovolemia requiring volume resuscitation; high numbers (≥20) suggest ventricular failure requiring inotropy or mechanical support (e.g. intra-aortic balloon pump).

Chronic constrictive pericarditis produces dyspnea on exertion, hepatomegaly, and ascites, and shows a classic "square root sign" and equalization of pressures (right atrial, right ventricular diastolic, pulmonary artery diastolic, pulmonary capillary wedge, and left ventricular diastolic) on cardiac catheterization. Surgical pericardiectomy is curative.

A 72-year-old man has a history of angina and exertional syncopal episodes. He has a harsh midsystolic heart murmur best heard at the right second intercostal space and along the left sternal border.

This is a common presentation of aortic stenosis with the triad of angina, dyspnea, and syncope. Diagnose with echocardiogram. Surgical valvular replacement is indicated if gradient >50 mm Hg or at the first indication of CHF, angina, or syncope.

A 35-year-old woman has dyspnea on exertion, orthopnea, paroxysmal nocturnal dyspnea, cough, and hemoptysis. She has had these progressive symptoms for about 5 years. She looks thin and cachectic, and has atrial fibrillation and a low-pitched, rumbling diastolic apical heart murmur. At age 15 she had rheumatic fever.

This is more information than is likely to be provided on the exam but is classic for mitral stenosis. Start with an echocardiogram and eventually surgical mitral valve repair (or replacement) will be necessary.

A 55-year-old lawyer has progressive, unstable, disabling angina that does not respond to medical management. His father and 2 older brothers died of heart attacks at age 50. The patient stopped smoking 20 years ago but still has a sedentary lifestyle, is a bit overweight, has type II diabetes mellitus, and has high cholesterol.

This is a heart attack waiting to happen: this man needs a cardiac catheterization to see whether he is a suitable candidate for coronary revascularization, either percutaneous or surgical.

A 55-year-old lawyer has progressive, unstable, disabling angina that does not respond to medical management. His father and 2 older brothers died of heart attacks at age 50. The patient stopped smoking 20 years ago but still is a bit overweight and has a sedentary lifestyle, type II diabetes mellitus, and high cholesterol. Cardiac catheterization demonstrates 70% occlusion of 3 coronary arteries, with good distal vessels. His left ventricular ejection fraction is 55%.

The patient is lucky. He has good distal vessels (smokers and diabetics often do not) and enough cardiac function left. He clearly needs coronary artery bypass grafting. With triple-vessel disease, he is not a good candidate for a percutaneous intervention.

A 55-year-old lawyer is found to have coronary artery disease and undergoes a coronary artery bypass grafting. Postoperatively he is found to have a cardiac index 1.7 L/min/m^2 and left ventricular end-diastolic pressure of 3 mm Hg.

The postoperative management of open heart surgery is too esoteric for the exam, but a bit of applied physiology is not. Be able to recognize a dangerously low cardiac index without a high end-diastolic pressure, indicative of hypovolemia. Administer fluid.

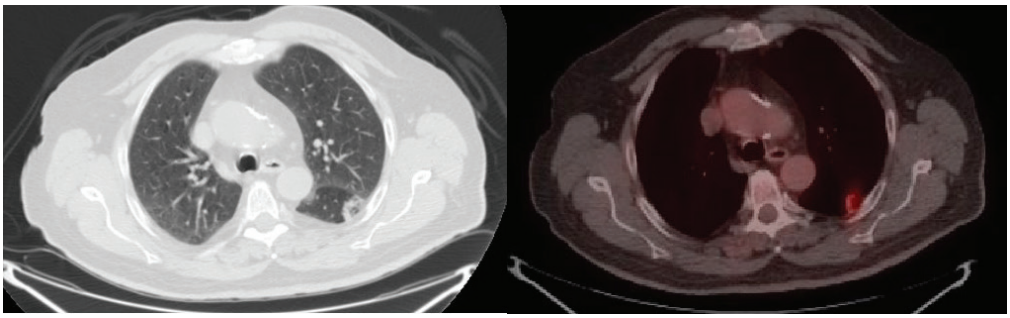
A 55-year-old lawyer is found to have coronary artery disease and undergoes a coronary artery bypass grafting. Postoperatively he is found to have a cardiac output 2.3 L/min. Pulmonary wedge pressure is 27 mm Hg.

Cardiac output is low but wedge pressure is high; this is left ventricular dysfunction. Support pharmacologically with inotropes; if not responsive, consider mechanical support such as an intra-aortic balloon pump.

PULMONARY

A **solitary "coin" lesion** found on chest x-ray has a significant chance of being malignant in people age >50, and even higher if there is a history of smoking.

- Seeking an older x-ray is always the first step when a solitary pulmonary nodule is detected: if the lesion is old, it needs continued interval surveillance; if it is new, it needs further evaluation starting with CT of the chest.
- CT findings and clinical characteristics will determine if further workup is necessary: high suspicion of lung cancer should proceed with a PET scan and then decision whether to obtain a biopsy.
  - If there is a PET-avid lesion in a smoker that is likely to be malignant, consider resection if a reasonable candidate; a false negative biopsy is not helpful.
  - An unclear clinical picture or poor surgical candidate should undergo biopsy via transbronchial fine needle aspiration for central lesions or transthoracic core needle biopsy for peripheral lesions. If unsuccessful, surgical wedge resection or biopsy via video-assisted thoracic surgery (VATS) may be necessary.
  - Factoring into this algorithm is the surgical candidacy of the patient. This includes age, functional status, comorbidities, cardiac disease, degree of lung impairment, and extent of disease and therefore the ability to cure.



Courtesy of Gary Schwartz, MD

Figure 5-1. CT and PET Scan Lung Nodule

Small-cell cancer of the lung is treated with chemotherapy and radiation, so assessment of operability and curative chances with surgery are not applicable. Operability and possibility of surgical cure apply only to non–small-cell cancer.

Clinical Pearl

Small-cell lung cancer is notorious for causing paraneoplastic syndromes; patients may present with Cushing syndrome, myasthenic crisis, and encephalitis, among other presentations.

- The operability of lung cancer is predicated on residual pulmonary function that would be left after resection. Determine how much lung would need to be resected (wedge resection, lobectomy, pneumonectomy) and measure baseline pulmonary function.
- Minimum residual FEV_1 of 800 mL is mandatory to undergo lung resection (less residual function could render the patient a pulmonary cripple—ventilator dependent but cured of cancer is not an acceptable outcome.)
- Alternative options for nonsurgical candidates include stereotactic beam radiotherapy with or without systemic chemotherapy.

The ability to cure lung cancer is directly related to stage. Staging is completed based on PET scan and sampling of mediastinal lymph nodes via endobronchial U/S-guided fine needle aspiration (EBUS-FNA) or surgical mediastinoscopy.

- **Stage I** disease is localized to the lungs and is cured by surgical resection.
- **Stage II** may have larger lesions or involve local nodes and are treated with surgical resection and adjuvant chemotherapy.
- **Stage III** relates to mediastinal lymph node involvement or very large tumors and can be cured in a subset of patients using a trimodal therapy: chemotherapy, radiotherapy, and surgical resection in some combination.
- **Stage IV** disease with distant metastases is not curable, so surgical resection is not an option.

> On a routine pre-employment physical examination, a chest x-ray is done on a 45-year-old chronic smoker. A solitary pulmonary nodule is found in the upper lobe of the right lung.

The concern, of course, is lung cancer. Look for an old x-ray to compare; otherwise start workup with a CT of the chest.

> A 65-year-old man with a 40-pack-year history of smoking presents with a chronic cough. Chest x-ray performed demonstrates a peripheral 2-cm solitary nodule not present on x-ray 1 year prior. CT reveals no mediastinal adenopathy, no calcification in the mass, and no other suspicious masses. Bronchoscopy and percutaneous needle biopsy have not been diagnostic. PET scan shows mild hypermetabolism in the mass and no other locations of uptake. He has good pulmonary function and is otherwise in good health.

In dealing with lung cancer there are 3 issues: diagnosis, ability to cure, and assessment of surgical candidacy. This man could tolerate a lung resection, which could be curative. Biopsy has been unsuccessful. A reasonable strategy would be a VATS wedge resection, and if it indeed is a cancer, completion lobectomy (lower long-term recurrence risk than a wedge resection alone).

Clinical Pearl

Immunotherapy is emerging as a valuable tool for advanced cancers that bear a genetic mutation; this option is unlikely to show up on the exam.

> A 72-year-old chronic smoker with severe chronic obstructive pulmonary disease (COPD) is found to have a central, hilar mass on chest x-ray. Bronchoscopy establishes a diagnosis of squamous cell carcinoma of the lung. His FEV_1 is 1.1L, and a ventilation/perfusion scan shows that 60% of his pulmonary function comes from the affected lung.

The history and physical exam suggested that the main limiting factor would be pulmonary function, so that issue was properly evaluated first. It takes an FEV_1 of at least 800 mL to survive surgery and not be a pulmonary cripple afterward. If this patient underwent a pneumonectomy—which he would need for a central tumor—he would be left with FEV_1 440 mL, which is not compatible with oxygen-free life. No further testing is necessary; he is not a surgical candidate and should be treated with some combination of radiation therapy, chemotherapy, and possibly immunotherapy.

> A 62-year-old chronic smoker has an episode of hemoptysis. Chest x-ray shows a central hilar mass. Bronchoscopy and biopsy establish a diagnosis of squamous cell carcinoma of the lung. His FEV_1 is 2,200 ml, and a ventilation/perfusion scan shows that 30% of his pulmonary function comes from the affected lung.

This patient could tolerate a pneumonectomy, but staging needs to be completed for the best treatment strategy. PET scan is the best noninvasive test for mediastinal or distant metastasis, followed by endobronchial ultrasound (EBUS) or surgical biopsy of mediastinal nodes if suspicious for cancer.

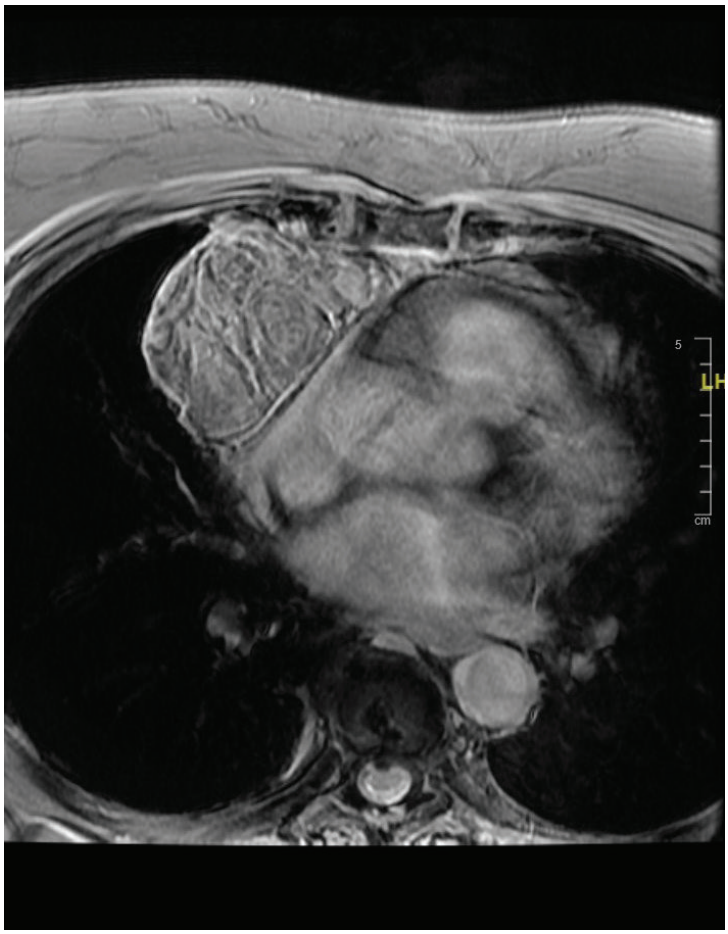
MEDIASTINUM

The mediastinum is divided into anterior, middle, and posterior compartments.

Tumors of the anterior mediastinum are easily remembered by the "4 Ts," each with discrete clinical and radiographic features.

- **T**hyroid (substernal goiter)
  - Typically extends from standard thyroid goiters, which are palpable.
  - Thyroid function testing and resection with or without upper sternotomy is indicated.
- **T**hymoma
  - Tends to be asymptomatic and incidentally discovered, but is also associated with myasthenia gravis.
  - Check for serum antibodies to anticholinesterase.
  - Thymectomy even in the absence of thymoma has been shown to improve quality of life in myasthenia and should be considered.
- "**T**errible" lymphoma
  - Typically presents in younger patients.
  - Symptoms tend to be systemic: fever, chills, night sweats, and weight change.

- Teratoma
  - Can be benign or malignant.
  - Measure serum tumor markers (AFP, HCG) prior to resection to surveil for future recurrence.



Courtesy of Gary Schwartz, MD

Figure 5-2. MRI Anterior Mediastinal Mass

The middle mediastinum includes the great vessels, the airway, and the esophagus. Masses in this location include aneurysms and malignancies, but benign congenital growths such as bronchogenic cysts also occur. Lymphadenopathy can also be present.

The posterior mediastinum is well known to harbor neurogenic tumors such as paraganglionic and nerve sheath tumors. MRI is necessary to evaluate for spinal cord involvement ("dumbbell tumor") and for surgical planning.

VASCULAR

Carotid artery stenosis is caused by atherosclerotic disease leading to progressive narrowing of the vessels. Flow limitation or plaque embolism can lead to transient ischemic attack (TIA) or frank cerebrovascular accident (CVA). Diagnosis is with U/S measuring diameter, as well as Doppler flow. Management includes lifestyle management (smoking, diet, exercise), antiplatelet therapy, and surveillance for progression. Symptomatic lesions and asymptomatic lesions with >70% stenosis should be repaired by surgical carotid endarterectomy (CEA).

Clinical Pearl

Carotid stenting has demonstrated good results with potentially fewer periprocedural complications, but for the exam, choose surgical repair.

Subclavian steal syndrome is rare but commonly tested. An arteriosclerotic stenotic plaque at the origin of the **left subclavian artery (proximal to the takeoff of the vertebral artery)** allows enough blood supply to reach the arm for normal activity, but does not allow enough to meet higher demands when the arm is exercised. When that happens, the arm diverts blood away from the brain by "reversing" blood flow in the vertebral artery.

Clinical presentation includes decreased brain perfusion and possible CNS symptoms (most commonly dizziness and even syncope):

- Claudication of the arm (coldness, tingling, muscle pain)
- Posterior neurologic signs (visual symptoms, equilibrium problems) when arm is exercised

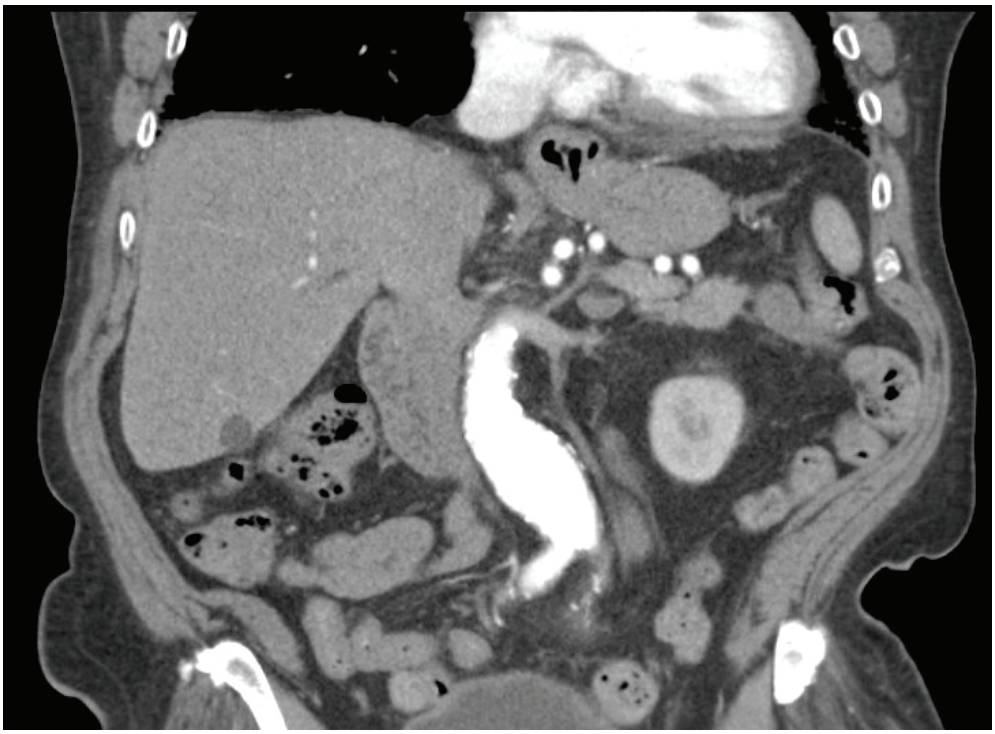
Vascular symptoms alone would suggest thoracic outlet syndrome, but the combination with neurologic symptoms identifies the subclavian steal. Duplex scan is diagnostic when it shows reversal of flow. Treatment is endovascular stenting (curative), or surgical bypass if that is not anatomically feasible.

Abdominal aortic aneurysm (AAA) is typically asymptomatic, presenting as a pulsatile epigastric abdominal mass on examination or found incidentally on imaging for another purpose. Size as measured by U/S or CT is the key to management, as well as the presence of symptoms (U/S is used for screening patients with hypertension and smoking; if you are thinking of aneurysm, begin with CT).

- If aneurysm $\leq$4 cm, it can be safely observed as chance of rupture is near zero.
- If aneurysm $\geq$5 cm, it should be electively repaired to prevent rupture.
- If aneurysm grows $\geq$1 cm per year during observation, it needs elective repair.
- If the abdomen is tender in the presence of a large or enlarging aneurysm, it is at risk for imminent rupture and needs urgent surgical repair. Similarly, new-onset back pain is concerning for an early rupture, with retroperitoneal bleeding causing the symptom.

Treatment is now endovascular stents inserted percutaneously. If that is not possible, do an open aneurysmectomy. Factors preventing an endovascular approach include specific anatomic criteria (neck of aneurysm, landing zone, and tortuosity of vascular tree) and available resources (angiography team/equipment). Surgical options include:

- Open surgical AAA repair using an interposition graft within the aneurysm sac (10–15% perioperative morbidity due to MI, renal failure, bowel ischemia)
- Emergency surgery for ruptured AAA (very high morbidity and mortality), although some of these have been treated with endovascular stents



Courtesy of Gary Schwartz, MD

Figure 5-3. CT Angiogram AAA Coronal

Arteriosclerotic occlusive disease of the lower extremities has an unpredictable natural history (except for the predictable negative impact of smoking), and so there is no role for "prophylactic" surgery in claudication.

- Lifestyle changes including smoking cessation and exercise are encouraged.
- Antiplatelet therapy is typically initiated, as is evaluation for other sites of atherosclerotic disease (e.g., coronary and carotid arteries).
- Surgery is done only to relieve disabling symptoms or to save the extremity from impending necrosis, i.e., when presenting with rest pain, which is the penultimate presentation prior to ulceration and frank gangrene.

When intermittent claudication becomes disabling, workup begins with a pulse exam, ankle-brachial index, and Doppler study looking for a pressure gradient that provides information about the location, level, and severity of an arteriosclerotic lesion.

- If there isn't a significant gradient, the disease is in the small vessels and not amenable to surgery.
- If there is a significant gradient, CT angiogram or MRA is performed to identify specific areas of stenosis or complete obstruction, and to locate good distal vessels to which a bypass graft could be anastomosed.

Treatment for short stenotic segments is angioplasty and stenting, but for more extensive disease the management is bypass graft, sequential stent, or longer stenting. When multiple lesions are present, proximal ones are usually repaired before distal ones are addressed.

Clinical Pearl

- Grafts originating at the aorta (aortobifemoral) and procedures on larger arteries are done with prosthetic material.
- Bypass between more distal vessels (femoropopliteal or beyond) is usually done with reversed saphenous vein grafts.

Clinical Pearl

Of the 6 Ps, **paralysis** is the most feared finding—and also typically the latest. The motor nerves are typically the most "resistant" to ischemia. Management should be initiated prior to progression to frank paralysis, or recovery is unlikely.

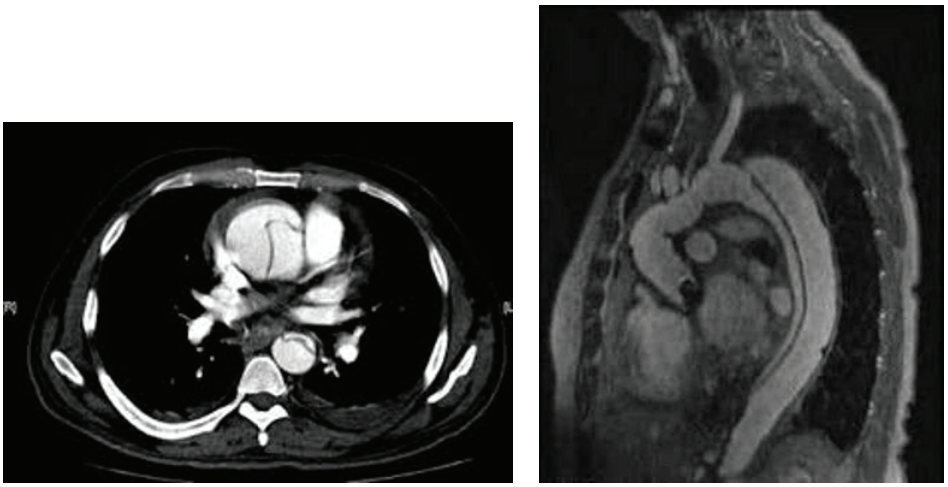
Arterial embolization from a distant source is seen in those with atrial fibrillation (a clot breaks off from the atrial appendage) or those with recent MI (the source of the embolus is the mural thrombus). Another source can be the aorta. The patient acutely develops the 6 Ps:

- **P**ain
- **P**aleness
- **P**oikilothermia
- **P**ulselessness
- **P**aresthesia
- **P**aralysis

Urgent evaluation and treatment should be completed within 6 hours because the likelihood of irreversible muscle and nerve injury increases after this time. Doppler study or CT angiogram will locate the point of obstruction. Early incomplete occlusion may be treated with thrombolytic therapy. Embolectomy with Fogarty catheters is effective for complete obstructions. Fasciotomy should be added if several hours have passed before revascularization in order to prevent compartment syndrome from reperfusion edema. Empiric heparin bolus should be given upon suspicion of this disease.

Dissection of the thoracic aorta is common in poorly controlled hypertensive patients. Clinical presentation resembles an MI, with sudden onset of extremely severe, tearing chest pain that radiates to the back and migrates down shortly after its onset. There may be unequal pulses in the upper extremities, and chest x-ray shows a widened mediastinum.

EKG and cardiac enzymes rule out an MI but confirm diagnosis with CT angiogram, magnetic resonance angiogram (MRA), or even transesophageal echocardiography (TEE). Type A dissection (involving the ascending aorta) is treated surgically, whereas type B (those in the descending only) is managed medically with control of the hypertension.



Courtesy of Gary Schwartz, MD

Figure 5-4. CT Angiogram Ascending Dissection and MRI Descending Dissection

A 54-year-old laborer who is right-handed notices coldness and tingling in the left hand, plus pain in the forearm when he does strenuous work. What really concerns him, however, is that in the last few episodes he also experienced transitory dizziness and blurred vision.

This presentation is concerning for subclavian steal syndrome. Claudication of the arm plus posterior brain neurologic symptoms is classic for this rare but fascinating condition. (It is often tested on the exam.) Duplex scan will demonstrate retrograde flow through the vertebral artery when the patient exercises the arm. Endovascular stenting or surgical bypass is curative.

A 62-year-old man has vague, poorly described epigastric and upper back discomfort. He is found on physical examination to have a 6-cm pulsatile mass deep in the abdomen between the xiphoid and the umbilicus. The mass is tender to palpation.

This is an abdominal aortic aneurysm that is beginning to leak. Get an immediate vascular surgery consultation, as urgent surgical repair is necessary.

A 68-year-old man is brought to the ED with excruciating back pain of 45 minute duration. He is diaphoretic and has systolic blood pressure 90 mm Hg. Examination reveals an 8-cm, pulsatile mass palpable deep in the abdomen, above the umbilicus.

Pain in the presence of an AAA is concerning; hemodynamic instability is life-threatening. This patient needs immediate emergency surgery.

A retired physician has claudication when walking more than 15 blocks.

Vascular surgical and endovascular interventions are palliative procedures; they do not cure arteriosclerotic disease. Claudication has an unpredictable course but is generally stable, so there is no indication for early operation or intervention. No workup is needed. If the patient smokes he should quit, and he would benefit from a program of exercise. Antiplatelet therapy may be helpful, and don't forget to work up for other sites of disease (coronary, carotid arteries).

A 56-year-old postal worker describes severe pain in his right calf when he walks 2–3 blocks. The pain is relieved by resting 10–15 minutes but recurs if he walks again the same distance. He cannot perform his job with this problem, but he does not yet qualify for retirement so he is most anxious to have this problem resolved. He does not smoke.

This patient needs help. Start with a pulse exam, ankle-brachial index, and Doppler study. If he has a significant gradient, do a CT angiogram or formal angiogram at the same setting of endovascular stenting or bypass grafting.

> A 56-year-old former smoker presents with pain in the right calf that keeps him from falling asleep. The pain goes away if he sits by the side of the bed and dangles the leg. His wife adds that she has watched him do that, and she has noticed that the leg, which was very pale when he was lying down, becomes deep purple several minutes after he is sitting up. On physical examination the skin of that leg is shiny, there is no hair, and there are no palpable peripheral pulses.

Pain at rest signifies an acutely threatened extremity. This patient needs a full workup to see whether a vascular intervention could help.

> A 65-year-old man presents to the ED with pain in his left lower extremity. The process began suddenly 2 hours ago. Physical examination reveals a cool extremity with no palpable pulses; pulse at the wrist is 95/min and irregular.

This scenario is highly concerning for an embolic event to the lower extremity, likely secondary to atrial fibrillation. This is a surgical emergency. Start systemic anticoagulation with heparin, and get the patient to the operating room ASAP for an embolectomy. If the ischemia has been ongoing for several hours, perform a fasciotomy.

> A 74-year-old man has sudden onset of extremely severe, tearing chest pain that radiates to the back and migrates down shortly after its onset. Blood pressure is 220/110 mm Hg and there are unequal pulses in the upper extremities. Chest x-ray reveals a wide mediastinum. EKG and cardiac enzymes are negative for myocardial infarction.

This is dissecting aneurysm of the thoracic aorta. Assuming renal function is normal, CT angiogram is the best study.

- If the aneurysm is in the ascending aorta, proceed to emergency surgery.
- If the aneurysm is in the descending aorta, admit to the ICU and proceed with IV management of hypertension.
- If there is evidence of compromised visceral perfusion (acidosis, renal failure), urgent surgical intervention is indicated.

Ulcers

Diabetic ulcer is typically indolent and located at pressure points (first metatarsophalangeal joint most commonly, secondly the calcaneus). It results from altered gait due to neuropathy with abnormal pressure points, and does not always heal because of the microvascular disease. Good blood glucose control and wound care can help, but it often becomes chronic and may require amputation due to osteomyelitis. Proceed with MRI to look for osteomyelitis and foreign body.

Ulcers from arterial insufficiency are usually as far away from the heart as possible, i.e., at the tip of the toes. They are generally pale and devoid of granulation tissue. The patient has other manifestations of arteriosclerotic occlusive disease (absent pulses, trophic changes, claudication, or rest pain). Workup begins with Doppler study looking for a pressure gradient, though in the presence of microvascular disease this may not be present (and these lesions are less amenable to surgery). Further evaluation with CT angiogram may be necessary and ultimately formal angiography leading to angioplasty, stenting, or surgical revascularization.

Venous stasis ulcers develop in chronically edematous, indurated, and hyperpigmented skin above the medial malleolus. The ulcer is painless, typically with a granulating bed. The patient often has varicose veins due to incompetent venous valves and suffers from frequent bouts of cellulitis. Duplex scan is useful in the workup.

Treatment revolves around physical support to keep the veins empty and avoid infection: support stockings, Ace bandages, and Unna compression boots. Surgery may be required (vein stripping, grafting of the ulcer, injection sclerotherapy); endovascular ablation with laser or radiofrequency may also be used.

A **Marjolin ulcer** is a SCC of the skin that has developed in a chronic leg ulcer. The classic setting is one of many years of healing and breaking down, such as seen in untreated third-degree burns that underwent spontaneous healing, or in chronic draining sinuses secondary to osteomyelitis. A dirty-looking, deeper ulcer develops at the site, with heaped up tissue growth around the edges. Biopsy is diagnostic. Treatment is wide local excision and skin grafting if necessary.

> A 67-year-old man with poorly controlled diabetes presents to his primary care doctor with a nonhealing ulcer on his heel. His hemoglobin A1C is 9.

Ulcer at a pressure point in a diabetic is caused by neuropathy, and once it has developed it is unlikely to heal due to microvascular disease. Goals of care are to keep the ulcer clean and prevent infection, which could result in osteomyelitis and ultimately require amputation. Improved glycemic control is mandatory although unlikely to reverse the damage. The other common location for diabetic foot ulcers is the first metatarsophalangeal joint.

> A 67-year-old man with hypertension and hyperlipidemia and a heavy smoking history presents with an ulcer at the tip of his left second toe. It is ecchymotic and insensate. There are no pulses palpable.

Lack of pulses is concerning for underlying vascular insufficiency, as ischemic ulcers present at the most distal points on the body. Management starts with local wound care and U/S to assess for a pressure gradient, followed by MRA or CT angiogram. Revascularization via endovascular stenting or surgical bypass may be possible and enable wound healing.

Clinical Pearl

You may not be able to completely heal a venous stasis ulcer, but the **most important** aspect of treatment is to **avoid infection**, which is exceedingly common and a frequent presentation of elderly patients in the ED.

A 40-year-old man has had a chronic draining sinus in his lower leg since he had an episode of osteomyelitis at age 12. In the last few months he has developed an indolent, dirty-looking ulcer at the site, with "heaped up" tissue growth at the edges.

"Heaped up" is a buzz word for SCC arising in a chronic wound (Marjolin ulcer). Biopsy is the first diagnostic step, and management is wide local excision (with subsequent skin grafting if necessary).

Coarctation of the aorta (CoA) may become symptomatic at any age, but typically it presents in youth with upper extremity hypertension and lower extremity hypotension or lack of palpable dorsal pulses. Chest x-ray shows scalloping of the ribs due to erosion from large collateral intercostal arteries, and CT angiogram is diagnostic. Treatment is surgical repair.

A 12-year-old boy undergoes a physical examination for his high school football team. He is found to have blood pressure 190/110 mm Hg on two separate evaluations. The remaining physical exam is normal, other than very faint dorsalis pedis pulses bilaterally.

This is a classic scenario describing coarctation of the aorta. An alternative question stem might include a chest x-ray with "scalloping" of the ribs. Diagnose with CT angiogram of the chest and repair surgically.

Pediatric Surgery 6

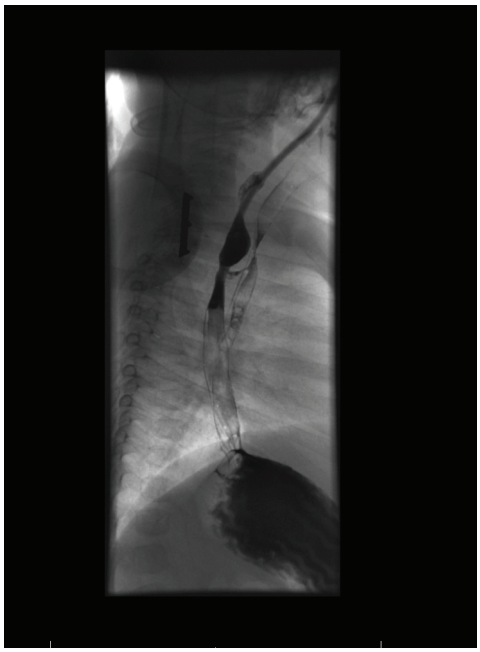
Learning Objectives

- ❑ Demonstrate understanding of common surgical problems in children within the first 24 hours of birth, within the first 2 months of life, and later in infancy
- ❑ Know the diseases thoroughly

FROM BIRTH TO FIRST 24 HOURS

Most congenital anomalies require surgical correction, but many occur in clusters; therefore, the presence of other anomalies must be assessed.

Esophageal atresia presents with excessive salivation noted shortly after birth or with choking spells when first feeding is attempted. A small NG tube is passed, and it will be seen coiled in the upper chest on x-ray. If there is normal gas pattern in the bowel, the baby has the most common form of the 4 types, in which there is a blind pouch in the upper esophagus and a fistula between the lower esophagus and the tracheobronchial tree.



Courtesy of Gary Schwartz, MD

Figure 6-1. Esophagram TEF

Note

The most important aspect of pediatric surgery is that the **diseases are congenital**. You cannot just "figure them out"; you must know them for the exam.

Before treatment begins, rule out associated anomalies: vertebral, anal, cardiac, tracheal, esophageal, renal, and radial (VACTER).

- Anorectal exam for imperforation
- X-ray for vertebral and radial anomalies
- Echocardiogram for cardiac anomalies
- U/S for renal anomalies

Initial surgical treatment is gastrostomy to provide nutrition and decrease aspiration. Once the child is healthier, then definitive surgical repair is performed.

Note

An important anatomical point is that even though the rectum may be only several millimeters from the imperforate skin, one cannot just "poke a hole."

Imperforate anus may be the clinical presentation noted on physical exam for the VACTER anomalies. If so, the others must be ruled out. Assess for a fistula to the vagina or perineum. If a fistula is present, repair can be delayed until further growth (but before toilet training). If no fistula is present, high rectal pouches must be temporarily diverted via a colostomy, whereas a blind pouch approaching the anus can be repair primarily ("pull-through").

Congenital diaphragmatic hernia is always on the left, and the defect results in the bowel herniating into the chest leading to a hypoplastic lung that ultimately retains its fetal-type circulation. Repair must be delayed 3–4 days to allow maturation. Babies often develop respiratory distress and need endotracheal intubation, low-pressure ventilation (careful not to hyperinflate the contralateral lung), sedation, and NG suction. Difficult cases may require extracorporeal membrane oxygenation (ECMO). U/S can diagnose (and occasionally repair) many babies in utero.

Gastroschisis and omphalocele present with a defect in the abdominal wall.

- In **gastroschisis**, the location of the umbilical cord is normal (it reaches the baby).
  - Defect is to the right of the cord (lateral), with no protective membrane
  - Bowel looks inflamed and matted, as if floating in amniotic fluid (which is very irritating)
  - **Clinical pearl: "sausage"**
- In **omphalocele**, the cord goes to the defect (central).
  - Defect has a thin membrane under which one can see a normal-looking bowel
  - **Clinical pearl: "spaghetti"**

Both of these conditions represent an open abdomen and thus mandate IV antibiotics.

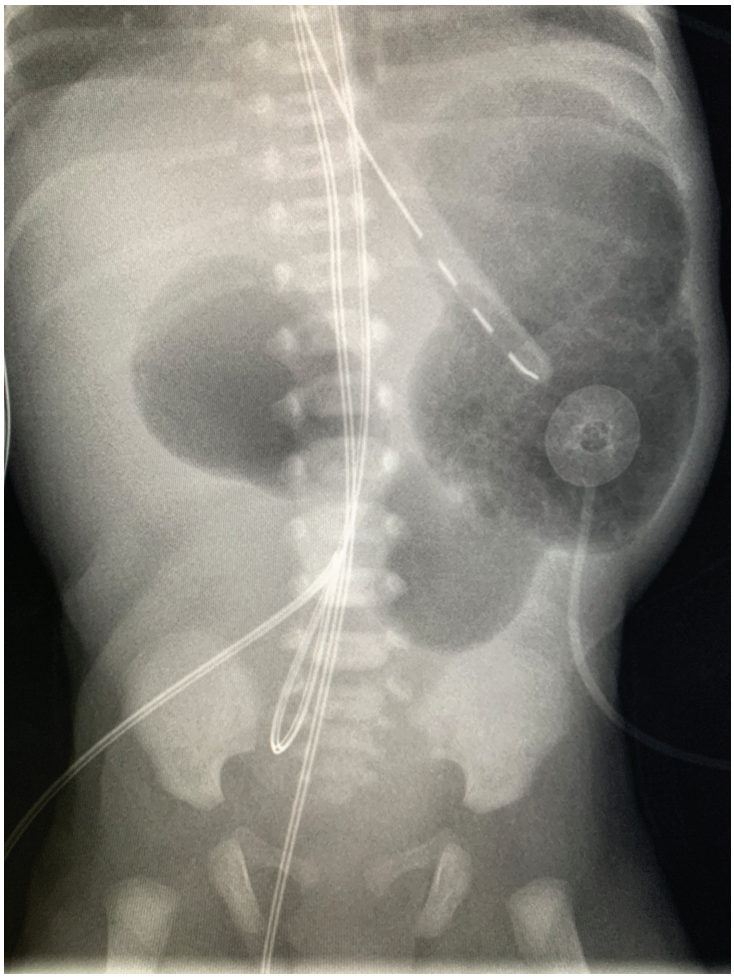
- Small defects can be closed primarily or with skin closure alone, leaving a ventral hernia to repair later when the child has grown.
- Large defects require construction of a prosthetic "silo" to house and protect the bowel. The contents of the silo are then manipulated into the peritoneal cavity over several days.

Babies with gastroschisis also need vascular access for parenteral nutrition because the inflamed bowel will not function normally for several weeks.

Exstrophy of the urinary bladder is also an abdominal wall defect of the lower abdominal wall, frequently associated with separation of the pubic symphysis and an exposed bladder and/or urethral mucosa. Delayed repair does not work, so surgical repair must be performed within the first 1–2 days of life.

Bilious vomiting in the newborn is strongly suggestive of a proximal intestinal obstruction. Bowel gas pattern on plain abdominal x-ray can provide important clues as to the underlying cause.

- Green vomiting and a "double bubble" on x-ray (a large air-fluid level in the stomach and a smaller one to its right in the first portion of the duodenum) are found in **duodenal atresia, annular pancreas, or malrotation**. The diagnosis is made definitively by surgical exploration. These anomalies all require surgical correction, but malrotation is the most dangerous because the bowel can become ischemic.
- If, in addition to the double bubble, there is some "typical gas pattern" beyond, the chances of malrotation are higher. Malrotation is diagnosed with contrast enema (safe, but not always diagnostic) or upper GI study (more reliable, but riskier due to potential for aspiration). Although described as a problem of the newborn, the first signs of malrotation can show up at any time within the first few weeks of life.
- Treatment for duodenal atresia and annular pancreas is commonly gastroduodenostomy or gastrojejunostomy. Treatment for malrotation is dividing the "Ladd bands" (just peritoneum) and an appendectomy, as the cecum is commonly not in the RLQ.



Courtesy of Gary Schwartz, MD

Figure 6-2. X-Ray Double Bubble

Clinical Pearl

In duodenal atresia, annular pancreas, and malrotation, the mother will have polyhydramnios (the child swallows the amniotic fluid and it is absorbed in the small bowel).

Intestinal atresia also shows up with green vomiting, but instead of a double bubble there are multiple air-fluid levels throughout the abdomen. There may be more than one atretic area, but no other congenital anomalies have to be suspected because this condition results from a vascular insufficiency in utero.

> Within 8 hours after birth, it is noted that a baby has excessive salivation. A small, soft nasogastric tube is inserted, and x-ray demonstrates the tube is coiled back on itself in the upper chest. There is air in the gastrointestinal tract.

This is the classic presentation of the most common type of tracheoesophageal (TE) fistula, with a proximal blind esophageal pouch and a distal TE fistula. First, rule out the associated anomalies (VACTER: vertebral, anal, cardiac, TE, and renal/radial). If no other anomalies, proceed with surgical repair.

> A newborn baby is found on physical examination to have an imperforate anus.

This is another part of the VACTER group, so rule out the other components. For the anal problem, if there is a fistula to the vagina or perineum repair can be safely done later, as the GI tract is not obstructed. If there is no fistula, barium enema will demonstrate the proximal level of the pouch: low imperforate anus can be corrected primarily; higher levels may need diverting colostomy and delayed repair.

> A newborn baby is found to be tachypneic, cyanotic, and grunting. The abdomen is scaphoid, and there are bowel sounds heard over the left chest. An x-ray confirms that there is bowel in the left thorax. Shortly thereafter, the baby develops significant hypoxia and acidosis.

Although most congenital diaphragmatic hernias are diagnosed prenatally, they can still present in extremis. The main problem is the hypoplastic lung. It is better to wait 36–48 hours to operate, in order to allow transition from fetal circulation to newborn circulation. Meanwhile, support the baby with supplemental oxygen, or even mechanical ventilation and nasogastric decompression.

> At the time of birth, it is noted that a child has a large abdominal wall defect to the right of the umbilicus. There is a normal cord, but protruding from the defect is a matted mass of angry-looking edematous bowel loops.

> A newborn baby is noted to have a shiny, thin, membranous sac at the base of the umbilical cord, with the cord entering the sac that contains liver and loops of normal bowel.

The first vignette is gastroschisis, the second one omphalocele. Quite simply, the bowel needs to be back in the abdomen and the abdomen closed; however, the "loss of domain" prevents immediate reduction. Therefore a silicon "silo" is used to house the bowel and gradually

return it to the abdomen. The baby with gastroschisis will also need vascular access for parenteral nutrition, as the bowel will not function normally for several weeks. Both will require IV antibiotics.

> Half an hour after the first feed, a baby vomits green fluid. X-ray demonstrates a large air-fluid level in the stomach and a smaller one in the first portion of the duodenum. There is air in the distal bowel, beyond the duodenum, in nondistended loops of bowel.

This represents bowel obstruction with 3 possible etiologies: duodenal atresia, annular pancreas, or malrotation. Upper GI study is diagnostic. Treatment is surgical repair.

> A newborn baby has green vomiting during the first day of life and does not pass any meconium. Except for abdominal distention, the baby is otherwise normal. X-ray demonstrates multiple air-fluid levels and distended loops of bowel.

This scenario is more consistent with intestinal atresia. Because it is caused by a vascular accident in utero, there are no other congenital anomalies to look for, but there may be multiple points of atresia.

FROM A FEW DAYS TO FIRST 2 MONTHS

Necrotizing enterocolitis is caused by bacterial invasion of the intestinal wall that develops in premature infants when they are first fed. There is feeding intolerance. Additionally, there is abdominal distention and rapidly developing thrombocytopenia (a sign of sepsis).

- Treatment is to stop all feedings and antibiotics, IV fluids, and parenteral nutrition.
- Surgical intervention is required if patients develop intestinal necrosis and perforation, which typically presents as abdominal wall erythema, air in the portal vein, intestinal pneumatosis, or pneumoperitoneum.

Unfortunately, resection of the involved bowel puts the child at risk for short gut syndrome, leading to malnutrition and the need for lifelong total parenteral nutrition. However, bowel resection is lifesaving and must be undertaken immediately to prevent further sepsis and death.

Meconium ileus is caused by abnormally thick meconium with resultant intestinal obstruction, typically seen in babies who have cystic fibrosis (often suspected due to by family history). There is feeding intolerance and bilious vomiting.

- X-ray shows multiple dilated loops of small bowel and a ground-glass appearance in the lower abdomen.
- Gastrografin enema is both diagnostic (microcolon and inspissated pellets of meconium in the terminal ileum) and therapeutic (gastrografin draws fluid in and dissolves the pellets).

Hypertrophic pyloric stenosis presents at age ~3 weeks, more commonly in first-born boys. There is nonbilious projectile vomiting after each feeding. The baby is hungry and eager to eat again after he vomits.

Clinical Pearl

The metabolic derangement is the same pathophysiology as adults, with extensive vomiting, as reviewed in the fluids and electrolytes section. Resuscitate with crystalloid and supplemental potassium before proceeding to surgery.

By the time patients receive medical attention they tend to be dehydrated, with visible gastric peristaltic waves and a palpable "olive-size" mass in the RUQ. If the mass cannot be felt, U/S is diagnostic. Treatment is rehydration and correction of the hypochloremic, hypokalemic metabolic alkalosis, followed by pyloromyotomy.

Biliary atresia should be suspected in infants age 6–8 weeks who have persistent, progressively increasing jaundice (which includes a substantial conjugated fraction). Check viral serologies and sweat test to rule out other problems (e.g., cystic fibrosis), and do a HIDA scan after 1 week of phenobarbital (a powerful choleretic).

If no bile reaches the duodenum even with phenobarbital stimulation, surgical exploration is needed.

- Surgical repair is long-lasting in 1/3 of patients.
- Surgical repair is short-lived in 1/3 of patients, who ultimately require liver transplantation.
- Liver transplantation is required immediately in 1/3 of patients.

Hirschsprung disease (aganglionic megacolon) is a functional physiologic obstruction of the bowel that can be recognized in early life or may go undiagnosed for many years. The cardinal symptom is chronic constipation.

- With short segments, rectal exam may lead to explosive expulsion of stool and flatus, with relief of abdominal distention.
- In older children in whom the differential diagnosis with psychogenic problems is an issue, the presence of fecal soiling suggests the latter.
- X-ray demonstrates distended proximal colon (the uninvolved portion) and "normal-looking" distal colon, which is the aganglionic part.
- Diagnosis is made with full-thickness biopsy of rectal mucosa looking for the absence of ganglia.
- Initial treatment is usually colostomy in order to optimize general health (nutrition, etc.), and then once "healthy," a "pull-through" definitive procedure.

A 4-day old premature baby is born with a patent ductus arteriosus (PDA) and treated with indomethacin. On day 14 of leave, he develops feeding intolerance, abdominal distention, and a platelet count of 30K.

The PDA has nothing to do with the current problem; this information only stresses that prematurity puts babies at risk for multiple problems. The PDA can be treated medically or surgically (via angiographic methods) as indicated (see the congenital heart surgery section). The problem now is necrotizing enterocolitis. Stop all feedings and start broad-spectrum antibiotics, IV fluids, and parenteral nutrition. Surgical intervention may be needed if the baby develops abdominal wall erythema, air in the portal vein, or pneumoperitoneum signifying bowel perforation.

A 3-day-old, full-term baby is brought in because of feeding intolerance and bilious vomiting. X-ray demonstrates multiple dilated loops of small bowel and a ground-glass appearance in the lower abdomen. The mother has cystic fibrosis.

The family history and clinical presentation are consistent with meconium ileus. Gastrografin enema may be both diagnostic and therapeutic, so it is the obvious first choice. If unsuccessful, surgery may be needed. If the baby does indeed have cystic fibrosis, management of the other manifestations of the disease will also be necessary.

A 3-week-old baby has had "trouble feeding" and is not gaining weight. He presents with bilious vomiting, and x-ray demonstrates a "double bubble" with a normal gas pattern distally.

This was reviewed in the first section but repeated here, as it can show up at any point in the first few weeks of life: malrotation. Proceed with upper GI series and likely surgical exploration.

A 3-week-old first-born, full-term baby boy began to vomit 3 days ago. The vomiting is projectile and nonbilious, and occurs after each feeding. The baby is hungry and eager to eat again after he vomits. An olive-size mass is palpable in the right upper quadrant.

This is a straightforward description of hypertrophic pyloric stenosis. Check electrolytes, which will likely demonstrate a hypokalemic, hypochloremic metabolic alkalosis. Rehydrate and correct potassium, then proceed to the operating room for pyloromyotomy.

A 2-month-old baby boy is brought to the pediatrician due to chronic constipation. He has abdominal distention, and abdominal x-ray demonstrates gas in dilated loops of bowel throughout the abdomen. Rectal examination is followed by explosive expulsion of stool and flatus, with remarkable improvement of the distention.

This scenario is suspicious for Hirschsprung disease (aganglionic megacolon). Barium enema will define the normal-looking aganglionic distal colon and the abnormal-looking, distended, normal proximal colon, but the diagnosis is established with full thickness biopsy of the rectal mucosa to look for the **absence of ganglia**. Definitive surgical repair is usually performed after initial diverting colostomy.

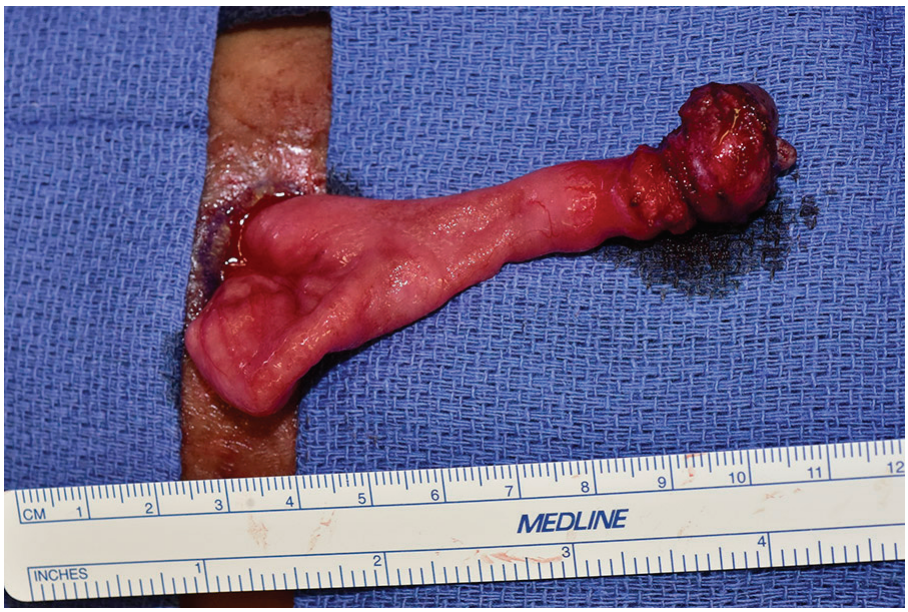
LATER IN INFANCY

Intussusception occurs in chubby, healthy babies age 6–12 months, who have episodes of colicky abdominal pain that make them draw their knees up to their chest.

- The pain lasts for ~1 minute, and the child looks perfectly happy and normal until the next episode.
- Physical exam may reveal a vague mass on the right side of the abdomen or an "empty" RLQ.

- Parents may describe stools as "currant jelly" (stool mixed with blood, mucous and sloughed epithelium).
- Barium or air enema is both diagnostic and often therapeutic.
- If complete reduction is not achieved radiologically (seeing reflux in the terminal ileum) or if it recurs, surgery is indicated.

Meckel's diverticulum should be suspected in lower GI bleeding in the pediatric age group. Diagnose with a radioisotope scan looking for gastric mucosa in the lower abdomen, and perform a small bowel resection. Recall the rule of 2s, where this condition usually occurs before age 2 years and within 2 feet of the ileocecal valve. The bleeding results from ulceration of the abnormal gastric mucosa.



Courtesy of Gary Schwartz, MD

Figure 6-3. Meckel's Diverticulum

Child abuse should always be suspected when injuries cannot be properly accounted for. Some classic presentations include:

- Subdural hematoma plus retinal hemorrhages (shaken baby syndrome)
- Multiple fractures in different bones at various stages of healing
- All scalding burns particularly burns of both buttocks and burns with distinct lines of demarcation

Refer to the proper authorities, but before doing so make certain it is indeed abuse and not a very unusual experience. Once the call is made, it is irreversible until a judge intervenes.

A 9-month-old boy is brought to the pediatrician due to episodes of abdominal pain that are severe but intermittent. His mother reports bloody stools but states he is otherwise very healthy and happy.

Intussusception is the most likely diagnosis. Barium or air enema are both diagnostic and therapeutic in most cases. If reduction is not achieved radiologically with reflux in the terminal ileum, then surgery is necessary.

A 7-year-old boy passes a large bloody bowel movement.

GI bleed in this age group is a Meckel's diverticulum until proven otherwise. Diagnose with a radioisotope scan looking for gastric mucosa in the lower abdomen and manage surgically.

A 1-year-old child is brought in with second-degree burns of both buttocks. The stepfather relates that the child fell into a hot tub.

This pattern of burn is suspicious for child abuse.

Eye, Ear, Nose, and Throat Surgery 7

Learning Objectives

- ❑ List the common ophthalmological conditions and procedures, with indications, complications, and alternatives
- ❑ Describe the common head and neck masses and their prognoses and management
- ❑ List the presenting features, diagnosis, and management of ENT emergencies

EYE (OPHTHALMOLOGY)

Pediatric Ophthalmology

Amblyopia is a vision impairment caused by interference with the processing of images by the brain during the first 6 or 7 years of life. The most common expression of this phenomenon is the child with strabismus (dysconjugate gaze, so-called "wandering eye"). Faced with 2 overlapping images, the brain suppresses one of them. If the strabismus is not corrected early on, there will be permanent cortical blindness of the suppressed eye, even though the eye is structurally normal. Should an obstacle impede vision in one eye during those early years (for instance, a congenital cataract), the same problem will develop.

Strabismus is verified by showing that the reflection from a light comes from different areas of the cornea in each eye. Strabismus should be surgically corrected when diagnosed to prevent the development of amblyopia. When reliable parents relate that a child did not have strabismus in the early years but develops it later in infancy, the problem is an exaggerated convergence caused by refraction difficulties. In that case corrective glasses instantly resolve the problem. True strabismus does not resolve spontaneously.

A **white pupil in a baby** is an ophthalmologic emergency, as it may be caused by a retinoblastoma. Even if the white pupil is caused by a less lethal problem like a congenital cataract, it should be addressed urgently to in order to prevent amblyopia.

Adult Ophthalmology

Glaucoma is a very common source of blindness, but because of its silent nature it is unlikely to be discovered by routine exam. **Acute closed-angle glaucoma** (a variant) presents as very severe eye pain or a frontal headache, typically starting in the evening when the pupils have been dilated for several hours, e.g., watching television in a dark room; it may be associated with seeing halos.

- On physical exam the pupil is dilated and does not react to light, the cornea is cloudy with greenish hue, and the eye feels "hard as a rock."
- Emergency surgery is required to decompress fluid trapped in the anterior chamber.
- While waiting for ophthalmologist, administer systemic carbonic anhydrase inhibitors (e.g., acetazolamide) and apply topical beta-blockers and alpha-2–selective adrenergic agonists (alternatively, mannitol and pilocarpine).

Orbital cellulitis is an ophthalmologic emergency that presents with tender, red, and swollen eyelids. Patients tend to be febrile, but the key finding when the eyelids are pried open is that the pupil is dilated and fixed and ocular motion is very limited, potentially with pus in the orbit. Diagnosis is clinical, but CT is necessary for surgical planning; proceed with emergency surgical drainage. They will require IV antibiotics as well.

Chemical burns of the eye require massive irrigation, as is required anywhere on the body. Start irrigation with plain water as soon as possible, and do not wait until arrival at the hospital. Once the eye has been pried open and washed under running water for about 30 minutes, get the patient to the ED. At the hospital, irrigation with saline is continued, and corrosive particles are removed from hidden corners.

Note

Anywhere on the body and ingested, alkaline burns are worse than acid burns.

Before the patient is sent home, pH is tested to assure that no harmful chemicals remain in the conjunctival sac.

Retinal detachment is another emergency that presents with flashes of light and "floaters." The number of floaters gives a rough idea of the magnitude of the problem: 1 or 2 floaters may only have vitreous tugging at the retina with little actual detachment, whereas dozens of floaters ("snow storm") may have a larger piece of the retina pulled away and there is risk for detachment of the remaining retina. Emergency intervention with laser "spot welding" will protect the remaining retina.

Note

Any neurologic abnormality must have CVA ruled out first.

Embolic occlusion of the retinal artery is also an emergency, although little can be done about it. The patient (typically elderly) describes sudden loss of vision from one eye; within 30 minutes the damage will be irreversible, but the standard recommendation is for the patient to breathe into a paper bag and have someone repeatedly press hard on the eye and release while he is in transit to the ED, in order to vasodilate and shake the clot into a more distal location so that a smaller area becomes ischemic.

Newly diagnosed diabetics need ophthalmologic evaluation if they have type II because they may have had it for years before diagnosis was made. Retinal damage may have already occurred, and proper treatment may prevent its progression. Young people diagnosed with type I often develop eye problems after 20+ years of living with diabetes.

> A young mother is visiting your office for routine medical care. She happens to have her 18-month-old baby with her, and you happen to notice that one of the pupils of the baby is white, whereas the other one is black.

An ophthalmologic and potentially life-and-death emergency. A white pupil (leukocoria) at this age can be due to a retinoblastoma. This child needs to see the ophthalmologist immediately. If it turns out to be something more innocent, like a cataract, it still needs correction to avoid amblyopia.

> A 53-year-old woman arrives at the ED complaining of extremely severe frontal headache and nausea. The pain started about an hour ago, shortly after she left the movies where she watched a double feature. On further questioning she reports seeing halos around the lights in the parking lot when she left the theater. On physical examination the pupils are mid-dilated and do not react to light. The corneas are cloudy with a greenish hue, and the eyes feel hard.

This is a classic description of acute glaucoma. Although most are asymptomatic, this requires immediate treatment. Treat with systemic carbonic anhydrase inhibitors, topical beta-blockers, and alpha-2–selective adrenergic agonists while awaiting an ophthalmologist for surgical drainage.

> A 32-year-old woman presents in the ED with swollen, red, hot, tender eyelids on the left eye. She has fever and leukocytosis. When prying the eyelids open you can ascertain that her pupil is dilated and fixed and that she has very limited motion of that left eye.

This scenario is obviously describing an infectious problem, and orbital cellulitis is an ophthalmologic emergency. Start with a CT to assess the extent of the orbital infection and begin IV antibiotics

> A frantic mother reaches you on the phone, reporting that her 10-year-old boy accidentally splashed drain remover on his face. He is screaming in pain, complaining that his right eye hurts terribly.

Copious irrigation is the main treatment for chemical burns. The point of this vignette is to remind you that time is a key element. If the mother is instructed to bring the boy to the ED, his eye will be cooked to a crisp by the time he arrives. The correct answer here is to instruct the mother to pry the eye open under cold water from the tap at home and irrigate for 30 minutes before bringing the child to the hospital. You will do more irrigation in the ED, remove solid matter, and eventually recheck the pH before the child goes home.

> A 59-year-old, myopic gentleman reports "seeing flashes of light" at night when his eyes are closed. Further questioning reveals that he also sees "floaters" during the day that number 10 or 20. He also sees a cloud at the top of his visual field.

This description if very concerning for retinal detachment; the frequency of "floaters" is an ominous sign. The "cloud" at the top of the visual field is hemorrhage settling at the bottom of the eye. This is another ophthalmologic emergency that requires laser treatment to "spot weld" the retina and prevent further detachment.

A 77-year-old man suddenly loses sight from the right eye. He calls you on the phone 10 minutes after the onset of the problem. He reports no other neurologic symptoms.

The acute onset is typical of an embolic occlusion of the retinal artery. First clinically evaluate for a CVA. If negative, this is an ophthalmologic emergency, although little can be done. Get the patient to the ED immediately. It might help for him to take an aspirin and breathe into a paper bag en route and have someone press hard on his eye and release it repeatedly.

A 55-year-old man is diagnosed with type II diabetes mellitus. On questioning about eye symptoms, he reports that sometimes after a heavy dinner the television becomes blurry and he has to squint to see it clearly.

The blurry TV is no big deal: the lens swells and shrinks in response to swings in blood sugar. The important point is that he needs to start getting regular ophthalmologic follow-up for retinal complications. It takes 10–20 years for these to develop, but type II diabetes may be present that long before it is diagnosed.

EAR, NOSE, AND THROAT (OTOLARYNGOLOGY)

Neck Mass

Neck mass can be congenital, inflammatory, or neoplastic.

- **Congenital** masses (seen in young people) are typically present for years before they become symptomatic (get infected).
- **Inflammatory** masses are typically measured in days or weeks, after which they typically resolve.
- **Neoplastic** masses typically present with several months of relentless growth.

Congenital

A **thyroglossal duct cyst** is a 1–2 cm neck mass located in the midline at the level of the hyoid bone that originates from the foramen cecum in the tongue (pulling at the tongue retracts the mass). Surgical removal includes the cyst, the middle segment of the hyoid bone, and the track that leads to the base of the tongue (Sistrunk procedure). You must also make certain that the patient has a thyroid gland, as sometimes the only thyroid tissue is in the cyst.

A **branchial cleft cyst** occurs laterally, along the anterior edge of the sternomastoid muscle, anywhere from in front of the tragus to the base of the neck. It is typically several centimeters in diameter and sometimes has a punctate opening and blind tract in the skin overlying it.

Cystic hygroma is a lymphatic overgrowth malformation made up of **normal lymphatics** found at the base of the neck as a large, spongy, ill-defined mass that occupies the entire supraclavicular area and seems to extend deeper into the chest. In fact, they often extend into the mediastinum; therefore CT is necessary prior to surgical excision.

Inflammatory and Neoplastic

The vast majority of recently enlarged lymph nodes are benign, so an extensive workup should not be undertaken right away. Complete history and physical should be followed by reevaluation in several weeks; if the mass is still there, further workup is necessary.

A persistently solitary enlarged **lymph node** (over weeks or months) could still be inflammatory, but neoplasia has to be ruled out. There are several patterns that are suggestive of specific diagnosis:

Lymphoma is typically seen in young people; they often have **multiple enlarged nodes** (in the neck and elsewhere) and have been suffering from low-grade fever and night sweats. FNA can be done, but usually a node has to be surgically removed for flow cytometry to determine specific subtype. Chemotherapy is the usual treatment.

Metastatic cancer that has spread to supraclavicular nodes invariably comes from below the clavicles, not from the head and neck. Lung or intra-abdominal tumors are the usual primaries. Biopsy of the lymph node may help establish a tissue diagnosis. It is commonly on the left side (Virchow's node), close to where the thoracic duct empties into the left subclavian-internal jugular vein junction.

SCC of the mucosa of the head and neck is seen in older men who smoke, drink, and have rotten teeth, as well in those with immunocompromised states such as HIV. Often the first manifestation is a metastatic node in the neck (typically to the jugular chain). The ideal diagnostic workup is a triple endoscopy ("panendoscopy") looking for the primary tumor; if found, biopsy will confirm the diagnosis and CT will demonstrate the extent. Ideally avoid biopsy of the node, as an incision in the neck may interfere with the appropriate surgical approach for the tumor. If no primary lesion is identified on panendoscopy, FNA of the node is the best step to obtain a tissue diagnosis. Treatment involves surgical resection, radical lymph node dissection, and very often radiotherapy and platinum-based chemotherapy.

Clinical Pearl

Other presentations of SCC include persistent hoarseness, persistent painless ulcer in the floor of the mouth, or persistent unilateral earache.

Acoustic neuroma should be suspected in an adult with unilateral sensory hearing loss. MRI is the best diagnostic modality. Make certain the patient was not involved in unilateral loud noise (e.g., firearm shooting).

Facial nerve tumors produce gradual unilateral facial nerve paralysis affecting both the forehead and the lower face, as opposed to sudden onset paralysis, which suggests Bell's palsy (but a **CVA must be ruled out**). Gadolinium-enhanced MRI is the best diagnostic study.

Parotid tumors typically present as visible and palpable in front of the ear or around the angle of the mandible. Most are pleomorphic adenomas ("mixed" tumors), which produce no pain or facial nerve paralysis. A hard parotid mass that is painful or produces paralysis is likely a parotid cancer.

- Resect with a normal tissue margin via superficial parotidectomy due to the potential for malignant degeneration.
- FNA may be done, but open biopsy is absolutely contraindicated.

In malignant parotid tumors, the facial nerve is sacrificed and a nerve interposition graft performed.

A 15-year-old girl has a round, 1-cm cystic mass in the midline of her neck at the level of the hyoid bone. When the mass is palpated while the tongue is pulled, there seems to be a connection between the two. The mass has been present for at least 10 years, but only recently bothered the patient because it got infected.

This is a typical presentation of a thyroglossal duct cyst. Management is surgical via the Sistrunk procedure: removal of the mass and the track to the base of the tongue, along with the medial segment of the hyoid bone. On the exam it is unlikely that all of these features will be present, but the midline location is the key. Make certain that the patient has a thyroid gland, as the only thyroid tissue may be in the cyst.

An 18-year-old woman has a 4-cm, fluctuant round mass on the side of her neck, just beneath and anterior to the sternocleidomastoid. She reports that it has been there at least 10 years, although she thinks that it has become somewhat larger in the last year or two. A CT shows the mass to be cystic.

This can be a branchial cleft cyst. Elective surgical removal is indicated.

A 6-year-old girl has a mushy, fluid-filled mass at the base of her neck that has been noted for several years. The mass is ~6 cm in diameter, occupies most of the supraclavicular area, and seems by physical examination to go deeper into the neck and chest.

A common description of a cystic hygroma. Perform a CT to see how deep the mass goes into chest to plan surgical resection.

A 22-year-old woman notices an enlarged lymph node in her neck. The node is in the jugular chain, measures ~1.5 cm, is not tender, and was discovered by the patient yesterday. The rest of the history and physical examination are unremarkable.

Give it some time before pursuing a complicated workup, as this may be simple lymphadenitis. Schedule the patient to be rechecked in 2–3 weeks. If the node has gone away by then, it was inflammatory and nothing further is needed. If it's still there, it could be neoplastic and FNA should be performed for further information. A few weeks of delay will not significantly impact the overall course of a neoplastic process.

A 22-year-old woman presents with an enlarged lymph node in her neck. The node is in the jugular chain, measures ~2 cm, is firm, is not tender, and was discovered by the patient 6 weeks ago. There is a history of low-grade fever and night sweats for the past 3 weeks. Physical examination reveals mildly enlarged lymph nodes in the axilla and left groin.

The presence of systemic symptoms and multistation lymphadenopathy in this age group is highly suspicious for lymphoma. Tissue diagnosis will be needed; start with FNA of the most accessible node, but typically excisional lymph node biopsy is necessary for flow cytometry to subtype the malignancy and guide choice of chemotherapy.

A 72-year-old former smoker presents with a 3-cm hard mass in the left supraclavicular region. The mass is movable and not tender and has been present for 3 months. The patient has had a 20-pound weight loss in the past 2 months but denies fever or night sweats.

"Virchow's node" describes a supraclavicular site of metastases, typically from chest or abdominal primary cancers. Biopsy the node to diagnose the primary cancer, but the presence of this node represents metastatic disease (stage IV).

A 69-year-old former smoker presents with a hard, fixed, 4-cm mass in his neck. The mass is just medial and is in front of the sternocleidomastoid muscle, at the level of the upper notch of the thyroid cartilage. It has been there for several months and is growing.

The age, smoking history, and location all point to metastatic SCC to a jugular chain node from a primary in the mucosa of the head and neck. The best diagnostic approach is panendoscopy, with biopsy of any identifiable lesions. CT will establish extent and operability. Treatment is multimodal: radiation, platinum-based chemotherapy, and surgery if possible. Other potential presentations on the exam include hoarseness, oral ulcers, and earache, especially in heavy smokers and HIV patients.

A 52-year-old man complains of hearing loss. When tested he is found to have unilateral sensory hearing loss on one side only. He does not engage in any activity (such as sport shooting) that would subject that ear to noise that spares the other side.

Unilateral versions of common ENT problems in the adult suggest malignancy—in this case, acoustic neuroma. Note that if the hearing loss had been conductive, a cerumen plug would be the most likely diagnosis. Physical examination followed by MRI of the head is diagnostic.

A 56-year-old man develops slow, progressive paralysis of the facial nerve on one side. It took several weeks for the full-blown paralysis to become obvious, and it has been present now for 3 months. It affects both the forehead and the lower face.

Gradual, unilateral nerve paralysis suggests a neoplastic process. Diagnose with MRI.

A 45-year-old man presents with a 2-cm firm mass in front of the left ear, which has been present for 4 months. The mass is deep to the skin, and it is painless. The patient has normal function of the facial nerve.

Pleomorphic adenoma ("mixed" tumor) of the parotid does not typically involve the facial nerve and therefore does not present with neurological findings. FNA may be appropriate, but the point of the exam question will be to *not* biopsy the mass via an open approach; superficial parotidectomy is used for both diagnosis and treatment.

A 65-year-old man presents with a 4-cm hard mass in front of the left ear that has been present for 6 months. The mass is deep to the skin, and it is fixed. He has constant pain in the area, and for the past 2 months has had gradual progression of left facial nerve paralysis. He has rock-hard lymph nodes in the left neck.

In contrast to the previous vignette, this mass has caused neurological deficits in the facial nerve territory and is most suspicious for parotid cancer. He will need total parotidectomy with facial nerve reconstruction.

Emergencies and Miscellaneous

Ludwig's angina is an abscess of the floor of the mouth, often as the result of a dental infection. The usual findings of an abscess are present, but the special issue here is the threat to the airway that arises from swelling of the tongue. Incision and drainage are done, but intubation and tracheostomy may also be needed to protect the airway.

Bell's palsy produces sudden paralysis of the facial nerve for no apparent reason. Although not an emergency per se, current practice includes the use of antiviral medications—and as is the case for other situations in which antivirals are used, prompt and early administration is the key to their success. Steroids are also typically prescribed. First rule out stroke prior to treating for Bell's palsy.

Facial nerve injuries sustained in trauma produce paralysis right away. Patients who have normal nerve function at the time of admission and later develop paralysis are likely to have swelling that will resolve spontaneously.

Cavernous sinus thrombosis is heralded by the development of diplopia (secondary to paralysis of extrinsic eye muscles) in a patient suffering from frontal or ethmoid sinusitis. This is a serious emergency that requires hospitalization, CT scan, IV antibiotics, and drainage of the affected sinuses.

Epistaxis in children is typically from nose-picking; the bleeding comes from the anterior septum, and phenylephrine spray and local pressure control the problem. Also suspect cocaine abuse (with septal perforation) or juvenile nasopharyngeal angiofibroma. Posterior packing may be needed for the former, and surgical resection is mandatory for the latter (the tumor is benign, but it can erode into nearby structures). In the elderly and hypertensive, nosebleeds can be copious and life-threatening. BP control is paramount, and posterior packing is usually required. Sometimes angiographic embolization or surgical ligation of the **external** carotid if angiography is not available is the only way to control the problem.

Dizziness may be caused by inner ear disease or cerebral disease. When the inner ear is the culprit, the patients describe the room spinning around them (vertigo); when the problem is in the brain, the patient is unsteady but the room is perceived to be stable. In the first case **meclizine, Phenergan, or diazepam** may help. In the second case, full neurologic workup is in order.

A 45-year-old woman presents with a large, warm, red mass on the lower side of the face and upper neck. She was recently evaluated and treated by her dentist for a tooth infection. The mass pushes up the floor of the mouth on that side. She is febrile.

An abscess of the floor of the mouth, also known as Ludwig's angina, is a surgical emergency. It needs to be incised and drained like all abscesses, but if it continues to enlarge it could compromise her airway; urgent intubation or tracheostomy may be required.

A 29-year-old woman calls your office reporting that she awoke this morning unable to move one side of her face.

Despite her age, make sure to rule out a CVA with a CT of the head, but this is suggestive of Bell's palsy. Treat with antiviral medication and steroids or watchful waiting.

An 18-year-old boy has epistaxis. He denies picking his nose. No source of anterior bleeding can be seen on physical examination.

In this young age group, this condition is either septal perforation from cocaine abuse or posterior juvenile nasopharyngeal angiofibroma. Septal perforation may need posterior packing. Posterior juvenile nasopharyngeal angiofibroma needs to be removed surgically (it is benign but can locally invade other structures).

A 72-year-old man on a baby aspirin with hypertension and diabetes presents to the ED with headaches. Blood pressure is 220/115 mm Hg. He acutely develops severe epistaxis.

This is clearly epistaxis secondary to hypertension. Significant blood can be lost. Pharmacological management of hypertension is obviously needed, but urgent control is necessary—usually with posterior packing. Rarely, emergency arterial ligation or angiographic embolization is necessary.

Neurosurgery 8

Learning Objectives

- ❑ List the differential diagnoses for common presenting complaints
- ❑ Describe treatment options for cerebrovascular occlusive disease
- ❑ Describe primary and metastatic brain tumors, treatment options, and prognosis
- ❑ Provide an approach to treating chronic pain syndromes

The timetable and mode of presentation of neurologic diseases provide the first clues to etiology:

- **Vascular problems** have sudden onset without headache when they are occlusive and with very severe headache when they are hemorrhagic.
- **Brain tumors** have a timetable of months, and produce constant, progressive, severe headache, sometimes worse in the mornings. As intracranial pressure increases, blurred vision and vomiting occur. Focal deficits may be anatomically based.
- **Infectious problems** have a timetable of days or weeks, and often an identifiable source of infection in the history.
- **Metabolic problems** develop rapidly (hours or days) and affect the entire CNS.
- **Degenerative diseases** usually have a timetable of years.

VASCULAR OCCLUSIVE DISEASE

Transient ischemic attack (TIA) is sudden, transitory loss of neurologic function that comes on without headache. It resolves spontaneously within 24 hours without leaving permanent neurologic sequelae.

Symptoms depend on the area of the brain affected, which is related to the vessels involved. The most common origin is high-grade stenosis (≥70%) of the internal carotid or ulcerated plaque at the common carotid bifurcation. TIAs are predictors of stroke, and timely recognition and management can minimize that potential. Workup starts with noninvasive duplex U/S studies.

Treatment is antiplatelet therapy and possible carotid endarterectomy if the lesions are found in a location that explains the neurologic symptoms. In high-risk surgical patients, angioplasty and endovascular stent placement has had some success.

Ischemic stroke also has sudden onset without headache, but in contrast to a TIA the neurologic deficits are present >24 hours and often leave permanent sequelae.

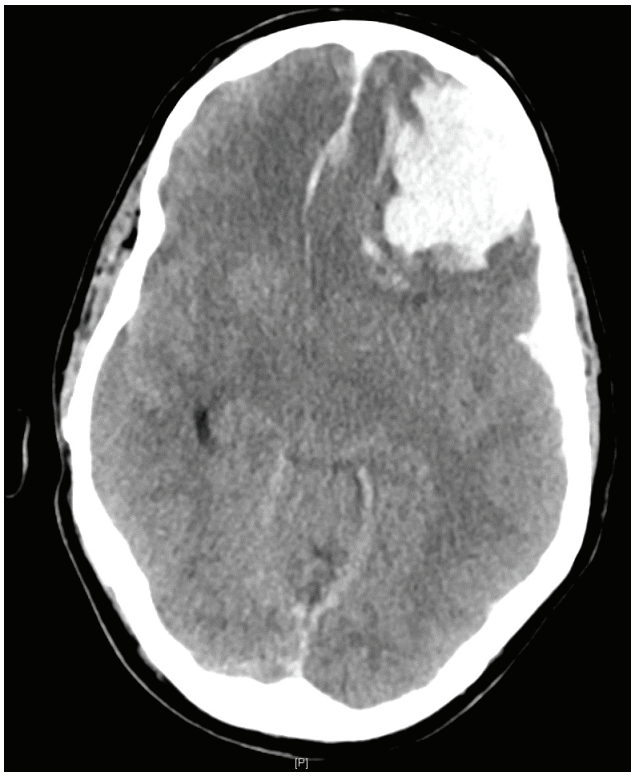
- Very early ischemic stroke (<3 hours) may be amenable to IV tissue plasminogen activator (tPA) or endovascular thrombectomy, but most strokes are not amenable to revascularization.
- Furthermore, an ischemic infarct may be complicated by a hemorrhagic infarct if blood supply to the brain is suddenly increased.
- Vascular workup will eventually be done to identify lesions that might produce another stroke (and treat them), but for the existing infarct, assessment is CT and treatment is rehabilitation.

Intracranial Bleeding

Hemorrhagic stroke is seen in the uncontrolled hypertensive who complains of very severe headache of sudden onset and goes on to develop severe neurologic deficits. CT is used to evaluate the location and extent of the hemorrhage, and treatment is directed at control of the hypertension and rehabilitation efforts.

Subarachnoid hemorrhage can be caused by rupture of an intracranial aneurysm, trauma, or spontaneous bleeding. The amount of pressure that the free blood exerts on the brain determines the severity of symptoms and resultant outcome.

- If there is significant pressure exertion (especially when caused by an aneurysm), patients complain of severe, sudden onset headache, "the worst of their life." Physical exam can demonstrate nuchal rigidity due to meningeal irritation. Testing includes CT and possible MRA or formal angiogram to identify the neurovascular anatomy. Treatment for a cerebral aneurysm is open clipping of the aneurysm or endovascular coiling (both have good results).
- If there is limited bleeding from an aneurysm, there may be only minimal pressure exerted on the brain; symptoms may not appear until 7–10 days after the "sentinel bleed." When that happens, the degree of intracranial hematoma is often significant, and patients cannot always be helped. Therefore, a very high index of suspicion at initial presentation can be lifesaving.



Courtesy of Gary Schwartz, MD

Figure 8-1. Subarachnoid Hemorrhage

A 62-year-old right-handed man has transient episodes of weakness in the right hand, blurred vision, and difficulty expressing himself. There is no associated headache, and the episodes have sudden onset, lasting 5–10 minutes and resolving spontaneously with no neurological sequela.

This scenario is most consistent with TIA in the territory of the left carotid artery caused by stenosis or an ulcerated plaque at the left carotid bifurcation. Start workup with duplex scan. If stenosis exceeds 70%, proceed to carotid endarterectomy.

A 61-year-old man presents with a 1-year history of episodes of vertigo, diplopia, blurred vision, dysarthria, and instability of gait. The episodes have sudden onset, last several minutes, have no associated headache, and leave no neurologic sequela.

This is another version of TIA, but now the vertebral arteries may be involved. Start with duplex scan.

A 60-year-old diabetic man presents to the ED after abruptly developing right-sided hemiparesis 6 hours ago. There was no associated headache and he is alert, but the neurologic deficits have not resolved.

Neurologic catastrophes that begin suddenly and have no associated headache are vascular occlusive in origin. This patient needs a CT to assess the extent of the infarct and supportive treatment with emphasis on rehabilitation. Eventually his neck vessels will be looked at by duplex scan to see whether a second stroke elsewhere may be preventable.

If the vignette had described a patient much earlier in presentation, IV infusion of tissue-type plasminogen activator (tPA) could be started within 90 minutes of the onset of symptoms.

A 39-year-old woman presents to the ED with a history of a severe headache of sudden onset that she says is different and worse than any headache she has ever had before. Her neurologic examination is completely normal, so she is given pain medication and sent home. She improves over the next few days, but 10 days after the initial visit she again gets a sudden, severe, and singular diffuse headache and returns to the ED. This time she has some nuchal rigidity on physical exam.

This is a classic and commonly tested scenario: a subarachnoid bleeding from an intracranial aneurysm. The "sentinel bleed" that is not identified is a common feature; the "sudden, severe, and singular" nature of the pain is also very common. The nuchal rigidity betrays the presence of blood in the subarachnoid space. We are looking for blood inside the head, thus start with CT. Angiograms will eventually follow, in preparation for surgery to clip the aneurysm or endovascular coiling.

BRAIN TUMORS

Brain tumor may present with focal deficits based on location but may be vague:

- Progressively increasing headache for several months
- Worse in the mornings
- Eventual signs of increased intracranial pressure (blurry vision, papilledema, and vomiting)
- Bradycardia and hypertension due to the Cushing reflex

Brain tumor can be visualized very well on CT scan, but MRI gives better detail and is the preferred study. While awaiting surgical removal, treat any increased intracranial pressure with high-dose steroids (e.g., dexamethasone).

Clinical localization of brain tumors may be possible:

- Motor and speech centers are often affected in tumors that press on the lateral side of the brain, producing symptoms on the opposite side of the body.
- **Tumor at the base of the frontal lobe** produces inappropriate behavior, optic nerve atrophy on the side of the tumor, papilledema on the other side, and anosmia (Foster-Kennedy syndrome).
- **Craniopharyngioma** occurs in children who are short for their age; they show bitemporal hemianopsia and a calcified lesion above the sella on x-rays.

- **Prolactinomas** produce amenorrhea and galactorrhea in young women. Diagnostic workup includes ruling out pregnancy and hypothyroidism, determination of prolactin level, and MRI of the sella. Treatment is bromocriptine. Transnasal, transsphenoidal surgical removal is reserved for those who do not respond or those who wish to get pregnant.
- **Acromegaly** develops from the effects of excess growth hormone from a pituitary tumor. It is recognized by the height and the presence of large hands, feet, tongue, and jaws. Additionally, there is hypertension, diabetes, sweaty hands, headache, and the history of wedding bands or hats that no longer fit. Check serum somatomedin C levels and perform an MRI. Treatment is surgical removal, but radiation is an option.
- **Pituitary apoplexy** occurs when there is bleeding into a pituitary tumor, with subsequent destruction of the pituitary gland. The history may have clues to the longstanding presence of a pituitary tumor (headache, visual loss, endocrine problems). The acute episode starts with a severe headache, followed by signs of increased compression of nearby structures by the hematoma (deterioration of remaining vision, bilateral pallor of the optic nerves) and pituitary destruction (stupor and hypotension). Steroid replacement is urgently needed, and eventually other hormones will need to be replaced. MRI or CT will delineate the extent of the problem.
- **Tumor of the pineal gland** produces loss of upper gaze and the physical finding known as "sunset eyes" (Parinaud syndrome).
- **Brain tumor in children** is most commonly in the posterior fossa. It produces cerebellar symptoms (stumbling around, truncal ataxia), and children often assume the knee-chest position to relieve their headache.

Brain abscess present with many of the same manifestations of brain tumor, as it is a space-occupying lesion. However, brain abscess develops more quickly (1–2 weeks). There is fever, and usually an obvious source of the infection nearby, such as otitis media or mastoiditis. It has a very typical appearance on CT; thus the more expensive MRI is not needed. Surgical resection is required.

> A 31-year-old nursing student presents with persistent headaches of increasing intensity that began 4 months ago. They are worse in the mornings. For the past 3 weeks she has been having occasional vomiting. Thinking that she may need new glasses, she sees her optometrist, who discovers that she has bilateral papilledema.

The insidious pattern of progressive symptoms over months is suspicious for a brain tumor. Start with a CT scan, but most likely an MRI will be necessary. Employ measures to decrease ICP while awaiting surgery, including high-dose steroids.

> A 42-year-old right-handed man has had a history of progressive speech difficulties and right hemiparesis for 5 months. He has had progressively severe headaches for the last 2 months. At the time of admission he is confused and vomiting and has blurred vision, papilledema, and diplopia. Shortly thereafter his blood pressure rises to 190/100 mm Hg, and he develops bradycardia.

Another presentation of a brain tumor, but with localizing signs (left parietal and temporal) and presenting with the Cushing reflex due to high ICP. Manage as above, but as an emergency.

A 23-year-old nun presents with a history of amenorrhea and galactorrhea of 6 months' duration. She is very concerned that others might think that she is pregnant, and she vehemently denies such a possibility.

When suspecting a prolactinoma, first confirm that the patient is not pregnant or hypothyroid. Check a prolactin level and perform an MRI. Treatment is bromocriptine. Surgery is reserved for those who do not respond or those who wish to become pregnant.

A 44-year-old man is referred for treatment of hypertension. His physical appearance is impressive: he has big, fat, sweaty hands; large jaw and thick lips; a large tongue; and huge feet. He is also found to have a touch of diabetes. In further questioning he admits to headaches and relates that his wedding ring no longer fits his finger.

There are the hallmark features of acromegaly, which will typically present on the exam with some of these features and potentially an image (hands, jaw). Measure serum somatomedin C level; then perform an MRI and eventually pituitary surgery or radiation therapy.

A 15-year-old girl has gained weight and developed acne and facial hair. She has mild diabetes and hypertension.

Some variant of Cushing syndrome will be presented on the exam, often with "before" and "after" pictures. Management is as described in the endocrine section: an overnight low-dose dexamethasone suppression test and if no suppression, 24-hour urinary cortisol. If cortisol is high, do a high-dose dexamethasone suppression test. If she suppresses at high dose, do an MRI of the sella and follow with transsphenoidal pituitary surgery.

A 27-year-old woman develops a severe headache of sudden onset, making her stuporous. She is taken to the hospital, where she is found to have blood pressure 75/45 mm Hg. Relatives indicate that for the past 6 months she has been complaining of morning headaches, loss of peripheral vision, and amenorrhea.

This scenario is most consistent with pituitary apoplexy—she has bled into a pituitary tumor. Steroid replacement is urgently needed. Other hormones will need to be replaced eventually. MRI or CT will determine extent of the problem.

A 6-year-old boy has been stumbling around the house and complaining of severe morning headaches for the past several months. While waiting in the office to be seen, he assumes the knee-chest position as he holds his head. Neurologic examination demonstrates truncal ataxia.

Brain tumors in children typically occur in the posterior fossa, affecting cerebellar function. MRI and neurosurgery are required.

A 23-year-old man develops severe headaches, seizures, and projectile vomiting over a period of 2 weeks. He has low-grade fever and was recently treated for mastoiditis.

The short interval of presentation and recent infection as suggestive of a brain abscess. Start with a CT; management is surgical.

PAIN SYNDROMES

Pain syndromes are very difficult to diagnose and manage. Other etiologies must be satisfactorily ruled out prior to diagnosing a chronic pain condition.

Trigeminal neuralgia (**tic douloureux**) produces extremely severe, sharp shooting or burning pain in the face in the distribution of the trigeminal nerve. Patients often describe the pain as a "bolt of lightning" brought about by touching a specific area and lasting 60 seconds. Patients, typically elderly, have a completely normal neurologic exam. The only finding on physical exam may be an unshaven area in the face (the trigger zone, which the patient avoids touching). MRI is done to rule out organic lesions. Treatment with anticonvulsants is often successful. If not, radiofrequency ablation can be done.

Reflex sympathetic dystrophy (**causalgia**) develops several months after peripheral nerve injury (e.g., crush injury of nerve). There is constant, burning, agonizing pain that does not respond to the usual analgesics. The pain is aggravated by the slightest stimulation of the area. The extremity is cold, cyanotic, and moist. A successful sympathetic block is diagnostic, and surgical sympathectomy is curative.

Organ Transplantation 9

Learning Objectives

- ❑ Describe the policies related to waiting lists for organ transplantation
- ❑ Describe the common complications in organ transplantation

DONOR SELECTION

The selection of donors for transplant has been liberalized in order to alleviate the acute shortage of organs, with improving results. The general rule is that all potential donors are referred to the United Network for Organ Sharing (UNOS), and they will exclude the rare donors that cannot be used at all.

- Virtually all brain-dead patients are potential candidates, regardless of age.
- Some donors with specific infections (e.g., hepatitis) can be used for recipients who have the same underlying infection.
- Even donors with metastatic cancer can donate corneas, because the cornea does not have a blood supply.

Historically, infectious diseases such as hepatitis and HIV were considered absolute contraindications to organ transplantation. This has recently changed:

- Seropositive organs are now being transplanted to seropositive recipients.
- Hepatitis can now be pharmacologically cured, allowing for transplantation into seronegative recipients with subsequent treatment.

TRANSPLANT REJECTION

After an organ has been transplanted, rejection can develop despite immunosuppressive medications. Tissue typing and a close tissue match may minimize that risk, but it is an ever-present concern for most patients.

Transplant rejection can occur in 3 ways: hyperacute, acute, or chronic.

Hyperacute Rejection

Hyperacute rejection is a vascular thrombosis that occurs within minutes of reestablishing blood supply to the organ. It is caused by preformed antibodies. It is preventable by ABO matching and lymphocytotoxic crossmatch; therefore it is rarely seen clinically.

Acute Rejection

Acute rejection (most common) often occurs after the first 5 days but always within the first 3 months. Episodes occur even if the patient is on maintenance immunosuppression.

Signs of organ dysfunction suggest it, and biopsy confirms it.

- **Liver**: Technical problems are more commonly encountered than immunologic rejection. Thus, the initial priorities if liver function deteriorates post-transplant (rising gamma-glutamyl transferase [GGT], alkaline phosphatase, and bilirubin) are to rule out biliary obstruction by U/S and vascular thrombosis by Doppler study.
- **Heart**: Signs of functional deterioration occur too late to allow effective treatment, so routine myocardial biopsy (percutaneously via the jugular vein) is done at set intervals. First-line treatment for acute rejection is high-dose steroids. If unsuccessful, antilymphocyte agents have been used, though their high toxicity is a problem. Newer anti-thymocyte serum is tolerated better. Efforts are underway to utilize MRI as a non-invasive way to diagnose rejection without the need for biopsy. Rarely, retransplantation is necessary.
- **Lung**: Worsening dyspnea and the need for oxygen supplementation should prompt chest x-ray, CT scan, and ultimately transbronchial biopsy. Treat as with heart transplant rejection.

Chronic Rejection

Chronic rejection is seen years after the transplant, with gradual, insidious loss of organ function. It is poorly understood and irreversible. Although there is no treatment, the transplant can be biopsied in the hope that it may be a delayed (and treatable) case of acute rejection. Occasionally, retransplantation is necessary.

> A 62-year-old man who had a motorcycle accident has been in a coma for several weeks. He is on a respirator, has had pneumonia on and off, has been on vasopressors, and shows no signs of neurologic improvement. The family inquires about brain death and possible organ donation.

All patients that are moribund should be considered for organ donation. Neurological reflex exam, apnea testing, and cerebral blood flow studies are all utilized to establish brain death. Age cutoffs for donation are organ-specific. Infectious diseases such as hepatitis and HIV are no longer absolute contraindications to organ transplantation.

> Ten days after liver transplantation, alkaline phosphatase and bilirubin are noted to be increasing. The patient is asymptomatic.

So early after a transplant, this scenario is concerning for a technical problem versus acute rejection. Do an U/S; if a technical problem exists, surgical or endoscopic interventions may salvage the organ. If absent, immunomodulation is necessary, typically starting with a steroid bolus.

On week 3 after a closely matched renal transplant, there are early clinical and lab signs of decreased renal function.

This is likely acute rejection requiring immunomodulation. If a technical problem existed it would be expected earlier, but assess arterial and venous patency with U/S.

Two weeks after a lung transplant, the patient develops fever, dyspnea, hypoxemia, decreased FEV1, and interstitial infiltrates on chest x-ray.

This is likely acute rejection, but an infectious etiology must also be considered. Treatment is antibiotics and possible antifungal therapy, as lung transplants are prone to fungal infection. Bronchoscopy with bronchoalveolar lavage is diagnostic, but patients may not tolerate without intubation. Transbronchial biopsy may be needed to establish a diagnosis of rejection, but given the need to intubation, empiric immunosuppression is often administered once an infectious etiology has been ruled out or treated.

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