General surgery

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Pre-operative evaluation

- General evaluation
    - History and physical examination:
        - Past medical history
        - Past surgical history
        - Social history
        - Drug history
        - Family history of bleeding disorders, hemophilia, and scolene apnea
    - Pre-operative medications: all medications should be continued in the immediate preoperative period except for:
        - Anticoagulants
        - Antiplatelets
        - Diabetic medications
        - ACE-I and statins (individualized)
    - Routine diagnostic testing:
        - CBC:
            - As baseline (due to possibility of blood loss)
            - If estimated blood loss is less than 500 mL
            - Patients with chronic illness or symptoms of anemia
        - Urine analysis:
            - Urologic symptoms
            - Instrumentations of urinary tract
            - Possible surgical placement of prosthesis
        - Serum electrolytes, Cr, BUN (KFT):
            - Age >50
            - Chronic diarrhea
            - Major procedure
            - Renal disease, liver disease, cardiac disease, HTN, DM
            - Diuretic use, digoxin use, ACE-I use
        - Coagulation studies (PT, PTT, INR, and bleeding time):
            - Anticoagulant use
            - Family history of bleeding disorders
            - History of abnormal bleeding
            - Liver disease, malnutrition, alcohol use
        - Beta-hCG: any female patient within the childbearing age
        - LFT (including albumin)
            - Major procedure
            - History of liver or biliary disease
            - Albumin is a strong predictor for preoperative morbidity

        - Type and cross match: if estimated blood loss is >500 mL; otherwise, there is no need to do it
        - Chest X-ray:
            - Acute cardiac or pulmonary symptoms
            - Smokers
        - ECG:
            - All patients >50; done within 6 months prior to surgery
            - Patients with a known heart disease; 3 months within surgery
            - Diabetic patients to detect silent MI
- Specific considerations:
    - Cardiovascular risk:
        - A leading cause of death especially in patients with an ejection fraction < 35% (Normally 55%)
        - Risk factors:
            - Age >70
            - DM
            - Unstable angina: elective surgeries are contraindicated and should be delayed until further investigations
            - Recent MI (within 6 months)
            - CHF: it is the worst finding predicting high cardiac risk and should be treated prior to surgery
            - Valvular heart disease
            - Arrhythmias and conduction defects
            - Peripheral vascular disease
            - Functional impairment
        - Cardiovascular risk is calculated using the modified cardiac risk index and Goldman's cardiac risk index
        - Peri-operative beta blockers decrease peri-operative cardiac events and decrease the risk of MI in high risk patients. Titrate the dose of beta blockers to maintain a heart rate between 60-80 bpm in the absence of hypotension
    - Pulmonary disease:
        - Risk factors:
            - COPD: increase risk 3-4 fold
            - Smoking: risk is decreased after 8 weeks of smoking cessation; however, there are physiological benefits of stopping smoking 48 hours before surgery
            - Advanced age
            - Obesity (BMI >30)

        - Acute respiratory infection: elective surgeries should be postponed
        - Poor functional status
    - Postpone elective surgeries for patients who are actively wheezing
    - ABG's should be performed preoperatively in patients with a history of lung disease or smoking as a baseline
    - EG should be done in any patient >30 years of age with shortens of breath to exclude myocardial ischemia
- Renal risk:
    - Risk factors:
        - Coexisting illnesses (DM, HTN, CAD)
        - Metabolic and physiological derangement of CKD:
            - Hyperkalemia
            - IV volume overload
            - Infectious complications
        - Type of procedure: usually, major procedures are associated with higher morbidity and mortality
    - Evaluation:
        - History:
            - Ask about the specific etiology of CKD, because patients with CKD due to HTN or DM are at a higher risk for peri-operative morbidity and mortality
            - Ask about dialysis:
                - 1st time of dialysis (this gives important information about the patient's expected volume status)
                - Amount of fluid removed
                - Pre-operative weight
        - Physical examination: asses volume status using JVP and lung crackles as indicators
        - Investigations:
            - CBC, electrolytes, Creatinine, and BUN
            - Urine analysis and culture (as indicated)
        - Management:
            - Dialysis should done within 24 hours of surgery, if indicated
            - Intravascular volume status monitoring. Both hypovolemia and hypervolemia carry a higher risk for morbidity and mortality.
            - CAD is the most common cause of death in patients with CKD

        - Risk of AKI in patients without preexisting CKD is 1.5-2.5% for cardiac surgical procedure, while it is >10% for patients undergoing AAA repair
        - Normal levels of platelets can mask platelet dysfunction in patients with chronic uremia
        - Indications for dialysis:
            - Intavascular volume overload
            - Hyperkalemia
            - Severe metabolic acidosis
            - Complications of uremia (encephalopathy, pericarditis)
        - Risk factors for AKI:
            - Increased BUN/ increased Creatinine
            - CHD/introperative hypotension
            - Advanced age
            - Sepsis
            - Administration of nephrotoxic substances
- Cerebrovascular risk:
    - Uncommon: 1% in general population; 2-5% in cardiac surgical patients)
    - The majority of events are post-operatively, mostly due to hypotension or cardiogenic emboli during A-fib
    - Patients with a recent CVA should have their surgeries delated for 2 weeks (ideally, 6 weeks)
    - Asymptomatic carotid bruit is relatively common in patients >55 years of age. It does not increase the risk of stroke
- Infectious disease:
    - Assessment of risk preoperatively
        - Patient specific factors: Age, DM, obesity, immune-suppression, malnutrition, pre-existing infections, chronic illnesses
        - Procedure specific risk factors (Check the table)

Wound Class	Definition	Example	%	Micro-organism
Clean	-Non-traumatic -No entry of GI, biliary, tracheobronchia, respiratory, or gut	-Wide local excision of mass - Hernia repair - Thyroid surgeries	2%	Staph
Clean-contaminated	-Respiratory, GU, GI entered but minimal contamination (controlled entrance)	-Gastrectomy -Hysterectomy -Cholecystectomy	<10 %	Related to site
Contaminated	-Open, fresh, traumatic wounds	-Ruptured appendix	20%	Related to site

	-Uncontrolled spillage from poorly prepared hollow viscus -Minor breaks in sterile techniques	-Resection of unprepared bowel		
Dirty	-Open, traumatic, dirty wounds -Traumatic perforated viscus -Pus in the operative field	-Intestinal fistula resection -Hartman's for diverticular perforation	30-70%	Related to site

- Prophylaxis:
  - Strict sterile techniques
  - Maintaining normal body temperature, blood glucose levels, and hyperoxygenation
  - Pre-operative skin antisepsis by chlorhexidine-alcohol (better) or using Povidone-iodine scrub
  - Antibiotic prophylaxis to decrease superficial wound infection risk. Given within a period of 60 minutes pre-operatively up to 1 day post-operatively

Nature of operation	Likely pathogens	Recommended anatibiotics
Cardiac (prosthetic valve and other procedures)	-Staphylococci -Corynebacteria -Enteric gram negative bacilli	-Vancomycin and cefazolin -Vancomycin and aztreonam (if allergic)
Thoracic	-Staphylococci	-Cefazolin -Vancomycin (if allergic)
Vascular (peripheral bypass or aortic surgery with prosthetic graft)	-Staphylococci -Streptococci -Enteric grame negative bacilli -Clostridia	-Cefazolin -Vncomycin and Aztreonam (if allergic)
Orthopedic (total joint replacement)	-Staphylococci	-Cefazolin -Vancomycin (if allergic)
Upper GI and hepato-biliary	-Enteric gram negative bacilli -Enterococci -Clostridia	-Cefazolin -Cefatetran -Cefoxitin -Clindamycin + Gentamycin (if allergic) -Ciprofloxacin + metronidazole
Colrectal or appendictomy without preparation	-Enteric gram negative bacilli -Anaerobes	-Cefoxiting -Cefotetan

	-Enterococci	-Ciprofloxacin and metronidazole (if allergic)
OBS/GYNE	-Enteric gram negative bacilli -Anaerobes -Group B steptococci -Enterococci	-Cefatetan -Cefoxitin -Cefazolin -Clindamycin + Gentamycin

- Diabetes:
  - Patients with diabetes have 50% more risk of mortality and morbidity compared to non-diabetics
  - They have more infectious complications
  - Impaired wound healing
  - Vascular disease and silent CAD must always be considered and investigated
  - When undergoing and elective surgery, blood glucose levels should be controlled between 100-250
  - Preoperative evaluation:
    - Patients with diet controlled DM can be maintained safely wiithout food glucose infusion before surgery
    - Patients on oral hypoglycemic agents should discontinue their medications on the evening before the scheduled surgery, but patients who take long-acting hypoglycemics should discontinue their drugs 3-4 days prior to surgery
    - Patients on insulin:
      - Those require insulin and glucose pre-operatively to prevent ketosis and catabolism
      - Patients undergoing major surgeries should receive ½ their insulin dose and 5% dextrose IV at 100-125 mL/hour
  - MI is the leading cause of death peri-operatively among diabetic patients
- Anticoagulants:
  - It is considered safe to perform surgery when INR is below 1.5
  - If INR is 2-3 discontinue medications for 4 days preoperatively
  - If INR is more than 3, discontinue medications for longer periods
  - Measure INR the day before operation
  - For emergent procedures, you can either give factor VIII (immediately effective) or vitamin K (effective within 8 hours)
  - Most common indications for warfarin treatment:
    - Atrial fibrillation
    - Venous thromboembolism
    - Mechanical heart valve
- Steroid dependence:

- All patients who need steroids should take hydrocortisone in the IV form, even if they used to take orally because the adrenals depend on external steroids
- Stress dose is 100 mg IV; one on the evening of the operation and another at the beginning of the operation

Postoperative care

- IV fluids:
  - Intravascular volume of surgical patients is decreased by both insensible fluid losses and redistribution into 3rd space . As a general rule, patients should be maintained on IV fluids until they can tolerate oral intake
  - Extensive abdominal procedures require aggressive fluid resuscitation
  - Insensible fluid losses associated with an open abdominal procedure can reach 500-1000 mL/hour
- DVT prophylaxis:
  - It should be started preoperatively in patients undergoing major procedure because of venous stasis and relative hypercoagulability that happens during the operation.
  - Levels of VTE risk and recommended prophylaxis:

Level of risk		**Risk without prophylaxis**	**Recommended prophylaxis**
Low	-Major surgery in mobile patients -patients who are fully mobile	<10%	Early and aggressive mobilization
Moderate	-Open gyne/uro surgical patients -Patients on bed rest "sick" -Moderate VTE risk and high bleeding risk	10-40%	-LMWH, UHF, or fundopuranix -Pneumotic compression devices
High	-Total hip/knee replacement -Major trauma -Spinal cord injury -High VTE and high bleeding risk	40-80%	-LMWH, fundopuranox, warafarin (INR 2-3) -Pneumotic compression devices

- Pulmonary toilet:
  - Pain and immobilization decrease clearance of secretions and decrease recruitment of alveoli
  - What to do postoperatively?
    - Early mobilization
    - Incentive spirometry: the patient can document tidal volume and will have an incentive to increase it. Patients breath in from the device as slowly and as deeply as possible, then they hold their breath for 2-6 seconds
    - Cough

        - Deep breathing exercises
    - Patients with inadequate pulmonary toilet can develop fever, hypoxemia, pneumonia, and atelactasis
- G tachycardia
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- Medications:
    - Antiemetics: postoperative nausea is common in patients after general anesthesia and in patients receiving narcotics
    - Ulcer prophylaxis:
        - Indications:
            - For patients with a history of peptic ulcer disease
            - For patients with coagulopathy or prolonged ventilator dependence
        - Give acid-reducing or cytoprotective agents (sucralfate)
    - Pain control:
        - Morphine is the main drug of choice
        - It is important to control pain because inadequate pain control leads to:
            - Slow recovery
            - Had Increased postoperative complications
            - Patients are less likely to ambulate and take a deep breath
            - Increased chance for have tachycardia
    - Antibiotics: as indicated
- Labs:
    - CBC: in any procedure with significant blood loss
    - LFT:
        - NPO patients
        - Renal insufficiency
        - Patients receiving large volumes of IV fluids
        - TPN or transfusion
    - Coagulation studies: for patients who have had insults to the liver, and if large transfusions are required
    - Daily ECH and series of 3 troponin-I levels (8 hours apart): to monitor MI in patients with significant cardiac risk factors
    - Chest X-ray:
        - If thoracic cavity is entered
        - Central venous access is attempted
        - Patients with significant pulmonary or cardiovascular disease

Postoperative complications:

- Fever:
    - If intraoperative think of:
        - Malignant hyperthermia
        - Transfusion reaction
        - Pre-existing infection
    - If postoperative, think of the 5 W's:
        - Wind: atelactasis (within the first 2 days)
        - Water: UTI (after the 3rd day)
        - Wound: wound infection (after the 5th day)
        - Walking: DVT/thrombophlebitis (7-10 days after the operation)
        - Wonder drug: drug fever
    - Beta hemolytic strep aor clostridium can cause fever within the first two days after the operation m
    - IV site infection, central line infection, or drug fever can occur any time in relation to the operation
    - If atelactaisis is not resolved, pneumonia will ensue in 3 days
    - Clostridium infections appear as painful bronze/brown weeping wounds
    - What is malignant hyperthermia?
        - Scolene apne' develops shortly after the onset of anesthesia. Usually associated with halothane or succinylcholine
        - Temperature >40
        - Usually positive familty history
        - Treatment:
            - Dantrolene (antidote)
            - 100% oxygen
            - Correct acidosis and cooling blankets
            - Water for developing myoglobinurea
- Cardiovascular complications:
    - Postoperative MI:
        - 2/3 of postoperative MI occur between day 2-5
        - They are usually silent with atypical symptoms because most postoperative patients receive painkiller; an MI can pass unnoticed
        - Risk factors:
            - History of angina/MI (especially if recent)
            - Advanced age
            - Congestive heart failure
            - Extensive surgical procedure
            - Q waves of ECG or ECG changes

        - S3 heart sound/aortic stenosis
    - Clinical presentation:
        - Often without chest pain
        - New onset congestive heart failure
        - New onset cardiac arrhythmias
        - Abnormal vital signs: hypotension, tachypnea, tachycardia, or bradycardia
    - ECG findings:
        - Inverted T-waves
        - ST elevation or depression
        - Arrhythmias (new onset A.fib, PVC, or V.Tac)
    - Labs:
        - Troponin I (3 samples, 8 hours apart)
        - Cardiac isozymes (CK-MB)
    - Treatment: MONAH-B
        - Morphine
        - Oxygen
        - Nitrates
        - Aspirin
        - Heparin
        - Beta blockers
- Postoperative CHF:
    - Causes:
        - Fluid overload due to excessive fluid administration
        - MI
    - Physical examination: looks for signs and symptoms of fluid overload (tachypnea, edema, elevated JVP, crackles)
    - Labs:
        - Troponin I/BNP
        - CBC/ABG
        - KFT
    - Management:
        - Oxygen
        - Diuretics
        - Morphine
        - Arterial vasodilators to decrease afterload
        - Inotropic agents (vasopressors)
    - Pulmonary artery cathetetrization is an invasive measure than can be used to assess volume status

- Respiratory complications:
    - Atelactasis:
        - Collapse of the alveoli
        - Most common cause of postopertative fever days 1-2
        - Risk factors:
            - COPD/smoking
            - Abdominal/thoracic surgery
            - Poor pain control: patient cannot breathe in deeply secondary to pain on inspiration
            - Oversedation
        - Causes:
            - Inadequate alveolar expansion: poor ventilation of the lungs during surgery
            - High levels of inspired O_2
        - Signs:
            - Fever, tachypnea, and tachycardia
            - Decreased breath sounds with crackles
            - Increased density on chest X-ray
        - Prophylaxis:
            - Preoperative smoking cessation
            - Adequate pain control
            - Postoperative incentive spirometry
        - Treatment:
            - Postoperative incentive spirometry
            - Deep breathing exercises
            - Coughing
            - Early ambulation
            - Chest and physiotherapy along with NT suction
    - Aspiration pneumonia:
        - Pneumonia following aspiration of vomitus
        - Risk factors:
            - Intubation/extubation
            - Chest pain
            - Increased Impaired level of consciousness (drugs/ethanol overdose)
            - Non functioning NG tube
            - Tendelburg position
            - Emergent intubation on full stomach
            - Gastric dilation

        - Signs and symptoms:
            - Respiratory failure/cyanosis
            - Increased sputum production
            - Fever/tachypnea
            - Infiltrates on chest X-ray
        - Common pathogens:
            - Community acquired: gram positive/ mixed
            - Hospital/ICU: gram negative rods
        - Investigations:
            - Chest X-ray
            - Gram stain/ sputum culture
            - Broncho-alveolar lavage
        - Treatment:
            - Antibiotics: if pneumonia
            - Intubation: if respiratory failure
            - Ventilation with PEEP: if ARDS develops
        - Common lobes:
            - Supine: right upper lobe
            - Sitting/semi-recumbent: right lower lobe
        - Chest X-ray findings:
            - Early: fluffy infiltrate or normal X-ray
            - Late: pneumonia or ARDS
        - No antibiotic prophylaxis is required in aspiration pneumonia
    - Other respiratory complications:
        - Respiratory failure
        - Pulmonary embolism
        - Pneumothorax
        - COPD/asthma exacerbation
- Renal complications:
    - Urinary retention: (common)
        - Enlarged urinary bladder resulting from medications or spinal anesthesia
        - Diagnosis:
            - Physical examination: palpable bladder
            - Bladder residual volume upon placement of catheter
        - Treatment: urinary catheter (Foley's)
        - With massive urinary bladder distention don't drain all urine immediately to avoid a vasovagal reaction. Clamp after draining 1 liter of urine, then drain the rest slowly.
        - The classic symptom of urinary retention in elderly is confusion

- Postoperative renal failure:
    - Increased serum creatinine and decreased creatinine clearance
    - Usually associated with decreased urine output:
        - Anuria: <50 mL per day
        - Oliguria: 50-500 mL per day
    - Differential diagnosis:
        - Prerenal: inadequate perfusion
        - Renal: kidney parynchemal dysfunction
        - Postrenal: obstruction to outflow of urine
    - Work up:
        - LFT
        - U/A
        - FENa (fractional excretion of sodium): this should be taken before administration of diuretics. If not possible, use fraction excretion of urea.
        - Renal ultrasound
            - To rule out obstructive uropathy
            - To assess chronicity
            - To evaluate renal vasculature (using doppler ultrasound)
    - Interpretation of work up:
        - BUN:Cr ratio:
            - >20:1 pre-renal
            - <20:1 renal
        - Specific gravity:
            - >1.02 pre-renal (the body is trying to hold on to fluids)
            - <1.02 renal (kidney has decreased ability to concentrate urine)
        - Urine Na:
            - <20 pre-renal
            - >40 renal
        - Urine osmolality:
            - >500 pre-renal
            - <350 renal
        - FENa:
            - <`1% pre-renal
            - >1% renal
    - Indications for dialysis:
        - Fluid overload
        - Refractory hypotension
        - Severe metabolic acidosis

- BUN >130
- Uremic complications

- Neurological complications:
  - Delirium termans:
    - 3rd or 4th day postoperatively
    - Very common in alcoholics whose drinking was suddenly interrupted by surgery
    - Clinical presentation:
      - Confusion with hallucination; the patient becomes hostile
      - Hypertension, tachycardia and extensive sweating
    - Treatment:
      - IV benzodiazepenes: standard treatment
      - IV alcohol: old method; rarely used
    - Minor alcohol withdrawal occurs 6-8 hours after cessation of alcohol intake. Usually resolves within 24-48 hours.
  - Postoperative CVA:
    - Signs and symptoms:
      - Aphasia
      - Motor/sensory deficits
    - Work up:
      - Head CT (must rule out hemorrhage if you are contemplating the use of anticoagulants)
      - Carotid doppler ultrasound: to evaluate carotid occlusive disease
    - Treatment:
      - Aspirin + heparin (if feasible postoperatively)
      - Thrombolytics are not a postoperative option
    - Prevention:
      - Avoid hypotension
      - Continue aspirin preoperatively in high risk patients
      - Preoperative carotid doppler study
- GI complications:
  - NG tube complications:
    - Aspiration pneumonia
    - Atelactasis if the tube is clogged
    - Sinusitis
    - Minor upper GI bleeding
  - Paralytic ileus:
    - Occurs in the first few days postoperatively
    - Postoperative small bowel obstruction (functional not mechanical)
    - Order of recovery of bowel function:

        - Small intestines
        - Stomach
        - Colon
    - Causes:
        - Laprotomy
        - Hypokalemia
        - Narcotics
        - Intraperitoneal infection
    - Signs and symptoms:
        - Mild distension
        - No passage of stool or flatus
        - Absent bowel sounds
    - Ileus resolves spontaneously
    - Passage of stool/flatus are signs of resolving small bowel obstruction
- Mechanical small bowel obstruction:
    - Causes:
        - Adhesions (most common cause)
        - Increased hernia
    - Abdominal X-ray findings:
        - Dilated loops
        - Multiple air fluid levels
    - CT for confirmation
    - Management: surgical intervention
- Constipation: caused by narcotics and immobility
- Short bowel syndrome: malabsorption and diarrhea resulting from extensive bowel resection (<120 cm of small intestines remaining). Treated with TPN followed by many small meals chronically
- Blind loop syndrome:
    - Bacterial overgrowth in the small intestines
    - Causes: anything that disrupts the normal flow of intestinal contents causing stasis
- B12 deficiency:
    - Gastrectomy (decreased secretion of intrinsic factor)
    - Excision of terminal ileum (site of B12 absorption)
- Dumping syndrome:
    - Delivery of hyperosmotic chyme to the small intestine causing massive fluid shifts into the bowel. Normally, the stomach decreases the osmolarity of chyme before dumping it

        - Caused by any procedure that bypasses the pylorus or compromises its function (gastrectomy/pyloroplasty), thus dumping the chyme into small intestines.
        - Signs and symptoms:
            - Post prandial diaphoresis
            - Tachycardia
            - Emesis
            - Dizziness, weakness
            - Increased flatus
            - Abdominal pain and distention
        - Diagnosed on the bases of history
        - Treatment:
            - Small, multiple low fat meals that high in protein content
            - Avoidance of liquids with meals (to slow gastric emptying)
            - Surgery: last resort treatment; Roux-en-y
    - Jaundice:
        - Causes:
            - Prehepatic:
                - Hemolysis
                - Resolving hematoma
                - Transfusion reaction
                - Post-cardiopulmonary bypass
            - Hepatic:
                - Drugs
                - Hypotension/hypoxia
                - Sepsis
                - Pre-existing cirrhosis
                - Right sided heart failure
                - Gilbert/ Criglar-Najjar syndrome
            - Post hepatic:
                - Choledocholithiasis
                - Stricture
                - Cholangitis
        - Investigations for prehepatic jaundice:
            - Decreased Hb and blood count
            - Increased LDH and reticulocyte count
            - Fragmented RBC's on peripheral smear
- Infectious complications:
    - Catheter related infection
    - Prosthetic device related

    - Facial muscle infection
    - Intra-abdominal abscess/peritonitis
    - Respiratory/GI/GU infection
    - Wound infection
    - Patients requiring mechanical ventilation for longer than 48 hours are at risk of developing ventilator associated pneumonia
- Wound complications:
    - Wound infection:
        - Signs and symptoms:
            - Erythema
            - Swelling
            - Pain and heat
        - Treatment:
            - Open wounds: leave open with wet to dry dressing changes
            - Antibiotics: if cellulitis is present
    - Wound hematoma:
        - Collection of blood (blood clot) in an operative wound
        - Treatment:
            - Acute: remove with hemostasis
            - Subacute: observe (heat helps resorption)
    - Wound seroma:
        - Postoperative collection of lymph and serum in the operative wound
        - Treatment: needle aspiration (repeat if necessary); prevent through the use of a closed drain
- Endocrine complications:
    - DKA:
        - Deficiency of body's insulin resulting in hyperglycemia, increased ketoacids, osmotic diuresis, and metabolic acidosis
        - Signs and symptoms:
            - Tachypnea/dehydration
            - Polyurea
            - Confusion
            - Abdominal pain
        - Labs:
            - Increased glucose
            - Hyperkalemia (because insulin decreases potassium entry to cells)
            - HAGMA
            - Urine ketones
        - Treatment:
            - Insulin drip

- IV fluids rehydration
- Potassium supplements
    - Contraindicated in cases of hyperkaemia with ECG changes or when potassium >6
    - Dosing:
        - <3: 30-40 mg/hour
        - 3-4: 20-30 mg/hour
        - >4 10-20 mg/hour
        - 5: stop treatment
- Bicarbonate: if pH is <7.1

- Addisonian crisis:
    - Acute adrenal insufficiency due to stressor (surgery, trauma, or infection)
    - Caused by inadequate cortisol release
    - Signs and symptoms:
        - Tachycardia, hypotension (eventual hypovolemic shock), fever
        - Progressive lethargy
        - Nausea, vomiting, abdominal pain, and diarrhea
        - In infants, it presents as tachycardia and hypotension refractory to IV fluids and pressors
    - Labs: hyponatremia and hyperkalemia due to decreased aldosterone levels
    - Treatment:
        - IV fluids: D5 or normal saline
        - Hydrocortisone IV
        - Fludrocortisone orally (to replace aldosterone)
- SIADH
    - Causes:
        - CNS trauma/stroke
        - Oat cell lung CA
        - Postoperative
    - Labs:
        - Decreased Na and Cl
        - Decreased serum osmolarity
        - Increased urine osmolarity
    - Treatment:
        - Treat the cause
        - Restrict fluid intake
- Diabetes insipidus:
    - Hypernatremia
    - Increased serum osmolarity

        - Decreased urine osmolarity
- Other complications:
    - DIC (dissimated intravascular coagulation)
        - Activation of the coagulation cascade leading to thrombosis and consumption of clotting factors along with platelets. Activation of the fibrinolytic system resulting in bleeding
        - Signs and symptoms:
            - Acrocyanosis and other signs of thrombosis
            - Diffuse bleeding from incision sites, venipuncture sites, catheter site, and mucous membranes
        - Causes:
            - Massive tissue injury: trauma, burns, and extensive surgery
            - Infections/sepsis
            - Cancer
            - Obstetric masses
            - Miscellaneous: shock, liver disease
        - Work up:
            - PT, PTT
            - D-dimmer
            - Fibrinogen
            - Platelets
        - Treatment:
            - Treat the underlying cause
            - Supportive care: IV fluids, oxygen, platelets, fresh frozen plasma, and cryprecipitate
    - Pseudomembranous colitis:
        - Antibiotic associated diarrhea
        - Signs and symptoms:
            - Diarrhea
            - Fever
            - Hypotension, tachycardia
        - Caused by Clostridium difficile
        - Classic antibiotic (causative agent) clindamycin, but almost all antibiotics can cause it
        - Diagnosis:
            - Clostridium difficile in stool
            - Fecal WBC
            - Flexible sigmoidoscopy (you see mucous pseudomembranes in the lumen of the colon)

        - Treatment:
            - Flagyl (Metronidazol): oral or IV
            - Oral vancomycin: if refractory to metronidazol
- Summary:
    - If a patient presented with fever: think of the 5 W's
    - Chest pain: think of perioperative MI or PE
    - Shortness of breath with respiratory secretions:
        - Atelactasis/pneumonia
        - PE
        - MI/CHF
        - Hypo/hyper-natremia
        - Pneumothorax
    - Disorientation/coma:
        - Hypoxia
        - ARDS
        - Delirium
        - Hypo/hyper-natremia
        - Ammonium intoxication (common cause of coma in cirrhotic patients with a bleeding esophageal varix)
    - Urinary retention:
        - Anuria usually indicated a mechanical obstruction
        - Oliguria: fluid deficit or AKI
    - Abdominal distention: paralytic ileus or early mechanical bowel obstruction
    - Differential diagnosis for postoperative pleural effusion:
        - Fluid overload
        - Pneumonia
        - CHF

Enteral nutrition

- In general the enteral route is preferred over the parenteral. Enteral feeding is simple, physiologic, and relatively inexpensive.
- Enteral feeding maintains the GI tract cytoarchitecture and mucosal integrity (through trophic effects), absorptive function, and normal microbial flora. This results in less bacterial translocation and exotoxin release from the intestinal lumen to the bloodstream.
- Choice of an appropriate feeding site, administration technique, formal and equipment may circumvent many of these problems.
- It is indicated for patients who have a functional GI tract, but are unable to sustain and adequate oral diet.
- Contraindications:
    - Intestinal obstruction/ileus
    - GI bleeding
    - Severe diarrhea/vomiting
    - Enterocolitis
    - High output enterocutaneous fistula
- Feeding tubes:
    - Nasogastric, nasojejunal, gastrostomy, and jejunal tubes
    - Gastrotomy tubes can be placed using minimally invasive techniques such as endoscopic or laporoscopic insertion
    - Jejunal tubes are preferred for long term access and require a continuous infusion rather than bolus administration
- Enteral feeding products:
    - A variety of commercially available enteral feeding formulas are available
    - Standard solutions provide 1 kCal/mL
    - Calorically concentrated solutions (>1 kCal/mL) are available for patients who require volume restriction
    - Currently available dietary formulations for enteral feeding can be divided into polymeric (blenderized and nutritionally complete commercial formulas), chemically defined formulas (elemental diets), and modular formulas.
    - Types of enteral formulas:
        - Blenderized tube feedings can be composed of any food products that can be blended. Caloric distribution of these formulas should parallel that of a normal diet
        - Nutritionally complete commercial formulas (standard enteral diets) varying protein, carbohydrates, and fat composition. They are recommended for patients experiencing minimal metabolic stress with a normal gut function.
        - Chemically defined formulas are commonly called elemental diets. The nutrients are provided in a predigested readily absorbable form. However,

they are more expensive than nutritionally complete commercial formulas and are hyperosmolar, which cause cramping and diarrhea.
        - Modular formulas include special formulas that are used for specific clinical situations (e.g. pulmonary, renal, hepatic failure, or immune-dysfunction)
    - Enteral feeding protocols:
        - It is recommended to start with a full strength formula at a slow rate. Them, it is steadily advanced. This reduces the risk of microbial contamination and achieves full nutrient intake earlier
        - Conservative initiation and advancement rates are recommended for patients who are critically ill, those who have not been fed for some time, ad those who are receiving high-osmolality or caloric-dense formulas.
        - Bolus feeding:
            - Reserved for patients with nasogastric or gastrostomy feeding tubes.
            - Feedings are administered by gravity and begin at 50-100 mL/hour every 4 hours. Then, they are increased in 50 mL increments until you arrive to the optimal intake (240-360 mL every 4 hours)
            - Tracheo-bronchial aspiration is a potentially serious complication. To prevent this, the patient's head should be elevated to 30-45 degrees during feeding and for 1-2 hours after each feeding
            - The residual gastric volume should be measured every 4 hours and before the administration of the feeding bolus. If the gastric residual volume is greater than 50% of the previous bolus, the next feeding should be withheld.
            - The feeding tube should be flushed with approximately 30 mL of water after each use
        - Continuous infusion:
            - Administered by a pump, and is generally required for nasojejunal, gastrojejunal, or jejunal feeding tubes.
            - Feedings are initiated at 20 mL per hour and increased in 10-20 mL increments every 4-6 hours until the desired goal is reached
            - The feeding tube should be flushed with 30 mL of water every 4 hours
            - For some patients, the entire days feeding volume can be infused over an 8-12 hour period at night to allow the patient to be disconnected from the infusion pump during the day
    - Conversion to oral feeding:
        - When indicated, an oral diet is resumed gradually. In an effort to stimulate appetite, enteral feeding can modified using the following measures:

- Providing fewer feedings
- Holding daytime feedings
- Decreasing the volume of feedings. When oral intake provides approximately 75% of the required calories, tube feeding can be discontinued.

- Complications:
  - Metabolic derangement:
    - Abnormalities in serum electrolytes, calcium, magnesium and phosphorus can be minimized through vigilant monitoring.
    - Hypernatremia may lead to the development of mental lethargy or obtundation
    - Hyperglycemia may occur in any patient, but it is particularly common in individuals with pre-existing diabetes or sepsis. The serum glucose level should be determined frequently, and regular insulin should be administered accordingly
  - Clogging:
    - Can usually be prevented by careful attention to routine flushing of the feeding tube
    - Wire stylets should not be used to unclog a feeding tube because of the risk of tube perforation and injury to the esophagus or stomach
    - Installation of carbonated soda, cranberry juice, or meat tenderizer, or a teaspoon of papain dissolved in 30 mL of water
  - Tracheobroncial aspiration of tube feedings may occur with patients as a result of outlet obstruction, dysmotility, intestinal ileus, or bowel obstruction. This may limit the usefulness of nasogastric or gastrostomy feeding tubes. Treatment of this problem should be directed at correcting the underlying cause. If obstruction can be excluded, a nasojejunal or jejunostomy feeding tube may be necessary
  - Diarrhea:
    - It a potential consequence of enteral feeding, occurring in 10-20% of patients; however, other causes of diarrhea should be considered
    - Diarrhea may result from numerous causes: too rapid of an increase in the volume of hyperosmolar tube feeding, some medications (metoclopramide), a diet that is high in fat content, or the presence of components not tolerated by the patient (lactose)
    - If other causes of diarrhea can be excluded, the volume or strength of tube feedings should be diminished. If no improvement occurs, a different formula should be used. Antidiarrheal agents should be reserved for patients with severe diarrhea.

Disease specific nutrition

- Thermal injury:
    - It has a tremendous impact on metabolism because of prolonged, intense neuroendocrine stimulation. The increase in metabolic demands following thermal injury is proportionate to the extent of ungrafted body surface. Decreasing the intensity of neuroendocrine stimulation by providing analgesia and thermneutral environments lowers the accelerated metabolic rate in many of these patients and helps to decrease catabolic protein loss until the burned surface can be grafted.
- Diabetes:
    - It often complicates nutritional management. Complications that are associated with TPN administration (e.g. catheter-related sepsis) are more common with prolonged hyperglycemia. Unopposed glycosuria may cause osmotic diuresis, loss of electrolytes in urine, and nonketotic coma. The goal in glucose-intolerant patients is to maintain the serum glucose level at 100-200 mg/dL. Hypoglycemia can result in shock, seizures, or vascular instability. This can be prevented by adjusting the insulin dosing with the understanding that insulin requirements will decrease as the patient recovers from the initial stress that is associated with the illness.
- Renal failure:
    - It may be associated with glucose intolerance, negative nitrogen balance (resulting from increased losses through dialysis), loss of protein with decreased protein synthesis, and diminished excretion of phosphorus. Dialysis should be adjusted accordingly, and these patients should be nutritionally replenished according to their calculated needs. Patients who receive peritoneal dialysis absorb approximately 80% of the dextrose in the dialysite fluid (assuming a normal serum glucose level). These factors must be considered when designing a nutritional strategy.
- Hepatic failure:
    - It may result in wasting of lean body mass, fluid retention, vitamin and trace metal deficiencies, anemia, and encephalopathy.. more than 70-80 gm/day of amino acids are required to maintain nitrogen balance in these patients. It may be difficult of impossible to limit the amount of nitrogen that a patient receives each day, yet still provide adequate nutritional support. Branched chain amino acids (BCAA's) are metabolized by skeletal muscles and serve as an energy source during periods of stress. These amino acids are available enterally to decrease the levels of aromatic amino acids and, therefore, the severity of encephalopathy; however, their efficacy has not been proven.
- Cachexia:

    - Cachexia and cancer are associated with lean muscle wasting. More than two-thirds of patients with cancer experience significant weight loss during their illness, and malnutrition is a contributing cause of mortality in 20-40% of these individuals. Reasons for this development include decreased nutrient intake and impaired nutrient use. Antineoplastic therapies, such as chemotherapy, radiation therapy, or operative modalities in clinical studies have shown improvement in weight, nitrogen balance, and biochemical markers. There is little evidence to suggest better response rates or survival. Use of specialized formulas supplemented with various substrates (arginine, glutamine, nucleic acids, and omega-3 fatty acids) may reduce morbidity and length of hospital stay; however, ongoing studies need to be done before these formulas are routinely recommended.
- Short-bowel syndrome:
    - Commonly occurs in patients with less than 200 cm of function jejunum. It may result from mesenteric ischemia, Crohn's disease, or necrotizing enterocolitis. It is characterized by nutrient malabsorption, electrolyte imbalance, diarrhea, and dehydration. Most of these patients require intravenous nutrition for life, at costs of more than $100,000 per year, with frequent hospitalizations for conditions such as catheter sepsis, progressive organ dysfunction, and osteoporosis. The estimated length of small bowel that is required for adult patients to become independent of TPN is greater than 12- cm without colon or greater than 60 cm with some colonic continuity. Salvage of the ileocecal valve improves the outcome. Intestinal adaptation may occur in some patients, thereby allowing for the transition from intravenous to enteral feeding. Uniquely formulated diets (supplemented with glutamine and growth hormone) show promise for accelerating this process.
- Patients with AIDS:
    - They develop PCM and lose weight. Malnourished AIDS patients require 35-40kCal and 2-2.5 gm protein/kg/day. In addition to the required electrolytes, vitamins, and minerals, they should receive glutamine, arginine, nucleotides, omega-3 polyunsaturated fats, branched chain amino acids, and trace metal supplements. Those with normal gut function should be given a high protein, high-calorie, low fat, lactose-free oral diet. Patients with compromised gut function require an enteral (amino acid, polypeptide, or immune-enriched) diet or TPN.

Nutritional assessment

- Nutrition plats an important role in the recovery of surgical patients.
- While most healthy patients can tolerate 7 days of starvation, subjects to major trauma, surgery, sepsis, or other clinical illnesses require notional intervention earlier.
- Poor nutrition has deleterious effects on wound healing and immune function, which increase postoperative morbidity and mortality.
- Types of malnutrition:
    - Overnutrition: obesity is defined BMI >30
    - Undernutrition:
        - Caloric (Marasmus):
            - Characterized by inadequate protein and caloric intakes
            - Typically caused by illness induced anorexia
            - It is a chronic nutritional deficiency marked by losses in weight, body fat, and skeletal muscle mass (as identified by anthromorphic measurements. Visceral protein stores remain normal as do most lab indices
            - Patients with marasmus may lose substantial amounts of body weight, but are able to resist infection and respond appropriately to minor or moderate stress
    - Non-caloric:
        - Kwashiorkor:
            - Characterized by catabolic protein loss resulting in hypoalbumenimia and generalized edema.
            - This malnutrition develops when the period of starvation is prolonged or if the stress is severe
            - Even in a well-nourished patient, a severe stress(major burn or prolonged sepsis) may rapidly lead to depletion of the visceral protein stores and impairment in immune function
        - Vitamins and trace elements:
            - Vitamins are involved with wound healing and healthy immune function while many trace elements are important as cofactors and enzymatic catalysts.
            - These substrates cannot be synthesized de novo and must be part of dietary intake
- Clinical assessment:
    - History:
        - History of weight fluctuation with attention to the timing as intent.

        - Recent weight loss (5% in the last month or 10% over 6 months) or a current body weight of 80-85% of ideal body weight suggest significant malnutrition
        - Anorexia, nausea, vomiting, dysphagia, odynophaia, gastresophageal reflux, or a history of generalized muscle weakness should prompt further investigations.
        - A complete history of current medications is essential to alert caretakers to potential underlying deficiencies as well as drug-nutrient interactions
    - Physical examination:
        - May identify:
            - Muscle wasting especially thenar and temporal muscles
            - Loose or flabby skin, which indicates loss of subcutaneous fat
            - Peripheral edema and/or ascites as a result of hyporoteinemia
        - Subtle findings may include skin rash, pallor, glossitis, gingival lesions, hair changes, hepatmegaly, neuropathy, and dementia
        - Adjuncts to physical examination:
            - Anthropometric measurements such as triceps skin fold thickness and midarm muscle circumference. These are indications of body fat stores and skeletal muscle mass respectively. Typically, anthropometric measurements include assessment of body weight, height, and BMI. These values allow the clinician to assess the patient's visceral and somatic protein mass and fat reserve.
            - Creatinine height index (CHI) is used to determine the degree of malnutrition. A 24-hour urine creatinine excretion ratio is measured and compared to normal standards. If it is greater than 80% there is zero to mild depletion. If is between 60-80% there is moderate depletion. If it less than 60% , it indicates severe depletion.
    - Laboratory tests:
        - Tests associated with nutrition are nonspecific indicators of the degree of illness rather than strict markers.
        - Albumin, prealbumin, and transferrin vary with hepatic metabolism (decreased synthesis, and capillary leak response as well as nutritional status.
        - Levels associated with illness are as follows:
            - Serum albumin of less than 3.5 g/dL in a stable, hydrated patient' half life of 14-20 days
            - Serum prealbumin is a more useful indicator of nutritional status. 10-17 mg/dL indicate mild depletion. 5-10 mg/dL indicate

moderate depletion. Less than 5 mg/dL indicates severe depletion' half life 203 days.

- Serum transferrin of less than 200 mg/dL; half life of 8-10 days.

- Estimation of energy needs:
    - Basal energy expenditure (BE) can be predicted using the Harris-Benedict formula or Mifflin-St Jeor formula. The Harris-Benedict formula is as follows:
        - Males: 66.4 + (13.7 x weight in kg) + (5 x height in cm) – (6.8 x age in years)
        - Females: 65.5 + (9.6 x weight in kg) + (1.8 x height in cm) – (4.7 x age in years)
    - These equations provide a reliable estimate of the energy requirements in approximately 80% of hospitalized patients. The actual caloric needs are obtained by multiplying BEE by a specific stress factor (it depends on the activity of the patient). Most stressed patients require 25-35 kcal/kg/day
- Estimates of protein requirements:
    - The appropriate calorie-nitrogen ratio is approximately 150:1 (calorie: protein ratio 24:1). In the absence of severe hepatic dysfunction 1.5 gm/kg should be provided daily.
    - 24- hour nitrogen balance is calculated by subtracting nitrogen secretion from nitrogen intake. Nitrogen intake is the sum of nitrogen excreted in the urine, fistula drainage, diarrhea, and so forth. The usual approach is to measure the urine urea (nitrogen) concentration of a 24-hour urine collection, and then multiply the value by urine volume to estimate 24-hour urinary loss. Nitrogen loss equals 1.2 x(24-hour urine urea nitrogen + 2 gm/day as a correction factor to account nitrogen losses in stool and skin)

Total parenteral nutrition

- It provides the patient with complete nutritional support through the IV route (central or peripheral).
- Indications:
    - NPO > 7 days
    - Short bowel syndrome
    - Entercutaneous fistula (high output fistula)
    - Prolonged ileus
- Access:
    - Peripheral: only for short term feeding (< 2 weeks)
    - Central: through a central venous catheter (single/multi-lumen)
    - Catheters should be replaced for unexplained fever/bacteremia
- Solutions:
    - Administered as a 3-in-1 admixture:
        - Protein: amino acids (10%) – 4 kcal/g
        - Fat: lipid emulsion of soybean (20%) – 9 kcal/g
        - Carbohydrates: dextrose (70%) – 4 kcal/g
    - Additives:
        - Electrolytes (Na, Cl, K, Ca, acetate, Mg/ PO_4)
            - Should be administered daily
            - Ca:PO_4 ratio must be maintained to prevent salt precipitation
        - Medications: (H_2 blockers, heparin, iron, dextran, insuluin, metoclopramide)
            - Regular insulin should be initially administered subcutaneously, then administered via TPN (2/3 of daily subcutaneous dose)
        - Vitamins and trace elements (copper and zinc)
            - Vitamin K is not included in most multivitamin mixtures, and must be added separately if needed.
- Administration (continuous vs. cyclic)
    - It is usually given as a continuous infusion (especially if short term)
    - Cyclic TPN: feeding for 8-16 hours during the night and fasts during the day. This gives the long-term TPN patients freedom from the machinery to lead a less restricted life during the day
    - Indications for cyclic TPN:
        - Patients who will be discharged from hospital and subsequently will receive home TPN
        - Patients with limited IV access who require TON lines for medications during certain times of the day

- Discontinuation:
    - Timing: when the patient can satisfy 75% of caloric and protein needs with oral or enteral intake
    - Infusion rate:
        - Halved for 1 hour
        - Halved again for 1 hour
        - Discontinued
    - Tapering prevents rebound hypoglycemia caused by hyperinsulinemia
    - No need for tapering in case of glycemic stability
- Complications:
    - Central line complications (infection and pneumothorax)
    - Electrolyte disturbances
    - Glucose problems
    - Loss of gut barrier (PUD)
    - Acalculus cholecystitis/gallstones
    - Fatty infiltration of the liver
    - Refeeding syndrome:
        - Severe fluid and electrolyte shifts in malnourished patients undergoing refeeding
        - Can occur in both TPN or enteral nutrition (more common in TPN)
        - Labs: decrease potassium, decreased magnesium, decreased phosphate
        - This will lead to:
            - Altered myocardial function and arrhythmias
            - Deteriorating respiratory function
            - Liver dysfunction
            - Seizure, confusion, coma, and tetany
            - Death

Stoma

- Surgically made opening of the bowel in the anterior abdominal wall
- The stoma should go through the rectus abdominus muscle not through the apponeurosis. If it is possible, the more distal the stoma the better (closer to normal physiology)
- Types:
    - Esophagostomy
    - Gastrostomy
    - Jejunostomy
    - Cecostomy
    - Ileostomy
    - Colostomy
- Temporary vs. permanent stoma:
    - Temporary:
        - There is a distal bowel segment remaining after resection
        - Done to divert the fecal stream
    - Permanent:
        - When no distal bowel segment remains after resection
        - Done when, for some reason, the bowel segments cannot be rejoined
- Indications:
    - Feeding or administration of drugs
    - Diversion decompression
- Stoma appliance is a removable plastic bag attached by adhesives to the abdominal skin
- Ileostomy:
    - Types:
        - End ileostomy
        - Loop ileostomy
    - Site: usually at the right iliac fossa
    - Shape: fashioned with a spout of bowel protruding around 3 cm above the skin to protect the surrounding skin from the highly irritant contents. It is called Crooke's ileostomy
    - Bag contents: watery stool (bile, gastric juice, chyme)
    - Smell: offensive
    - Surrounding skin is usually inflamed(irritated from acid)
    - Median or paramedian scars are usually seen for colectomy or pouch colectomy
    - Indications for the temporary type:
        - Defunctioning stoma to protect a more distal anastamosis that at a particular risk of leakage or breakdown
    - Indications for the permanent type:
        - Following pan-proctocolectomy, which is usually done in FAP and IBD.
    - Ileostomies discharge small quantities of liquid material continuously

    - Ileostomies do not require irrigation
    - An appliance should be worn all the time
- Colostomy:
    - Types:
        - Loop colostomy
        - End colostomy
        - Double barrel colostomy
    - Site:
        - left iliac fossa at the sigmoid colon (most common type)
        - Right upper quadrant at the transverse colon
        - Right iliac fossa at the cecum
    - Shape: the bowel mucosa is in direct contact with the skin (unilke ileostomy) because stool is not irritant to the skin
    - Bag contents: formed stool; no skin changes around it
    - Indications for the temporary type:
        - To protect a more distal anastamosis
        - To rest a more distal segment of bowel involved in an inflammatory process
        - Emergency measure to relieve complete distal large bowel obstruction causing proximal dilation
    - Indications for the permanent type:
        - Abdominoperineal resection of a low rectal/anal tumor
    - Require daily or every other day irrigation
    - An appliance is not required
    - A sigmoid colostomy expels stool once a day
    - Transverse collostomy should not be constructed as a permanent stoma because of its bulky, foul smelling, and wet discharge. The appliance must be worn daily, and it is prone to leakage and prolapse
- Complications (ileostomy (40% complications) and colostomy (20% complications)):
    - Early:
        - Obstruction of stoma due to edema or fecal impaction
        - Mucosal necrosis/sloughing of terminal bowel due to ischemia
        - Persistent leakage between stoma and appliance which leads to skin erosions. Usually due to inappropriate placement of a stoma over a skin crease.
    - Late:
        - Stenosis of stomal orifice
        - Prolapse of bowel (usually the distal part)
        - Retraction of spout ileostomy
        - Perforation after colonic irrigation

        - Parastomal hernia (due to abdominal weakness)
        - Parastoma fistula
- Gastrostomy:
    - Site: at the epigastric area
    - Indications: feeding or decompression in cases of intestinal obstruction. G-tube is inserted through the abdominal wall
    - Types:
        - Loop stoma:
            - Usually temporary
            - Both proximal and distal segments drain on the skin surface through a single skin aperture
            - Distal loop has no function
        - Split stoma:
            - Defunctioning stoma
            - Not used nowadays (replaced by loop stomas)
            - Brought separately on skin
        - Single end stoma
    - Proximal loop: end stoma, passes stool into the stoma appliance
    - Distal loop: produces little mucus; called mucus fistula
    - Kock's pouch (continent ileostomy)
        - It is a formed by the terminal ileum after a colectomy
        - It has a volume of 500-1000 mL . Feces are stored temporarily and the patient does need to carry stoma bag. It improves the quality of life
- Hartman's procedure:
    - The surgical resection of the rectosigmoid colon with closure of the rectal stump along with the formation of an end colostomy
    - Indications: used after emergency resection of rectosigmoid lesions where a primary anastamosis is inadvisable because of obstruction. Moreover, it is indicated in cases of fecal contamination
- Ileostomies and colostomies do not close due to epithelization
- Gastrostomies don't close due to the presence of a foreign body

Tubes and drains

- Tubes are used to drain or instill fluid from into body cavity
- Nasogastric tube (NG tube) :
    - Indications:
        - To decompress the stomach or small bowel
        - To initiate an enteral feeding cycle
        - To perform gastric lavage
    - Contraindications:
        - Facial bone fracture (to avoid the entry of the tube through the cribriform plate to the brain)
        - Nasopharyngeal destruction
    - Technique:
        - Placement:
            - The patient should sit upright in his bed or lying supine with the head flexed at a 45 degrees angle
            - The tube should lubricated
            - Use topical local anesthetic (lidocaine)
            - If you suspect abnormal placement, order an X-ray (the tube has a radio-opaque line)
            - Identification of the tube's location:
                - Aspiration of the fluid and looking at its nature
                - Infusing air and auscultation (a rumbling voice in the stomach area)
                - Radiology through the opaque stripe
            - Removal:
                - Give the patient a tissue
                - Discontinue suction
                - Remove quickly and tell the patient to blow nose
    - Types:
        - Single lumen tubes: best for feeding and administration of medications
        - Double lumen tubes: best for decompression functions. Since one port of the tube is always patent for air, it cannot collapse.
    - Complications:
        - Obstruction (clogged tube): managed by a saline flush, suction, then air flush
        - GERD: if the caliber is large
        - Esophagitis
        - Strictures
        - Recurrent aspiration pneumonia

        - Necrosis of the nasal skin due to pressure of the tube
        - Impairment of the nasal sinus drainage leading to sinusitis
        - Passage through the cribriform plate to the brain (most serious)
        - Perforation of esophagus or stomach leading to mediastinitis or peritonitis
    - Notes:
        - If the patient can talk without difficulty and succus returns, the tube should be in the stomach
        - The length of the tube to reach the stomach is around 40-50 cm
        - Before feeding via any tube, you should perform a high abdominal X-ray to confirm placement into GIT not the lung
        - If the NGT is clogged, it will not decompress the stomach and will keep the lower esophageal sphincter open, which increases the risk of aspiration
- Gastrostomy (G-tube) and jejunostomy (J-tube):
    - Indications:
        - Initiation of enteral feeding and medications
        - Decompression of the stomach and small bowel
    - Technique:
        - Placement:
            - Inserted through the anterior abdominal wall surgically, endoscopically, or radiologically
            - In order to replace these tubes, you have to wait for a mature tract to form. This needs 2-6 weeks (depends on the type of tube used). It is better performed under fluoroscopic guidance in order not to lose access
        - Removal: at bedside; opening closes spontaneously within 1-2 days.
    - Types:
        - Single lumen tube: mainly for feeding
        - Double lumen tube: mainly for decompression
    - Enteral feeding through a G-tube occurs in bolus fashion, but in J-tube it must be in a continuous fashion to avoid diarrhea.
    - Complications (rare): mainly due to incorrect placement and include hemorrhage, peritonitis, and local cellulitis
- T-tubes:
    - T shaped tubes placed into the bile duct often through or adjacent to the cystic duct
    - Indications:
        - Cholecystectomy with CBD exploration
        - Biliary anastomosis after liver transplant
        - Many forms of biliary surgery
    - Advantages:

        - Connected to gravity drainage, thus can drain the bile easily
        - Can be used to perform T-tube cholangiography and can give access to interventional instrument
    - Removal: once the track has matured, they can be removed by gentle traction
    - Complications:
        - Cholangitis : tube malfunction in the setting of bile duct obstruction
        - Leakage of the site of insertion
        - Biloma or abscess formation
- Cholecystomy tube: tubes placed surgically or percutaneously with ultrasound guidance to drain the gall bladder.
- Foley's catheter:
    - Balloon-tipped catheters that are placed in the bladder through urethra and for gravity drainage
    - Indications:
        - Relief of urinary retention
        - Measuring urine output accurately(most common indication)
        - Instill irrigant to the bladder
    - Contraindication: urethral injury
    - If a Foley's catheter cannot be inserted:
        - anesthetize the urethra with lidocaine gel
        - try a large Foley's catheter
    - Technique: lidocaine gel is injected into the urethra to make the process less uncomfortable
    - Complications: UTI; manage by removing the catheter and administering antibiotics
- Central lines:
    - Catheters placed into the major veins (central veins) via subclavian, internal jugular, or femoral vein approaches
    - Major complications:
        - Pneumothorax (always obtain a post-placement chest X-ray)
        - Bleeding
        - Infection
        - Malposition
        - Dysarrhythmias
    - Cordis: a large central line catheter used for massive fluid resuscitation or for placing a Swan-Ganz catheter.
- Drains:
    - Indications:
        - Withdrawal of fluids
        - Apposition of tissues to remove a potential space by suction

- Chest tube (thoracostomy tube):
    - Indications:
        - To oppose the parietal and visceral pleura: to seal any visceral holes
        - To drain pus, fluid, chyle, blood, or air
    - Technique of placement:
        - Administer local anesthetic
        - Incise skin in the $4^{th}/5^{th}$ intercostal space between the mid and anterior axillary lines
        - Perform blunt Kelly-Clamp dissection over the rib into the pleural space
        - Perform finger exploration to confirm intrapleural placement
        - Place the tube posteriorly and superiorly
    - Safe triangle for insertion:
        - Anterior border of latissmus dorsi
        - Lateral border of pectoralis major
        - A line superior to the horizontal level of the nipple
        - Apex below axilla
    - Notes:
        - Chest tube is placed over the rib to avoid the vessels and nerves
        - In most cases, it should be positioned posteriorly into the apex
    - Mechanism of action: (three-chambered box)
        - Collection chamber: collects fluid, pus, blood, chyle, or air and measures its amount. It connects to the water seal bottle and the chest tube
        - Water-seal chamber: a one-way valve that allows air to be removed from the pleural space, but does not allow air to enter back into the pleural cavity. It connects to the suction control bottle and to the collection chamber.
        - Suction control chamber: controls the amount of suction by the height of the water columns. Sucking in room air releases excessive suction it connects to wall suction and to the water seal bottle.
    - To ensure correct placement, at the last hole in the tube. This hole passes through the radio-opaque line; on chest X-ray it is seen as a break in the line within the pleural cavity.
    - Never clamp off the chest tube except to run the system momentarily. This is used to check whether there is a leak in the pleural cavity or in the tube itself. You momentarily occlude the chest tube. If the air leak still persists, it is from the pleural cavity.
    - A different method used to check for a leak is to look at the water seal chamber on suction. If bubbles pass through the water seal fluid, a large air leak is present

(. If no air leak is evident on suction, remove suction and ask the patient to cough. If air bubbles through the water seal, a small leak is present.

- The usual course for removing a chest tube:
  - Suction until the pneumothorax resolves and air leak is gone
  - Water seal for 24 hours
  - Remove the chest tube if no pneumothorax or air leak is present after 24 hours of water seal.
- The procedure of removal:
  - Cut the stitch
  - Ask the patient to exhale and inhale maximally
  - Rapidly remove the tube and at the same time, place a petroleum jelly covered gauze.
  - Obtain a chest X-ray

Tracheostomy

- Opening in the anterior of the neck to create a surgical airway
- Indications:
    - Relive upper airway obstruction:
        - Foreign body
        - Trauma
        - Bloody or mechanical edema
        - Croup (acute laryngitis)
        - Bilateral vocal cord paralysis
        - Congenital web/atresia
    - Improve respiratory function:
        - Acute severe pneumonia or chronic bronchitis
        - Flail chest
        - Unconscious patient (following a severe head or chest injury)
        - Bulbar polyomyelitis (paralysis)
    - Substitute intubation: in any patient who needs intubation for more than 2 weeks.
- Contraindications:
    - Absolute:
        - If we can do translaryngeal intubation easily
        - Fractured larynx or a damaged cricoid
        - Transsection of trachea with distal end retracted into mediastinum
        - Laryngeal cancer
    - Relative:
        - Infants and toddlers (Risk of subglottic stenosis)
        - Acute laryngeal disease
        - Massive neck edema tube
        - Bleeding tendency
- Technique:
    - Position: neck hyperextended
    - Under local anesthesia
    - Skin incision: longitudinal or transverse 2-3 cm above the suprasternal notch
    - Expose trachea at midline by retracting strap muscles laterally and everting the thyroid isthmus superiorly
    - Open a longitudinal, transverse or H-shaped incision to remove a small piece of the trachea
    - Use a dilator, and then insert the tube. Its size should be ¾ of the tracheal lumen
- Complications:
    - Immediate:
        - Bleding from thyroid vein, thyroid artery, or carotid artery

        - Injury to neighboring structures including the esophagus, recurrent laryngeal nerve, pleura, vocal cord, or the larynx
        - Technique related: malposition, incorrect placement, or prolonged time
        - Cardiac arrhythmias
    - Intermediate:
        - Tracheal erosion from movement
        - Tube obstruction or displacement
        - Subacute emphysema
        - Aspiration
        - Fistula
        - Infection
    - Late:
        - Late bleeding
        - Infection
        - Granuloma
        - Voice changes, vocal cord adhesion and incontinence
        - Tracheal stenosis
        - Tracheomalacia
- How to prevent complications?
    - Sterile technique
    - Change tube daily
    - Proper care:
        - Atraumatic suctioning
        - Humidified oxygen
        - Use mucolytics if secretions are thick
        - Physiotherapy
    - Chest X-ray after placement
    - Deflate cuff every five minutes to prevent tracheal ischemia
- Advantages over intubation:
    - Easier nursing care
    - Facilitated oral feedings
    - Patient can speak
    - Easier for patient to move
    - Less work of breathing
    - Facilitate transfer from ICU to wards
- When to remove a tracheostomy tube?
    - $PO_2 > 60$ or $PCO_2 < 45$
    - Patient requires less suction
    - Return of cough reflex
    - Good general status

- Cricothyrotomy vs. tracheostomy: cricothyrotomy is quicker and easier. It can be performed in emergent cases. Tracheostomy is placed in an OR or at bedside at the ICU.

Shock

- Inadequate tissue perfusion resulting in generalized cellular hypoxia and dysfunction. It is recognized by evidence of end organ dysfucntion
- Compensatory changes in response to hypotension are the release of catecholamine, aldosterone, renin, and cortisol. This leads to anincreased heart rate, preload, and afterload.
- Types of shock:

Type	Skin	JVP	CO	PCWP	SVR	Mixed venous O_2
hypovolemic	Cool/pale	decrease	decrease	decrease	increase	decrease
Cardiogenic	Cool/pale	increase	decrease	increase	increase	decrease
Early septic	Warm/pink	normal	increase	decrease	decrease	increase
Late septic	Cool/pale	decrease	decrease	decrease	increase	normal
Neurogenic	Warm/pink	decrease	decrease	decrease	decrease	decrease

- Signs:
    - Pale, diaphoretic, cool skin
    - Vitals: hypotension, tachycardia, tachypnea
    - Decreased mentation
    - Poor capillary refill and poor urine output (urine output and mental state are the best indicators for tissue perfusion)
- Labs: used to assess tissue perfusion. Increased lactate, a base deficit, and a drop in pH
- Aim of treatment:
    - SaO_2 >92%
    - Hb 7-9
    - Sufficient cardiac output
- Hypovolemic shock: (decrease in intravascular volume >20%)
    - Causes:
        - Hemorrhage
        - Burns
        - Bowel obstruction
        - Crush injuries
        - Pancreatitis
    - Signs:
        - Early:
            - Orthostatic hypotension
            - Mild tachycardia, anxiety and diaphoresis
            - Vasoconstriction leading to a decreased pulse pressure with an increase in the diastolic blood pressure

        - Late: change in mental state with marked tachycardia

Blood loss (%)	<15%	15-30%	30-40%	>40%
Blood loss (mL)	<750	750-1500	1500-2500	>2000
Heart rate	normal	>100	>120	>140
Blood pressure	normal	Systolic: normal Diastolic: increase	Both decreased	Both decreased
Respiratory rate	normal	elevated	elevated	elevated
Urine output	normal	decreased	oliguria	anuria
Mental status	Minimal anxiety	Mild anxiety	confusion	Lethargy

    - the most common vital sign change associated with early hypovolemic shock is tachycardia
    - decreased pulse pressure appears with early hypovolemic shock due to vasoconstriction resulting in a higher diastolic blood pressure
    - treatment:
        - stop the bleeding
        - bolime expansion (IV isotonic Ringer's lactate), blood products if needed.
    - What type of patients does not mount a normal tachycardiac response to hypovolemia?
        - Patients on beta blockers
        - Spinal shock
        - Endurance athletes
- Cardiogenic shock:
    - Cardiac insufficiency usually resulting from left ventricular failure.
    - Causes:
        - MI
        - Papillary muscle dysfunction
        - Cardiac tamponade
        - Tension pneumothorax
        - Cardiac valve failure
    - Signs and symptoms:
        - SOB, crackles
        - Loud S2 (P2)
        - Gallop rhythm
        - Pulsis alternans
        - Pulmonary edema on chest X-ray
    - Treatment (based on diagnosis/mechanism)
        - If CHF: diuretics and afterload reduction (ACE-I)
        - If LV failure: pressure and afterload reduction
- Septic shock: documented infection with hypotension
    - Causes:

        - Gram negative septecemia
        - Gram positive septicemia
        - Fungal septicemia
    - Complications:
        - Multiple organ failure
        - DIC
        - Death
    - Signs and symptoms:
        - Early: vasodilation, warm skin, full pulses with normal urine output
        - Late: vasoconstriction, poor urine output, mental status changes, hypotension, renal and hepatic failure
        - Fever, hyerventilation, tachycardia
    - Factors that increase susceptibility to septic shock:
        - Steroids
        - DM
        - Immune-suppression
        - Trauma
        - Hemodynamic instability
    - Labs:
        - Early:
            - Hyperglycemia, glycosuria
            - Respiratory alkalosis
            - Leukopenia
            - Heme-concentration
        - Late:
            - Acidosis, increased lactate
            - Leukocytosis
    - Treatment:
        - IV fluids
        - Antibiotics (empiric, then based on culture)
        - Drainage of infection
        - Pressors; as needed
        - Zygris (as needed): an activated form of protein C shown to decrease mortality in septic shock and multiorgan failure. Rarely used nowadays. In fact, many studies have shown it to be ineffective. However, it still remains part of the classical teaching.
- Neurogenic shock: inadequate tissue perfusion due to loss of sympathetic vasoconstrictive tone
    - Causes:
        - Complete transection of spinal cord

        - Partial cord injury with spinal shock
        - Spinal anesthesia
    - Treatment:
        - IV fluids
        - Vasopressors are reserved for hypotension refractory to fluid expansion
    - Always rule out a hypovolemic shock in patients with suspected spinal shock
    - Spinal shock is defined as complete flaccid paralysis immediately following spinal cord injury. It may or may not be associated with a circulatory shock

Sepsis, SIRS, and MOF

- Infection: presence of organisms in a closed space or location where they are not normally found.
- Sepsis: known or suspected infection
- Severe sepsis: sepsis with acute organ dysfunction
- SIRS: a clinical response arising from a non-specific insult manifested by 2 of the following criteria:
    - Body temperature >38 or <36
    - Heart rate: >90
    - Respiratory rate >20
    - WBC >12 or <4 or >10% bandemia
- Risk factors:
    - Preexisting disease: CVS, RS, renal
    - Age: extremes of age
    - Gender: males
    - Genetics: TNF polymorphisms
- Respose:
    - Physiology:
        - Heart rate, respiration, fever and blood pressure
        - Cardiac output
        - White blood cells
        - Hyperglycemia
    - Makers of inflammation:
        - TNF
        - IL-1, IL-6
        - Procalcitonin
        - PAF
- Organ dysfunction:
    - Lungs: ARDS
    - Kidneys: ATN
    - CVS: shock
    - CNS: metabolic encephalopathy
    - PNS: critical illness
    - Coagulation: DIC
    - GI: gastroperesis, ileus, or cholestasis
    - Endocrine: adrenal insufficiency
    - Skeletal muscles: rhabdomyolysis
- Spectrum of severity: infection → SIRS → sepsis → severe sepsis
- Pathogenesis of SIRS/MOD:
    - Preoperative illness

    - Trauma/operation
    - Tissue injury: this might lead to recovery (if optimal O_2 delivery and support) or SIRS/MODS (if inadequate resuscitation or excessive inflammatory response)
- Sepsis is an imbalance of inflammation, coagulation mad fibrinolysis. In sepsis coagulation and inflammation are more than fibrinolysis. It is continual process of proinflammation, which overwhelms the anti-inflammatory cytokines.
- Coagulation and inflammation are closely linked. The cytkoines from inflammation increase the activation of coagulation pathways. This leads to the formation of the enzyme thrombin, which produces clotting in the body. Microclotting leads to impaired blood flow.
- Fibrinolysis (breakdown of clots) is the body's response to increased clotting and inflammation. In sepsis, fibrinolysis is inhibited or slowed down because of the following mediators: PAI-1 and TAFI
- Notes:
    - Sepsis is the leading cause of death in the non-coronary ICU
    - 1/3 of patients who develop severe sepsis will die within one month
    - Severe sepsis is common; it is increasing in incidence
    - Causes of sepsis can bacterial, fungal, parasitic, or viral.
- Treatment:
    - Addressing the infection: empiric then according to the culture
        - Broad spectrum IV antibiotics
        - Source control: drainage, debridement, or removal of the infection source
    - Circulatory support:
        - During the first 6 hours you aim at:
            - CVP: 8-12
            - MAP > 65 mmHg
            - UOP: >0.5 mL/kg/hour
            - Mixed S_vO_2: >70%
        - Vasoactive medications: dopamine and norepinephrine
    - Adjunctive treatment:
        - Activated protein C: has been documented to decrease mortality
        - Disadvantages include a short half life and an increased risk of serious bleeding.
- Patients with increased risk for infection with resistant organisms:
    - Prior treatment with antibiotics during hospitalization
    - Prolonged hospitalization
    - Presence of invasive devices

Surgical infection

- Definitions:
    - Bacteremia: bacteria in the blood
    - SIRS: systemic inflammatory response syndrome. Characterized by fever, tachycardia, tachypnea, and leukocytosis
    - seosusL documented infection + SIRS
    - septic shock: sepsis and hypotension
    - cellulitis: blanching erythema from a superficial dermal or epidermal infection
    - abscess: collection of pus within a cavity
    - superinection: a new infection arising while a patient is receiving antibiotics for the original infection at a different site
    - nosocomial infection: infection originating in the hospital. The most common nosocial infection is UTI. The most common nosocomial infection causing death is RTI (pneumonia)
- UTI:
    - Investigations:
        - Urine analysis:
            - Positive nitrite (from bacteria)
            - Positive leukocyte esterase (from WBC)
            - >10 WBC/HPF
            - Presence of bacteria (supportive)
        - Culture
        - Urine microscopy for WBC
    - Microorganisms:
        - E. coli
        - Klibsiella
        - Proteus
    - Treatment:
        - Antibiotics with gram negative spectrum (SMX/TMP, gentamycin, ciprofloxacin, aztreonam)
        - Check culture and sensitivity
    - Treatment of bladder candidiasis:
        - Removal/change of Foley's catheter
        - Administer systemic fluconazole or amphotericin
        - Bladder washings
- Central line infections:
    - Signs and symptoms:
        - Unexplained hyperglycemia
        - Fever

        - Mental status change
        - Hypotension
        - Tachycardia: shock
        - Pus and erythema at the central line site.
    - Most common causes of catheter related blood stream infections are:
        - Coagulase negative staph
        - Enterococcus
        - Staph aureus
        - Gram negative rods
    - When to change a central line?
        - When it is infected: there is no advantage in changing them every 7 days in non-burn patients
        - Angiocatheters (peripheral IV catheters) should be changed every 3-4 days.
    - Treatment:
        - Remove the central line (send for culture) + IV antibiotics
        - Place a new central line at a different site
- Suppurative hydradinitis:
    - Infection/abscess formation in apocrine sweat glands
    - Sites:
        - Perineum
        - Inguinal area
        - Axilla
    - Causative agent: staph aureus
    - Treatment:
        - Antibiotics
        - Incision and drainage
- Peritoneal abscess:
    - It is an abscess within the peritoneal cavity
    - Causes:
        - Postoperative status after a laporotomy
        - Ruptured appendix
        - Peritonitis
        - Any inflammatory intraperitoneal process
        - Anastomotic leak
    - Sites:
        - Pelvis
        - Subphrenic
        - Lesser sac
        - Paracolic gutters

        - Morison's pouch
    - Signs and symptoms:
        - Fever (classically spiking)
        - Abdominal pain
        - Mass
    - Diagnosis:
        - Abdominal CT or ultrasound:
            - Done after day 7 postoperatively. Otherwise, it won't be organized and it will look like a normal postoperative fluid collection
        - Findings: fluid collection with a fibrous ring, gas in fluid collection
    - Treatment:
        - Percutaneous CT-guided drainage
        - Transrectal drainage
    - You should drain all abscess except for amebiasis
- Pseudomembranous colitis:
    - It is an antibiotic induced colonic overgrowth of C. difficile secondary to loss of competitive non-pathogenic bacteria that comprise the normal colonic flora.
    - It can be caused by any antibiotic; however, the most common are penicillins, cephalosporines, and clindamycin
    - Signs and symptoms:
        - Diarrhea
        - Fever
        - Increase in WBC
        - Abdominal cramps
        - Abdominal distention
    - Microorganism: exotoxin of C. difficile
    - Diagnosis:
        - Assay stool of exotoxin titer
        - Fecal leukocytes
        - Colonoscopy: exudate that looks like a membrane
    - Treatment:
        - Stop the causative agent (antibiotic)
        - PO metronidazole or PO vancomycin
        - Never give anti-peristaltics

Surgical site infection

- 3rd most reported nosocomial infection
- Most common surgical nosocomial infection
- 2/3 involved in surgical incision. 1/3 involves deep structures accessed by the incision
- Levels of SSI:
    - Superficial SSI (skin and subcutaneous tissue)
        - Infection within 30 days of the operation that only involved skin and subcutaneous tissue with at least one of the following:
            - Purulent drainage from superficial incision
            - Positive culture from closed surgical site obtained by a specialist
            - One of the signs and symptoms of infection
        - Early SSI occurs within 24 hours of the operation. It is usually due to step or clostidium
    - Deep incisional SSI:
        - Infection within 30 days of the operation if no implants were left in place or within 1 year if an implant is left in place.
        - It involved deep soft tissues (muscles and fascia) and one of the following:
            - Purulent drainage from deep incision but not from the organ/space compartment
            - Deep incision dehiscence or opened by the surgeon when the patient has: fever or localized pain/tenderness
            - Abscess or other evidence of infection of deep incision
        - The infection must appear to be related to the operation
    - Organ/space SSI:
        - Infection within 30 days of the operation if no implant was left or within one year if an implant was left.
        - The infection appears to be related to the operation
        - Involved any part of the anatomy (organs or spaces)
        - One of the following:
            - Purulent drainange from a drain that placed in the organ/space
            - Positive culture obtained by a specialist from organ/space
            - Abscess or othe evidence of infection of organ/space
- Microorganisms:
    - Staph aureus
    - Coagulase negative staph
    - Enterococcus species
    - E. coli
    - Pseumonas aeruginosa

- Risk factors:
    - Long operation (> 2hours)
    - Length of preoperative hospitalization
    - Procedure specific risk factor: clean, clean-contaminated, contaminated, or dirty
    - Patient specific risk factors:
        - Local:
            - Increased bacterial load
            - Wound hematoma/seroma
            - Necrotic tissue
            - Foreign body
            - Obesity
            - Dead space (that prevents delivery of phagocytic cells to bacterial foci)
            - Poor approximation of the wound
            - Increased tension
        - Systemic:
            - Age
            - DM
            - Chronic disease (renal or liver disease)
            - Alcoholism/smoking
            - Immunosuppression
            - Drugs: steroids or chemotherapy
            - Preexisting infection
            - Shock: decreased blood flow will result in poor delivery of PMNs
            - PAD
- Prevention:
    - Strict sterile technique
    - Maintenance of normal temperature, blood glucose, and hyperoxygenation
    - Antibiotic prophylaxis (within 1 hour of incision
    - Preoperative skin antisepsis: the use of chlorhexidin-alcohol is better than povidine-iodine scrub

Wound infections

- Infection of an operative wound. Classically happens 5-7 days postoperatively
- Signs and symptoms:
    - Pain at the incision site
    - Erythema
    - Drainage
    - Induration
    - Warm skin
    - Fever
- Management:
    - Remove skin sutures/staples
    - Rule out fascial dehiscence
    - Pack wound open
    - Send wound culture
    - Give antibiotics
- Microorganisms:
    - Staph aureus
    - E. coli
    - Enterococcus
    - Other causes: staph epidermis, pseudomonas, anaerobes, or strep.
- Classification of procedure:
    - Clean
    - Clean-contaminated
    - Contaminated
    - Dirty
- Complications:
    - Fistula
    - Abscess
    - Sepsis
    - Decreased wound healing
    - Superinfection
    - Hernia
- Risk factors:
    - Procedure related:
        - Type of procedure (clean, clean-contaminated…)
        - Long operation >2 hours
        - Hypothermia in the OR
        - Length of preoperative hospitalization
    - Patient specific:
        - Local:

        - Increased bacterial load
        - Wound hematoma, necrotic tissue, foreign body, or seroma
        - Obesity
        - Poor approximation of tissue
        - Increased tension
        - Dead space
    - Systemic:
        - Age
        - DM
        - Chronic diseases
        - Malnutrition
        - Alcoholism/smoking
        - Immunosuppression
        - Drugs: steroids or chemotherapy
        - Preexisting infection/uremia
        - Decreased blood flow
- Investigations:
    - CBC: leukocytosis or leukopenia
    - Blood culture
    - CT or other imaging studies
- Treatment:
    - Incision and drainage
    - Antibiotics for deep abscesses and some superficial abscesses if the patient has DM, surrounding cellulitis, prosthetic heart valve, or immunosuppression.
- Fluctuation is a sign of a superficial abscess

Necrotizing tissue infections

- It is a rare, server, and progressive bacterial infection of the skin, soft tissue fascia, or muscles
- Risk factors:
    - Old age
    - Immunosuppression
    - DM
    - Chronic disease
    - Alcoholism
    - Blood supply compromise
- It is associated with high morbidity and mortality. The earlier the treatment, the better.
- Microorganisms: usually polymicrobial (type I) or due to a single organism such as group A streptococcus pyogens (type II). Polymicrobial infections work in a synergestic fashion. Strep pyogens are flesh eating bacteria
- Signs and symptoms:
    - Pain out of proportion to examination
    - Bullae
    - Systemic signs of toxicity
    - WBC >15,400
    - Tenderness beyond the area of erythema
    - Crepitus
    - Cutnaeous anesthesia
    - Cellulitis refractory to antibiotic treatment
- Forms:
    - Necrotizing fascitis
    - Necrotizing myositis
    - Necrotizing cellulitis
- General treatment principles:
    - Resuscitation as necessary
    - Empiric broad spectrum antibiotics
    - Debridement
    - Nutrition (1.5-2 times the basal requirement)
- Detailed discussion of the forms of infection:
    - Cellulitis:
        - Acute bacterial infection
        - Involves the skin and subcutaneous tissue including the superficial fascia
        - Most commonly found in the lower limbs; however, it can be found in periorbital regions, incisions, puncture wounds, bites, and areas of preexisting skin conditions (venous stasis, ischemia, and decubitus ulcers)
        - Caused by:

        - Strep pyogens (most common)
        - Staph aureus
        - H. influenza (rare)
- Fascitis:
    - Flesh eating disease that involves the subcutaneous tissue and deep fascia
    - It is an emergency. The patient must be taken to the OR immediately.
    - Clinical presentation might be masked as the changes in the overlying skin may only be observed later in the disease process.
    - Classically caused by group A step pyogens; however, it is often polymicrobial.
    - Trauma is the most common cause (8% of the cases). 20% of the cases occur in patients without a known injury.
    - Treatment:
        - IV fluids
        - IV antibiotics
        - Aggressive early extensive surgical debridement
        - Tetanus prophylaxis
    - Fornier's gangrene: a type of necrotizing infection or gangrene that usually affects the perineum or scrotum. Usually seen in patients with diabetes. Treated with triple antibiotics and wide surgical debridement.
- Myositis:
    - Gas gangrene
    - A clostridial muscle infection
    - The most common microorganism is Clostridium perfingnans
    - Divided into:
        - Myonecrosis: associated with gangrene and clostridial infection
        - Pyomyositis: due to puncture wound with abscess formation.
    - Signs and symptoms:
        - Pain, fever, shock
        - Crepitus
        - Foul-smelling brown fluid
        - Subcutaneous air on X-ray
    - Treatment:
        - IV antibiotics
        - Aggressive surgical debridement of the involved muscle
        - Tetanus prophylaxis.

Critical care

- ICU checklist (FAST HUG)
    - Feeding
    - Analgesia
    - Sedation
    - Thromboembolic prophylaxis
    - Head of bed elevation
    - Ulcer prevention
    - Glucose control
- The most common bacteria in ICU patients is gram negative rods
- Monitoring:
    - Temperature: every 4 hours; obtain core temperature (best is rectal)
    - ECG: continuous, to detect heart rate, rhythm, and arrhythmias
    - Arterial pressure monitoring
        - Indirect: by sphygmomanometer; every one hour
        - Direct: by intra-arterial catheter
            - Indications:
                - Need for continuous monitoring as in unstable patients
                - If frequent ABG measurements are required
            - Site of insertion:
                - Most commonly in the radial artery due to its accessibility and good collateral flow
                - Other sites: femoral artery, less commonly dorsalis pedis or axillary artery
            - Complications:
                - Occlusion: limb ischemia
                - Infection: cellulitis/bactermia due to catheter colonization or contamination
        - Intra-arterial lines should be avoided in infants because occlusion may cause limb ischemia and subsequent deformity
        - Always assess the extremity distal to the catheter before and after insertion
        - If there is evidence for ischemia, remove the catheter immediately
    - Central venous pressure monitoring
        - Indications:
            - To measure CVP
            - To measure C_vO_2
            - To administer vasoactive drugs
            - TPN
    - Pulmonary artery catheter (Swan-Ganz catheter)

        - To determine cardiac filling pressure, cardiac output, systemic vascular resistance, mixed venous O_2 saturation, and pulmonary artery pressure
        - Used in unstable patients to assess response to treatment with fluids and cardioactive agents
        - Requirements and considerations:
            - ECG must be checked to rule out LBBB because a PA catheter causes a transient RBBB. If a patient has LBBB, you should place a transcutaneous pacemaker
        - Complications:
            - Balloon rupture:
                - Risk of air embolism
                - Suspect when inflated air doesn't return
                - Confirm by aspiration of blood
                - Manage by removal of the catheter
            - PA perforation: presents as hemoptysis
            - Dysarrhythmia: usually self limited.
        - The use of PA catheter has not been shown to decrease mortality
        - Doppler is an alternative to Swan-Ganz:
            - Less invasive
            - Measure aortic flow velocity over time
            - Measures stroke volume
            - It is used to titrate fluid administration
            - Complications: esophageal perforation
    - Respiratory monitoring:
        - Pulse-oximetry:
            - Used in all critically ill patients
            - It provides quantitative continuous assessment of arterial O_2 saturation.
            - Causes of poor signal detection/unreliable measurement:
                - Probe malposition/motion
                - Hypothermia/vasoconstriction
                - Hypotension
            - Causes of falsely decreased saturation:
                - Nail polish
                - Dark skin
                - Increased serum lipids
            - Causes of falsely elevated saturation:
                - Carboxyhemoglobin
                - Methemoglobin
        - Capnography:

- Provides quantitative assessment of CO_2 concentration and gradient between PCO_2 and end-tidal CO_2.
- Causes of increased end-tidal CO_2:
    - Decreased alveolar ventilation
    - Increased CO_2 production in cases of sepsis, overfeeding, exercise, and acute increases in CO
- Causes of decreased end tidal CO_2:
    - Increased alveolar ventilation
    - Increased dead space without an increase in CO_2 due to PE, air embolism, and ET intubation

- Sedation and analgesia:
    - Sedation allows critically ill patients to tolerate invasive supportive interventions including intubation and mechanical ventilation.
    - Dilirium is associated with increased in-hospital and ICU stay
    - Modified Ramsey sedation scale:
        - (1) anxious, agitated
        - (2) cooperative, oriented
        - (3) responds to commands easily
        - (4) asleep, but responds to stimuli
        - (5) asleep but responds sluggishly to stimuli
        - (6) no response
    - Control of agitation:
        - Most commonly used drugs are benzodiiazepenes. They are associated with higher risks of delirium. These drugs are potent for sedation, anxiolysis, and amnesia. Their actions are mediated through GABA receptors. They inhibit this receptor.
        - Patients tolerant to benzodiazepenes:
            - Previous intake of similar agents
            - Alcoholics and smokers
        - Patients susceptible to benzodiazepenes:
            - Elderly >50 years
            - Patients with pre-existing cardiopulmonary, hepatic, or renal dysfunction
        - Medications:
            - Midozolam (benzodiazepene)
                - Onset: 1-3 minutes
                - Short t1/2
                - Active metabolities
            - Lorazepam:
                - Onset 10-20 minutes

        - Longer t1/2
        - No active metabolites
    - Propofol:
        - It does not accumulate like benzodiazepenes, earlier ambulation
        - More expensive
        - Short t1/2
        - Side effects:
            - Hypotension
            - Hypertriglyceremia
            - Metabolic acidosis
            - Risk of pancreatitis
    - Dexamedetomide (selective alpha 2 adrenergic agonist)
        - Used in short term sedation; patients are more easily aroused
        - Maximum use for 24 hours
- Control of delirium:
    - By antipsychotics (halopridole; this drug is used for emergent treatment of delirium)
    - Side effects of halopridole:
        - Hypotension
        - Arrhythmia
        - Prolonged QT interval
        - Extrapyramidal symptoms
    - Always perform an ECG on patients on long term halopridole
- Control of pain:
    - Medications:
        - Morphine:
            - PRN (administered when needed)
            - Beware of active metabolites accumulation in patients with renal impairments
            - Side effects: histamine release; hypotension
        - Fentanyl:
            - Most commonly used drug for continuous drips
            - Half life: 30-60 minutes. Short due to rapid redistribution
            - Unlike morphine, it does not cause histamine release. It causes less hypotension
        - Hydromorphine:
            - Used in patients allergic to morphine or phentanyl
            - No active metabolites: used in renal failure patients

- Meperidine (pethidine)
    - Least frequently used drug due its many side effects
    - Risk of accumulation of metabolites (normeperidine
    - Side effects: seizures
- Methadone:
    - Narcotic with long t1/2
    - Facilitates withdrawal from narcotics due to its long t1/2
- Thoracic/lumbar epidural catheter:
    - Well tolerated
    - Side effects: hypotension

▪ For patients on long term sedation and analgesia, daily interruption of sedation wakefulness reduces time on mechanical ventilation; thus, reducing ICU stay. However, this is not applied in the surgical ICU patients due to higher analgesia requirements in such patients

- Respiratory failure:
    - Inadequate exchange of O_2 and/or CO_2
    - Diagnosis:
        - History and physical examination:
            - Increased respiratory rate
            - Shortness of breath
            - Decreased level of consciousness
        - Pulse oximetry and ABGs:
            - SaO_2 <90%
            - PO_2 <60 mmHg
        - Chest X-ray: to identify the cause
    - Ventilation Vs. oxygenation:
        - Ventilation: air through lungs monitored by PCO_2. We increase ventilation by increased respiratory rate or tidal volume
        - Oxygenation: O_2 delivery to alveoli. Monitored by PO_2 and SaO_2. We increase oxygenation by increasing FiO_2, and PEEP
        - Adequate oxygenation does not guarantee adequate ventilation
    - Treatment of respiratory failure:
        - Oxygen
        - Airway management
        - Ventilation
- UGI hemorrhage and prophylaxis:
    - ICU patients are at high risk for stress induced mucosal ulceration; this will result in GI hemorrhage
    - Risk factors:

        - Head injury (Cushing ulcers)
        - Burns: curling ulcers
        - Requirement of mechanical ventilation
        - Previous history of PUD
        - Use of NSAIDs or steroids
        - Presence of shock, respiratory failure, portal hypertension or coagulopathy
    - Prophylaxis:
        - H_2 blockers
        - PPI: if patients bleed despite being on appropriate H_2 blockers treatment
- Renal dysfunction:
    - Presents as progressive oliguria in the setting of increased BUN and creatinine. This can progress to renal failure and anuria
    - Causes:
        - Pre-renal:
            - Due to hypovolemia
            - Most common cause of renal failure in ICU patients
            - Labs: BUN/Cr >20, urine osmolality >500, FENa <1
        - Renal:
            - Due to ischemia (prolonged prerenal status) or toxins
            - Susceptible patients: DM or preexisting renal disease
            - Labs: urine osmolality <350, FENa >1
        - Post-renal:
            - Due to bilateral renal flow obstruction
            - Urinary catheter malfunction must be always ruled out
            - Do an ultrasound
    - Renal insufficiency might present as polyurea
    - Some nephrotoxins (prevention is by good hydration):
        - Aminoglycosides
        - Amphoterecin
        - IV radio-contrast
        - Chemotherapy
- Anemia
    - Indications for transfusion (usually packed RBC)
        - Hb <7 mg/dL
        - Hb 7-10 in patients with acute coronary syndrome, severe hypoxemia, or active bleeding
    - Goal: Hb >10
    - Don’t transfuse if Hb >10:
        - TRALI : transfusion related acute lung injury
        - Increased hospital and ICU stay

        - Death
- Blood glucose control:
    - Tight glycemic control is associated with less mortality
    - Goal: <140 mg/dL: safe and beneficial
    - Hypoglycemia is still a major risk of tight glycemic control

ARDS (acute respiratory distress syndrome)

- Acute lung injury, lung damage, and release of inflammatory cells leading to increased permeability and pulmonary edema. It is often associated with multiorgan failure
- Causes:
    - Direct:
        - Pneumonia
        - Aspiration
    - Indirect:
        - Sepsis (most common case
        - Severe trauma
        - Acute pancreatitis
        - Drug overdose (aspirin, heroin)
        - Fat embolism
        - Near drowning
- ARDS is type I respiratory failure (hypoxemic)
- Clinical features:
    - Cyanosis
    - Tachypnea/tachycardia
    - Peripheral vasodilation
    - Bilateral fine inspiratory crackles
- PO_2/FiO_2:
    - Normal: >300
    - Acute lung injury 200-300
    - ARDS <200
- Investigations:
    - Blood tests: CBC, electrolytes, clotting (PT, PTT), amylase, CRP, and blood culture
    - ABG
    - Chest X-ray: bilateral pulmonary infiltrates
    - Pulmonary artery catheterization: to measure PCWP
- Diagnostic criteria:
    - A: acute onset
    - R: refractory hypoxemia
    - D: diffuse bilateral infiltrates
    - S: shunt hypoxemia mechanism (no left sided heart failure; this, PCWP <18)
- Phases of ARDS:
    - Exudative phase: cellular phase
        - A lot of cells
        - Alveolar space damage
        - Capillary injury

        - Chest X-ray findings:
            - Bilateral infiltrates
            - Can't be differentiated from cardiogenic pulmonary edema if heart size is normal
    - Proliferative phase: fibrosing alveolitis:
        - Improper healing process: fibrosis
        - Significant pulmonary hypertension
        - Chest X-ray findings: not as prominent as exudative phase
        - During this phase, there is nothing that can be done
    - Recovery phase:
        - Gradual resolution of hypoxemia
        - Chest X-ray is normal
        - Functionally, the lung is back to normal
        - Alveolar septa are back to normal
- Management:
    - Admit the patient to ICU
    - Supportive therapy:
        - Mechanical ventilation: low tidal volume and pressure limited approach (<30 cm H_2O)
        - IV fluids: give the least fluids as possible. Monitor by a Swan-Ganz catheter
    - Treat the underlying case
- Prognosis:
    - The mortality has decreased from 60% to 30%
    - Poor prognosis is associated with:
        - Chronic liver disease
        - Sepsis (especially in the end-stage)
        - Old age
        - Non-pulmonary organ dysfunction

Fluids and electrolytes

- Total body water (TBW) → 60% of the body's weight
    - 40% intracellular (2/3)
    - 20% is extracellular:
        - 5% intravascular
        - 15% interstitial (3rd space)
- The principle extracellular cation is Na^+ and the principle anions are Cl^- and HCO^{3-}
- The principle intracellular cations are potassium and magnesium. The principle anions are phosphate and negatively charged proteins
- Lean tissues (muscles and solid organs) have higher water content than fat and bone
- Total body water based on gender and age:
    - Females: 50%
    - Males: 60%
    - Newborns: 80%
- The concentration gradient between the compartments is maintained by ATP-dependent Na-K pump. Movement of water across a cell membrane depends primarily on osmosis
- Serum osmolarity rough estimate: 2Na + Glucose/18 + BUN/2.8. the normal range is 290-310
- Definitions:
    - Osmolality: number of osmoles/kg of water. Comprised of effective and ineffective components
    - Tonicity: the physiological parameter that the body attempts to regulate. It is equal to the effective osmoles
    - Effective osmoles: cannot freely permeate through the cell membrane. These include Na, glucose, mannitol, and glycine extracellularly. Moreover, they include potassium, amino acids, and organic acids intracellularly. Any asymmetric accumulation of effective osmoles will cause transcompartmental movement of water.
    - Ineffective osmoles: can freely cross the cell membrane; they are unable to affect water movement. These include urea, ethanol, and methanol.
- Water intake and losses:
    - Water intake (2L/day):
        - 75% oral intake
        - 25% extracted from solid food
    - Daily water losses:
        - Urine: 1-1.5 L
        - Feces 250 mL
        - Insensible losses from skin (200-400 mL) and respiratory losses (500-700 mL)

- Physiological response to hypovolemia:
    - Na/water retention: via renin-aldosterone
    - Water retention: via ADH
    - Vasoconstriction via angiotensin II and sympathomemitics
    - Decreased urine output
- Electrolyte disturbances:
    - Sodium: (normal range 135-145)
        - Sodium balance is maintained by the kidneys
        - All (but 2-5%) of sodium in the body is located in the extracellular fluid, and difference in distribution is maintained by the Na/K pump
        - Sodium salts account for >90% of total osmolality of ECF
        - Plasma sodium concentration reflects the relative proportions of sodium and water not the absolute amount of sodium in the body
        - Hyponatremia (sodium <135):
            - Causes:
                - Hypotonic hyponatremia:
                    - Hypovolemic:
                        - GI losses
                        - Skin losses
                        - Lung losses
                        - 3rd spacing
                        - Renal losses
                    - Hypervolemic:
                        - CHF
                        - Cirrhosis
                        - Iatrogenic fluid overload
                    - Isovolemic:
                        - Water intoxication/SIADH
                        - Potassium losses
                        - Drugs: sulfonurea, carbamizipines, phenothiazines, and antidepressants
                - Hypertonic hyponatremia:
                    - Hyperglycema (pseudohyponatremia)
                    - Hypertonic infusions of glucose, mannitol, or glycine
                - Isotonic hyponatremia:
                    - Lab error (due to old method of calculating sodium amounts)
                    - Hyperlipidemia
                    - Hyperproteinemia

- Work-up:
    - Urine osmolarity
    - Urine Na
        - If >10: renal cause
        - If <10: extrarenal cause
- Signs and symptoms:
    - Predominantly neurological due to brain cells' swelling and cerebral edema
    - Lethargy/confusion
    - Nausea and vomiting
    - Seizure/coma
    - Chronic hyponatremia is usually asymptomatic until serum sodium drops below 110
    - Symptoms are rare when sodium is >125
- Treatment:
    - Isotonic/hypertonic hyponatremia: treat the cause
    - Hypotonic hyponatremia:
        - Hypovolemic: give normal saline and correct ongoing losses
        - Hypervolemic: water restriction and diuretics and BNP
        - Euvolemic:
            - SIADH: lasix and fluid restriction
            - Water intoxication: fluid restriction
    - In symptomatic hyponatremia or extreme hyponatremia, hypertonic saline is indicated. The goal is >120; when it is reached, discontinue the hypertonic saline.
    - Hypertonic saline should not be administered without concomitant diuretics
- Central pontine demylination ;
    - It is a complication of rapid correction of hyponatremia
    - Signs:
        - Confusion
        - Spastic quadriplegia
        - Horizontal gaze paralysis
    - To avoid this fate, the rate of correction should be <12 meq/L/day
- Measurement of Na deficit: 0.6 x weight x (120-measure Na)

- Hypernatremia (always hypertonic hypernatremia)
    - Cause: typically due to loss of more water than solutes

        - Surgical causes:
            - Inadequate hydration
            - Renal losses: DI, diuresis
            - GI losses: vomiting and diarrhea
            - Sweating/tachypnea/iatrogenic TPN
    - Signs and symptoms:
        - Mainly neurological due to dehydration of the brain cells.
        - Lethargy, weakness, irritability, fasciculations, seizures, and coma
    - Treatment:
        - Give oral water and IV hypotonic or isotonic solution; slowly over a period of 12-24 hours
        - Treat the underlying cause
        - The major complication of rapid correction of hypernatremia is seizures
    - Renal Na excretion/reabsorption:
        - Effective blood volume: a decrease in volume will activate the RAAS system, which will decrease filtered Na and increase renal reabsorption.
        - Natriuretic hormones:
            - Secreted by atria
            - They function to increase the excretion of Na by increased filtration and decreased reabsorption
- Potassium: (normal range 3.5-5.3)
    - Requirements: 50-100 mmol/day
    - Major intracellular cation (only 2% is extracellular)
    - Its concentration is influenced by acid base balance and hormones
    - Renal exertion
    - Hypokalemia:
        - Causes:
            - GI: decreased intake (rare), or GI losses due to vomiting, diarrhea, villous adenoma or a fistula
            - Renal: metabolic alkalosis, diuretics, steroids, RTA (secondary aldosteronism), or a decrease in magnesium
            - Shift into cells: insulin effect and alkalosis
        - Hypomagnesemia is frequently associated with hypokalemia and must be corrected. Always give Mg before K replacement.
        - Clinical presentation:
            - Mainly cardiovascular and neuromuscular:
                - If mild (>3): asymptomatic

            - If severe (<3): weakness, tetanus, parasthesia, nausea, vomiting, and ileus
            - ECG changes:
                - T-wave depression
                - ST depression
                - Prominent U wave
                - Extopy
    - Treatment:
        - Oral replacement: KCl (if mild)
        - IV replacement: KCl. If severe, significant symptoms, or in cases of oral intolerance.
        - Maximum amount of K infusion is 40mmol/L
        - Maximum infusion rate is 10 mmol/hour on a peripheral line and 20 mmol/hour on a central line. Rapid infusion might lead to a cardiac arrest and thrombophlebitis.
- Hyperkalemia >5.3 mmol/L
    - Causes:
        - Pseudohyperkalemia:
            - Poor venipuncture technique
            - Leukocytosis/thrombocytosis
            - In vitro hemolysis
        - Excissive intake
        - Impaired excretion:
            - Renal failure/tubular disease
            - Adrenal insufficiency/Addison's
            - Diuretics: K sparing (spironolactones)
        - Shifts:
            - Acidosis
            - Insulin deficiency
            - Tissue damage (hemolysis, internal bleeding, or muscle damage)
            - Drugs: digitalis poisoning, arginine
    - Clinical presentation:
        - Cardioarrhytmias, muscle weakness, and decreased deep tendon reflexes
        - ECG abnormalities:
            - Peaked T-wave
            - Prolongation of PR interval
            - Prolonged QRS complex
            - Complete heart block

        - Cardiac arrest
    - Treatment (when >6.5) CB DIAL K
        - Calcium IV: cardioprotective with ECG monitoring
        - Bicarbonate: $NaHCO_3^-$ IV: alkalosis drives K into the cells
        - Dialysis: definitive
        - Insulin/dextrose
        - Albutarol (beta agonist)
        - Lasix: furosemide
        - Kay exalate (Na polystyrene sulfonate)
- Calcium (normal range 8.5-10.5)
    - Calcium is found in three forms
        - Ionized: 45%; the only active form
        - Protein bound 40%
        - Complex with freely diffusible compounds (15%)
    - Metabolism is controlled by PTH and vitamin D
    - Hypocalcemia
        - Diagnosis should be based on the ionized form only
        - Causes:
            - Vitamin D deficiency
            - Calcium sequestration due acute pancreatitis, rhabdomyolysis, or rapid transfusion
            - Surgical causes:
                - Total thyroidectomy: secondary to vascular compromise to the parathyroid glands
                - Parathyroidectomy: serum calcium reaches its lowest levels within 2-3 days after the operation
            - In conjugation with magnesium depletion, which simultaneously impairs PTH secretion and function
            - Acute alkalemia due to rapid administration of sodium bicarbonate or hyperventilation
            - Drugs: aminoglycosies, and loop diuretics
        - Clinical presentation of hypocalcemia:
            - Peri-oral numbness
            - Tetany (Chovsteck and Trousseau's signs)
            - Increased deep tendon reflexes
            - ECG changes: QT prolongation and ventricular arrhythmias
        - Treatment:
            - Acute treatment: calcium gluconate 10% IV
            - Chronic treatment: oral Ca and vitamin D

        - During therapy, always monitor magnesium, phosphorus, and potassium levels
        - Tissue necrosis is a complication of calcium infusion. Never administer peripherally unless absolutely necessary.
        - Calcium gluconate is less toxic than CaCl
    - Hypoalbumenemia decreases total Ca, while ionized calcium is left unaffected.
        - Every 1 gm/dL drop in albumin will result in a serum drop of Ca by 0.8
        - Correction formula: (4-measured albumin) X 0.8
- Hypercalcemia:
    - Causes (CHIMPANZEES)
        - Calcium supplements IV
        - Hyperparathyroidism (primary or tertiary)
        - Immobility
        - Metastasis/ milk alkali syndrome
        - Paget's disease
        - Addison's/acromegaly
        - Neoplasm (colon, lung, breast, or prostate)
        - ZES as part of MENI
        - Excessive vitamin A
        - Excessive vitamin D
        - Sarcoid
    - Clinical presentation:
        - Stones: nephrolithiasis
        - Bones: bone disease and pain
        - Abdominal groans: nausea, vomiting, coonstpation, and dehydration
        - Psychotic overtones: change in mental status
        - Polyuria, polydypsia, and constipation
        - ECG changes: short QT, prolonged PR
    - Treatment:
        - If mild (<12):
            - Calcium restriction and treatment of the underlying cause
            - Rehydration
        - If severe:
            - Hydration with normal saline and diuretic (furosamide)

        - Steroids, calcitonin, bisphoshphanates, and mithramycin
        - Dialysis (last resort
- Phosphorus (normal range 2.5-4.5)
    - Usually coexists with phosphorus derangement
    - Hypophosphatemia:
        - Causes:
            - Decreased intestinal absorption:
                - Vitamin D deficiency
                - Malabsorption
                - Use of phosphate binders
            - Renal loss (acidosis, alkalosis)
                - Diuretic treatment especially acetazolamine
                - Hyperglycemia: osmotic diuresis
                - During recovery from ATN
            - Shifts from extracellular compartment to intracellular compartment: respiratory alkalosis
            - Burn patients
        - Clinical presentation: usually asymptomatic; symptoms appear when it is <1
            - Respiratory muscle dysfunction → respiratory failure
            - Diffuse weakness
            - Flaccid paralysis
        - Treatment:
            - Treatment is important especially in critically ill patients.
            - IV replacement 7-10 days
            - Once it is >2, oral treatment is initiated. 4 times per day.
        - Risks of IC phosphate replacement:
            - Hyperphosphatmia
            - Hypocalcemia
            - Hypomagnesemia
            - Hypotension and hyperosmolarity
            - Metastatic calcifications
            - Renal failure
    - Hyperphospatemia:
        - Causes:
            - Impaired renal excretion
            - Transcellular shift due to tissue trauma, tumor lysis, insulin deficiency, or acidosis
            - Postoperative hypoparathyroidism

- Clinical presentation:
    - In the short term: hypocalcemia and tetany
    - Chronically: soft tissue calcification secondary to hyperparathyroidism
- Treatment:
    - Dietary restriction
    - Hydration to increase excretion
    - Diuresis
    - Aluminum hydroxide
    - Dialysis: only in extreme, severe cases

- Magnesium (normal range 1.5-2.5)
    - Mainly intacellular
    - Renal excretion and retention play the physiological role in regulating body stores
    - Magnesium is not regulated under hormonal influence
    - Hypomagnesemia:
        - Usually associated with hypocalcemia and hypophosphatemia. Frequency encountered in trauma patients
        - Causes:
            - GI or renal losses
            - Shifts:
                - Acute MI
                - Alcohol withdrawal
                - Receiving glucose containing solutions
                - After parathyroidectomy
            - Surgical causes:
                - TPN
                - Hypocalcemia
                - Gastric suctioning
                - Diarrhea, vomiting
                - Aminoglycosides
                - Renal failure
        - Clinical presentation:
            - Neuromusclar: change in mental status, tremors, hyperreflexia, tetany
            - Cardiovascular: QT, PR, and QRS prolongation, ventricular arrhythmias
        - Treatment:
            - Acute treatment: $MgSO_4$
            - Chronic treatment: oral MgO (side effects: diarrhea)

        - Indications for IV $MgSO_4$
            - Severe cases
            - Symptomatic patients
            - If patients develop Torsade de points
        - The antidote for $MgSO_4$ is calcium gluconate
- Hypermagnesemia:
    - Causes:
        - Iatrogenic: TPN, renal failure, IV oversupplementation
    - Clinical presentation:
        - Mild (5-6): asymptomatic
        - Severe >8:
            - Decreased deep tendon reflexes
            - Hypotension. Sinus bradychardia
            - CNS depression
            - Respiratory failure
            - Prolonged PR, QRS, and QT
    - Treatment:
        - Stop exogenous Mg
        - Give calcium gluconate: 10% IV
        - Dialysis: the definitive therapy

IV fluid therapy

- Solutions:
  - Crystalloids:
    - Isotonic
    - Hypertonic
    - Hypotonic
  - Colloids:
    - Albumin
    - Dextran
    - Hydroxyl starch
- Composition of different solutions:
  - Normal saline:
    - 154 meq Cl
    - 154 meq Na
  - ½ normal saline:
    - 77 meq Cl
    - 77meq Na
  - ¼ normal saline:
    - 39 meq Cl
    - 39 meq Na
  - D5W: 50 grams of dextones in H_2O
  - Ringer's lactate:
    - 130 meq Na
    - 109 meq Cl
    - 28 meq HCO^{3-}
    - 3mg Ca
    - 4 mg K
- Isotonic crystalloids:
  - Ex: 0.9% normal saline and ringer's lactate
  - Distribute uniformly through the extracellular compartment. After one hour, only 25% of the total volume remains in the intravascular space
  - Normal saline is preferred in cases of:
    - Hyperkalemia
    - Hypercalcemia
    - Hyponatremia
    - Hpochloremia
    - Metabolic alkalosis
  - The lactate in Ringer's lactate will be converted to bicarbonate, so it cannot be used for maintenance. Patients will become alkalotic

    - Ringer's lactate is designed to mimic the extracellular fluid; it is called a balanced salt solution
    - The most common trauma resuscitation fluid is Ringer's lactate
- Hypertonic solutions:
    - Examples include 7.5% normal saline and 3% normal saline
    - Indications:
        - Used in shock/burns (usually in combination with colloids like dextran)
        - TRN
    - Effects:
        - Studies have shown that it causes significant blunting of neutrophil activation with a transient increase in serum sodium that normalizes within 24 hours.
        - This effect may help in decreasing widespread tissue damage and multiorgan dysfunction seen after a traumatic injury.
    - Side effects:
        - Hypernatremia (hyperosmolarity) and hyperchloremia
        - Hypokalemia
        - Central pontine demylenation
- Hypotonic solutions:
    - Examples include D5W and 0.45% NaCl
    - Should not be sued for volume expansion, because they only expand 10% of the infused volume
    - Indicateed to replace free water deficits.
- Colloid solutions:
    - They contain high molecular weight substances that remain in the intravascular space
    - More expansive than crystalloids.
    - Indications:
        - When crystalloids fail to sustain plasma volume. This is due to the low colloid osmotic pressure in burn patients and in cases of peritonitis.
    - Side effects:
        - Pulmonary edema
        - Renal failure (max dose)
        - Bleeding disorders
    - Early use of colloids in the resuscitation regimen may result in more prompt resuscitation of tissue perfusion. Moreover, it might decrease the total volume of required fluids.
    - Albumin preparations: 5% or 25% albumin. Indicated for volume expansion. However, they are not indicated for patients with adequate colloid oncotic pressure (albumin >2.5)

    - Dextran:
        - Dextran 40 or dextran 70
        - Synthetic glucose polymer (undergoes renal elimination)
        - Indications:
            - Volume expansion (expands the intravascular volume by an amount equal to the volume infused)
            - Trhromboembolism prophylaxis
        - Side effects:
            - Renal failure
            - Osmotic diuresis
            - Coagulopathy
            - Laboratory abnormality: increased blood glucose and protein. Interferes with blood cross matching
    - Hetasartch (hydroxyl starch)
        - Synthetic molecule (similar to glycogen)
        - Replaces same amount of fluid infused
        - Less expansive than albumin
        - Less side effects than dextran. Side effects include a 2X increase in amylase.
- Principles of fluid management:
    - Normal individuals consume 2-2.5 liters of water daily
    - Daily losses:
        - 1-1.5 L in urine
        - 250 mL in stool
        - 750 mL insensible losses
    - Normal daily electrolyte losses:
        - Sodium and potassium: 100meq
        - Chloride: 150meq
        - These losses increase with hypermetabolism, hyperventilation, and fever.
    - Preoperative management: any preexisting electrolyte disturbances should be corrected before the operation
    - Intraoperative management: replace preoperative losses (deficit) and ongoing losses. The replacement includes maintenance, hemorrhage, and 3rd space losses
    - Postoperative management:
        - Monitor urine output
        - Monitor GI losses from NGT/stroma
    - 3rd spacing:
        - Fluid accumulation in the interstitium of tissues (ex. Edema)

        - It occurs 3rd day postoperatively. Beware of fluid overload. Once the fluid begins to return back to the intravascular compartment, switch to hypotonic fluids and decrease the rate of infusion
        - Classical signs of third spacing include tachycardia and decreased urine output
        - Treatment: IV hydration with isotonic fluids.
- IV replacement by anatomical site:
    - Gastric (NGT): D5W, ½ normal saline, 20 KCl
    - Biliary: Ringer's lactate + $NaHCO_3$
    - Small bowel: Ringer's lactate
    - Colonic (diarrhea): Ringer's lactate + $NaHCO_3$
- Notes:
    - The most common trauma resuscitation fluid is Ringer's lactate
    - The most common postoperative fluid after laporotomt: RL/D% with RL for 24-36 hours
    - After laporotomy, patients' fluids should be monitored after the 3rd day
    - Pancreatic fluid losses are replaced by RL
    - After 5 hours of infusion, only 20% of normal saline will stay in the intravascular space
- Fluid management:
    - IV fluid replacement includes maintenance, deficit, and ongoing losses
    - Calculation of maintenance:
        - 100/50/20 rule:
            - 1st 10 kg: 100 mL/kg/day
            - 2nd 10 kg: 50 mL/kg/day
            - Rest: 20 mL/kg/day
        - 4/2/1 rule (per hour)
            - 1st 10 kg: 4mL/kg/hour
            - 2nd 10 kg 2 mL/kg/hour
            - Rest: 1mL/kg/hour
    - Maintenance fluid is usually normal saline.
    - Sodium: 2-4meq/kg/day
    - Potassium: 1-2meq/kg/day
    - Administration:
        - ½ total amount over 8 hour
        - ½ of total amount over the next 16 hours

Trauma

- The widely accepted protocol is the advanced trauma life support (ATLS) protocol
- Elements of the ATLS protocol:
    - Primary survey
    - Secondary survey
    - Tertiary survey
- Primary survey:
    - History is obtained while performing primary survey
    - 5 steps:
        - Airway: and C-spine stabilization
        - Breathing
        - Circulation
        - Disability
        - Exposure and environment
    - Airway + C-spine:
        - Goal: securing the airway and protection of the spinal cord
        - Spinal immobilization must be considered during airway assessment. This is done via the a cervical collar.
        - Maneuvers used to establish an airway:
            - Chin lift, jaw thrust or both:
                - If successful, an oral or nasal airway can be used to temporarily maintain the airway
                - If unsuccessful, perform ET intubation. If ET intubation was not successful, consider cricothyrotomy.
            - Circothyrotomy: incision through the cricothyroid membrane
        - Ask the patient a question; if the patient can answer, the airway is intact.
    - Breathing:
        - Goals:
            - Securing oxygenation and ventilation
            - Treating life-threatening thoracic injuries
        - Assessment:
            - Inspection: for air movement, respiratory rate, cyanosis, increased JVP, tracheal shift, asymmetric chest expansion, and use of accessory muscles
            - Palpation: for presence of subcutaneous emphysema and flail segments
            - Percussion: hyperresonance or dullness over either lung field
            - Auscultation: for breath sounds.
        - Life threatening conditions:

- Tension pneumothorax
- Open pneumothorax
- Massive hemothorax
- Tamponade

- Pneumothorax:
  - It is an injury to the lung resulting in release of air into the pleural space between the normally opposed parietal and visceral pleuras.
  - Signs and symptoms:
    - Usually asymptomatic
    - Chest pain shortness of breath, and anxiety
    - Hyperresonance of affected side
    - Decreased breath sounds of the affected side
  - Diagnosis:
    - Clinical
    - Chest X-ray (83% sensitive): demonstrates absence of lung makings where the lung has collapsed.
  - Treatment: tube thoracotomy (chest tube)
- Tension pneumothorax:
  - Life threatening emergency
  - It causes total ipsilateral lung collapse and mediastinal shift away from the injured lung impairing venous return. This decreases cardiac output and leads to shock
  - Signs and symptoms: same as pneumothorax + mediastinal shift
  - Treatment: immediate needle decompression, then chest tube
- Open pneumothorax:
  - Diagnosis: usually obvious with air movement though a chest wall defect
  - Treatment:
    - Chest tube
    - Occlusive dressing
- Flail chest:
  - 2 separate fractures in three or more consecutive ribs
  - Diagnosis: the flail segment of the chest move paradoxically (sucks in with inspiration and pushes out with expiration)
  - Treatment: intubation with PPV and PEEP
- Cardiac tamponade:
  - Bleeding into the pericardial sac resulting in constriction of heart and decreased cardiac output.
  - Diagnosis: ultrasound (echo)

        - Treatment: pericardial window; if blood returns, then median sternotomy to rule out and treat cardiac injury
        - Beck's triad:
            - Hypotension
            - Muffled heart sounds
            - Increased JVP
    - Massive hemothorax:
        - Diagnosis:
            - unilateral decrease or absence of breath sounds
            - Dullness on percussion
            - Chest X-ray
            - Chest tube output
        - Treatment:
            - Volume replacement
            - Chest tube
        - Indications for emergent thoracotomy in case of a hemothorax:
            - Massive hemothorax >1.5 L of blood on initial placement of chest tube
            - Persistent >200 cc of bleeding via a chest tube per hour after four hours
- Circulation:
    - Goals: securing adequate tissue perfusion and treatment of external bleeding
    - Initial test for adequate perfusion: palpation of pulses. Roughly speaking, if the radial pulse was palpable systolic blood pressure is >90. If femoral or carotid pulses were palpable, the systolic pressure is roughly >60.
    - Assessment for circulation:
        - Heart rate and blood pressure
        - Peripheral perfusion and capillary refill
        - Urine output
        - Mental status
        - Exam of skin: cold and clammy indicate hypovolemia
    - sites of external bleeding treatment: direct pressure with or without a tourniquet
    - best IV access in trauma patients: 2 large-bore IV canulas (14-16 gauge) and IV catheters in upper extremities
    - fluid of choice in trauma patients: Ringer's lactate: lactate helps buffer the hypovolemia-induced metabolic acidosis
    - types of decompression in trauma patients:
        - gastric decompression with NGT

        - bladder decompression with Foley's catheter.
    - Patients who may not mount a normal tachycardiac response to hypovolemia:
        - Patients on beta blockers
        - DM (orthostatic hypotension)
        - Patients with spinal cord injuries
        - Well-conditioned athletes
    - Contraindications to Foley's:
        - Signs of urethral injury
        - Blood at urethral meatus or penile opening
        - High riding prostate
        - Scrotal or perineal injury
- Disability:
    - Goals: determination of neurologic injury
    - Assessment:
        - Mental status: Glasgow coma scale
        - Pupils: a blown pupil suggest an ipsilateral mass (blood) in the cases of herniation of the brain compressing CNIII
        - Motor/sensory: screening exam for lateralizing extremity movement or sensory deficit.
    - Glasgow coma scale:

Eye opening	Motor response	Verbal response
4 opens spontaneously	6 obeys commands	5 appropriate and oriented
3 opens to voice	5 localizes pain	4 confused
2 opens to painful stimuli	4 withdrawal from pain	3 inappropriate words
1 does not open eyes	3 decorticate position	2 incomprehensible sounds
	2 decerebrate posistion	1 no sounds
	1 no movement	

        - GCS: normal 15: if intuabtes, the score is out of 11.
        - A patient with a coma has a score <8
        - A score for a dead man is 3
- Exposure/environment:
    - Goals: complete undressing to allow for a thorough visual inspection and digital palpation of the patient during the secondary survey
    - Environment: keep a warm environment. A hypothermic patient can become coagulopathic

- Secondary survey:

    - Trauma history:
        - It begins once the primary survey is complete and resuscitative efforts are done.
        - Whenever possible, take an AMPLE history:
            - Allergies
            - Medications/mechanism of injury
            - Past medical history/ pregnancy
            - Last meal
            - Events surrounding the mechanism of injury
    - Complete physical examination:
        - Includes all orifices: ears, nose, mouth, vagina, and rectum
        - Don't forget to examine a patient's back
    - Neurological exam/ procedures/ labs/ imaging
    - Notes on physical examination:
        - On eye examination, look for traumatic hyphema (blood in the anterior chamber of the eye)
        - On ear examination, look for hemotympanum (a sign of basilar skull fracture)
        - On nasal examination , don't miss nasal septal hemoatoma. Hematoma must be evacuated; if it was not evacuated, it can result in pressure necrosis of h septum
        - The best indication of a mandibular fracture is dental malocclusion
- Types of trauma:
    - Head trauma:
        - Penetrating head trauma: as a rule, requires surgical intervention and repair of the damage
        - Open skull fracture: there is an overlying wound
        - Closed skull fracture: no overlying wound
        - Linear skull fracture:
            - If closed: left alone
            - If open: requires wound closure
            - If depressed: must be treated in the OR
        - Signs of basilar skull fracture:
            - Raccoon eyes
            - Clear rhinorrhea
            - Otorrhea
            - Hemotympanum
            - Battle's sign (ecchymosis behind the ear)
    - Neck trauma (penetrating or blunt)
        - Anatomy of the neck trauma zones:

        - Zone III: angle of mandible and up
        - Zone II: angle of mandible to cricoid cartilage
        - Zone I: below cricoid cartilage
    - These divisions help drive the diagnostic and therapeutic management decisions for penetrating neck injuries
    - The majority of the vital structures of the neck lie within the anterior triangle
    - Penetrating injury (penetrating through the platysma) must be further evaluated.
    - Management of penetrating injuries (According to the zone)
        - Zone III: selective exploration
        - Zone II: surgical Vs. selective exploration
        - Zone I: selective exploration
    - Selective exploration: is based on diagnostic studies that include angiograms, CT angiograms, bronchoscopy, and esophagoscopy.
    - Indications for surgical exploration:
        - Expanding hematoma/ pulsatile hematoma
        - Subcutaneous emphysema
        - Tracheal deviation
        - Air bubbling through the wound
        - Shock
        - Neurological injury
    - Notes:
        - Hyoid fractures indicate significant neck injury
        - C-spine injuries are more common with blunt neck injury
- Spinal cord injuries:
    - Complete transection: nothing works (Sensory/motor) below the lesion
    - Hemisection
        - Typically from clean cut injury (knife or blade)
        - Paralysis and loss of proprioception distal to the injury site and loss of pain perception on the other side
    - Anterior cord syndrome:
        - Typically seen in burst fractures of vertebral bodies
        - Loss of motor functions. Pain and temperature on both sides distal to the injury with preservation of most functions of the lower extremities.
    - Central cord syndrome:
        - Usually in elderly with forced hyperextension of the neck

        - Paralysis and burning pain in upper extremities with preservation of most of the low extremities function
    - Diagnosis:
        - MRI for precise diagnosis
        - Coricosterois immediately after injury may help
- Chest trauma:
    - Rib fracture:
        - Can deadly in the elderly due to progression of pain which will cause hyperventilation, then atelectasis, and finally pneumonia
        - Treatment: local nerve block and epidural catheter
    - Pericardial tamponade:
        - Beck's triad
        - Life threatening emergency
        - Diagnosis:
            - History and physical examination
            - Confirmed by ultrasound
        - Treatment: immediate decompression via needle pericardiocentesis, pericardial window or thoracotomy with manual decompression.
        - Clinically apparent tamponade may result from 60-100 mL of blood
    - Blunt cardiac trauma:
        - Usually secondary to motor vehicle collision, fall from heights, crushing injuries and direct violent trauma
        - Screening: ECG
        - Treatment is focused on the complications
    - Pneumothorax: air in the pleural space (discussed previously)
    - Hemothorax:
        - Blood in the chest
        - > 200 cc of blood must be present to be apparent on chest X-ray
        - Massive hemothorax if more than 1.5 L of blood upon initial placement of chest tube
    - Flail chest
    - Air embolism: suspected when sudden death occurs in a chest trauma patient
    - Fat embolism:
        - Typical scenario: patient with multiple traumas (including several long bone fractures) who developed petichial rashes in the axilla and neck, fever, tachycardia, and decreased platelet count. Full

blown picture of respiratory distress with hypoxemia and bilaterally patchy infiltrates on chest X-ray
        - Treatment: respirator y support
    - Abdominal trauma:
        - Penetrating:
            - Direct injury by gunshot or stab wound
            - Injury from fragmentation of the bullet
            - Indirect injury as a result of a shock wave
        - Blunt:
            - Injury caused by direct blow
            - Crush injury
            - Deceleration injury
            - Decompression
            - Shearing
        - Studies:
            - FAST
            - CT scan
            - DPL
        - Gunshot wound: requires exploratory laporotomy for repair of intraabdominal injury
        - Stab wounds: individualized: if it is clear that the penetration as occurred, do exploratory laporotomy
        - Blunt trauma to the abdomen: if signs of peritoneal irritation (Acute abdomen), do acute laporotomy
- Trauma studies:
    - Trauma labs:
        - CBC, chemistry, amylase, LFT, lactic acid
        - Coagulation studies
        - Blood typing and cross match (Major: donor RBC + recipient serum; minor: recipient RBC + donor's serum)
        - Urine analysis
        - After an acute injury, hematocrit will not be low.
    - Imaging:
        - Classic blunt trauma ER X-rays: AP chest and AP pelvis film
        - C-spine evaluation (after physical): X-ray, CT to rule out C-spine fracture
        - For evaluation of C-spine ligaments:
            - CT of the mediastinum looking for mediastinal hematoma with CTA
            - Thoracic arch aortogram (gold standard)
        - CT is usually done only if patient is stable

        - Most common site of thoracic aortic traumatic tear is just distal to the takeoff of the left subclavian artery
        - X-ray findings that are suggestive of thoracic aortic injury:
            - Widened mediastinum (most common)
            - Apical pleural capping
            - Loss of aortic contour/knob
            - Depression of left main bronchus
            - Tracheal deviation
            - Pleural fluid
            - Elevation of right main bronchus
        - CT advantages:
            - Used for specific organ injuries
            - Can be used for retroperitoneal injuries; very specific
    - FAST: (focused assessment with sonography for trauma)
        - By ultrasound
        - Positive if fluid is demonstrated in the abdomen
        - 4 views are utilized to search for free intraperitoneal fluid that collects and appears and hypoechoic areas on ultrasound:
            - RUQ (Morrison's pouch): between liver and kidney
            - LUQ (spleonrenal recess: between spleen and kidney
            - Pouch of Douglas: lies above rectum (prove placed in suprapubic region)
            - Subcypohoid nad parasternal: to look for hemopericardium
        - Advantages of FAST:
            - Rapid bedside screening study
            - Non-invasive
            - Not time consuming
            - 80-95% sensitive for intraabdominal blood
        - Disadvantages of FAST:
            - Operator dependent
            - Decreased specificity for individual organ injury
        - The diagnostic test of choice for abdominal trauma is FAST (unstable patients)
    - DPL (diagnostic peritoneal lavage) mostly for bowel injury
        - Open DPL : similar to open port placement in laporoscopic surgery (peritoneal cavity is entered under direct vision) using the Hassan Port
        - Closed DPL: a catheter is placed through the needle and advanced into the peritoneum (placed blow umbilicus). Then, you aspirate for blood and if <10 cc aspirated, infuse 1 L of saline or Ringer's lactate. Then, drain the

fluid by gravity and analyze. A grossly positive DPL is aspiration of >10 cc of blood.

- If there is a pelvic fracture, place the catheter above the umbilicus to avoid a false positive DPL.
- Indications:
  - Unstable patient
  - Stable but ultrasound is not available
  - Previous surgery, morbid obesity, coagulopathy, or cirrhosis
- NGT and Foley's ust be in place before DPL
- Celiotomy: incision through the abdominal wall to gain access in the abdominal cavity
- What is a positive DPL?
  - Classic:
    - Blurred or cloudy lavage fluid
    - RBC >100,000
    - WBC > 500
    - Lavage fluid (NS or RL) drained from chest tube, Foley's or NGT
  - Less common:
    - Presence of bile
    - Presence of bacteria
    - Presence of feces
    - Increased amylase levels
- Advantages of DPL:
  - Done at bedside
  - Widely available
  - Highly sensitive for hemoperitoneum
  - Rapidly removed
- Disadvantages:
  - Invasive
  - Risk of iatrogenic injury (<1%)
  - Decreased specificity(many false positives)
  - Does not evaluate retroperitoneal structures

- Indications for exploratory laprotomy:
  - Abdominal trauma and unstable patient
  - Evisceration
  - Peritonitis
  - Diaphragmatic injury
  - Hollow viscus perforation: free intraperitoneal air
  - Intraperinoeal bladder rupture

    - Positive DPL
    - Surgically correctable injury diagnosed on CT
    - Removal of implanted weapon
    - Rectal perforation
    - Funshot wound injury in the abdomen
- Notes:
    - Most common solid organ injured with penetrating trauma is liver
    - Most common solid organ injured with blunt trauma: spleen and liver. Recent studies say that liver is the most common injured organ in both injuries
    - 3-for-1 rule: trauma patients in hypovolemic shock require 3L of crystalloids for every 1 L loss of blood
    - Minimal urine output for an adult is less than 50 mL/hour
    - Pancreatic injury is usually penetrating
    - Indication of abdominal CT in blunt trauma: normal vital signs with abdominal pain and tenderness
    - Indications for DPL/FAST in blunt trauma: unstable patient
    - Signs of laryngeal fracture:
        - Subcutaneous emphysema in neck
        - Altered voice
        - Papable laryngeal fracture
    - Treatment of rectal penetrating injury:
        - Diverting proximal colostomy
        - Closure of perforation
        - Presacral drainage
    - Bleeding from pelvic factures is most commonly caused by venous injuries (85%)
    - Treatment of extensive irreparable bilairy, duodenal, or pancreatic injury is Whipple's procedure
    - Treatment of penetrating injury to the colon:
        - If shock: resection and colostomy
        - If stable: primary anastamosis/ repair
    - Treatment of small bowel injury: primary closure or resection and primary anastamosis
    - Treatment of minor pancreatic injury: drainage
    - Treatment of massive tail of pancreas injury: distal pancreatectomy with or without splenectomy
    - Lethal triad (ACH): acidosis, coagulopathy, and hypothermia
    - What can present after blunt trauma with neurological deficit and a normal brain CT?
        - Diffuse axonal injury
        - Carotid artery injury

Hernias

- It is the protrusion of perioneal sac through a musculoperitoneal barrier (abdominal wall); a fascial defect
- Incidence:
    - Overall: 5-10%
    - Indirect hernia: 50%
    - Direct hernia: 25%
    - Femoral hernia: 5%
    - Obturator hernia : less common
- Risk factors:
    - Increased intraabdominal pressure due to:
        - Chronic constipation
        - Staining on urination (prostate enlargement)
        - Chronic cough (smoker, asthmatic patients, and COPD patients)
        - Obesity, pregnancy, and ascites
    - Age: elderly weaker abdominal muscles
- Treatment is indicated to avoid complications
- Complications:
    - Incarceration or strangulation
    - Bowel necrosis
    - Small bowel obstruction
    - Pain
- Small hernial defects are more dangerous than large ones
- Terminology:
    - Reducible: the ability to return the displaced organ or tissue/hernia contents to their usual anatomical site
    - Incarcerated: swollen or fixed within the hernia sac. may cause intestinal obstruction (an irreducible hernia)
    - Strangulation: resulting ischemia. Signs and symptoms of ischemia and intestinal obstruction or bowel necrosis.
    - Complete: hernia sac and its contents protrude all the way through the defect
    - Incomplete: defect presents without sac or contents
- Types of hernias:
    - Indirect inguinal: inguinal hernia lateral to Hasselbach's triangle
    - Direct inguinal: inguinal hernia within the Hasselbach's triangle
    - Incisional hernia: hernia through an incision site. The most common cause is wound infection
    - Femoral hernia: hernia medial to femoral vessels under the inguinal ligament
    - Obturator hernia: hernia through obturator canal more common in females than in males

    - Umbilical hernia: hernia through the umbilical ring. In adults, it is associated with obesity, pregnancy, and ascites
    - Hiatal hernia: hernia through the esophageal hiatus. Types include sliding and paraesophageal
    - Internal hernia: hernia into or involving intraabdominal structures
    - Spigelian hernia: hernia through the linea Similinaris (or Spigelian fascia). Spontaneous lateral ventral hernia
    - Sliding hernia: hernia sac partially formed by the wall of a viscus (bladder or cecum)
    - Pantaloon hernia: hernia sac exists as both a direct or indirect hernia straddling through the inferior epigastric vessels and protruding through the floor of the canal as well as the internal ring (2 sacs separated by inferior epigastric vessels)
    - Parastomal hernia: hernia adjacent to an ostomy
    - Ventral hernia: incisional hernia in the ventral abdominal wall
    - Richter's hernia: incarcerated or strangulated hernia involving only one side of the bowel, which can spontaneously reduce. Gangrenous bowel and perforation within the abdomen without signs of obstruction.
    - Diaphragmatic hernia: Bochdalek's hernia or Morgagni's hernia.
    - Amyand's hernia: hernia sac containing a ruptured appendix
- Layers of the abdominal wall:
    - Skin
    - Subcutaneous fat
    - Scarpa's fascia
    - External oblique
    - Internal oblique
    - Transversus abdominus
    - Transversalis fascia
    - Periperitoneal fat
    - Peritoneum
- All 3 muscles layer aponeuroses form the anterior rectus sheath with the posterior rectus sheath being deficient below the arcuate line.
- Conjoint tendon: it is the apponeurotic attachment of the conjoining of the internal oblique and transversus abdominus to pubic tubercle
- Notes:
    - Boundaries of Hasselbach's triangle:
        - Inferior epigastric vessels
        - Inguinal ligament: (Poupart's ligament)
        - Lateral border of rectus sheath
    - Intraoperative notes:

        - What is the of the subcutaneous vein that is ligated: superficial epigastric vein
        - What happens if you cut the ilioinguinal ligament/ numbness of inner thigh or lateral scrotum; it usually disappears within 6 months
        - Some surgeons deliberately cut the ilioinguinal nerve to remove the risk of entrapment and postoperative pain
        - Hernia sac is made of:
            - Direct: peritoneum
            - Indirect: patent processus vaginalis
    - Inguinal anatomy:
        - Inguinal ligament
        - Transversus aponeurosis
        - Conjoint tendon
    - What is reducing a hernia en masse? Reducing the hernia contents and hernia sac
    - Paraumbilical hernia (above the umbilicus) causes a crescent umbilicus
    - Paraumbilical hernia is at more risk of strangulation that umbilical hernia due to the smaller orifice.

Inguinal hernia; a detailed discussion

- Inguinal hernias:
    - Indirect inguinal hernia
    - Direct inguinal hernia
    - Femoral hernia
- Inguinal and femoral hernias are in the inguinal region
- Patients may complain of bulge, swelling, pain, or cosmetic appearance
- Incarceration Vs. strangulation:
    - incarcerated: hernia is irreducible, but there are no local signs
    - Strangulation: local signs of inflammation
- Indirect inguinal hernia:
    - Most common type of hernia in males and females
    - Protrudes at the internal inguinal ring
        - The origin of the hernia sac is located lateral to the inferior epigastric artery
        - Indirect hernias develop more frequently on the right in both sexes. In males, this is due to the later descent of the right testicle. In females, it is due to the asymmetry of the pelvis
    - Most indirect inguinal hernias in adults are congenital, even though they may not be clinically apparent in the neonatal period or during childhood.
    - The deep inguinal ring is the site where the spermatic cord in the males and the round ligament in females exit the abdomen. The ring is found 1-2 cm above the midway point on the inguinal ligament. The inguinal ligament stretches between the anterior superior iliac spine and pubic tubercle.
    - The midiniguinal point is different; it is midway between pubis symphysis and ASIS. It is where you feel the femoral pulse
    - Spermatic cord contents:
        - 3 arteries: cremasteric artery, artery to Vas, testicular artery
        - 3 nerves genital branch of genitofemoral nerve, sympathetic nerves (ilioinguinal nerve runs above the cord in the canal but not in the cord itself)
        - 3 layers of fascia: external spermatic (From external oblique), cremasteric (from internal oblique), and internal spermatic fascia (from transversus abdominus)
        - 3 others: pampiniform plexus of veins, Vas deferens, and lymphatics.
    - These hernias are usually reducible. If the thumb is kept on the deep inguinal ring and the patient is asked to cough, and indirect hernial will not appear. However, a direct hernia will.
    - The inguinal ligament is derived from the external muscle aponeurosis.

    - A helpful mnemonic to remember the inguinal canal walls (MALT; 2M, 2A, 2L, and 2T)
        - Superior wall (roof) 2 muscles:
            - Internal oblique muscle
            - Transverse abdominus muscle
        - Anterior wall: 2 apneuroses:
            - Apneurosis of external oblique
            - Apneurosis of internal oblique
        - Lower wall (floor) 2 ligaments:
            - Inguinal ligament
            - Lacunar ligament
        - Posterior wall (2T's)
            - Transversalis fascia
            - Conjoint tendon
- Direct inguinal hernia:
    - Direct inguinal hernias protrude medial to the inferior epigastric vessels within Hasselbach's triangle
    - Direct inguinal hernias occur as a result of a weakness in the floor of the inguinal canal. This weakness appears due to connective tissue abnormalities in many cases, although some may occur due to deficiencies in the abdominal musculature resulting from chronic overstretching injury.
    - Hasselbach's triangle borders:
        - Inferior: inguinal ligament
        - Lateral: inferior epigastric vessels
        - Medially: rectus abdominus muscle
    - Direct hernias are usually bilateral
    - If they can be reduced, the reappear with cough impulse if the thumb is kept on the deep inguinal ring.
- Femoral hernia:
    - Femoral hernias appear below the inguinal ligament, and are more common in females.
    - Overall, inguinal hernias are more common in both females and males. So, the most common hernia in females is still inguinal hernia. But, patients, with femoral hernias are more likely to be females.
    - Femoral canal borders:
        - Superiorly: inguinal ligament
        - Medially: lacunar ligament
        - Base: pectineal ligament
        - Laterally: femoral vein

    - Femoral hernias are more likely to have complication than inguinal hernias. This is due to the rigid borders of the femoral canal. The femoral vein is the only compressible wall of the canal. The rest of the borders are ligaments
    - Femoral hernias are usually repaired using the Mcvay's procedure, which is repair of Cooper's ligament
- Management:
    - Asymptomatic hernias can be management with watchful waiting in patients who are at high risk for surgery. Young patients should be repaired, and infants should be repaired immediately
    - Trusses are the only non-surgical option; however, they are strongly discouraged. Trusses are hernia belts. They are devices with metal or plastic plugs that are positioned over the hernial defect. They are no enough data to prove their benefit, but they may potentially lead to harm if they impinge on hernial contents. Prolonged tissue pressure can lead to atrophy of the spermatic cord or fusion to the hernia sac. It might also lead to atrophy of fascial margins, which can complicate surgical repair.
    - Surgical indications:
        - Elective surgery: uncomplicated hernia, by symptomatic (painful, cosmetic appearance is bothersome, or interrupts lifestyle)
        - Emergent surgery: complicated hernia.
- Hernia repair:
    - Herniotomy: ligating and cutting the sac. Only done in pediatric patients, because they have a patent processus vaginalis. It is an emergent surgery due to the high risk of complications.
    - Hernioraphy: hernia repair by approximation and suturing of the ligaments and tissue. These produce tension and later anatomy. Largely abandoned due to high recurrence
    - Hernioplasty: hernia repair using a mesh. Using a mesh allow for repairs to be tension free. Tissues do not need to be approximated. May be done open or laporoscopically.
- Open Vs. laporoscopic repair:
    - Open repair:
        - Non-mesh: primary tissue approximation. Examples include Bassine, McVay, and Shoudlice. These three have been largely abandoned due to higher recurrence rates and pain.
        - Tension free repair with mesh: Lichtenstein plug and patch. Here, a mesh is used to reconstruct the inguinal canal. Minimal tension is used to bring tissues together.
    - Laporoscopic:
        - TEP: totally extraperitoneal

        - TAPP: transabdominal properitoneal
        - Indications:
            - Bilateral hernia
            - Recurrent hernia
            - Minimal post-op time needed
    - Tension free repair with mesh: although hernia surgeries are considered clean, the use of a mesh, a foreign body, makes it class 1D. This requires prophylactic antibiotics, because control of infection with prosthesis is difficult, it sometimes may necessitate the removal of the prosthesis.