VI BOARD REVIEW
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Infection Control

Hand Hygiene

• Hand washing
• Alcohol Gel
• Fingernails
• Surgical Scrub
Infection Control

**Isolation Mask**

- Designed for contact with symptomatic patients
- Not fluid resistant
Infection Control

Contact Precautions

• Standard precautions
• Gown
• Gloves
• Mask
Infection Control

**Airborne Precautions**

- Use an N-95 respirator for patients on Airborne Precautions
- All employees need to be fit-tested annually
Infection Control

**PAPR**

- Designed for staff with facial hair
- Not MRI compatible
Infection Control

**Surgical Mask**

- OSHA standards require healthcare workers with the potential for exposure to blood & body fluids to wear a fluid-resistant mask.
Patient Care

**Patient Education**

- Required by JACHO-Joint Commission on the Accreditation of Health Care organizations and by law

**Informed Consent**

- Patients authorization or agreement to undergo a specific medical intervention
- Ethical and legal obligation
Patient Assessment

**Respirations**
- Normal: 16-20 breaths per minute
  - Tachypnea
  - Bradypnea
  - Apnea

**Temperature**
- Normal: 37°C or 98.6°F
  - High: Hyperthermia
  - Low: Hypothermia
Patient Assessment

**Blood Pressure**

- Measurement of the arterial pressure during systemic circulation
- Pressure exerted on upon the walls of blood vessels by circulating blood

- Normal: 120/80
- Systolic pressure is peak pressure in the arteries
- Diastolic pressure is minimum pressure in the arteries
- High: Hypertensive
- Low: Hypotensive
Patient Assessment

**Heart Rate**
- Normal: 60-100 beats per minute
- High: Tachycardia
- Low: Bradycardia

**Cardiac Cycle**
- The cardiac cycle refers to a complete heartbeat from its generation to the beginning of the next beat
- Initiated by electrical impulse
Atrial Depolarisation  

QRS Duration  

Ventricular Depolarisation  

Ventricular Repolarisation  

PR Interval  

QT Interval  

Normal Heartbeat  

Fast Heartbeat  

Slow Heartbeat  

Irregular Heartbeat  

Activation of the atria  

Activation of the ventricles  

Recovery wave
Patient Assessment

Identify a Rhythm

• Determine Regularity of R waves
• Calculate Rate
• Identify P waves and examine
• Measure PR Interval
• Measure QRS Complex
## Patient Assessment

**Peripheral Pulses**
- Posterior tibial
- Dorsalis Pedis
- Ulnar
- Radial

**Scale**
- 0 absent
- 1 diminished
- 2 normal
- 3 bounding
- Doppler
Patient Assessment

Lab Values

• Bilirubin
  • Normal: 0.1-1.2 mg/dl

• Blood Urea Nitrogen (BUN)
  • Normal: 6-23 mg/dl

• Creatine
  • Normal: 0.5-1.4 mg/dl

• Sodium (Na)
  • Normal: 135-147 mg/dl

• Potassium (K)
  • Normal: 3.5-5.2 meq/l
Patient Assessment

**Hematology**

- **Hematocrit**
  - Normal: 35-50%

- **Hemoglobin (Hgb)**
  - Normal: 12-16 g/dl

- **Platelets (Plt)**
  - Normal: 100,000-450,000 per micro liter
Patient Assessment

• **Red Blood Cells**
  • Normal: 4.6-6.2 million/ul

• **White Blood Cells (WBC)**
  • Normal: 10,000-15,000
Patient Assessment

**Coagulation**
- **Partial Thromboplastin Time (PTT)**
  - Normal: 32-45 seconds
- **Prothrombin Time (PT)**
  - Normal: 10-14 seconds
- **International Normalization Ratio (INR)**
  - Normal: 0.9-1.2

**Fibrinogen**
- Normal: 160-450 mg/dl

**Activated Clotting Time**
- Normal: 90-130 seconds
Patient Assessment

**Pulse Oximetry**

- Pulse oximetry measures the percent of Hemoglobin that is saturated with oxygen
Patient Care

Oxygen Delivery Systems

• Nasal Cannula
  • 1-6 liters per minute

• Venturi Mask
  • 24-60%

• Non-rebreather
Patient Care

Chest Tube

• Inserted into the pleura space to withdraw air, pus, or blood
Patient Care

**Urinary Catheter**

- Catheters used to drain urine from the bladder into a collection bag
  - Foley
  - Coude
  - Three-way
Analgesics

• **Fentanyl (Sublimaze)**
  • **Indication**
    • Pain
  • **Contraindications**
    • Elderly, CNS or respiratory depression, head injury
  • **Dose:** 25-50 mcg IVP over 1-2 minutes
    • Onset: 1 minute
    • Peak: 10-15 minutes
    • Duration 30-60 minutes

• **Route**
  • IV push, IV drip, transdermal patch, lozenges, PCA

• **Complications**
  • Respiratory depression
  • Chest wall rigidity
  • Laryngospasm
  • Bradycardia
  • Cardiac arrest
Analgesics

**Morphine**

- **Indication**
  - Pain

- **Contraindications**
  - Elderly, CNS or respiratory depression

- **Dose:** 2-4 mg increments up to a max of 10-20mg
  - Onset: 2-3 minutes
  - Peak: 20 min
  - Duration: 2-4 hours

- **Route**
  - Oral, IV, Subcutaneous, Intramuscular rectal

- **Complications**
  - Bradycardia
  - Respiratory depression
  - Respiratory arrest
Analgesics

- **Demerol (Meperidine)**
  - **Indication**
    - Pain
  - **Contraindication**
    - Elderly, respiratory or CNS depression
  - **Dose:** 25-50mg increments, max of 150mg
    - Onset - 1 minutes
    - Peak - 5-7 minutes
    - Duration - several hours (varies by patient)

- **Route**
  - Oral, Subcutaneous, Intramuscular, IV

- **Complications**
  - Seizures
  - Increased intracranial pressure
  - Respiratory depression
  - Respiratory arrest
Analgesics

- **Dilaudid (Hydromorphine)**
- **Indications**
  - Pain
- **Contraindications**
  - Lung disease, Hypotension, Head injury
- **Dose**: 0.2-0.6 IV (Procedural)
  - Onset-15 min
  - Peak-30 min-1hr
  - Duration-greater than 5hrs

- **Route**
  - Subcutaneous, Intramuscular, IV

- **Complications**
  - Respiratory depression
  - Apnea
  - Respiratory Arrest
  - Bradycardia
IV Sedatives

**Versed (Midazolam)**

**Indications**
- Sedative

**Contraindication**
- Allergy, CNS depression, Respiratory depression

**Dose:** 0.2-2mg (Up to 5mg)
- Onset: 2-15 minutes
- Duration: 90 minutes

**Route**
- Oral, IV, Nasal, Rectal

**Complications**
- Over sedation
IV Sedatives

• **Ativan (Lorazepam)**
  • Indications
    • Sedative

• **Contraindications**
  • Allergy, CNS Depression, Respiratory Depression

• **Dose:** 1-2mg q 3-4 minutes (4mg)
  • Onset-3-7 minutes
  • Peak-10-20 minutes
  • Duration-6-8 hours

• **Route**
  • Oral, IV, Intramuscular

• **Complications**
  • Over sedation
IV Sedatives

• **Valium (Diazepam)**

• **Indications**
  • Sedative

• **Contraindications**
  • Allergy, CNS Depression, Respiratory Depression

• **Dose:**

• **Route**
  • Oral, IV, Inhalation, Intramuscular

• **Complications**
  • Over sedation
Anticoagulant

- **Warfarin (Coumadin)**
- **Indications**
  - Inhibits bloods ability to clot or coagulate
  - Effectiveness is measured with either PT or INR
- **Dose:** 2-10mg per day

- **Route**
  - Oral
- **Complications**
  - Bleeding
Anticoagulant

**Heparin**

**Indications**
- Inhibits blood's ability to clot or coagulate
- Effectiveness is measured with PTT

**Dose:**
- Loading Dose: 3,000u-5,000u
- Maintenance Dose: 800u/h-1200u/h

**Route**
- IV or Subcutaneous

**Complications**
- HITT, Bleeding
Anticoagulant

Argatroban

• Indications
  • HITT

• Dose: 2mcg/kg/minute

• Route
  • IV Infusion
Anticoagulant

- **Dalteparin (Fragmin)**
- **Indications**
  - Inhibits blood's ability to clot or coagulate
  - Low molecular weight heparin
  - Prolonged half life
  - No lab value to measure effectiveness
- **Route**
  - Subcutaneous
- **Complications**
  - Bleeding
Anticoagulant

**Enoxoparin (Lovenox)**

- **Indications**
  - Inhibits bloods ability to clot or coagulate
  - Low molecular weight heparin
  - Prolonged half life
  - No lab value to measure effectiveness

- **Route**
  - Subcutaneous

- **Complications**
  - Bleeding
Antiplatelet

- **Plavix**
- **Indications**
  - CAD and PVD
- **Contraindications**
  - Bleeding ulcer, Allergy, Hemorrhagic stroke
- **Dose**
  - Loading Dose: 300mg
  - Daily: 75mg

- **Route**
  - Oral
- **Complications**
  - Bleeding
- **Discontinue use 3-5 days prior to surgery**
Antiplatelet

**Aspirin**

**Indications**
- Anti-inflammatory, Analgesic
- Prevent recurrence of MI, Ischemic stroke, TIA, and Angina

**Contraindications**
- GI bleed, Thrombocytopenia
- Bleeding disorders, Allergy

**Dose:** 81mg-325mg

**Route**
- Oral, Rectal

**Complications**
- Bleeding
Antiplatelet

• **Integrillin**

• **Indications**
  • Prevents platelet aggregation

• **Contraindications**
  • Major surgery within past 6 weeks, ESRD, History of stroke within 30 days, Hypertension

• **Dose:**
  • Loading 180mcg/kg bolus x 2 (10 min apart)
  • Infusion at 2mcg/kg/min

• **Route**
  • IV

• **Complications**
  • Bleeding
Thrombolytic

• Alteplase
• Urokinase
• Streptokinase

• Indications
  • Used to dissolve existing clot

• Contraindications
  • Recent surgery, GI Bleeding, Traumatic injury, Intracranial hemorrhage, Atrial fibulation

• Patient Preparation
  • Check Coags and fibrinogen
  • Two IV’s
  • Available blood products

• Complications
  • Bleeding
Vasoconstrictor

**Indication**

- Increases systemic vascular resistance thereby increasing blood pressure and heart rate
- Increases blood flow to vital organs
- Increases contractile force and bronchodilation
Vasoconstrictor

• Epinephrine (Adrenaline)
  • Dose
    • 1mg IV/IO (1:10,000)
    • Repeat every 3-5 min
  • Route
    • Intracardiac, ET, infusion

• Vasopressin
  • Indications
    • Asystole, PEA, Pulseless VT, VF
  • Dose
    • 40 units IV only once
    • Always follow with 20ml saline
  • Route
    • IO, ET
Vasoconstrictor

**Atropine**

**Indications**

- Asystole, Bradycardia

**Dose**

- 0.5mg IV for symptomatic bradycardia
- 1mg IV for asystole; total 3mg

**Route**

- IO, IV

**Dopamine**

**Indications**

- Low dose helps renal perfusion
- High dose increases blood pressure

**Dose**

- 2-20mcg/kg/min IV infusion

**Route**

- IV
Vasodilator

• Relax the smooth muscle in blood vessels

• Vasodilators are used to treat hypertension, heart failure and angina

• Increase O2 demand
Vasodilator

**Hydralazine (Apresoline)**

- **Indications**
  - Hypertension, Heart failure, Angina

- **Risks**
  - Can cause angina attacks and ECG changes due to myocardial ischemia

- **Dose**: 5-20mg IV

- **Route**
  - IV

**Nitroglycerine**

- **Indications**
  - Hypertension, Heart failure, Angina

- **Risks**
  - Dizziness, headache

- **Dose**: Start with 5 mcg/min and titrate up to desired effect

- **Route**
  - IV, ointment, Sublingual Patch, Spray
# Contrast Reaction (Allergic)

<table>
<thead>
<tr>
<th>Minor</th>
<th>Intermediate</th>
<th>Severe</th>
</tr>
</thead>
<tbody>
<tr>
<td>• Uticaria</td>
<td>• HTN</td>
<td>• VTACH</td>
</tr>
<tr>
<td>• Dizziness</td>
<td>• Palpitations</td>
<td>• Low blood pressure</td>
</tr>
<tr>
<td>• Coughing</td>
<td>• Tachycardia</td>
<td>• Syncope</td>
</tr>
<tr>
<td>• Nausea</td>
<td>• Bradycardia</td>
<td>• Pulmonary edema</td>
</tr>
<tr>
<td>• Vomiting</td>
<td>• SOB</td>
<td>• Seizures</td>
</tr>
<tr>
<td>• Sweating</td>
<td>• Bronchospasm</td>
<td>• Death</td>
</tr>
<tr>
<td></td>
<td>• Laryngeal edema</td>
<td></td>
</tr>
<tr>
<td></td>
<td>• Facial edema</td>
<td></td>
</tr>
<tr>
<td></td>
<td>• Headache</td>
<td></td>
</tr>
</tbody>
</table>
Contrast Reaction (Allergic)

**Urticaria**

**Treatment**
- Mild: Observe
- Moderate: Benadryl 25-50mg IV

**Bronchospasm**

**Treatment**
- Oxygen
- Albuterol inhaler: 2-3 deep inhalations
- Epinephrine:
  - Subcutaneous: 1:1000, 0.1-0.3ml
  - IV 1:10,000, 1ml slowly over 5 min
Contrast Reaction (Allergic)

- **Laryngeal Edema**
  - **Treatment**
    - Epinephrine: IV 1:10,000, 1ml slowly over 3-5 min
    - Solu-Cortef (Hydrocortisone): 100mg IV
    - Consider intubation if not responsive to therapy
    - Call code

- **Hypotension and tachycardia**
  - **Treatment**
    - Elevate legs
    - Oxygen
    - IV fluids rapidly: Normal Saline or Lactated Ringers
Contrast Reaction (Allergic)

- **Hypotension and bradycardia**

- **Treatment**
  - Elevate legs
  - Oxygen
  - IV fluids rapidly: Normal Saline or Lactated Ringers
  - Atropine: 0.5mg IV, repeat every 3-5 min, total 2-3mg
Contrast Reaction (Allergic)

• **Anaphylaxis**
  • Oxygen
  • Elevate legs
  • IV fluids
  • Epinephrine:
    • Subcutaneous 1:1000, 0.1-0.3ml
    • IV 1:10,000, 1ml slowly over 5 min

• **Treatment**
  • Benadryl 50mg IV
  • Albuterol treatment: Nebulized in 2ml saline
  • Hydrocortisone: 0.5-1gm IV
  • Methylprednisolone: 500mg IV
### Contrast Reaction (Adverse)

<table>
<thead>
<tr>
<th>Hemodynamic or CNS</th>
<th>Nephrotoxic</th>
</tr>
</thead>
<tbody>
<tr>
<td>• Bradycardia</td>
<td>• Affects renal function</td>
</tr>
<tr>
<td>• Seizures</td>
<td>• Creatine will increase 50% from baseline</td>
</tr>
<tr>
<td>• Tachycardia</td>
<td></td>
</tr>
<tr>
<td>• Syncope</td>
<td></td>
</tr>
<tr>
<td>• Vasovagal</td>
<td></td>
</tr>
<tr>
<td>• Arrhythmias</td>
<td></td>
</tr>
</tbody>
</table>
IV Therapy

**Indications**
- Maintain normal BP
- Re-expand cellular fluid volume
- To return intracellular fluid volume to normal

**Contraindications**
- Heart failure
- Hypertension
- Pulmonary edema
# IV Therapy

## Solutions
- Normal Saline
- Lactated Ringers
- Dextrose

## Complications
- Fluid Overload
- Extravasation
- Phlebitis
- Electrolyte imbalance
Antiarrhythmic

• Control heart rate and rhythm

• Suppress or slow transmission of fast electrical impulses
Antiarrhythmic

• Drug: Calcium channel blockers
  • Examples: Amlodipine (Norvasc), Verapamil (Calan), Cardiazem (Diltiazem)

• Indications
  • High Blood pressure, chest pain, arrhythmias

• Function
  • Lowers blood pressure, treats chest pain, slows heart rate

• Drug: Beta Blockers
  • Examples: Metoprolol (Iopressor), Atenolol (Tenormin), Cordarone (Amiodarone)

• Indications
  • High blood pressure, chest pain, fast rates, arrhythmias

• Function
  • Slows heart rate, lowers blood pressure
Antiarrhythmic

• **Amiodarone**
  • **Indication:** VT and VF
  • **Route:** IV or Interosseous
  • **Dose:**
    • Stable VT 150mg over 10 minutes
    • Pulseless VT or VF 300mg IV push

• **Lidocaine**
  • **Indication:** VT and VF
  • **Route:** IV, Interosseous, Endotracheal
  • **Dose:**
    • Bolus: 1-1.5mg/kg
    • Q 5-10 minutes: 0.5-0.75mg/kg
    • Total dose of 300mg/kg
Antiarrhythmic

• **Magnesium**
• **Indication:** Torsades de Pointes
• **Route:** IV or Interosseous
• **Dose:** 1-2gm over 50-60 minutes
Basic Life Support

• Follow ACLS (advanced cardiac life support) guidelines

• Access
  • IV
  • Central line
  • Femoral line
  • Intraosseous
  • Endotracheal route

Basic Life Support

• Compression to breath ratio: 30-2

• Compression rate: 100 per minute

• Minimize interruptions

• CPR increases chances of survival 2-3 times
Basic Life Support

Defibrillation

• Terminates electrical activity in hopes that a perfusing rhythm takes over
• VFIB is the most common cause of cardiac arrest in adults
• Survival decreases 7-10% with every minute that passes without defibrillation

Know your institution’s type of defibrillator
• Shockable rhythms include VFIB and pulseless VTACH
• Defibrillation is not the same as cardioversion
Air Embolus

- Air enters artery or vein

**Symptoms:** Immediate loss of consciousness, Convulsions, CVA, MI, pain in joints, itching, mottled skin, low BP, arrhythmia, visual disturbances, disorientation, hypoxia

**Treatment:** Seal any open blood vessel, O2, IV fluids, Cardiac support
Medical Emergencies

Anaphylaxis

- Severe allergic reaction

- **Symptoms:** Low BP, SOB, Hives, arrhythmia, edema, death

- **Treatment:** Epinephrine, protect the airway, Basic Life Support
Medical Emergencies

Hemothorax

• Blood accumulation in the pleural cavity

• **Symptoms:** tachypnea, dyspnea, cyanosis, decreased or absent sounds, tracheal deviation, unequal chest rise, tachycardia, hypotension, pale, cool, clammy skin

• **Treatment:** Chest tube
Medical Emergencies

Pneumothorax

• Air accumulation within the pleural space

• **Symptoms:** sudden SOB, cyanosis, chest pain, back pain, arm pain

• **Treatment:** Chest tube, cover entry wound, Pleurodosis
Medical Emergencies

Congestive Heart Failure

- Caused by MI, Cardiomyopathy, HTN, Rhythm or valve abnormalities

- **Right Sided Heart Failure**: LE edema, enlarged liver and stomach

- **Left Sided Heart Failure**: SOB, cough, sputum

- **Treatment**: Reduce pressure on heart
Medical Emergencies

Myocardial Infarction

• Blood clot in a coronary artery

• **Symptoms**: Chest pain, Radiating pain from jaw to wrist, SOB, nausea, vomiting, feeling of impending doom, cold, clammy, or grey skin

• **Treatment**: CPR, Morphine, O2, thrombolytics, Aspirin
Medical Emergencies

**Transient Ischemia Attack**

- Temporary reduction in O2 and blood supply to a part of the brain

- **Symptoms**: Mimic stroke symptoms but last only up to 30 minutes and disappear within 24 hours

- **Treatment**: Plavix, Coumadin, Lifestyle control, Carotid endarterectomy
Medical Emergencies

Sepsis

• Viral, fungal or bacterial infection in the blood causing symptoms throughout the whole body

• **Symptoms**: Fever, tachycardia, tachypnea, shock, low BP, confusion, decreased urine output, cold, clammy, or pale skin, loss of consciousness, Rigors

• **Treatment**: IV antibiotics, cardiac and respiratory support, treat source
Medical Emergencies

Vasovagal Response

• Over stimulation of vagus nerve

• **Symptoms:** Decreased heart rate, and/or blood pressure, hot, sweaty

• **Treatment:** Stop stimulating the nerve, IV fluids, Atropine 0.5mg IV
Diagnostic Inventory

• Needles
• Wires
• Catheters
• Sheaths

• Characteristics
• Basic construction and design of diagnostic inventory
• Indications for use
Needles

**Access**

• Vascular
• Non-vascular
  • Lymph nodes
• Renals
• Liver
• Bone
Needles

**Characteristics:**
- Hub
- Cannula
- Bevel
- Stylet
- Echogenic

**Size**
- Measured in gauge with larger number indicating a smaller size
- 30g-11g
- 22g, 21g, 19g, 18g, and 16g
Needles

**Design:**

- **Seldinger:** Cannula, beveled stylet
  - 19g, 18g
- **Single wall:** Beveled cannula
  - 21g, 18g
- **Trocar:** Cannula, diamond tip stylet
  - 21g, 18g
- **Chiba:** Beveled Cannula and stylet
  - 22g, 21g

- **Angiocaths:** Beveled cannula with plastic cover
  - 24g-12g
- **Lymphangogram:** Beveled cannula
  - 27g, 30g
- **Vertebroplasty:** Diamond tip
  - 11g
Seldinger Technique

Developed by Sven-Ivar Seldinger in 1953

Access technique that utilizes a trocar needle, guidewire, and transitional dilator
Guidewires

• A long and flexible spring used to introduce and position intravascular devices.
Guidewires

**Construction**

- **Coiled Spring**
  - Outer portion of a guidewire
  - Usually stainless steel

- **Mandril**
  - Inner portion of a guidewire
  - Stainless steel
  - Nitinol

- **Wire guide or “Jacket”**
  - Holds the coiled spring together
Guidewires

Characteristics

- **Straight or Curved**
  - Curved tips are more atraumatic to the vessel wall.
  - Causes less arterial dissections

- **Taper**
  - Refers how flexible the mandril of a guide wire is at the distal tip.

- **Stiffness**
  - How ridged the guide wire is
  - Provides support for catheter exchanges

- **Torque**
  - The force applied to a guide wire, which allows the tip to rotate.
  - 1:1 ratio
Guidewires

**Characteristics**

- **Coated:**
  - Heparin
  - Teflon

- **Tip materials:**
  - Stainless steel
  - Platinum
  - Nitinol
  - Gold
  - Tungsten
## Guidewires

### Diameters:
- Measured in fraction of an inch
- Scale
  - .008” -.056”
- Common Sizes: .018-.038

### Common color system:
- .018=Green
- .021=Black
- .025=Blue
- .028=White
- .032=Orange
- .035=Purple
- .038=Red
Guidewires

**Length:**
- Measured in centimeters
- 145cm, 180cm, 200cm, 260cm, or 300cm
Catheters

A hollow tube that allows for the passage of contrast, embolization materials, or therapeutic medications, or instruments.

**Diagnostic**
- Specialized shape
- End hole

**Flush**
- Multiple side holes allow for faster injection rates
- Prevent “whipping”
Catheters

Characteristics:
• Inner diameter expressed in inches
  • .038 inches
• Outer diameter measured in French
  • 1 French=1/3 of a mm
  • 3Fr=1mm

Flow Rates:
• Inner Diameter
• Length
• Contrast Viscosity
• Number of side holes
• Presence of a taper
Catheters

Characteristics

- Stiffness
- Memory
  - Ability of a catheter to maintain its shape
- Torque
  - Ease that catheter turns when force is applied
- Trackability
  - Hydrophilic polymers

- Pushability
- Visibility
  - Tungsten
  - Bismuth
  - Barium
  - Lead
Catheters

**Materials**
- Polytetrafluoroethylene (PTFE): Teflon
- Polyethylene
- Polyurethane
- Nylon
- Polycarbonate
- Polyvinylchloride
- Silicone
- Latex
- Braided materials
  - Nitinol
  - Stainless steel
Catheters

Flush Catheters

- Multiple side holes allow for faster injection rates
- 4Fr-8Fr
- 65cm, 90cm, 100cm, 110cm
- Injections: 18-40cc/sec
- PSI: 1050-1200
- 10 side holes
- Pigtail, Omniflush, Straight flush, etc.
Diagnostic Catheters

- 4Fr and 5Fr
- 65cm, 80cm, 150cm
- Injections:
- PSI: 800
- May have sideholes
Catheters

Cerebral Catheters

• Usually an end hole catheter
• Specialized shape to aid in engaging the origins of cerebral vessels
• Vert, H1, H3, Simmons etc.

Visceral Catheters

• Usually end hole catheter
• Specialized shape to aid in engaging the origin of a visceral vessel
• C1, C2, RC, RIM, etc.
Catheters

**Pulmonary Catheters**

- Larger in diameter
- Longer
- Usually an end hole catheter
- Specialized shape to aid in navigating through pulmonary arteries
- Van Aman, Montefiore, Grollman, etc.
Catheters

**Sizing Catheters**

- Used to confirm accurate calibration as well as measure.
- Radiopaque markers or bands
Catheters

**Guiding Catheters**
- Used for interventional purposes
  - PTA
  - Stent
  - Suction embolectomy
  - Embolizations

- Materials
  - Braided Nylon
  - Non-tapered
  - 5Fr-9Fr
  - Size indicates outer diameter
  - Inner diameters determines what can be used for
    - C1, RC, Renal Double Curve, Straight, Lima, etc.
Dilators

Expand the tract of a catheter or arterial site

- **Materials**
  - Teflon
  - Nylon

- **Coating**
  - Hydrophilic

- 4Fr-18Fr
- 15-20cm
Sheaths

• Protects the arteriotomy site
• Allows for better torqueability and pushability of the catheter
• Used for induction of non-tapered catheters
• Allows for multiple catheter exchanges
• Simplifies interventional procedures
Sheaths

**Characteristics**

- Measured in French
- Measurement is indicative of the inner diameter of the sheath
- Usually causes a 2Fr larger hole in the artery
- Greater than 10Fr sheath will create greater than 2Fr hole

**Color scheme for common sizes**

- 4FR=Red
- 5Fr=Grey
- 6Fr=Green
- 7Fr=Orange
- 8Fr=Blue
- 9Fr=Black
- 10Fr=Lavender
- 11Fr=Yellow
Sheaths

**Construction**

- **Materials**
  - Polyurethane
  - Teflon

- Braided or non-braided
  - Stainless steel

- Inner dilator
- Hub
  - Check flo valve
  - Tuohy-Borst adaptor
Iodinated Contrast

**Ionic**

- Creates a high osmolality in blood
- May cause contrast media reaction

**Non-Ionic**

- Decreases risk
- Expensive

**CO2**

- Renal insufficiency
- Limitations
Automatic Power Injectors
Atherosclerosis

• Occurs when fat, cholesterol, and other substances build up in the walls of arteries and form hard structures called plaques.

• Over time, these plaques can block the arteries and cause problems throughout the body.
Atherosclerosis

**Risk Factors**
- Smoking
- Hypertension
- Age
- Genetics
- Obesity
- Diabetes
- Hyperlipidemia
Thrombus

- Intravascular clots can be initiated by roughened endothelial surfaces of a blood vessel
- Atherosclerosis
- Trauma
- Infection
- Stasis
Embolus

- Occurs when thrombus moves from its site of origin
Hemorrhage

• Loss of blood from the circulatory system

**Causes**

• Traumatic injuries
• Intravascular changes
• Intramural changes
• Extravascular changes
Percutaneous Transluminal Angioplasty

- Used to mechanically open or repair a blood vessel that is either stenotic, occluded or dissected
Percutaneous Transluminal Angioplasty

**Classifications**
- Compliant
- Non compliant
- Semi compliant

- Cutting Balloons
- Scoring Balloons
- Cryoplasty
## Percutaneous Transluminal Angioplasty

<table>
<thead>
<tr>
<th>Construction</th>
<th>Characteristics</th>
</tr>
</thead>
<tbody>
<tr>
<td>• Generally true double or triple lumen catheters</td>
<td>• Crossing profile</td>
</tr>
<tr>
<td>• Balloons are usually attached to catheters by adhesive and thermal welding</td>
<td>• Balloon profile</td>
</tr>
<tr>
<td>• Shaft</td>
<td>• Uniform inflation and deflation</td>
</tr>
<tr>
<td>• Polyester</td>
<td>• Coating</td>
</tr>
<tr>
<td>• Polyethylene</td>
<td>• Shoulders</td>
</tr>
<tr>
<td>• Nylon</td>
<td></td>
</tr>
</tbody>
</table>
Percutaneous Transluminal Angioplasty

**Mono-rail**

- Inflation hub
- Second lumen allows for a guide wire
- Guidewire runs 20-30cm up the distal shaft
- Advantage
  - Do not need long guide wire for exchanges
- Disadvantage
  - Decreased pushability
Percutaneous Transluminal Angioplasty

Complications

• Vasospasm
• Dissection
• Thrombus
• Distal Emboli
• Pseudoaneurysm
• Rupture
Stents

- **Design**
  - Closed cell
  - Opened cell

- **Metal**

- **Deployment**
  - Balloon expandable
  - Self-expanding

- **Covered or Non-covered**
Self Expanding Stents

**Indications for Use**
- Compressible areas
- Dissections
- Tortuous anatomy
Balloon Expandable Stents

**Indications for Use**

- Origins
- Areas that require accurate stent placement
- Non-compressible areas of atherosclerosis
Thrombectomy

- The mechanical removal of thrombus and emboli occluding a blood vessel

**Indications**
- Treatment of acute thrombus
- “Debulking” occlusions prior to thrombolysis
Thrombectomy

**AngioJet**
- Works off the Venturi effect
- Saline jets travel backwards at half speed of sound to create a low pressure zone causing a vacuum effect
- Low pressure draws thrombus into catheter and is fragmented and removed
Thrombectomy

**Fogarty Balloon**
- Compliant balloon
- Allows for the mechanical retrieval of clot under local anesthesia
Thrombectomy

Trerotola

• An expandable fragmentation basket that macerates and removes thrombus

• Indicated for use in patients with dialysis grafts
Thrombolysis

- Breakdown of thrombus through mechanical means
- Indicated for acute occlusions
- Administered through delivery catheter

**Types of Thrombolytics**

**1\textsuperscript{st} Generation**
- Streptokinase (AstraZeneca)
- Urokinase (Abbott)

**2\textsuperscript{nd} Generation**
- Tissue Plasminogen Activator-tPA (AltaPlase)

**3\textsuperscript{rd} Generation**
- Retaplace
- Tenecteplase
Thrombolysis

**Contraindications**

- Active or recent bleeding
- Irreversible limb ischemia
- Recent Stroke
- Intracranial neoplasm
- Afib

- History of GI bleed
- Recent Surgery
- Recent Trauma
- Recent CPR
- Uncontrolled HTN
- Coagulopathy
- Pregnancy or postpartum
- Severe Cerebrovascular disease
- Diabetic retinopathy
Thrombolysis

Complications

• Bleeding
• Systemic complications
• Limb complications
  • Distal embolization
  • Compartment syndrome
  • Limb loss
• Death
Embolic Protection Device

- Used to catch distal emboli during intervention
- Device can be a basket or balloon
Atherectomy

- Mechanical intraluminal removal of obstructive atheroma
- It attempts to debulk the plaque to create a smooth intraluminal surface with minimal injury to the intima
- Often used with PTA

- Directional
- Rotational
- Extraction
- Orbital
Atherectomy

**Indications**

- Restenosis
- Anastomosis of grafts
- Diffuse disease
- Short occlusions
- Calcified lesions
- Ulcerated Plaques

- Remove plaque without causing distal
- Create a smooth luminal surface
- Track over a guide wire
- Treat long segments in reasonable procedure time
Atherectomy

Complications
• Distal emboli
• Dissection
• Acute vessel occlusion
• Vessel perforation
• Pseudoaneurysm
Microcatheter

**Geometry Directed**

- 2.3Fr-3Fr
- Utilized with a guidewire
- Usually constructed using a hydrophyilic polymer
- Braided
  - Allows for better pushability and flexibility without kinking
Microcatheters

**Flow directed**
- 3Fr or smaller
- Distal 15-20cm of catheter will be constructed of a siliastic material
- Guidewires may be used to improve pushability
## Embolic Materials

<table>
<thead>
<tr>
<th>Permanent</th>
<th>Temporary</th>
</tr>
</thead>
<tbody>
<tr>
<td>• Coils</td>
<td>• Petressin</td>
</tr>
<tr>
<td>• Particulate</td>
<td>• Autologous Material</td>
</tr>
<tr>
<td>• Liquids</td>
<td>• Gelfoam: Gelatin</td>
</tr>
<tr>
<td></td>
<td>• Avitene: Collagen</td>
</tr>
</tbody>
</table>
Thoracic Anatomy

**Ascending Aorta**
- Rises from the left ventricle
- Includes aortic valve
- Gives rise to the coronary arteries

**Views**
- Visualized on 30 degree LAO

**Injection**
- 25cc for 50cc

**Frame rate**
- 4-6 frames a second
Thoracic Anatomy

**Aortic Arch**
- Arches over the heart and begins descending posteriorly
- Extends from the arch of the aorta to the intervertebral space between C4 and C5
- Gives rise to the **three great vessels**

**Views**
- 30 degree LAO profiles the arch
- 40-45 degree LAO profiles the great vessels

**Injection**
- 25cc for 50cc
- 20cc for 20cc

**Frame rate**
- 4-6 frames per second
Brachiocephalic (Inominate)

Left Common Carotid

Left Subclavian
# Thoracic Anatomy

## Descending thoracic aorta
- Lies between aortic arch and diaphragm

<table>
<thead>
<tr>
<th>Views</th>
</tr>
</thead>
<tbody>
<tr>
<td>Varies</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Injection</th>
</tr>
</thead>
<tbody>
<tr>
<td>25cc for 50cc</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Frame Rate</th>
</tr>
</thead>
<tbody>
<tr>
<td>2-6 frames a second</td>
</tr>
</tbody>
</table>
Thoracic Anatomy

Variants

• Left carotid and Innominate have common origin

• Variant Seen in 1% - 22% of Population
Thoracic Anatomy

Variants

• The left common carotid artery originates separately from the innominate artery.

• This anatomy occurs in 9% of the population.
**Thoracic Anatomy**

<table>
<thead>
<tr>
<th>Inflammatory arteritis</th>
<th>Risk Factors</th>
</tr>
</thead>
<tbody>
<tr>
<td>• Inflammation of the aorta caused by connective tissue disorders</td>
<td>• Unknown</td>
</tr>
<tr>
<td>• Takayasu’s arteritis</td>
<td></td>
</tr>
<tr>
<td>• Giant cell (temporal) arteritis</td>
<td></td>
</tr>
<tr>
<td>• Radiation arteritis</td>
<td></td>
</tr>
</tbody>
</table>
Thoracic Anatomy

**Symptoms**

- High blood pressure
- Difference in blood pressure between the arms
- Weak or absent wrist pulses
- Fever
- Inflammation
- Fatigue
- Skin rash
- Night sweats
- Weight loss
Thoracic Anatomy

Takayasu’s Arteritis

- Chronic inflammatory condition that affects the aorta as well as its branches

Symptoms

- Systemic phase
- Occlusive phase
## Thoracic Anatomy

<table>
<thead>
<tr>
<th><strong>Risk Factors</strong></th>
<th><strong>Treatment</strong></th>
</tr>
</thead>
<tbody>
<tr>
<td>• Generally occurs in females under the age of 30</td>
<td>• Medication</td>
</tr>
<tr>
<td>• African or Asian descent</td>
<td>• Surgery</td>
</tr>
<tr>
<td>• Unknown etiology</td>
<td></td>
</tr>
</tbody>
</table>
Thoracic Anatomy

**Marfans Syndrome**
- Disorder of the connective tissue that supports all of the body’s structures
- Caused by a defect in fibillin-1 (gene) which helps to form the body’s elastic tissue, resulting in a weakening of the connective tissue

**Risk Factors**
- Family history

**Risks**
- Prone to aneurysms
- Prone to dissections
Thoracic Anatomy
Thoracic Anatomy

Thoracic Aortic Aneurysm (TAA)

• A weakening and bulging within the wall of the thoracic aorta
• Can occur in all three portions of the thoracic aorta

Risks

• Rupture
• Embolus
Thoracic Anatomy

TAA of the Ascending Aorta

Risk Factors

• Atherosclerosis
• Family history
• Cystic medial degeneration
• Genetic disorders
  • Marfans
  • Ehlers-Danlos

Ascending aortic aneurysm
Thoracic Anatomy

**TAA of the Aortic Arch**

**Risk Factors**

- Atherosclerosis
- Takayasus arteritis
- Continuation of ascending aneurysm
Thoracic Anatomy

TAA of the Descending Aorta

Risk Factors

• Age
• Male gender
• Family history of TAA
• High cholesterol
• High blood pressure
• Smoking
• Diabetes
• Genetic disorders
Thoracic Anatomy

**Symptoms**

- Severe or dull pain in the abdomen, chest, lower back or groin
- Sharp, sudden pain in the back or abdomen (may signal a rupturing aneurysm)
Thoracic Anatomy

**Treatment**
- Monitoring
- Lifestyle change
- Medication
- Endovascular repair (TEVAR)
- Surgery
Thoracic Anatomy

**Infectious or mycotic aortitis**

- Infection in the wall of the aorta caused by bacteria, most often Staphylococcus, Streptococcal or Salmonella

**Risk Factors**

- Bacteria in the bloodstream
- Gallbladder disease
- Tooth abscesses
- Bacterial infections
Thoracic Anatomy

**Symptoms**
- Fever
- Fatigue
- Skin rash
- Night sweats
- Weight loss
Thoracic Anatomy

**Treatment**

- Antibiotics
- Surgery
- Endovascular repair
Thoracic Anatomy

Dissections
A tear within the inner wall of the aorta, which allows blood flow between the layers of the aortic wall.

Risks
• Aortic Insufficiency
• Poor perfusion
• Thrombus
• MI
• Death
Thoracic Anatomy

Anatomy and Classification of Aortic Dissection

False lumen
True lumen
Intimal tears

DeBakey I II III
Stanford A B
## Thoracic Anatomy

### Risk Factors
- Hypertension
- Trauma
- Connective tissue disorders
- Surgery
- Male Gender

### Symptoms
- Chest pain
- Back pain
Thoracic Anatomy

**Treatment**

- Medical management
- TEVAR
- Surgery
Thoracic Anatomy

**Traumatic Aortic Injury**

- Partial or complete tear in the wall of the aorta caused by sudden injury to the chest
Thoracic Anatomy

Risk Factors
• Serious injury to the chest
• Occurs most frequently with deceleration injuries which cause the wall of the aorta to fall apart

Symptoms
• Often overshadowed by other traumatic injuries
Thoracic Anatomy

**Treatment**

- Surgery
- EVAR
- TEVAR
Thoracic Anatomy

Coarctation of the Aorta

- Congenital narrowing of a portion of the aorta

Risk

- If left untreated, can lead to life threatening heart problems
Thoracic Anatomy

**Symptoms**
- Chest pain
- Shortness of breath
- Fainting or dizziness
- Headache
- Cold feet or legs
- Nosebleeds
- Leg cramps or high blood pressure during exercise
- Poor growth in children with the disease

**Treatment**
- Surgery
- Angioplasty (PTA)
## Thoracic Anatomy

### Causes
- Atherosclerosis
- Thrombus
- Birth defects
- Trauma
- Embolisms
- Takayasu's arteritis

### Risk Factors
- High blood pressure
- Diabetes
- Smoking
- High cholesterol
Thoracic Anatomy

Innominate Artery Disease

• Occurs when the innominate, or brachiocephalic, becomes blocked.

Causes

• Atherosclerosis
• Trauma
• Takayasu's arteritis
• Radiation arteritis
Thoracic Anatomy

**Subclavian Steal Syndrome (Aortic Arch Syndrome)**

- Involves structural problems or blockages in the arteries that branch off from the aortic arch.
# Thoracic Anatomy

<table>
<thead>
<tr>
<th>Symptoms</th>
<th>Treatment</th>
</tr>
</thead>
<tbody>
<tr>
<td>Dizziness</td>
<td>Endarterectomy</td>
</tr>
<tr>
<td>Blurred vision</td>
<td>PTA</td>
</tr>
<tr>
<td>Weakness</td>
<td>Stenting</td>
</tr>
<tr>
<td>Transient ischemic attacks, or &quot;mini-strokes&quot;</td>
<td></td>
</tr>
<tr>
<td>Sudden changes in blood pressure</td>
<td></td>
</tr>
<tr>
<td>Reduced pulse</td>
<td></td>
</tr>
<tr>
<td>Arm numbness</td>
<td></td>
</tr>
</tbody>
</table>
# Upper Extremity Anatomy (Arterial)

- **Subclavian**
  - Internal mammary
  - Head and neck
- **Axillary**
  - Lateral thoracic
  - Humeral Circumflex
- **Brachial**
- **Radial**
  - Supplies deep palmar arch
- **Ulnar Arteries**
  - Supplies superficial palmar arch
- **Interosseous**
- **Digital arteries**
Right Brachial
Radial

Ulnar

Interosseous
**Upper Extremity Anatomy (Arterial)**

<table>
<thead>
<tr>
<th>Indications for imaging</th>
<th>View</th>
</tr>
</thead>
<tbody>
<tr>
<td>• Peripheral vascular disease</td>
<td>• Varies depending on indication</td>
</tr>
<tr>
<td>• Congenital abnormalities</td>
<td>• Usually AP</td>
</tr>
<tr>
<td>• Vascular Pathology</td>
<td><strong>Injections</strong></td>
</tr>
<tr>
<td>• Trauma</td>
<td>• Flush aortagram</td>
</tr>
<tr>
<td>• Tumors</td>
<td>• Selective runs</td>
</tr>
</tbody>
</table>

**Frame rate**
- 2-4 frames per second
Upper Extremity Anatomy (Arterial)

Buergers Disease

• Inflammation of the blood vessels resulting in swelling and thrombus.
# Upper Extremity Anatomy (Arterial)

<table>
<thead>
<tr>
<th><strong>Risk Factors</strong></th>
<th><strong>Symptoms</strong></th>
</tr>
</thead>
<tbody>
<tr>
<td>Smoking</td>
<td>Claudication</td>
</tr>
<tr>
<td>Men under 40</td>
<td>Raynaud's Phenomenon</td>
</tr>
<tr>
<td></td>
<td>Loss of sensation</td>
</tr>
<tr>
<td></td>
<td>Ulcers</td>
</tr>
<tr>
<td></td>
<td>Gangrene</td>
</tr>
</tbody>
</table>
Upper Extremity Anatomy (Arterial)

**Treatment**
- Surgery
- Medication
- Treatment
Upper Extremity Anatomy (Arterial)

**Hypothenar Hammer Syndrome**

- Occurs from trauma to the distal ulnar artery or proximal portion of superficial palmar arch as a result of repetitive trauma to the hypothenar eminence.
Upper Extremity Anatomy (Arterial)

**Risk Factors**
- Occupations that require repetitive compression or blunt trauma to the palm of the hand

**Symptoms**
- Cold sensation and pain in the palm
- Raynaud syndrome
- Tender hypothenar eminence
- Ischemia of (usually) fourth and fifth fingers
Upper Extremity Anatomy (Arterial)

**Treatment**

- Surgery
Upper Extremity Anatomy (Arterial)

Raynaulds Syndrome

• Excessively reduced blood flow in response to cold or stress

• Occurs as a result of vasospasm
## Upper Extremity Anatomy (Arterial)

<table>
<thead>
<tr>
<th><strong>Risk Factors</strong></th>
<th><strong>Symptoms</strong></th>
</tr>
</thead>
<tbody>
<tr>
<td>• Vascular pathologies</td>
<td>• Symptoms induced by cold</td>
</tr>
<tr>
<td>• Eating disorders</td>
<td>• Typically have predictable asymmetric digital</td>
</tr>
<tr>
<td>• Connective tissue</td>
<td>pallor or cyanosis</td>
</tr>
<tr>
<td>disorders</td>
<td></td>
</tr>
<tr>
<td>• Trauma</td>
<td></td>
</tr>
<tr>
<td>• Tobacco use</td>
<td></td>
</tr>
<tr>
<td>• Occupation</td>
<td></td>
</tr>
<tr>
<td>• Female gender</td>
<td></td>
</tr>
</tbody>
</table>
Upper Extremity Anatomy (Arterial)

**Treatment**
- Treat the underlying cause
- Vasodilators
- Avoid triggers
- Surgery
Upper Extremity Anatomy (Venous)

- Returns the blood from the upper extremities to the right atrium
  - Radial
  - Ulnar
  - Cephalic
  - Basilic
  - Brachial
  - Axillary
  - Subclavian
Central Venous Catheters

• Temporary
  • Access
  • Dialysis
• Permanent
  • Long term access
  • Dialysis
Cephalic
Brachial
Radial
Brachial
Upper Extremity Anatomy (Venous)

**Indications for Imaging**
- Upper extremity swelling
- Surgery
- Vein mapping
- Central vein thrombosis

**Views**
- Varies

**Injection**
- Hand injections

**Frame Rate**
- 2 frames a second or “spot” films
Thoracic Anatomy

**Paget-Schroetter**
Compression of subclavian artery, subclavian vein, and brachial plexus in the costo clavicular space.

**Arterial**
- Numbness, loss of pulses, pain radiating to forearm

**Venous**
- Shoulder or neck discomfort, arm edema

**Nerve**
- Brachial plexus tenderness, arm or hand atrophy
# Thoracic Anatomy

## Causes
- Trauma to the shoulder or collarbone area
- An extra rib above the first rib
- Abnormally tight fibrous band (ligament) connecting the spinal vertebra with the ribs

## Risk Factors
- Repetitive motion with the arms extended over the head
- Long, muscular neck
- Droopy shoulders
- Poor posture
Thoracic Anatomy

**Symptoms**

- Pain, numbness and tingling in the last three fingers and inner forearm
- Weakness and fatigue in the forearm and hand muscles
- Pain and tingling in the neck and shoulders
- Arm turns pale when lifted
Thoracic Anatomy

**Diagnosis**
- Venogram
- Neutral
- Abduction
- Upper Extremity Blood Pressure
- MRI
- Nerve conduction velocity study
- Electromyography
Thoracic Anatomy

**Treatment**
- Antiocoagulation
- Catheter-directed thrombolysis
- Catheter directed mechanical thrombectomy
- Surgical thrombectomy
- Angioplasty
- Thoracic outlet decompression (1st rib resection)
Pulmonary Arteries

- Carries deoxygenated blood from the heart to the lungs
- Pulmonary trunk begins at the base of the left ventricle
- Branches into left and right

**Views**
- 40-45 degree ipsilateral for the apex
- 40-45 degree contralateral for the base

**Injection**
- 35cc for 70cc (main)
- 25cc for 50cc (selective)

**Filming rate**
- 3-6 frames per second
Pulmonary Arteries

**Indications for imaging**

- AVM
- Congenital abnormalities
- Pulmonary Embolus
# Pulmonary Arteries

## Contraindications
- Mean PA pressures greater than 50 mmHg
- Normal mean pulmonary pressure is 9-18 mmHg
- Greater than 25mmHg can indicate Pulmonary Hypertension
- Heart Block
- Contrast Allergy

## Complications
- Bleeding
- Infection
- Contrast Reaction
- Arrhythmias
- Acute Pulmonary Hypertension
## Pulmonary Arteries

<table>
<thead>
<tr>
<th>Pathway of Catheter</th>
<th>Approaches</th>
</tr>
</thead>
<tbody>
<tr>
<td>SVC/IVC</td>
<td>Trans-femoral</td>
</tr>
<tr>
<td>Right Atrium</td>
<td>Trans-Jugular</td>
</tr>
<tr>
<td>Tricuspid Valve</td>
<td>Trans-Brachial</td>
</tr>
<tr>
<td>Right Ventricle</td>
<td></td>
</tr>
<tr>
<td>Pulmonic Valve</td>
<td></td>
</tr>
<tr>
<td>Main Pulmonary</td>
<td></td>
</tr>
<tr>
<td>Right and Left Pulmonary Arteries</td>
<td></td>
</tr>
</tbody>
</table>
Bronchial Arteries

- Supply mainly bronchi and peribronchial connective tissue
- Originate at T4-T9
  - 90% originating at T5-T6

**Views**
- AP

**Injection**
- 20-30ccs for a total of 40-60ccs
- Hand injections for selective runs

**Frame rate**
- 4 frames per second for flush aortagram
- 2 frames per second for selective runs
Bronchial Arteries

**Right bronchial artery (with branches)**

**Originates**
- Right lateral
- Anterolateral
- Directly anterior on the descending thoracic aorta

**Left bronchial arteries (Superior and Inferior)**

**Originates**
- Directly anterior off of descending thoracic aorta
- Can share common origin with right
Bronchial Arteries

**Indications for imaging**
- Hemoptysis

**Treatment**
- Embolization
- When embolizing the right bronchial artery, make sure that you are distal to the spinal artery
Abdominal Anatomy

**Abdominal Aorta**

- Lies between diaphragm and common iliac artery bifurcation
# Abdominal Anatomy

<table>
<thead>
<tr>
<th>Anatomy</th>
<th>Corresponding landmark</th>
</tr>
</thead>
<tbody>
<tr>
<td>• Celiac</td>
<td>• Lower Half of T12</td>
</tr>
<tr>
<td>• SMA</td>
<td>• Upper Half of L1</td>
</tr>
<tr>
<td>• Renals</td>
<td>• L2 - L3 Innerspace</td>
</tr>
<tr>
<td>• IMA</td>
<td>• L3 - 3cm Above Aortic Bifurcation</td>
</tr>
<tr>
<td>• Aortic Bifurcation</td>
<td>• L4 – Level of Umbilicus</td>
</tr>
</tbody>
</table>
Abdominal Anatomy
Abdominal Anatomy

**CELIAC**
- First major mesenteric artery off of aorta
- Gives rise to left gastric
- Celiac axis bifurcates into:
  - Common Hepatic
  - Splenic

**Views**
- Origin: lateral
- Peripheral branches: AP (Varies)

**Injection**
- 6-8ccs for a total volume of 40-60ccs

**Frame Rate**
- 2-4 frames per second
## Abdominal Anatomy

### Indications for imaging
- Arcuate ligament syndrome
- Atherosclerosis
- Aneurysm or pseudo aneurysm
- Trauma
- Surgery
- Bleed
- Oncology
Abdominal Anatomy
Abdominal Anatomy
Abdominal Anatomy

**Hepatic Arteries**
- Common hepatic artery
- Proper hepatic artery
  - Right hepatic
  - Left Hepatic

**Views**
- 30 degree RAO

**Injection**
- 4-6ccs per second for a total volume of 25-35ccs
- 1-3ccs per second for a total volume of 9-12ccs

**Film rate**
- 2 frames per second
Abdominal Anatomy

**Indications for imaging**
- Aneurysm or pseudo aneurysm
- Trauma
- Hemobilia
- Atherosclerosis
- Surgery

**Hepatic Artery as a Conduit for Treatment**
- Oncology (HCC)
  - Planning
  - Treatment
**Abdominal Anatomy**

**Splenic Artery**
- Posterior Gastric Artery
- Short Gastric Artery
- Left Gastroepiploic Artery

**Views**
- AP

**Injection**
- 6-8ccs per second for a total volume of 40-60ccs

**Frame rate**
- 2 frames per second
<table>
<thead>
<tr>
<th>Indications for imaging</th>
<th>Splenic artery as a conduit for treatment</th>
</tr>
</thead>
<tbody>
<tr>
<td>• Aneurysm or pseudoaneurysm</td>
<td>• Splenomegaly (Hyperspleen)</td>
</tr>
<tr>
<td>• Trauma</td>
<td>• Oncology</td>
</tr>
<tr>
<td></td>
<td>• Portal vein evaluation</td>
</tr>
</tbody>
</table>
Mesenteric Anatomy

**LEFT GASTRIC**
- Left hepatic may come off the LGA
- Accessory left hepatic artery may come from the LGA

**Views**
- AP

**Injection**
- 2-3ccs per second for a total volume of 9-15ccs

**Frame rate**
- 2 frames per second
# Abdominal Anatomy

## Indications for imaging
- Evaluation of a stomach bleed
- Mallory Weiss tear
- Aneurysm or pseudoaneurysm
- Bleed

## Left Gastric Artery as a conduit for treatment
- Oncology
  - Replaced or accessory left hepatic
Abdominal Anatomy

PANCREAS

• Superior pancreaticoduodenal artery
  • From GDA

• Inferior pancreaticoduodenal artery
  • From SMA
Mesenteric Anatomy

**GALLBLADDER**

- Cystic artery
  - Branch of the right hepatic artery
  - Supplies the Cystic duct
- Cystic vein drains directly into the portal vein
Abdominal Anatomy
Abdominal Anatomy

**Superior Mesenteric Artery**
• Second major mesenteric artery off of the abdominal aorta

**Views**
• Origin: Lateral
• Peripheral: AP (Varies)

**Injection**
• 5cc’s a second for a total volume of 40cc’s

**Frame rate**
• 2 frames per second
Mesenteric Anatomy

- **Inferior pancreaticoduodenal artery**
- First Branch off the SMA
- Anastomosis with the Superior Pancreaticoduodenal artery
- Provides blood to the Head of the pancreas and duodenum
Mesenteric Anatomy
Mesenteric Anatomy

**Middle colic artery**
- Supplies Blood to the Transverse Colon
- Anastomosis with the Right Colic at the Hepatic Flexure
- Anastomosis with the Left Colic at the Splenic Flexure

**Right colic artery**
- Supplies majority of the blood to the Ascending Colon

**Ileocolic artery**
- Supplies Blood to the terminal ileum, cecum, and lower ascending colon
Mesenteric Anatomy

Jejunal Arteries
• Supplies blood to the jejunum

Ileal Arteries
• Provides blood to most of the ileum
Mesenteric Anatomy

- A: Jejunal
- B: Ileal
- C: Middle Colic
- D: Right Colic
- E: Ileocolic
- F: Ileal
Mesenteric Anatomy

**Inferior Mesenteric Anatomy**
- Final mesenteric branch off of the abdominal aorta
- Located between L2-L4

**Views**
- 60-70 degree RAO

**Injection**

**Film rate**
- 2 frames per second
Mesenteric Anatomy

**Left Colic**
- Anastomosis with the Middle Colic at the Splenic Flexure and Sigmoid at the Descending Colon
- Absent in 12% of Patients

**Sigmoidal**
- Anastomosis with the Left Colic and Superior Rectal

**Superior Rectal Artery**
- Terminal of the IMA
- Divides into two terminal branches at the level of S3
Mesenteric Anatomy

• A: IMA
• B: Left Colic
• C: Sigmoid
• D: Superior Rectal
Mesenteric Anatomy

- **Arc of Buehler**
  - Persistent Embryonic communication between the Celiac Trunk and Proximal SMA
Mesenteric Anatomy

- **Arc of Riolan**
  - A bridge between the Left Colic and Middle Colic
Mesenteric Anatomy

**Marginal Artery of Drummond**

- Anastomoses between the SMA and IMA
- Runs along the border of the colon and provides the vasa recta
Mesenteric Anatomy

**Indications for imaging**

- Trauma
- PVD
- Bleeding
  - Upper GI
  - Lower GI
- Surgery
- Oncology
Mesenteric Bleeding

**Upper GI Bleed**

- Bleeding involving your stomach, esophagus, or small intestine
- Trauma
- Non-traumatic mesenteric hemorrhage
- Varices
Mesenteric Bleeding

**Symptoms**
- Hematemesis
- Hematochezia
- Anemia
- Syncope

- SOB
- Chest pain
- Fatigue
Mesenteric Bleeding

**Imaging Considerations**

- 0.5ml per minute
- Looking for active extravasation into the bowel
- Review images in multiple formats
- May require an antiperistaltic agent (Glucagon)
- Visualize mesenteric anatomy in its entirety
- Allow for adequate film acquisition time
- Prepare to compensate for patient limitations
Mesenteric Bleeding

**Diagnostic Inventory**
- Flush catheters
- Visceral Catheters
- Microcatheters

**Interventional Inventory**
- Coils
- PVA
- Gelfoam
- Vasopressin
Mesenteric Bleeding

Complications

• Non-targeted embolization
• Rupture of aneurysms
• Contrast reaction
• Contrast induced renal failure
• Arterial complications
• Puncture site complications
Mesenteric Bleeding

Lower GI Bleeding

- Any form of bleeding in the lower GI tract
- Coagulopathy
- Colitis
- Hemorrhoids
- Angiodysplasia
- Neoplasm
- Diverticular disease
Mesenteric Bleeding

**Symptoms**

- Hematochezia
- Hypotension
- Weakness
- Confusion

- Shock
- Tachycardia
- Angina
Mesenteric Bleeding

**Imaging Considerations**

- 1ml per minute
- Image from splenic flexure to below the ischial tuberosity
- Foley catheter
Mesenteric Bleeding

**Diagnostic Inventory**
- Flush catheters
- Visceral Catheters
- Microcatheters

**Interventional Inventory**
- Coils
- PVA
- Gelfoam
- Vasopressin
Mesenteric Bleeding

Complications
- Non-targeted embolization
- Rupture of aneurysms
- Contrast reaction
- Contrast induced renal failure
- Arterial complications
- Puncture site complications
Mesenteric Ischemia

**Acute Ischemia**

- Embolism
- Thrombosis
- Non-occlusive mesenteric ischemia
  - Vasoconstriction resulting from hypotension or hypovolemia
Acute Mesenteric Ischemia

**Symptoms**

- Acute on-set of abdominal pain
- Nausea
- Vomiting
Acute Mesenteric Ischemia

**Treatment**

- Non-occlusive Disease
  - Vasodilator infusion
- Thrombolytic
  - Thrombectomy
  - Thrombolysis
- Angioplasty
- Stent
Acute Mesenteric Ischemia

**Diagnostic Inventory**
- Flush catheters
- Visceral Catheters
- Guide catheters
- Sheaths

**Interventional Inventory**
- Balloons
- Stents
- Infusion catheters
- Thrombectomy devices
Acute Mesenteric Ischemia

Complications

• Puncture site
• Arterial complications
• Distal embolization
• Bleeding
Chronic Mesenteric Ischemia

**Chronic Ischemia**

- Atherosclerosis
- Thrombotic Occlusion
- Extrinsic Compression
- Dissection
- Vasculitis
- Coarctation Syndromes
- Fibromuscular Dysplasia
Chronic Mesenteric Ischemia

**Symptoms**

- Weight Loss
- Abdominal pain
- Nausea
- Vomiting
- Bleeding
- Constipation
Chronic Mesenteric Ischemia

Treatment

• PTA
• Stent
• Surgery
# Chronic Mesenteric Ischemia

**Diagnostic Inventory**
- Flush catheters
- Visceral Catheters
- Guide Catheters
- Sheaths

**Interventional Inventory**
- Balloons
- Stents
Chronic Mesenteric Ischemia

Complications

• Puncture site
• Arterial complications
• Distal embolization
Abdominal Anatomy

- "True Aortagram"

**View**
- AP

**Injection**
- 15-20cc’s per second for a total volume of 30-40cc’s

**Frame Rate**
- 2 frames a second
Abdominal Anatomy

Chronic Occlusive Disease

Risk Factors
• Smoking
• Atherosclerosis

Symptoms
• Bilateral claudication
• Impotence
• Distal leg pulse maybe absent
• Weak femoral pulses
# Abdominal Anatomy

## Acute Occlusive Disease
- Embolism
- Trauma
- Thrombosis
  - Secondary to atherosclerosis
  - Aneurysm
- Dissection
- Extrinsic compression

## Symptoms
- Sudden onset of bilateral lower extremity rest pain
- Absent pulses
- Cool and mottled skin
- Motor-Neurologic deficits
Abdominal Anatomy

**Treatment**
- Surgery
- IR
- Thrombectomy
- Thrombolysis
- Stenting
Abdominal Anatomy

• Weakening in all three layers of the aortic wall, which causes an increase in diameter size at the area of weakness

• Suprarenal Aortic Aneurysm
  • 7-12%

• Infrarenal Aortic Aneurysm
  • 20% extend into the common Iliac arteries
Abdominal Anatomy

**Causes**
- Degeneration (atherosclerosis-associated)
  - 90% AAA
- Inflammation
- Infection (Mycotic aneurysm)
- Trauma
- Connective tissue disorders
- Vasculitis
- Congenital disorders

**Risks**
- Rupture
- Embolus
Abdominal Anatomy

**Infrarenal Aneurysm**

- Monitor
- Surgery
- EVAR
Abdominal Anatomy

Suprarenal Aneurysm

Treatment
• Surgery
• EVAR
Abdominal Anatomy

**Advantages**
- Decreased Blood Loss
- Morbidity
- Mortality
- Shorter Hospital Stay
- Quicker Recovery
## Abdominal Anatomy

### EVAR Criteria

**Proximal Neck**
- Diameter at the renal arteries
  - 18-28 mm
- Length of Proximal neck
  - Greater than 15 mm
- Disease at proximal neck
  - Thrombus
  - Atheroma
  - Calcification

### Aneurysm
- Diameter
- Maximum aneurysm diameter
- Diameter at the bifurcation
- Length
- Angulation
  - Less than 60 degrees
Abdominal Anatomy

- **Common Iliacs**
  - Diameter greater than 7.5 mm
  - Landing length greater than 20 mm
  - Diameter less than 20 mm
  - Tortuosity

- **External Iliacs**
  - Diameter greater than 7 mm
  - Angulation and disease
  - Common femoral diameter
Abdominal Anatomy

**Endoleak**

Types:
- **I**: Attachment areas
  - Need immediate treatment
- **II**: Retrograde branch flow into the aortic sac
  - Most Common
  - Sites: SMA-IMA, Ileolumbar-lumbar
  - Often requires embolization
- **III**: Device deterioration
- **IV**: Graft Porosity
Abdominal Anatomy

Type I Endoleak

Treatment

• Aortic Cuff
• Bare Stent
  • Palmaz
• Embolization
  • Percutaneous
  • Translumbar
Abdominal Anatomy

Type II Endoleak

Treatment

- Coils
- Liquids
  - Cyanoacrylate
  - Onyx
  - Thrombin
  - Sclerosing agent
Abdominal Anatomy
Abdominal Anatomy

**Complications**

- Graft limb thrombosis
  - Lytic therapy
  - Bypass surgery
- Device Migration
- Angulation
- Kinks

**Less common:**

- Aortoenteric fistula
- Bleeding
- Infection
- Rupture
Mesenteric Anatomy

**Superior Mesenteric Vein**
- Small Intestine, cecum, ascending colon, and transverse colon all empty into the main SMV

**Inferior Mesenteric Vein**
- Normally enters the splenic vein prior to the splenic and SMV joining together
- Drains the descending colon, sigmoid, and rectum

**Main Portal Vein**
- It bifurcates into the left and right portal vein, which branch out to the different segments of the liver
Portal Vein

- Main Portal Vein
- Inflow from Splenic Vein
- SMV
- Jejunal Veins
Mesenteric Anatomy (Venous)

**Indications for imaging**

- Bleeding
- Varices
- Portal Hypertension
IVC

• Carries deoxygenated blood from the lower half of the body to the right atrium

• Located posteriorly in the abdominal cavity, on the right side of the spine

• Formed by the joining of the left and right iliac veins
IVC

Anatomy

• Hepatic veins
• Inferior phrenic vein
• Renal veins
• Right gonadal vein
• Lumbar veins
• Common iliac veins

Corresponding landmark

• T8
• L1
• L1
• L2
• L1-L5
• L5
Inferior vena cava

Left common iliac vein
Inflow from hepatic veins

Renal veins

Inferior vena cava
Urinary System

The organ system that produces, stores, and eliminates urine.

Includes:

• kidneys
• ureters
• bladder
• urethra
Urinary System

**KIDNEYS**

- Located in the retroperitoneum.
- The superior border of the right kidney is adjacent to the liver.
- Superior border of the left kidney is adjacent to the spleen.
- The kidney is approximately 11–14 cm in length, 6 cm wide and 4 cm thick.
- Upper portion: T12
- Lower portion: L3
Urinary System

• Produces hormones

• Filters blood and diverts waste and foreign substances to the bladder for excretion from the body.

• Regulates:
  • Blood ionic composition
  • Blood pH
  • Blood volume
  • Blood pressure
  • Blood osmolality
  • Blood glucose level
Urinary System

• The parenchyma of the kidney is divided into two major structures:
  • Superficial is the renal cortex
  • Deep is the renal medulla
Urinary System

**Nephron**
- Glomerular (Bowman’s) Capsule
  - Filters water and solutes in the blood
- Proximal convoluted tubule
  - Reabsorption and secretion
- Descending limb
- Loop of Henle
- Ascending limb
- Distal convoluted tubule
Urinary System

• Collecting ducts pass into the pyramids
• The tip of each pyramid empties urine into a minor calyx
• Minor calyces empty into major calyces
• Major calyces empty into the renal pelvis
• Ureter
Urinary System

• Peristaltic contractions
• Hydrostatic pressure
• Gravity
Urinary System

• The ureteropelvic junction (UPJ) is the junction between the ureter and the renal pelvis of the kidney.

• The uretovesical junction (UVJ) is located where the ureter meets the bladder.

• Three areas of narrowing:
  • UPJ
  • Crosses the Iliac artery
  • UVJ
Renal Disease

**Acute Renal Failure**

Sudden, severe loss of renal function.

- Obstruction of urinary outflow tract
- Renal ischemia
- Acute inflammation of glomeruli
- Decrease in cardiac output
- Trauma
Renal Disease

**Chronic Renal Failure**
- Medication
- Diabetes
- Renal Ischemia
- Trauma
- Progressive kidney disease

**Staged:**
- Stage 1: Diminished renal reserve
- Stage 2: Renal insufficiency
- Stage 3: Renal failure (Uremia)
Renal Disease

- Pyelonephritis
- Polycystic disease
- Hydronephrosis
  - Stones
  - Extrinsic compression
  - Tumors
Percutaneous Nephrostomy

**Indications**
- Progressive kidney disease
- Hydronephrosis
- Stricture dilatation or Stenting
- Fistula Diversion
- Surgery
- Stone Extraction
  - Litho

**Contraindications**
- Coagulation
- Contrast allergy
## Percutaneous Nephrostomy

### Inventory
- Access needle
- Access kit
- Dilators
- Stiff wire
- Neph tube
- Contrast

### Access

### PCN Site
- Medial to the posterior axillary line
- 2-3cm below the 12th rib

### Techniques
- “Down the Barrel”
- Ultrasound
Percutaneous Nephrostomy

Complications
- Bleeding
- Infection
- Pneumothorax
- Hydrothorax
- Contrast Reaction

Occlusion
- Caused by uncontrolled urinary infections
- Patients with tendencies for stone development
- Pregnancy

Displacement
- Techniques
Percutaneous Nephrostomy

**Patient Management**

- Patient education
- Dressing management
- Check for kinking
- Signs of obstruction
- Changed 4-8 weeks
Double J Stent

**Indications**

- Malignant ureteral obstructions
- Benign strictures in poor operative patients
- Failed attempt by urology
Double J Stent

**Inventory**

- PCN
- Inventory required to cross the stenosis
- Balloons
- Marking catheter or wire
- Internal Stent
Nephroureteral stent

**Indications**

• Internal to external stent

• Ability to easily change if tube becomes occluded or infected

• Come in a variety of diameters and lengths
Nephroureteral Stent

**Inventory**

- PCN
- Inventory required to cross the stenosis
- Balloons
- Marking catheter or wire
- Nephroureteral Stent
Percutaneous Lithotripsy

**Indications**
- Staghorn Calculi
- Cysteine stones
- Infected Stones
- Obesity
Percutaneous Lithotripsy

**Inventory**
- PCN
- Catheters
- Wires
- Balloon
- Renal conduit

**Procedure**
- Lower pole calyx is usually chosen for pelvic stones, upper calyces stones, and stones involving multiple calyces
- Anterior stone are difficult to reach even with a flexible endoscope
- Peripheral Stones may be punctured directly
Whitaker Test

• An invasive procedure that measures the pressure in the kidney and bladder to determine whether or not a significant obstruction is present

**Indications**

• Residual narrowing after treatment of ureteral strictures
• Subtle obstructions that are difficult to visualize
• Previous pyeloplasty, ureteral reimplantation, or reflux
Renal Arteries

- One main renal artery per kidney
- L1-L2 interspace
- Left originates lateral and posterior
- Right originates lateral and anterior

**Views**
- 15 degree LAO for origin
- 30 degree ipsilateral oblique for parenchymal branches

**Injection**
3-5ccs for a total volume of 12-20

**Film rate**
- 2-6 frames per second
Renal Artery Stenosis

**Causes**
- Atherosclerotic disease
- Fibromuscular disease
- Dissection
- Vasospasm
- Vasculitis
- Extrinsic compression
- Congenital diseases

**Symptoms**
- Elevated blood pressure
- Decreased renal function
Renal Artery Stenosis

**Diagnostic Inventory**
- Flush catheters
- Selective wires
- Visceral catheters
- Pressure transducers
- Guidecath
- Sheath

**Interventional Inventory**
- Balloons
- Stents
# Renal Artery Stenosis

<table>
<thead>
<tr>
<th><strong>Contraindications</strong></th>
<th><strong>Complications</strong></th>
</tr>
</thead>
<tbody>
<tr>
<td>• Contrast</td>
<td>• Contrast reaction</td>
</tr>
<tr>
<td>• Coagulation factors</td>
<td>• Contrast induced renal failure</td>
</tr>
<tr>
<td>• Renal function</td>
<td>• Thrombosis</td>
</tr>
<tr>
<td></td>
<td>• Emboli</td>
</tr>
<tr>
<td></td>
<td>• Perforation</td>
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<td>• Access site complications</td>
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</tbody>
</table>
Renal Artery Stenosis

Atherosclerosis

• Most common cause of renal artery stenosis
• 30-50% the lesions are bilateral
• Treatment
  • PTA
  • Stenting
Renal Artery Stenosis

- **Fibromuscular dysplasia (FMD)**
  - Usually occurs in females over the age of 30
  - Not localized to the renal artery
  - “String of pearls”
- Treatment
  - Balloon
Renal Arteriogram

**Blunt trauma**
- 60-70% of renal trauma
- Evaluate with CT

**Penetrating Trauma**
- Medical Related
  - Biopsy
  - Drainage
- Non Medical
  - GSW
  - Stabbing
Renal Arteriogram

Inventory

• Diagnostic inventory
• Microcatheters
• Embolization materials
  • PVA
  • Coils
  • Gelfoam
Transplant Renal

- Therapy for ESRD
- Located in pelvis
- Most commonly anastomosed to the external iliac
Transplant Renal

**Indications**
- Renal Artery Thrombosis
- Hypertension
- Clamp injury
- Plaque
- Kinking
- Periarterial fibrosis
- Arterial-venous Fistulas
- Aneurysms
- Pseudoaneurysms
- Renal Failure
Transplant Renal

**Inventory**
- Diagnostic inventory
- Pressure transducers
- Minimize profile

**Procedure**
- Minimize contrast
- Adequately profile origin
Renal Veins

**Left Renal Vein**
- Longer than the right due to the aorta
- Anterior to Aorta and Inferior to the SMA
- Left gonadal vein
- Left inferior phrenic vein
Renal Veins

**Right Renal Vein**

• Right renal vein empties directly into the IVC.
• Right gonadal vein empties directly into IVC
• Right Adrenal vein empties directly into IVC
Renal Veins

Circumaortic Renal Vein
• Variant Anatomy of the Left Kidney
Renal Vein

**Nutcracker Phenomenon**

- Left renal vein is compressed between the SMA and aorta
- Can result in renal vein varices
- Causes gonadal vein distention and pelvic varices
Nutcracker Phenomenon

**Symptoms**

- Flank pain
- Hematuria

**Treatment**

- Gonadal Vein embolization
- PTA
- Stenting
Renal Vein

**Pelvic Congestion Syndrome**

Occurs in the presence of varicose veins in the lower abdomen

**Causes**

- Pregnancy
- Polycystic ovaries
- Hormonal disorders
Renal Vein

**Symptoms**

• Chronic pelvic pain
• Abnormal bleeding
• Varicosities

**Treatment**

• Gonadal vein embolization
The Liver

• Largest internal organ

• Located in the right upper quadrant

• Extends from the 5th intercostal space to the lower margin of the ribs
The Liver

Functions:

• Vascular functions including formation of lymph and the hepatic phagocytic system.

• Metabolic achievements include the synthesis and utilization of carbohydrates, lipids and proteins.

• Secretory and excretory functions, particularly with respect to the synthesis of secretion of bile
The Liver

• Two principle lobes, the right and left lobes.
• The two smaller lobes are the caudate and quadrate lobes
• **Porta Hepatis**: fissure where the portal vein, hepatic artery enter the liver and the bile ducts exit
The Liver

- The liver is unique because it has two blood supplies
  - Come together in the sinusoids
- The arterial blood supplies 25%
- The portal system supplies 75%
The Liver

• There are eight functionally independent segments
• Each segment has its own vascular inflow, outflow and biliary drainage
The Liver

• Lobule: functional unit of the liver

• Consists of masses of liver cells arranged around a central vein that is a terminal branch of one of the hepatic veins.
The Liver

PORTAL TRIAD

• A component of the hepatic lobule, it consists of the following structures:
  • hepatic artery
  • hepatic portal vein
  • common bile duct
The Liver

**Sinusoids**

- Low pressure vascular channels
- Receive blood from terminal branches of the hepatic artery and portal vein at the periphery of lobules
- Deliver it into central veins
The Liver

Biliary System

- The biliary system is a series of channels and ducts that conveys bile from the liver into the lumen of the small intestine
- Bile is first secreted from the liver cells and it passes into tiny biliary caniculi
The Liver

• Right before the CBD enters the duodenum, the pancreatic duct (duct of Wirsung) and the CBD join at the Ampulla of Vater

• The flow of bile is regulated by the sphincter of Oddi
The Liver

Gallbladder

- A pear shaped structure attached to the ventral surface of the liver
- Stores bile between meals
- Concentrates bile by reabsorbing water
- Releases bile into the small intestines
- Attaches itself to the liver by connective tissue
Hepatocellular Carcinoma (HCC)

- Malignant tumor that develops at the hepatocellular level

Risk Factors:
- Alcoholic cirrhosis
- Viral hepatitis
- Metabolic liver disease
- Vascular invasion is common
- Biliary system usually doesn’t become involved
Hepatitis

• Inflammation of the liver cells.
• Caused or transmitted by
  • Alcohol
  • Bacteria parasite
  • Contaminated drinking water
• Hepatitis A
• Hepatitis B
• Hepatitis C
• Hepatitis D
• Hepatitis E
Nonalcoholic Steatohepatitis (NASH)

• Fat builds up in the liver eventually causing scar tissue.

• NASH appears to be associated with:
  • Diabetes
  • Protein malnutrition
  • Obesity
  • Coronary artery disease

• Treatment:
  • Corticosteroid medications
Cirrhosis

• Scar tissue replaces normal healthy tissue

• Risk Factors:
  • Chronic alcoholism
  • Hepatitis C
Budd-Chiari Syndrome

Thrombosis of the hepatic vein

Treatment:
- PTA
- Thrombolysis
- Mechanical Thrombectomy

Risk Factors:
- Most common in postpartum females
- Maligancy
- Hepatomegaly secondary to vascular congestion
Biliary Atresia

• Congenital condition that occurs when bile flow from the liver to the gallbladder is blocked.
• Results in liver damage, cirrhosis, and finally liver failure.

**Symptoms:**
• Jaundice
• Dark Urine
• Weight loss and irritability
• Treated with transplant
Primary Biliary Cirrhosis

- Liver disease that slowly destroys the bile ducts in the liver
- The disease affects women more often than men
- Usually occurs between the ages of 30 and 60 years
- Suggested as an immune system disorder
Primary Sclerosing Cholangitis

- Inflammation and scarring of bile ducts
- Bile builds up in the liver and damages liver cells
- Eventually causing liver failure
- PSC appears to be associated with ulcerative colitis
Secondary Sclerosing Cholangitis

- Biliary atresia present
- Intra ductal stones
- Blunt trauma
- Intra arterial chemo
- Pancreatitis
Transjugular Intrahepatic Portal Shunt

- TIPS allows for decompression of portal pressure through the creation of a conduit from the portal to hepatic veins
Transjugular Intrahepatic Portal Shunt

**Indications**

- Failed medical therapy
- Refractory ascites
- Mallory-Weiss syndrome
- Portal hypertension
- Budd Chiari Syndrome
## Transjugular Intrahepatic Portal Shunt

### Absolute
- CHF with right heart failure
- Severe pulmonary hypertension
- Hepatic encephalopathy

### Relative
- Portal vein thrombosis
- Significant pressure gradient between the hepatic vein and the right atrium
- Moderate pulmonary hypertension
Transjugular Intrahepatic Portal Shunt

- Access
- Catheterize hepatic vein
- Pressures
  - Wedge
  - Occlusion balloon
Transjugular Intrahepatic Portal Shunt

- Tract is balloon dilated
- Sizing run is used to select appropriate stent
Transjugular Intrahepatic Portal Shunt

- Repeat pressures
- Post run
  - Stent placement
  - Flow
  - Varices
Transjugular Intrahepatic Portal Shunt
Transjugular Intrahepatic Portal Shunt

- New or worsening encephalopathy
- Bleeding complication from puncture site or misdirected portal vein puncture
- Hepatic vein stenosis resulting in stent thrombosis
- Stent closing off due to exposed liver parenchyma being left unstented
- Hemobilia
- Renal failure
- Infections
- Heart damage
Percutaneous Transhepatic Cholangiogram

**Indications**

- Evaluate the biliary ductal system
- Obstruction
- Pre-procedure to a biliary decompression or stone extraction
- To determine the site of a bile leak
- To evaluate after a failed ERCP
- Surgical stricture from a transplant or reconstructive surgery
- Jaundice
Percutaneous Transhepatic Cholangiogram

**Puncture Site Planning**

- The puncture site is planned 2-3 cm anterior to the mid-axillary line
- Two intercostal spaces below costophrenic angles
- The puncture is made in the lower half of the rib space
Percutaneous Transhepatic Cholangiogram
Percutaneous Transhepatic Cholangiogram

• Opacify the biliary tree
• Evaluate the need for a biliary decompression procedure
• Left sided puncture may be needed
Percutaneous Transhepatic Cholangiogram

**Left Sided Puncture**

- Punctured under the xiphoid process
- Angled 30-40 degrees to the right transverse plane
- The needle is advanced under inspiration
- The left ducts run anterior along a straight horizontal course
21G Trocar needle

22G Chiba needle

0.018 wire
### Percutaneous Transhepatic Cholangiogram

<table>
<thead>
<tr>
<th>Complications</th>
<th>Delayed complications</th>
</tr>
</thead>
<tbody>
<tr>
<td>• Pericatheter leaking</td>
<td>• Cholangitis can occur if initial tube is to small</td>
</tr>
<tr>
<td>• Hemorrhage</td>
<td>• Catheter dislodgement</td>
</tr>
<tr>
<td>• Septic shock</td>
<td>• Peritonitis</td>
</tr>
<tr>
<td>• Pancreatitis</td>
<td>• Biliopleural fistula</td>
</tr>
<tr>
<td>• Pneumothorax</td>
<td>• Skin infections</td>
</tr>
<tr>
<td>• Contrast reaction</td>
<td></td>
</tr>
</tbody>
</table>

- [Percutaneous Transhepatic Cholangiogram](#)
Endobiliary Stenting

**Indications**

- Anastomotic site stricture
- Sclerosing cholangitis
- Failed balloon dilatation
- Progression of fibrosis
- Persistent benign strictures
- Palliative care
Endobiliary Stenting

- PTC
- Evaluate the ducts and lesion
- Exchange the tube for a delivery sheath
Endobiliary Stenting

- Proximal stent positioned about 2-3cm above lesion
- Distal end is in the duodenum well across the ampulla or clearly in the ductal system
- May leave a safety catheter in place
Endobiliary Stenting

**Complications**

- Same as a PTC
- Migration
- Occlusion of stent
Percutaneous Cholecystostomy

- Drainage of purulent materials in patients who are poor surgical candidates
- Patients with unexplained sepsis where all other sites have been eliminated
- As a conduit through which lithotripsy or chemical gallstone dissolution can be performed
Percutaneous Cholecystostomy

Contraindications

• A gallbladder so packed with stones where a catheter may be difficult or impossible to pass

• Contrast allergy

• Uncooperative patient
Percutaneous Cholecystostomy

• Preferred entry is through the liver so if leakage occurs it is extraperitoneal

• After the gallbladder is punctured contrast is injected to confirm location
Percutaneous Cholecystostomy

Complications

• Bile leakage
• Hemobilia
• Catheter dislodgement
Pelvic Anatomy

Common Iliac Artery
- Iliac bifurcation occurs at L4
  - Internal (Hypogastric)
  - External

View
- 30 degree contralateral oblique

Injection
- 10cc’s per second for a total of 20cc’s

Frame Rate
- 2 frames per second
Pelvic Anatomy

**Internal Iliac (Hypogastric)**

- **Anterior:**
  - Vescicular, Internal pudendal, obturator, inferior gluteal arteries
  - Others: Middle Rectal, Uterine

- **Posterior:**
  - Lateral sacral, and superior gluteal

**View**
- 40 degree ipsilateral oblique

**Injection**
- 4cc’s per second for a total volume of 12cc’s

**Frame Rate**
- 2 frames a second
A: Iliolumbar Artery
B: Superior Gluteal
C: Inferior Gluteal
D: Inferior Pudendal
E: Opturator
F: Vescicular Branches
Pelvic Anatomy

**External Iliac**

- Inferior epigastric artery
- Deep circumflex iliac artery
Lower Extremity Anatomy

**Common Femoral Artery**
- Superficial femoral artery
- Deep femoral artery (Profunda)

**View**
- 30 degree ipsilateral oblique

**Injection**
- 3cc’s a second for a total volume of 9cc’s

**Frame Rate**
- 2 frames per second
A: Common Femoral Artery
B: Superficial Femoral Artery
C: Profunda
Common Femoral Artery Access

- Allows for compression post procedure
- Common femoral bifurcation occurs on the lower 1/3 of the femoral head
- Puncture above bifurcation
- Below inguinal ligament
### Lower Extremity Anatomy

<table>
<thead>
<tr>
<th>Deep femoral artery (Profunda)</th>
<th>Superficial femoral artery</th>
</tr>
</thead>
<tbody>
<tr>
<td>• Runs anteriolateral in the thigh</td>
<td>• Runs anteriomedial in the thigh</td>
</tr>
<tr>
<td>• Supplies</td>
<td>• SFA passes through the adductor canal and becomes the popliteal artery</td>
</tr>
<tr>
<td>• Quadriceps</td>
<td></td>
</tr>
<tr>
<td>• Adductors</td>
<td></td>
</tr>
<tr>
<td>• Hamstrings</td>
<td></td>
</tr>
</tbody>
</table>
A: Superficial femoral artery
B: Level of Adductor Canal
C: Popliteal artery
Lower Extremity Anatomy

**Popliteal artery**

- Continuation of the SFA through the popliteal fossa
- Lies posterior to the femur and deep to the vein
- Major branches
  - Sural Arteries
  - Geniculate Arteries

**View**

- AP

**Injection**

- 3cc’s a second for a total of 12cc’s

**Frame Rate**

- 2 frames per second
Lower Extremity Anatomy

**Anterior tibial artery**
- Originates laterally and runs in front of the lower tibia
- Crosses the ankle onto the dorsum of the foot
- Terminates as the dorsalalis pedis (DP) artery

**Tibioperoneal trunk**
- Direct continuation of the popliteal
- Bifurcates into the posterior tibial artery (PT) and peroneal
Lower Extremity Anatomy

**Posterior tibial artery**
- Runs posterior and medial to the flexor compartment
- Passes behind the Medial Malleolus
- Divides into the medial and lateral plantar arteries
- Plantar arch is formed by the lateral plantar artery

**Peroneal**
- Runs between the anterior and posterior tibial arteries
- May provide collateral circulation when the primary tibials are occluded
A: Popliteal Artery
B: Genicular
C: Tibioperoneal Trunk
D: Posterior Tibial
E: Peroneal
F: Anterior Tibial
A: Anterior Tibial
B: Posterior Tibial
C: Peroneal
D: Dorsalalis Pedis
E: Deep Plantar Arch
## Lower Extremity Anatomy

### Indications
- Atherosclerosis
  - Stenosis
  - Occlusion
- Thrombus
- Embolus
- AV Fistulas
- Aneurysms

### Treatment
- PTA
- Stent
- Atherectomy
- Thrombectomy
- Embolectomy
- Surgery
# Lower Extremity Anatomy

## Symptoms
- Claudication
- Rest pain
- Non-healing ulcers
- Limb ischemia

## Five “P”’s of Assessment
- Pain
- Pallor
- Pulse
- Poikilothermia ("coldness")
- Paralysis
## Lower Extremity Anatomy

<table>
<thead>
<tr>
<th>Indications</th>
<th>Relative Contraindications</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pressure gradient greater than 10mm Hg</td>
<td>Long segment</td>
</tr>
<tr>
<td>Lifestyle-limiting claudication</td>
<td>Multifocal stenosis</td>
</tr>
<tr>
<td>Chronic leg ischemia</td>
<td>Multifocal stenosis with infrapopliteal disease</td>
</tr>
<tr>
<td>Increase in or outflow prior to or after bypass surgery</td>
<td>Occlusion</td>
</tr>
<tr>
<td>Bypass graft stenosis</td>
<td>Heavy calcified eccentric lesions</td>
</tr>
<tr>
<td>Amputation</td>
<td>Lesions involving essential collateral vessel</td>
</tr>
</tbody>
</table>
Lower Extremity Anatomy

**Complications**

- Vasospasm
- Dissection
- Pseudoaneurysm
- Distal Emboli
- Rupture
Lower Extremity Anatomy

**Stents**

**Indications**

- Failed angioplasty
- Elastic Recoil
- Flow limiting dissection
- Aneurysms
- AV Fistulas
- Risk of Emboli
- Restenosis
## Lower Extremity Anatomy

### Atherectomy

#### Indications
- Eccentric, bulky, ulcerated lesion
- Short occlusion
- Instent stenosis

#### Contraindications
- Long Occlusions
- Diffuse, stenotic lesions
Lower Extremity Anatomy

Complications

- Distal emboli
- Dissection
- Acute vessel occlusion
- Vessel perforation
- Pseudoaneurysm
- Site complications
# Acute Lower Extremity Ischemia

## Symptoms
- Pain
- Progressive motor dysfunction
- Paresthesia
- Tissue Infarction
  - Cell death after 4 hours
  - Irreversible after 6 hours

## Treatment
- Medical
  - Anticoagulation
- Thrombolysis
- Thrombectomy
- Thromboaspiration
Acute Lower Extremity Ischemia

**Risks**

- Embolus
- Trauma
- Dissection
- Vasculitis
- Extrinsic Compression
- Microemboli
Thrombolysis

**Indications**
- Thrombotic or Embolic occlusions

**Absolute Contraindications**
- Active or recent bleeding
- Irreversible limb ischemia
  - Severe sensorimotor deficits
  - Muscle rigor
- Recent Stroke
- Intracranial neoplasm
- Left heart thrombus
Thrombolysis

**Relative Contraindications**
- History of GI Bleed
- Recent Surgery
- Recent Trauma
- Recent CPR
- Uncontrolled Hypertension
- Emboli from heart
- Coagulopathy
- Pregnancy or postpartum
- Severe Cerebrovascular disease
Thrombolysis

- Available ICU Bed
- Vitals signs
- Monitored
- Fluid overload
- Renal failure
- Bleeding
- Pulses: Doppler

Labs

- Hematocrit
- PTT
- Fibrinogen level
- Lytic check 4-12 Hours
- Hematocrit
- PTT
Thrombolysis

Complications

• Bleeding
• Limb complications
• Systemic complications
• Death
Thrombectomy

• Immediate thrombus debulking
• Decreases dose and duration of lytics
• Minimally invasive
Thrombectomy

**Fogarty Balloon**
- Compliant balloon
- Allows for the mechanical retrieval of clot under local anesthesia
Thromboaspiration

- Non-tapered catheters
- Specifically designed
Lower Extremity Venous Anatomy

Superficial System

• Lesser Saphenous Vein
  • Lateral
  • Ankle to popliteal vein

• Greater Saphenous Vein
  • Medial
  • Ankle to common femoral vein
Lower Extremity Venous Anatomy

**Deep System**
- Tibial and Peroneal Veins
  - Paired
- Popliteal Vein
- Superficial Femoral Vein
- Deep Femoral Vein
- Common Femoral Vein
- External Iliac Vein
- Internal Iliac Vein
- Common Iliac Vein
- Inferior Vena Cava
Lower Extremity Venous Anatomy

- Blood flows from the superficial to the deep veins
- Perforating veins
- Incompetent Perforators
  - Can result in high pressure in the superficial veins and varicosities
## Ascending Venogram

### Indication
- DVT
- Evaluation of venous malformations
- Road map for pre-surgical vein harvesting

### Relative Contraindications
- Pregnancy
- Patients with severely compromised cardiopulmonary status
Ascending Venogram

- Puncture Site
  - Access as medially and distally as possible
- Apply tourniquets above the ankle and knee
- Tilt table

**Imaging**

- Follow bolus of contrast from ankle to IVC
  - Image in two projections
  - AP and External Oblique
- IVC image
  - Compress Common Femoral Vein
  - Lower table to horizontal position
  - Elevate leg as you image IVC
Ascending Venogram

**Complications**

- Infection
- Post venography thrombophlebitis
- Extravasation
Lower Extremity Venous Anatomy

Deep Vein Thrombosis

• Formation of thrombus in a deep vein

• Risks
  • Pulmonary Embolus
  • Chronic Venous Insufficiency
Lower Extremity Venous Anatomy

**Symptoms**
- Swelling
- Pain or tenderness
- Feeling of increased warmth in the leg
- Redness or discoloration
- Enlargement of superficial leg veins

**Risk Factors**
- Immobility
- Hospitalization
- Surgery
- Obesity
- Pill or Estrogen therapy
- Health: Varicose Veins, blood disorders, etc.
Ascending Venogram

Deep Vein Thrombosis Treatment

• Medically
• Thrombolysis
• Mechanical thrombectomy
• IVC filter placement
Lower Extremity Venous Anatomy

May Thurner

• Right Common Iliac Artery compresses the Left Common Iliac Vein

• Causes intimal webs or banding that can lead to thrombosis

• Usually occurs in young female patients between ages 20-40s
Lower Extremity Venous Anatomy

**Treatment**

- Surgery
- Thrombolysis
- Mechanical Thrombectomy
- Stent
- PTA
Lower Extremity Venous Anatomy

Chronic Venous Insufficiency

• Caused by high venous pressures from either DVT or phlebitis
• Occluded blood flow results in pooling and back flow damaging the valves
Lower Extremity Venous Anatomy

**Symptoms**
- Similar to DVT
- Varicose veins
- Skin ulcers
- Scaling skin

**Treatment**
- Compression stockings
- Exercise
- Ablation
- Sclerotherapy
- PTA
- Stenting
- Surgery
IVC Filter

• Designed to prevent life threatening PE
• Recommended for high risk scenarios
Retrievable Caval Filters

**Indications for Use**

- Prophylaxis
- Surgery
- Trauma
- Documented PE or DVT
- As a protection device prior to or during thrombolysis
- Transient contraindication to coagulation
Non-Retrievable Caval Filters

Indications for Use

• Elderly patients with known PE
• Patients with chronic DVT and or PE
• Patients that can not receive anticoagulation therapy
• Patients with “megacavas”
Filter Placement

- **Cavagram**
  - Marker pigtail
  - Visualize from right atrium to iliac bifurcation
  - Caval diameter
  - Renal location
  - Caval anomalies
  - Intrinsic disease

- **Injection**
  - 15cc’s for a total volume of 30cc’s

- **Rate**
  - 2 frames per second
## Filter Placement

### Complications
- Migration
- Fracture
- Perforation
- Filter thrombosis

### Ease of Retrieval
- Tilt
- Time

### Contraindication
- Clot within the filter