Angiography

- Angiography is the examination of the blood vessels after injection of a contrast medium.

Informed Consent

- Process of communication between a patient and physician that results in the patient's authorization or agreement to undergo a specific medical intervention.
- Information is provided to the patient regarding the procedure and the patient makes an “informed” decision regarding their care.
Informed Consent should include:

- The patient's diagnosis, if known
- The nature and purpose of a proposed treatment or procedure
- The risks and benefits of a proposed treatment or procedure
- Alternatives (regardless of their cost or the extent to which the treatment options are covered by health insurance)

Informed Consent should include:

- The risks and benefits of the alternative treatment or procedure
- The risks and benefits of not receiving or undergoing a treatment or procedure

Prior to scheduling procedure

- History related to procedure
- Status of renal function
  - BUN, Creatinine
- Verification of clotting status
  - PT, PTT, INR
- Prior contrast media reactions
Normal Lab Ranges

• BUN
  – Blood Urea Nitrogen
  – 7-20 mg/dl
• Creatinine
  – 0.6 to 1.2 mg/dl in adult males
  – 0.5 to 1.1 mg/dl in adult females

Normal Lab Ranges

• PT
  – Time it takes plasma to clot after addition of tissue factor (obtained from animals)
  – Normal is 12-15 seconds
• INR
  – International normalized ratio
  – Normal is 0.8-1.2

Sterile Field

• Involves many facets:
  – Patient preparation
  – Preparation of sterile tray
  – Maintenance of sterile field
  – Surgical scrub of personnel
Sterile Field

- A microorganism-free area which can receive sterile supplies
- Maintenance of sterility:
  - Place sterile drape to cover all of table
  - Confirm sterility of supply
    - Date of sterilization process
    - Date of expiration of sterility
    - Package is intact and dry

Rules of Sterile Field

- Only verified sterile items are placed on sterile field
- If you think it’s contaminated—it is
- Sterile field must be monitored at all times
- Setup trays as close to procedures as possible
- Only sterile persons can touch sterile field

Rules of Sterile Field

- Below the level of the tabletop or the waist is considered unsterile
- Gowns are sterile on sleeves and the front above the waist
  - The back of the gown and below waist level are considered nonsterile
- Do not reach across sterile field if you are not sterile
Only dry supplies are considered sterile unless table field is covered with protective backing to prevent “wicking”
Redrape or remove potentially contaminated areas
Sterile gloves are to be kept above the waist and visible at all times

Prep of Patient Area
Shave or clip hair from area of procedure if needed wearing examination gloves
Wearing sterile gloves:
- Cleanse area of interest with solution of choice
  - Circle vs. linear?
- Place sterile drape over examination area maintaining sterility of drape and prepped area
The Surgical Scrub

• Hands should be washed prior to donning of sterile gloves
• Reasons for surgical scrub:
  – Remove debris and microorganisms from hands, nails and forearms
  – Reduce microbial count of skin to an absolute minimum
  – Inhibit rebound growth of microbes

Surgical Scrub

• Can involve soap, water, nail brush and/or mild germicidal solution
• Remove all jewelry prior to scrubbing in
  – Reduces risk of microbes in jewelry
  – Reduces risk of jewelry tearing sterile gloves during case

Types of Precautions

• Standard (formerly Universal)
  – Used when in contact with blood, bodily fluids, secretions, excretions, mucous membranes, nonintact skin
  – Also items soiled or contaminated with these substances
• Transmission-based (additional)
  – Isolation techniques
Tools of Standard Precautions

- Hand washing
- Gloving
- Personal Protective Equipment (PPE)
- Avoidance of recapping
- Appropriate clean-up of biospills

Basic IV Therapy

- Intravenous Lines
  - Allow rapid access to patient’s circulatory system to administration of medications
  - Are vital in the event an emergency occurs
  - Administration of fluids and electrolytes
    - Most commonly used are normal saline and 5% dextrose in water
  - Allow for administration of contrast media during procedure if needed

Venipuncture Methods

- Butterfly set
  - Used for direct injections with syringe
  - Not as commonly used as Angiocath
- IV catheter or Angiocath
  - Allows for infusion of large amounts of fluids and/or medications
  - Typically connected to IV fluids with continuous slow drip
Basic Venipuncture

• Most commonly utilized sites are:
  – Anterior forearm
  – Posterior hand
  – Radial aspect of wrist
  – Antecubital space

Vein Selection

• Ideal vein is readily seen and felt
• Vein is at least 2X diameter of needle or Angiocath
• Vein is straight and does not visibly curve for the length of needle and/or catheter

Venipuncture Procedure

• Gather supplies and prep solutions
• Wash hands
• Verify patient ID
• Explain procedure
• Secure tourniquet around arm above elbow
• Have patient open/close fist to distend veins then hold their fist closed
Venipuncture Procedure

• Cleanse skin with alcohol or Povidone-iodine in circular motion about a 2” radius
• Put on gloves
• Anchor vein to prevent movement
• Position access needle with bevel up
• Puncture skin at 20–45° angle quickly and then puncture vein

• Verify blood return, decrease needle angle and further introduce needle into vein
• Release tourniquet, attach IV tubing and verify proper flow
• Secure IV catheter or butterfly in place

Complications

• Extravasation (infiltration)
  – IV fluid or medication leaks into surrounding tissues outside of puncture site
• To prevent Extravasation:
  – Check for backflow
  – Secure the needle or catheter properly
  – Discontinue injection or IV fluid if patient feels discomfort or there is resistance to easy injection
Extravasation

Generator
- DSA generator allows short exposure ties
- Exposure times must be less than 33 milliseconds
  - Takes 33 milliseconds for computer to read an image

X-ray Tube
- Must be able to withstand high heat units due to rapid exposures during digital imaging
- Heat unit ranges of 400,000-800,000
Components of X-ray tube

- Housing
  - Prevents leakage of radiation out of tube
  - Prevents electric shock of operator
  - Mechanical support of x-ray tube
  - Protects inside of tube from damage

Components of the X-ray tube

- Cathode (-)
  - Filament
  - Focusing cup

- Anode (+)
  - Rotates
  - Focal spot or focus
The Image Intensifier (II)

• This device receives remnant or leftover radiation from the patient’s tissue
• The radiation energy is fed into a system which intensifies or improves the image
• This allows us to expose the patient to less radiation and produce a brighter, intensified image

The II

• Multiple options for field sizes
  – 14” field size will cover larger areas
Digital System

Digital Subtraction Angiography

- DSA
- Stores angiographic image and subtracts them real time
- Allows imaging up to 30 images/see
- Images can be manipulated by the radiographer or the physician
**Digital Imaging**

- The system functions at a range of 10-20 mA
- Subtracted imaged is processed as the imaging run is made
- Image from II converted from analog data to digital and processed for display and storage

**DSA**

- Data is received and converted from analog to digital format by analog-digital converter
- Image to converted into a matrix
  - Minimum of 512X512 matrix
- Each box or number in matrix is known as a pixel (picture element)

**Image Manipulation**

- Window and Level
  - Allows for manipulation of density and contrast of image
- Pixel shifting
  - Used to remove motion from the image
- Edge Enhancement
  - Enhances edges of vessels to smooth out the image for better detail
Image Manipulation

• Landmarking
  – A special fluoroscopic setting which allows MD to place landmarks on subtracted image
  – Allows for better catheter placement by superimposing vascular anatomy on mask image

Image Manipulation

• Road Mapping
  – Vascular region is injected with contrast media
  – Region with CM is superimposed over live fluoro image
  – Allows MD to follow tract of CM or vessel to place catheter tip more readily in selected vessel

Advantages of DSA

• Uses less CM than conventional imaging
  – Use half of CM in injection
  – CM diluted significantly with saline
• Images can be filmed to laser system or uploaded to PACS
• Images can be viewed during procedure and manipulated as needed
Automatic Pressure Injectors

- Components
  - Control Panel
  - Syringe
  - Heating device or blanket
  - High Pressure Mechanism

Flow Rate

- Delivery rate of contrast media for a set time parameter
- Injection rate is determined by:
  - Procedure being performed
  - Patient
  - Vessel diameter
  - Pathology
  - Catheter size

Other injector parameters

- Volume: total amount of CM to be infused
- Linear rise: time to reach the desired flow rate
- PSI (Pounds per inch²): pressure used to inject the CM
  - Catheter inner lumen
  - Vessel inner lumen
  - Potential pathology/obstruction
Catheters, Needles, Guidewires

Catheters

• Thin hollow tubes of different diameters used for the instillation of contrast media
• Vary in configuration or shape

Advantages of Using Catheters

• Reduces amount of CM used for procedure
• Ensures possibility of biopsy
• Ability to obtain pressures within vessel lumens
Flow Rate Factors

- Length and diameter of catheter
- French size
- Number of side holds
- Viscosity of CM
- Resistance outside of catheter
- Material catheter is made of

Catheter Size

- Outside diameter (OD) of catheter measured in French
- 1 French = .33 mm
- Ranges of sizes:
  - 3-6 French
    - Pediatrics
  - 4-7 French
    - Adults

Side Holes

- Reduces resistance to flow of CM
- Reduces catheter recoil
- Improves distribution of CM
- Used primarily in large vessels to deliver large bolus of CM
Catheter Shapes

- Four basis configurations:
  - Straight
  - Single curve
  - Multiple curve
  - Pigtail
- Shape determined by distal curve
  - Primary curve: closest to end or tip
  - Secondary curve: forces primary curve and assists with seating catheter into vessel

Catheter Categories

- Flush (Non Selective)
  - Delivers large bolus of CM into large vessel
  - Demonstrates gross anatomy
  - Numerous side holes at tip

Catheter Categories

- Selective
  - Designed for placement into smaller vessels
  - Usually has an end hole only at tip
Maintenance of Patency

- Catheters must be flushed every 2-3 minutes with heparinized saline
- Multi-side hole catheters clot more readily
- Flushing procedure:
  - Aspirate a small amount of blood into syringe
  - Flush forward with clean end of solution

Caution

- Catheters with no sideholes may not aspirate if against vessel wall
- Catheters which are not able to aspirate may be clotted and need to be removed
  - Do not forcefully flush a clotted catheter

Percutaneous Entry Needles

- Used for vascular access
Biopsy Needles

- Chiba
- Trocar
- Coaxial outer needle permits multiple biopsies with Quick-Core® needle through single access site.

Needle Components

- Classified by gauge and length
- Parts include:
  - Cannula
  - Hub
  - Base plate
  - Stylet
  - Obturator

CLOSURE DEVICES
**EVS Vascular Stapling System**

- Medtronic, Inc.
- 3 mm sheath
- Closure site location: femoral artery
- First system to use a staple to close arteriotomy

**EVS System**

- Following the procedure, a guidewire is reintroduced through the introducer and the introducer sheath is removed.
- The hole (arteriotomy) is then closed by advancing the EVSTM System over the guidewire through the skin and soft tissue into the arteriotomy.
- Once positioned, the dilator and guidewire are removed from the introducer and the stapler is advanced through the introducer and locked into place.
- The staple is deployed by squeezing the trigger and the device is removed.

**Closer S Suture-Mediated Closure**

- Abbott Vascular
- Braided polyester suture
- Sheath Size: 5-8 F access sites
ProStar

- Abbott Vascular
- 8 and 10 French Sheaths
- Sheath has a hydrophilic coating to facilitate insertion
- Standard .038" guide wire compatible
- Four Nitinol needles deployed from below the arteriotomy
- Two braided polyester sutures

Perclose ProGLide Suture Mediated Closure

- Abbott Vascular
- Polypropylene Monofilament suture
- 5-8 Fr sheath size
- No re-access restrictions if previous arteriotomy repairs were achieved w/Perclose Suture-Mediated Closure-devices

StarClose

- Abbott Vascular
- Nitinol clip instantly closes Arteriotomy with nothing left in vessel
- Used with 5 or 6 French sheath system
Mynx Vascular Closure System

- Water-soluble sealant that seals both the puncture site and the tissue tract
- Extravascular and leaves nothing behind inside the artery
- Preserves vessel integrity by eliminating sheath exchange
- Freeze dried polyethylene glycol

Mynx CVD

- Seals the arteriotomy using a conformable, water-soluble, extravascular sealant that rapidly expands in the tissue tract by absorbing blood and subcutaneous fluids
- As blood collects inside the sealant's matrix it clots, producing a durable hemostasis.
- The sealant dissolves within 30 days, leaving nothing behind but a healed artery

Mynx Procedure

- Mynx into the existing 6F or 7F procedural sheath and inflate a small semi-compliant balloon to create temporary hemostasis
- Deliver and unsleeve the sealant, exposing it to blood and subcutaneous fluids
**Mynx Procedure**

- Balloon deflated and device removed
- Sealant is left on surface of the arteriotomy
- Within 30 days the sealant is absorbed by the body

**Boomerang ClosureWire**

- The original arteriotomy (e.g., 8 Fr. OD for a 6 Fr. arterial sheath) is “down-sized” to diameter of Boomerang Wire (approximately a 20 gauge needle).
- Nitinol braided mesh disc
- Device creates a site-specific compression of both the arteriotomy and tract, unlike manual compression where general pressure is diffused across a broad area.
- Temporary placement of low-profile, conformable disc against the intima provides immediate hemostasis and secure seal in the cath lab in under 30 seconds.

**Duett System**

- Is the only sealing device to seal both the arteriotomy and the tissue tract with a flowable procoagulant
- Using a dual approach - a balloon catheter and procoagulant - the Duett sealing device is designed to rapidly and safely stop the bleeding
**Duett System**

- Seals the entire puncture site with a one-size-fits-all device that leaves nothing rigid behind which could interfere with re-access or potentiate an infection.
- Also used as an adjunct treatment in sealing residual oozing of tissue tracts of femoral access sites that have been previously closed by suture/collagen-based hemostatic devices.

**PTA**

- Percutaneous Transluminal Angioplasty
- Angiography is performed
- Hemodynamic pressures are measured before and after lesion

**PTA**

- Angioplasty balloon is inflated at area of stenosis
- Follow-up pressures and imaging are completed to verify patency of vessel
Atherectomy Devices

- Used to remove plaque from the inside of the vessel
- Types of devices:
  - Directional
  - Rotational
  - Transluminal

Directional Device

- Not used as often
- Cutting window <360 degrees with mechanical plaque removal
- Includes a balloon device to force the blade against the plaque
- Plaque is mechanically removed by withdrawing the catheter

Rotational Device

- Uses a cutter or burr to grind plaque
- More frequently used in coronaries
Transluminal Extraction Device

- Uses cutting blades and suction to remove excised plaque from vessel
- Plaque is drawn into a vacuum bottle or bag

Intravascular Stents

- The use of an expandable device (stent) at the site of percutaneous transluminal angioplasty achieves a greater patency rate over time
- Typically made of stainless steel or Nitinol
- Two Options:
  - Balloon Expanding Stent
  - Self-expanding Stent
Balloon-Expanding Stent

• Palmaz Stent

Self-Expanding Stents

• Recommended for tortuous vessels
  – Wallstent
  – Smart Stent (can be shortened to match lesion)

Wallstent

• delivered to the obstructed site by traversing over a wire
• outer protective covering is then retracted allowing stent to self expand to keep the artery open
**Smart Stent**

- A combination of a stent and a graft
- Composed of fabric supported by a metal mesh

**Indications for Stent Graft**

- Aortic aneurysm support
- Traumatic vascular injury
- Patients who are not surgical candidates
- Lower risk option for surgical candidates
Basic Stent Graft Procedure

• Preimplantation angiography is performed
• Stent graft is placed via surgical cut down through artery
• Upon deployment, graft expands and anchors itself to vessel walls

Selection of Embolic Agent

• Size of vessel to be occluded
• Duration of occlusion
• Ease of catheter placement into vessel or pathology

Options

• Temporary Devices
  – Autologous clot
  – Surgical gelatin (Gelfoam)
  – Oxidized cellulose (Oxycel)
  – Microfibrillar collagen (Avitene)
**Embolic Protection Device**

- Used to prevent downstream travel of plaque and clot during intervention
- Options:
  - Filter Wires
  - Occlusion Balloons

**Vena Cava Filters**

- Indications:
  - Reduce or prevent pulmonary embolus
  - Deep vein thrombosis
  - When anticoagulant therapy must be discontinued
  - Preop patients at risk for developing DVT or PE

**Filter Types**

- Permanent
  - Bird’s Nest
  - Greenfield 12 and 24-French
  - Greenfield Titanium
  - Simon Nitinol
  - TrapEase
  - VenaTech
Filter Types

- Removable
  - Gunther Tulip
  - OptEase
  - Recovery

Central Venous Catheters

- “Vascular Access Device”
- Used to deliver medications, fluids, blood products to patients
- Types:
  - PICC Line
  - Tunnel Cath
  - PortaCath

PICC Line

- “Peripherally Inserted Central Catheter”
- Inserted in the arm rather than the neck or chest
Tunnel Cath

- Inserted in vein in chest or neck and “tunneled” under the skin
- Is more stable and less visible than PICC line

Port A Cath

- Embedded under the skin completely
- Has a reservoir for access
- Usually best tolerated by the patient as compared to PICC and Tunnel

Overview

- Functions of Cardiovascular System
- Anatomy of Circulation
- Vascular Access for procedures
Functions of CV System

- Transportation of vital nutrients, oxygen, hormones, chemicals to maintain body functions
- Removal of waste products via the kidneys and lungs
- Maintenance of body temperature and fluid and electrolyte balance

Arteries

- Blood vessels that carry blood away from the heart
- All arteries, with the exception of the pulmonary and umbilical arteries transport oxygenated blood

Arterial System

Is divided into:
- Systemic arteries: carrying blood from the heart to the whole body away from the heart, and returns deoxygenated blood back to the heart.
- Pulmonary arteries: carrying blood from the heart to the lungs and returns oxygenated blood back to the heart
Veins

- Carry blood back toward the heart
- Most veins low-oxygen blood from the tissues back to the heart
- Exceptions include pulmonary and umbilical veins which carry oxygenated blood

Anatomy of a Vein

- Outer-most layer:
  - Made of collagen wrapped in smooth muscle bands
- Inner-most layer:
  - Lined with endothelial cells known as intima

Anatomy of a Vein

- Most veins have valves
  - Prevent blood from flowing back
  - Prevent pooling in the lower extremities due to gravity
Vascular Access

- Catheter must be placed in either an artery or vein for imaging purposes
- Criteria for access:
  - Large vessel
  - Minimal tortuosity
  - Minimal complications secondary to access

Types of Approach

- Cut-down
  - Typically used to access brachial veins for procedure
  - Not method of choice for today’s MDs

Percutaneous Approach

- Most desired approach
- Uses the Seldinger technique for access
- Locations:
  - Femoral
  - Brachial
  - Axillary
  - Abdominal Aorta
  - Carotid
Vascular Anatomy

- NAVEL (lateral to medial)

Translumbar Approach

- Patient is typically prone
- Upper aorta:
  - Access at level of T-12
- Lower aorta:
  - Access at level of L-2

Seldinger Technique

- Procedure began in 1953
- Allows for exchange of catheters and guidewires during procedure
Seldinger Technique

![Seldinger Technique Diagram]

General Information

- Aneurysms
- Dissections

Aneurysm

- Localized, blood-filled dilation (balloon-like bulge) of a blood vessel
- Caused by disease or weakening of the vessel wall
- Most commonly occur:
  - Circle of Willis
  - Aorta
    - 75% are abdominal
    - 25% are thoracic
True Aneurysm
• involves all three layers of vessel

Pseudoaneurysm
• Involves only outside layer
• Typically a result of trauma to aorta

Fusiform
• Most are true aneurysms
• Found along an extended section of the aorta
• Involves the aorta's entire circumference
• Appears as a roughly symmetrical bulge
Saccular

- Usually considered a pseudoaneurysm
- Typically caused by trauma or an ulcer on the aorta
- Resemble a small blister or bleb on the side of the aorta and are asymmetrical

Dissections

- Most common acute aortic syndrome
- Three layers of aorta are separating
- Dissection weakens the wall of the aorta, and the aorta enlarges
- Blood flow occurs between layers

Dissection Classifications

- DeBakey
  - Type I
    - Involves entire aorta
  - Type II
    - Least common
    - Ascending aorta only
  - Type III
    - Most common
    - Descending aorta only
Dissection Classifications

- Stanford
- Similar to Daley’s
  - Type A
    - Ascending aorta involved
    - More than 50% develop aortic regurgitation
  - Type B
    - Ascending aorta NOT involved

Anatomy of Thoracic Aorta

- Four sections:
  - Aortic bulb (root)
    - Origination of coronary arteries
  - Ascending aorta
    - Terminates at 2nd sternocostal joint

- Aortic Arch
  - Three branches
- Descending aorta
  - Ends at level of 12th dorsal vertebrae
Most Common Aortic Variations

- Lt Circumflex aorta
  - Normal arch with descending extending inferiorly and to the right
- Inverse aorta
  - Reverse of normal aorta
- Pseudocoarctation
  - Arched descending aorta

Indications

- Detection of acute and chronic aortic injury
- Preop planning for Aortic aneurysms/dissection
- Aortic abnormalities
- Paraortic masses
  - Aortic diverticula, Pulmonary sequestrations, neoplasms
- Hemoptysis

Catheter selection

- Pigtail catheter
  - End hole and multiple side holes for increased CM delivery
  - Closed-end catheter to reduce recoil and possible injections into carotid arteries
Imaging

- 4 frames per second/2 seconds, 2 per second/3-5 seconds
- Injections: 30 cc per second/total of 60 cc
- Positioning:
  - 45 degree LPO
    - PDA or coarctation of aorta
  - 45 degree RPO
    - Ventricular septal defect
    - Aortic arch and great vessels

Aortic Aneurysm
Indications for Pulmonary Angiography

- Diagnosis for acute pulmonary embolism
  - Suction embolectomy
- Planning or followup for the following:
  - Chronic PE
  - Developmental abnormalities
  - Arterial hypoplasia or stenosis
  - Pulmonary sequestration
  - Aneurysms
  - AVMs
  - Vascular occlusions from disease or tumor
Catheter Placement

- Venous puncture
- Common femoral vein ***
- Brachial vein
- Jugular vein

Supplies

- Pigtail for large injection into pulmonary system
  - Typically Grollman catheter
  - Soft pigtail
- Tip deflecting wire to negotiate pulmonary arteries

Catheter placement

- Venous access to vein leading to Vena Cava
- Access to right atrium via Superior or Inferior Vena Cava
- Catheter into Right Atrium to Tricuspid Valve to Right Ventricle
- Right Ventricle into Pulmonic Valve
- Catheter placed in lower lobe pulmonary arterial trunk
- Monitor ECG for ventricular tachycardia during manipulation in right heart
Imaging

- At least two views of each lung
- Biplane imaging will further reduce CM used
- Minimal imaging
  - AP
  - Posterior obliques of side of interest
    - Best projection to reduce overlap of vessels

Normal vs. Abnormal

Anatomy

- Aortic arch
  - Used to demonstrate the take-offs or origins of vessels
- Anterior circulation
  - Right and left common carotids
- Posterior circulation
  - Right and left vertebral arteries
- Venous drainage is via the jugular veins
**Arch Anatomy**

- Innominates
  - Brachiocephalic
  - RCC
  - Right subclavian
- Left Common Carotid
- Left Subclavian

**Circle of Willis**

- Formed by the carotid and vertebrobasilar arteries
- These vessels form a circle in the event a main artery becomes occluded, the distal smaller arteries that it supplies can receive blood from the other arteries

**Common Carotid**

- Branches into internal and external carotid arteries
- Internal carotid supplies:
  - Anterior portion of brain
  - Orbits
  - Anterior portion of nasal cavity
  - Forehead
Common Carotid

- Carotid Sinus
  - Localized dilation of the ICA at its origin or bifurcation
  - Assists in BP regulation
- Carotid Siphon
  - S-shaped structure which runs through cavernous sinus
- External carotid supplies:
  - Tissues of face and neck

Vertebral Arteries

- Converge to form the basilar artery
- Vertebrals typically originate from subclavian arteries
- Supply blood to posterior portion of brain
- Largest branch of VA is the posterior inferior cerebellar artery (PICA)

Indications

- Diagnosis of occlusive disease
- Aneurysms
- AVMs
- Fistulae
- Pre-op planning
- Post-op
- As a follow-up for a positive CT or MRA
Typical Imaging

- Aortic arch
  - LAO (30-45°)
- Carotid
  - AP Axial
  - Lateral
  - AP Oblique Transorbital
- Vertebral
  - AP Axial
  - Lateral
AP Carotid Imaging
1. Internal Carotid
2. External Carotid
3. Anterior Cerebral
4. Middle Cerebral

Lateral Carotid Imaging
1. Internal Carotid
2. External Carotid
3. Anterior Choroidal
4. Anterior Cerebral

AP Vertebral Imaging
1. Vertebral
2. Post. Inferior Cerebellar
3. Ant. Inferior Cerebellar
4. Basilar
5. Posterior Cerebral
Lateral Vertebral Imaging

1. Vertebral
2. Post. Inferior Cerebellar
3. Basilar
4. Superior Cerebellar
5. Posterior Cerebral
6. Occipital
7. Posterior Temporal

Transorbital

GSW to Face
Neuropathology/Disease

Athero, arterio, what?

- Chronic inflammatory response in walls of arteries
- **Arteriosclerosis** is a general term describing any hardening (and loss of elasticity) of medium or large arteries an atheromatous plaque
- Atherosclerosis is a form of arteriosclerosis

Subclavian Steal

- Arises from reverse vertebral artery blood flow or reversed internal thoracic artery flow
- Caused by proximal subclavian artery stenosis or pressure from cervical rib
- The blood flow from the brain to the UE is considered to be stolen as it is blood flow the brain must do without
Subclavian Steal

Thoracic Outlet Syndrome

• Symptoms:
  – Arm pain, numbness, weak pulse, and decrease of blood pressure in that arm, bruit, cold or blue hand.

• Causes:
  – Usually caused from a rib compressing the Subclavian artery or vein.
  – Can also be from abnormalities of the Scalene muscle, vertebrae, or clavicle.

Thoracic Outlet Syndrome

• Thoracic Outlet is a compression of the Brachial Plexus, Subclavian artery or vein between the clavicle and first rib

• Images are performed with the arm in neutral position and hyperextended
Carotid Angioplasty/Stent

- Some exclusion criteria:
  - Any type of IC hemorrhage
  - Pregnant or lactating women
  - Major trauma within 3 months
  - Hx of brain tumor, AVM, aneurysm
  - Major surgeries within 14 days
  - Severe systemic diseases with a life expectancy <3 months.
Indications

- Gastrointestinal hemorrhage
- Suspected intestinal angina
- Acute Mesenteric Ischemia
- Splenic or Splanchnic artery aneurysm
- Detection of Islet Cell tumor
- Trauma
- Pre-op planning

Abdominal Aorta Anatomy

- Abdominal aorta begins below level of diaphragm and extends to level of L4 (iliac bifurcation)

Celiac Axis or Trunk

- First branch of abdominal aorta
- Three Divisions:
  - Left gastric (smallest branch)
    - Stomach and esophagus
  - Hepatic (middle size branch)
    - Right and left lobes of liver
  - Branches
    - Right Gastric
    - Gastroduodenal
    - Right Gastroepiploic
    - Superior Pancreaticoduodenal
    - Cystic
Celiac Axis or Trunk

- Three Divisions:
  - Splenic or Lienal (largest branch)
  - Its branches are:
    - Pancreatic
    - Short Gastric
    - Left Gastroepiploic

Superior Mesenteric Artery (SMA)

- 2nd branch
- Arises anterior off of AA
- Supplies the whole length of the small intestine, except the superior part of the duodenum
- Cecum
- Ascending colon
- About one-half of the transverse colon

Superior Mesenteric Artery (SMA)

- Branches of SMA
- Inferior Pancreaticoduodenal
- Ileocolic
- Intestinal
- Right Colic
- Middle Colic
**Renal Arteries**

- Paired R and L branches
- Arise below SMA
- Right is longer than the left, on account of the position of the aorta
- Left is somewhat higher than the right
- Each RA provides branches to **inferior suprarenal branches**
  - Suprarenal gland
  - Ureter

**Inferior Mesenteric Artery (IMA)**

- Smaller than SMA
- Left half of transverse colon
- Descending and iliac parts of the colon
- Sigmoid colon
- Most of rectum

**Inferior Mesenteric Artery (IMA)**

- IMA Branches
- Left Colic
- Sigmoid
- Superior Hemorrhoidal
Procedure

• Flush aortogram done to visualize or provide roadmap of abdominal vasculature
  – Pigtail catheter
  – Approximately 50 cc total/25 cc per second
• Selective imaging of vessels
  – Cobra, Simmons
  – Decreased injection based on vessel
  – Extended filming for patients with GI bleed

Blood Supply

• Typically one renal artery per kidney
  – 70-75% of population demonstrates normal arterial anatomy
• Blood return is via renal veins
  – Renal veins arise off of IVC at level of L1/L2
  – Right renal vein enters IVC posteriorly
  – Left renal vein is longer than right (making Lt kidney more likely to be used for transplant)
Indications for Arteriography

- Follow-up from other studies
- Pathology
- Transplant donation and recipient studies
- Renal trauma
- Acute tubular necrosis
- Vascular occlusion
- HTN
- Aneurysms

Injection Procedure for Arteriography

- Flush aortogram with pigtail to localize renal arteries
  - 50cc total/25 cc per second
- Selective catheterization with Cobra or Simmons catheters
  - 6-10cc total/5-6 cc per second
- Some MDs may opt to infuse epinephrine into renal arteries prior to CM injection to better demonstrate tumor blood flow

Filming for Renal Arteriography

- Rapid filming at level of L2/L3
  - Sequence includes 2-3 per second/1.5-2 seconds, 1 per second/2 seconds, every other/6 seconds
- Collimation to anatomy of choice
- AP Projections
- Oblique projections
  - 30-45 degree obliquity
Wilm’s Tumor

- Nephroblastoma
- Malignant tumor of kidney which occurs primarily in children
- Approximately 500 cases are diagnosed in the U.S. annually
- The majority (75%) occur in otherwise normal children; a minority (25%) is associated with other developmental abnormalities
Wilm’s Treatment
• It is highly responsive to treatment, with about 90% of patients surviving at least five years
• Biopsy to determine pathology
• Surgery, chemotherapy, radiation therapy

ABDOMEN AND LOWER EXTREMITY ANGIOGRAPHY

Anatomy
• Abdominal aorta begins at level of the diaphragm
• Bifurcates at about the level of L4 into the right and left common iliacs
**Anatomy**

- Common iliacs further divide into internal/external iliac arteries
  - Internal supplies pelvis and pelvic organs
  - External continues down the LE

**Indications**

- To develop a roadmap of vasculature of abdominal aorta and lower extremity
- Rule out aneurysm, AVM, congenital anomalies, stenosis or occlusion
- Assessment prior to intervention or surgery
- PVD
- Atherosclerosis

**Imaging**

- Abdomen
  - Single
  - Biplane imaging
Imaging

• Pelvis
  – AP
  – Oblique to demonstrate iliac arteries
    • RPO-right iliac
    • LPO-left iliac

Imaging

• Lower Extremity
  – Some form of step system
    • Table steps
    • C-Arm steps
    • Imaging from pelvis to feet to cover anatomy
    • Invert feet to place vessels in anatomical position

Catheter selection

• Pigtail utilized for abdominal and pelvic imaging
• Femoral imaging
  – Can be injected unilateral or bilateral catheters
  – Straight, multi-side hole catheter
  – Curved catheter
    • Cobra
    • Headhunter
Approaches for femoral imaging

- Ipsilateral
  - same
- Contralateral
  - opposite

Injection Parameters

- Abdominal Aorta
  - 50-60 cc total over about 2 seconds
- Pelvis
  - 30 cc total over about 2 seconds

Injection Parameters

- Lower Extremity
  - Hand or power injection
  - 20-30 cc total for unilateral
  - 50-70 cc total for bilateral
  - 8-10 cc/second
Filming

• Abdominal Aorta/Pelvis
  – 2 for 3 seconds
  – 1 for 5 seconds
  – Every other for about 5 seconds
• Lower Extremity
  – 2 for 4 seconds
  – 1 for 8 seconds
  – Hand panning or stepping of images

Pelvis Arteriogram
1. Aortic bifurcation
2. Common Iliac Artery
3. Internal Iliac Artery
4. External Iliac Artery

Thigh Arteriogram
Common Findings

• AAA

Common Findings

• Atherosclerosis
  – Most common areas of involvement
  – 58% femoral artery
    • With femoral occlusion there is typically collateral flow to deep femoral artery
  – 34% iliac artery
Peripheral Vascular Disease

- Usually caused by atherosclerosis
- Some symptoms include
  - Pain
  - Pallor
  - Pulselessness
  - Intermittent claudication
  - Impotence

Inferior Vena Cava Gram

- Indications:
  - Thrombus in IVC
  - DVT
  - For anatomy for placement of vena cava filter

Inferior Vena Cava Gram

- Vascular access:
  - Typically Femoral Vein
- Pigtail catheter is placed in the lower IVC
- CM infusion
  - Hand injection
  - Power injection
  - 40 cc total / 20 cc per second
Vena Cava Filter Placement

- IVC must be evaluated prior to placement of filter
  - Localization of renal veins
  - Documentation of size of IVC
  - Use radiopaque ruler or markers for IVC assessment

Filter procedure

- Can be placed in two manners
  - Femoral Vein approach
    - More likely to encounter iliofemoral thrombus
  - Internal Jugular approach
    - More awkward for MD
    - Less comfortable for patient
    - Higher risk of air embolus

Filter Procedure

- Filter is typically placed inferior to renal veins
- Post study to verify filter placement
May-Thurner Syndrome

- Common cause of DVT
- Right Iliac artery compresses Left iliac vein
- More common in females 3:1
- Approximate age of 48

May-Thurner Syndrome

Placement of measuring catheter

Treatment of Venous Stasis

- Venography is performed
- Infusion of thrombolytics to lesion
Treatment of Venous Stasis

- PTA of vessel performed
- Stent is placed

Renal Venography

- Pigtail or flush catheter to IVC
  - Catheter below level of renal vein takeoffs
- Selective catheterization of renal veins
- Filming slower than arteriography
  - 1 per second/10-15 seconds

Portal Venography

Indications include:
- Evaluation of patients with portal HTN prior to TIPS or shunting
- F/U of TIPS or shunting
- Mesenteric vein thrombosis
- Colonic or SB varices
- Patency and size of portal veins for transplant evaluation
Hepatic Portal System

Portography Methods

• Direct access
  – Splenic or hepatic puncture via transhepatic route

• Indirect access
  – Most common
  – Injection of Mesenteric, Splenic, Hepatic arteries with large CM injection
  – Use long film sequence to allow for opacification of portal system (25 seconds)

Imaging

• Catherization with Simmons catheter
• Injection volumes
  – 50-80 cc total
  – 6-10 cc/second
• IV infusion of glucagon can enhance imaging
Pressure measurements

• It is important to measure portal venous pressure via hepatic vein
• WHVP
  – Wedged Hepatic Vein Pressure
  – Should be < 5 mm Hg
• Other measurements
  – Right Atrium
  – IVC below intrahepatic portion

Biliary Drainage Placement

• Begins as a PTC
• GW is advanced through biliary system to small bowel
• Tract is dilated

Biliary Drainage Placement

• Catheter placed with distal end in small bowel
• Follow-up imaging is completed
TIPS

• Indications:
  – Continuing or recurrent variceal bleeding
  – Massive ascites not responding to diuretics
  – Budd-Chiari Syndrome
    • Hepatic veno-occlusive syndrome

Budd-Chiari Syndrome

• Occlusion of hepatic vein (75%)
• Occlusion of IVC (25%)
  – Mass
• Symptoms
  – Abdominal pain
  – Liver enlargement
  – Ascites
**TIPS Procedure**

- Right jugular vein is typical approach
- TIPS sheath advanced to right atrium
- Selection of right hepatic vein
- Wedge pressures taken
- Tunnel is created through liver parenchyma

**TIPS Procedure**

- Access to portal vein through tunnel
- Angioplasty performed to establish tract
- Stent or stentgraft placed
- Follow-up pressures taken
- Follow-up US within 24 hours of procedure

**TIPS Complications**

- Puncture of biliary structures
- Rupture of liver parenchyma
- Puncture of gallbladder
- Renal failure
- Heart attack
- Death
TIPS Complications

- Most common include:
- Restenosis or occlusion of stent
- Hepatic encephalopathy
- Recurrent variceal bleeding
- Intra-abdominal hemorrhage
- Pneumothorax
- Portal vein thrombosis
- Hematoma

GU Interventional Procedures

- Percutaneous Nephrostomy
- Ureteral Dilatations/Stent
- Percutaneous stone extraction

Percutaneous Nephrostomy

- PCN
- Utilized to mechanically drain the renal collecting system to the outside of the body
- Performed under US, Fluoroscopy both
Contrast Media

- Used to delineate the renal structures
- Used to distend the renal structures if necessary to each nephrostomy tube placement
- Options:
  - Iodinated CM
  - Carbon Dioxide

Procedure

- Iodinated CM can be used to delineate system via peripheral IV injection
- Patient is prone and prepped in sterile fashion
- Local anesthesia introduced
- System is cannulated with a 21-gauge needle if possible to distend system and minimize bleeding risk

- Optimum needle placement is into a lower pole or middle/posterior calyx
- Once system is initially punctured, the C-arm is rotated to the angle of the percutaneous needle for ease of work
- Needle is advanced until urine is returned through stylet
**Procedure**

- Once puncture of collecting system is verified, CM can be injected to further distend collecting system
- A larger needle can then be introduced to allow for placement of GW into the system through ureter into bladder
- Tract is dilated and catheter is placed
- Catheter is secured and placed to external drainage

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**Chemoembolization**

- A combination of chemotherapy and embolization of tumors
- Types of tumors treated:
  - Hepatoma (primary liver cancer)
  - Liver metastasis from:
    - Colon cancer
    - Ocular melanoma
    - Sarcomas
    - Other primary tumors

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**Chemoembolization Contraindications**

- Occlusion of portal vein
- Cirrhosis of liver
- Blockage of biliary ducts
Intra-arterial Chemotherapy

Embolization

Chemo-embolization
Thrombolysis

Indications

• Acute myocardial infarction
• Acute ischemic stroke
• Acute pulmonary embolism
• Acute deep venous thrombosis
• Clotted AV fistula and shunts
• Clotted Central Venous Catheter
• Intra-arterial occlusions

Complications

• Bleeding is the major complication of thrombolytic therapy. (Cerebral hemorrhage would be the worst)
  – Absolute contraindications include dissecting aortic aneurysm, pericarditis, stroke, or neurosurgical procedures within 6 months or known intracranial neoplasm.
  – Relative contraindications include major surgery or bleeding within 6 weeks, known bleeding diathesis, and severe uncontrolled hypertension.
Fistula vs. Graft

Different Configurations

Graft Evaluation

- Determination of type of graft or fistula
- Identifies “venous or arterial” sides of graft
- Physical examination-“thrill or buzz”
- Signs of active infection
- Venous pressure measurements
- Angiography
Procedure

- Graft is prepped and draped in sterile fashion
- Graft is accessed at both arterial and venous sides:
  - Percutaneous needle
  - Micropuncture kit
  - Butterfly needle
- CM injected and angiography performed to verify patency of graft

Interventional Options

- Stenosis:
  - Angioplasty
  - Stent placement
- Clot Removal:
  - Thrombolytic medications
  - Mechanical

Stenosis at Venous Anastomosis

Pre angioplasty  Post angioplasty
Thrombolytic Medications

• “Lyse and wait”
• Medication of choice can be infused prior to procedure
• Lysing agent is massaged into graft for dissolving of clots prior to placing patient on table

Mechanical

Percutaneous Needle Biopsy

• Indications:
  – Suspicion of primary of metastatic lesion
  – Provides staging information related to cancer
  – Confirms recurrence of tumor
  – Diagnosis of infection
**Percutaneous Needle Biopsy**

- **Contraindications**
  - Patients with vascular lesions
  - Patients with severe pulmonary hypertension
  - Cystic lesion with potential for malignancy

**Obtaining specimen:**
- Large gauge core needle
- Percutaneous fine needle aspiration

- Very safe method of obtaining information

**PNB Methods**

- **Guidance:**
  - Fluoroscopy, US, CT
  - Ultrasound uses no radiation, cheaper than CT
  - CT
    - Use for extremely obese patients
    - Presence of overlying structures
    - Skin pathology which would not allow for accurate transducer placement
    - Provides 3-D reconstruction data
Puncture and Drainage

• Used to remove fluid from GU and Biliary system, abdominal cavity
• Drains abscesses in GU, Biliary system and abdominal cavity
• Used to dilate areas of stenosis, occlude areas of leakage, treat fistulae, infuse meds to dissolve or remove calculi
• Perform biopsys

Puncture and Drainage

• Safe option for patient
  – No incision
  – No general anesthesia
  – Less invasive
• Relieves symptoms related to fluid collection
• Lower complication rates

Puncture and Drainage Risks

• Hemorrhaging from puncture site or adjacent structures
• Extravasation of contrast media
• Bile leakage related to liver biopsy
**Abscess Drainage**

- Small gauge needle placed into abscess area under guidance
- .018 GW coiled into abscess cavity
- Tract is dilated
- Sheath placed into tract
- Stiff GW placed into sheath
- Drainage catheter placed and secured

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**Thank you for your time**