Residency Essentials℠
Comprehensive curriculum for your IR residency

RESIDENCY ESSENTIALS
FULL CURRICULUM SYLLABUS

Click on the topic below to jump to a specific section.

Clinical Topics

Requisite Knowledge

Fundamental

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Gastrointestinal

1. Portal hypertension
    a) Pathophysiology
        (1) definition and normal pressures and gradients, MELD score
        (2) Prehepatic
            (a) Portal, SMV or Splenic
                (i) thrombosis
                (ii) stenosis
            (b) Isolated mesenteric venous hypertension
            (c) Arterioportal fistula
        (3) Sinusoidal (intrahepatic)
            (a) Cirrhosis
                (i) ETOH
                (ii) Non-alcoholic fatty liver disease
                (iii) Autoimmune
                (iv) Viral Hepatitis
                (v) Hemochromatosis
                (vi) Wilson's disease
            (b) Primary sclerosing cholangitis
            (c) Primary biliary cirrhosis
            (d) Schistosomiasis
            (e) Infiltrative liver disease
            (f) Drug/Toxin/Chemotherapy induced chronic liver disease
        (4) Post hepatic
            (a) Budd Chiari (Primary secondary)
            (b) IVC or cardiac etiology
        (5) Ectopic perianastomotic and stomal varices
        (6) Splenorenal shunt
        (7) Congenital portosystemic shunt (Abernethy malformation)
    b) Measuring portal pressure
        (1) Direct vs wedge
        (2) Portosystemic gradient
    c) Relevant anatomy (CR)
        (1) Portal vein
        (2) Coronary vein
        (3) Posterior gastric veins
        (4) Short gastric veins
        (5) Inferior phrenic veins
        (6) Paraumbilical vein
        (7) Splenic vein
        (8) Superior mesenteric vein
        (9) Inferior mesenteric vein
        (10) Hepatic veins
    d) Clinical sequelae
        (1) Hepatorenal syndrome
        (2) Varices formation
            (a) classification
        (3) Cirrhosis (in post hepatic causes)
        (4) Ascites
        (5) Hepatic hydrothorax
        (6) Portomesenteric thrombosis
        (7) Portal hypertensive gastropathy
        (8) Hepatopulmonary syndrome
    e) Diagnosis of portal hypertension
        (1) US
        (2) CT
        (3) MRI

(4) Portography
(a) Direct – Transhepatic, transjugular, transplenic, trans-umbilical vein
(b) Indirect – arterioportography, wedged hepatic venography, splenoportography

f) Management of portal hypertension
(1) Pharmacologic
(2) Endoscopic
(a) Banding/sclerosis of varices
(3) Surgical management of portal hypertension
(a) Splenorenal shunt placement
(b) Mesocaval shunt placement
(c) Rex shunt
(d) Splenectomy
(e) Devascularization procedures (e.g. Sugiura procedure)

g) Interventional management of portal hypertension
(1) Splenic arterial embolization
(2) Transjugular intrahepatic portosystemic shunt placement (TIPS)
(a) Indications
(i) Variceal bleeding
(ii) Medically refractory ascites or hydrothorax
(iii) Preoperative decompression
(iv) Hepatic venoocclusive disease (Budd Chiari)
(v) Access for management of portomesenteric thrombosis or ectopic varices
(b) Contraindications
(i) Elective
(a) Elevated MELD score
(b) Encephalopathy
(c) Polycystic liver disease
(d) Unrelieved biliary obstruction
(e) Systemic infection/SBP
(f) Right heart failure
(g) Coagulopathy
(c) Evaluation
(i) MELD
(ii) Imaging/echo
(iii) History of encephalopathy
(a) West Haven criteria
(iv) Physical exam findings
(d) Technique
(i) TIPS sets and components
(ii) Hepatic vein access
(iii) Right-to-right, left-to-left, middle-to-right access
(iv) Measuring and placement of the TIPS stent
(v) Direct Intrahepatic Portosystemic Shunt (DIPS)
(vi) Use of IVUS to facilitate TIPS
(vii) Gunsight technique and other advanced techniques
(viii) Trans-splenic approaches
(ix) Embolization of varices
(a) Mechanical (coils, plugs, glue, etc.)
(b) Sclerotherapy
(x) Target portosystemic gradients
(e) Complications
(i) Bleeding
(ii) Infection
(iii) Encephalopathy

(a) Medical management
(b) TIPS constraint (e.g suture, stent side-by-side stent)

(iv) Liver failure
(a) TIPS occlusion
(b) TIPS constraint

(v) Right heart failure
(a) Medical management
(b) TIPS constraint/occlusion

(vi) TIPS thrombosis
(a) Etiologies of TIPS thrombosis (e.g. biliary-TIPS fistula)
(b) TIPS thrombectomy techniques

(f) Follow up
(a) US imaging evaluation
(b) TIPS revision for stenosis, occlusion
(c) Constrained TIPS or TIPS reduction

(3) Retrograde occlusion of varices
(a) Indications
(i) History of encephalopathy
(ii) Poor liver function and high risk for decompensation after TIPS
(iii) Bleeding gastric varices

(b) Contraindications
(i) Esophageal varices that cannot be controlled endoscopically
(ii) Inability to isolate the varices
(iii) Portal thrombosis - relative

(c) Technique
(i) Balloon assisted
(ii) Plug-assisted
(iii) Coil-assisted
(a) Equipment
(b) Non-target structures to identify
(c) Intra-procedural imaging
(d) Sclerosants
(e) Liquid embolics

(d) Complications
(i) Non-target embolization
(ii) Portomesenteric thrombosis
(iii) Worsening portal hypertension
(iv) Incomplete embolization

(e) Follow up
(i) Surveillance for further varices

(f) TIPS vs BRTO

2. Acute Portomesenteric Thrombosis
a) Pathophysiology
(1) Portal hypertension
(2) Hypercoagulable state
(3) Anatomic abnormality

b) Patient evaluation
(1) Signs of ischemia
(a) Physical exam
(b) Radiologic
(c) Laboratory evaluation (e.g. lactate)

(2) Signs of prehepatic portal hypertension

c) Anatomy (CR portal anatomy?)

d) Medical management
    (1) Anticoagulation
e) Surgical management
    (1) Resection of bowel
    (2) Surgical thrombectomy
f) Interventional management
    (1) Transhepatic/transjugular transhepatic portal access
    (2) Lysis and mechanical techniques (CR lysis catheters and devices?)
    (3) SMA lysis
g) Complications
    (1) Hemorrhage, ischemia

3. Chronic Portomesenteric Thrombosis
    a) Pathophysiology
    b) Patient and imaging evaluation
    c) Indications for treatment
        (1) Suitability for liver transplantation
        (2) Relieve prehepatic portal hypertension
        (3) Bleeding ectopic varices
    d) Follow up imaging and evaluation
    e) Anticoagulation (CR anticoagulants?)
    f) IR management
        (1) Portal vein recanalization PVR-TIPS
        (2) Portosplenic vein stenting
        (3) Mesenteric vein stenting
        (4) Splenic arterial embolization
4. GI Bleeding
    a) Upper GI bleeding
        (1) Patient evaluation
            (a) Evaluation of the unstable patient with hemorrhage (CR ICU?)
            (b) Determining upper vs lower GI bleed (e.g. NG lavage, character of blood, history)
        (2) Role of imaging and modality
        (3) Management
            (a) Medical
            (b) Endoscopic
            (c) Surgical
        (4) Interventional treatment
            (a) Ulcer
                (i) Embolization of duodenal GDA territory ulcers
                (ii) Embolization of distal esophageal and fundal left gastric territory ulcers
            (b) Variceal
                (i) Transjugular intrahepatic vs transhepatic vs transsplenic access with variceal embolization
            (c) Completion imaging to evaluate for collateral supply
    b) Lower GI bleed
        (1) Patient evaluation
            (a) Determining upper vs lower GI bleed (e.g. NG lavage, character of blood)
                (i) Causes
                    (a) Diverticular
                    (b) Mass
                    (c) Vascular malformations (e.g. AVM)
                    (d) Meckel's (CR peds?)
                    (e) Intussusception
                    (f) Ischemic bowel
                    (g) Aorto-enteric fistula

(h) Perianastomotic
(i) Rectal/stomal bleeding
(j) Other
(2) Laboratory evaluation (Hgb/Hct, lactate, etc.)
(3) Anatomy
(a) SMA-ileocolic, right colic, middle colic, marginal artery, Arc Riolan, Arc of Buhler (CR anatomy?)
(b) IMA- left colic, sigmoidal, superior rectal arteries (CR anatomy?)
(c) Middle and inferior rectal arteries (CR anatomy?)
(4) Imaging evaluation
(a) Nuclear medicine bleeding scan
(b) CT angiography
(c) Angiography
(5) Medical management
(a) Endoscopic management and challenges
(6) Surgical management
(a) Bowel resection
(7) Interventional management
(a) Mesenteric angiography technique
(i) Order of catheterization
(ii) Catheters and selection techniques
(iii) Imaging parameters
(iv) Types of pathology
(a) Diverticular bleeding, AVM, angiodysplasia, mass
(v) Vasopressin infusion
(vi) Principles of embolization
(a) Distal to marginal branch
(b) Number of vasa recta embolized
(c) Embolic materials
(vii) Imaging after embolization and collateral pathways
(viii) Complications
(a) Continued bleeding
(b) Ischemia
(c) Non-target embolization
(ix) Provocative angiography for lower GI bleeding
(a) Heparin
(b) Tpa
c) Embolization for hemorrhoids (emborrhoid technique)
d) Embolization of stomal/superficial varices
(1) Technique
(2) Endovascular (CR portal hypertension section?)
(3) Embolization/sclerosis technique (CR embolics in general IR section?)
e) Embolization of ectopic, jejunal varices (CR portal hypertension?)

5. Mesenteric ischemia (CR XXX, should live in vascular)
a) Chronic
(1) History and physical examination (e.g. food fear)
(2) Imaging evaluation
(a) US/CT/MRI evaluation
(b) Usually 2 of 3 mesenteric vessels involved (often SMA)
(3) Anatomy
(a) SMA, Celiac and IMA anatomy (CR anatomy section in general IR?)
(b) Arc of Riolan and Buhler (CR anatomy section?)
(4) Surgical management
(a) Surgical repair/bypass
(5) Interventional management

(a) SMA stenting considerations (diameter, length, side branches, ostial involvement)
(b) Complications
(i) Acute Mesenteric ischemia
(ii) SMA dissection
(iii) Stent thrombosis
(c) Follow up and management
(i) Antiplatelet therapy (CR anticoagulation in general IR section?)
(ii) Follow up imaging and clinic evaluation

b) Acute
(1) Pathophysiology
(a) Occlusive- embolic, thrombotic
(b) Non-occlusive
(2) History and Physical examination
(3) Laboratory evaluation
(4) Imaging evaluation
(a) CTA
(b) Angiography
(5) Surgical management
(a) Surgical thrombectomy, bypass
(6) Interventional Management
(a) Approach and techniques
(i) Aspiration
(ii) Local thrombolysis
(iii) Mechanical thrombectomy -e.g. Angioplasty, stent
(b) Follow up and management
(i) Anticoagulation (CR anticoagulants?)

6. Celiac stenosis/Occlusion
a) Etiology and pathophysiology
(1) Atherosclerotic
(2) Median Arcuate Ligament
(3) Association with pancreaticoduodenal arcade aneurysms
b) History and Physical Exam
(1) Abdominal pain
(2) Abdominal bruit
(3) Weight loss
c) Anatomy (CR anatomy section?) celiac, IPDA, SPDA, GDA, Crux of diaphragm
d) Imaging evaluation
(1) CTA
(2) Angiography
(a) Inspiratory
(b) Expiratory
(3) Surgical management
(a) Decompression
(b) Bypass
(4) Interventional management
(a) Embolization of aneurysms
(b) Celiac stenting
(5) Follow up
(a) Imaging
(b) Celiac stent patency-worse than SMA stenting
(c) Natural course of pancreaticoduodenal aneurysms

7. Liver dysfunction and focal lesion assessment (excluding biliary obstruction)
a) Pathophysiology (CR general IR section or ICU section?)
b) Etiology
(1) Transplant - many causes including

(a) Arterial or venous compromise
(b) rejection
(c) Infiltration (e.g. graft vs host)
(2) Native - many causes including
(a) Genetic
(b) Viral
(c) Toxic exposure - medications, etoh, mushrooms
(d) Hepatic injury/trauma
(e) Malignant infiltration
c) Liver biopsy
(1) Percutaneous
(a) Indication
(i) Sampling of mass
(ii) Sampling of non-targeted liver parenchyma
(b) Technique
(i) Coaxial access
(ii) Direct access
(iii) US guidance
(iv) CT guidance
(v) Tract embolization
(vi) Imaging fusion techniques
(vii) Contrast enhanced US
(c) Complications
(i) Bleeding, subcapsular, intraperitoneal, hemobilia
(ii) Tumor seeding
(iii) Injury to adjacent organs
(2) Transjugular
(a) Indication
(i) Sampling of liver, typically non-targeted
(ii) Coagulopathy
(iii) Ascites
(iv) Obesity
(v) Need for venous pressure measurements
(b) Technique
(i) TJLB biopsy kits
(ii) Hepatic vein access and cannula position
(iii) Right atrial, free and wedge pressure measurements
(c) Complications
(i) Intraperitoneal hemorrhage
(ii) Hemobilia
(iii) Inadvertent sampling of adjacent organs
(d) Interpretation of hepatic pressures

8. Cholecystitis
a) Pathophysiology
(1) Calculous vs Acalculous
(2) Acute vs Chronic
b) History and Physical examination
(1) RUQ tenderness
(2) Pain on eating fatty foods
(3) Fever or signs of sepsis
c) Imaging evaluation
(1) US
(2) CT
(3) Nuclear scintigraphy
d) Surgical therapy
(1) Cholecystectomy
(a) Associated complications

(i) Bile leak
(a) Cystic duct stump
(b) CBD or biliary branch laceration
(ii) Retained stones, choledocholithiasis
(iii) Dropped stones

e) Interventional therapy
(1) Cholecystostomy tube placement
(a) Technique
(i) Percutaneous transhepatic
(ii) Percutaneous free-wall
(b) Follow up and management
(i) Evaluation for tract maturation and removal (acalculous)
(ii) Stone retrieval
(iii) Interval cholecystectomy
(iv) Cholecystoduodenal stenting
(c) Management of iatrogenic bile leak
(i) Endoscopic stent placement across area of leak
(ii) Percutaneous drainage with diversion of bile, drain across leak (CR biliary drainage under biliary obstruction)

9. Biliary Obstruction
a) Pathophysiology
(1) Bilirubin production, conjugation
(2) Causes of obstruction including
(a) Intrinsic biliary tumor
(b) Extrinsic mass, intrahepatic or porta hepatis
(c) Choledocolithiasis
(d) Mirizzi syndrome
(e) Ischemic stricture
(f) Idiopathic stricture
(g) PSC
(h) Hemobilia
(i) Pyogenic cholangitis
(j) Radiation induced
(3) Causes of elevated bilirubin other than obstruction
(a) Genetic causes Crigler-Najjar Gilbert's syndrome
(b) Liver failure

b) Anatomy (CR biliary anatomy in anatomy section?)
(a) CBD, cystic duct, common right hepatic duct, common left hepatic duct, anterior right hepatic duct, posterior right hepatic duct, common variants

c) History and physical exam
(a) Jaundice
(b) Pruritus
(i) "Clay-colored" stool
(c) Signs of cholangitis
(i) Triad
(a) Fever
(b) Jaundice
(c) Right upper quadrant pain
(ii) Pentad
(a) Mental status changes
(b) Sepsis

d) Endoscopic therapy
(1) ERCP limitations
(a) Post-surgical anatomy - gastric bypass, Roux-en-Y, Whipple
(b) Ampullary mass
(c) Duodenal diverticulum

(d) Stricture of alimentary tract limiting access to the duodenum
(e) Duodenal stenting

e) Interventional therapy
(1) Percutaneous drainage
(a) External
(b) Internal-external
(c) Internal (stenting)
(2) Technique
(a) Fluoroscopic 2-stick
(b) US guided
(c) Left vs right vs bilateral vs trilateral access
(d) Cholangioplasty
(e) Stone retrieval and sweep of ducts
(f) Transhepatic biliary endoscopy (cholangioscopy)- experimental
(g) Transhepatic lithotripsy- experimental
(3) Complications
(a) Pseudoaneurysm
(b) Hemobilia
(c) Intraperitoneal hemorrhage
(d) Acute cholangitis
(e) Pancreatitis
(f) Bile leak, bile peritonitis
(4) Follow up and management
(a) Management of bag and drain output
(b) Troubleshooting drains
(i) Clogged
(ii) Bloody drainage from tube
(iii) Bloody drainage around tube
(iv) Tube associated vascular injury
(c) Following lab values
(d) Capping trials
(e) Internalization
(i) Metallic stenting
(a) Covered
(b) Uncovered
(c) Through ampulla or above ampulla
(d) CBD stenting, right and left duct stenting, right anterior and right posterior and left duct stenting (trilateral)
(f) Management of benign stricture
(i) Balloon dilatation
(ii) Cutting balloon
(iii) Serial upsize of drain
(iv) Other benign stricture protocols
(v) Referral for surgical revision
(g) Management of malignant obstruction
(i) Intraductal brachytherapy

10. Failure to thrive
a) Pathophysiology
(1) Inadequate caloric intake
(2) Inadequate caloric absorption
(3) Excessive caloric expenditure (chronic disease, malignancy)
b) History and Physical Examination
(1) Nutrition
(2) Socioenvironmental factors
(3) Functional ability
(4) Medical, psychiatric, and surgical history

(5) Medication
c) Laboratory Evaluation
(1) CBC, CMP, TSH, urinalysis, ESR/CRP
(2) Disease specific causes (HIV, lead, TB, CF)
d) Short term nutritional support/supplementation
(1) Parenteral vs enteral
e) Long term nutritional support
(1) Surgical feeding tube placement
(a) Open
(i) Laparoscopic
f) Endoscopic management
(1) Percutaneous endoscopic gastrostomy (PEG) tube
g) Interventional management
(1) Percutaneous radiologic gastrostomy (PRG) tube
(a) Indication
(i) Nutritional support
(ii) Decompression of gastroenteric contents
(b) Contraindications
(i) Unsuitable anatomy
(ii) Coagulopathy
(iii) Ascites
(c) Access in post-surgical stomach
(i) Techniques
(ii) Trans-esophageal access
(d) Technique
(i) Liver margin visualization
(ii) +/- glucagon
(iii) NG tube air insufflation
(iv) Fluoroscopic puncture of distal body of stomach
(v) +/- gastropexy
(vi) Dilate over stiff wire
(vii) Catheter placement (pigtail, internal retention bumper or balloon)
(viii) “Pull” Technique
(a) Guidewire inserted into stomach and pulled out month
(b) Catheter pulled own esophagus and out abdominal wall
(ix) “Push” Technique
(a) Guidewire inserted into the stomach
(b) Catheter pushed over guidewire into the stomach
(x) CT guided G-tube placement
(e) Follow up and Management
(i) Feeding initiation and tolerability
(ii) Tube maintenance
(iii) Exchange indications
(iv) Conversion to gastrojejunostomy
(a) Indications
(b) Techniques
(f) Complications
(i) Bleeding
(ii) Peritonitis
(iii) Gastrointestinal perforation
(iv) Tube dislodgement
(v) Aspiration
(vi) Wound infection
(vii) Pericatheter leakage

(2) Interventional Management: Percutaneous jejunostomy tube
(a) Indications
(i) Chronic aspiration
(ii) History of gastric surgery/altered anatomy
(iii) Abnormal gastric position
(iv) Bowel obstruction (rare)
(b) Technique
(i) Nasojejunal passage for saline distension
(ii) Jejunal access
(a) fluoroscopic guidance
(b) ultrasound guidance
(c) CT guidance
(d) Techniques to secure access
(iii) Dilation and catheter placement
(c) Follow up and Management
(i) Feeding initiation and tolerability
(ii) Removal of anchors
(iii) Tube maintenance

11. Miscellaneous
a) Percutaneous cecostomy
(1) Indications
(2) Technique
(3) Complications
(4) Follow up
b) Trans-gastric drainage
(1) Indications
(2) Techniques
(3) Complications
(4) Follow up

Genitourinary

1. Emergencies
    a) Obstructive
        (1) Pyonephrosis
    b) Hemorrhagic
        (1) Trauma
        (2) Iatrogenic
            (a) Post-partial nephrectomy
            (b) Post-biopsy
        (3) Angiomyolipoma rupture
        (4) Post-partum hemorrhage
2. Urologic obstructive disease
    a) Epidemiology
    b) Clinical presentation
        (1) Renal/pelvic
        (2) Ureteral
        (3) bladder
        (4) Urethral
    c) Examination and laboratory findings
    d) Imaging findings
        (1) radiographs
        (2) Ultrasound
        (3) Computed tomography
    e) Management
        (1) Medical
        (2) Surgical
        (3) Interventional
            (a) Percutaneous nephrostomy placement
                (i) Indications
                (ii) Pre-procedural evaluation
                (iii) Equipment
                (iv) Technical Considerations
                (v) Complications
                (vi) Post-procedural care
            (b) Ureteral stent placement
                (i) Antegrade
                    (a) Indications
                    (b) Pre-procedural evaluation
                    (c) Equipment
                    (d) Technical Considerations
                    (e) Complications
                    (f) Post-procedural care
                (ii) Retrograde
                    (a) Indications
                    (b) Pre-procedural evaluation
                    (c) Equipment
                    (d) Technical Considerations
                    (e) Complications
                    (f) Post-procedural care
            (c) Antegrade ureteric dilation
                (i) Indications
                (ii) Pre-procedural evaluation
                (iii) Equipment
                (iv) Technical Considerations
                (v) Complications
                (vi) Post-procedural care
            (d) Suprapubic cystostomy

(i) Indications
(ii) Pre-procedural evaluation
(iii) Equipment
(iv) Technical Considerations
(v) Complications
(vi) Post-procedural care

3. Renal stone disease
    a) Epidemiology
    b) Clinical presentation
    c) Examination and laboratory findings
    d) Imaging findings
        (1) Radiographs
        (2) Computed tomography
        (3) Ultrasound
    e) Management
        (1) Medical
        (2) Surgical
            (a) Percutaneous nephrolithotomy
            (b) Extracorporeal shockwave lithotripsy (ESWL)
        (3) Interventional
            (a) Nephrostomy placement
            (b) Ureteral stent placement
            (c) Antegrade ureteric dilation
            (d) Percutaneous nephrolithotomy access
                (i) Indications
                (ii) Pre-procedural evaluation
                (iii) Equipment
                (iv) Technical Considerations
                (v) Complications
4. Renal masses
    a) Renal Cell Carcinoma
        (1) Epidemiology
        (2) Diagnosis and Clinical presentation
        (3) Examination and laboratory findings
        (4) Imaging findings
            (a) Computed tomography
            (b) Magnetic resonance
            (c) Ultrasound
        (5) Staging and Treatment by Stage
            (a) Stage I - renal mass <7cm confined to kidney
                (i) Resection (radical nephrectomy or nephron-sparing partial nephrectomy)
            (b) Stage II - renal mass >7cm confined to kidney
                (i) Radical nephrectomy
            (c) Stage III - Extension into major veins or perinephric tissue, or nodal involvement
                (i) Radical nephrectomy
            (d) Stage IV - tumors extending beyond Gerota fascia or into ipsilateral adrenal gland
                (i) Molecular-targeted therapy
                (ii) Cytokine immunotherapy
                (iii) Combination cytokine immunotherapy + bevacizumab
        (6) Interventional Radiological services in RCC Management
            (i) Biopsy
                (a) Percutaneous
                    (i) Indications
                    (ii) Pre-procedural evaluation

(iii) Equipment
(iv) Technical Considerations
(v) Complications
(vi) Post-procedural care
(b) Transvenous
(i) Indications
(ii) Pre-procedural evaluation
(iii) Equipment
(iv) Technical Considerations
(v) Complications
(vi) Post-procedural care
(ii) Percutaneous ablation
(a) Indications
(b) Pre-procedural evaluation
(c) Imaging guidance
(i) Ultrasound
(ii) Computed tomography
(iii) Magnetic resonance
(d) Equipment
(i) Microwave
(ii) Radiofrequency
(iii) Cryoablation
(iv) Irreversible electroporation
(e) Technical Considerations
(f) Complications
(g) Post procedural care

b) Angiomyolipoma
(1) Epidemiology
(2) Clinical presentation
(3) Examination and laboratory findings
(4) Imaging findings
(a) Computed tomography
(b) Magnetic resonance
(c) Ultrasound
(5) Management
(a) Surgical
(b) Interventional
(i) Intra-arterial embolization
(a) Indications
(i) Emergent
(ii) Elective
(b) Pre-procedural evaluation
(c) Equipment
(i) Embolic agent
(d) Technical Considerations
(e) Complications
(f) Post-procedural care
(ii) Percutaneous ablation
(a) Indications
(b) Pre-procedural evaluation
(c) Equipment
(i) Microwave/radiofrequency
(ii) Cryoablation
(d) Technical Considerations
(e) Complications
(f) Post-procedural care

c) Renal cystic disease
    (1) Epidemiology
    (2) Clinical presentation
    (3) Examination and laboratory findings
    (4) Imaging findings
        (a) Computed tomography
            (i) Bosniak Classification
        (b) Magnetic resonance
        (c) Ultrasound
    (5) Management
        (a) Surgical
        (b) Interventional
            (i) Percutaneous drainage and sclerotherapy
                (a) Indications
                (b) Pre-procedural evaluation
                (c) Equipment
                    (i) Sclerosant
                (d) Technical Considerations
                    (i) Seldinger technique
                    (ii) Trocar technique
                (e) Complications
                (f) Post-procedural care

5. Renal vascular disease
    a) Renovascular hypertension and renal artery stenosis
        (1) Epidemiology
        (2) Clinical presentation
        (3) Examination and laboratory findings
        (4) Imaging findings
            (a) Computed tomography angiography
            (b) Magnetic resonance angiography
            (c) Ultrasound
            (d) Angiography
        (5) Management
            (a) Medical
            (b) Interventional
                (a) Indications
                (b) Pre-procedural evaluation
                (c) Equipment
                (d) Technical Considerations
                (e) Complications
                (f) Post-procedural care
                (g) Special considerations for renal transplants
    b) Fibromuscular dysplasia
        (1) Epidemiology
        (2) Clinical presentation
        (3) Exam and laboratory findings
        (4) Imaging findings
            (a) Computed tomography
            (b) Magnetic resonance imaging
            (c) Ultrasound
            (d) Angiography
        (5) Management
            (a) Medical
            (b) Interventional
                (a) Indications
                (b) Pre-procedural evaluation
                (c) Equipment

(d) Technical Considerations
(e) Complications
(f) Post-procedural care

c) Renal artery aneurysm
(1) Epidemiology
(2) Clinical presentation
(3) Exam and laboratory findings
(4) Imaging findings
(a) Computed tomography
(b) Magnetic resonance imaging
(c) Ultrasound
(d) Angiography
(5) Management
(a) Medical
(b) Surgical
(c) Interventional
(a) Indications
(b) Pre-procedural evaluation
(c) Equipment
(d) Technical Considerations
(e) Complications
(f) Post-procedural care

d) Nutcracker syndrome
(1) Epidemiology
(2) Clinical presentation
(3) Examination and laboratory findings
(4) Imaging findings
(a) Computed tomography
(b) Magnetic resonance imaging
(c) Ultrasound
(d) Venography
(5) Management
(a) Medical
(b) Surgical
(c) Interventional
(i) Indications
(ii) Pre-procedural evaluation
(iii) Equipment
(iv) Technical considerations
(v) Complications

6. Women's Health
a) Prevalence and pathophysiology including discussion on Leiomyosarcoma
b) Clinical presentation
(1) Bleeding
(2) Bulk symptoms
(3) Fibroids effect on fertility
c) Imaging evaluation: US and MRI
d) Medical management
(1) Diet and exercise
(2) Endocrine therapy
(3) Progesterone containing IUD
(4) Tranexamic acid
e) Surgical management
(1) Myomectomy
(a) Open surgery
(b) Laparoscopic surgery w/ and without morcellation
(c) Hysteroscopic resection of intracavitary fibroids

(2) Hysterectomy
(a) Abdominal
(3) Lap-assisted RF ablation

f) Uterine fibroid disease
1. UFE
a. Pre-Procedure
i. Nerve blockade
ii. Steroids
iii. Compression stockings
iv. Antibiotics
v. Zofran
b. Procedure
i. Femoral vs radial access
ii. Anatomy
a. Uterine artery origins
b. Utero-ovarian anastomoses
iii. Devices: 5 French system vs Micro catheters
iv. Embolic choices
v. Embolization endpoint
vi. Unilateral vs. bilateral embolization
vii. Imaging and procedural technique
viii. Intra-arterial lidocaine
ix. Toradol
x. Post UAE cone beam CT to document coverage
c. Post-procedure care
i. Pain management
i. PCA
b. IV tylenol
c. IA lidocaine
ii. Post embolization syndrome
d. Complications and their management
i. Immediate
ii. Delayed
e. Comparative effectiveness: Not just outcomes but also compared to Hyst, Myomectomy, MRgFUS
f. Fertility after UAE
g. Contraindications
h. Special considerations: What to do when faced with fibroids AND:
i. IUD
ii. Very large Fibroid uterus
iii. Pedunculated fibroids
iv. Intracavitary fibroids
v. Varying degrees of adenomyosis
2. MR-Guided Focused US
a. Basics/methodology of FUS
b. Patient selection
c. Procedure
d. Outcomes: comparative effectiveness
e. Complication

g) Adenomyosis
(1) Pathophysiology
(2) Clinical presentation
(3) Imaging evaluation: US & contrast MRI
(4) Medical management
(a) IUD
(5) Surgical management
(a) Hysterectomy

(6) Percutaneous interventions
(a) Uterine artery and uterine fibroid embolization
(i) Particle size
(ii) Outcomes

h) Hemorrhage
a. Etiology
1. Post-partum
a. definition
2. Abnormal placenta
a. Occlusion balloons
3. Ectopic pregnancy
4. Trophoblastic disease
5. Malignancy
a. Cervical cancer/radiation
b. Uterine cancer
6. Uterine AVM/AVF
a. Pathophysiology
b. Etiology
c. Imaging evaluation
d. Percutaneous treatment
i. Technique
ii. Complications

i) Pelvic congestion syndrome
a. Pathophysiology
b. Clinical presentation
c. IVUS!!
d. Medical and surgical management
e. Surgical management
f. Percutaneous interventions
1. Image-guided procedures
a. Ovarian vein embolization/sclerotherapy
b. Pelvic vein embolization/sclerotherapy
g. Other considerations
1. May-Thurner
a. IVUS/venography
b. Stent placement
c. Post-stent anti-plt/anti-coags
2. Nutcracker
3. LE venous insufficiency; often co-exists with PCS

j) Infertility
a. Pathophysiology
1. Female infertility
2. Male infertility
b. Definition
c. Imaging evaluation
d. Medical management
e. Surgical management
f. Percutaneous interventions
1. Hysterosalpingogram
a. Pre-procedure
b. Technique
2. Fallopian tube interventions
a. Recanalization
i. Technique
ii. Equipment
iii. Contrast: oil based vs. water based
iv. Outcomes

k) Pelvic Pathology
    (1) Solid ovarian mass
        (a) Biopsy techniques
            (i) Transgluteal
            (ii) Transrectal
            (iii) Transvaginal
        (b) Devices
    (2) TOA
    (3) Cystic ovarian mass
        (a) Endometrioma
        (b) Ovarian cyst
        (c) Percutaneous drainage
            (i) Aspiration
            (ii) Sclerosis
    (4) Pelvic abscess
        (a) Etiologies
            (i) Pecutaneous drainage
            (ii) Transgluteal
            (iii) Transrectal
            (iv) Transvaginal

7. Men's Health
    a) Male varicocele
        (1) Varicocele embolization
    b) Benign prostatic hypertrophy and lower urinary tract symptoms
        (1) Prostate artery embolization

Men's Health

1. Men's health anatomy
    a) Prostate
        (1) Glandular and stromal tissue
        (2) Anatomic relationships to pelvic structures
        (3) Embryological development
        (4) Lobes
            (a) Anterior
            (b) Median
            (c) Lateral
            (d) Posterior
        (5) Zones
            (a) Central zone
            (b) Peripheral zone
            (c) Transitional zone
        (6) Arterial Supply
            (a) Inferior vesicular
            (b) Prostatic artery
                (i) Origin
                (ii) Course
                (iii) Branches
        (7) Venous drainage
        (8) Lymphatic drainage
        (9) Innervation
        (10) Radiologic features
            (a) US
            (b) CT
            (c) MRI
    b) Seminal vesicles
    c) Spermatic cord
        (1) Ductus deferens
        (2) Artery of the ductus deferens, arising from the superior vesical artery
        (3) Testicular artery, arising from the abdominal aorta
        (4) Cremasteric artery, arising from the inferior epigastric artery
        (5) Pampiniform plexus draining into the testicular vein
        (6) Genital branch of the genitofemoral nerve
        (7) Lymphatics
        (8) Nerves
            (a) sympathetic nerve fibers on arteries
            (b) parasympathetic nerve fibres on the ductus deferens
        (9) Fascial layers
    d) Scrotum
        (1) Contents
        (2) Vascular supply
            (a) Perineal artery
            (b) Anterior scrotal branches
            (c) Cremasteric artery
        (3) Venous drainage
        (4) Innervation

(a) Anterior ⅓ - Ilioinguinal and genitofemoral nerves (L1)
(b) Posterior ⅔ - Perineal and posterior femoral cutaneous nerve

e) Pelvic arterial and venous anatomy (CR XXX)

2. Benign prostatic hyperplasia (BPH)
   a) Epidemiology
   b) Pathophysiology
      (1) Roles of hormones
      (2) Roles of DHT
      (3) BPH and BPE
      (4) Prostatic obstruction
   c) Lower urinary tract symptoms
      (1) Prevalence
      (2) Causes other than prostate
      (3) BPH and LUTS
         (a) Static component
         (b) Dynamic component
      (4) Storage symptoms
      (5) Voiding symptoms
   d) Validated symptom evaluation methods/diagnosis
      (1) AUA-SI
      (2) International Prostate Symptom Score (I-PSS)
      (3) BPH Impact Index
      (4) Range of scores, meaningful change
   e) Medical management and complications
      (1) Behavioral interventions
      (2) Medications
         (a) Alpha blockers
         (b) 5-alpha reductase inhibitors
         (c) Anticholinergic agents
         (d) Beta-3 adrenergic agonist
         (e) Phosphodiesterase type 5 inhibitors
      (3) First line therapy
         (a) Mild symptoms
         (b) Moderate symptoms
         (c) Severe symptoms/ineffective monotherapy
   f) Surgical management of BPH
      (1) Patient selection
      (2) Work up
         (a) Imaging
         (b) Post Void residual
         (c) Uroflometry
      (3) Surgical techniques and complications
         (a) TURP
         (b) Simple prostatectomy
         (c) TUIP
         (d) TUVP
         (e) Prostatic urethral lift (PUL)
         (f) Water vapor thermal therapy
         (g) Transurethral microwave therapy (TUMT)

(h) Photoselective vaporization of the prostate (PVP)
(i) Laser enucleation
(j) Surgical complications
(k) Comparison of effectiveness between approaches

g) Endovascular management of PBH
(1) Rationale
(a) Role of DHT
(b) Alpha1 adrenergic receptor density
(2) Patient selection
(a) prostate vol >30m
(b) IIPSS: ≥ 18
(c) QoL: ≥ 3IEFF: only monitoring
(d) Qmax: ≤ 15 ml/s at micturition volume of ≥ 150 ml
(e) Postvoid residual volume: only monitoring, no upper or lower limit
(3) Indications
(a) Patients with special risks regarding surgery/anesthesia.
(b) Sexually active men (risk of retrograde ejaculation in standard methods)
(c) prostate vol. >65ml (alternative to open prostate adenomectomy)
(d) refractory BPS medication
(e) permanent bladder catheter
(f) recurrent bleeding caused by BPH
(4) Contraindications
(a) prostate cancer
(b) large bladder diverticula or bladder concretions (relative)
(c) acute infections (prostatitis, urethritis)
(d) urethral strictures
(e) neurogenic bladder dysfunction
(f) pronounced arteriosclerosis (relative)
(g) renal insufficiency (eGFR <60ml/min)
(5) Procedural technique
(a) Aortogram
(b) Role of cone beam CT and MIP reconstructions
(c) Commonly used catheters
(d) Addressing non-target arteries
(e) Embolization technique
(i) Material
(ii) Size
(iii) PErFecTED technique
(6) Periprocedural management
(a) Antibiotics
(i) Pre Procedure
(ii) Post procedure
(b) NSAIDs
(7) Adverse events
(a) light pressure or minimal pain in the pelvic region radiating into the perineal region → 2 days

(b) blood or coagulum in their ejaculate up to 1 month
(c) post-embolization syndrome
(d) hematuria
(e) urinary tract infections
(f) increased urgency
(g) <1%: hematospermia, rectal bleeding

(8) Clinical follow up
(a) Repeat IPSS, Qol, IIEF etc
(b) Frequency

h) Important clinical trials

3. Varicoceles
a) Epidemiology
b) Pathophysiology
(1) Pampiniform plexus
(2) Laterality
(3) Anatomic factors
(a) Left renal vein insertion
(b) Lack of anti reflux valves

c) Classification criteria
(1) Large
(2) Moderate
(3) Small

d) Varicocele and infertility
(1) Mechanisms
(2) Scrotal US
(3) Spermatic venography

e) Indications for treatment
(1) Palpable
(2) Infertility
(3) Abnormal smen analysis of sperm function tests
(4) Other indications
(5) Adolescents
(6) Monitoring

f) Treatment technique
g) Peri-procedural management
h) Follow up clinical and imaging protocols

Neurological

1. Fundamentals
    a) Neurological examination
        (1) Cranial nerve exam
        (2) Neurological exam – cranial pathology
        (3) Neurological exam – spinal pathology
    b) Neurovascular anatomy
        (1) Cervical
            (a) Typical 3 vessel Arch Anatomy
            (b) Great Vessel Variants
                (i) Bovine Arch
                (ii) Aberrant Right Subclavian Artery
                (iii) Vertebral Artery Variants
            (c) Congenital Absence of the Carotid Artery
            (d) External Carotid Artery Anatomy
                (i) Extra to Intracranial Collaterals
                (ii) Collateral pathways to the Orbit/Ophthalmic artery
            (e) Segments of the Internal Carotid Artery
            (f) Segments of the Vertebrobasilar system
        (2) Intracranial
            (a) Intracranial segments of internal carotid and vertebral arteries
            (b) Normal Anatomy
                (i) ACA
                (ii) MCA
                (iii) PCA
                (iv) Circle of Willis
            (c) Persistent Fetal Communications
                (i) PCOM
                (ii) Persistent Trigeminal Artery
            (d) Understanding Nomenclature for Middle Cerebral Artery Segments
        (3) Spinal
            (a) Segmental Artery
            (b) Radicular Branches
            (c) Medullary Branches
            (d) Thyrocervical Trunk
            (e) Supreme Intercostal Arteries
            (f) Anterior spinal Artery
            (g) Posterior spinal artery
            (h) Artery of Adamkiewicz
        (4) Venous
            (a) Cerebral veins
            (b) Dural venous sinuses
            (c) Common variants (i.e. vein of Trolard, vein of Labbe, persistent occipital sinus)
    c) Common tools and devices used in Neuro Interventional Radiology (NIR) (CR XXX)
        (1) Sheaths
        (2) Guide catheters
        (3) Distal access catheters
        (4) Catheters
        (5) Microcatheters
        (6) Wires and microwires
    d) Drugs used in NIR
2. Cervical pathology
    a) Fibromuscular Dysplasia (CR XXX)
        (1) Prevalence

(2) Natural history
(3) Imaging considerations
(4) Management

b) Carotid webs
(1) Prevalence
(2) Natural history
(3) Imaging considerations
(4) Management

c) Vasculitides (Takayasu, Giant Cell)
(1) Prevalence
(2) Natural history
(3) Imaging considerations
(4) Management

d) Dissections
(1) Prevalence
(a) Iatrogenic
(b) Spontaneous
(c) Traumatic
(2) Clinical presentation
(3) Natural history
(4) Exam and laboratory findings
(5) Imaging findings
(6) Management
(a) Medical
(b) Surgical
(c) Interventional
(i) Indications
(ii) Pre-procedural workup
(iii) Equipment
(iv) Technical considerations
(v) Complications

3. Vascular anomalies
a) Acquired
(1) Dural AV Fistula
(a) Classification systems
(b) Imaging findings
(c) Natural history
(d) Management
(i) Medical
(ii) Surgical
(iii) Interventional

b) Congenital
(1) Cavernous malformation
(2) Capillary Telangiectasia
(3) Developmental Venous Anomaly
(4) Arteriovenous Malformation
(a) Classification systems
(b) Imaging findings
(c) Natural history
(d) Management
(i) Medical
(ii) Surgical (open, radiosurgery)
(iii) Interventional
(iv) Combined treatment

c) Spine vascular anomalies
(1) Prevalence
(2) Natural history

(3) Imaging considerations
(4) Management

4. Tumors of Head and Neck
    a) Glomus Tumors
        (1) Prevalence/Natural History/Management
        (2) Imaging Considerations
        (3) Indications for Pre-operative Embolization
    b) Juvenile Nasopharyngeal Angiofibroma
        (1) Prevalence/Natural History/Management
        (2) Imaging Considerations
        (3) Indications for Pre-operative Embolization
5. Intracranial tumors
    a) Meningioma
        (1) Prevalence/Natural History/Management
        (2) Imaging Considerations
        (3) Indications for Pre-operative Embolization
6. Epistaxis
    a) Prevalence
    b) Clinical presentation
    c) Natural history
    d) Exam and laboratory findings
    e) Imaging findings
    f) Management
        (1) Medical
        (2) Surgical
        (3) Interventional
            (a) Indications
            (b) Pre-procedural workup
            (c) Equipment
            (d) Technical considerations
                (i) Dangerous colaterals
            (e) Complications
7. Atherosclerosis (CR XXX)
    a) Carotid artery atherosclerosis
        (1) Prevalence
        (2) Clinical presentation
        (3) Natural history
        (4) Exam and laboratory findings
        (5) Imaging findings
        (6) Management
            (a) Medical
            (b) Surgical
            (c) Interventional
                (i) Indications
                (ii) Pre-procedural workup
                (iii) Equipment
                (iv) Technical considerations
                (v) Complications
        (7) Key trials
        (8) Credentialing for carotid intervention
    b) Vertebrobasilar insufficiency
        (1) Prevalence
        (2) Clinical presentation
        (3) Natural history
        (4) Exam and laboratory findings
        (5) Imaging findings
        (6) Management

(a) Medical
(b) Surgical
(c) Interventional
(i) Indications
(ii) Pre-procedural workup
(iii) Equipment
(iv) Technical considerations
(v) Complications

c) Subclavian steal
(1) Prevalence
(2) Clinical presentation
(3) Natural history
(4) Exam and laboratory findings
(5) Imaging findings
(6) Management
(a) Medical
(b) Surgical
(c) Interventional
(i) Indications
(ii) Pre-procedural workup
(iii) Equipment
(iv) Technical considerations
(v) Complications

d) Intracranial atherosclerosis disease
(1) Prevalence
(2) Clinical presentation
(3) Natural history
(4) Exam and laboratory findings
(5) Imaging findings
(6) Management
(a) Medical
(b) Surgical
(c) Interventional
(i) Indications
(ii) Pre-procedural workup
(iii) Equipment
(iv) Technical considerations
(v) Complications
(7) Key trials

e) Vascular entrapment syndromes

8. Intracranial aneurysms
a) Prevalence
b) Clinical presentation
c) Natural history
d) Exam and laboratory findings
e) Imaging findings/Surveillance
f) Management
(1) Medical
(2) Surgical
(3) Interventional
(a) Indications
(b) Pre-procedural workup
(c) Equipment
(d) Technical considerations
(e) Complications

g) Key trials

9. Venous sinus thrombosis

10. Acute subarachnoid hemorrhage
11. Acute ischemic stroke
    a) Prevalence
    b) Clinical presentation
    c) Natural history
    d) Exam and laboratory findings
        (1) Pre-Hospital stroke tools
        (2) NIHSS
        (3) mRS
    e) Imaging findings
        (1) CT Aspects score
        (2) CT/MR perfusion
        (3) CTA/MRA
        (4) Assessment of collaterals
    f) Management
        (1) Medical
        (2) Surgical
        (3) Interventional
            (a) Indications
            (b) Pre-procedural workup
            (c) Equipment
            (d) Technical considerations including techniques
            (e) Complications
    g) Systems of Care
        (1) Primary
        (2) Thrombectomy capable
        (3) Comprehensive
    h) Key endovascular stroke trials

Oncology

1. Core principles of oncology
    a) Trial design
        (1) FDA trial phases
            (a) Phase I - Evaluate safety and toxicity
            (b) Phase II - Evaluate efficacy at the maximum tolerated dose
            (c) Phase III - Compare new treatment with standard of care
            (d) Phase IV - Postmarketing
        (2) Trial design
            (a) Randomized controlled trials (RCTs)
                (i) Blinding
                    (a) Single-blind - participant blinded
                    (b) Double-blind - participant and investigator blinded
                    (c) Triple-blind - participant, investigator, and data evaluator blinded
            (b) Comparative trials (nonrandomized) - vulnerable to bias
                (i) Sources of bias
                    (a) Selection bias
                    (b) Allocation bias
                (ii) Minimizing bias
                    (a) Propensity scoring
                    (b) Match pairing
            (c) Intention-to-treat analysis - indicates all patients assigned to a study arm at time of randomization are analyzed regardless of subsequent events
            (d) Per-protocol analysis - only patients who complete clinical trial according to trial protocol are evaluated
    b) Oncology statistics
        (1) Time-to-Endpoint analysis (Kaplan-Meier)
            (a) Progression free survival (PFS) or overall survival (OS)
                (i) X-axis - time
                (ii) Y-axis - Proportion of patients free from disease progression/death (PFS analysis) or proportion of patients alive (OS analysis)
        (2) Hazard/Relative Risk Ratio, Absolute Risk Reduction, Number Needed to Treat
            (a) Hazard Ratio (HR) - Probability that a patient will experience a hazardous event during a specified time interval
            (b) Relative Risk Ratio (RR) - Probability that a hazardous event will occur over the entire course of the study
                (i) Indicates whether two characteristics are significantly related (risk factor vs event)
            (c) Absolute Risk Reduction (ARR
            (d) Relative Risk Reduction (RRR)
            (e) Number Needed to Treat
        (3) Correlation
            (a) Spearman rank correlation coefficient -
        (4) Confidence Intervals
            (a) Indicators of variability and reliability of an estimate
            (b) Indicate probability that the interval provided will contain the true parameter value
        (5) Error and Power
            (a) Null Hypothesis - States that there is no difference between the rates of a particular event in two groups
            (b) Type I error - “False-positive” - Find a difference between two interventions when it actually does not exist in the larger population

(i) α - probability that the sample studied provides artificial evidence of a difference (probability of a type I error)
(ii) Must be cautious of type I error in the setting of multiple comparisons
(iii) Bonferroni methodology can avoid type I error
(a) observed P value multiplied by number of tests
(c) Type II error - “False-negative” - Find no difference between two interventions when a difference exists in the larger population
(i) β - probability that type II error will occur
(ii) Power of a study is the probability that a type II error will not occur (1 - β)

c) Levels of evidence
(1) Level I
(a) Randomized controlled trial (RCT)
(b) Meta-analyses of RCTs
(2) Level II evidence
(a) Nonrandomized controlled trials
(b) Subset analyses of RCTs
(3) Level III evidence
(a) Cohort studies
(b) Case series
(c) Case-control studies
(4) Strength of study endpoints:
(a) Level A - Total mortality (strongest and most easily-defined)
(b) Level B - Cause-specific mortality
(c) Level C - Quality of Life assessment
(d) Level D - Event-free survival, disease-free survival, PFS, tumor response rate

d) Tumor staging systems
(1) Staging - reflects extent of disease, useful in determining treatment options and prognosis
(a) TNM staging (tumor / node / metastasis)
(b) Disease specific staging systems
(c) Clinical staging - physical exam + imaging
(d) Pathologic staging
e) Response assessment
(1) Tumor Response Assessment
(a) WHO - Tumor Response Assessment (cross-product = product of largest diameter and largest perpendicular of each tumor present)
(i) Complete Response (CR) - Disappearance of all disease
(ii) Partial Response (PR) - ≥50% decrease in sum of cross-products
(iii) Disease Progression (DP) - ≥25% increase in size of 1 or more tumors or appearance of new lesion
(iv) Stable Disease (SD) - Does not meet criteria for CR or PR
(b) RECIST 1.0
(i) Complete response - Disappearance of all disease
(ii) Partial response - ≥30% decrease in sum of longest diameters
(iii) Disease Progression - ≥20% increase in smallest sum measured on any previous study or appearance of new lesions
(iv) Stable Disease - Does not meet criteria for CR or PR
(c) RECIST 1.1

(i) Complete response - Disappearance of all lesions and pathologic lymph nodes
(ii) Partial response - ≥30% decrease in sum of longest diameters
(iii) Disease Progression - ≥20% increase in smallest sum measured on any previous study but increase must be 5 mm, or appearance of new lesions
(iv) Stable disease - Does not meet criteria for CR or PR

(d) EASL (HCC)
(i) Complete Response - Disappearance of all lesions
(ii) Partial Response - ≥50% decrease in sum of cross-products of enhancing lesion
(iii) Progressive disease - ≥25% increase in enhancing lesion or appearance of new lesion
(iv) Stable Disease - Does not meet criteria for CR or PR

(e) mRECIST (HCC)
(i) Complete Response - Disappearance of any intratumoral enhancement in all target lesions
(ii) Partial response - ≥30% decrease in sum of longest diameters of viable (enhancement in arterial phase) target lesions
(iii) Progressive Disease - ≥20% increase in smallest sum of diameters of viable (enhancement in arterial phase) target lesions measured on any previous study
(iv) Stable Disease - Does not meet criteria for CR or PR

(2) Clinical Response Assessment
(a) Efficacy vs. effectiveness
(i) Efficacy - ability of therapy to bring about intended effect in ideal setting
(ii) Effectiveness - ability of therapy to bring about intended effect in real-life circumstances

(b) Overall response rate (ORR)
(i) Proportion of patients in a study with measurable reduction in tumor size based on radiologic assessment or physical exam
(ii) Response duration - time of response until time at which progression is identified
(iii) ORR - number of patients with CR or PR
(iv) Disease Control Rate (DCR) - Sum of CR, PR, and SD

(c) Overall Survival (OS)
(i) Gold-standard endpoint for cancer research/trials
(ii) Definition - period of time from randomization to death
(iii) Reflects most valuable benefit to patient

(d) Time-to-Progression and Progression-free Survival
(i) Time-to-progression (TTP) - time from randomization to time of objective disease progression
(a) Death occurring without evidence of tumor progression is censored in this analysis (will not take into account drug toxicity)
(ii) Progression-free Survival (PFS) - time from randomization to time of objective disease progression or death
(a) Takes into account drug toxicity
(iii) These are beneficial because they are shorter endpoints for clinical trials

f) Toxicity
(1) Common Terminology Criteria for Adverse Events (CTCAE)
(a) Grade 1: mild

(b) Grade 2: moderate
(c) Grade 3: severe
(d) Grade 4: life-threatening
(e) Grade 5: fatal

g) Essentials concepts of chemotherapy
  (1) Common chemotherapy classes
    (a) Anti-metabolite
      (i) Mechanism
      (ii) Examples
    (b) Platinum based
      (i) Mechanism
      (ii) Examples
    (c) Taxane
      (i) Mechanism
      (ii) Examples
    (d) Topoisomerase inhibitors
      (i) Mechanism
      (ii) Examples
  (2) Chemotherapy settings
    (a) Induction
    (b) Neoadjuvant
    (c) Adjuvant
    (d) Loco-regional

h) Molecular therapies
  (1) Common cell signal pathway receptors
    (a) Epidermal growth factor receptor (EGFR)
    (b) Vascular endothelial growth factor receptor (VEGFR)
    (c) KRAS
    (d) HER2/neu
  (2) Therapeutics targeting molecular receptors
    (a) Cetuximab
    (b) Bevacizumab
    (c) Sunitinib
    (d) Sorafenib
    (e) Regorafenib

i) Concepts of surgical oncology
  (1) Curative surgery
    (a) Definition
      (i) Primary tumor vs metastasectomy
    (b) Tumor margins
      (i) R0
      (ii) R1
      (iii) R2
  (2) Cytoreductive surgery
    (a) Definition
      (i) Survival prolongation vs palliation
  (3) Prophylactic surgery
    (a) Definition
    (b) Current roles
      (i) BRCA mutation
      (ii) Polyposis syndromes
  (4) Fundamentals of hepatic resections
    (a) Liver segmental anatomy
      (i) Couinaud segmental anatomy
      (ii) Common hepatic resections
        (a) Right hepatectomy (segments 5-8)
        (b) Right trisegmentectomy (segments 4-8)

(c) Left hepatectomy (segments 2-4)
(d) Left lateral segmentectomy (segments 2-3)
(e) Left trisegmentectomy (segments 2-5, 8)
(b) Functional liver remnant (FLR)
(i) Requirements with and without cirrhosis
(ii) Techniques to increase FLR
(a) Surgical – PV ligation
(b) Portal vein embolization
(i) Techniques
(ii) Embolic selection
(iii) Access sites
(c) Radiation lobectomy with Y90

j) Concepts of radiation oncology
(1) Mechanism of cell death
(a) Radiation induced DNA damage
(2) Role of cellular oxygen level in lethality
(a) Oxygen enhancement ratio
(3) Fractionation
(a) Rationale - DNA repair in tumor cells vs normal cells
(i) Methods
(a) Accelerated fractionation
(b) Hyperfractionation
(c) Hypofractionation
(4) Techniques of radiation therapy
(a) Three-dimensional conformal radiation therapy
(b) Intensity modulated radiation therapy (IMRT)
(c) Stereotactic radiosurgery
(d) Brachytherapy

2. Interventional oncology techniques and devices
a) Percutaneous therapies
(1) Radiofrequency ablation
(a) Mechanism of cell death
(b) Advantages
(c) Disadvantages
(d) Current applications
(2) Microwave ablation
(a) Mechanism of cell death
(b) Advantages
(c) Disadvantages
(d) Current applications
(3) Cryoablation
(a) Mechanism of cell death
(b) Advantages
(c) Disadvantages
(d) Current applications
(4) Chemical ablation
(a) Ethanol & acetic acid
(i) Mechanism of cell death
(ii) Advantages
(iii) Disadvantages
(iv) Current applications
(5) Irreversible electroporation
(a) Mechanism of cell death
(b) Advantages
(c) Disadvantages
(d) Current applications
(6) High-intensity focused ultrasound

(a) Mechanism of cell death
(b) Advantages
(c) Disadvantages
(d) Current applications

b) Transarterial therapies
(1) Bland embolization
(a) Mechanism of cell death
(b) Advantages
(c) Disadvantages
(d) Current applications
(2) Portal vein embolization
(3) Chemoembolization
(a) Methods
(i) Conventional transarterial chemoembolization (TACE)
(ii) Drug eluting beads TACE
(b) Mechanism of cell death
(c) Advantages
(d) Disadvantages
(e) Current applications
(4) Radioembolization
(a) Mechanism of cell death
(b) Dosimetry
(c) Advantages
(d) Disadvantages
(e) Current applications

3. Disease-Specific Review
a) Hepatocellular carcinoma
(1) Epidemiology
(a) Worldwide vs United States
(b) Trends by ethnicity
(c) Trends by etiology
(d) Risk factors
(i) Cirrhosis is largest risk factor
(e) Effect of sustained virologic response (SVR)
(f) Prevention of HCC
(g) Screening recommendations
(2) Diagnosis
(a) Role of ultrasound, CT, MRI
(i) CT, MRI Imaging characteristics
(a) Lesion >1cm with hypervascularity on arterial phase and washout on portal venous/delayed phases
(b) Role of biomarkers (alpha fetoprotein - AFP)
(c) Role of biopsy
(i) Reserved for indeterminate lesions on imaging
(3) Staging
(a) Evaluation of hepatic function
(b) Evaluation of portal hypertension
(i) Varices
(ii) Spleen size
(iii) Thrombocytopenia
(iv) Hepatic venous pressure gradient
(c) Evaluation of disease extent
(i) Chest CT
(ii) Bone Scan
(d) Barcelona Clinic Liver Cancer (BCLC) Staging System

(i) Very Early (0)
(ii) Early (A)
(iii) Intermediate (B)
(iv) Advanced (C)
(v) Terminal (D)
(e) Child-Pugh classification
(f) Hong-Kong staging system
(g) National Comprehensive Cancer Network (NCCN) guidelines
(4) Treatment options (based on BCLC staging system)
(a) Hepatic resection
(i) Recommended for very early disease (BCLC 0)
(ii) Resection criteria
(a) Child Pugh class A
(b) Preserved liver function
(i) Hepatic venous pressure gradient <10 mmHg
(ii) Platelet count >100k
(iii) Bilirubin < 1 mg/dL
(iv) Lack of varices
(iii) Couinaud liver segments
(b) Liver transplantation
(i) Concept - removes both tumor and underlying liver disease
(ii) Transplant criteria
(a) Milan criteria - single tumor < 5cm or up to 3 tumors, all < 3cm
(b) Other criteria (UCSF, Milan+AFP, etc)
(c) Concept of downstaging
(iii) Recommended for very early or early disease (BCLC 0-A)
(iv) Bridging and downstaging for transplant
(a) Selection of local control.
(c) Thermal and percutaneous ablation
(i) Recommended for BCLC A patients (early HCC) who are not optimal surgical candidates
(ii) Several modalities
(a) RF ablation
(b) Microwave ablation
(c) Cryoablation
(d) Percutaneous ethanol ablation
(iii) Rates of tumor recurrence
(a) Resection vs thermal ablation
(d) Transarterial therapy
(i) Recommended for intermediate stage disease (BCLC B)
(ii) Conventional transarterial chemoembolization (TACE)
(a) Advantages / rationale
(i) Embolize arterial blood supply
(ii) Drug administration to tumor
(b) Sentinel RCTs
(i) Llovet / Lo
(iii) Bland embolization
(a) Advantages / rationale
(i) Embolize arterial blood supply
(ii) Simple / reproducible
(iv) Drug eluting beads (DEB TACE)
(a) Advantages / rationale
(i) Embolize arterial blood supply
(ii) Drug administration to tumor
(iii) Standardized dosing / controlled delivery

(v) Radioembolization (yttrium 90)
(a) Advantages / rationale
(i) Non-embolic or microembolic
(ii) Reproducible dose administration
(iii) Outpatient treatment
(iv) Use for segmentectomy
(e) Systemic therapy
(i) Recommended for advanced disease (BCLC C)
(a) First line agent - Sorafenib
(i) Mechanism - multikinase inhibitor
(ii) Common adverse events
(b) Second line agent – Regorafenib
(f) Immunotherapy use in HCC
(i) Nivolumab
(ii) Lenvatinib
(iii) Cabozantinib
(g) Radiation therapy for HCC
(i) Protons
(ii) Photons

b) Colorectal Cancer
(1) Epidemiology
(2) Diagnosis
(3) Staging (AJCC TNM Classification)
(a) Stage I - does not extend beyond muscularis propria
(b) Stage II - extends beyond colon and may be locally invasive
(c) Stage III - lymph node metastasis
(d) Stage IV - distant metastases
(4) Molecular profiling
(a) MSI
(b) KRAS
(5) Treatment
(a) Stage I and II (no evidence of distant metastasis)
(i) Surgical resection of primary tumor and en bloc removal of regional lymph nodes is standard of care
(ii) Laparoscopic colectomy vs open colectomy
(b) Stage III disease
(i) 5-FU-based chemotherapy combined with oxaliplatin
(c) Stage IV disease
(i) First-line treatment is FOLFOX or FOLFIRI with/without molecular targeted therapy:
(a) Bevacizumab + FOLFOX/FOLFIRI
(b) Panitumumab + FOLFOX/FOLFIRI
(c) Cetuximab + FOLFIRI
(ii) Patients with isolated hepatic metastasis may be candidates for surgical resection
(iii) Patients with hepatic metastasis who are not surgical candidates
(a) RFA for tumors <4cm
(b) Recurrence after hepatic resection
(iv) Patients with unresectable hepatic metastases
(a) Y90
(i) Upfront (1st line)
(ii) 2nd line
(iii) Salvage/Chemo holiday
(b) Hepatic arterial embolization with Irinotecan DEBs
(c) Intra-arterial infusion catheters/ports

c) Neuroendocrine Tumors

(1) Epidemiology
(2) Diagnosis
    (a) Cross-sectional multiphase imaging
    (b) Nuclear medicine imaging with somatostatin analogue
    (c) Chromogranin A
    (d) 5-HIAA
(3) Staging/Classification
    (a) TNM Staging
    (b) Classification:
        (i) G1 - Well-differentiated, low grade
        (ii) G2 - Well-differentiated, intermediate grade
        (iii) G3 - Poorly differentiated, high grade
    (c) Treatment
        (i) For <2cm NET
            (a) Surgical resection curative
        (ii) NET with limited hepatic disease
            (a) Surgical resection of primary tumor + hepatic metastases
        (iii) Unresectable but asymptomatic disease
            (a) Observation
        (iv) Symptomatic but unresectable disease
            (a) Octreotide
            (b) Molecular-targeted therapy (everolimus/sunitinib)
            (c) PRRT
            (d) TACE
            (e) Y90
            (f) CAPTEM

d) Intrahepatic Cholangiocarcinoma
(1) Epidemiology
    (a) Risk factors - chronic biliary inflammation (primary sclerosing cholangitis, liver fluke, hepatolithiasis, cirrhosis)
(2) Staging
    (a) Number of tumors
    (b) Presence of vascular invasion
    (c) Lymph node metastases
(3) Treatment
    (a) Surgical candidate
        (i) Resection is only curative therapy
        (ii) If R1/R2 resection - may receive additional resection with locoregional therapy, chemoradiation with fluoropyrimidine, or fluoropyrimidine and gemcitabine therapy
    (b) Locoregional therapies
        (i) RFA shown to provide good local tumor control in patient with unresectable cholangiocarcinoma (optimal tumor size <5cm)
        (ii) TACE
        (iii) Y90
        (iv) Proton therapy
        (v) SBRT
    (c) Chemotherapies
        (i) Gemcitabine & cisplatin
        (ii) Bevacizumab

e) Lung Cancer
(1) Diagnosis
(2) Staging
    (a) Stage I - tumor size <5cm

(b) Stage IIa - tumor size 5-7cm without lymph node involvement, or <5cm with ipsilateral peribronchial or hilar lymph node involvement
(c) Stage IIb - tumor size 5-7cm with ipsilateral peribronchial or hilar lymph node involvement or >7cm without lymph node involvement, or tumor with local invasion
(d) Stage IIIa - tumor of any size with ipsilateral mediastinal or subcarinal lymph node involvement or invasion of critical structures with lymph node involvement limited to peribronchial or hilar lymph nodes
(e) Stage IIIb - Any involvement of supraclavicular or contralateral lymph nodes
(f) Stage IV - separate tumor in contralateral lobe, pleural nodules, malignant effusion, distant metastases

(3) Treatment
(a) Molecular analysis important in guiding treatment
(i) EGFR mutations → associated with sensitivity to molecular-targeted therapy with tyrosine kinase inhibitors erlotinib and gefitinib
(ii) EML4-ALK mutation → use of Tyrosine Kinase inhibitor crizotinib
(iii) ERCC1 mutation → sensitivity to platinum-based chemotherapy
(iv) KRAS mutation → associated with shorter survival than wild-type KRAS
(b) Lung cancer resection with complete ipsilateral mediastinal lymph node dissection indicated for stage I, II, and IIIa disease
(c) Chemotherapy can be given neoadjugant or adjuvant for advanced or metastatic disease
(i) Platinum-based chemo is foundation
(d) Chemotherapy + Radiation is standard for unresectable stage III disease
(e) SBRT treatment options
(f) Ablation is an option for localized, node-negative lung cancer in patient who refuses surgery or would not tolerate surgery
(g) Ablation selection
(i) Cryoablation
(ii) RFA
(iii) Microwave ablation
(iv) IRE

(4) Treatment of lung metastasis
(a) Approach based on tumor biology
(b) Surgical resection
(c) SBRT
(d) Percutaneous ablation

f) Renal cell carcinoma has been moved to the GU section
g) Osseous metastatic disease
(1) Diagnosis
(2) Treatment
(a) Painful osseous metastases
(i) External beam radiation
(ii) Cryoablation
(iii) RFA
(iv) Embolization
(v) Cementoplasty
(vi) Percutaneous internal fixation
(b) Painful vertebral compression fracture due to osseous tumor
(i) Cementoplasty (vertebroplasty/kyphoplasty)

(ii) RFA
(iii) Combination therpay

4. Principles of pediatric interventional oncology
    a) Differences between pediatric and adult cancers
        (1) Origin cell
            (a) Pediatric: developmental tissue progenitors in the embryo and fetus; fetal blood
            (b) Adult: epithelia; adult blood
        (2) Timeline of natural history
            (a) Pediatric: Months to 15 years
            (b) Adult: 2-3 decades
        (3) Genetic instability
            (a) Pediatric: Rare
            (b) Adult: Common
        (4) Risk factors
            (a) Pediatric: Endogenous, proliferative, stress
            (b) Adult: Genotoxic, exposures, persistent proliferative stress or infection
        (5) Cumulative risk
            (a) Pediatric: ~1 in 800 (0-15 years)
            (b) Adult: ~1 in 3 (16-90 years)
        (6) Age associated incidence distribution
            (a) Pediatric: Defined, age linked peak, incidence in infancy or childhood
            (b) Adult: Increases as power of age
    b) Predisposing syndromes causing childhood cancers
        (1) Li-Fraumeni syndrome
        (2) Tuberous sclerosis
        (3) Rhabdoid tumor syndrome
        (4) Von Hippel-Lindau syndrome
        (5) Familial Adenomatous polyposis
        (6) Beckwith-Weidmann syndrome
        (7) Neurofibromatosis-1
        (8) PTEN hamartoma syndrome
        (9) Hereditary neuroblastoma
        (10) Herreditary retinoblastoma
        (11) Multiple endocrine neoplasia type 2
    c) Common pediatric solid tumors
        (1) Neuroblastoma
        (2) Wilm’s tumor
        (3) Retinoblastoma
        (4) Hepatoblastoma
        (5) Hemangiomas-congenital
        (6) Focal nodular hyperplasia
        (7) Hemangioendothelioma
        (8) Angiosarcoma
        (9) Rhabdosarcoma
        (10) Ewing’s sarcoma
        (11) Osteosarcoma
        (12) Desmoid tumor
        (13) Chondrosarcoma
        (14) Giant cell tumor
        (15) Osteoid osteoma
        (16) Infantile myofibroma
        (17) Kaposiform hemangioendothelioma
        (18) Synovial sarcoma

Pain and Palliation

1. Epidemiology/Basic Science
    a) Epidemiology
        (1) Frequency of medical consultation for pain issues
        (2) Demographics of patients with pain issues
        (3) Various medical disciplines involved in pain issues
        (4) Chronicity of pain issue consultations
            (a) Pre-procedural - prevention
            (b) Post-procedural
            (c) Acute non-procedural related
            (d) Chronic non-procedural related
    b) Common terminology and definitions (IASP)
        (1) Pain
        (2) Acute versus sub-acute versus chronic
        (3) Breakthrough pain
        (4) Incident pain
        (5) Referred pain
        (6) Phantom pain
        (7) Total pain
        (8) Allodynia
        (9) Anesthesia
        (10) Dysesthesia
        (11) Hyperalgesia
        (12) Hyperesthesia
        (13) Neuralgia
        (14) Neuritis
        (15) Paresthesia
        (16) Sensitization

    c) Basic science of pain signals
        (1) Origin of pain signals
            (a) Nociceptive
            (b) Neuropathic
            (c) Other
        (2) Pain receptors
            (a) Nociceptor
            (b) Sensory fibers (C, Aβ, Aδ)
            (c) Interplay +ve and -ve signals – The pain gate model
        (3) Pain pathways
            (a) Pain signaling pathways from receptor to brain
                (i) Ascending pathway
                    (a) Dorsal root ganglion
                    (b) Spinal column pathways
                        (i) Lateral spinothalamic tract
                        (ii) Spinoreticulothalamic tract
                        (iii) Spinoreticular tract
                        (iv) Spinohypothalamic tract

            (b) Negative regulating pathways
                (i) Spinomesencephalic tract
        (4) Pain neurotransmitters
            (a) At the nociceptor receptor
            (b) At the spinal column
        (5) Opiate receptors
            (a) Endogenous opioids
            (b) Opioid receptors (δ, κ, μ, ζ, nociceptin)
        (6) Nerve block agents

(a) Mechanism of action
(b) Family types

2. Clinical Presentation
    a) Disease processes associated with pain
        (1) Inflammation (ex. Arthritis)
        (2) Degenerative (ex. Disk related nerve entrapment)
        (3) Oncologic
        (4) Trauma/Surgical Iatrogenic
        (5) Chemotherapy induced
        (6) Idiopathic
    b) Disease processes that can present in response to pain, especially chronic pain, including depression, poor sleep, fatigue, reduced activity
3. Patient Workup
    a) Identifying cause of pain
        (1) Description and localization of pain
        (2) Triggering and relieving positions
        (3) Pain questionnaires including neuropathic pain questionnaires and quantification questionnaires such as pain visual analog scale
        (4) Medical History
        (5) Physical exam
            (a) Localize pain
            (b) Triggering maneuvers
            (c) Nerve function (motor and sensory)
        (6) Drug history
4. Lab and Imaging Findings
    a) Nerve function studies (esp. for neuropathic pain)
        (1) Electromyography
        (2) Nerve conduction velocity test
    b) X-ray – ex. For MSK type pain
    c) CT scan – ex. Screening for pathology
    d) MRI scan – ex. For spinal pathology
    e) US – especially for localizing nerves and treatment
    f) Bone scans – if suspect diffuse bony pathology such as metastases
    g) Lab tests esp. for inflammatory processes
    h) Future imaging: MRI neurography/Diffusion tensor imaging
5. Patient Management
    a) WHO analgesic pain ladder
    b) Medical
        (1) Anti-inflammatories/acetaminophen
        (2) Combination anti-inflammatory+ weak opiates
        (3) Opiates
        (4) Adjuvants
            (a) Anti-convulsants
            (b) Anti-depressants
        (5) Topical analgesics
        (6) Corticosteroids
        (7) Others (ex IV Xylocaine/Ketamine/Triptans/CGRP Monoclonal Antibodies)
    c) Surgical
        (1) Correction of painful pathology (ex. oncologic or disk resection)
        (2) Cordotomy
        (3) Sympathectomy
        (4) Midline myelotomy
        (5) Mesencephalotomy/Cingulotomy
        (6) Spinal cord stimulation
        (7) Spinal Fusion
        (8) Spinal Decompression

(9) Motor cortex stimulation
(10) Deep brain stimulation

d) Interventional
    (1) Indications for Intervention
        (a) Pre-procedural prophylactic pain control
            (i) Ex. Superior Hypogastric nerve block pre-UFE, peripheral nerve block prior to painful procedures such as ischemic leg thrombolysis, alcohol injection in vascular malformations, liver/celiac plexus block prior to liver ablations, etc.
        (b) Iatrogenic pain control
            (i) Post-surgical pain control with nerve blocks or neurolysis procedures
            (ii) Post-treatment pain control with nerve block, such as post-radiation pain
        (c) Pathologic pain control – ex oncological pain
    (2) Most common types of Interventional procedures
        (a) Nerve blocks
        (b) Neurolysis (chemical, cryoneurolysis, thermal neurolysis)
        (c) Pulsed radiofrequency treatments
        (d) Cryoablation
        (e) Radiofrequency or microwave ablation
        (f) Vertebroplasty/Kyphoplasty (has own individual module)
        (g) Cementoplasty and bone fixation
        (h) Injections of anti-inflammatory medications
        (i) Joint infiltration and distention
        (j) Aspiration and lavage of calcific tendinitis
        (k) Insertion of narcotic infusion pumps
        (l) Insertion of spinal cord stimulators or peripheral nerve stimulators
        (m) Insertion of interspinous process devices
        (n) Angioembolization of painful lesions (ex. vascular malformation)
        (o) Angioembolization for inflammatory processes (i.e. genicular artery embolization)
    (3) Most common specific pathologies and IR management
        (a) Spinal disease
            (i) Nerve entrapment
                (a) Symptoms
                (b) Workup
                (c) IR procedures
                    (i) Nerve block and steroid injections
                    (ii) Tools and medications needed
                    (iii) Approach -fluoroscopic
                    (iv) Complication risks
                    (v) Expected outcome
                (d) Follow-up
            (ii) Disk herniation
                (a) Symptoms
                (b) Workup
                (c) IR procedures
                    (i) Percutaneous laser ablation, desiccation, sonication
                    (ii) Endoscopic discectomy
                    (iii) Tools and medications needed
                    (iv) Approach -fluoroscopic
                    (v) Complication risks
                    (vi) Expected outcome
                (d) Follow-up

(iii) Facet disease
    (a) Symptoms
    (b) Workup
    (c) IR procedures
        (i) Facet joint injection, Medial branch neurolysis/ablation
        (ii) Facet stabilization or resurfacing device placement
        (iii) Tools and medications needed
        (iv) Approach -fluoroscopic, US
        (v) Complication risks
        (vi) Expected outcome
    (d) Follow-up

(b) MSK procedures
    (i) Vertebral fracture/collapse (pathologic vs osteopenic)
        (a) Symptoms
        (b) Workup
        (c) IR procedures
            (i) Vertebroplasty/Kyphoplasy/Implant Vertebral Augmentation, Radiofrquency ablation, Cryoablation
            (ii) Tools and medications needed
            (iii) Approach – fluoroscopic, CT
            (iv) Complication risks
            (v) Expected outcome

    (ii) Painful bony metastases +/- fractures
        (a) Symptoms
        (b) Workup
        (c) IR procedures
            (i) Cryoablation +/- Cementoplasty or bony fixation
            (ii) Tools and medications needed
            (iii) Approach -fluoroscopic
            (iv) Complication risks
            (v) Expected outcome
        (d) Follow-up
    (iii) Ablation of painful benign bony lesions (ex. osteoid osteoma, ABC, etc.)
        (a) Symptoms
        (b) Workup
        (c) IR procedures
            (i) Ablation (RFA or MWA), sclerosant injection (ex with acetic acid)
            (ii) Tools and medications needed
            (iii) Approach -fluoroscopic
            (iv) Complication risks
            (v) Expected outcome
        (d) Follow-up
    (iv) Painful ST lesions (ex. intramuscular hemangiomas, cysts)
        (a) Symptoms
        (b) Workup
        (c) IR procedures
            (i) Cryoablation, Sclerotherapy injection
            (ii) Peripheral nerve stimulation
            (iii) Tools and medications needed

(iv) Approach – US, CT
(v) Complication risks
(vi) Expected outcome
(d) Follow-up
(v) Joint pain
(a) Symptoms
(b) Workup
(c) IR procedures
(i) Joint steroid/anesthetic injection, capsule distention, neurolysis, arterioembolization
(ii) Tools and medications needed
(iii) Approach – fluoroscopy, US, CT, angio
(iv) Complication risks
(v) Expected outcome
(d) Follow-up
(vi) Tendon pain
(a) Symptoms
(b) Workup
(c) IR procedures
(i) Fenestration, lysis and aspiration of calcific tendinitis, PRP and other regenerative medicine injections
(ii) Tools and medications needed
(iii) Approach – fluoroscopy, US, CT, angio
(iv) Complication risks
(v) Expected outcome
(d) Follow-up
(c) Head and neck
(i) Migraines
(a) Symptoms
(b) Workup
(c) IR procedures
(i) Occipital nerve block Sphenopalatine nerve block
(ii) Cervical medial branch blocks
(iii) Stellate ganglion block
(iv) Botulinum toxin injection
(v) Tools and medications needed
(vi) Approach – fluoroscopy, US,
(vii) Complication risks
(viii) Expected outcome
(d) Follow-up
(ii) Trigeminal neuralgia
(a) Symptoms
(b) Workup
(c) IR procedures
(i) Gasserian ganglion nerve block
(ii) Gasserian ganglion neurolysis
(iii) Ablation
(iv) Tools and medications needed
(v) Approach – fluoroscopy, CT
(vi) Complication risks
(vii) Expected outcome
(d) Follow-up
(iii) Tumor related pain
(a) Symptoms
(b) Workup

(c) IR procedures
(i) Ablation, embolization, nerve block
(ii) Tools and medications needed
(iii) Placement of intrathecal pain pump
(iv) Approach –US, CT
(v) Complication risks
(vi) Expected outcome
(d) Follow-up
(d) Visceral pain
(i) Pancreatic/Liver cancer
(a) Symptoms
(b) Workup
(c) IR procedures
(i) Celiac plexus or splanchnic nerve bock
(ii) Placement of intrathecal pain pump
(iii) Tools and medications needed
(iv) Approach – fluoroscopy, US, CT
(v) Complication risks
(vi) Expected outcome
(d) Follow-up
(ii) Gynecological pelvic pain
(a) Symptoms
(b) Workup
(c) IR procedures
(i) Superior hypogastric nerve block, pudendal nerve block
(ii) Tools and medications needed
(iii) Approach – fluoroscopy, US, CT
(iv) Complication risks
(v) Expected outcome
(d) Follow-up
(iii) Rectal pain
(a) Symptoms
(b) Workup
(c) IR procedures
(i) Impar Ganglion Block, anesthetic discography
(ii) Tools and medications needed
(iii) Approach – fluoroscopy, US,
(iv) Complication risks
(v) Expected outcome
(d) Follow-up
(e) Chest/Abdominal wall pain
(i) Chest wall pain
(a) Symptoms
(b) Workup
(c) IR procedures
(i) Intercostal or paravertebral nerve block
(ii) DRG stimulation
(iii) Tools and medications needed
(iv) Approach – fluoroscopy, US, CT
(v) Complication risks
(vi) Expected outcome
(d) Follow-up
(ii) Abdominal wall pain
(a) Symptoms
(b) Workup

(c) IR procedures
(i) Anterior – TAP block, posterior – QL block
(ii) DRG or spinal cord stimulation
(iii) Tools and medications needed
(iv) Approach –US
(v) Complication risks
(vi) Expected outcome
(d) Follow-up

(f) Limb pain
(i) Upper extremity – ex. Fistula or AVM treatment
(a) Symptoms
(b) Workup
(c) IR procedures
(i) Brachial plexus block
(ii) DRG or spinal cord stimulation
(iii) Tools and medications needed
(iv) Approach –US
(v) Complication risks
(vi) Expected outcome
(d) Follow-up
(ii) Lower extremity – ex. Ischemic leg treatment
(a) Symptoms
(b) Workup
(c) IR procedures
(i) Below knee – Sciatic nerve block, Above knee – Sciatic and Femoral nerve block
(ii) Peripheral nerve stimulation
(iii) Tools and medications needed
(iv) Approach –US
(v) Complication risks
(vi) Expected outcome
(d) Follow-up

(4) Pain control during IR procedures
(a) “Practice Guidelines for Moderate Procedural Sedation and Analgesia”
(b) Narcotics
(c) Anxioloytics
(d) Nerve blocks
(e) Others
(f) Reversal agents and dealing with complications

Pediatric

1. General Principles of Pediatric Interventional Radiology
    a) Age appropriate vital signs, common lab values
    b) Pediatric resuscitation
    c) Weight-based dosages of commonly used drugs
        (1) Local anesthetics
        (2) Sedation
    d) Use of general anesthesia
    e) Appropriate pediatric fluid maintenance and resuscitation rates
    f) Elements of substitute decision maker, legal guardianship, biological parents
    g) Assent vs Consent
    h) Elements of family dynamics and establishing rapport
    i) Sources available to educate parents regarding procedure and care
    j) Know how to discuss procedural risks, radiation risks and contrast agent risks with parents and children
    k) Knowing what is typical blood volume and critical blood loss in pediatric patients (eg. 80 mL blood per kg)
    l) Temperature control/monitoring in neonates and infants
    m) Reducing radiation exposure – ALARA
    n) Syndromic associations
2. Special considerations for procedures in children
    a) Increased risk of vasospasm, thrombosis, and vessel occlusion in children and the need for intraprocedural heparin in children weighing less than 10 kg.
    b) Umbilical artery consideration as an alternative to femoral access
    c) Appropriate size sheaths, wire and catheters available
        (1) Vascular sheath as small as 3Fr
        (2) Abscess drainage drainage catheter selection
    d) Appropriate needle size and difference in biopsy technique
    e) Weight-based contrast limits for children
    f) Injection rates for selective arteriography.
    g) Minimizing radiation exposure to patient and operator.
    h) Hemostasis without closure devices
    i) Preventing and correcting hypoglycemia and hypothermia in infants.
    j) Managing contrast nephropathy and volume overload.
3. Thromboembolic disease
    a) Presentation
        (1) Peripheral
        (2) Hepatic
        (3) Renal
        (4) Pulmonary
    b) Evaluations and work up
        (1) Focus on non-invasive imaging when possible
    c) Medical management
        (1) systemic therapies including anticoagulation and thrombolysis for treatment of thromboembolism
    d) Interventional management
        (1) Indications and contraindications for catheter directed intervention
            (a) Thrombolysis
            (b) Thrombectomy
            (c) IVC filter
4. Hemoptysis
    a) common causes of hemoptysis in children
    b) non-invasive imaging techniques
    c) medical therapy for treatment of hemoptysis
    d) Indications and contraindication for bronchial artery embolization.

(1) Technique
(a) Identifying normal variant bronchial anatomy and spinal cord supply
(b) identifying sources of hemorrhage on arteriography
(c) embolic agents used for embolization of bronchial embolization
(d) Complications, including spinal ischemia

5. GI bleeding
   a) common causes of GI bleeding in children
   b) non-invasive imaging choice for identifying source of hemorrhage in children
   c) Medical therapy for treatment of GI hemorrhage
   d) Indications for nuclear medicine bleeding scan, surgery and endoscopy
   e) Indications for catheter direct therapy
6. Post-transplantation organ complications
   a) Anastomotic complications:
      (1) Portal vein stenosis/occlusion
      (2) Hepatic artery thrombosis and stenosis
      (3) Hepatic vein stenosis/occlusion
      (4) Biliary stenosis
      (5) Renal artery stenosis
      (6) Renal vein stenosis
      (7) Ureteric kinking and stenosis
   b) Indications for intervention
   c) Technical approach in children
7. Venous disease
   a) common causes of venous stenosis and occlusion in pediatric patients
   b) congenital conditions/anatomic variants that predispose children to venous stenosis or occlusion
   c) indications and contraindications for venous recanalization in children
   d) clinical presentation of venous stenosis/occlusion
   e) appropriate imaging modality and findings for venous stenosis/occlusion
   f) indications for covered versus uncovered venous stenting
   g) medical and surgical management options for venous occlusion/stenosis
   h) technical considerations for venous stenting
   i) postprocedural management and ongoing clinical care
8. Venous access
   a) types of catheters used for particular indications in children
   b) risk factors for central venous access complications
   c) pre-procedural workup of CVC placement: venous anatomy/patency
   d) common sizes of central venous devices in children
   e) catheter complications: device malfunction, swelling, infection, bleeding
   f) postprocedural ongoing clinical care
   g) Weight-based large bore catheter selections for dialysis and apheresis
9. Varicocele/venous congestion
   a) epidemiology of varicoceles in pediatric and adolescent patients.
   b) causes of varicocele in pediatric and adolescent patients, including congenital anatomic abnormalities
   c) clinical presentation of varicocele.
   d) imaging (ultrasound) findings and diagnostic criteria for varicocele.
   e) indications and contraindications for sclerotherapy of varicocele in children.
   f) types of sclerosing and embolic agents used in varicocele treatment.
   g) general steps and technical considerations for varicocele embolization.
   h) Bahren classification for assessing gonadal vein reflux during venography.
   i) complications of varicocele embolization.
   j) postprocedural management and ongoing clinical care
10. Portal hypertension in children
    a) Etiology
    b) Medical management

c) Surgical and Interventional management
    (1) Rex shunt
    (2) Splenorenal shunt
    (3) TIPS
d) Congenital portosystemic shunts (Abernathy Malformations)

11. Vascular malformations
a) Vascular
    (1) High flow
        (a) Extra-cranial AVM
            (i) Presentation, history, imaging, treatment
    (2) Low flow
        (a) Venous malformations
            (i) Presentation, history, imaging, treatment
        (b) Lymphatic malformations
            (i) Presentation, history, imaging, treatment
b) Mixed malformations and malformations associated with overgrowth syndromes
    (1) Presentation, history, imaging, treatment
    (2) Techniques of percutaneous sclerotherapy/embolization, laser, cryoablation
c) Agents for sclerotherapy and embolization - techniques for preparation, percutaneous/endovascular delivery,
d) Complications of percutaneous and endovascular therapy
e) Management of complications
f) Medical therapy considerations - serolimus, MEK inhibitors
g) Biopsy consideration for genomic analysis for targeted medical therapy
h) Pulmonary AVM
    (1) Presentation, history, imaging, treatment1
    (2) Evaluation for syndromes associated with multifocal pulmonary AVMs

12. Enteric access
a) Gastrostomy, gastrojejunostomy, jejunostomy
    (1) Indications, contradindications
    (2) Differences in technique compared with adult experience
b) Cecostomy
    (1) Common indications for cecostomy tube placement
    (2) common contraindications for cecostomy tube placement
    (3) preprocedural workup including
        (a) Appropriate bowel preparation prior to procedure
        (b) Admission including all necessary laboratory workup
    (4) technique for placement of a cecostomy tube
        (a) Utilization of appropriate antibiotic prophylaxis
        (b) Identifying anatomy and crucial nearby structures
        (c) Technique to insufflate the colon for procedure
        (d) Tube insertion technique
    (5) Common complications of cecostomy tube placement and their management
    (6) Short term, long term and clinical follow up guidelines for cecostomy

13. Perinephric Collection/Urinoma
a) anatomy relevant to perinephric interventions
b) common anatomic variants that result in urinary obstruction in children
    (1) Ureteropelvic junction configuration
    (2) Ureterovesicular junction configuration
    (3) Posterior urethral valves
c) common causes of perinephric collection in a pediatric patient
d) complications associated with perinephric collection/urinoma
    (1) Hydronephrosis
    (2) Paralytic ileus
    (3) Electrolyte abnormalities

(4) Abscess formation
(5) Know when drainage of perinephric collections are indicated

14. Urinary obstruction
    a) Etiology
    b) Indications for percutaneous nephrostomy and how they may differ from an adult
    c) Understand modified techniques for nephrostomy in very young patients
    d) Know the post procedural care and management of nephrostomy tubes and their associated conditions
    e) Indications and technique for ureteral stricture dilatation
    f) indications and technique for ureteral calculus removal and percutaneous nephrolithotomy
15. Hepatobiliary interventions in pediatric patients
    (1) Indications for drainage
    (2) Techniques
16. Interventional Oncology in the pediatric patient
    a) Differences in indications and techniques in the pediatric population.
        (1) RFA
        (2) Microwave
        (3) Laser
        (4) Cryo
        (5) Embolization
    b) Osteoid osteoma
        (1) Etiology and presentation
        (2) Management
            (a) Medical
            (b) Surgical
            (c) Interventional
    c) Pediatric Hepatic malignancies
        (1) Epidemiology
        (2) Medical treatments
        (3) Surgical treatments
            (a) Transplant
        (4) Interventional treatments

Vascular

1. Arterial
    a) General
        (1) Arterial anatomy, embryology, physiology (CR XXX)
        (2) Examination of arterial disease
            (a) History and Physical examination
            (b) Noninvasive vascular evaluation
                (i) ABI (CR XXX)
                (ii) US (CR XXX)
                (iii) CT/MR Angiography (CR XXX)
        (3) Principles of medical management of arterial disease (CR XXX)
    b) Trauma
        (1) Principles of arterial trauma management
            (a) Clinical assessment of trauma patient
            (b) Cross-sectional imaging (US/CT) of trauma patient
            (c) Management (Surgical vs Interventional)
    c) Peripheral Arterial Disease
        (1) Acute arterial disease (thrombo-embolic)
            (a) Clinical presentation & Physical examination findings
            (b) Risk factors and evaluation of thromboembolic source
            (c) Imaging assessment
                (i) US findings
                (ii) Indications and findings for (CTA/MRA)
                (iii) Indications and findings of angiography

            (d) Management
                (i) Medical
                (ii) Surgical
                (iii) Endovascular
                    (a) Thrombolysis
                    (b) Thrombectomy
                    (c) Interventions for treatment of underlying disease during or after thrombolysis/thrombectomy
            (e) Follow up care
                (i) Risk factor modification
            (f) Clinical outcomes
        (2) Chronic arterial disease (atherosclerotic)
            (a) Clinical presentation
                (i) Classification (Rutherford Stages)
                (ii) History and physical examination to assess disease stage (asymptomatic, claudicant (degree), or critical limb ischemia)
            (b) Risk factors
            (c) Imaging assessment and findings
                (i) ABI/PVR patterns
                (ii) US
                (iii) CTA
                (iv) MRA
            (d) Classification systems
                (i) TASC
                (ii) Rutherford-Becker
            (e) Management
                (i) Medical/Supervised exercise therapy
                (ii) Surgical
                (iii) Endovascular
                    (a) Aorto-iliac
                    (b) Femoro-popliteal

(c) Tibio-pedal
(f) Follow up care
(i) Risk factor modification
(g) Clinical outcomes
(3) Vasculitis/digital ischemia
(a) Etiology
(i) Microembolic
(a) Frostbite
(ii) Small vessel vasculitis
(a) Autoimmune disorders
(4) Adventitial cystic disease
(5) Popliteal artery entrapment syndrome
(6) Buerger's disease
(7) Raynoud's disease

d) Aortic Aneurysms
(1) Abdominal aortic aneurysmal disease
(a) Etiology
(b) Risk factors
(i) Screening protocols
(c) Clinical Presentations & Physical Examination
(d) Imaging assessment
(i) US findings
(ii) Indications and findings for cross sectional imaging
(e) Classification systems
(f) Management
(i) Medical
(ii) Surgical
(iii) Endovascular
(a) Stent grafts
(b) Technique
(c) Endoleaks
(i) Types
(ii) Diagnosis
(iii) Endovascular treatment
(g) Follow up care
(i) Risk factor modification
(ii) Clinical and imaging surveillance protocols
(h) Clinical outcomes
(2) Thoracic aortic aneurysmal disease
(a) Etiology
(b) Risk factors
(i) Screening protocols
(c) Clinical Presentations & Physical Examination
(d) Imaging assessment
(i) US findings
(ii) Indications and findings for cross sectional imaging
(e) Classification systems (Ascending/Arch/Descending)
(f) Management
(i) Medical
(ii) Surgical
(iii) Endovascular
(a) Stent grafts
(b) Technique
(c) Endoleaks
(i) Types
(ii) Diagnosis
(iii) Endovascular treatment

(g) Follow up care
(i) Risk factor modification
(ii) Clinical and imaging surveillance protocols
(h) Clinical outcomes
(3) Thoracoabdominal aortic aneurysmal disease
(a) Etiology
(b) Risk factors
(i) Screening protocols
(c) Clinical Presentations & Physical Examination
(d) Imaging assessment
(i) US findings
(ii) Indications and findings for cross sectional imaging
(e) Classification systems
(f) Management
(i) Medical
(ii) Surgical
(iii) Endovascular
(a) Stent grafts
(b) Technique
(c) Endoleaks
(i) Types
(ii) Diagnosis
(iii) Endovascular treatment
(g) Follow up care
(i) Risk factor modification
(ii) Clinical and imaging surveillance protocols
(h) Clinical outcomes
(4) Dissection of the Aorta
(a) Type A vs Type B
(b) Etiology
(c) Risk factors
(i) Screening protocols
(d) Clinical Presentations & Physical Examination
(e) Imaging assessment
(i) US findings
(ii) Indications and findings for cross sectional imaging
(f) Classification systems
(g) Management
(i) Medical
(ii) Surgical
(iii) Endovascular
(a) Stent grafts
(b) Fenestration
(c) Stenting of visceral arteries, aorta and iliacs for management of ischemic complications
(d) Technique
(iv) Follow up care
(v) Risk factor modification
(vi) Clinical and imaging surveillance protocols
(h) Clinical outcomes
(5) Intramural hematoma
(6) Penetrating Aortic ulcer
(7) Saccular/mycotic aneurysms of the aorta
(8) Aortic traumatic injury
(9) Acute occlusive disease
(10) Chronic occlusive disease

e) Renal

(1) Renal artery stenosis
(2) Fibromuscular dysplasia
(3) Refractory hypertension
(4) Embolization for trauma
(5) Renal artery aneurysms

f) Visceral/mesenteric
(1) Acute GI bleeding
(a) Upper GI bleeding (CR XXX)
(b) Lower GI bleeding (CR XXX)
(2) Acute mesenteric ischemia
(3) Chronic mesenteric ischemia
(4) Hepatic arterial occlusion
(5) Visceral artery aneurysms
(6) Segmental arterial mediolysis
(7) Visceral artery dissections
(8) Visceral vascular malformations (CR XXX)
(9) Splenic steal syndrome
(10) Hypersplenism

2. Vascular anomalies
a) Diagnosis
(1) Malformation basics
(2) Diagnostic modalities
b) Classification systems
(1) High flow
(2) Low flow
(3) Mixed
c) Treatment of vascular anomalies
(1) Medical
(2) Surgical
(3) Endovascular

3. Lymphatic disease
a) Basics
b) Etiology
c) Diagnostic modalities
d) Intervention
(1) Thoracic duct injury
(2) Lymphatic malformations
(3) Lymphedema

4. Pulmonary vascular disease
(1) Acute pulmonary embolism (CR XXX)
(a) Etiology
(b) Risk factors
(c) Clinical Presentations
(d) Imaging assessment
(e) Classification systems
(f) Management
(i) Medical
(ii) Surgical
(iii) Endovascular
(g) Follow up care
(h) Clinical outcomes
(2) Chronic pulmonary hypertension
(3) Pulmonary artery stenosis
(4) Pulmonary artery AVM
(5) Pulmonary artery malignancy
(6) Pulmonary artery sequestration
(7) Pulmonary artery aneurysms/pseudoaneurysms

Vascular

1. Venous system
    a) General venous anatomy, embryology, physiology (CR XXX)
        (1) Hemostasis physiology
    b) Examination and classification of venous disease
        (1) Physical examination
        (2) Noninvasive vascular imaging
            (a) Plethysmography for reflux
            (b) US (CR XXX)
            (c) CT/MR venography (CR XXX)
        (3) Classification methods
            (a) CEAP
            (b) VCSS
            (c) Villalta
        (4) Patient reported outcomes
            (a) VVSymQ
            (b) CIVIQ14
            (c) VEINES Qol/Sym
            (d) AVVQ
    c) Thoracic, Neck, and Upper Extremity Venous Diagnosis and Intervention
        (1) Superior vena cava and central veins
            (a) Veno-occlusive disease
            (b) SVC Stenosis/Occlusion
                (i) Clinical symptoms of SVC syndrome
                (ii) Indwelling catheters and wires
                (iii) Trauma
                (iv) Infectious/Inflammatory
                (v) Malignancy/External Compression
        (2) Pulmonary artery
            (a) Acute pulmonary embolism
            (b) Chronic pulmonary embolism
                (i) Chronic thromboembolic pulmonary disease
                (ii) Chronic thromboembolic pulmonary hypertension
            (c) Pulmonary artery hypertension
            (d) Pulmonary artery stenosis
            (e) Pulmonary AVM
            (f) Pulmonary sequestration
            (g) Pulmonary artery malignancy
            (h) Pulmonary artery aneurysms and pseudoaneurysms
        (3) Right heart thrombi/mass
            (a) Endocarditis
            (b) Hardware/catheter associated
            (c) Clot in Transit
            (d) Management
                (i) Percutaneous thrombectomy
                (ii) Open surgical thrombectomy
                (iii) Conservative management
        (4) Internal Jugular Vein
            (a) Acute upper extremity deep venous thrombosis
            (b) Chronic venous occlusion
        (5) Upper Extremity Veins
            (a) Upper extremity deep venous thrombosis
            (b) Venous thoracic outlet syndrome/Paget-Schroetter syndrome
            (c) Catheter/Pacemaker associated central venous stenosis/occlusion
    d) Abdominal and Pelvic Venous Diagnosis and Intervention
        (1) Venous thromboembolic Disease

(2) Prevention of venous thromboembolism
(3) Inferior Vena Cava
(a) IVC obstruction and thrombosis
(b) Acute
(i) Pharmacological, mechanical, and combination treatments
(c) Chronic IVC occlusion
(i) Key collateral pathways
(ii) Management
(d) Malignant IVC compression
(e) Inferior vena cava filter - indications, placement, risks, removal
(f) Inferior vena cava filter retrieval
(4) Iliofemoral Veins
(a) Iliofemoral thrombosis
(b) May-Thurner Syndrome
(c) Post thrombotic syndrome
(5) Hepatic Veins (CR)
(a) Budd-chiari syndrome
(b) Hepatic congestion
(c) Hepatic infarction
(d) Hepatic AVMs
(e) Hepatic hemangiomas
(6) Renal/Adrenal
(a) Occlusion/Stenosis
(i) Nutcracker Syndrome
(b) Thrombosis
(c) Renal vein renin sampling (CR XXX)
(d) v
(7) Pelvic Venous Insufficiency (CR Mens, Womens)

e) Lower Extremity Venous Diagnosis and Intervention
(1) Deep Venous Disease
(a) Acute Deep Vein Thrombosis
(i) Phlegmasia cerulea dolens/albans and venous gangrene
(b) Chronic Venous Obstruction
(c) Deep Venous Reflux
(d) Post Thrombotic Syndrome
(e) Phlebolymphedema
(2) Superficial Venous Disease
(a) Superficial Venous Reflux/Varicose Veins
(i) Truncal veins
(ii) Tributaries
(iii) Perforator vein
(iv) Pelvic derived lower extremity varicose veins
(b) Superficial thrombophlebitis
(i) Sterile
(ii) Septic
(c) Syndromes
(i) Klippel-Trenaunay Syndrome
(ii) Parkes-Weber
Venous Malformations

f) Venous Access
(1) Algorithm for Choosing Types of Venous Access
(2) Troubleshooting and Complications in Venous Access
(3) Hemodialysis Access Creation and Management
(a) KDOQI Guidelines
(b) Fistula First Initiative
(4) Hemodialysis Shunt Access Creation
(a) Surgically-created hemodialysis access creation

(b) Fistulas
(c) Grafts
(d) Hybrid (HeRO catheters)
(e) Percutaneously-created hemodialysis access creation
(f) Methods for determination of fistula adequacy for cannulation

(5) Hemodialysis Shunt Access Maintenance
(a) Noninvasive assessment of dysfunctional access
(b) Fistulagram
(c) Balloon angioplasty
(d) Drug-coated balloon angioplasty
(e) Stenting
(f) thrombectomy/Thrombolysis
(g) Side branch/competing branch treatment
(h) Banding/steal syndrome

(6) Hemodialysis catheters
(a) Tunneled
(b) Non-tunneled

Women's Health

1. Fibroids
    a) Prevalence and pathophysiology including discussion on Leiomyosarcoma
    b) Clinical presentation: bleeding and pressure symptoms
        (1) Fibroids effect on fertility
    c) Imaging evaluation: US and MRI
    d) Medical management
        (1) Diet and exercise
        (2) Endocrine therapy
        (3) Progesterone containing IUD
        (4) Tranexamic acid
    e) Surgical management
        (1) Myomectomy
            (a) Open surgery
            (b) Laparoscopic surgery w/ and without morcellation
            (c) Hysteroscopic resection of intracavitary fibroids
        (2) Hysterectomy
            (a) Abdominal
        (3) Lap-assisted RF ablation
    f) Percutaneous interventions
        (1) UFE
            (a) Pre-Procedure
                (i) Nerve blockade
                (ii) Steroids
                (iii) Compression stalkings
            (b) Procedure
                (i) Femoral vs radial access
                (ii) Anatomy
                    (a) Uterine artery origins
                    (b) Utero-ovarian anastomoses
                (iii) Devices: 5 French system vs Micro catheters
                (iv) Embolic choices
                (v) Embolization endpoint
                (vi) Unilateral vs. bilateral embolization
                (vii) Imaging and procedural technique
                (viii) Intra-arterial lidocaine
                (ix) Toradol
            (c) Post-procedure care
                (i) Pain management
                    (i) PCA
                    (b) IV tylenol
                    (c) IA lidocaine
                (ii) Post embolization syndrome
            (d) Complications and their management
                (i) Immediate
                (ii) Delayed
            (e) Comparative effectiveness: Not just outcomes but also compared to Hyst, Myomectomy, MRgFUS
            (f) Fertility after UAE
            (g) Contraindications
            (h) Special considerations: What to do when faced with fibroids AND:
                (i) IUD
                (ii) Very large Fibroid uterus
                (iii) Pedunculated fibroids
                (iv) Intracavitary fibroids
                (v) Varying degrees of adenomyosis
        (2) MR-Guided Focused US

(a) Basics/methodology of FUS
(b) Patient selection
(c) Procedure
(d) Outcomes: comparative effectiveness
(e) Complication

2. Adenomyosis
    a) Pathophysiology
    b) Clinical presentation
    c) Imaging evaluation: US & contrast MRI
    d) Medical management
        (1) IUD
    e) Surgical management
        (1) Hysterectomy
    f) Percutaneous interventions
        (1) UAE
            (a) Particle size
            (b) Outcomes
3. Pelvic Congestion
    a) Pathophysiology
    b) Clinical presentation
    c) IVUS!!
    d) Medical and surgical management
    e) Surgical management
    f) Percutaneous interventions
        (1) Image-guided procedures
            (a) Ovarian vein embolization/sclerotherapy
            (b) Pelvic vein embolization/sclerotherapy
    g) Other considerations
        (1) May-Thurner
            (a) IVUS/venography
            (b) Stent placement
            (c) Post-stent anti-plt/anti-coags
        (2) Nutcracker
        (3) LE venous insufficiency; often co-exists with PCS
4. Hemorrhage
    a) Etiology
        (1) Post-partum
            (a) definition
        (2) Abnormal placenta
            (a) Occlusion balloons
        (3) Ectopic pregnancy
        (4) Trophoblastic disease
        (5) Malignancy
            (a) Cervical cancer/radiation
            (b) Uterine cancer
        (6) Uterine AVM/AVF
            (a) Pathophysiology
            (b) Etiology
            (c) Imaging evaluation
            (d) Percutaneous treatment
                (i) Technique
                (ii) Complications
5. Infertility
    a) Pathophysiology
        (1) Female infertility
        (2) Male infertility
    b) Definition

c) Imaging evaluation
d) Medical management
e) Surgical management
f) Percutaneous interventions
(1) HSG
(a) Pre-procedure
(b) Technique
(2) Fallopian tube interventions
(a) Recanalization
(i) Technique
(ii) Equipment
(iii) Contrast: oil based vs. water based
(iv) Outcomes

6. Pelvic Pathology
a) Solid ovarian mass
(1) Biopsy techniques
(a) Transgluteal
(b) Transrectal
(c) Transvaginal
(2) Devices
b) TOA
c) Cystic ovarian mass
(1) Endometrioma
(2) Ovarian cyst
(3) Percutaneous drainage
(a) Aspiration
(b) Sclerosis
d) Pelvic abscess
(1) Etiologies
(2) Pecutaneous drainage
(a) Transgluteal
(b) Transrectal
(c) Transvaginal

Fundamentals

Clinical Medicine

1. Inpatient Clinical Medicine
    a) General Inpatient Service and Documentation
        (1) Elements of focused H&P and consult note
        (2) Elements of a medical sign-out
        (3) Essentials of inpatient service management
            (a) Consults
            (b) Resource utilization and appropriateness
        (4) Comprehensive admission orders
            (a) Fluid orders
            (b) Prophylaxis
            (c) Labs
    b) Inpatient management of disorders by system
        (1) Respiratory (CR A.b.ii)
            (a) Types of respiratory failure
                (i) Hypercapnic
                (ii) Hypoxemic
            (b) Causes of respiratory failure
                (i) ARDS
                (ii) Pneumonia
                (iii) COPD/Asthma
                (iv) PE
                (v) Pulmonary edema
                (vi) Decreased respiratory drive
            (c) Pulmonary function tests
            (d) Indications for
                (i) Supplemental oxygen
                (ii) NIPPV/High flow oxygen
                (iii) Intubation
            (e) Ventilator management (CR to ICU section)
        (2) Cardiac
            (a) Hypertension
            (b) Chest pain
            (c) Arrhythmias
            (d) Tachycardia
        (3) Renal
            (a) Acid-base disturbances
            (b) Obstruction
            (c) Fluid management
        (4) Electrolytes disturbances
        (5) Hepatic
            (a) Acute liver insufficiency
            (b) Chronic liver insufficiency
        (6) GI/Endocrine
            (a) Nausea
            (b) Vomiting
            (c) Diarrhea
            (d) Constipation

(e) GERD
(f) Inpatient management of diabetes
(7) fluid management
(8) Infectious disease and antibiotics
(a) New onset fever
(b) Leukocytosis
(9) Anticoagulation
(a) IV/IM agents
(b) Oral agents
(c) Platelet inhibitors
(10) Neuro
(a) Altered mental status
(b) Stroke

2. Outpatient clinical medicine essentials
   a) Hypertension
   b) Hyperlipidemia
   c) Smoking cessation
   d) Obesity
   e) Diabetes
   f) Screening studies
   g) Cardiac disease
      (1) CHF
      (2) CAD
      (3) Angina
      (4) Atrial fibrillation
   h) GI
   i) Peripheral artery disease
   j) Musculoskeletal disease
   k) Wound care
3. Preoperative assessment
   a) Functional status
   b) Cardiac evaluation
   c) Pulmonary evaluation
   d) Renal function

Fundamentals

Intensive care Medicine

i. Global care of the ICU patient
    1. Documenting ICU care
    2. End of life planning/advanced directives
    3. Prophylaxis
        a. DVT
        b. GI
        c. Stress ulcers

ii. Neurological
    1. Assessment of status
        a. Glasgow coma scale (GCS)
        b. Neurological exam in the ICU
        c. Cerebral pressure monitoring
        d. Cerebral perfusion pressure
    2. Neurological deficits
        a. Acute mental status change
        b. Delirium
    3. Intracranial hemorrhage
        a. Medical management
        b. Surgical management
    4. Management of acute stroke
        a. Indications for tpa thrombolysis
        b. Monitoring for complications of TPA
        c. Indications for thrombectomy

iii. Respiratory (CR A.1.b.(1))
    1. Types of respiratory failure
        a. Hypercapnic
        b. Hypoxemic
    2. Causes of respiratory failure
        a. ARDS
        b. Pneumonia
        c. COPD/Asthma
        d. PE
        e. Pulmonary edema
        f. Decreased respiratory drive
    3. Indications for
        a. Supplemental oxygen
        b. NIPPV/High flow oxygen
        c. Intubation
    4. Ventilator management
        a. Parameters
        b. Settings
        c. Modifying settings based on ABG (CR)
        d. Extubation
    5. Pulmonary embolism
        a. Risk stratification (CR)
        b. Anticoagulation
        c. Thrombolysis

i. Systemic
ii. Endovascular

d. Thrombectomy
i. Surgical
ii. Endovascular

iv. Cardiovascular

1. Essentials of hemodynamic monitoring
a. Swan-Ganz monitoring
2. Shock
a. Types
i. Hypovolemic
ii. Cardiogenic
iii. Obstructive
iv. Distributive
1. Septic
2. Anaphylaxis
3. Neurogenic
v. Hemorrhagic
1. Transfusion protocols
2. DIC management
b. Role of reversal agentsInitial treatment strategies
c. Use of vasopressors
i. Drug selection
ii. Titration
iii. Cessation
iv. Complications
d. Transfusion
i. Indications for basic transfusion
ii. Massive transfusion protocols
e. Extracorporeal membrane oxygenation (ECMO)
i. Background
1. Types
ii. Indications
3. Acute Coronary Syndromes
a. Identification
i. History
ii. EKG
iii. Laboratory
b. Treatment
i. Pharmacologic
ii. Endovascular
iii. Complications of myocardial infarction
4. Atrial fibrillation
a. Etiology
i. Diagnosis and presentation
ii. Management
1. Pharmacologic
2. Cardioversion
5. Acute heart failure

6. Arrhythmias
    a. Identification of arrhythmias
    b. Treatment algorithms
7. Post cardiac arrest management
    a. Indications for hypothermia
    b. Prognostic indicators
    c. Brain death protocols

v. Fluids, electrolytes, GI and Endocrine
1. Assessing fluid status
2. Use of crystalloids, colloids and electrolytes in the ICU
3. Nutrition
    a. Assessment of nutritional status
    b. Indications for routes of nutrition in the ICU
4. Blood sugar management
    a. Sliding scale
    b. Ketoacidosis
    c. Hyperosmolar hyperosmotic state (HHS)
5. Assessing ABG and electrolyte results (CR)
    a. Metabolic acidosis
    b. Metabolic alkalosis
    c. Respiratory acidosis
    d. Respiratory alkalosis

vi. Renal
1. Electrolyte management in the ICU
2. Acute kidney injury
    a. Pharmacologic treatments
    b. Indications for dialysis

vii. Infectious disease
1. Sepsis
    a. Early recognition
    b. Intervention/sepsis protocols
2. Diagnosis and treatment of common ICU infections
    a. Hospital acquired pneumonia
    b. Ventilator associated pneumonia
    c. CAUTI
    d. CLABSI
    e. C. Diff
3. Antibiotics
    a. Broad spectrum
    b. Tailoring

viii. Common ICU procedures
1. Central line
2. Swan Ganz Catheter
3. Bedside chest tube
4. Arterial line placement
5. Pericardiocentesis

ix. ACLS protocols

Fundamentals

Image-Guided interventions

i. Basic Tools
    1. Needles
        a. Standard needles
        b. Specialty needles
    2. Wires
        a. Materials and special characteristics
        b. 0.035”
        c. 0.018”
        d. 0.014”
    3. Catheters
        a. Sizes/French system
        b. Materials
        c. Dottering/dilators
        d. Common flush catheter
        e. Common base catheters
        f. Radial access catheters
        g. Microcatheters
            i. Sizing systems
            ii. Materials
            iii. Specialty microcatheters
    4. Sheaths
        a. Sizes/French system
        b. Common sheaths and lengths
        c. Transitional sheaths
        d. Peel-away sheaths
        e. Radial access and other specialty sheaths
ii. Techniques and specialty tools
    1. Vascular access
        a. Tools
            i. Micropuncture access sets
            ii. Essential lines
                1. PICC lines
                2. Hickman catheter
                3. Quinton catheter
                4. Tunneled dialysis catheters
            iii. Implantable port catheters
                1. Port selection
                2. Skin sutures: absorbable, nylon or glue
            iv. TIPS sets
        b. Techniques
            i. Seldinger technique
            ii. Ultrasound guidance
            iii. Arterial access
                1. US vs palpation techniques
                2. Femoral
                3. Radial
                4. Brachial

5. Pedal and posterior tibial

iv. Venous access

1. Femoral
2. Jugular
3. Subclavian
4. Arm: basilic, cephalic or brachial
5. Portal
    a. Wedged hepatic venous
    b. Transhepatic
    c. Transplenic
    d. TIPS

2. Vascular closure devices and techniques
    a. Manual compression
    b. Suture based
        i. Perclose
        ii. Pro-start
        iii. Pre-close technique
    c. Selent
        i. Mynx
        ii. Duett
        iii. Vasoseal
    d. Collagen
        i. Angioseal
    e. Staple
        i. Starclose
        ii. EVS
    f. Patch
        i. Syvek
        ii. D-stat dry
    g. Compression
        i. Femostop
3. Diagnostic angiography
    a. Vessel selection basics
    b. Contrast selection
    c. Rate and volume selection
    d. Cerebral angiography catheters and technique
4. Endovascular intervention
    a. Angioplasty
        i. Balloon types
            1. High and low compliance
            2. Drug coated
            3. Cutting
            4. Specialty devices
        ii. Technique
    b. Stents
        i. Stent types
            1. Bare metal
                a. Self-expanding
                b. Balloon expandable

            c. Drug coated
        2. Covered stents
            a. Self-expanding
            b. Balloon expandable
            c. TIPS stents

c. Thrombolysis
    i. Devices
        1. Infusion catheters
        2. Infusion wires
    ii. Technique
        1. Catheter placement
        2. Tpa infusion rates
        3. Monitoring tpa infusions
        4. Other used drugs for thrombolysis (streptokinase, etc)
d. Thrombectomy
    i. Devices and technique
        1. Rheolytic
            a. Angiojet
        2. Suction
            a. Angiovac
            b. Penumbra
        3. Maceration
            a. Cleaner
            b. Trerotola
        4. Stentrievers
            a. Solitaire
            b. Trevo
            c. Inari
            d. 3D
e. Atherectomy
    i. Devices and technique
        1. Rotational
        2. Excisional
f. Chronic total occlusions
    i. Techniques
        1. Luminal
        2. Subintimal
    ii. Crossing devices
    iii. Re-entry devices
g. IVC filtration
    i. Access options
    ii. Types of filters
        1. Permanent
        2. Temporary
        3. Optional
        4. Novel devices
    iii. Basic removal techniques

1. Endovascular snares
2. Endobronchial forceps

h. Embolization
    i. General principles
        1. Macro vs micro embolization
        2. Sizes of vascular system
        3. End organ vasculature
        4. Collateral pathways
        5. Proximal and distal control
        6. Non-target embolization
        7. Tumor vascularity
        8. Selection of embolic device
    ii. Specific tools and techniques
        1. Coils
            a. Size
            b. Shapes
            c. Materials
            d. Delivery mechanisms and technique
        2. Plugs
            a. Size
            b. Materials
            c. Delivery mechanisms and technique
        3. Liquid embolics
            a. Onyx
            b. NBCA
            c. Ethanol
        4. Gelfoam
        5. Sclerosants
            a. Sotradecol
            b. Doxycycline
            c. Ethanol
            d. Sodium Tetradecyl Sulfate (STS)
            e. Bleomycin
        6. Particle
            a. PVA
            b. Embolic spheres
                i. Material
                ii. Size
                iii. Technique
        7. Chemoembolics
            a. Lipiodol
                i. Mixing technique
            b. Drug eluting beads
        8. Radioembolics
            a. Glass microspheres
            b. Resin microspheres

5. Enteric access tools and technique
    a. Selection of enteric access route
    b. Single function

i. Gastrostomy
    1. Feeding
    2. Venting
ii. Jejunostomy
iii. Cecostomy (CR peds)

c. Dual function
i. Gastrojejunostomy

d. Catheter maintenance
e. Catheter troubleshooting
f. Catheter removal

6. Drainage
a. Catheter sizes
b. Material
c. Types
i. All-purpose drainage catheter (APD)
ii. Tunneled drainage catheters
    1. Abdominal
    2. Pleural
iii. Malecot
iv. Biliary catheters
    1. Cope type
    2. Ring type
    3. Bentec catheters
v. Nephroureteral catheters

d. General techniques
i. Seldinger
ii. Trocar
iii. Tandem Trocar

e. Abscess drainage
i. Techniques
ii. Catheter care
iii. Troubleshooting
    1. Tpa/Dornase
iv. Catheter removal

f. Biliary drainage
i. Techniques
ii. Catheter care
iii. Troubleshooting
iv. Catheter removal

g. Cholecystostomy
i. Techniques
ii. Catheter care
iii. Troubleshooting
iv. Catheter removal

h. Renal drainage
i. Techniques
ii. Catheter care
iii. Troubleshooting
iv. Catheter removal

i. Chest tube
    i. Techniques
    ii. Catheter care
    iii. Troubleshooting
    iv. Catheter removal

7. Biopsy
    a. Devices
        i. Core (cutting needles)
            1. End cutting
            2. Side cutting
        ii. Aspiration needles
            1. Chiba
        iii. Mixed needles
            1. Turner
            2. Wescott
        iv. Needle systems and techniques
            1. Single needle
            2. Coaxial needle system
                a. Greene
                b. Jamshedi
            3. Tandem technique
        v. Biopsy devices
            1. Biopty
            2. Temno
            3. Drill powered devices
            4. MRI compatible devices
            5. Biliary brush devices
            6. Forceps
    b. Techniques
        i. Principles of tissue acquisition
        ii. Special circumstances
8. Pain interventions
    a. Tools
        i. Cement
        ii. Cannulas
        iii. Balloons
        iv. Drills
        v. Obturators
        vi. Needles
            1. Vertebroplasty
            2. Kyphoplasty
        vii. Screws
        viii. Pins
    b. Basic techniques
        i. Vertebroplasty
        ii. Kyphoplasty
        iii. Ablation
        iv. Joint injections
        v. Selective lumbar nerve root injections

vi. Epidural steroid injections
vii. Facet injections
viii. Visceral blocks
1. Celiac plexus
2. Superior hypogastric plexus block
3. Ganglion Impar block

9. Ablation Systems
a. Chemical ablation:
i. Ethanol
ii. Acetic acid
b. Thermic ablation
c. Radiofrequency ablation
i. Mechanism
ii. Types
iii. Basic techniques
d. Microwave ablation
i. Mechanism
ii. Types
iii. Basic techniques
e. Cryoablation
i. Mechanism
ii. Types
iii. Basic techniques
f. Irreversible electroporation
i. Mechanism
ii. Types
iii. Basic techniques
g. Ablation techniques
i. Overlapping probes
ii. Separation techniques
iii. Thermocouples
h. Combine techniques
i. Ablation and embolization
ii. Ablation and flow control

Fundamentals

Imaging and Anatomy

i. Imaging systems
    1. Computed Tomography
        a. Basic principles of CT imaging
        b. CT image acquisition
            i. Technical factors and their selection
                1. CT protocols
                2. Tube current modulation
            ii. Adaptation of technical factors to patient size
            iii. CT modes of operation
                1. Axial
                2. Helical
                3. CT fluoroscopy
        c. Image reconstruction
            i. Reconstruction parameters and their selection
            ii. Reducing metal artifact from needles and probes
            iii. Multiplanar reconstruction
            iv. Maximum intensity projection reconstruction
            v. Recursive reconstruction for CT fluoroscopy
        d. Interventional features
            i. Axial interventional imaging (i.e., “biopsy” mode)
            ii. Helical interventional imaging
                1. Multiplanar reconstruction
            iii. Interventional table motion
            iv. Path planning
        e. Adjunct techniques
            i. Dual energy CT
            ii. Dynamic CT
            iii. Use of CT images for fusion navigation
        f. Hybrid systems
            i. Role of CT in CT/angiography hybrid systems
        g. Patient dose at CT
            i. Dose indices and how they relate to patient dose
            ii. Typical dose index values for CT interventions
        h. Operator dose at CT
            i. Distribution of scatter radiation in CT
            ii. Operator location
            iii. Operator dosimetry
            iv. Use of personal protective equipment
            v. Mobile shields
            vi. Other strategies
                1. Sterile protective drapes
                2. Sterile protective gloves
        i. Radiation protection strategies
            i. Patient
            ii. Operator
        j. Regulations concerning CT
        k. SIR Best Practices Guidelines

2. Fluoroscopy
    a. Principles of fluoroscopic systems
        i. Inverse square law
        ii. Penetration of radiation through matter
        iii. The fluoroscopic imaging chain
    b. Operation of fluoroscopic systems used for interventional purposes
        i. Modes of operations of fluoroscopes
        ii. Electronic magnification
        iii. Automatic exposure control (AEC)
        iv. Recursive filtering
        v. Image processing
    c. Fluoroscopic exposure outputs
        i. Radiation quantities and units
        ii. Dose rate limits
    d. Dose management techniques
        i. Factors affecting patient dose
        ii. Importance of collimation
        iii. Advanced dose management techniques
        iv. Special considerations for pediatric patients
        v. Special considerations for pregnant patients
        vi. System-based dose optimization
    e. Operator dose at fluoroscopy
        i. Geometry
        ii. Location of the operator
        iii. Mobile and suspended shields
        iv. Managing operator dose
        v. Other strategies
            1. Sterile protective drapes
    f. Strategies for managing motion
    g. Procedures for recording and monitoring patient dose
        i. Fluoroscopy time
        ii. Kerma area product
        iii. Reference air kerma
        iv. Measuring the peak skin dose
        v. Notification levels
        vi. Dose metrics and patient follow-up
    h. Contrast agents for fluoroscopy
        i. Risk factors for contrast reactions
        ii. Patient screening
        iii. Carbon dioxide angiography
    i. Regulations concerning fluoroscopy
    j. Cone Beam CT (CBCT)
        i. Image creation
            1. Technical factors
                a. Partial rotation for certain procedures – radial access
            2. CBCT with contrast
        ii. Applications

        a. Vascular
        b. Non-vascular
    iii. Patient factors affecting image quality

3. Magnetic resonance imaging
    a. Level 2 Personnel MRI Safety training, such as the following
    b. ACR MRI Safety Guidelines
    c. Hazards in the MRI environment
        i. Static field
        ii. Primary spatial gradient field
        iii. Fringe field
        iv. Time-varying magnetic fields
        v. Radiofrequency energy
        vi. The projectile effect
        vii. Displacement of implanted devices
    d. MR personnel
        i. Level 1 MR personnel
        ii. Level 2 MR personnel
        iii. Non-MR personnel
        iv. MR medical director
    e. MRI Safety zones
        i. Zone I
        ii. Zone II
            1. MRI Safety Screening
            2. MRI Safety Screening workflow
            3. MRI Safety Screening resources
        iii. Zone III
        iv. Zone IV
    f. MRI Safety signage
    g. MRI equipment and device labeling
        i. MR Safe
        ii. MR Conditional
        iii. MR Unsafe
    h. Surveying objects for the MRI environment
        i. Surveying tools
            1. Permanent magnets
            2. Ferromagnetic detectors
        ii. False alarms
    i. Emergencies in Zone IV
    j. Patient-specific safety concerns
        i. Time-varying magnetic fields
        ii. Thermal injury
        iii. Peripheral nerve stimulation
        iv. Hearing protection
        v. RF heating
            1. Specific Absorption Rate (SAR)
        vi. Special considerations for implanted devices
            1. How to confirm that an implantable medical device is MRI compatible-FDA website, mfg labelling

k. MRI and pregnancy
i. Personnel pregnancy
ii. MRI scanning of pregnant patients
l. MRI of pediatric patients
m. Quenching a superconducting magnet\
i. Safety procedures during a quench

4. Ultrasound
a. Basic principles of ultrasound imaging
i. transducer shape, frequency on image quality
ii. time gain curve
iii. Doppler imaging
iv. artifacts that degrade image quality
b. US in the interventional suite
i. Nonvascular applications
1.
ii. Vascular applications
1. Vascular access
2. IVUS
3. Vascular Lab studies
iii. Pediatric IR applications
c. Vascular lab certification
i. RPVI certification

5. Nuclear Imaging
a. Basic physics of PET imaging
i. clinical indications for PET
1. Oncologic pts b. Basic physics of SPECT imaging
i. clinical indications for SPECT
1. Oncologic pts (MAA)
2. Functional liver reserve

ii. Radiation safety
1. Radiation biology
a. Interaction of radiation with tissue
b. Radiosensitivity
c. Stochastic vs. deterministic radiation effects
d. Effects of radiation on the skin and hair
e. Radiation cataractogenesis
f. Radiation effects in utero
2. Principles of radiation protection
a. Cardinal rules of radiation protection
b. Selecting and using protective garments
c. Orthopedic strain and protective garments\
d. Monitoring occupational dose
e. Dose limits
i. Reporting
f. Regulations
g. ALARA considerations

iii. Normal and Variant Arterial anatomy

1. Diagnostic conventional aortography/arteriography (CR C._)
    a. Appropriate contrast injection rates for aortography and various arterial beds for diagnostic digital subtraction arteriography (DSA)
    b. Appropriate obliquities for DSA in order to define arterial anatomy/pathology
    c. Arterial access sites
        i. Advantages to accessing specific sites
        ii. Disadvantages and specific site related complications
2. Aorta
    a. Criteria for normal vs. aneurysmal ascending/descending aorta
    b. Normal and most common variant branching patterns of the aortic arch
        i. Symptomatic variants
        ii. Asymptomatic variants
    c. Major branches of the descending thoracic and abdominal aorta
        i. Descending thoracic aorta
            1. Location and branching pattern of bronchial arteries
            2. Location and course of intercostal arteries
            3. Most common locations for the origin of the Artery of Adamkiewicz
        ii. Descending abdominal aorta
            1. Locations of the origins of the Celiac, Superior Mesenteric, Inferior Mesenteric, and renal arteries
            2. Location and course of the gonadal arteries
            3. Typical level of the aortic bifurcation
    d. Collateral pathways for aortoiliac stenosis/occlusion
        i. Pathway of Winslow
        ii. Other collateral pathways
3. Arterial anatomy of the head and neck
    a. Approximate size and course of the head/neck arteries
    b. 5 segments of the internal carotid arteries
    c. Normal arterial supply to:
        i. Frontal, temporal, parietal, occipital lobes
        ii. Cerebellum and brainstem
        iii. Face and scalp
        iv. Neck structures
    d. Most common variant anatomy of the head and neck arteries
        i. Variant origins from the aortic arch
        ii. Intracranial variant anatomy including Circle of Willis variants
    e. Collateral pathways for carotid stenosis/occlusion
        i. Cervical
        ii. Intracranial (ICA/ECA)

4. Arterial anatomy of the upper extremities
    a. Approximate size and anatomic boundaries of the upper extremity arteries
    b. Normal arterial anatomy of the upper extremities
        i. Typical arterial supply to the:

1. Upper arm
2. Forearm
3. Hand
4. Digits

c. Variant anatomy of the upper extremities
   i. High origin of the radial artery
   ii. Variations of brachial artery branching

5. Mesenteric arterial anatomy
   a. Normal arterial supply to segments of stomach, small bowel, and large bowel
   b. Celiac axis
      i. Normal branching pattern of the left gastric, splenic, and common hepatic arteries
      ii. Variant branching patterns
         1. Replaced vs accessory hepatic arteries
         2. Origins direct from aorta
      iii. Various origins of the right gastric artery
      iv. Collateral pathways to hypervascular liver tumors from other vascular territories including but not limited to phrenic and internal thoracic arteries
   c. Superior Mesenteric Artery (SMA)
      i. Normal origin and branching pattern
         1. 1st branch – Inferior Pancreaticoduodenal Artery
         2. 2nd Branch – Middle colic
         3. 3rd Branch – right colic
         4. Multiple jejunal and ileal branches
         5. Terminal ileocolic artery
      ii. Variant anatomy
         1. Replaced/accessory hepatic branches
         2. Celiacomesenteric trunk
      iii. Techniques or selection and imaging
   d. Inferior Mesenteric Artery
      i. Normal branching pattern
         1. 1st branch – left colic artery
         2. Sigmoid branches
         3. Terminal bifurcation into right and left superior hemorrhoidal branches
      ii. Techniques or selection and imaging
   e. Collateral pathways between mesenteric vessels
      i. Celiac to/from SMA – Arc of Buehler
      ii. SMA to/from IMA
         1. Marginal arteries of Drummond
         2. Arc of Riolan
         3. Middle colic to left colic

6. Renal Arteries
   a. Typical diameter
   b. Normal location of origins of both left and right renal arteries
   c. Accessory renal arteries (ARA)
      i. Prevalence

ii. Most common types of ARAs
d. Adrenal arteries
7. Arterial anatomy of the lower extremities
a. Typical diameter and anatomic/fluoroscopic boundaries of the lower extremity arteries.
b. Iliac arteries
i. Typical diameter of common and external iliac arteries
ii. Branches of the internal iliac artery
1. Anterior division
a. Obturator artery
b. Inferior gluteal artery
c. Umbilical artery
d. Uterine/prostatic artery
e. Inferior vesicle artery
f. Middle rectal artery
g. Internal pudendal artery
2. Posterior division
a. Superior gluteal artery
b. Iliolumbar artery
c. Lateral sacral artery
3. Most common variant origins of the uterine and prostatic arteries
c. Femoral, popliteal, and tibial arteries
i. Typical diameters of lower extremity arteries
ii. Typical arterial supply to:
1. Compartments of the thigh and lower leg
2. Angiosomes of the foot
iii. Normal branching patterns and anatomic boundaries of the lower extremity arteries
iv. Collateral pathways for
1. Femoropopliteal stenosis/occlusion
2. Tibial artery stenosis/occlusion
v. Variant anatomy
1. Upper leg
a. Persistent sciatic artery
2. Lower leg
a. Dominant peroneal artery
b. Peronea arteria magna
c. Variant branching patterns of the popliteal artery into the tibial arteries
i. High takeoff of anterior tibial artery

iv. Normal and Variant Venous Anatomy
1. Chest/Abdomen/Pelvis
a. Heart
i. Coronary Sinus
ii. Small Cardiac Vein
b. Lung
i. Pulmonary Vein

c. Vertebral venous plexus
d. Superior Vena Cava - union of the right and left brachiocephalic veins
    i. Brachiocephalic - union of the subclavian and internal jugular vein
    ii. Azygous - union of ascending lumbar and right subcostal veins at the 12th thoracic vertebral level
        1. Drains posterior thorax and abdomen into the SVC.
    iii. Hemiazygous - begins in ascending lumbar or left renal vein
        1. Passes upward through the left crus of diaphragm to enter thorax on left, mirroring the lower azygous vein
    iv. Accessory hemiazygous - courses inferiorly along left side of the spine, draining the upper posterior thorax.
    v. Superior Intercostal - drain 2nd - 4th intercostal spaces posteriorly
    vi. Internal thoracic (mammary) - arises from superior epigastric vein and terminates in the brachiocephalic vein.
    vii. Variants
        1. Left SVC - most common congenital venous anomaly of the thorax
            a. Termed as duplication if both present
            b. Can result in right-to-left shunt in minority of cases
        2. Left azygous arch - may occur in association with left SVC
            a. Left superior intercostal vein forms communication between left SVC and accessory hemiazygous vein
e. Inferior Vena Cava
    i. External Iliac - arises at the inguinal ligament and terminates when joined with the internal iliac vein.
    ii. Internal Iliac (hypogastric) - arises near the greater sciatica foramen, terminates when joined with the external iliac vein.
    iii. Common Iliac - formed by the union of the internal and external iliac veins
    iv. Variants
        1. Duplicated IVC – persistent supracardinal veins
            a. Left IVC typically ends at left renal vein to join right.
            b. Prevalence – 0.2-3%
        2. Left IVC – regression of right supracardinal and persistence of left supracardinal vein.
            a. Left IVC joins left renal vein crosses to join with right renal vein to form normal suprarenal IVC
            b. Prevalence – 0.2-0.5%

3. Azygous continuation of IVC – absence of hepatic IVC
    a. IVC receives blood supply from kidneys and passes posterior to enter thorax as azygous vein, which joins SVC at normal location
4. Circumaortic left renal vein (2 left renal veins)
    a. Superior renal vein crosses anteriorly
    b. Inferior renal vein crosses posteriorly
    c. Prevalence – as high as 8.7%
5. Retroaortic left renal vein – single variant renal vein
    a. Passes posterior to aorta
        i. At risk for posterior nutcracker syndrome
    b. Prevalence – 2.1%

f. Portal Vein
    i. Splenic Vein
    ii. Superior Mesenteric Vein
    iii. Direct Supply into Portal

2. Cervical Veins
    a. Internal Jugular - forms from the confluence of the sigmoid and inferior petrosal sinuses draining the brain, face, and neck
        i. Courses with the common carotid artery and vagus nerve inside the carotid sheath
    b. External Jugular - forms from the posterior retromandibular and posterior auricular vein
        i. Drains into the subclavian vein lateral to the internal jugular vein
    c. Thyroidal Veins
        i. Superior and Middle - drain into the internal jugular vein
        ii. Inferior - drains into the brachiocephalic vein
    d. Vertebral vein - venus plexus terminates into a single trunk that exits the 6th vertebral transverse foramen into the brachiocephalic vein posteriorly
3. Lower Extremity
    a. Deep veins of the thigh
        i. Femoral - continuation of the popliteal vein beginning at the adductor canal and terminating at the inguinal ligament
        ii. Popliteal - junction of the posterior and anterior tibial veins
            1. Courses with the popliteal artery
    b. Deep veins of the leg/calf
        i. Peroneal (fibular)
            1. Drains the lateral compartment of calf
        ii. Anterior tibial - arises from dorsal pedal veins
            1. Drains the ankle, knee and anterior portion of lower leg.
        iii. Posterior tibial - arises from medial and lateral plantar veins
            1. Drains the posterior calf and plantar surfaces of the foot.

c. Superficial veins of the leg/calf
    i. Small saphenous (SSV) - originates laterally from dorsal venous pedal arch and usually enters the popliteal vein at the saphenopopliteal junction
        1. Variations
            a. Drain into the greater saphenous
            b. Continue as Giacomini vein
    ii. Great saphenous (GSV) - originates in the dorsal venous pedal arch and joins the common femoral vein at the saphenofemoral junction in the femoral triangle.
        1. External pudendal
        2. Superficial or penis/clitoris
    iii. Giacomini – communicating vein between GSV and SSV, usually as a thigh extension of an SSV branch.
d. Lower extremity perforator veins – connect superficial and deep veins
    i. Valves direct blood from superficial to deep system
    ii. Located in the foot, leg, knee, and thigh
e. Foot branches
    i. Dorsal arch
    ii. Dorsal metatarsal
    iii. Dorsal digital
    iv. Plantar arch
    v. Plantar metatarsal
    vi. Common digital
    vii. Plantar digital

4. Upper Extremity
    a. Superficial
        i. Arm - drains into axillary vein
            1. Cephalic - courses along the radial aspect of the arm
                a. Median cubital - communication between basilic vein
            2. Basilic - courses along the ulnar aspect of the arm
            3. Median antebrachial
        ii. Forearm/Hand – Superficial palmar arch, dorsal network
    b. Deep
        i. Shoulder
            1. Axillary - continuation of the brachial vein, begins at the border of teres major muscle and ends at the edge of the 1st rib
            2. Subclavian - begins at the edge of the 1st rib and ends at the medial border of the anterior scalene muscle.
                a. Thoracic duct drains into the left subclavian vein.
        ii. Arm
            1. Brachial - drains into axillary vein
            2. Radial

3. Ulnar

iii. Forearm/Hand – Deep palmar arch

5. Neuro
    a. Ventricle System
        i. Lateral ventricle
        ii. Interventricular foramen
        iii. 3rd ventricle
        iv. Aqueduct of Sylvius
        v. 4th Ventricle
            1. Drains into the subarachnoid space via foramen of Magendie and Luschka
                a. Foramen of Magendie (median aperture) – single midline structure that drains CSF into the subarachnoid space.
                b. Foramen of Luschka (lateral apertures) – two lateral structures that drain CSF into the subarachnoid space
            2. CSF is reabsorbed via the arachnoid granulations into the dural venous sinus.
            3. The dural venous sinus drains into the jugular vein
    b. Cranial Venous Anatomy
        i. Superior sagittal sinus and straight sinus join to form the confluence.
        ii. The venous confluence drains into the transverse sinuses → sigmoid sinus → Internal Jugular Vein
        iii. Superior Cerebral Veins (Trolard) and the Superior Anastomotic Vein drain into the Superior Sagittal Sinus.
        iv. Thalamostriate Veins drain into the Internal Cerebral Veins.
            1. The internal cerebral veins drain into the Vein of Galen (Great Cerebral Vein)
            2. Vein of Galen drains and the Inferior Sagittal drain into the à Straight Sinus
        v. Inferior Anastomotic Vein (Labbe) drains into the Transverse sinus
        vi. Superficial Middle Cerebral Vein drain into the Cavernous Sinus into the Petrosal Sinus and subsequently the Sigmoid Sinus

v. Normal and Variant Lymphatics
    1. Lymphatic Vessels (general function and structure)
    2. General function & clinical importance
        a. Superficial vs. deep lymphatic vessels, Lymph nodes, lymph trunk and lymph ducts
        b. Right lymph duct
            i. R side of head, neck, R thorax + RUE
            ii. Enters R venous angle (junction of RIJV + subclavian)
        c. Thoracic Duct
            i. Drains rest of body

        ii. Enters L venous angle (confluence of left subclavian and internal jugular veins)
    d. Cisterna chyli
        i. Location
        ii. Drains lower part of body
        iii. Gives rise to thoracic duct - target for access and subsequent thoracic duct embolization
3. Abdominal lymph drainage
    a. Pre-aortic nodes
        i. Celiac nodes
        ii. Superior and inferior mesenteric nodes
        iii. Para-aortic
4. Pelvic Lymph drainage
    a. External iliac nodes
    b. Internal Iliac nodes
    c. Sacral nodes
    d. Common Iliac nodes
5. Lower Extremity Lymphatic Drainage
    a. Superficial Inguinal nodes
        i. T-shape configuration
        ii. Drainage areas
        iii. Target in thoracic duct embolization
    b. Deep inguinal lymph nodes
        i. Anatomic location
        ii. Drainage area
        iii. Efferent vessels
6. Upper Extremity Drainage
    a. Superficial lymphatics
        i. Drainage areas
        ii. Efferent nodes
    b. Deep lymphatics
        i. Drainage areas
        ii. Axillary nodes
            1. Arrangement
            2. Drainage area

Requisite knowledge

Systems

i. Fundamentals
    1. Basic of system functioning
    2. System based approach to quality improvement
        a. Models for QI
        b. System analysis of complications
        c. Creating action plans for individual patient care
        d. How to create and monitor action plans for improvement of hospital and system wide levels\
ii. Resources, providers, and systems
    1. Resources
        a. Understand the different resources available to providers within your healthcare system
        b. Understand patient resources and how economic, geographic and cultural factors affect individual health care outcomes
        c. Understand how to access available resources for IR patients
        d. Insurance plans and how they affect a patient's ability to members and be able to act as a team leader
            i. Physician extenders
            ii. Nurses
            iii. Technologists
            iv. Others
        e. IR physicians need to understand how to coordinate with other specialties both as sources of referrals AND as consultants on IR patients
        f. Work with multidisciplinary groups, such as tumor boards, to provide care for complex patients
    2. Systems
        a. IR residents should have a basic understanding of health care delivery systems and policy nationally
        b. IR residents should understand the state and local health care policy and how it affects patients
        c. Understand hospital and clinic administrative structures and how to work within them to optimize care
        d. Be able to advocate for cost effective care for IR patients and be able to help access resources for required care
    3. Transitions in Care
        a. Be able to identify different types of transitions in care and problems that may occur
            i. Inpatient
            ii. Outpatient
            iii. Admission and Discharge
            iv. Clinic
        b. Understand how improved transitions lead to better outcomes and decreased readmission rates
        c. Work to optimize patient transitions
    4. Cost Appropriate care

    a. Understand cost of recommended therapies and work to deliver cost effective care for IR patients
    b. Work in local hospital system to reduce costs and improve care
5. Patient Advocacy
    a. Understand systemic and personal biases that affect patient care
    b. Develop cultural competency and understand how a patients' background intersects with and affects their health care
    c. Be sensitive to patients from diverse cultures and orientations
    d. Be an advocate for IR patients on individual and systemic levels

I. Requisite knowledge

A. Healthcare Economics and Law

1. Health care economics
    a) Introduction to economics
        (1) Definitions
        (2) Market forces
        (3) Stakeholders
        (4) Macroeconomics
        (5) Microeconomics
    b) Payers
        (1) Public
            (a) Medicare
                (i) Parts and history
                (ii) National coverage determinations (NCD's)
                (iii) Medicare Evidence Development and Coverage Advisory Committee (MEDCAC)
                (iv) Medicare Physician Fee Schedule (MPFS)
                (v) Hospital Outpatient Prospective Payment System (HOPPS)
                (vi) Hospital Inpatient Prospective Payment System (IPPS); DRGs
            (b) Medicaid
                (i) Eligibility
                (ii) Medicaid Physician Fee Index
            (c) Children's Health Insurance Program (CHIP)
        (2) Private
            (a) Indemnity
            (b) Health maintenance organization (HMO)
                (i) Open vs closed panel HMO
                (ii) Staff Model
                (iii) Group model
                    (a) Captive group model
                    (b) Independent group model
                (iv) Network model
            (c) Preferred Provider Organization
                (i) Utilization review
                (ii) Pre-authorization
            (d) Employee based plans
            (e) Self insured
    c) Payment models
        (1) Cost based reimbursement
        (2) Prospectively set payment rates
            (a) Fee for service
        (3) Global payments/Capitation
        (4) Bundled payment/episode based payment
        (5) Patient centered medical homes
        (6) Pay for performance/value based care
    d) Care delivery models
        (1) Accountable care organizations
            (a) Pioneer ACO's
            (b) Next Generation ACOs
            (c) Bundled Payments for Care Improvement Initiative
            (d) State Innovation Models Initiative (SIM)
        (2) Patient centered medical home
        (3) Direct patient contracting
    e) Mechanisms of reimbursement
        (1) ICD-10

(2) CPT terminology
(3) Relative value scale update Committee (RUC)
(a) Resource-based relative value scale (RBRVBS)
(i) Relative value units RVU
(4) Full time equivalent FTE
f) Health care finance
(1) Financial statements: Income statements (P&L), balance sheets, and cash flows
(2) Costs: Fixed and variable costs
(a) Time driven activity based costing
(b) Personnel costs
g) Site of service
(1) Hospital based
(2) Ambulatory Surgical Center
(3) Office-based Lab/Free standing IR centers
h) Contracting
i) Quality & Economics
j) Economic health care disparities
2. Health care policy
a) History
(1) Department of Health and Human Services (HHS)
(a) Centers for Medicare and Medicaid services (CMS)
(i) Medicare
(ii) Medicaid
(2) Sustainable growth rate (SGR)
b) MACRA
c) Quality Payment Program (QPP)
(1) Merit based Incentive Payment System (MIPS)
(a) MU,PQRS,VBM combined into one score
(b) Categories
(i) Quality
(ii) Cost
(iii) Promoting Interoperability
(iv) Improvement Activities (CPIA's)
(2) Advanced Alternative Payment models (APM)
(a) ACO with risk sharing
(b) Patient centered medical homes
(c) Bundled payment models
d) Affordable care act (ACA)
(1) Individual mandate
(2) Medicaid expansion
(3) Effects on employers
(4) Essential health benefits
(5) Changing rate regulations
(6) Health insurance marketplaces
(7) Small Business Marketplace
e) Strategies for proposed alternatives health care laws
(1) Single payer system (Medicare for All)
(2) Block grants
(3) Health savings accounts
(4) Per capita allotments
(5) Association health plans
f) Regulation
(1) Medical research
(a) Stem cells
(b) Genetics
(c) Devices

g) Public health
    (1) US infrastructure
    (2) US global health policy
    (3) Vaccination policies
h) Advocacy and politics
    (1) Political action committee (PAC)
        (a) SIRPAC
        (b) RADPAC
    (2) American Medical Association (AMA)
        (a) AMPAC
    (3) State and County PACS
    (4) Legislative advocacy
        (a) Congressional lobbying
        (b) Grassroots efforts
    (5) Regulatory advocacy
        (a) FDA
        (b) CMS

3. Coding and Reimbursement
    a) ICD-10 reporting
    b) CPT terminology
        (1) Types of CPT Codes (I vs III)
        (2) Global periods
        (3) Evaluation and management (E&M) codes and documentation requirements
        (4) Multiple procedure payment reduction (MPPR)
        (5) Practical elements to coding IR procedures
        (6) Specific outpatient coding
            (a) Office based labs
            (b) Ambulatory surgery centers
        (7) Coding for moderate sedation
        (8) Telemedicine codes
        (9) Care Coordination Codes
    c) RUC and Resource-based relative value scale (RBRVBS)
        (1) Relative value units RVU
            (a) Professional Component (Work)
            (b) Technical Component (Practice Expense)
    d) Reimbursement
        (1) public vs private payers
        (2) Procedural documentation
        (3) Documentation of E & M services
        (4) Structured reporting
    e) Clinical Decision Support
    f) Qualified Clinical Data Registries
        (1) National Radiology Data Registry
            (a) The Interventional Radiology Registry
    g) Pre-authorization and peer-to peer
    h) Coverage denials
4. Practice models and Contracts
    a) Models
        (1) Solo practitioner
        (2) Group practices
            (a) Interventional only
            (b) Diagnostic and Interventional Radiology
            (c) Multispecialty group
            (d) National practices
        (3) Employed physician practices
            (a) Private practice

(b) Academic practice
(c) National corporations
(4) Hybrid practices
(5) Locum tenens/Independent contractors
(6) MSOs
(7) VA/Government/Military

b) Location
(1) Hospital based practice
(2) Ambulatory surgery center
(3) Office based labs
(4) Teleradiology

c) Contracts
(1) Essential elements of partnership group contracts
(2) Essential elements of employment contracts
(3) Essential elements of independent contracts
(4) Non-compete clauses
(5) Exclusive hospital contracts
(6) Obtaining hospital privileges
(7) Call coverage contracts
(8) FTE

d) Compensation
(1) Benchmarks
(2) Variability

e) Personal finance
(1) Insurance
(a) Life
(b) Disability
(c) Health
(2) Investments

5. Essentials of medical malpractice
a) The doctor patient relationship
(1) Proper termination

b) Standard of care
(1) Negligence
(2) Errors

c) Patient rights
(1) Informed consent
(2) Competency and capacity
(3) Refusal of care
(4) Advanced directives
(5) Required reporting
(6) Ethical dilemmas

d) Liability
(1) Economic vs. Non-economic damages

e) Pharmaceuticals and prescribing

f) Essentials of documentation from a legal perspective
(1) Charting errors/complications
(2) Patient non-compliance
(3) Discrepancies with other providers

g) Off label use of medical devices

h) Medical negligence cases
(1) Essentials
(2) Depositions
(3) Settlements
(4) Trial process

i) Liability insurance
(1) Occurrence

(2) Claims made
(a) Tail coverage
j) Being an expert witness
k) Health Insurance Portability and Accountability ACT (HIPAA)
(1) Essentials
(2) Common HIPAA dilemmas
(3) Incidental disclosure vs HIPAA violation

6. Devices and Innovation
a) History of innovation in IR
b) Principles of medical innovation
(1) Framework of innovation process
(2) Trends in medical device development
(3) Concept selection
(4) Meaningful observation
(5) Resources for concept mapping
c) Product design and development
(1) Idea validation
(2) Prototype development
(3) Partnerships
d) Intellectual property and technology transfer
(1) Patents
(2) Copyrights
(3) Trademarks
(4) Trade secrets
(5) Filling process
(6) Technology transfer
e) Regulatory basics
(1) Federal agencies
(2) Pathways for approval
(a) Exception
(b) 510(k)
(c) PMA
(3) Common regulatory pitfalls
f) Financial aspects of innovation
(1) Stakeholder identification
(2) Market analysis
(3) Developing a financial model
(4) Developing a business plan
(5) Sources of funding
(6) Key elements of a pitch
(7) Marketing and commercialization
(8) Exit strategies

Requisite knowledge

Physician Wellness and Development

1. Introduction to physician wellness
    a) Definitions
    b) Wellness in the workplace
2. Mental and emotional health
    a) Depression
    b) Physician suicide
        (1) Recognizing risk factors in others and yourself
    c) Physician substance abuse
        (1) Recognizing abuse in others and yourself
    d) Dealing with difficult patients, consultant and staff
    e) Dealing with traumatic events and death
    f) Delivering bad news
    g) Medical errors and shame
3. Physician burnout
    a) Definitions
        (1) Moderate burnout
        (2) Frequent burnout
    b) Drivers of burnout (Shanafelts/Maslach)
        (1) Work overload
        (2) Lack of control
        (3) Insufficient reward
        (4) Breakdown of community
        (5) Absence of fairness
        (6) Misalignment of values
4. Assessing wellness
    a) Environmental determinants of wellness
    b) Environmental audit techniques
        (1) Healthy Workplace Initiative (HWI)
        (2) Institutional Burnout-Engagement Initiative
    c) Assessment of work related well being
        (1) Colin West 2-question survey
5. Promoting wellness
        (1) Self care
            (a) Sleep
            (b) Nutrition
            (c) Fitness
            (d) Financial health
        (2) Well being activities
            (a) Physical
            (b) Psychological
            (c) Social
        (3) Building support networks
6. Getting help
    a) Mental health resources
        (1) General
        (2) For physicians
    b) Suicide help resources
        (1) General
        (2) For physicians
    c) Substance abuse help resources
        (1) General
        (2) For physicians

Requisite knowledge

Research and Statistics

1. Introduction
    a) Basic definitions
    b) Need for quality research in IR
    c) Formulating research questions
2. Research processes
    a) Principles of regulatory compliance
        (1) Human research
        (2) Animal research
    b) Intellectual integrity
        (1) Conflict of interest
        (2) Data integrity
        (3) Appropriate citations
        (4) Plagiarism
    c) Preparation
        (1) Protocols for clinical research for IRB approval
        (2) Protocols for animal research for IACUC approval
        (3) Preparation of informed consent
        (4) HIPPA compliant data collection systems
3. Study design and methodology
    a) Sample size
    b) Choosing endpoints
    c) Choosing statistical tests
4. Research reporting
    a) Case reports
    b) Observational studies
    c) Retrospective studies
    d) Prospective studies
    e) Clinical trials
    f) Systematic reviews and meta-analysis
5. Interpreting data
    a) Determining validity and impact of scientific articles
    b) Determining the power of the study design
    c) Assessing the bias in reported literature
    d) Assessing the validity of controls
    e) Evaluating the appropriateness of statistical analysis
    f) Evaluating the clinical relevance of the study outcomes
    g) Evaluating the level of evidence presented in the literature
6. Research publishing process
    a) Submission
    b) Peer-review
    c) Editorial decisions
    d) How to respond to comments
7. Mentorship and grants
    a) Grant systems for funding clinical trials