ULTRASOUND STUDY GUIDE

• **Technical knowledge**
  - Physics and Safety
    - Sound properties and interactions
      - Reflection
      - Attenuation
      - Refraction
      - Acoustic impedance
    - Transducer fundamentals
      - Transmit frequencies
      - Transducer types
    - Beam formation
      - Focusing
      - Steering
      - Other
    - Imaging modes
      - Panoramic imaging
      - Compound imaging
      - Harmonic imaging
      - Elastography
      - Contrast imaging
        - 3D
        - M-mode
        - Doppler
    - System Controls & Quality Assurance
      - Gain
      - Time gain compensation
      - Power output
      - Focal zone
      - Transmit frequency
      - Depth
      - Dynamic range
      - Frame rate
- **Doppler**
  - Doppler phenomenon
  - Doppler equation
  - Modes
    - Pulsed/Spectral Doppler
    - Duplex Doppler
    - Color Doppler
    - Power Doppler
    - Continuous wave Doppler
    - B-flow
    - Microflow imaging
    - Vector imaging
  - Doppler controls & Quality assurance
    - Color box
    - Gain
    - Doppler angle
    - Pulse repetition frequency / Scale
    - Transmit frequency
    - Wall filter
    - Color write priority
    - Sample volume size
    - Beam steering
  - Doppler measurements
    - Velocity
    - Resistive index
    - Pulsatility index
    - Systolic acceleration time
    - Volume flow
- **Artifacts**
  - Grayscale
    - Shadowing
    - Increased through transmission
    - Mirror imaging
    - Reverberation
    - Ring-down
    - Comet tail
    - Speed propagation
    - Refraction
    - Side-lobe
    - Slice thickness
    - Anisotropy
    - Noise
- **Electrical interference**
  - Doppler
    - Aliasing
    - Motion/Tissue vibration
    - Mirror imaging
    - Spectral broadening
    - Blooming
    - Twinkle
    - Acoustic streaming
  - Other
    - Safety
    - Mechanical / Cavitation
    - Thermal
    - Mechanical index
    - Thermal index
- **Pathological Diagnosis**
  - Gastrointestinal (nonvascular)
    - Bowel
      - Normal (including congenital anomalies)
      - Appendicitis
      - Diverticulitis
      - Epiploic appendicitis
      - Inflammatory bowel disease
      - Colitis
      - Intussusception
      - Ischemic bowel
      - Small bowel obstruction
      - Cancer (primary, metastases, lymphoma)
      - Benign masses
      - Anal sphincter (normal, tear, fistula)
  - Liver
    - Normal (including congenital anomalies)
    - Focal masses
      - Cystic
        - Simple
        - Complex
      - Hemangiomas
• Biloma
• Abscess
• Echinococcus

○ Solid
  ▪ Focal nodular hyperplasia
  ▪ Adenoma
  ▪ Metastases
  ▪ Hepatocellular carcinoma
  ▪ Cholangiocarcinoma - intrahepatic
  ▪ Lymphoma
  ▪ Biliary hamartomas

• Perihepatic collections

• Diffuse disease
  ○ Steatosis (diffuse and focal)
  ○ Hepatitis (acute and chronic)
  ○ Cirrhosis
  ○ Edema
  ○ Infarction (diffuse and focal)
  ○ Infiltrative diseases
  ○ Elastography
  ○ Fat quantification
  ○ Other

• Trauma

• Transplant (nonvascular)
  ○ Biloma
  ○ Hematoma
  ○ Abscess
  ○ Bile duct abnormalities
  ○ Post-transplant lymphoproliferative disease
  ○ Perihepatic collections

▪ Gallbladder

• Normal (including congenital anomalies)
• Gallstones
• Sludge
• Acute cholecystitis
  ○ Calculous
  ○ Acalculous
  ○ Gangrenous
  ○ Perforated
  ○ Emphysematous
  ○ Hemorrhagic
• Chronic cholecystitis
- Wall thickening (nonbiliary related)
- Polyp
- Adenomyomatosis
- Porcelain
- Carcinoma
- Metastases
- Lymphoma

- **Bile ducts**
  - Normal (including congenital anomalies)
  - Dilatation (extra- and intrahepatic)
  - Choledocholithiasis
  - Cholangitis
    - Primary sclerosing cholangitis
    - Pyogenic cholangitis
    - Recurrent pyogenic cholangitis
    - AIDS cholangitis
  - Caroli disease
  - Choledochal cyst
  - Pneumobilia
  - Cholangiocarcinoma
  - Stents

- **Pancreas**
  - Normal (including congenital anomalies)
  - Cystic lesions
    - Simple cysts
    - PSAs
    - Pseudocysts
    - Abscess
    - Cystic neoplasms
  - Acute pancreatitis
  - Chronic pancreatitis
  - Pancreatic necrosis
  - Cancer
    - Adenocarcinoma
    - Islet cell neoplasm
    - Metastases
    - Lymphoma
  - Transplant (nonvascular)
    - Pancreatitis
    - Pseudocyst
    - Hematoma
    - Abscess
Post-transplant lymphoproliferative disease

**Spleen**
- Normal (including congenital anomalies)
- Splenomegaly
- Splenosis
- Infarction
- Cystic lesions
  - Simple
  - Complex
  - Abscess
  - Necrotic tumor
- Solid lesions
  - Hemangioma
  - Hamartoma
  - Malignancy (Lymphoma, Metastases, Angiosarcoma)
- Trauma
  - Hematoma
  - Laceration

**Peritoneum**
- Normal
- Ascites
- Abscess/infection/peritonitis
- Hemorrhage
- Carcinomatosis
- Lymphoma
- Primary peritoneal cancer
- Mesothelioma
- Free air
- Mesenteric lymphadenopathy

**Abdominal wall**
- Normal
- Hematoma
- Abscess
- Endometriosis
- Hernia
- Primary neoplasm
- Metastasis
- Lymphoma
- Desmoid
- Lipoma
• Postsurgical changes
  • Genitourinary
    ▪ Kidney (nonvascular: native and transplant) and intrarenal collecting system
      • Normal (including variants and congenital anomalies)
      • Cortical abnormalities
        o Renal parenchymal disease
        o Pyelonephritis
        o Infarction
        o Cortical necrosis
        o Nephrocalcinosis (Medullary and cortical)
    • Cystic lesions and cystic renal disease
      o Simple
      o Complex
      o Polycystic disease – Autosomal dominant
      o Multicycstic dysplastic
      o Acquired renal cystic disease
      o Lithium toxicity
    • Masses (solid or with solid components)
      o Angiomyolipoma
      o Oncocytoma
      o Multilocular cystic nephroma
      o Renal cell carcinoma (all types)
      o Metastasis
      o Lymphoma
      o Post transplant lymphoproliferative disease
      o Urothelial carcinoma
    • Infections
      o Pyelonephritis
      o Pyonephrosis
      o Abscess
      o Emphysematous pyelonephritis/pyelitis
      o Xanthogranulomatous pyelonephritis
    • Collecting system abnormalities
      o Hydronephrosis
      o Pyonephrosis
      o Calculi
      o Clot/Fungus ball in collecting system
      o Malignancy
    • Perinephric abnormalities
      o Urinoma
      o Hematoma
- Lymphocele
- Abscess
- Lymphoma

**Ureter**
- Normal (including variants and congenital anomalies)
- Dilated ureter
- Ureteral calculus
- Clot/fungus ball in collecting system
- Urothelial cancer
- Stents

**Bladder**
- Normal
- Calculi
- Wall thickening
- Solid masses
  - Urothelial cancer
  - Polyp
  - endometriosis
  - Urachal remnant/CA
  - [heochromocytoma
- Cystitis
  - Emphysematous cystitis
- Hemorrhage/clot/fungus ball
- Bladder outlet obstruction
- Neurogenic bladder

**Urethra**
- Normal
- Diverticulum
- Cyst
- Abscess
- Mass
- Stricture/stenosis

**Scrotum**
- Testes
  - Normal (including variants and congenital anomalies)
  - Orchitis
  - Torsion/detorsion
  - Microlithiasis
  - Masses
    - Germ cell tumor
    - Lymphoma
    - Metastasis
- Stromal tumor
- Adenomatoid tumor
- Epidermoid cyst
- Hematoma
- Intratesticular varicocele
- Abscess
- Cyst – Intratesticular
- Cyst – Tunica albuginea
- Adrenal rest
  - Focal atrophy/fibrosis
  - Sarcoidosis
  - Tuberculosis
  - Infarct
  - Trauma/laceration/hematoma
- Epididymis
  - Normal
  - Epididymitis
  - Abscess
  - Cyst/Spermatocele
  - Adenomatoid tumor
  - Sperm cell granuloma
  - Postvasectomy/Congestion
- Miscellaneous
  - Hydrocele
  - Pyocele
  - Hematocele
  - Varicocele
  - Fournier gangrene
  - Scrotal wall edema
  - Scrotal wall abscess
  - Hernia
  - Scrotolith
  - Vas deferens
  - Appendix testis/epididymis
  - Torsed appendix
  - Spermatic cord
    - Cyst
    - Hematoma
    - Abscess
    - Lipoma/benign tumor
    - Malignant tumor

- Prostate
  - Normal
• Benign prostatic hypertrophy
• Cancer
• Prostatitis
• Abscess

▪ Seminal vesicles
  ▪ Normal
  ▪ Cyst/Mass
  ▪ Dilated duct

▪ Penis
  ▪ Normal
  ▪ Peyronie disease
  ▪ Masses
  ▪ Doppler
    ▪ Normal
    ▪ Abnormal

▪ Adrenal gland
  ▪ Normal
  ▪ Solid mass
    ▪ Adenoma
    ▪ Pheochromocytoma
    ▪ Myelolipoma
    ▪ Metastasis
    ▪ Lymphoma
    ▪ Cancer
  ▪ Hyperplasia
  ▪ Hemorrhage

▪ Retroperitoneum
  ▪ Normal
  ▪ Adenopathy
    ▪ Lymphoma
    ▪ Metastatic disease
    ▪ Reactive/Infectious/Inflammatory
  ▪ Primary tumor
    ▪ Location
    ▪ Relationship to blood vessels and surrounding structures
  ▪ Hemorrhage
  ▪ Abscess
  ▪ Fibrosis

▪ Gynecology
  ▪ Uterus
    ▪ Normal (including congenital anomalies, pre- and post-menopausal)
- **Endometrium**
  - Effects of hormone replacement
  - Intrauterine device
    - Normal location
    - Migrated/perforated
  - Endometrial fluid/hemorrhage
  - Polyp
  - Hyperplasia
  - Carcinoma
  - Endometritis
- **Myometrium**
  - Fibroids
  - Lipoleiomyoma
  - Leiomyosarcoma
  - Adenomyosis
  - C-section scar
  - Vascular lesions
  - Cervix
    - Stenosis
    - Polyp
    - Cancer
    - Adenoma malignum
    - Fibroid
  - Ovary/Adnexa
    - Normal (pre and post-menopausal)
    - Polycystic ovarian disease
    - Ovarian hyperstimulation syndrome
    - Masses/cysts
      - Follicles/Simple cyst
      - Hemorrhagic/ruptured cyst
      - Endometrioma
      - Cystadenoma/carcinoma
      - Dermoid
      - Other germ cell tumors
      - Fibroma/thecoma
      - Other stromal tumors / granulosa cell tumor
      - Metastasis
    - Ovarian torsion
    - Pelvic inflammatory disease
    - Tubo-ovarian abscess/complex
    - Peritoneal inclusion cyst
- Fallopian tube
  - Hydrosalpinx
  - Pyosalpinx
  - Hematosalpinx
  - Torsion
  - Mass
- Vagina
  - Cysts
  - Solid mass
  - Congenital anomalies
- Obstetrics
  - First trimester
    - Normal
      - Gestational Sac
      - Yolk sac
      - Embryo/Fetus
      - Cardiac activity/rate
      - Amnion
      - Chorion
      - hCG levels / menstrual dates
    - Multiple gestations (chorionicity and amnionicity)
    - Failed early pregnancy and embryonic demise
      - Diagnosis
      - Risk factors
    - Miscarriage
    - Retained products of conception
    - Ectopic pregnancy
      - Tubal
      - Interstitial
      - Cervical
      - Ovarian
      - Cesarean scar
      - Abdominal
      - Rudimentary horn
      - Heterotopic
    - Pregnancy of unknown location
    - Gestational trophoblastic disease
    - Nuchal translucency / first trimester screening
    - Chorionic villus sampling (CVS)/Amniocentesis
    - Cell free DNA
    - Embryonic/fetal structures: Normal and abnormal
  - Second and third trimester
- Normal findings
  - Fetus
  - Placenta, cervix
  - Biometry
  - Amniotic fluid
  - Multiple gestations (including chorionicity and amnionicity)

- Fetal abnormalities
  - Abnormal growth/well-being
  - Hydrops
  - Fetal death
  - Structural abnormalities
    - CNS
    - Face and Neck
    - GU
    - GI
    - Chest
    - Skeletal
    - Chromosomal abnormalities
      - Down syndrome
      - Turner syndrome
      - Trisomy 18
      - Trisomy 13
    - Syndromes
      - Amniotic band
      - Meckel-Gruber
      - Beckwith-Wiedmann
      - VACTERL
      - Caudal regression
  - Congenital infections

- Aneuploidy markers / Borderline findings
  - Nuchal thickening
  - Choroid plexus cyst
  - Echogenic intracardiac focus (EIF)
  - Echogenic bowel
  - Borderline hydrocephalus

- Oligohydramnios
- Polyhydramnios

- Twins/multiple gestations
  - Types
  - Multiple gestation abnormalities
    - Twin-to-twin transfusion / Stuck twin
    - Acardiac twin (twin reversed arterial perfusion [TRAP])
- Twin demise
- Monoamniotic twins / cord entanglement
- Abnormal growth

### Placenta
- Placenta previa
- Marginal
- Succenturiate placenta
- Circumvallate
- Vasa previa
- Abruption
- Placenta accreta spectrum
- Masses
- Subchorionic bleed
- Thick placenta

### Cervix
- Shortening / Dilatation
- Cerclage
- Risks for preterm labor

### Umbilical cord
- Two-vessel umbilical cord
- Cord masses
- Placental cord insertion site
- Velamentous cord insertion
- Cord prolapse
- Umbilical cord Doppler
- Nuchal

### Uterine abnormalities during pregnancy
- Adnexal abnormalities during pregnancy

### Postpartum
- Retained products of conception
- Ovarian vein thrombosis
- Uterine rupture
- Uterine atony
- Infection
- Complications s/p Cesarean section delivery

### Vascular
- Arterial pathology involving the following beds:
  - Extracranial carotid arteries
  - Vertebral arteries
  - Aorta
  - Mesenteric arteries (Celiac, SMA, IMA)
  - Renal arteries
- Splenic artery
- Hepatic artery
- Peripheral arteries (upper and lower extremities)
- Pelvic arteries

For all the above arterial territories, evaluation of the following:
- Normal grayscale, color Doppler and spectral Doppler waveforms (including variants and congenital anomalies)
- Plaque / Fibrointimal thickening
- Stenosis
- Occlusion
- Dissection
- Arteriovenous fistula
- Aneurysm
- Pseudoaneurysm
- Imaging s/p intervention: arterial bypass grafts, endarterectomy, stent, vascular access
  - Normal
  - Restenosis/occlusion
  - Complications, including infection, PSA, AVF
- Vasculitis/arteritis
- Waveform abnormalities

Additional pathology specific to individual arterial beds:
- Vertebral artery
  - Subclavian steal
- Upper extremity arteries
  - Thoracic outlet syndrome
  - Takayasu arteritis
  - Palmar arch (harvesting)
    - Patency
    - Direction of flow
- Hemodialysis graft/fistula
  - Lack of maturation
  - Steal
  - Fluid collections
  - Flow volume
- Lower extremity arteries
  - s/p arterial bypass grafts
    - Persistent perforators
- Aorta
  - Screening for AAA
  - Stent grafts: normal
  - Endoleak
- Coarctation
  - Renal artery
    - Screening for renovascular hypertension
    - Fibromuscular dysplasia
  - Venous pathology
    - Extremity venous (including IVC)
      - Normal grayscale, color Doppler and spectral Doppler waveforms (including variants and congenital anomalies)
      - Thrombus
        - IVC filter
        - Tumor in IVC (metastatic or primary)
      - Stenosis
      - Abnormal waveforms
        - Tricuspid regurgitation / Right-sided heart failure
        - Cephalad obstruction to flow
    - Venous insufficiency
    - Venous mapping (harvesting and dialysis access creation)
    - Venous thoracic outlet syndrome
  - Portal, coronary, splenic and superior mesenteric veins
    - Normal grayscale, color Doppler and spectral Doppler waveforms (including variants and congenital anomalies)
    - Bland thrombus
    - Tumor in vein
    - Stenosis
    - Cavernous transformation
    - Aneurysm/Varix
    - Portal hypertension
    - Portosystemic collaterals
    - Congestion / heart failure
    - Gas
    - PV to HV fistula
- Hepatic vein
  - Normal grayscale, color Doppler and spectral Doppler waveforms (including variants and congenital anomalies)
  - Bland thrombus
  - Tumor in vein
  - Budd Chiari syndrome
  - Stenosis
  - Tricuspid regurgitation/congestive heart failure
  - Portohepatic vein fistula (arterial or venous)
- TIPS
  - Normal
• Stenosis
• Occlusion

- Renal vein
  • Normal grayscale, color Doppler and spectral Doppler waveforms (including variants and congenital anomalies)
  • Thrombus
  • Tumor in vein
  • Stenosis
  • Nutcracker syndrome

- Kidney Transplant Vasculature
  • Normal
  • Elevated resistive index
    • Rejection
    • Acute tubular necrosis
    • Page kidney
    • Hydronephrosis
    • Pyelonephritis
    • Renal vein thrombosis
    • Compartment syndrome, torquing of pedicle
    • Transducer pressure
      • Arterial stenosis / thrombosis
      • Pseudoaneurysm
      • Arteriovenous fistula
      • Venous stenosis/thrombosis
      • Infarction
      • in flow or outflow pathology

- Liver Transplant Vasculature
  • Normal
  • Arterial stenosis / thrombosis
  • Resistive index abnormalities
  • Vasospasm
  • Portal vein thrombosis / stenosis
  • Hepatic vein thrombosis/stenosis
  • Inferior vena cava stenosis / thrombosis Heart Failure / Congestion
  • Pseudoaneurysm
  • Arteriovenous fistula

- Pancreas Transplant Vasculature
  • Normal
  • Arterial thrombosis / stenosis
  • Venous thrombosis / stenosis
  • Pseudoaneurysm
  • Arteriovenous fistula
• Neck and Head (nonvascular)
  o Thyroid
    ▪ Normal (including variants and congenital anomalies)
    ▪ Hashimoto thyroiditis
    ▪ Graves disease
    ▪ Subacute thyroiditis
    ▪ Benign hyperplastic nodule
    ▪ Adenoma – follicular/Hurthle cell
    ▪ Papillary cancer
    ▪ Follicular cancer
    ▪ Medullary cancer
    ▪ Anaplastic cancer
    ▪ Lymphoma
    ▪ Metastasis
    ▪ Multinodular goiter
    ▪ Cyst
      ▪ Simple
      ▪ Complex
    ▪ Guidelines for fine-needle aspiration
    ▪ Metastatic cervical lymph nodes
  o Parathyroid
    ▪ Normal
    ▪ Adenoma
    ▪ Hyperplasia
    ▪ Carcinoma
    ▪ Cyst
  o Lymph nodes
    ▪ Normal
    ▪ Reactive / inflammatory
    ▪ Infectious
    ▪ Metastatic
    ▪ Lymphoma
  o Salivary glands
    ▪ Normal
    ▪ Infection/inflammation
    ▪ Abscess
    ▪ Stones
    ▪ Dilated duct
    ▪ Pleomorphic adenoma
    ▪ Warthin’s neoplasm
    ▪ Mucoepidermoid cancer
    ▪ Adenoid cystic cancer
    ▪ Acinic cell cancer
- Lymphoma
- Cyst
  - Simple
  - Complex
- Neck Soft tissues
  - Branchial cleft cyst
  - Thyroglossal duct cyst
  - Lymphangioma/Hemangioma
  - Lipoma
  - Keratinous/Epidermal inclusion/Sebaceous cyst
  - Hematoma
  - Abscess
  - Carotid body tumor
  - Hypopharynx cancer
- Musculoskeletal (nonvascular)
  - Normal (including variants & congenital anomalies)
    - Tendon
    - Muscle
    - Ligament
    - Cartilage
    - Bone
    - Nerve
  - Tendons
    - Tear of major tendons (complete or partial)
    - Tendinosis
    - Tenosynovitis
    - Subluxation (pulley injury)
  - Muscle
    - Tear
    - Hematoma
    - Abscess
    - Neoplasm
    - Atrophy
    - Fatty infiltration
    - Myositis
    - Necrosis
  - Nerve
    - Compression
    - Neuroma
    - Neoplasm
    - Neuritis
    - Trauma/laceration
    - Subluxation
o Bone
  ▪ Fracture
  ▪ Osteomyelitis
  ▪ Neoplasm
  
o Ligaments
  ▪ Tear
  ▪ Plantar fasciitis
  ▪ Plantar fibroma
  ▪ Pulley rupture
  
o Soft tissues / Joints / General extremity
  ▪ Joint effusion (simple vs complex)
  ▪ Synovitis
  ▪ Cystic lesions
    • Simple
    • Complex
  ▪ Soft tissue edema vs Cellulitis
  ▪ Necrotizing fasciitis
  ▪ Solid lesions
    • Lipoma
    • Desmoid
    • Primary neoplasm
    • Metastasis
    • Lymphoma
    • Giant cell tumor tendon sheath
  ▪ Trauma
    • Foreign body
    • Hematoma
  
• Thoracic (nonvascular)
  o Lung, Pleura
    ▪ Normal
    ▪ Pleural effusion
    ▪ Empyema
    ▪ Hemothorax
    ▪ Pneumothorax
    ▪ Atelectasis
    ▪ Pneumonia
    ▪ Lung cancer
    ▪ Metastasis
    ▪ Mesothelioma
  o Mediastinum
    ▪ Adenopathy
    ▪ Primary neoplasm
- Hematoma
- Abscess

- Noninterpretive Clinical applications
  - Protocols
  - Appropriateness
  - Documentation, reporting, communication
  - Clinical quality assurance