SRU Resident Curriculum

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Recently, the American College of Graduate Medical Education (ACGME) in a joint initiative with the American Board of Radiology revised the criteria by which each resident in radiology is expected to be evaluated during their training years. In the past, residents were graded on 6 areas including patient care, medical knowledge, practice-based learning and improvement, interpersonal and communication skills, professionalism, and system-based practice. This has been changed to a core competency assessment that includes the following:

- medical knowledge
- educational attitude
- perception and judgment
- technical skills
- clinical effectiveness
- communication/consultation

As a further refinement of these core competencies, the 12 milestones listed below have been created to ensure that resident education is consistent throughout the United States and that expectations of radiologists match the expectations of numerous regulatory bodies within state and federal government. It is essential that the training programs reflect the changing values of medical care policy particularly with regard to quality, safety, and ultimately patient outcome. The ability to interpret images, integrate clinical information, and communicate with other health care professionals and patients as an effective consultant is of paramount importance for the future of our specialty.

The milestones are as follows:

1. consultant
2. competence in procedures
3. selection and optimization of images
4. interpretation of examinations
5. professional values and ethics
6. effective communication with patient, families, and caregivers
7. effective communication with members of health care team
8. quality improvement
9. health care economics
10. patient safety
11. self-directed learning
12. scholarly activity

It is evident that none of these milestones specifically applies to ultrasound (US), yet as we all know, US is an area where a great deal of interaction occurs with patients, families, other health care professionals especially sonographers, and among ourselves. Because many procedures are carried out with US guidance, the ability to perform procedures safely is necessary for all radiologists, not just sonologists. Knowledge and consideration of financial issues related to the practice of radiology are important milestones. Ultrasound, as the least expensive cross-sectional modality, has the capability in many cases to replace the use of more expensive technologies, such as computed tomography (CT) and magnetic resonance imaging (MRI). However, this can only be done by someone who is well trained, competent, and confident to make such diagnoses. Radiology has changed with advancing technology as much if not more than any other specialty in medicine, and clearly for all of us who wish to practice radiology at the state-of-the-art level, a lifelong commitment to learning and scholarly activity is required, and ensuring that trainees understand this needs to be a core value for all practicing radiologists.

The ACGME has left it to each specialty to create curriculum specifics regarding the body of knowledge and technical skills needed to practice medicine in their respective specialty. For radiology, and US in particular, a well-defined body of knowledge is necessary to achieve competency. The ACGME has developed 5 levels of achievement to assess whether a trainee has reached a certain level of practice. Each area is defined as beginner, advanced beginner, competent, proficient, and expert. These 5 levels apply to all areas in radiology including US. It is left up to each society overseeing these parts of radiology to develop curricula that define what is required to achieve each level, and it is even more essential for radiologists to define the necessary US criteria, given that many other specialties now use and teach US as part of their training. By keeping the bar high for training in US, radiology ensures that high standards are maintained, which of course benefits patient care and safety as well as health care economics.

This document therefore represents the cumulative work of the members of the training and outreach committees over the last several months. We chose to define each level of achievement within each area of US as follows:

- **Beginner**: knowledge of basic anatomy
- **Advanced Beginner**: knowledge of basic pathology
- **Competent**: knowledge of advanced pathology and the performance and interpretation of color Doppler US
- **Proficient**: ability to assimilate clinical information and radiologic imaging studies to manage cases and consult effectively.
- **Expert**: ability to scan all types of cases and perform US-guided procedures

Each member of the committee is an expert in their respective area of US, and collectively we have developed basic guidelines for determining which milestones a resident has achieved in a given area of US. We have defined beginner as understanding basic anatomy seen on US, advanced beginner as recognizing basic pathology, competent as recognizing advanced pathology and having gained technical and interpretive skill in using color, proficient as having sufficient skill and knowledge to manage cases that include an assessment of when to do CT or MRI, biopsy, follow-up, or simply indicating that no further follow-up is needed. Expert level is in effect, an attending level of skills that include the ability to scan, perform procedures, manage patients, and consult effectively with other members of the medical team with regard to the results of the US examination.

The curriculum guidelines we have produced are just that a guideline for training will vary from institution to institution. Radiologists’ knowledge of physics is part of what makes our specialty unique, and a section on physics and instrumentation has been included as part of each area within the perform procedures, which is a major part of being competent in US, and this is one of the milestones. Procedures are done by many subspecialties in curriculum.

In today’s practice of US, residents are often exposed to transplants, high-risk obstetric vascular studies, and complex musculoskeletal and emergency cases on their first day. This document is not intended to indicate any particular order or sequence by which residents will learn the US skills listed in this document. Some institutions do not perform obstetric or vascular studies, and thus residents may not actually become competent or proficient in these areas, and it is important to recognize shortcomings in the training of our residents. A resident may become competent at doing color flow imaging within the first few days of their first US rotation, yet may not have seen a case of hydrenephrosis. Some may not ever see a testicular torsion in clinical practice, but most will have been shown these entities in teaching sessions or lectures, and for the purposes of this curriculum, this would satisfy completion of that particular requirement.

The idea is not to make everyone competent in each area, but to produce guidelines that give a clearer picture of what level of expertise a resident has achieved in any given area. Most of us are not experts in every area of US, and so we may not even competent in certain areas of US because this is not within the scope of our practice. The performance of procedures as well as the knowledge and judgment of when to perform a biopsy of any given lesion is an integral part of US, and the performance of procedures is included in each section of this US curriculum where relevant. For patient safety, we have designated the performance of procedures at an expert level of achievement and expect an expert level of practice for anyone performing procedures on patients within his/her given specialty.

These guidelines can perhaps best be thought of as a checklist that each resident would use as a guide for learning US including self-directed learning

SRU RESIDENT CURRICULUM
Radiology Residency Ultrasound Curriculum Second Drafts

PHYSICS AND ELASTOGRAPHY
Brian S. Garra, MD

Beginner: Normal Anatomy
- What is US, sound, infrasound? Basic applications in medicine and other fields
- History of ultrasound
- Ultrasound pulse echo imaging—basic process (transducer, pulser, beam former, receiver, scan converter, postprocessor, display)
- Generation of ultrasound (piezo electric effect, piezo electric materials)
- Basic interaction of ultrasound with tissue (scattering, acoustic properties of materials)
- Transducers and transducer types and image shapes produced by various types
- Digital beam former (functions: firing order, timing of firings, focus control, beam steering)
- Receiver (gain, AM detection, time gain compensation)
- Postprocessing and scan conversion
- Display types (A, B, C, M modes, duplex Doppler, color Doppler-triplex)
- Basic ultrasound controls and usage of each control
- Ultrasound safety (typical intensities, AIUM safety statement, on-screen output display)

Advanced Beginner: Basic Pathology
- Ultrasound pulses—properties and interaction with tissue (CW vs pulsed, pulse characteristics, frequency dependencies—penetration, lateral resolution, scattering intensity)
- Velocity and wavelength (wavelength-frequency relationship, sound speed standards and uses in US, pulse length—bandwidth, axial resolution)
- Measures of amplitude and power (amplitude, intensity, SPTA, SPPA)
- Ultrasound pulse interactions with tissue (attenuation, scattering-reflection)
- Ultrasound beam (properties vs depth, Fresnel and Fraunhofer zones, focusing, beam steering methods)
- Ultrasound artifacts (slice thickness, speckle, side lobes, reverberation, ring down, mirror image, refraction, speed of sound error, range ambiguity, shadowing, edge shadowing, enhancement, banding, focal zone effects)

Competent: Knowledge of Advanced Pathology/Performance and Interpretation of Color Flow/Duplex Imaging
- Doppler ultrasound basics (Doppler principle, Doppler equation, spectral, power, color Doppler and main uses)
- Flow (Poiseuille equation, laminar flow types, turbulent flow, pulsatile flow, flow in stenosis, continuity rule)
- Spectral Doppler appearance of flow types
- Doppler angle and sampling effects (alising, Shannon’s theorem, Nyquist criterion)
- Harmonic imaging (definition, creation, detection of harmonics, advantages, disadvantages, practical uses)

Proficient: Ability to Assimilate Clinical Information and Radiologic Imaging Studies to Manage and Consult Effectively
- Methods for increasing ultrasound power/penetration—pulse compression
- Doppler instrumentation, signal processing, and controls (CW, spectral, color/power)
- Doppler artifacts (alasing, mirror image, range ambiguity, twinkle, usage of artifacts)
- Non-Doppler methods for flow detection (cross correlation, b-flow)
- Doppler tissue motion methods and uses
- Extended field of view imaging and variants
- Speckle and speckle reduction methods (nature of speckle, uses, speckle reduction methods, advantages and disadvantages)

Expert: Able to Perform US-Guided Procedures and Scan All Pathology
- 3D and 4D imaging (transducers, display modes, fusion imaging)
- Elasticity imaging (types: sonoelasticity, strain, shear wave, axial shear strain, poroelastography)
- Ultrasound contrast agents (types, commercial agents, agent preparation, contrast agent safety-bioeffects)
- Ultrasound contrast agent imaging (low MI, high MI, wash in-wash out, uses of each mode)
- Ultrasound and transmission of images and measurements—DICOM, other formats
- Basic ultrasound QA (phantoms-test objects, QA parameters, transducer tests, Doppler QA, daily QA)
- Ultrasound bioeffects and safety (bioeffects, thermal and mechanical indices, FDA limits, ALARA principle, application to daily practice)

ABDOMEN
Carl C. Reading, MD

Beginner: Normal Anatomy
- Gallbladder
- Normal anatomy, wall thickness
- Bile ducts
- Normal intrahepatic and extrahepatic anatomy
- Normal duct diameter and where to measure (measure hepatic duct at level of portal vein)
- Liver
- Normal anatomy (both transverse and longitudinal)—traditional nomenclature (lobes and segments), ligamentum teres, ligamentum venosum
- Normal echotexture
- Spleen
- Normal anatomy, size
- Pancreas
- Normal anatomy, echotexture
- Normal pancreatic duct location and diameter
- Peritoneum
- Knowledge of dependent locations in abdomen where free fluid resides—hepatorenal fossa, splenorenal fossa, posterior cul-de-sac (female)/retrovesical space (male)
- Abdominal wall
- Normal anatomy

Advanced Beginner: Basic Pathology
- Understand clinical indications for a US examination of the abdomen, which include but are not limited to the following:
  - Abdominal pain
  - Signs or symptoms that may be referred from the abdominal regions such as jaundice
  - Palpable abnormalities such as an abdominal mass or organomegaly
  - Abnormal laboratory values or abnormal findings on other imaging examinations (CT, MRI, positron emission tomography [PET], nuclear medicine, plain film) suggestive of abdominal pathology

and faculty could use as a template for resident education in US. I am hopeful that this curriculum will be very helpful to most of us in our own institutions for organizing the training of residents in US, and it will demonstrate to specialties outside radiology that we have set high standards for the training of residents in the performance of US.

I would like to thank the members of the training and outreach committee for their contributions to this document.

REFERENCES
Follow-up of known or suspected abnormalities in the abdomen
Search for metastatic disease or an occult primary neoplasm
Evaluation of suspected congenital abnormalities
Abdominal trauma
Planning for and guiding an invasive procedure
Searching for the presence of peritoneal fluid

Galbladder
- Normal variants—folds, Phrygian cap
- Sludge
- Stones—including wall-echo-shadow appearance. How to increase sensitivity for detecting gallstones and shadowing from stones with use of higher frequency transducers
- Acute cholecystitis findings

Bile ducts
- Advanced age/postholecystectomy state may be associated with dilatation of mid–extrahepatic duct

Liver
- Anatomy—modern nomenclature (Couinaud)
- Normal variant—Reidel lobe, papillary process of caudate lobe
- Normal diaphragmatic muscle bundles (slips) indentation on liver
- Detect focal disease—cyst vs solid
- Doppler evaluation of normal hepatic vasculature—hepatic veins, portal veins, splenic vein, upper inferior vena cava (IVC), hepatic artery, superior mesenteric vein, portal confluence; characteristics of normal waveforms

Spleen
- Splenomegaly
- Detect mass
- Splenule

Pancreas
- Detect mass
- Detect ductal dilatation

Gastrointestinal (GI) tract
- Normal bowel appearance—gut signature (bowel wall layers, lumen, peristalsis)
- Detect bowel dilation, obstruction

Peritoneum
- Recognize ascites, amount and location; mark skin surface for paracentesis

Competent: Knowledge of Advanced Pathology/Performance and Interpretation of Color Flow/Duplex Imaging

Galbladder
- Wall thickening differential, and evaluate for extraluminal findings to narrow differential
- Polyps
- Adenomyomatosis (diffuse, focal)
- Cancer

Bile ducts
- Obstruction—level, cause
- Choledocholithiasis
- Pneumobilia
- Stent

Liver
- Characterize cystic mass
  - Simple cyst
  - Complex cyst—hematoma, abscess, necrotic tumor
  - Characterize focal solid mass
  - Benign—cavernous hemangioma (typical and atypical appearances), focal nodular hyperplasia
  - Malignant—metastasis, hepatocellular cancer
  - Characterization of diffuse disease
- Parenchymal disease
- Steatosis—diffuse, focal, and focal sparing
- Hepatitis
- Cirrhosis
- Doppler evaluation of abnormal hepatic vasculature
  - Portal hypertension
  - Portal systemic collaterals—recanalized paraumbilical vein
  - Dilated portal vein, decreased flow, loss of respiratory variation, above and below baseline flow, hepatofugal flow
  - Recognize acute portal vein thrombosis and cavernous transformation/collar vessels of chronically thrombosed portal vein
- Passive hepatic congestion
  - Enlarged IVC, hepatic veins
- Prominent pulsatility in hepatic and portal veins

Parenchymal liver biopsy
- Recognition of perihilar hematoma postbiopsy

Spleen
- Laceration/hematoma
- Characterize cystic mass—simple, complex
- Characterize solid mass—hemangioma, metastasis, lymphoma

Pancreas
- Acute and chronic pancreatitis
- Staging of pancreatic cancer—regional vascular involvement
- Characterize cystic mass
  - Simple vs complex—cystic tumor, intraductal papillary mucinous neoplasm, pseudocyst
- Pseudocysts
- Characterize solid mass—adenocarcinoma, islet cell neoplasm
- Stone in pancreatic duct

GI tract
- Loss of gut signature
- Diffuse wall thickening—colitis, ischemia
- Hypertrophic pyloric stenosis
- Appendicitis
- Peritoneum
- Appendicitis—findings suggestive of perforation

Biloma
- Abscess
- Perform paracentesis
- Abdominal wall
  - Characterize mass—hematoma, seroma, lipoma, desmoid, other

Proficient: Ability to Assimilate Clinical Information and Radiologic Imaging Studies to Manage and Consult Effectively

Galbladder
- Complications of acute cholecystitis—perforation, gangrenous, emphysematous
- Acalculous cholecystitis
- Tumefactive sludge
- Duplication
- Porcelain
- Metastases to galbladder

Bile ducts
- Thick walled—primary sclerosing cholangitis, bacterial cholangitis, AIDS cholangiopathy
- Cholangiocarcinoma (intrahepatic, hilar, distal)
- Caroli disease
- Choledochal cyst
- Cystic duct remnant

Liver
- Biliary hamartoma
- Hepatic adenos...
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- Primary lymphoma—including posttransplant lymphoproliferative disease
- Amoebic abscess, hydatid cyst, cystadenoma/cystadenocarcinoma
- Doppler
  - TIPS (transjugular intrahepatic portosystemic shunt), portocaval shunt, splenorenal shunt
  - Arteriovenous fistula, venous fistula, pseudoaneurysm
  - Budd-Chiari
  - Portal vein tumor thrombus vs bland thrombus
- Air in portal veins
- Parenchymal biopsy
- Spleen
  - Granulomatous disease/fungal infection
  - Infarct
  - Splenic artery aneurysm
- Pancreas
  - Staging of pancreatic cancer—regional vascular involvement
  - Lymphoma
  - Metastases to pancreas
  - Pseudoaneurysm
  - Invasion/obstruction of vessels by pancreatic mass or in setting of pancreatitis
  - Percutaneous fine-needle aspiration (FNA)/biopsy of mass
- GI tract
  - Focal wall thickening—carcinoma, GI stromal tumor, lymphoma, metastasis
  - Inflammatory bowel disease
  - Typhlitis
  - Intussusception
  - Mucocele of appendix
  - Detect mesenteric lymph nodes
- Peritoneum
  - Carcinomatosis, omental involvement
  - Pneumoperitoneum
- Abdominal wall
  - Detect/characterize hernia and contents
  - FNA/core biopsy of abdominal wall mass

Expert: Able to Perform US-Guided Procedures and Scan All Pathology

- Gallbladder
  - Cholecystotomy tube insertion
- Bile ducts
  - Ascariasis, clonorchiasis, filariasis
  - Mirizzi syndrome
- Liver
  - Schistosomiasis
  - Biopsy liver mass
  - Drain hepatic abscess
  - Hepatic mass characterization with microbubble contrast agents
  - Image fusion with CT/MRI
  - Percutaneous ablation of mass with ethanol (cyst, hepatocellular carcinoma)
  - Percutaneous RF ablation of mass
  - Intraoperative US of the liver
  - Intraoperative RF and cryoablation of mass
- Spleen
  - Mass biopsy/abscess drainage
- Pancreas
  - Percutaneous FNA/biopsy of mass
  - Intraoperative US of the pancreas.
- GI tract
  - Diverticulitis
- \( \text{o} \) Epiplac appendagitis
- \( \text{o} \) Pneumatosis intestinalis
- \( \text{o} \) Anal sphincter tear/fistula
- \( \text{o} \) Staging rectal carcinoma with rectal US
- \( \text{o} \) Peritoneum
  - \( \text{o} \) Omental infarct
  - \( \text{o} \) Abdominal wall
  - \( \text{o} \) Endometrial implant after cesarean delivery

KIDNEY, URETERS, BLADDER, PROSTATE
Mariam Moshiri, MD

Beginner: Normal Anatomy
- Kidney: location, size, shape, appearance (corticomedullary differentiation), extrarenal pelvis
- Junctional parenchymal defects
- Renal sinus lipomatosis
- Ureter: usually not visible without pathology
- Bladder: size, shape, appearance (empty, partially filled, completely filled)
- Prostate: location, size, shape, appearance
- Seminal vesicles: location, shape, appearance

Advanced Beginner: Basic Pathology
- Kidney: cyst, calculus, cortical scar, “dromedary hump” not a mass, renal pelvis dilatation
- Diffuse parenchymal disease (increased cortical echogenicity)
- False positives, mimickers (paradiventricular cysts, diuresis, reflux, diabetes insipidus, recently relieved obstruction, prominent renal vessels)
- Pyonephrosis
- Milk of calcium (differentiate from renal calculus)
- Congenital abnormalities (renal agenesis, ectopia, cross fused ectopia, horseshoe kidney, duplicated system)
- Ureter: ureteric dilation (proximal and/or distal), ureterocele, urothelial thickening
- Bladder: diverticulum, debris, calculus, postvoid residual
- Prostate: calcification, ejaculatory duct cysts
- Seminal vesicles: cysts, calcification, ureteral insertion

Competent: Knowledge of Advanced Pathology and the Performance and Interpretation of Color/Doppler US
- Kidney: twinkle artifact, mass solid/cystic/mixed differentiation from the cortex/medulla with color Doppler
- Papillary necrosis (atrophy, calcification, sloughed papilla, causes)
- Medullary nephrocalcinosis (stages, early, mid, late; causes; medullary sponge kidney)
- Other renal pelvic mass (blood clot, fungus ball, papilla, pass ball)
- Renal infarct (color Doppler)
- Renal, subcapsular, perirenal hematoma
- Hyperechoic mass (not all are angiomyolipoma, differential diagnosis)
- Ureters: mass, calculus
- Bladder: UVJ lesions, ureteral jets, bladder mass
- Prostate: mass, inner zone, peripheral zone

Proficient: Ability to Assess Clinical Information and Radiologic Imaging Studies to Manage and Consult Effectively
- Kidney: decide the next imaging modality (if needed) for clarification
- If the lesion is accessible for percutaneous biopsy
- Recognize complications of a biopsy/procedure performed on follow-up imaging (pseudoaneurysms, arteriovenous fistula [AVF], scarring, calyceal diverticulum)
- Recommend appropriate follow-up of lesions

Expert: Able to Perform US-Guided Procedures and Scan All Pathology
- Percutaneous biopsy
- Intraoperative examinations

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Advanced Beginner: Basic Pathology

○ Uterus
  ○ Normal appearance during female life cycle (prepubertal, menstrual, postpartum, postmenopausal)
  ○ Normal size, shape, position
  ○ Echogenicity and echotexture (myometrial layers, arcuate vessels)
  ○ Fibroid identification
  ○ Cervix (normal appearance)
○ Endometrium
  ○ Normal appearance during phases of menstrual cycle
  ○ Thickness measurement (premenopausal, postmenopausal, effects of hormone replacement)
○ Cervix
  ○ Normal appearance
○ Ovary
  ○ Normal appearance during female life cycle (prepubertal, menstrual, postmenopausal)
  ○ Normal size, shape, position
  ○ Follicles, corpus luteum
○ Cul-de-sac
  ○ Free fluid (physiologic)
○ Urinary bladder
  ○ Degrees of filling
  ○ Transabdominal
  ○ Transvaginal

Competent: Knowledge of Advanced Pathology/Performance and Interpretation of Color Flow/Duplex Imaging

○ Uterus
  ○ Adenomyosis (features, myometrial cysts)
  ○ Adenomyoma (color flow distinction from fibroid)
  ○ Pedunculated fibroid (feeding vessels)
  ○ Fatty tumors
  ○ Torsion of fibroid
  ○ Leiomyosarcoma
  ○ Arteriovenous malformation
○ Endometrium
  ○ Endometrial polyp (feeding vessel)
  ○ Endometrial hyperplasia
  ○ Endometrial carcinoma (arterial blood flow)
  ○ Tamoxifen effects
  ○ Pyometrium
  ○ Endometritis (air/gas)
○ Cervix
  ○ Polyp (feeding vessel)
  ○ Prolapsing polyp/fibroid (vascular pedicle)
○ Ovary
  ○ Ruptured ovarian cyst
  ○ Endometrioma (atypical)
  ○ Fibroma
  ○ Ovarian torsion (variety of blood flow patterns)
  ○ Ovarian mass characterization: benign versus malignant features, including Doppler evaluation. (cystadenoma/carcinoma, germ cell tumors, adenocarcinoma, metastases to ovary, etc)
○ Fallopian tube
  ○ PID (pelvic inflammatory disease: salpingitis, pyosalpinx, tubo-ovarian complex, tubo-ovarian abscess)
  ○ Adnexal torsion
  ○ Isolated tubal torsion
○ Cul-de-sac
  ○ Hemoperitoneum (complex with blood clots)
  ○ Pelvic collection

Expert: Able to Perform US-Guided Procedures and Scan All Pathology

○ QA
  ○ Able to judge quality of the US scan
  ○ Pitfalls in scanning
○ Fibroid mimickers
  ○ Therapeutic options for fibroids based on imaging findings (hysteroscopic resection, laparoscopic resection, myomectomy/laparotomy, UAE-uterine artery embolization, ablation, hormones, etc)
○ Ovarian mass characterization: benign versus malignant features, including Doppler evaluation. (cystadenoma/carcinoma, germ cell tumors, adenocarcinoma, metastases to ovary, etc)
○ Ovarian Cysts
  ○ Simple hydrosalpinx
  ○ Simple hydrosalpinx
  ○ Free fluid (ascites, echogenic fluid: blood, pus, debris)
  ○ Fatty tumors
  ○ Torsion of fibroid
  ○ Leiomyosarcoma
  ○ Arteriovenous malformation
○ Endometrium
  ○ Endometrial polyp (feeding vessel)
  ○ Endometrial hyperplasia
  ○ Endometrial carcinoma (arterial blood flow)
  ○ Tamoxifen effects
  ○ Pyometrium
  ○ Endometritis (air/gas)
○ Cervix
  ○ Polyp (feeding vessel)
  ○ Prolapsing polyp/fibroid (vascular pedicle)
○ Ovary
  ○ Ruptured ovarian cyst
  ○ Endometrioma (atypical)
  ○ Fibroma
  ○ Ovarian torsion (variety of blood flow patterns)
  ○ Ovarian mass characterization: benign versus malignant features, including Doppler evaluation. (cystadenoma/carcinoma, germ cell tumors, adenocarcinoma, metastases to ovary, etc)
○ Fallopian tube
  ○ PID (pelvic inflammatory disease: salpingitis, pyosalpinx, tubo-ovarian complex, tubo-ovarian abscess)
  ○ Adnexal torsion
  ○ Isolated tubal torsion
○ Cul-de-sac
  ○ Hemoperitoneum (complex with blood clots)
  ○ Pelvic collection

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Ovarian cancer staging
- Nongynecologic findings
  - GI (pelvic appendicitis, colitis)
  - Genitourinary (UVJ renal calculus, bladder mass, pelvic kidney)
  - Abdominal wall (endometriosis)
- Assist in interventional procedures
  - Saline infusion sonohysterography
  - Pelvic abscess drainage

**FIRST TRIMESTER**
Robert D. Harris, MD

**Beginner: Normal Anatomy**
- Gestational sac: appearance/shape, size, decidual reaction, sac growth
- Yolk sac
- Embryo
- Embryonic cardiac activity including normal embryonic heart rate
- Amnion/chorion
- Normal early embryonic anatomy/growth
- Crown-rump length measurement
- Correlation with $\beta$-human chorionic gonadotropin levels and menstrual dates
- Nuchal translucency measurements

**Advanced Beginner: Basic Pathology**
- Pelvic fluid
  - Simple
  - Hemorrhage
- Failed early pregnancy: spontaneous complete/incomplete/missed abortion, anembryonic gestation (blighted ovum), embryonic death (in utero demise)
- Tubal ectopic pregnancy
  - Adnexal ring
  - Adnexal mass
  - Pelvic hemorrhage
- Abnormal nuchal translucency
- Multiple gestations (chorionicity and amnionicity)
- Intrauterine hematoma
- Gestational trophoblastic disease
  - Complete mole
  - Partial mole
- Embryonic structural abnormalities
  - Anencephaly/exencephaly
  - Abdominal wall defects

**Competent: Knowledge of Advanced Pathology/Performance and Interpretation of Color Flow/Duplex Imaging: Color Flow Imaging**
- Multiple gestations co demise
- Pregnancy in didelphic or rudimentary horn vs ectopic
- Unusual ectopic pregnancy locations: interstitial, cervical, ovarian, scar, abdominal, rudimentary horn
- Nuchal translucency and serum screening

**Proficient: Ability to Assimilate Clinical Information and Radiologic Imaging Studies to Manage and Consult Effectively**
- Disappearing twins
- Appearing twins
- Follow-up of abnormal pregnancy
- Follow-up rule out ectopic
- Staging of trophoblastic disease
- Abnormal embryonic heart rate
- Pelvic hemorrhage

**Expert: Able to Perform US-Guided Procedures and Scan All Pathology**
- Chorionic villus sampling guidance
- D and C guidance
- Guidance of methotrexate injections

**SECOND/THIRD TRIMESTER**
Teresita Angtuaco, MD

**Beginner: Basic Anatomy**
- American Institute of Ultrasound in Medicine/American College of Radiology guidelines
- Fetal dating measurements (BPD, HC, AC, FL)
- Amniotic fluid index
- Single deep pocket measurements
- Subjective amniotic fluid assessment
- Placenta
- Cervix
- Internal cervical os
- Fetal orientation
- Cephalic
- Breech
- Transverse
- Lateral ventricle
- Cisterna Magna
- Cavum septum pellicudum
- Nose lips
- Profile
- Spine, axial, sagittal, coronal
- 4-Chamber heart
- Left ventricular outflow tract
- Right ventricular outflow tract
- Stomach
- Cord Insert
- Kidneys
- Bladder
- Femurs
- Tibia/tibula
- Radius ulna
- Hands
- Feet
- 3-Vessel cord
- Twins
- Chorionicity/amnionicity

**Advanced Beginner: Basic Pathology**
- Uterine and adnexal evaluation
- Placenta previa
- Sucenturiate placenta
- Gestational trophoblastic disease
- Hydrops
- Anencephaly
- Cystic hygroma
- Fetal demise
- Oligohydramnios
- Polyhydramnios

**Competent: Knowledge of Advanced Pathology/Performance and Interpretation of Color Flow/Duplex Imaging**
- Hydrocephalus/ventriculomegaly
- Holoprosencephaly
- Hydranencephaly
- Dandy-Walker malformation
- Chiari II malformation
- Agenesis of the corpus callosum
Beginner: Normal Anatomy

Carl C. Reading, MD

THYROID/NECK

Can counsel or talk to patients about fetal anomalies, etiologies, management, and so on
Be able to teach basic obstetric US to other trainees
Perform an independent comprehensive fetal US

Achondroplasia

Osteogenesis imperfecta

Thanatophoric dysplasias

Cloacal anomalies

Enteric/colonic obstruction

Congenital pulmonary airways malformation

Pulmonary sequestration

Truncus arteriosis

Tetralogy of Fallot

Transposition of great vessels

Vein of Galen malformation

Intrauterine growth restriction criteria

Imaging Studies to Manage and Consult Effectively

Proficient: Ability to Assimilate Clinical Information and Radiologic Imaging Studies to Manage and Consult Effectively

Intrauterine growth restriction criteria

Doppler cord/middle cerebral artery

Vasa previa

Placenta accreta/increta/percreta

Genetic testing/screening

Findings in trisomies

Schizencephaly

Hydranencephaly

Hemorrhage

Tumors

Vein of Galen malformation

Transposition of great vessels

Tetralogy of Fallot

Truncus arteriosis

Pulmonary sequestration

Congenital pulmonary airways malformation

Enteric/colonic obstruction

Limb body wall complex

Body stalk anomaly

Pentalogy of Cantrel

Cloacal anomalies

Thanatophoric dysplasias

Osteogenesis imperfecta

Achondroplasia

Expert: Able to Perform US-Guided Procedures and Scan All Pathology

Perform an independent comprehensive fetal US
Be able to teach basic obstetric US to other trainees
Can counsel or talk to patients about fetal anomalies, etiologies, management options, and so on

Lymph nodes

O Normal appearance, hilum, shape, vascular supply

Parathyroid

O Normal “expected” location and number (although normal glands are rarely seen)

Salivary glands

O Normal submandibular and parotid appearance and location

Advanced Beginner: Basic Pathology

Thyroid

O Recognize focal disease, diffuse disease, and multinodular gland
O Recognize normal variants (pyramidal lobe, hypoplasia of lobe)

Lymph nodes

O The location of abnormal lymph nodes should be described according to the clinical nodal classification system developed by the American Joint Committee on Cancer and the American Academy of Otolaryngology-Head and Neck Surgery, or in a fashion that allows the referring clinician to convert the location of abnormal nodes to that system (ie, lymph node anatomy of 6 anatomic levels)

O Parathyroid

O Recognize parathyroid adenoma appearance, gray scale and color Doppler; “polar” pattern of color Doppler blood flow in adenoma

Salivary glands

O Recognize focal and diffuse disease, calcifications, obstruction
O Recognize normal variants (prominence of tail of parotid below mandible and tissue along parotid duct in cheek)

Other neck masses

O Normal thymus in child visible in base of neck
O Congenital cysts—thryroglossal duct cyst, second branchial cleft cyst

Competent: Knowledge of Advanced Pathology/Performance and Interpretation of Color Flow/Duplex Imaging

Ability to correlate US findings with PET, CT, MRI, and nuclear medicine findings

Thyroid

O Characterize focal disease (benign vs malignant)
  - Echotexture, calcifications, margin, shape, vascularity
  - Suggests benign—pure cyst, predominantly cystic with echogenic foci with reverberation artifacts, “spongiform" pattern
  - Suggests malignant—hypoechoic, solid, microcalcifications, taller than wide
  - Suggestive of follicular neoplasm—homogeneous, solid, oval shape
  - Non discriminatory characteristics—halo, vascularity, heterogeneity

O Characterize diffuse disease
  - Hashimoto, Graves, subacute thyroiditis

O Guidelines/recommendations for FNA based on size/appearance, patient risk factors

Lymph node

O Characterize benign vs malignant
  - Size, shape, echogenicity, internal architecture, vascularity
  - Suggests benign—normal slender shape (short-to-long axis ratio <0.5), normal branching hilar blood flow
  - Suggests malignant—rounded, abnormal internal architecture (cystic components, calcification), asymmetric cortex, loss of echogenic hilum, vascularity is irregular/peripheral/increased

O Parathyroid

O Recognize multigland enlargement

Salivary glands

O Characterize mass
  - Benign—pleomorphic adenoma, Warthin tumor, intraparotid lymph node

THYROID/NECK

Carl C. Reading, MD

Beginner: Normal Anatomy

Thyroid

O Normal echotexture, shape, and size

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Malignant
- Testes
  - Normal echotexture
  - Shape and size
- Epididymis
  - Normal size
  - Shape
  - Appendic epididymis

Expert: Able to Perform US-Guided Procedures and Scan All Pathology
- Testicular mass
- Microlithiasis
- Granulomas
- Ectasia of rete testes
- Hydrocele

Competent: Knowledge of Advanced Pathology/Performance and Interpretation of Color Flow/Duplex Imaging
- Normal testicular flow
- Normal epididymal flow
- Orchitis
- Epididymitis
- Testicular torsion
- Pyoceles

Proficient: Ability to Assist Clinical Information and Radiologic Imaging Studies to Manage and Consult Effectively
- Torsion of appendix epididymis
- Nondescended testis
- Fournier gangrene
- Hernia

Expert: Able to Perform US-Guided Procedures and Scan All Pathology
- Torsion of appendix epididymis
- Nondescended testis
- Fournier gangrene
- Hernia

VASCULAR
Leslie M. Scoutt, MD

Beginner: Basic Anatomy/Physics
- Blood flow hemodynamics
- Doppler principles
- Differences between color, power and spectral Doppler (color, hue, direction of flow, sensitivity to low velocity flow)
- Normal spectral Doppler waveform
  - Peak systolic velocity (PSV)
  - End-diastolic velocity
  - Resistive index (RI)

Advanced Beginner: Basic Pathology
- Testicular mass
- Microlithiasis
- Granulomas
- Ectasia of rete testes
- Hydrocele

Competent: Knowledge of Advanced Pathology/Performance and Interpretation of Color Flow/Duplex Imaging
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- Normal epididymal flow
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  - End-diastolic velocity
  - Resistive index (RI)
Pulsatility index
Systole
Diastole
Flow direction
Acceleration

Normal anatomy
- Upper- and lower-extremity venous compression
- Aorta, including measurement
- IVC
- Upper- and lower-extremity venous

Importance of compression
- Aorta
- IVC
- Carotid
- Liver
- Native kidney
- Renal transplant
- Vein mapping
- Liver transplant
- Normal peripheral arteries
- Aorta: endovascular aneurysm repair
- Reproductive tracts (testes, ovaries)
- Pancreas transplants
- Peripheral arterial
  - Native arteries
  - Bypass grafts
  - Hemodialysis fistulas/grafts
  - Stents
  - Transcranial Doppler
  - Ankle-brachial Index

Advanced Beginner: Basic Pathology
- Liver
  - Portal hypertension
  - Portal vein thrombosis
  - Budd Chiari
  - TIPS
  - AVMs/AVFs, pseudoaneurysms
  - Differentiate venous tumor thrombus from bland thrombus
- Native kidney
  - Renal artery stenosis
  - Duplicated renal arteries
  - Renal artery aneurysms
- Venous thrombus upper and lower extremity
  - Occlusive
  - Nonocclusive
- Lower-extremity venous
  - Reflux
  - Evaluation s/p ablation
- Complex reflux patterns
- Superficial thrombophlebitis
  - Arterial
  - Stenosis
  - Occlusion
  - Aneurysm
  - Pseudoaneurysm
- Peripheral arterial
  - Postintervention complications (pseudoaneurysm, AVF, thrombus, dissection, deep vein thrombosis)
- Aorta
  - Plaque
  - Aneurysm
  - Dissection
  - Mesenteric ischemia

- Aneurysms and pseudoaneurysms of branch vessels from aorta
- Endoleaks s/p endovascular aneurysm repair
- Median arcuate ligament syndrome
- Peripheral arteries
  - Plaque
  - Aneurysm
  - Pseudoaneurysm
  - Native artery stenoses
  - Arterial bypass graft complications (stenoses, retained valves, pseudoaneurysms, persistent perforators)
  - ABI/PVR—findings c/w arterial insufficiency
- IVC
  - Dehydration
  - Thrombus
  - Filters
- Liver transplant
  - Hepatic artery stenosis/thrombosis
  - Portal vein stenosis/thrombosis
  - IVC/hepatic vein stenosis/thrombosis
- Renal transplant
  - Renal artery stenosis/thrombosis
  - Renal vein stenosis/thrombosis
  - Postbiopsy complications AVF/pseudoaneurysm
  - Differential diagnosis of increased RI/reversed diastolic flow
- Transplants
  - Partial liver, pediatric en bloc, pancreas
- Reproductive tracts
  - Testicular/ovarian torsion
  - Varicoceles
- Carotid
  - Evaluation of plaque/intima media thickness
  - Complex waveforms
  - Evaluation postintervention
  - Nonatherosclerotic pathology (dissections, pseudoaneurysms, AVFs)
- Pancreas transplant
  - Vascular complications: arterial stenosis/occlusion
- Carotid
  - Pitfalls in grading internal carotid artery (ICA) stenoses
  - Common carotid artery and vertebral artery stenoses
  - Vasculitis
- Hemodialysis access complications
  - Stenosis, thrombosis, pseudoaneurysm
  - Failure to mature (inflow disease, competing branches, stenosis, outflow stenosis, depth)
- Reproductive tracts
  - Erectile dysfunction
  - Penile/testicular trauma
  - Pelvic congestion syndrome
- Transcranial Doppler
  - Vasospasm
  - Emboli, high-intensity transient signal
  - Intracranial stenoses

Competent: Knowledge of Advanced Pathology/Performance and Interpretation of Color Flow/Duplex Imaging
- Physics
  - Image optimization (eg, detection of slow flow)
  - Doppler artifacts
  - Aliasing
  - Mirror image

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SRU Resident Curriculum

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Flash (motion)
Soft tissue bruit
Color blooming
○ Sensitivity to angle of insonation
○ Abnormal waveforms or blood flow patterns
○ ↑ PSV, spectral broadening, turbulence
○ ↓ or ↓ RI
○ High resistance vs low resistance waveform patterns
○ Recognize and understand causes
○ Tardus parvus waveform
○ Charges in flow dynamics prestenoses, at stenoses, and poststenoses

Scanning technique
○ How to obtain a color or power Doppler image
  ■ Color box, angle of color box, gain
○ How to obtain a Doppler tracing
  ■ Placement of sample volume
  ■ Calculation of Doppler angle
  ■ Choosing the correct Doppler angle
  ■ Gain, pulse repetition frequency, baseline, wall filter, color box
○ Upper- and lower-extremity venous
  ○ Abnormal waveforms (increased pulsatility, loss of respiratory phasicity)
  ○ Reflux in lower extremities
○ Carotid
  ■ Grading carotid stenoses (PSV, end-diastolic velocity, ICA/common carotid artery—PSV ratio)
  ■ Abnormal waveforms (tardus parvus, high resistance)
  ■ Vertebral artery/subclavian artery—steal and presteal

Proficient: Ability to Assimilate Clinical Information and Radiologic Imaging Studies to Manage and Consult Effectively
○ Physics
  ■ B-mode
  ■ Pseudoaneurysms/AVFs
  ■ Endografts
○ Controversies in management of vascular pathology
○ Carotid stenosis in native vessels and post intervention
○ Clinical correlation
○ Carotid stenosis
○ Abdominal aorta aneurysms
○ Vascular complications of transplants

Expert: Able to Perform US-Guided Procedures and Scan All Pathology
○ Physics
  ○ IV US contrast
  ○ 3D vascular imaging
  ○ Vessel reactivity
  ○ Calculation of flow volume
○ Intervention
  ○ Pseudoaneurysm injection with thrombin
  ○ Thoracentesis, paracentesis
  ○ Fluid collection aspiration and/or drainage
  ○ FNA thyroid, lymph nodes
  ○ Core biopsies, various organs
  ○ When to do core vs FNA
  ○ Complications
  ○ Risk factors
  ○ Contraindications
  ○ How to manage the patient who is anticoagulated
  ○ EtOH ablation for lymph nodes, thyroid nodules
○ Intraoperative
  ○ Evaluation of post vascular endarterectomy/bypass in operating room (carotid, renal, mesenteric, transplants, arterial bypass grafts, etc)
  ○ Localization of lymph nodes, masses, and so on
  ○ Correlation with other imaging modalities
  ○ Peripheral arterial: CT angiography, MR angiography, angiography
  ○ Current controversies/new horizons
○ Carotid
  ■ Optimizing Doppler criteria
  ■ Carotid endarterectomy vs stent vs medical management
  ■ Are the NASCET (North American Symptomatic Carotid Endarterectomy Trial) criteria enough?
  ■ Evaluation of plaque/IMT
  ■ Follow-up s/p intervention
  ■ Potential of IV US contrast in vascular imaging

PEDIATRICS

Harriet J. Paltiel, MD

BRAIN

Beginner: Normal Anatomy
○ Normal echotexture
○ Normal sulcal pattern (premature infant/full-term infant)

Advanced Beginner: Basic Pathology
○ Intracranial hemorrhage (premature and term infant)
○ Posthemorrhagic hydrocephalus
○ Periventricular leukomalacia

Competent: Knowledge of Advanced Pathology/Performance and Interpretation of Color Flow/Duplex Imaging
○ Normal arterial flow/resistive indices in anterior cerebral arteries
○ Normal flow in superior sagittal sinus
○ Increased intracranial pressure (abnormal arterial resistive indices)
○ Superior sagittal sinus thrombosis
○ Subarachnoid hemorrhage
○ Subdural hemorrhage

Proficient: Ability to Assimilate Clinical Information and Radiologic Imaging Studies to Manage and Consult Effectively
○ Intracranial hemorrhage (premature and term infant)
○ Posthemorrhagic hydrocephalus
○ Periventricular leukomalacia
○ Cerebral edema
○ Cerebral/cerebellar infarction

Expert: Able to Perform US-Guided Procedures and Scan All Pathology
○ Chiari II malformation
○ Agenesis of corpus callosum
○ Dandy-Walker malformation
○ Aque ductal stenosis
○ Transcranial Doppler US screening for sickle cell disease

HEAD AND NECK

Beginner: Normal Anatomy
○ Thyroid gland
○ Parotid gland
○ Submandibular gland
○ Great vessels
**Advanced Beginner: Basic Pathology**
- Cervical adenitis
- Fibromatosis colli
- Infantile hemangioma
- Thyroglossal duct cyst
- Branchial cleft cyst

**Competent: Knowledge of Advanced Pathology/Performance and Interpretation of Color Flow/Duplex Imaging**
- Internal jugular vein thrombosis
- Lymphatic malformation
- Venous malformation

**Proficient: Ability to assimilate clinical information and radiologic imaging studies to manage and consult effectively**
- Hashimoto thyroiditis
- Ectopic thymus

**Expert: Able to Perform US-Guided Procedures and Scan All Pathology**
- Thyroid nodules
- Soft tissue tumors
- Rhabdomyosarcoma
- Neuroblastoma
- Metastatic nodal disease

**CHEST**

**Beginner: Normal Anatomy**
- Thymus
- Pleura-lung interface
- Trachea
- Esophagus
- Great vessels
- Internal mammary compartment
- Diaphragm

**Advanced Beginner: Basic Pathology**
- Pleural effusion
- Lung consolidation
- Chest wall soft tissue mass
- Lipoma
- Cellulitis
- Abscess
- Cartilaginous rib abnormalities

**Competent: Knowledge of Advanced Pathology/Performance and Interpretation of Color Flow/Duplex Imaging**
- Venous stenosis
- Venous thrombosis
- Arterial stenosis
- Arterial thrombosis
- Bronchopulmonary sequestration
- Vascular chest wall lesions
- Hemangioma
- Lymphatic malformation
- Venous malformation

**Proficient: Ability to Assimilate Clinical Information and Radiologic Imaging Studies to Manage and Consult Effectively**
- Lung necrosis
- Lung abscess
- Empyema
- Fibrothorax
- Diaphragmatic paralysis and eventration

**Expert: Able to Perform US-Guided Procedures and Scan All Pathology**
- Diaphragmatic hernia
- Mediastinal mass
- Teratoma
- Thymic cyst
- Adenopathy
- Neuroblastoma

**BREAST**

**Beginner: Normal Anatomy**
- Glandular tissue
- Connective tissue

**Advanced Beginner: Basic Pathology**
- Gynecomastia
- Mastitis
- Abscess
- Fibroadenoma
- Intramammary lymph node
- Hematoma

**Competent: Knowledge of Advanced Pathology/Performance and Interpretation of Color Flow/Duplex Imaging**
- Hemangioma

**Proficient: Ability to Assimilate Clinical Information and Radiologic Imaging Studies to Manage and Consult Effectively**
- Intraductal papilloma
- Fibrocystic disease

**Expert: Able to Perform US-Guided Procedures and Scan All Pathology**
- Phyllodes tumor
- Metastases
- Lymphoma
- Leukemia
- Rhabdomyosarcoma

**LIVER**

**Beginner: Normal Anatomy**
- Normal size
- Normal echotexture

**Advanced Beginner: Basic Pathology**
- Fatty infiltration
- Focal mass
  - Infantile hemangioma
  - Congenital hemangioma
  - Hepatoblastoma

**Competent: Knowledge of Advanced Pathology/Performance and Interpretation of Color Flow/Duplex Imaging**
- Normal blood flow in hepatic arteries, veins, portal veins
- Portal hypertension
- Cirrhosis

**Proficient: Ability to Assimilate Clinical Information and Radiologic Imaging Studies to Manage and Consult Effectively**
- Trauma

**Expert: Able to Perform US-Guided Procedures and Scan All Pathology**
- Transplant
- Transplant complications
- Heterotaxy
GALLBLADDER AND BILIARY TRACT

Beginner: Normal Anatomy
- Normal gallbladder
- Gallbladder variants
- Normal biliary tree

Advanced Beginner: Basic Pathology
- Cholelithiasis
- Choledocholithiasis
- Biliary sludge
- Acute cholecystitis
  - Calculous
  - Acalculous
- Hydrops of gallbladder

Competent: Knowledge of Advanced Pathology/Performance and Interpretation of Color Flow/Duplex Imaging
- Gallbladder varices
- Choledochal cyst
- Caroli disease

Proficient: Ability to Assimilate Clinical Information and Radiologic Imaging Studies to Manage and Consult Effectively
- Neonatal hepatitis
- Biliary atresia
- Inspissated bile syndrome

Expert: Able to Perform US-Guided Procedures and Scan All Pathology
- Sclerosing cholangitis
- Hyperplastic cholecystoses
  - Adenomyomatosis
  - Cholesterosis

PERITONEAL CAVITY

Beginner: Normal Anatomy
- Ligaments
- Mesenteries
- Peritoneal compartments

Advanced Beginner: Basic Pathology
- Abscess
- Hematoma
- Omental cyst

Competent: Knowledge of Advanced Pathology/Performance and Interpretation of Color Flow/Duplex Imaging
- Mesenteric lymphadenopathy
- Malignant masses
  - Lymphoma
  - Other primary malignant tumors
  - Metastatic disease

Proficient: Ability to Assimilate Clinical Information and Radiologic Imaging Studies to Manage and Consult Effectively
- N/A

Expert: Able to Perform US-Guided Procedures and Scan All Pathology
- Trauma
  - Hemoperitoneum
  - Pneumoperitoneum
  - Peritonitis

SPLENE

Beginner: Normal Anatomy
- Normal splenic anatomy
- Normal variants
  - Accessory spleen

Advanced Beginner: Basic Pathology
- Cyst
- Abscess
  - Pyogenic
  - Fungal

Competent: Knowledge of Advanced Pathology/Performance and Interpretation of Color Flow/Duplex Imaging
- Normal arterial and venous flow
- Splenic vein thrombosis

Proficient: Ability to Assimilate Clinical Information and Radiologic Imaging Studies to Manage and Consult Effectively
- Trauma
- Leukemic infiltration
- Lymphatic malformation
- Lymphoma
- Storage disease

Expert: Able to Perform US-Guided Procedures and Scan All Pathology
- Heterotaxy
  - Polysplenia
  - Asplenia

GASTROINTESTINAL TRACT

Beginner: Normal Anatomy
- Stomach
- Small intestine
- Large intestine
- Normal superior mesenteric artery/vein relationship

Advanced Beginner: Basic Pathology
- Pyloric stenosis
- Pylorospasm
- Intussusception
- Acute appendicitis

Competent: Knowledge of Advanced Pathology/Performance and Interpretation of Color Flow/Duplex Imaging
- Inflammatory bowel disease

Proficient: Ability to Assimilate Clinical Information and Radiologic Imaging Studies to Manage and Consult Effectively
- Duplication cyst
- Malignant mass
  - Lymphoma
  - GI stromal tumor
  - Hemolytic-uremic syndrome
  - Henoch-Schönlein purpura
URINARY TRACT

Beginner: Normal Anatomy
- Kidney
- Ureter
- Bladder
- Anatomic variants
  - Fetal lobation
  - Ureteral duplication

Advanced Beginner: Basic Pathology
- Congenital anomalies
  - Abnormal number
  - Abnormal position
  - Abnormal fusion
  - Duplication anomalies
- Congenital hydronephrosis
  - Ureteropelvic junction obstruction
  - Primary megaureter
  - Vesicoureteral reflux
  - Cystitis
  - Pyelonephritis
  - Renal scarring
  - Urolithiasis

Competent: Knowledge of Advanced Pathology/Performance and Interpretation of Color Flow/Duplex Imaging
- Renal artery stenosis
- Renal vein thrombosis
- Arteriovenous fistula

Proficient: Ability to Assimilate Clinical Information and Radiologic Imaging Studies to Manage and Consult Effectively
- Cystic disease
  - Multicystic dysplastic kidney
  - Autosomal recessive polycystic disease
  - Autosomal dominant polycystic disease
- Duplication anomalies
  - Ectopic ureter
  - Ectopic ureteroceles
  - Posterior urethral valves
  - Neurogenic bladder
  - Nephrocalcinosis
  - Wilms tumor
  - Trauma

Expert: Able to Perform US-Guided Procedures and Scan All Pathology
- Renal transplant
- Renal transplant complications
- Tuberous sclerosis
  - Angiomyolipomas

ADRENAL GLANDS

Beginner: Normal Anatomy
- Cortex (neonate/older child)
- Medulla

Advanced Beginner: Basic Pathology
- Hemorrhage
- Tumor
  - Neuroblastoma

Competent: Knowledge of Advanced Pathology/Performance and Interpretation of Color Flow/Duplex Imaging
- Use of color flow to exclude neoplasm

Proficient: Ability to Assimilate Clinical Information and Radiologic Imaging Studies to Manage and Consult Effectively
- Cortical tumor
  - Adenoma
  - Carcinoma
- Pheochromocytoma
- Adrenal hypertrophy with renal agenesis

Expert: Able to Perform US-Guided Procedures and Scan All Pathology
- Congenital adrenal hyperplasia

PANCREAS

Beginner: Normal Anatomy
- Parenchyma
- Duct

Advanced Beginner: Basic Pathology
- Pancreatitis
  - Acute
  - Chronic
  - Trauma

Competent: Knowledge of Advanced Pathology/Performance and Interpretation of Color Flow/Duplex Imaging
- Use of color flow to exclude pseudoaneurysm

Proficient: Ability to Assimilate Clinical Information and Radiologic Imaging Studies to Manage and Consult Effectively
- Congenital cyst
- Cystic fibrosis
  - Atrophy
  - Fatty infiltration
  - Calcification
  - Pancreatic cystosis
  - Autosomal dominant polycystic disease

Expert: Able to Perform US-Guided Procedures and Scan All Pathology
- Pancreatitis complications
  - Pseudocyst
  - Pseudoaneurysm
  - Thrombosis splenic/mesenteric veins

RETROPERITONEUM

Beginner: Normal Anatomy
- Great vessels
- Crura of diaphragm
Advanced Beginner: Basic Pathology
- Retroperitoneal lymphadenopathy
- Retroperitoneal hemorrhage

Competent: Knowledge of Advanced Pathology/Performance and Interpretation of Color Flow/Duplex Imaging
- IVC thrombosis
- Aortic stenosis

Proficient: Ability to Assimilate Clinical Information and Radiologic Imaging Studies to Manage and Consult Effectively
- Retroperitoneal tumor
  - Teratoma
  - Hemangioma
  - Lymphatic malformation
  - Neurogenic tumor (benign/malignant)

Expert: Able to Perform US-Guided Procedures and Scan All Pathology
- Congenital anomalies of vena cava
  - Interrupted IVC with azygous continuation
  - IVC duplication
- Retroperitoneal fibrosis

GYNECOLOGY

Beginner: Normal Anatomy
- Uterus (neonatal/juvenile/postmenarcheal)
- Ovaries (neonatal/juvenile/postmenarcheal)

Advanced Beginner: Basic Pathology
- Ovarian cyst
- Ovarian neoplasm
  - Dermoid cyst
  - Germ cell tumor (benign/malignant)

Competent: Knowledge of Advanced Pathology/Performance and Interpretation of Color Flow/Duplex Imaging
- Ovarian torsion

Proficient: Ability to Assimilate Clinical Information and Radiologic Imaging Studies to Manage and Consult Effectively
- Pelvic inflammatory disease
- Polycystic ovarian disease

Expert: Able to Perform US-Guided Procedures and Scan All Pathology
- Congenital vaginal anomalies
- Congenital uterine anomalies
- Disorders of sexual differentiation

SCROTUM

Beginner: Normal Anatomy
- Testes
  - Echotexture, shape and size
- Epididymis
  - Echotexture, size

Advanced Beginner: Basic Pathology
- Testicular mass
- Microlithiasis
- Hydrocele

Competent: Knowledge of Advanced Pathology/Performance and Interpretation of Color Flow/Duplex Imaging
- Normal testicular flow
- Normal epididymal flow
- Orchitis
- Epididymitis
- Testicular torsion
- Torsion of testicular appendages
- Hematocele

Proficient: Ability to Assimilate Clinical Information and Radiologic Imaging Studies to Manage and Consult Effectively
- Testicular mass characterization
- Seminoma
- Other germ cell tumors
- Stromal tumors
- Lymphoma
- Metastases
- Abscess
- Hematoma

Expert: Able to Perform US-Guided Procedures and Scan All Pathology
- Fournier gangrene
- Hernia
  - Direct
  - Indirect
- Scrotal edema/vasculitis (idiopathic/Hench-Schönlein purpura)
- Disorders of sexual differentiation

MUSCULOSKELETAL SYSTEM

Beginner: Normal Anatomy
- Skin and subcutaneous tissues
- Skeletal muscle
- Tendons and ligaments
- Nerves
- Bursae
- Bones and cartilage
- Normal anatomy of major joints
  - Hip
  - Knee
  - Elbow
  - Ankle
  - Wrist and hand

Advanced Beginner: Basic Pathology
- Developmental dysplasia of hip
- Hip joint effusion
Cellulitis
Abscess
Hematoma
Foreign body localization

Competent: Knowledge of Advanced Pathology/Performance and Interpretation of Color Flow/Duplex Imaging
- Congenital vascular lesions
  - Hemangioma
  - Venous malformation
  - Lymphatic malformation
  - Arteriovenous malformation
  - AVF

Proficient: Ability to Assimilate Clinical Information and Radiologic Imaging Studies to Manage and Consult Effectively
- Benign nonvascular masses
  - Lymphadenopathy
  - Nerve sheath tumors
  - Lipoma
  - Popliteal cyst
  - Ganglion cyst
- Malignant tumors
  - Rhabdomyosarcoma

Expert: Able to Perform US-Guided Procedures and Scan All Pathology
- Synovitis
- Pyomyositis
- Myositis ossificans
- Tendon tears

PERIPHERAL VASCULAR IMAGING

Beginner: Normal Anatomy
- Gray scale imaging
  - Lower extremity
  - Upper extremity

Advanced Beginner: Basic Pathology
- Stenosis
  - Venous
  - Arterial
- Thrombosis
  - Venous
  - Arterial

Competent: Knowledge of Advanced Pathology/Performance and Interpretation of Color Flow/Duplex Imaging
- Normal color and spectral Doppler flow patterns
- Color and spectral Doppler flow patterns in stenosis and thrombosis
- Pseudoaneurysm
- Arteriovenous fistula

Proficient: Ability to Assimilate Clinical Information and Radiologic Imaging Studies to Manage and Consult Effectively
- Pitfalls and limitations of Doppler imaging

Expert: Able to Perform US-Guided Procedures and Scan All Pathology
- Knowledge of how to differentiate and correct technical issues with color Doppler imaging

SPINE

Beginner: Normal Anatomy
- Lumbar spinal cord
- Position of conus medullaris
- Filum terminale
- Nerve roots and nerve root pulsations
- Normal variants
  - Terminal ventricle
  - Filar cyst

Advanced Beginner: Basic Pathology
- Tethered cord
- Dermal sinus tract
- Tumor
  - Lipoma
  - Teratoma
  - Neuroblastoma

Competent: Knowledge of Advanced Pathology/Performance and Interpretation of Color Flow/Duplex Imaging
- Hemangioma

Proficient: Ability to Assimilate Clinical Information and Radiologic Imaging Studies to Manage and Consult Effectively
- Arachnoid cyst
- Epidural abscess
- Trauma

Expert: Able to Perform US-Guided Procedures and Scan All Pathology
- Dysraphism
  - Overt
  - Occult with associated mass
- Syringomyelia
- Hydromyelia

MUSCULOSKELETAL
Levon N. Nazarian, MD

Beginner: Normal Anatomy
- Shoulder
  - Long head of the biceps tendon
  - Rotator cuff
  - Subacromial-subdeltoid bursa
  - Acromioclavicular joint
  - Glenohumeral joint
- Elbow
  - Common flexor and extensor tendons
  - Ulnar and radial collateral ligaments
  - Distal biceps and triceps tendons
  - Ulnar nerve at the cubital tunnel
- Wrist
  - Median nerve in the carpal tunnel
  - Flexor tendons
  - Extensor tendons
- Hip
  - Hip joint
  - Anterior/superior hip labrum
  - Iliopsoas tendon
  - Iliopsoas bursa
  - Gluteus medius tendon
Expert: Able to Perform US-Guided Procedures and Scan All Pathology

- Performing US-guided aspiration and/or injection of shoulder, elbow, wrist, hip, knee, ankle joints; Baker cyst; bursas; ganglion cysts.
- Acting as an effective consultant to referring physicians seeking the best way to perform a musculoskeletal imaging workup on their patients.

THORAX
Theodore J. Dubinsky

Beginner: Normal Anatomy
- Ribs
- Intercostal muscles
- Pleural line
- Sliding pleura
- Subclavian artery and vein
- Mediastinum
- Heart
  - Apical 4-chamber
  - Vertical left ventricular long axis
  - Aortic outflow tract
  - Parasternal short-axis view
  - Parasternal long-axis view
- Mitral valve
- Aortic valve
- Pericardium

Advanced Beginner: Basic Pathology
- Pleural effusion
  - Loculated/complex effusion
  - Fluid in the fissures
- Pericardial effusion
- Atelectatic lung
- Pulmonary edema
- Masses
  - Pleural based
  - Intraparenchymal
- Pneumothorax
- Cardiomegaly

Competent: Knowledge of Advanced Pathology/Performance and Interpretation of Color Flow/Duplex Imaging
- Aortic aneurysm
- Aortic dissection
- Hemopericardium
- Tamponade
- Valvular stenosis and regurgitation
- AVFs of chest wall

Proficient: Ability to Assimilate Clinical Information and Radiologic Imaging Studies to Manage and Consult Effectively
- When to get MRI
- When to follow up suspected lesions
- Thoracentesis

Expert: Able to Perform US-Guided Procedures and Scan All Pathology
- Pericardiocentesis
- Biopsy of pleural based masses
- Biopsy of deeper masses with surrounding atelectasis
- Mediastinal lymph node biopsies and aspirations
- Echocardiography
BREAST

Beverly Hashimoto, MD

Beginner: Normal Anatomy
- Ducts
- Fibroglandular tissue
- Fat
- Cooper ligaments
- Pectoralis muscle
- Skin

Advanced Beginner: Basic Pathology
- Cyst vs solid mass
- Lymph node characterization: axillary, supraclavicular, intramammary

Competent: Knowledge of Advanced Pathology/Performance and Interpretation of Color Flow/Duplex Imaging
- Normal flow pattern in lymph nodes
- Flow pattern in abnormal lymph nodes
- Flow pattern in solid masses

Proficient: Ability to Assimilate Clinical Information and Radiologic Imaging Studies to Manage and Consult Effectively
- Cross correlate US mass with mammographic findings
- Characterization of solid masses: benign versus malignant
- Architectural distortion
- Intraductal masses/abnormalities
- Galactocele
- Multifocal malignancy
- (Ultrasound-guided biopsies of masses: including cyst aspiration, fine needle aspiration of masses or lymph nodes, core needle biopsy of masses)

Expert: Able to Perform US-Guided Procedures and Scan All Pathology
- Cross correlation sonography with MRI
- Screening whole breast
- Elastography