DIAGNOSTIC RADIOLOGY RESIDENCY
ULTRASOUND CURRICULUM

DEVELOPED BY
THE SOCIETY OF RADIOLOGISTS IN ULTRASOUND

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PREFACE

This ultrasound curriculum is intended to serve as a guideline for diagnostic radiology residency training programs, utilizing the goals and objectives format required by the American Council of Graduate Medical Education (ACGME). Each program should facilitate learning specific knowledge skills, behavior and attitudes, as well as provide an educational experience and mentorship for residents. At the conclusion of each one-month rotation, the resident should be able to demonstrate competence in these six specific areas: medical knowledge, patient care, practice-based learning and improvement, interpersonal and communication skills, professionalism, and systems-based practice, as outlined below.

The resident should understand this material through a “hands-on” clinical experience, including ultrasound scanning, combined with formal didactic teaching such as conferences, and independent learning utilizing teaching files, textbooks, and on-line electronic web-based tools such as medical journal articles, etc. Depending on the organization of each residency program, this material could be covered during a dedicated ultrasound rotation, in a series of organ-based rotations that include more than one imaging modality, or in a combination of these modality-based or organ-based approaches.

It is recognized that each program will have different schedules for rotating residents through ultrasound. For the purpose of this curriculum, the material is divided into three categories: basic,

intermediate and advanced, understanding that one program may have three rotations while others may have four or use other educational formats.

Topics and/or questions that may appear on residency examinations such as the ACR in-service exam or the American Board of Radiology exams are not necessarily limited to the contents of this curriculum.

This curriculum is intended to be a guideline for the sole purpose of radiology residency education. The clinical ultrasound evaluation of each patient depends on specific clinical circumstance and appropriate clinical management in each individual institution or practice.

There are two parts to the medical knowledge portion of the curriculum. The first, Section A, lists hands-on scanning objectives to be mastered by the end of each clinical rotation. The second, Section B, is a more comprehensive list of entities that the resident should understand by the end of each rotation. Each institution may have its own individual system for acquiring this knowledge base.

I. MEDICAL KNOWLEDGE

A. "HANDS-ON" SCANNING

By the end of each level of training, the resident should be able to scan most of the clinical scenarios listed below in each training category.

BASIC (First Month)

Gallbladder (gallstones/acute cholecystitis)
Liver (masses)
Kidney (hydronephrosis, stones)
Transabdominal/transvaginal pelvis (mass/cyst/free fluid)
Lower extremity (deep vein thrombosis)
Abdominal aorta (aneurysm)
Pleural effusion and ascites
Pregnancy (normal early intrauterine pregnancy)
Thyroid nodules

INTERMEDIATE (Second Month)

Pancreas (pancreatitis, mass)
Biliary (common bile duct, biliary ductal dilatation)
Abdominal mass/adenopathy
Kidney (mass/cyst)
Basic Doppler (portal vein, pseudoanerysm, arteriovenous fistula)
Pregnancy (first trimester, failed pregnancy, ectopic pregnancy)
Adnexal mass (ovarian and non-ovarian)
Testis (pain and masses)
Basics obstetrics (basic fetal biometry, basic second/third trimester fetal anatomy, placental localization, amniotic fluid volume)
Neonatal brain

ADVANCED (Third and Fourth Months)

Advanced obstetrics (comprehensive second/third trimester)
Pediatrics (abdomen, spine, hips)
Ultrasound-guided interventional procedures
Parathyroid
Carotid artery
Advanced abdominal Doppler (visceral organs, organ transplants)
Peripheral vessels (arterial bypass grafts, upper extremity veins)

B. COMPREHENSIVE KNOWLEDGE

PHYSICS/INSTRUMENTATION

The resident should understand the basic principles of physics that form the foundation of clinical ultrasound.

BASIC (First Month)

Define ultrasound, including the relationship of sound waves used in imaging
Straight narrow sound beams, simple reflection, constant sound speed
Beam shape: linear, sector, curved array
Probes: transabdominal, endocavitary
Endocavitary imaging: transvaginal, transrectal, endoscopic, laparoscopic
Display: Gray scale, M-mode, pulsed wave Doppler, color and power Doppler
Image orientation: standard images in different planes
Image optimization: power output, gain, time gain compensation
Image recording options: electronic (digital), film, paper
Acoustic properties of fluid, cyst, calcification, complex fluid and solid structures
Tissue characteristics: acoustic shadowing and enhancement
Focal zone

INTERMEDIATE (Second Month)

Transducer choice: curvilinear, linear, sector, vector
Frequency, sound speed, wavelength, intensity, decibels, beam width, Fresnel zone, Fraunhoffer zone
Interaction of sound waves with tissues: reflection, attenuation, scattering, refraction, absorption, acoustic impedance pulse-echo principles
Generation/detection of ultrasound waves
Doppler phenomenon, Doppler formula
Beam formation/focusing
Gray scale, M-mode, pulsed wave Doppler, color Doppler imaging, power Doppler imaging

ADVANCED (Third and Fourth Months)

Beamwidth, sidelobe, slice thickness artifacts
Multiple reflection artifacts - mirror image/reverberation
Refractive artifacts
Doppler artifacts- pulse wave, color imaging, including aliasing
Gray scale versus Doppler (trade-off of penetration and resolution)

3-D volumetric imaging
Thermal/non-thermal effects on tissue: biological health risks
Image optimization
Harmonic imaging
Ultrasound contrast agents

Equipment quality assurance: phantoms, spatial/contrast resolution

CLINICAL APPLICATIONS

GENERAL

The resident should understand the importance of clinical ultrasound protocols. Published protocols/standards from the American College of Radiology (ACR) or the American Institute of Ultrasound in Medicine (AIUM) with or without local modification are acceptable frames of reference. Residents should also be familiar with ACR appropriateness criteria as a guide for appropriate clinical use of ultrasound and other imaging modalities.

The resident should gain a general understanding of both the clinical uses and limitations of ultrasound as well as the appropriate integration of other complementary cross-sectional imaging studies, particularly CT and MRI.

The resident should understand the importance of documentation and reporting skills/ requirements, including the electronic applications in their institution.

The resident should understand the importance of clinical quality assurance, including radiologic-pathologic correlation, as well as sonographer-physician discrepancies.

ABDOMINAL

BASIC (First Month)

Liver: normal echotexture, size, and shape (including anatomic variants), diffuse disease, (fatty infiltration, acute and chronic hepatitis, cirrhosis, edema), focal masses, metastases, granuloma
Gallbladder: normal appearance, wall thickening, gallstones, including supine, decubitus and erect positions, sludge, acute cholecystitis (calculous/acalculous), sonographic Murphy's sign, other etiologies of wall thickening, polyp
Bile ducts: normal intra- and extrahepatic bile duct diameters and dilatation
Pancreas: normal anatomy, pancreatic duct, mass
Spleen: normal echotexture, size and shape (including anatomic variants), focal masses (cystic versus solid), lymphoma, abscess, infarction, granuloma
Peritoneal cavity: ascites, fluid localization/quantification (free/loculated)
Pleural effusion

INTERMEDIATE (Second Month)

Liver: hematoma, biloma, abscess
Post-liver transplantation collections: hematoma, biloma, abscess (see vascular section)
Gallbladder: hyperplastic cholecystoses, carcinoma
Bile ducts: bile duct stones, inflammatory disease, cholangitis, pneumobilia
Pancreas: neoplasm, cysts

Pancreatitis complications: abscess, pseudocyst and pseudoaneurysm, chronic pancreatitis
Peritoneal cavity: abscess, hemorrhage, omental mass, metastasis, carcinomatosis
Spleen: varices

ADVANCED (Third and Fourth Month)

Liver: trauma
Bile ducts: neoplasm (cholangiocarcinoma)
Spleen: trauma
Chest: pericardial effusion, mass, atelectasis/pneumonia
Organ transplants: see vascular section
Gastrointestinal tract: normal gut ultrasound signature, acute appendicitis, diverticulitis, Crohn's disease
Peritoneal cavity: free air
Abdominal wall hernia, inguinal hernia

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KIDNEYS, URINARY BLADDER AND PROSTATE

BASIC (First Month)

Normal renal cortical echotexture, size and shape, glomerulointerstitial renal disease, simple renal cyst
Ureters: hydronephrosis, pyonephrosis
Urinary bladder: calculi, wall thickening, ureteral jets, bladder volume, including post-void residual

INTERMEDIATE (Second Month)

Abscess/pyelonephritis, perinephric fluid
Post-renal transplant collections: hematoma, urinoma, abscess, lymphocele (see vascular section)
Complex renal cyst, adult polycystic disease and acquired renal cystic disease, renal cell carcinoma, angiomyolipoma
Urinary bladder: mass, infection, hemorrhage, wall thickening, bladder outlet obstruction, diverticula, ureterocele
Transabdominal prostate
Ureters: hydroureter

ADVANCED (Third and Fourth Months)

Kidneys: xanthogranulomatous pyelonephritis, emphysematous pyelonephritis, congenital anomalies, pelvic kidney (see pediatrics section), medullary nephrocalcinosis
Adrenal glands: mass
Retroperitoneum: adenopathy, mass
Ureters: ureteral stone
Urinary bladder: ectopic ureterocele
Renal artery stenosis, renal vein thrombosis (see vascular section section)
Transrectal prostate

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GYNECOLOGY

BASIC (First Month)

Uterus: normal size, shape, position, echogenicity, fibroid identification
Endometrium: normal appearance during phases of menstrual cycle and thickness measurement (pre-menopausal, post-menopausal, effects of hormone replacement), intrauterine device, fluid
Ovary: normal size, shape, echogenicity, physiologic variation during phases of menstrual cycle (follicles, corpus luteum, hemorrhagic ovarian cyst)
Free pelvic fluid

INTERMEDIATE (Second Month)

Uterus: congenital anomalies, endometrial polyp, endometrial hyperplasia, endometrial carcinoma, endometritis, pyometrium, fibroid localization (submucous, intramural, subserosal), adenomyosis
Ovarian cyst: hemorrhagic/ruptured cyst, endometrioma, polycystic ovarian disease, ovarian hyperstimulation syndrome
Ovarian neoplasm: cystic/solid adnexal masses, cystadenoma/carcinoma, dermoid, fibroma, germ cell tumor, Doppler evaluation
Ovarian torsion
Pelvic inflammatory disease, tubo-ovarian abscess
Cervix: mass, stenosis, endometrial obstruction
Fallopian tube: hydrosalpinx, pyosalpinx
Post-hysterectomy

ADVANCED (Third and Fourth Months)

Peritoneal inclusion cyst
Ovarian cancer staging
Saline hysterosonography

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OBSTETRICS

FIRST TRIMESTER

BASIC (First Month)

Normal findings: gestational sac appearance, size, gestational sac growth, yolk sac, embryo, cardiac activity including normal embryonic heart rate, amnion, chorion, normal early fetal anatomy/growth, crown-rump length measurement, correlation with BHCG levels and menstrual dates

INTERMEDIATE (Second Month)

Multiple gestations (chorionicity and amnionicity), failed early pregnancy, spontaneous complete/incomplete abortion, ectopic pregnancy, blighted ovum, embryonic death, subchorionic hematoma, gestational trophoblastic disease, gross embryonic structural abnormalities, anencephaly

ADVANCED (Third and Fourth Months)

Unusual ectopic pregnancy: interstitial, cervical, ovarian, scar, abdominal, rudimentary horn
Nuchal translucency
Chorionic villous sampling

SECOND AND THIRD TRIMESTER

BASIC (First Month)

Normal findings: normal fetal anatomy/situs/development, placenta, biometry, amniotic fluid volume, multiple gestations
Anencephaly
Oligohydramnios (spontaneous premature rupture of membranes, renal disease, fetal death, intrauterine growth retardation, infection)
Polyhydramnios, placenta previa
Cervical appearance and length

INTERMEDIATE (Second Month)

Recognition of fetal abnormalities that require high risk obstetrics referral, including intrauterine growth retardation, hydrops, holoprosencephaly, hydrocephalus, neural tube defects, multicystic dysplastic kidney, hydronephrosis
Placental abruption, placental masses, two-vessel umbilical cord, cord masses, retained products of conception

ADVANCED (Third and Fourth Months)

Recognition of fetal abnormalities that require high risk obstetrics referral, including congenital anomalies/chromosomal abnormalites and syndromes such as Down's syndrome and Turner's syndrome, hydrops, congenital infections, chest masses, cardiac malformations and arrhythmias, diaphragmatic hernia, abdominal wall defects, abdominal masses, gastrointestinal tract obstruction/abnormalities, ascites, skeletal dysplasias, cleft lip/palate, complications of twin pregnancy, hydrancephaly

Borderline findings: nuchal thickening, choroid plexus cyst, echogenic cardiac focus, echogenic bowel, borderline hydrocephalus
Placental cord insertion site/vasa previa, velamentous cord insertion, cord prolapse, succenturiate placenta, cervical incompetence
Umbilical cord Doppler, fetal cranial Doppler, biophysical profile
Guidance for amniocentesis
Placenta accreta, percreta, increta

THYROID/NECK

BASIC (First Month)

Normal thyroid echotexture, size and shape
Thyroid disease: diffuse and focal disease

Multinodular thyroid

INTERMEDIATE (Second Month)

Thyroid nodule characterization: echotexture, calcifications including microcalcifications, margins, recommendations for fine needle aspiration biopsy
Hashimoto's thyroiditis/Graves' disease

ADVANCED (Third and Fourth Months)

Parathyroid mass: adenoma
Congenital cysts: branchial cleft
Lymph nodes: benign and malignant characterization
Post-thyroidectomy recurrence
Submandibular and parotid glands: normal and abnormal

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VASCULAR/DOPPLER

BASIC (First Month)

Abdominal aorta: normal appearance and measurement, aneurysm
Inferior vena cava: normal appearance, thrombosis
Lower extremity deep vein thrombosis
Hematoma
Iatrogenic pseudoaneurysm

INTERMEDIATE (Second Month)

Peripheral vascular aneurysm, including iliac and popliteal arteries
Hepatic vasculature: pulsed Doppler and color Doppler imaging of the portal veins, splenic vein, hepatic arteries and hepatic veins, including normal direction of flow
Hemodynamics of cirrhosis, portal hypertension and varices, portal vein thrombosis
Upper extremity venous thrombosis: subclavian and internal jugular vein thrombosis, axillary and brachial vein thrombosis
Carotid artery: normal, atherosclerotic plaque, carotid artery stenosis and occlusion
Renal vein thrombosis
Iatrogenic arteriovenous fistula
Pre-graft vein mapping

ADVANCED (Third and Fourth Months)

Renal transplant: arterial resistive index (rejection, acute tubular necrosis), transplant vein thrombosis, renal infarction, post-biopsy complications, renal arterial stenosis
Liver transplants, including hepatic artery stenosis or thrombosis (resistive index), portal vein thrombosis, post-biopsy complications, inferior vena cava stenosis
Pancreas transplant: arterial and venous anastomosis, patency and stenosis
TIPS evaluation and complications
Lower extremities: chronic venous insufficiency
Arterial bypass graft
Hemodialysis graft/fistula

Carotid artery: waveform analysis, stenosis, dissection, pseudoaneurysm, stent
Vertebral artery: subclavian steal syndrome
Mesenteric ischemia
Renal artery stenosis

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SCROTUM

BASIC (First Month)

Testes: normal echotexture, shape and size
Epididymes
Testicular mass
Hydrocele

INTERMEDIATE (Second Month)

Epididymitis, orchitis
Testicular torsion
Testicular mass characterization: microlithiasis, germ cell tumor, lymphoma, metastasis
Cystic ectasia of rete testis
Extratesticular masses/cysts, spermatocele, adenomatoid tumor, epidydimal head cyst
Varicocele
Trauma

ADVANCED (Third and Fourth Months)

Hernia
Non-descended testis
Fournier's gangrene

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PEDIATRICS

BASIC (First Month)

Normal abdominal anatomy
Normal renal anatomy
Normal brain anatomy
Normal neck anatomy

INTERMEDIATE (Second Month)

Brain: intracranial hemorrhage and complications, including periventricular leukomalacia and hydrocephalus, shunt evaluation
Kidneys: hydronephrosis, stones, hydroureters, anomalies of position and fusion, renal scarring, masses, cystic disease
Adrenal hemorrhage, masses (neuroblastoma)
Liver: cirrhosis, choledochal cysts, liver masses, hepatitis/biliary atresia
Gallbladder: gallstones, biliary stones, hydrops
Pancreatitis

Normal hip
Intussusception
Acute appendicitis
Acute pancreatitis
Hypertrophic pyloric stenosis
Scrotal: torsion, epdidymitis, orchitis, masses, undescended testis, mass
Ovarian torsion
Neck mass
Deep vein thrombosis of upper and lower extremities

ADVANCED (Third and Fourth Months)

Organ transplant
Polysplenia, asplenia
Hip dislocation
Congenital brain malformations, agenesis of corpus callosum, vein of Galen aneurysm, Dandy Walker Malformation, aqueductal stenosis
Neonatal spine: tethered cord, intraspinal mass
Liver Doppler
Imperforate hymen, uterine anomalies

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MUSCULOSKELETAL

BASIC (First Month)

Mass
Hematoma
Baker's cyst, including rupture
Cellulitis
Abscess

INTERMEDIATE (Second Month)

Normal tendon appearance
Foreign body
Soft tissue gas
Joint fluid
Muscle tear

ADVANCED (Third and Fourth Months)

Tendon tear, inflammation
Rotator cuff tear

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BREAST

BASIC (First Month)

Sonomammographic anatomy
Cystic versus solid mass
Mastitis/abscess

INTERMEDIATE (Second Month)

Characterization of cysts
Lymph node characterization: axillary, supraclavicular, intramammary

ADVANCED (Third and Fourth Months)

Characterization of solid masses: benign versus malignant
Architectural distortion
Intraductal masses/abnormalities
Galactocele
Screening
Multifocal malignancy
Elastography

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INTERVENTIONAL

BASIC (First Month)

Informed consent
Sterile technique
Localization of fluid for paracentesis or thoracentesis to be performed by another service
Ultrasound-guided paracentesis

INTERMEDIATE (Second Month)

Pre-procedural evaluation: coagulation laboratory studies, anticoagulation medication
Stratification of risk for percutaneous procedures
Techniques for ultrasound-guided invasive procedures: understanding important landmarks and pitfalls of percutaneous procedures, including recognition of critical structures to be avoided
Biopsy of soft tissue masses
Random core liver biopsy
Aspiration of fluid collections, cysts and catheter placement for abscess and fluid drainage (pleural, peritoneal and other spaces)
Ultrasound-guided thoracentesis
Post-procedural evaluation: radiographic studies, patient monitoring, management of complications

ADVANCED (Third and Fourth Months)

Fine needle biopsy versus core biopsy in specific application, such as focal liver mass, renal mass, thyroid/parathyroid mass, retroperitoneal lymphadenopathy

Pseduoaneurysm management: contraindications and technique of non-surgical treatment with ultrasound-guided compression repair versus thrombin injection
Intraoperative ultrasound guidance

II. PATIENT CARE

BASIC (First Month)

Gather essential and accurate clinical and radiologic information about patients relevant to the interpretation of the ultrasound examination
Communicate effectively and demonstrate caring, respectful behavior when interacting with patients and their families, answering their questions and helping them to understand the ultrasound procedure as well as its clinical significance
Use information technology to support patient care decisions

INTERMEDIATE (Second Month)

Screen and supervise more complex ultrasound studies
Understand the importance of the physician/patient interaction during an ultrasound examination

ADVANCED (Third and Fourth Months)

Screen and supervise, with increasing level of responsibility, most ultrasound studies
Understand the bioeffects and safety issues in diagnostic ultrasound

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III. PRACTICE-BASED LEARNING AND IMPROVEMENTS

BASIC (First Month)

Use information technology to manage information, to access on-line medical information, and for self learning

INTERMEDIATE (Second Month)

Demonstrate knowledge of principles of research methods, statistical methods, study design and their implementation
Demonstrate critical assessment of the scientific literature
Demonstrate knowledge and application of the principles of evidence-based medicine in practice

ADVANCED (Third and Fourth Months)

Facilitate teaching of medical students, sonographers, other residents and other health care professionals
Participate in quality assurance programs for sonographers and physicians
Be aware of equipment quality assurance programs
Apply basic knowledge of study design and statistical methods to the appraisal of clinical studies and other information on diagnostic and therapeutic effectiveness

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IV. INTERPERSONAL AND COMMUNICATION SKILLS

BASIC (First Month)

Dictate prompt, accurate and concise radiologic reports for basic ultrasound studies using available electronic software applications
Develop effective communication skills with patients, patients' families, physicians and other members of the health care team
Promptly communicate urgent, critical or unexpected ultrasound findings to residents, referring physicians or clinicians and document the communication in the radiological report

INTERMEDIATE (Second Month)

Interact with residents and attending physicians in consultation when clinical-radiologic correlation is necessary
Dictate accurate and concise radiologic reports for more complex ultrasound studies with concise impression including diagnosis and/or differential diagnoses

ADVANCED (Third and Fourth Months)

Dictate accurate and concise reports for the most complex ultrasound studies with concise impression including diagnosis and/or differential diagnoses as well as recommendations for further imaging and/or management, when appropriate

Consult effectively with senior residents and attending physician in most aspects of ultrasound

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V. PROFESSIONALISM

BASIC (First Month)

Demonstrate honor, integrity, respect and compassion to patients, other physicians and other health care professionals
Demonstrate positive work habits, including punctuality and professional appearance

INTERMEDIATE (Second Month)

Demonstrate a commitment to the ethical principles pertaining to confidentiality of patient information
Demonstrate responsiveness to the needs of patients that supercedes self-interest (altruism)

ADVANCED (Third and Fourth Months)

Demonstrate accountability to patients, society and the profession

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VI. SYSTEMS-BASED PRACTICE

BASIC (First Month)

Understand how medical decisions affect patient care within the larger system

INTERMEDIATE (Second Month)

Know how types of ultrasound practice and delivery systems differ from one another
Effectively prioritize patients requiring ultrasound studies

ADVANCED (Third and Fourth Months)

Practice cost-effective evaluation of patients requiring ultrasound studies that does not compromise the quality of care