

Goals

Point-of-care ultrasound (POCUS) is the biggest advance in bedside diagnosis since the advent of the stethoscope 200 years ago. While diagnostic ultrasound has been a cornerstone of radiology, cardiology, and obstetrics for decades, the increased portability and affordability of ultrasound technology in the mid-1990s has allowed for the widespread adoption of bedside POCUS.

A large body of evidence clearly demonstrates that using POCUS improves clinical outcomes, reduces failure and complication rates during procedures, can help with differential diagnosis and to support a diagnosis, Can shorten time to treatment, reduce costs, reduction of CT utilization, improve patient doctor experience and patient satisfaction, can help differentiate between conditions with similar presentations.

POCUS is especially empowering and critical for front-line providers in rural, underserved, or resource-constrained environments where advanced imaging and specialists are in scarce supply. Family physicians are often the providers in these key clinical contexts. Because of the wide range of clinical practice, family medicine physicians are in good position to use POCUS to enhance patient care. This Curriculum Guideline is an evidence-based roadmap for family medicine residencies to equip their residents with the competencies, attitudes, knowledge, and skills necessary to effectively utilize POCUS in clinical practice.

Competencies

At the end of residency training, a family medicine resident should be able to:

- Know the indications, benefits, and limitations of POCUS (Patient Care)
- Assess anatomy, physiology, and pathology with POCUS (Medical Knowledge)
- Advance POCUS knowledge with appropriate precepting, electives, and use of website resources (Practice-based Learning and Improvement)
- Communicate the results of a POCUS scan to the patient and treatment team, and document the results appropriately in the medical record (Interpersonal and Communication Skills)
- Talk to the patient about the risks and benefits of POCUS and alternatives to POCUS, and obtain verbal consent prior to a POCUS scan (Professionalism)
- Utilize POCUS to decrease time to diagnosis, decrease procedure complications, and expedite medical care (Systems-based Practice)

Attitudes and Behaviors

The resident should demonstrate attitudes and behaviors that encompass the following:

- POCUS is a limited, focused exam that should be quick and relatively easy to obtain. It is utilized to address a few clinically relevant questions, such as, "Is the common bile duct dilated."

- POCUS aids in diagnosis like an electrocardiogram (ECG), chest x-ray, or blood test, and is not a substitute for a good history and physical exam.
- POCUS is utilized with the physical exam and offers additional anatomic, functional, and physiologic information to guide patient care.
- POCUS enhances procedural competency and efficacy (e.g., paracentesis, thoracentesis, placement of central line, joint injections).
- POCUS can be used to “rule in” pathology that is part of the differential diagnosis. For example:
 - o In a patient who has a high pre-test probability of having biliary colic or acute cholecystitis, if the bedside ultrasound is inconclusive for gallstones, consider ordering a radiology-performed gallbladder ultrasound.
 - o Use Fundal, Eccentric, Elliptical, Decidual reaction, Size of gestational sac (FEEDS) criteria to rule in an intrauterine pregnancy (IUP) when evaluating a woman who has first trimester vaginal bleeding and lower abdominal pain, and the differential diagnosis includes ectopic pregnancy.
- To prevent CT scan-induced malignancies, POCUS should be used when evidence suggests that ultrasound is just as good as a CT scan to assess for a specific type of pathology (e.g., evaluation of the patient who has flank pain when ureteral colic is in the differential).

Knowledge

In the appropriate setting, the resident should demonstrate the ability to apply knowledge of the following:

- 1) Basic ultrasound
 - a) Physics: Use of piezoelectric effect and generation of ultrasound images; the frequency, wavelength, power, and intensity as it relates to ultrasound
 - b) Images: Ultrasound representation of fluid, soft tissues, solid organs, air, foreign bodies, and bone
 - c) Transducers: Four main types are linear, curvilinear, phased array, and intracavitary; each probe has a different crystal arrangement, size, and footprint that determines its preferred applications.
 - d) Orientation: Sagittal, transverse, and coronal planes; probe marker position and its relation to the patient’s body and screen image
 - e) Image optimization: Depth (near and far-field) and gain
 - f) Ultrasound image terminology: Echogenicity, artifacts, and anisotropy
 - g) Scanning techniques: Sliding, fanning, rotating, and rocking
 - h) Modes: Two-dimensional, M-mode, and Doppler imaging
 - i) Applications: Basic core applications of POCUS and incorporation into patient care. Advanced applications are optional and reserved for providers who have mastered the basic core applications.
 - j) Safety: Understand the “As Low As Reasonably Achievable” (ALARA) principle and specific safety issues as they apply to ultrasound exposure (e.g., ocular settings, avoidance of first trimester Doppler or color use); understand probe cleaning and which studies need normal versus high-level disinfection
 - k) Documentation: Understand the importance and methods of archiving and retrieving images; applicability to clinical decision making and quality improvement
- 2) Basic core applications of POCUS:
 - a) Obstetrics and gynecology (OB/GYN)
 - b) Cardiac

- c) Trauma
- d) Aorta
- e) Biliary
- f) Urinary tract
- g) Deep venous thrombosis (DVT)
- h) Soft tissue/musculoskeletal
- i) Thoracic/pulmonary
- j) Ocular
- k) Procedural guidance
- l) Clinical protocols

NOTE: “Basic” and “advanced” applications of POCUS are based on consensus opinion and are not meant to be all-inclusive or exclusive. It is anticipated that a family medicine residency will utilize this document to create their own POCUS curriculum based on their specific needs, clinical focus, and credentialing process. Other than the OB/GYN section, ultrasound skills/competencies listed below are only described for the basic applications of POCUS.

Skills

In the appropriate setting, the resident should demonstrate the ability to independently perform or appropriately refer the following:

I. OB/GYN

1. Limited first trimester evaluation: Essential ultrasonography components
 - a. Transabdominal and transvaginal scanning techniques
 - b. Presence of IUP: Utilize FEEDS criteria or other documentable criteria to assess for presence of IUP.
 - c. Viability of IUP (see Campion EW. Diagnostic criteria for nonviable pregnancy early in the first trimester. NEJM. 2013; 369:1443-1451.)
 - d. Detection of fetal heart rate in all stages of pregnancy: Using M-mode. Color imaging and Doppler are not recommended for heart rate detection in first trimester.
 - e. First trimester pregnancy gestational age assessment: By crown rump length detection of free fluid in the pelvis. Obtain suprapubic, transverse, and longitudinal views to assess for any free fluid anterior or posterior to the uterus.
2. Limited second/third trimester evaluation: Essential ultrasonography components
 - a. Determine placenta position (fundal, anterior, posterior, low-lying, previa) and know when transvaginal follow-up imaging is indicated
 - b. Fetal presentation: Vertex, breech, or transverse
 - c. Amniotic fluid volume: Identify the single deepest pocket of fluid on third trimester ultrasound and appropriately calculate an amniotic fluid index
 - d. Placenta abruption: Identification of chorionic hemorrhage
3. Advanced OB ultrasonography skills(optional)
 - a. Recognition of molar pregnancy: Identify “snowstorm appearance/cluster of grapes” of molar pregnancy
 - b. Components of the standard second/third trimester scan:

- i. Gestational age assessment and fetal weight estimation using abdominal circumference (AC), biparietal diameter (BPD), and femoral length (FL).
- c. Evaluation of cervical insufficiency: Preterm labor assessment; measure of cervical length transabdominal/transcervical
- d. Estimation of fetal weight
- e. Assessment of maternal anatomy
- f. Fetal anatomy
- g. Gender of fetus: Identify penis or labia during 18-to20-weekultrasound
- 4. Specialized examinations/special situations
 - a. Fetal well-being during third trimester, biophysical profile: Ultrasound assessment of amniotic fluid index (AFI), fetal breathing movements, gross body movements, and tone
 - b. Confirmation of fetal death: Absent fetal heart tones, fetal movement, skull deformity, maceration, and echogenic amniotic fluid
- 5. Gynecology ultrasound skills
 - a. Intra-uterine device (IUD) position: Presence or absence of IUD in uterus
 - b. Dysfunctional uterine bleeding: Measurement of endometrial stripe
 - c. Adnexal mass: Simple, complex, hemorrhagic cysts
 - d. Breast mass: Differentiate a simple cyst from a complex cyst/solid mass (see American Academy of Family Physicians. Diagnostic Ultrasonography in Women's Health Care [revised and approved 2013]. <http://www.aafp.org/about/policies/all/ultrasonography-diagnostic.html>. Accessed December 14, 2016.)

II. Cardiac

- 1. Echocardiograph (cardiac ultrasound) basic skills
 - a. Detection of pericardial effusion: Subxiphoid view
 - b. Assessment of global left ventricle (LV)contractility to assess systolic function (e.g., hyperdynamic/increased, normal, or reduced): Parasternal long/short, apical 4-chamber view
 - c. Assessment of right ventricle (RV) size to assess for right heart strain and possibility of pulmonary embolism (PE) in appropriate clinical setting: Parasternal long/short, apical 4-chamber view
 - d. Measurement of inferior vena cava (IVC) to approximate volume status: Size and respiratory variation in subxiphoid view
- 2. Echocardiograph (cardiac ultrasound) advanced skills(optional)
 - a. Calculationofejectionfraction
 - b. Regionalwallmotionabnormalities
 - c. Diastolic dysfunction
 - d. Left ventricular mass for left ventricular hypertrophy (LVH)diagnosis
 - e. Valvular abnormalities: Mitral/aortic regurgitation and stenosis

III. Trauma

- 1. Assessment of free fluid in the abdominal cavity: Hemoperitoneum-right upper quadrant - Morison pouch; left upper quadrant - sub-diaphragmatic and splenorenal view; suprapubic - fluid outside of bladder. Ascites can have similar appearance.
- 2. Assessment of free fluid around the heart: Hemopericardium—subxiphoid view

3. Assessment of a pneumothorax: Assess for evidence of lung sliding and M-mode variation; know differential diagnosis for lack of lung sliding
4. Assessment for a hemothorax: Assess for free fluid above the diaphragm and visualization of the thoracic spine

IV. Aorta

1. Aorta basic ultrasound skills
 - a. Abdominal aortic aneurysm: Screening using U.S. Preventive Services Task Force (USPSTF) recommendations versus diagnostic
 - ii. Identification of vertebral shadow, aorta, IVC, and iliac bifurcation with proximal, mid, and distal imaging views
 - iii. Scan from xiphoid to umbilicus in transverse and longitudinal views to assess for fusiform versus saccular aneurysm and proximal iliac artery aneurysm; evaluate for intramural thrombus detection
 - iv. Use of Doppler waveform imaging/color Doppler
2. Aorta advanced ultrasound skills(optional)
 - a. Proximal aortic root aneurysm or dissection
 - b. Abdominal aortic dissection

V. Biliary/abdominal

1. Biliary/abdominal basic ultrasound skills
 - a. Assess for symptomatic cholelithiasis: Identify presence of gallstone versus polyp or artifact
 - b. Assess for acute cholecystitis: Presence of stones, sonographic Murphy sign, anterior gallbladder wall thickening, and pericholecystic fluid
 - c. Assess for common bile obstruction: Choledocholithiasis – measure common bile duct (CBD) diameter
2. Biliary/abdominal advanced ultrasound skills
 - a. Appendicitis
 - b. Hepato-splenomegaly
 - c. Small bowel obstruction
 - d. Inguinal hernia

VI. Genitourinary tract

1. Genitourinary basic ultrasound knowledge
 - a. Evidence of ureteral stone or obstructive process: Identify mild, moderate, and severe hydronephrosis
 - b. Urinary retention and post-void residual volume: Calculate bladder volume and post-void residual
2. Genitourinary advanced ultrasound skills(optional)
 - a. Stone identification
 - b. Acuteversuschronicobstruction
 - c. Use of Doppler waveform imaging/color Doppler
 - d. Hydrocele
 - e. Varicocele
 - f. Testicular torsion
 - g. Ovarian torsion
 - h. Epididymitis
 - i. Orchitis
 - j. Prostate volume

VII. Deep venous thrombosis

- 1) 1.DVT basic ultrasound skills (lower extremities)
 - a. Use of Doppler waveform imaging/color Doppler
 - b. DVT: Know difference between vein, artery, nerve, and lymph node
 - i. Low-risk: Ambulatory patient, utilize 2-zone discrimination technique-compression at proximal femoral vein zone and popliteal vein zone
 - ii. High-risk patient: Complete compression of lower extremity from the common femoral vein to the popliteal vein
- 2) Differentiate DVT from cellulitis of lower extremity (see large lymph nodes and soft tissue swelling), superficial thrombophlebitis (deep versus superficial veins), and Baker cyst (cystic, no color flow)
- 3) DVT advanced ultrasound skills (upper extremities) (optional)
- 4) Anatomy of internal jugular, subclavian, axillary, brachial, basilic, and cephalic veins

VIII. Soft tissue and musculoskeletal

1. Soft tissue and musculoskeletal basic ultrasound skills
 - a. Cellulitis versus abscess in soft tissue: "Cobble stoning" (fluid in subcutaneous fat) versus discrete, hypoechoic, walled-off fluid collection in subcutaneous tissue
 - b. foreign body: Hyper-echoic material with shadowing
 - c. Joint effusions/bursitis: Hypoechoic fluid collection in joint space or bursa
 - d. Fractures: Cortical disruption with hematoma
 - e. Tendon rupture/ tear: Anisotropy vs. tear
 - f. Tendonitis/tendinopathy: Fluid collection around tendon and hyperemia on color/Doppler imaging. Some may consider this an advanced application.
 - g. Risks, benefits, indications, and contraindications to ultrasound-guided injection and aspiration
2. Soft tissue and musculoskeletal advanced ultrasound skills (optional)
 - a. Shoulder: Rotator cuff integrity and scanning protocols
 - b. Knee: Medial collateral ligament (MCL), lateral collateral ligament (LCL), and patellar tendon integrity
 - c. Ankle: Anterior talofibular ligament (ATFL), calcaneofibular ligament (CFL), and posterior talofibular ligament (PTFL) integrity
 - d. Median nerve area and ultrasound feature suggestive of carpal tunnel syndrome

IX. Pulmonary

1. Pulmonary basic ultrasound skills
 - a. Pulmonary ultrasound anatomy: Ribs, pleura, lung tissue, diaphragm, description of lung zones for scanning
 - b. Pulmonary ultrasound artifacts: A-line pattern, B-line pattern, and pleura ultrasound artifacts: evidence of lung sliding (see Trauma section)
 - c. In the appropriate clinical presentation, utilize pulmonary ultrasound anatomy and artifacts to assess for:
 - i. CHF: Presence of bilateral B lines in multiple lung zones
 - ii. Pneumonia: Focal B line pattern and other sonographic sign
 - iii. Pneumothorax: Lack of lung sliding (see Trauma section)
 - iv. Asthma/COPD exacerbation: Predominant A-line pattern

v. Pleural effusion and hemothorax (see Trauma section)

2. Pulmonary advanced ultrasound skills

- a. acute respiratory distress syndrome (ARDS)
- b. Chronic interstitial lung disease
- c. Pleural-based masses
- d. Interstitial pneumonia

X. Ocular

1. Ocular basic ultrasound skills

- a. Detached retina: Serpentine, undulating, hyperechoic, and linear density that appears above and tethered to retina
- b. Vitreous detachment: No tethering, different than hemorrhage
- c. Vitreous hemorrhage: Heterogeneous material that may layer above retina and “tumble” with ocular movement like “clothes in a washing machine”

2. Ocular advanced ultrasound skills (optional)

- a. Intraocular foreign body
- b. Papilledema
- c. Lens dislocation
- d. Eccentric pupillary light reflex in ocular trauma

XI. Procedural guidance

The physician should be able to identify appropriate ultrasound anatomy, including nerve, artery, vein, muscle, bone, and subcutaneous tissue, to aid the procedure. Use of ultrasound images in performing the procedure should be noted in the consent form and procedure note.

1. Procedural basic skills

- a. Thoracentesis
- b. Paracentesis
- c. Peripheral IV placement
- d. Central venous line placement
- e. Lumbar puncture
- f. Knee aspiration and injection
- g. Foreign body identification and removal

2. Procedural advanced skills (optional)

- a. Nerve blocks
- b. Fine needle aspiration/biopsy
- c. Shoulder, ankle, hip, wrist aspiration, and injection

XII. Clinical protocols

POCUS clinical protocols are systematic exams that serve as an adjunct to improve diagnostic acumen. Clinical protocols do NOT substitute for an appropriate history, physical exam, or other tests, such as ECG, blood tests, and other appropriate radiographic modalities.

- 1. FAST/E-FAST: Focused assessment with sonography for trauma
- 2. RUSH: Rapid ultrasound for shock and hypotension
- 3. BLUE: Bedside lung ultrasound in emergency
- 4. CLUE: Cardiac limited ultrasound exam
- 5. FEEDS criteria (see OB/GYN section)

Implementation

This curriculum should be taught during both focused and longitudinal experiences throughout the residency curriculum. Specifics of certain approaches have been described in the literature, with consensus being that a POCUS curriculum should contain the following components^{10,11}:

- Faculty champions: Drs. Knight and Turner will be handling US curriculum and will act as
- Didactic education: Shall be held during a dedicated lecture time. There will be videos provided followed with hands-on education
- Hands-on education: Visuomotor skills needed to competently perform POCUS can be developed under direct supervision by a faculty member or through self-directed learning during educational ultrasound sessions. Other options for hands-on education include the use of simulation and models. There are several good simulators available to help demonstrate pathology when patients are not available. It is best to have more direct supervision early in a resident's learning process and then transition to self-directed scanning as the resident's skills improve.
- Educational ultrasound: An educational ultrasound is intended for teaching purposes and gives the trainee hands-on experience. No clinical decisions should be based on educational ultrasounds unless first confirmed with a formal ultrasound examination or discussed with a credentialed provider. Patients should provide informed verbal consent before they are subjected to an educational ultrasound. Patients should be informed that it is for education only and that they will not be informed of the results. If anything, concerning is found, a credentialed provider should be notified immediately. Ideally, all educational ultrasound images should be reviewed by faculty, either during the scan or later by image review.
- Knowledge and skill assessment: Knowledge and skill assessment provides residents with formative feedback throughout the curriculum and helps them focus on areas for improvement. Knowledge is best assessed using multiple-choice tests that include images and video loops of ultrasound images. The resident should be asked to interpret images and use this information to guide patient management in clinical vignettes. Skill assessment is best done under direct observation by the faculty member. This can include informal evaluation, but it is helpful to have some sort of structured evaluation as well. Structured assessments utilize evaluation forms with a system of scoring and can be performed on the spot while the resident is scanning a patient or scheduled and performed as part of an observed structured examination.
- Quality improvement/assessment: The implementation of POCUS training within a residency setting should be accompanied by ongoing assessment of quality, including but not limited to image storage and archiving; periodic review and audit of a certain number/percentage of completed exams; attention to training and documentation of clinical activity for those providing instruction in POCUS; and ongoing continuing medical education (CME).
- Competency assessment: Competency assessment is utilized to provide the resident with summative feedback and determine recommendations for privileges upon graduation. Each family medicine residency program should develop its own criteria to quantify the number of precepted scans needed to assess their learners for POCUS competency. In general, the number of precepted ultrasounds performed correlates with a resident's competency level. Family medicine residency programs with well-established POCUS curricula have used 150 to 300 total scans for general point-of-care ultrasound

competency, 25 to 50 supervised exams for a specific diagnostic exam, and 5 to 10 supervised scans for ultrasound-guided procedures.

These numbers are consistent with recommendations from other specialty societies, such as the American College of Emergency Physicians (ACEP).^{12,13} Programs and residents should understand recommendations for training, skill performance, and documentation from other organizations, such as the American Institute of Ultrasound in Medicine (AIUM) and the American College of Obstetricians and Gynecologists (ACOG), and how those are similar to, and differ from, protocols utilized in POCUS. Consideration should be given to utilizing a summative knowledge exam and skill assessment in this process. In the end, residents must be deemed to be competent by the ultrasound faculty and program director on a case- by-case basis.

Resources

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Website Resources

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Toronto General Hospital Department of Anesthesia Perioperative Interactive Education. Virtual Transthoracic Echocardiography. <http://pie.med.utoronto.ca/TTE/index.htm>

Ultrasound of the Week. <http://www.ultrasoundoftheweek.com/>

123sonography.com

Coreultrasound.com

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