Domain 4: What to Teach in an Undergraduate Medical School Ultrasound Curriculum

Recommendation Statements with Rational --- 1st Draft ---

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Domain 4--- What to Teach

P1D4.1

Recommendation: An ultrasound curriculum should assure that learners understand fundamental ultrasound principles and instrumentation, demonstrate safe and appropriate use of ultrasound equipment, explain the basis of common ultrasound artifacts, and describe the technical aspects of optimizing ultrasound images.

Comments/Rationale (Blaivas)

Considering the importance of the physical properties of ultrasound and the resultant image artifacts, which are encountered multiple times in the course of most ultrasound examinations, it is imperative that all ultrasound providers have a thorough understanding of ultrasound fundamentals. Although generally considered safe in most cases, ultrasound should be used in adherence with ALARA like principles, minimizing any potential for harm. [Abuelhia E. Awareness of ionizing radiation exposure among junior doctors and senior medical students in radiological investigations. J Radiol Prot. 2017 Mar;37(1):59-67.]

Since ultrasound is an operator dependent modality and the difference between an optimized image and significantly suboptimal one may mean the difference between a diagnostic and a non-diagnostic examination, adequate understanding of instrumentation and ultrasound equipment operation is critically important. [Barrington MJ, Viero LP, Kluger R, Clarke AL, Ivanusic JJ, Wong DM.]
P1D4.2

**Recommendation**: Basic scientists and clinicians should collaborate to assure that relevant content within and across the foundational and clinical sciences is delivered at the optimal time within the broader curriculum. The ultrasound curriculum should encompass all organ systems, a continuum of patient populations and clinical scenarios.

**Comments / Rationale (Nace)**

Organ system approach to include anatomy, physiology, pathology, pathophysiology, pharmacology, physical diagnosis, and clinical applications, including pediatric and adult patients; multidisciplinary clinical expert opinion on what is appropriate and important for students to learn and when in their education it should be taught, multi-organ system ultrasound assessment to be included. Systems may include:

1. Cardiovascular system
2. Respiratory system
3. Gastrointestinal system
4. Endocrine system
5. Nervous system
6. Reproductive system
7. Musculoskeletal system
8. Genito-urinary system
9. Skin and soft tissue

**Comments / Rationale (Goodmurphy)**

Governing bodies for medical accreditation are increasingly encouraging schools to develop competencies in skills and contemporary scientific technologies that professionals and public expect (LCME accreditation standards 6.1 & 7.1) They also anticipate that medical students acquire such skills in hands on or simulated exercises to collect data, verify hypothesis that assist them in patient care, differential development and treatment planning (LCME accreditation standards 7.2 & thru 7.5).

Ultrasound Education and scanning practice provide robust opportunities for foundational scientists, clinicians and residents to work collaboratively to bring such opportunities to medical students. (Citation #1, 5,12, 37, 42, 149, 273, 313, 503). Clinical and Foundational scientist working together to appropriately pace, time and deliver integrated learning opportunities with both foundational and clinical implications is beginning to impact student curricular satisfaction with ultrasound programs. (Citation# 12,
Moreover, data shows that Ultrasound education utilizes problems solving, judgement, team based, self-directed and exploratory-learning methods that have been encouraged by accrediting bodies. (LCME accreditation standards 6.3 & 7.4) (Citations# 119, 420, 255, 272, 238, 743)

Data continues to grow showing that ultrasound can be both used to teach foundational sciences (citations#28, 73, 82, 94, 134, 137 147, 239, 273, 305, 503, 528, 563) but can also assist students with the understanding of foundational sciences. (citations# 121, 136,

Beyond simply assisting foundational concepts and understanding US has also been shown to assist with outcome improvements in the physical exam (Citations# 136, 238, 320, 373, 408, 611, 634, 684 ) and procedural interventions (Citations# 49, 350, 566, 642)

As curricula continue the shift from traditional subject based formats to integrated systems based formats there will continue to be a need for new bridges to be built between clinical and foundational sciences. Ultrasound provides such an opportunity and should therefore be considered as a practical tool for inclusion in each of the major systems including possible topics of coverage depending on school resources and expertise, appendix 2.

P1D4.3

**Recommendation:** Ultrasound education should be integrated with physical diagnosis training. Ultrasound provides immediate verification and feedback to learners. Ultrasound teaches students how to flexibly augment the classical physical examination with point-of-care imaging. An ultrasound curriculum should include evidence based measures of utility as it relates to the teaching, learning and performance of an ultrasound enhanced physical examination with inclusion of data that incorporates sensitivity, specificity, and likelihood ratios relevant to evidence based practice.

**Comments / Rationale (Nace)**

Teaching an ultrasound-enhanced physical examination [and/or “ultrasound-enhanced clinical assessment?”] offers compelling advantages to students learning physical diagnosis. First, ultrasound can provide immediate feedback to learners about the accuracy of an observation, the proper performance of an exam component, or the correct interpretation of a finding. Examples include verification of liver size estimated by percussion and palpation [272, 173], confirmation of a palpable thyroid nodule [a], determination of the inferior border of the lung [185], detection of valvular and non-valvular heart disease [115, 190], and proper localization of the femoral pulse [75].

More importantly, point-of-care ultrasound is diagnostically superior to many aspects of the traditional physical examination, even with brief training [b]. By incorporating ultrasound instruction within physical diagnosis courses, students may come to properly view ultrasound as an extension of the skills and tools available at the bedside that can be routinely used to improve the accuracy of the physical examination [218]. This may be particularly apparent when ultrasound is incorporated within an evidence-based physical diagnosis curriculum that includes measures of diagnostic utility (i.e., sensitivity, specificity, predictive value, and likelihood ratio) for both the physical diagnosis and point-of-care ultrasound components [c, d]. Such measures for bedside ultrasound performed by trainees and by more experienced practitioners have been published [b, 120, e, f, g, h, i, j, k, l, m].

Fox, et al. have compiled a list of 30 applications of point-of-care ultrasound aligned with corresponding components of the traditional physical examination [132]. Many medical schools already successfully integrate these ultrasound exams with traditional physical diagnosis instruction [66, n, 19, 36, others]. Objective structured clinical examinations (OSCEs) can be used to assess a
student’s ability to flexibly and appropriately incorporate ultrasound within a targeted physical examination (66).


**P1D4.4 (Blaivas)**

**Recommendation:** An ultrasound curriculum should address issues of: standards of competence, adherence to regulatory standards, licensure, relevance of contextualized clinical findings (incidental findings), medico legal documentation, patient and peer communication and the practices of informed consent

**Comments/Rationale**

Considering the historical challenges for medical applications where proper standards and

Adherence to medical standards and licensure has become the norm in medical practice and is designed to increase quality of care delivery and safety. Included in basic standards of medical practice is necessary medico legal documentation and proper informed consent as stipulated by local, regional and national laws, regulations and standards. Communication with peers and patients should be governed by the same standards as in any patient care setting. [Eric S. Holmboea, Jonathan Sherbinob, Robert Englanderc, Linda Snelld,e and Jason R. Franke,f; on behalf of the ICBME Collaborators. A call to action: The controversy of and rationale for competency-based medical education. MEDICAL TEACHER, 2017 VOL. 39, NO. 6, 574–581]

The concept of clinical relevance of findings is an established notion within clinician use of ultrasound in patient care. Similarly, students must learn how to incorporate findings into medical decision making. Further, incidental findings should be assumed to be a normal component of learning ultrasound in all areas of medical education including patient and model scanning and does not differ from other such encounters such as during practice physical examination and assessment. [Udrea DS, Sumnicht A, Lo D, Villarreal L, Gondra S, Chyan R, Wisham A, Dinh VA. Effects of Student-Performed Point-of-Care Ultrasound on Physician Diagnosis and Management of Patients in the Emergency Department. J merg Med. 2017 Jul;53(1):102-109.]

P1D4.5 Curricular content must necessarily be individualized based on unique needs of trainees and/or populations served, available resources, and to accommodate changes in educational and clinical practice. Whenever possible, such changes should be guided by validated criteria.

Comments/Rationale (Goodmurphy)

Accrediting bodies mandate that medical curricula be adequately and robustly assessed to ensure that curricular objectives are effective. Effectiveness is defined by evidence that the practices and processes outlined in the curriculum have produced anticipated results (LCME Standard 1 and 8.3).

Therefore, it is equally imperative to develop ultrasound associated objectives and reliable assessment tools that assess the skills, knowledge and values associated with effective and safe ultrasound practices.

This type of assessment is not new to medical education and can employ many well tested methods of assessment currently employed in other areas of medical education. Assessments should be appropriate to the objectives and adopted content delivery of an institutions specific curricular ultrasound objectives. They should take into account the principles of skills acquisition, repetition and reinforcement timings as shown in skill acquisition and mastery literature. (Citations from other education skills needed still) It should include some/all of the following to ensure a robust assessment of the adopted US curriculum proportional to resources, time and expertise; appendix 3.
Appendix

Appendix 1: Recommended Curriculum Inclusions, P1D4.1

1. Foundational basics of mechanics of sound waves.
2. Probe mechanical properties, strengths and limitations of various probes
3. Parts of the probe and cardinal probe movements
4. Appropriate understanding and use of sonographic terminology
5. Major parameters of spatial, temporal and grayscale resolution and their affect on image quality
6. Compare and contrast continuous and pulsed Ultrasound applications
7. Speed of sound in various bio-tissues and air
8. Phasing, steering and focusing of sound waves, near and far field
9. Compare and contrast major forms of attenuation, absorption, reflection, scatter
10. Discuss the through transmission and refraction of sound
11. Compare and contrast the Spectral, Power and Color Doppler
12. Appropriate use of B-mode and M-modes
13. ALARA principles and risks of ultrasound in terms of heat dissipation, cavitation
14. 10 most commonly seen artifacts (and all artifacts associated with curricular content)
15. Knobology effectiveness with institutionally available machines (gain, depth, TGC, On/off, focal position/number, Save, Freeze,
16. Ability to properly set up and enter patient data and label/save archive images appropriately for medical legal requirements and patient safety
17. Ability to properly care for, maintain and clean probes
18. Ability to recognize common forms of malfunctioning systems and damaged probes
19. Ability to measure 3 axis of an object as well as circumference
20. Recognize the sonotextures of basic tissues, tendon, muscle, nerve, fat, fluid, air, bone cartilage, ligament, organs
21. Ability to evaluate what needs adjusted/can be adjusted when an image is clinically substandard

Appendix 2: System ultrasound scanning examples, P1D4.2

1. **Cardiovascular system:** (Sonographic anatomy; anatomic and functional assessment of normal and abnormal valves, cardiac cycle (including correlates with ECG), normal and abnormal wall motion, PLAX, Subcostal, PSAX, Apical 4 chamber, qualitative and quantitative measures of cardiac output, Cardiac axis, Cardiac malformation, Aortic dissection, Pulmonary embolism, sonographic assessment of intravascular volume, pericardial effusion and cardiac tamponade; assessment of chamber enlargement and hypertrophy; peripheral IV and arterial line placement
2. **Respiratory system:** Rib counting and evaluation, normal lung sliding, sliding curtain sign, interstitial/lobar assessments, pathology of pneumothorax, hemothorax, intubation placement, M-mode, Thoracic cage anatomy
3. **Gastrointestinal system:** Liver, Gallbladder/biliary tract, portal system, IVC, Hepatorenal and splenorenal pouch, Free abdominal fluid, pancreas, spleen, kidney, aortic aneurism, Liver and spleen measurements, pathology of region, appendicitis; abdominal vasculature
4. **Endocrine system:** Thyroid, adrenal glands, Cervical anatomy
5. **Nervous system**: Peripheral nerves, ulnar, radial, median, sciatic, femoral, brachial plexus
6. **Reproductive system**: uterus, prostate, breast, ovaries, developmental defects, testicles, inguinal hernia, transvaginal scanning, fetal lie, BPD, femoral length, placental position, crown-rump length, gestational sac
7. **Musculoskeletal system/small parts**: Shoulder, Knee, Wrist, nerves, bones, tendon, ligaments, scrotal evaluation
8. **Genito-urinary system**: Bladder, Kidneys (including obstruction/stones), prostate
9. **Vascular system**: peripheral venous and arterial vasculature, central venous and arterial vasculature, DVT evaluation, vascular injury and anomaly evaluation
11. **Other**: eyes,

Appendix 3: Assessment components, P1D4.5

1. Knowledge based questions on machine operation, image idealization and physics of ultrasound.
2. Principles of safety and risk assessment
3. Ultrasound images and their sonographic descriptions
4. Reporting on sonographic anatomy or physiological properties as demonstrated by ultrasound images and clips
5. Interpretations of ultrasound studies as they would relate to the patient management or intervention
6. Interpretations of ultrasound image in conjunction with clinical presentations
7. Well formulated clinical scenarios integrating the foundational sciences knowledge, treatment plans or
8. Objectively Structures Clinical Exams (OSCE’s) expecting students to generate clinically relevant and appropriate images based on patient scenarios or presentatons
9. Spatial interpretation and rotations images assuring students understanding of probe handling and regional sonoanatomy of clinically relevant images.