Introduction

As ultrasound equipment has become smaller, more-affordable, and designed with simplified user interfaces, multiple non-traditional specialties have incorporated point-of-care ultrasound in their practice. Point-of-care ultrasound exams are simultaneously performed and interpreted by the clinician, usually within 3-5 minutes, to answer a specific clinical question. For example, does my patient have a history of cancer who is now hypotensive and shortness of breath have a pericardial effusion?

There is a growing body of research that demonstrates the value of point-of-care ultrasound for improving the quality of patient care and safety. The Agency for Healthcare Research and Quality has listed ultrasound-guided central venous access as 1 of 12 initiatives designed to decrease medical errors. Ultrasound-guided central venous access has been proven to reduce failure rate, risk of complications, and number of attempts particularly for less-experienced users $\frac{1}{2}$.

As a user dependent technology, early exposure to ultrasound in medical education will provide students with an enhanced opportunity to develop technical and interpretive skill regardless of their eventual specialty. Several medical schools (WSU, USC, OSU, UCI) have initiated undergraduate ultrasound curriculums over the past decade to prepare students for the evaluation of undifferentiated shock. The complexity of evaluating undifferentiated shock requires the integration of multiple point-of-care ultrasound exams. The rapid determination the etiology of shock is important to guide therapy of undifferentiated shock. The development of an integrated ultrasound curriculum will promote student with an enhanced learning experience that will further integrate clinical medicine into the preclinical years. This curriculum will promote patient safety and improve their understanding of the benefits of ultrasound as a diagnostic tool. Multidisciplinary leadership will be essential for widespread integration, especially in the third and fourth years.

Curriculum Objectives

- Introduce basic ultrasound physics, machine instrumention, and image acquisition and interpretation to enhance clinical skill development
- Integrate the evaluation of normal sono-anatomy and physiology of the endocrine, cardiovascular, pulmonary, musculoskeletal, gastrointestinal, and genitourinary systems during anatomy, physiology, and pathology-based learning courses
- Prepare students for the rapid assessment of undifferentiated shock and other life-threatening emergencies using ultrasound
- Assist MS3 students to gain experience with basic principles of ultrasound-guided procedures, including peripheral and central venous access, using high fidelity mannequins
- Assist clinical faculty from several medical specialties to develop two-week clinical ultrasound electives to improve patient quality and safety

Description of Curriculum

First Year (Integrated with Gross Anatomy and Physiology)

- History, ultrasound, physics, basic instrumentation, and screen orientation
- Basic Echocardiography - chamber and valve identification, orientation for subcostal and parasternal long axis views
- Ocular and Thyroid - identify normal sono-anatomy
- Musculoskeletal - image achilles tendon, knee effusion, distal radius and clavicle in long and short axes, recognize classic appearance of cellulitis vs. abscess vs. lymph node
- Introduction to Abdomen/Pelvic Ultrasound: Focused Assessment with Sonography in Trauma
- Introduction to vascular hemodynamics - discuss color and spectral doppler imaging, distinguish arterial vs. venous waveforms, measure peak systolic velocity
- Basic Echocardiography - apical 4 chamber and parasternal short axis views, review screen orientation, assess chamber size and contractility
- Basic Ultrasonography: Screen orientation, assess chamber size and contractility
- Basic Echocardiography: understanding indications and limitations for the evaluation for pneumothorax, pleural effusions, pulmonary edema, and consolidation
- Advanced Cardiac: assessment for pericardial effusion, pericardial tamponade, IVC volume assessment, recognition of classic examples of hypovolemic, cardiacogenic, and obstructive shock
- Aorta - measure transverse and longitudinal measurements of abdominal aorta proximal to distal bifurcation, review images of abdominal aortic aneurysm and dissection
- Lower Extremity Venous - review compression, augmentation, and pulse wave doppler techniques for the identification of proximal DVTs, discuss exam limitations
- Genitourinary - review normal renal sono-anatomy and perform bladder volume calculation
- After each lecture, standardized patient models will be used to assist students to acquire image acquisition skills while being mentored ultrasound faculty representing several medical specialties.

Second Year (Integrated into Problem-Based Learning)

- Physics Review - emphasis on imaging artifacts and limitations
- Pulmonary - understanding indications and limitations for the evaluation for pneumothorax, pleural effusions, pulmonary edema, and consolidation
- Advanced Cardiac assessment for pericardial effusion, pericardial tamponade, IVC volume assessment, recognition of classic examples of hypovolemic, cardiacogenic, and obstructive shock
- Aorta: measure transverse and longitudinal measurements of abdominal aorta proximal to distal bifurcation, review images of abdominal aortic aneurysm and dissection
- Lower Extremity Venous: review compression, augmentation, and pulse wave doppler techniques for the identification of proximal DVTs, discuss exam limitations
- Genitourinary: review normal renal sono-anatomy and perform bladder volume calculation

Third Year

- Students will be required to acquire designated ultrasound images during primary care rotations utilizing GE V-Scans. These exams will be representative of common problems encountered by these specialties. For example, perform an abdominal aorta screening exam while on family medicine, internal medicine, or cardiology rotations.

Fourth Year

- Physicians “champions” from a variety of specialties will be recruited to develop a two-week integrated ultrasound elective that is representative of point-of-care testing in their field

Discussion and Conclusions

The addition of an ultrasound curriculum at MSU-CHM will provide students with an enhanced learning experience that will further integrate clinical medicine into the preclinical years. This curriculum will promote patient safety and improve their understanding of the benefits of ultrasound as a diagnostic tool. Multidisciplinary leadership will be essential for widespread integration, especially in the third and fourth years.

Acknowledgments

- Ultrasound curriculum from the University of South Carolina, University of California-Irvine, Ohio State University, and Wayne State University medical schools were used as a model for this curriculum proposal
- Moore CL “Point of Care Ultrasonography” NEJM Feb 2011
- McGee DC “Preventing Complications of Central Venous Complications”. NEJM Mar 2003

Resources and Faculty

Each Lecture Lab Session

- 30-45 minute didactic lecture
- 5 minute hands-on demonstration by group instructor
- 6 stations (4-5 students per instructor / 30 minute period
- Total of 4 groups of 25 changing every 35 minutes
- Cleanup 10-15 minutes
- Total lecture / lab length= 3-3.5 hours

Equipment (All CHM Sites) - 5+ year lifespan

- 12 Ultrasound Systems with 3 Transducers= $700,000
- 100 GE V-Scans (3+4= Year Rotation)= $700,000
- 2 CAE Vimedix Simulators= $200,000
- 12 Central/24 Peripheral Line Mannequins= $100,000
- 12 Thoracocentesis & Paracentesis Models= $100,000
- Total Equipment Costs-$1,800,000

Faculty and Personnel (All CHM Sites)

- 2 x 0.25 FTE Physician Director= $80,000/year
- 2 x 0.50 FTE Ultrasound Technician Coordinators = $70,000/year
- 50 x Clinical Faculty Ultrasound Champion Training Scholarship= $50,000, ($1,000/each)
- 24 labs x 12 instructors x 3.5 hours/lab x $60/hour= $60,000
- Paid Models= $50/hour with pathology (AAA, CHE, Asacits) and $25/hour without pathology= $16,000
- MS, Outstanding Preceptor Stipend (>10 students/year)= $20,000
- Total Personnel and Faculty Cost-$300,000