Editorial

Point of care ultrasound: the next evolution of medical education

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Medical ultrasound was initially developed and implemented in the 1940s and has since held a traditional role in fields such as radiology, obstetrics, and cardiology. With the rise of technology and the increased accessibility and speed of imaging modalities, it is not surprising that point-of-care ultrasound (POCUS) has now increased in popularity. From trauma surveys for hemorrhage to assessment of volume status and delineation of shock etiology, POCUS is proving to be a useful tool that bridges the gap between the physical exam and more advanced imaging such as CT or MRI. POCUS is yet another by-product of the continual push for efficiency of diagnosis in modern hospitals. Point of care testing in general has been shown to minimize the delay between onset of symptoms and initiation of definitive therapy, ultimately decreasing morbidity and mortality in critically ill patients and achieving better patient outcomes (1).

In this issue of *Annals of Translation Medicine*, Lan and colleagues report on the use of echocardiography in septic shock (2). Echocardiography has been used to assist in the differentiation of various shock states, including left ventricular dysfunction and valvular heart disease, in addition to providing information on volume status. This retrospective study of the MIMIC III database from 2001 to 2009 examines multiple different clinical outcomes associated with the use of echocardiography, or lack thereof. Ultimately, a 4% increase in mortality rate was found in patients with septic shock who did not undergo echocardiography compared to those who did. The study showed no significant differences in days of ventilation, amount of epinephrine administered, or multiple other endpoints. While the retrospective nature of the study makes it impossible to know the clinical interventions performed in response to data gathered from echocardiography, this data still supports the hypothesis that accurate assessment of volume status is an integral part of correct clinical decision making and improvement of outcomes. Although this study concentrates on echocardiography, the implications on the broader use of portable ultrasound in assessing patients with septic shock is apparent.

In today's world, POCUS is used routinely and recommended in many different fields of medicine, including the emergency department and the intensive care unit. For example, for any bedside pleural procedure, the National Patient Safety Association now requires that ultrasound be used, due to robust evidence showing a decrease in iatrogenic pneumothorax with its use (3). POCUS can also help elucidate causes of respiratory failure more effectively than chest X-ray alone (4). Its speed and accessibility make it inherently useful in the emergency department, and studies have shown that its implementation can help to narrow diagnosis more rapidly and decrease unnecessary consults in the ED (5). In the setting of trauma, POCUS takes the shape of the Focused Assessment with Sonography in Trauma (FAST) exam to quickly evaluate a patient for common trauma pathologies. Literature supports that the FAST exam has outstripped the traditional peritoneal lavage in the evaluation of a traumatic

abdomen (6). Continually new research is being published evaluating the role of different approaches to POCUS (5,6). Although little doubt remains as to the versatility, flexibility, accessibility, and potential of POCUS, its limitations and protocols are still being developed.

Perhaps one of the most promising applications of this modality is in the assessment of volume status. In unstable patients, nearly half of all administered fluid boluses fail to improve cardiac output, and the addition of unnecessary fluids may worsen clinical outcomes (7,8). While clinical judgment, physical examination, and measurements such as blood pressure and heart rate are all important pieces of the picture in the shock patient, none of this information has been proven to reliably predict response to resuscitation with fluids (9). More invasive measurements such as central venous pressure monitoring, pulmonary artery catheter use, or Pulse Contour Cardiac Output have also have not consistently predicted fluid resuscitation effectiveness. For these reasons, the application of POCUS to assess intravascular volume via compressibility of the inferior vena cava (IVC) is an attractive, safe, low-risk, and easy-to-perform solution (2). Evidence supports that the IVC diameter is consistently low in hypovolemia as compared to euvolemia; additionally, IVC change can estimate fluid responsiveness with sensitivity of 0.78 and specificity of 0.86 (10,11). Fluid assessment via ultrasound is less expensive, is minimally invasive, and creates real-time data.

One of the most intriguing benefits of volume status measurement via ultrasound is its ability to differentiate between different kinds of shock (1). Patients with cardiogenic or obstructive shock should demonstrate non-collapsible IVCs; patients who are in hypovolemic or distributive shock ought to have compressible IVCs. Literature supports POCUS assessment of the IVC in septic ventilated patients revealing the association between distensibility of the IVC and volume responsiveness (12). This simple differentiation is the most important determinant of treatment approach in the shock patient, and as such, makes ultrasound a nearly indispensable tool in the acute care setting when urgent intervention is optimal.

As POCUS continues to grow in its accessibility, the challenge that currently exists is not whether POCUS is useful, but rather how to best train clinicians in this field. The Liaison Committee on Medical Education (LCME) does not currently include any mandatory ultrasound training during the four years of medical education in US medical schools. The time to introduce POCUS into medical school curricula is now. A shift has occurred in education where technology and digital aids have revolutionized the way in which students learn. Students and teaching faculty have become increasingly comfortable with computerized flashcard algorithms, informative videos, digital textbooks and online lectures. POCUS holds enormous potential to expand this digital horizon and increase the knowledge base of future physicians. Indeed, 62% of US medical schools report some level of ultrasound training in their programs (13). A majority of the students involved in these programs report favorable opinions regarding the implementation of this curriculum. Most of the programs currently employ ultrasound education that is concurrent with the anatomy lab. Nearly 90% of these students agreed that learning the anatomy in this manner gave them increased confidence in physical exam skills (13). Learning to ultrasound correctly can be challenging, and while curricula exist, they are only now being implemented in a meaningful, widespread way (14). Like any new disruptive tool in healthcare, there exists some skepticism regarding its potential and some educators may not deem the skill worth learning (3). Also, while POCUS is promising for many reasons, the information it provides is entirely user dependent. An obvious shortcoming of this modality is that the provider performing the imaging procedure is entirely responsible for the quality of the imaging data and interpretation. For example, a 2011 study showed that amongst credentialed ED providers there was a dramatic difference in assessment of patients' aortas in searching for evidence of abdominal aortic aneurysm (15). However, the study did note that the most ultrasound-experienced providers all performed markedly better than the newer providers, suggesting that competency is often due to little more than practice and experience.

Current medical curricula surrounding the acquisition of ultrasound skills remain piecemeal and lack standardization. Many institutions run small pilot programs which center on the cadaver lab as the touchpoint for ultrasound education (16). Students dissect anatomy on cadavers, and in the same sitting, ultrasound one another in the same region. This paradigm holds value in that it promotes the interweaving of multiple learning styles and allows the student to acquire knowledge in more than just one manner. Touching a structure and then immediately practicing the visualization of that structure via ultrasound allows a triangulation of theory, anatomy, and imaging which is often difficult for learning doctors.

The incorporation of POCUS curricula into the didactic portion of medical school may assist with difficulties in

balancing the bookwork and lecture requirements with the student's desire to develop bedside assessment skills. Traditionally, the first 2 years of US medical school are widely perceived to be very difficult, due to the amount of course work and the acquisition of an immense quantity of knowledge. Given that the goal of the first 2 years is mastery of the foundations of medicine with a considerable amount of time spent reading textbooks and attending lectures, it is often difficult to truly understand what one's future career might entail. With the recent announcement of a planned change to make US Medical Licensing Exam (USMLE) Step 1 pass/fail, there exists some optimism that this can open up the possibility to adapt the early years of medical education. Introducing a real-world medical skill, such as POCUS, during this time can accommodate learning objectives and provide practical applications of the vast quantity of knowledge acquired during the didactic years. Teaching POCUS also represents an opportunity for students to interact on a one-on-one basis with faculty and active clinicians, restoring traditional interpersonal education to medical school.

Implementation of POCUS in medical education has been limited by time, space, finances, and most importantly, faculty who are adequately trained enough to teach learners (13). However, at most academic institutions, nearly all emergency and internal medicine residents are expected to be comfortable with ultrasound. At the University of Utah, student desire to learn POCUS was so strong that an Ultrasound Interest Group was started. This group meets with residents and faculty who volunteer their time to create hands-on learning opportunities. Though lack of official funding and trained personnel often limit the scope and consistency of this training, students who have participated state that they feel empowered approaching residency with even this small amount of education. The team-based approach to teaching ultrasound with the help of enthusiastic faculty volunteers and older peers is the kind of collaborative teaching environment that our profession has employed for centuries.

The use of POCUS will continue to grow with time and implementation of educational protocols within medical schools. There remains little doubt that this skill will be implemented in medical school curricula. The urgency of providing POCUS education is clear, with a strong and growing body of literature to support its use in a wide range of clinical settings. In this issue of *Annals of Translation Medicine*, Lan and colleagues demonstrated a significant mortality improvement with the use of this readily available bedside tool for evaluation of volume status in septic shock patients to help guide clinical decision making. This is yet another example of improved patient outcomes using POCUS, which continues to build a strong case for implementation of this bedside tool. Inevitable development of less expensive machinery and propagation of faculty members with ultrasound backgrounds will increase the impact of POCUS education in the coming years. In order to achieve a more expansive use of POCUS and competency, implementation of formal training and educational programs need to become integral parts of medical education curricula.

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Footnote

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