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OBSERVATION

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Update on point of care ultrasound in the care of the critically ill patient

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Abstract

One of the most exciting developments to come to the aid of the critically ill patient in recent years is not new at all, but rather has been repackaged and evolved to a level where point-of-care use by critical care physicians has been made possible. Critical care or point-of-care ultrasound dates back more than twenty years, but has come to prominence in the last 5 years and is spreading quickly. Multiple critical care societies have taken up ultrasound policy and training and one organization has been formed that concentrates only on point-of-care ultrasound in critical settings and interventions. The amount of literature generated on the topic is increasing rapidly and hardly a major clinical journal exists that has not published ultrasound related topics.

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INTRODUCTION

Ultrasound has been spreading persistently in clinical medicine for more than two decades. However, it was not until the last 5 to 7 years that we have seen a true explosion in point-of-care ultrasound use in the care of critically ill patients. The term point-of-care ultrasound accurately describes the great utility of the powerful imaging modality when it falls into the hands of the clinician providing the actual medial care to the patient rather than going through an intermediary, the imaging consultant. There is good reason for this great spread and a booming popularity among clinicians of a variety of specialties. Once seen as having utility in cardiac anatomy evaluation and the occasional gallbladder infection that crept up in the intensive care unit (ICU), point-of-care ultrasound now touches virtually every disease process seen in the critically ill patient. Vascular access under ultrasound guidance is the standard of care in many settings and complications encountered obtaining vascular access without ultrasound use are hard to justify[1-3]. Other procedures are more frequently performed under ultrasound guidance as new applications continue to be developed[4]. There are several critical ultrasound topics that stand out among others in their utility, popularity and potential impact on patient care.

LUNG ULTRASOUND

Perhaps second to no other single issue, pulmonary pathology in the critically ill patient can both affect multiple other organ systems as well as be effected by other organ systems. Similarly, unlike any other single point-of-care ultrasound application in the critical care setting, lung

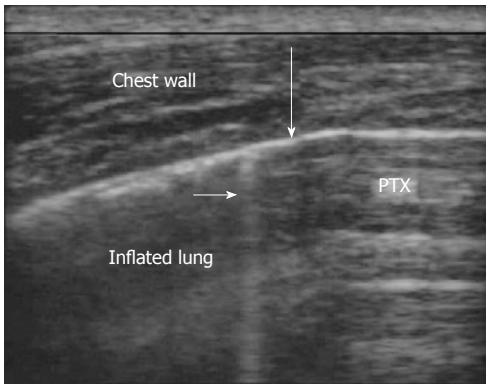

Figure 1 An ultrasound depiction of a pneumothorax is shown. This is the lung point. To the right of the image air blocks visualization of typical lung artifacts. On the left, the visceral and parietal pleura are sliding past each other. The large arrow shows where they meet. The small arrow shows a B line, seen only in inflated portions of the lung.

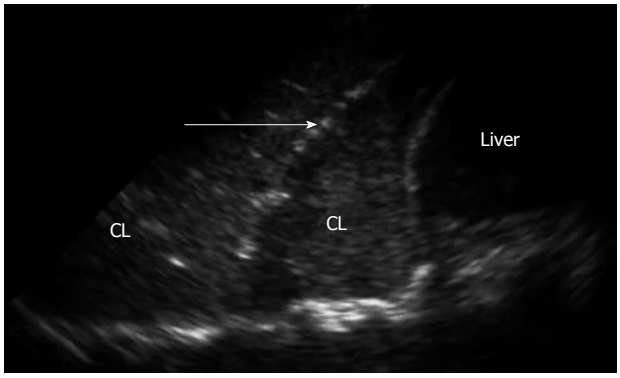

Figure 2 Pneumonia is seen just above the liver and diaphragm. An air bronchogram is also seen (arrow). Air can actually be seen moving through the bronchus within the consolidated, infected lung in real time. CL: Consolidated lung.

ultrasound has gained rapid popularity after finally being accepted in a variety of clinical situations. Its use was initially popularized in the detection and ruling out of a pneumothorax in the traumatized patient (Figure 1)[5-7]. However, there was much more to lung ultrasound than the simple, yet effective, addition to the standard Focused Assessment with Sonography in Trauma examination. While ruling out a pneumothorax, a common and potentially deadly complication in the critically ill patient, researchers recognized many additional features of the lung under ultrasound interrogation[8]. It was noted by some groups that ultrasound was also useful for the detection of pulmonary edema, pneumonia and even pulmonary embolism (Figure 2)[9-11]. This expanded list of pathology that can be evaluated by ultrasound has been well studied in multiple clinical settings. Interestingly, as a single modality it can be used as an initial, and often definitive, approach to the dyspneic or hypoxic patient. Such patients are a common and significant challenge in many critical care settings. In fact, many practitioners who are facile with the technology noted that chest X-ray use dropped dramatically and ultrasound even competed with computed tomography in cases of abscess and fluid collections.

Not just in the research stages, lung ultrasound has been described as part of protocols with great utility in the intensive care arena, regardless of where that is[12,13]. In fact, a consensus conference was recently completed on ultrasound applications using a rigorous evidence based medicine model and will be published in 2012[14]. The panel of over 30 internationally recognized experts from a variety of clinical specialties and nearly a dozen countries produced a comprehensive evidence based assessment of lung ultrasound and created direction for future researcher and education. The mere fact that a lung ultrasound consensus conference was held and supported by so many societies and international experts underlines the importance of this unique application. An application created entirely by clinicians and not borrowed from traditional imaging providers such as the consultant based service of radiology.

CARDIAC ULTRASOUND

Cardiac ultrasound in the critically patient has come a long way from simply looking for possible pericardial effusion in the arresting patient or penetrating chest trauma. Point-of-care ultrasound protocols now specifically focus on cardiac ultrasound to evaluate ejection fractions, cardiac output and patient volume status[15-17]. The dynamic nature of the techniques and ability to repeat an examination rapidly, as needed without additional radiation or waiting on an imaging specialist to perform the examination and interpret it, allows the individual intensivist to monitor patient progress and effects of therapeutic interventions[18]. Even something as simple as pulse detection in a pulseless patient has been redefined as cardiac ultrasound will frequently show cardiac activity and not cardiac standstill in patients that appeared to be in full arrest[19]. Transesophageal echocardiography, once seen exclusively in cardiology labs has been used extensively by anesthesiology in cardiac surgery and has also shown promise in critical ill patients outside of the operating room[20-22]. Since many critically ill patients are intubated, airway management is not an issue, and Transesophageal Echocardiography (TEE) has a number of distinct advantages over Transthoracic Echocardiography (TTE). The images obtained are highly superior to transthoracic echocardiography and acute measurements can be made in patients that are covered by bandages, edematous, suffer from burns or have severe lung disease that interferes with TTE examinations. TEE imaging does not interfere with resuscitation efforts and a patient can even be shocked for ventricular fibrillation with the probe left in place[22]. Pulse check or rather echo checks with TEE are nearly instantaneous and do not interfere with cardiopulmonary resuscitation efforts in any way (Figure 3).

If mechanical contractility without palpable pulse is identified, especially if the ejection fraction is assessed to be life sustaining, the management can then focus on hypotension rather than asystolic type resuscitation pathways. In fact, when point-of-care ultrasound has one of

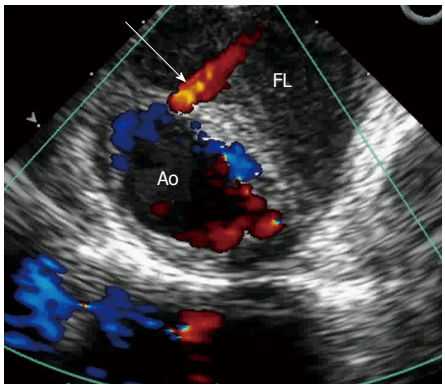

Figure 3 A jet of blood (arrow) is seen dissecting from the true lumen into the false lumen in this patient with a thoracic aortic dissection. Ao: Aorta; FL: False lumen.

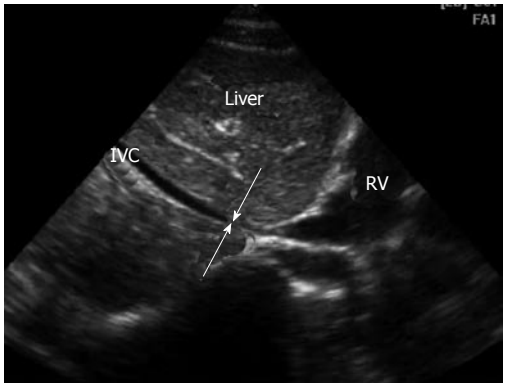

Figure 4 Inferior vena cava flat in this hypotensive and volume depleted patient. Arrows show the barely open inferior vena cava suggesting need to considerable fluid resuscitation to correct hypotension. RV: Right ventricle of the heart; IVC: Inferior vena cava.

its greatest advantages is when different applications are combined into a survey to answer specific questions such as cause of undifferentiated hypotension in a particular patient (Figure 4)[23-25]. The causes behind hypotension can range from blood loss, to pneumothorax or cardiogenic shock. Several hypotension protocols have been described and evaluated. Such protocols allow physicians to narrow their differential diagnosis more and do so more rapidly than without point-of-care ultrasound use.

As invasive monitoring is called more and more into question, pulmonary wedge pressures are being replaced by ultrasound evaluations that can rapidly tell the clinician the patients volume status and their response to diuresis, volume resuscitation or addition of various pressors. Simple assessment of the inferior vena cava and cardiac chambers can give the intensivist tremendous information on how to proceed with patient resuscitation and what interventions may work while others may actually hinder progress. It is likely that in the future these ultrasound assessments will become more automated such as creation of automatic ejection fraction and cardiac output calculations that allow clinicians of lower ultrasound skill levels to still obtain critical non-invasive data.

PROCEDURAL GUIDANCE

More and more procedures on critically ill patients are being performed under ultrasound guidance. Ultrasound guidance for vascular access has now been accepted as the standard of care and several consensus conferences on the topic are in the process of being published[26]. However, ultrasound guidance for critical care procedures goes far beyond ultrasound guidance for vascular access. Traditional blind procedures such as paracentesis and thoracentesis are performed by intensivists under ultrasound guidance at the patients bedside[27,28]. In addition new applications that were typically not done under ultrasound until critical care physicians explored these new applications along with other colleagues. Ultrasound guided crycothyrotomy and tracheostomy can keep the patient in the ICU and decrease complications[29]. When pain is an issue such as for extremity injury or even post surgical abdominal wall pain, regional nerve blocks under ultrasound guidance are more likely to be effected and have proven to be easy for non-traditional users to learn.

TRAINING AND PRIVILEGING

The standards for training of critical care physicians in point-of-care ultrasound is still a work in progress. Society recommendations should be followed when ever possible. Training is complicated by the presence of two potential pathways. Fellowship training as well as post graduate training of critical care physicians already in practice. Both pathways are in the process of ramping up and fellowships are incorporating ultrasound training at the same time that multiple courses are poping up around the world to train physicians in practice how to perform critical care ultrasound. Privileging or credentialing varies from region to region. North American models often involve hospital based privileging, where a physician is credentialed to perform ultrasound based on specialty society standards. In other parts of the world a certificate is necessary from a national or international body. These may be obtained after course completion but should also involve proctoring or mentoring and verification of ultrasound skills as well as the clinicians ability to incorporate ultrasound into their clinical decision making.

CONCLUSION

Few disease processes have not been touched by critical care or point-of-care ultrasound. In fact, a time may be coming when much of the evaluation of a critically ill patient is performed not which a stethoscope and physical examination but rather point-of-care ultrasound following a set of symptom based scanning protocols. These will improve assessment accuracy, decrease costs and most likely save lives.

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