CHEST

A Whole-Body Approach to Point of Care Ultrasound

Mangala Narasimhan, DO, FCCP; Seth J. Koenig, MD, FCCP; and Paul H. Mayo, MD, FCCP

VIDEO

Ultrasonography is an essential imaging modality in the ICU used to diagnose and guide the treatment of cardiopulmonary failure. Critical care ultrasonography requires that all image acquisition, image interpretation, and clinical applications of ultrasonography are personally performed by the critical care clinician at the point of care and that the information obtained is combined with the history, physical, and laboratory information. Point-of-care ultrasonography is often compartmentalized such that the clinician will focus on one body system while performing the critical care ultrasonography examination. We suggest a change from this compartmentalized approach to a systematic whole-body ultrasonography approach. The standard whole-body ultrasonography examination includes thoracic, cardiac, limited abdominal, and an evaluation for DVT. Other elements of ultrasonography are used when clinically indicated. Each of these elements is reviewed in this article and are accompanied by a link to pertinent cases from the Ultrasound Corner section of *CHEST.*

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Ultrasonography is an essential imaging modality in critical care to diagnose and guide the treatment of shock, respiratory failure, and multiorgan failure. Competence in critical care ultrasonography (CCUS) has been defined in the American College of Chest Physicians/La Société de Réanimation de Langue Française Statement on Competence in Critical Care Ultrasonography, which is the foundation document of the Statement on Training in Critical Ultrasonography.[1,2] The latter statement is the product of a cooperative effort by 22 international societies of critical care. By definition, CCUS requires that all image acquisition, image interpretation, and clinical application of ultrasonography is personally performed by the critical care clinician at the point of care. This allows for immediate integration of ultrasonography results with the history, physical examination, and laboratory results, yielding a powerful clinical synergy. This is different than traditional ultrasonography as performed by the consultant radiology or cardiology services, where there is a predictable delay in performance, interpretation, and transfer of information to the ICU team. In addition, the consultant is disassociated from the case (ie, they are not fully aware of the reality of the front-line ICU situation). The role of the point of care ultrasonographer is not to replace expert level consultation by radiology or cardiology services, but to recognize the need for these services when the critical care team determines that consultative service is required.

AFFILIATIONS: From the Division of Pulmonary and Critical Care Medicine, Hofstra-Northwell School of Medicine, Hempstead, NY.

CORRESPONDENCE TO: Mangala Narasimhan, DO, FCCP, 410 Lakeville Rd, Ste 107, New Hyde Park, NY 11040; e-mail: mnarasimhan@northwell.edu

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Point-of-care ultrasonography is often compartmentalized such that the intensivist will focus on one body system while performing the CCUS examination. We suggest a change from this compartmentalized approach to a systematic whole-body ultrasonography (WBU) approach. This is not a new concept. In 1993, Lichtenstein and Axler described a whole-body approach and how it had direct impact on the diagnosis and therapeutic plan of their ICU patients.[3] Volpicelli et al[4] described the utility of multiorgan ultrasonography for undifferentiated hypotension in the ED for accurate initial diagnosis and guidance of management. Laursen et al[5] used a point-of-care multiorgan approach to guide management of patients with respiratory symptoms and compared this with standard of care to see which approach led to a more accurate diagnosis. They found that the combination of cardiac, thoracic, and diagnostic vascular ultrasonography led to accurate diagnosis in their patients. In addition, we know that using this WBU approach leads to a decrease in overall utilization of other testing and therefore a decrease in cost.[6] We do not recommend any particular order for the examination because this may be driven by the clinical presentation. For example, if the patient presents with acute respiratory failure, there is logic to starting with the lungs. Conversely, with shock presentation, the cardiac examination may be first.

The authors have been course coleaders at the national level *CHEST* CCUS programs for past 11 years. The thousands of learners who have attended these courses often pose a similar set of questions: how, where, and when to incorporate the WBU approach into daily front-line practice of critical medicine; and who should perform the ultrasonography study? To help illustrate this paradigm shift to a WBU approach, real cases from *CHEST*'s Ultrasound Corner, an online section of *CHEST* featuring point-of-care ultrasound in the diagnosis and management of critically ill patients, are available to the reader to view by clicking on the links within each section.

How to Perform the WBU Examination

The standard WBU examination includes thoracic, cardiac, limited abdominal, and an evaluation for DVT. Other elements of ultrasonography are used when clinically indicated.

The Thoracic Examination (Lung and Pleural)

Lung ultrasonography (LUS) is performed with the low-frequency (3.5-5.0 MHz) phased-array cardiac probe in longitudinal scanning plane that is orientated perpendicular to the skin surface and adjusted to image through the rib interspaces. The optimal control settings for LUS vary according to different machine designs. The high-frequency (7.5-10.0 MHz) linear vascular probe is used for detailed analysis of pleural surface morphology, but is not used to examine deeper structures in the thorax because of its limited depth penetration. There are several scanning protocols of varying complexity that have been described for LUS. The simplest is that proposed by Dr Daniel Lichtenstein that examines three defined points on each hemithorax.[7] A pragmatic approach is to perform a series of scan lines over the thorax to identify the various finding of LUS. LUS is superior to chest radiography and similar to chest CT for detection of normal aerated lung, pneumothorax, alveolar consolidation, alveolar interstitial disease, and pleural effusion.[8] Use of WBU reduces the utilization of chest radiography and chest CT in the medical ICU as described by Oks et al.[6]

To see cases that illustrate the thoracic examination (lung and pleural) (Videos 1 and 2), the reader is encouraged to view the videos in these Ultrasound Corner articles:

Laursen CB, Frederiksen B, Posth S. A 69-year-old man with dyspnea following lung biopsy. *Chest.* 2015; 148(5):e139-e141. http://dx.doi.org/10.1378/chest.14-3152.[9]

Sarkar PK, Koenig SJ, Mayo PH. 47-year-old man with dyspnea and hypotension. *Chest.* 2013;143(4):e1-e3. http://dx.doi.org/10.1378/chest.13-0335.[10]

The Cardiac Examination

The basic critical care echocardiography (CCE) examination consists of five standard views: parasternal long-axis, parasternal short-axis, apical four-chamber, subcostal long-axis, and inferior vena cava long-axis views. Skill at basic CCE allows the intensivist to identify imminently life-threatening causes of hemodynamic failure, to categorize shock state to guide diagnosis and therapy, to identify coexisting diagnosis that complicate management, and to follow the evolution and response to treatment of the shock state. Several studies have reported on the utility of basic CCE for the assessment of hemodynamic failure and on the added advantage to combining basic CCE with LUS.[11,12] A key aspect of competence in basic CCE is that the intensivist knows the limitations of the technique and when to ask for advanced level echocardiography study, which includes many more views and Doppler analysis of flows and pressures.

Advanced CCE is well-established in many ICUs in Europe. The European Society of Critical Care Medicine has a well-defined set of training requirements and has developed a formal certification for advanced CCE.[13] Several North American intensivists are competent in advanced CCE, and this number is likely to increase. Basic CCE is a key skill for all intensivists. Advanced level competence is needed by only a proportion of critical care clinicians depending on practice needs.

To see cases that illustrate the cardiac examination (Videos 3 and 4), the reader is encouraged to view the videos in these Ultrasound Corner articles:

Lakticova V, Koenig S. Not all wheezing is from COPD. *Chest.* 2013;143(5):e1-e3. http://dx.doi.org/10.1378/chest.13-0107.[14]

Narula T, Raman D, Wiesen J, Choudhary C, Reddy AJ, Moghekar A. A patient with acute COPD exacerbation and shock. *Chest.* 2013;144(6):e1-e3. http://dx.doi.org/10.1378/chest.13-1412.[15]

The Limited Abdominal Examination

The competence statement specifies that full competence in all aspects of abdominal ultrasonography is not required of the intensivist. Rather, the emphasis is evaluation the urinary tract, identification of aortic pathology, and characterization of intraabdominal fluid. A working knowledge of the anatomy of these organ systems is also required, so that the intensivist can recognize abnormalities that require expert level scanning. Ultrasonography is a key component for the assessment of acute kidney injury in the ICU because it allows for the rapid evaluation of obstructive uropathy and other relevant renal pathology. Identification of intraabdominal fluid is a key component in management of trauma and for the identification and characterization of medical ascites, including procedural guidance. Identification of abdominal aortic pathology such as rupture or dissection is an important aspect of the evaluation of unexplained shock state.

To see cases that illustrate the limited abdominal examination (Videos 5-8), the reader is encouraged to view the videos in these Ultrasound Corner articles:

Patel P, Narasimhan M, Koenig S. An 87-year-old woman with diabetes, hypertension, and liver cirrhosis in respiratory distress. *Chest.* 2013;143(6):e1-e4. http://dx.doi.org/10.1378/chest.13-0824.[16]

Jones RA, Tabbut M, Shaman Z, Gramer D. RVT patient with cirrhosis and presumed spontaneous bacterial peritonitis. *Chest.* 2014;146(1):e11-e13. http://dx.doi.org/10.1378/chest.13-2997.[17]

Blanco P. A 43-Year-old man presenting with severe chest pain. *Chest.* 2015;148(3):e76-e79. http://dx.doi.org/10.1378/chest.14-2623.[18]

Tofts R, Kory P, Acquah S. A 72-year-old man presenting with melena and multiple falls becomes acutely decompensated. *Chest.* 2014;146(4):e130-e133. http://dx.doi.org/10.1378/chest.13-1822.[19]

The Vascular Examination for DVT

Intensivists can perform DVT studies with similar accuracy as the consultative radiology service.[20] Given the common delay in obtaining the ultrasonography study through the consultative pathway, the intensivist performs the examination and has immediate information that is relevant to the management of the patient if pulmonary embolism is a concern. The examination is performed at the point of care in a few minutes. The standard 5-point examination requires identification and compression of the femoral vein (common and superficial) and popliteal vein at defined anatomic levels. The presence of visible thrombus or lack of full compressibility of the vein is diagnostic of DVT.

To see cases that illustrate the vascular examination for deep venous thrombosis (Video 9), the reader is encouraged to view the videos in these Ultrasound Corner articles:

Koenig SJ, Narasimhan M, Mayo PH. Shock: a case of mistaken identity. *Chest.* 2013;143(1):e1-e3. http://dx.doi.org/10.1378/chest.12-2878.[21]

The Guidance of Procedures

The WBU approach includes, by implication, the guidance of critical care procedures with ultrasonography. Ultrasonography is productively integrated into central venous access (all sites), difficult peripheral venous access, arterial access, thoracentesis, paracentesis, percutaneous tracheostomy, and some aspects of airway management to improve the safety and success rate of these common procedures.

To see cases that illustrate the guidance of procedures (Videos 10 and 11), the reader is encouraged to view the videos in these Ultrasound Corner articles:

Cardenas-Garcia JL, Singh AK, Koenig SJ. A 75-year-old woman with fever and a right upper lobe pulmonary

mass. *Chest.* 2015;147(1):e1-e4. http://dx.doi.org/10.1378/chest.14-1161.[22]

Greenstein YY, Khanijo S, Narasimhan M, Koenig S. A man in his 60s with circulatory collapse. *Chest.* 2016;149(1):e11-e16. http://dx.doi.org/10.1016/j.chest.2015.11.007.[23]

When to Perform the WBU Examination?

The WBU examination is performed immediately in all patients who present with cardiopulmonary failure. It is always performed in conjunction with the history, physical examination, and initial laboratory evaluation, and never in an isolated fashion. Following the initial examination, WBU is performed repeatedly in a goal-directed fashion whenever indicated during the course of the critical illness.

Who and Where to Perform the WBU Examination?

The availability of high-quality portable ultrasonography machines allows the critical care clinician to use the WBU approach throughout the hospital: the ICU, the ED, and on rapid response team assignment. Prehospital uses of aspects of CCUS have been described.[24]

With proper training, critical care clinicians can become competent with all aspects of WBU. This includes intensivists, fellows, hospitalists, residents, and advanced care practitioners (ACPs; nurse practitioners and physician assistants). The key requirement is an effective training program that includes the following features: review of the cognitive base of CCUS, training in image interpretation including a large number of normal and abnormal studies, and training in image acquisition initially on normal human models followed by patient-based scanning under the supervision of a capable mentor. *CHEST* offers a number of high-quality courses on CCUS that provide a strong base of initial training; however, full competence in CCUS requires follow-through training at the bedside and an autodidactic approach. The practical aspects of the use of WBU will differ according to practice environments.

1. University-affiliated critical care divisions with fellowship and residency training programs:

In this practice environment, we can describe our approach as an example of the integration of CCUS into unit function. In our 31-bed medical ICU practice with a full resident/fellow training program and responsibility for critical care outreach, we have six fully capable ultrasonography machines and two transesophageal echo probes. An ultrasonography machine is with the rounding team at all times on morning rounds with one house staff or fellow ultrasonographer assigned to perform the indicated CCUS examination in real time while the team is rounding at the bedside. The results of the CCUS examination are integrated into the management plan while the group is on bedside rounds. Throughout the rest of the day, the machines are used on an ongoing basis for procedures and for guidance of ongoing management of patients in the ICU. In addition, any patient that is considered for admission to the ICU is evaluated using the WBU approach.

2. Community hospitals without fellow/resident training responsibility:

Although this is not our practice environment, we have colleagues in front-line practice as the primary providers of critical care services. Their practice is that the machine is immediately available for use whenever indicated. Some of our colleagues have acquired high-quality new-generation devices that can fit into a laboratory coat pocket. This approach allows the machine to be with them at all times with full, immediate integration into the management plan for all patients.

3. Units where the primary responsibility for patient care is with ACPs:

Because intensivist-level staffing is under challenge related to the shortage of intensivists to provide high-level coverage in smaller units, highly skilled ACPs have assumed major responsibility in critical care units. An increasing number of ACPs have been attending *CHEST* CCUS courses and, in our system, we have developed a training program that has afforded definitive competence for ACPs that are frontline in critical care units.

4. Application for electronic ICU (eICU) outreach:

An interesting application relates to the potential use of WBU through remote connection with eICU. From a technical point of view, high-quality transmission of the ultrasound image is possible by focusing the eICU camera on to the ultrasonography machine at the bedside.[25] The alternative is direct transmission of the digitized image. For eICU connectively to be used successfully, there must be a clinician who is skilled at image acquisition at the point of care and eICU personnel skilled at image interpretation. This remains an undeveloped application of eICU medicine.

Summary

We submit that an organized point-of-care WBU approach with a history, physical examination, and

review of laboratory values are key elements to diagnose and direct management of the critically ill. Physicians and ACPs in many practice environments may usefully integrate this approach into their daily practice. Important practical aspects of CCUS including billing, report design, and image storage are topics that will described in a separate article.

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Additional information: The Videos can be found in the Multimedia section of the online article.

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