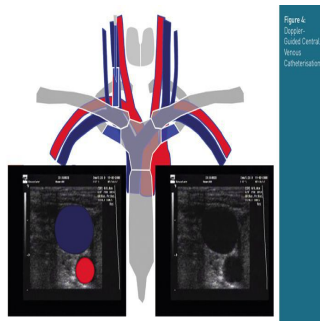


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Ultrasonography in Critical Care Medicine: The WAMS Approach



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Ultrasonography with a head-to-toe approach has become a comprehensive tool in evaluating critically ill patients from the bedside. In this article, authors propose an innovative approach to critical care ultrasonography, which is simple, fast and transferrable to different anatomical sites.

Introduction

In the past decade many authors have emphasised the role of ultrasonography in daily patient assessment (Beaulieu and Marik, 2005a;b), even proposing to replace, rather than accompany, the traditional stethoscope. A particular role for ultrasonography is emerging in the management of emergency room (Gunst et al. 2008) and ICU patients (Kendall et al. 2004), where its advantages are well known, including, but not limited to, the absence of radiation exposure, and cost-effectiveness (Kendall et al. 2007). For the critical care patient, instead of concentrating on a specific anatomical district, ultrasonography seems to evolve in the direction of a totalbody approach (Karabinis et al. 2010).

Critical Care Ultrasonography (CCU) is emerging as a multidisciplinary technique, where morpho-functional information, obtained with imaging in different anatomical districts, is integrated with clinical data in real-time by the intensivist (Bouhemad et al. 2007). Beyond already mentioned advantages, CCU permits 24-hour bedside availability and repeatability (Harding et al. 2011), rapid information accumulation on all anatomical districts, possibility to provide assistance to invasive manoeuvres (Hind et al. 2003; Sustic et al. 2000) and titration of mechanical ventilation (Luecke et al. 2012).

Why is CCU Different?

In the ICU or emergency department, where CCU is performed, the irregularity of the setting clearly discloses major differences in both patient approach and physician observation compared with those in traditional ultrasonography, performed by the radiologist.

The physical approach to the patient is somewhat unstructured: the physician may prefer not to follow an anatomical order, giving priority to ruling out potentially lifethreatening conditions (Nagdev and Stone, 2011), assessing the function of vital organs (Jambrik et al. 2004), or looking

for early signs of organ failure (Corradi et al. 2011). This subversion from the classical head-to-toe physical exam recalls that of Advanced Life Support, where priority is given to the identification of clinical situations that might precipitate a patient's conditions.

CCU is held at a clinical moment where a functional evaluation, rather than anatomical, is needed, since it consists of a problem-focused analysis that gives a multidisciplinary visual. Given the emerging relevance of CCU, the intensivist must focus his/her attention on using such tool appropriately; simple questions must be posed and simple answers sought. The main intent of CCU is to allow early goal-directed therapy.

The approach we are trying to propose is conceptual rather than practical, and the aim is to give the physician a short list of questions to pose each time the probe touches a specific part of the body. The simplicity of the approach we focus on does not want to be reductive and we share the invite of other authors (Vignon et al. 2007) for others to be involved in promoting continuous formation in ultrasonography for intensivists.

The WAMS-D Approach

Authors of this paper want to propose a generic approach that can adapt to different situations, involving disparate anatomical sites. Without pretending to give a universal approach, we suggest a conceptual flow that can help in disentangling complex questions that crowd the physician's mind once a probe is placed on the patient's skin.

To promote this fluidity, questions and answers have only one mandatory characteristic: simplicity. Yes/no questions are the most valuable, especially if answers are given in a reasonable timespan. The algorithm that follows focuses on the observation that ultrasonography can rapidly identify water and liquids (black), air (barrier effect), see moving parts and measure distances. This is all related to water, air, movement, size and Doppler.

□

Figure 1. The WAMS-D Approach Algorithm

In the WAMS-D approach, we must begin by asking: Is there liquid (water, blood, urine or other) in our image and, if so, is the position and quantity of such liquid abnormal? Then: Is an air collection hampering ultrasound transmission? Are movements of anatomical parts absent or altered? Are anatomical dimensions altered?

Critical care WAMS ultrasonography can give quick answers in most cases. Doppler gives extra functional information in particular circumstances.

WAMS-D in a Topographic Approach

The following tables, without claiming to be exhaustive, illustrate some of the possible WAMS-D approach applications grouped per anatomical district, as proposed by various authors.

Head

In the head region, precious information can be derived through direct visualisation of the optic nerve and its vascularisation (Rajajee et al. 2011b). Transcranial Doppler, born as a high specialisation exam, is now increasingly being performed at the bedside by adequately trained intensivists (Munoz-Sanchez et al. 2012).

Table 1. WAMS-D Ultrasonography of the Head

	W	A	M	S	D
Optic nerve				Increased diameter in raised intracranial pressure (Rajajee et al. 2011b)	Monitoring of cerebral hemodynamics (Nenekidis et al. 2011)
Cerebral arteries					Evaluation of cerebrovascular spasm in haemorrhage (Aaslid et al. 1984)
Brain death					Diagnosis of cerebral circulatory arrest (Ducrocq et al. 1998)

Thorax

Concerning the thoracic region, many critical cardiac conditions can be rapidly identified by the intensivist, preceding or, in some cases, substituting the conventional echocardiography performed by the cardiologist (Vignon 2005).

For decades air in the inflated lungs has been considered an impassable obstacle to direct parenchymal visualisation. Despite this, indirect signs have been widely investigated to identify many pulmonary conditions (Stefanidis et al. 2011).

Table 2. WAMS-D Ultrasonography of the Chest

	W	A	M	S	D	Abdomen

Pleura	Precise evaluation of pleural effusion or empyema (Maslove et al. 2011)	Indirect signs of pneumothorax (Stefanidis et al. 2011) Post-procedural pneumothorax (Vezzani et al. 2011)	Seashore sign in healthy lung (Stefanidis et al. 2011)			Abdominal CCU has various applications in the study of the hepatobiliary system, pancreas, spleen and genito-urinary system (Wang and Chen 2007). Important data can be obtained from investigation of abdominal vessels: evaluation of volume (Carr et al. 2007) and cases of thrombosis, stenosis or rupture of aneurysms. Protocols have been proposed, reviewed, criticised and refined for rapid assessment in polytrauma patients.
Lung and airways	B-Lines as sign of EVLW (Jambrik et al. 2010)	Assessment of PEEP-induced lung recruitment (Bouhemad et al. 2011) Differential diagnosis of non-pulmonary oedema (Copetti et al. 2008)		Assessment of tracheal trauma (Moriwaki et al. 2006)		
Vessels				Vena cava, vascular filling (De Vecchis et al. 2012)		
Heart and pericardium	Prompt detection of tamponade (Nagdev and Stone 2011)	Early detection of pneumopericardium (Howlett and Chua 2011) and pneumoperitoneum (Russo and Giangregorio 2012)	Right ventricular strain in pulmonary embolism (Stergiopoulos et al. 2011)	Monitoring volumes (Subramaniam and Talmor 2007) Estimate work of breathing (Vivier et al. 2012)	Focus-oriented echocardiography (Vignon et al. 2007)	
Diaphragm			Study of diaphragmatic dysfunction (Lerolle et al. 2009)			

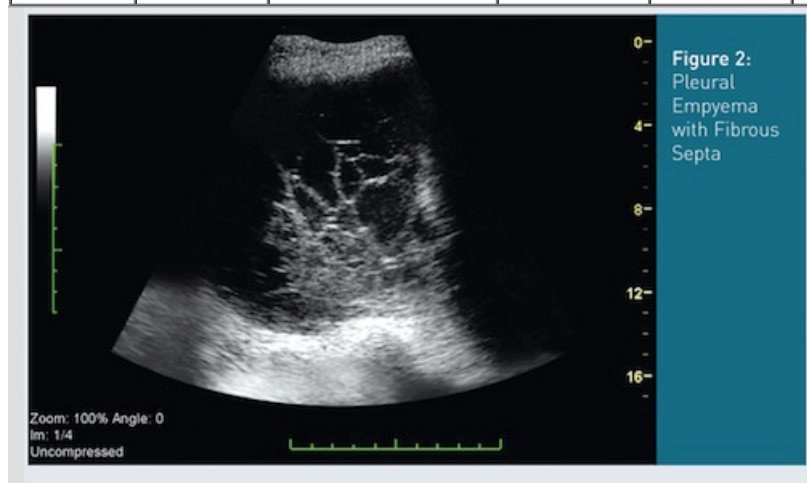


Table 3. WAMS-D Ultrasonography of the Abdomen

	W	A	M S	D
Abdomen	Free liquid in peritoneum (Tayal et al. 2004)	Perforation (Chen et al. 2002)	Study of biliary tree (Horrow 2010)	Aortic aneurysms, mesenteric infraction (Danse et al. 2009)
Kidney	Hydronephrosis (Barozzi et al. 2007)		Cortical thickness (Barozzi et al. 2007)	Resistance index as shock predictor (Corradi et al. 2011)

Limbs

In addition to guiding vascular access, CCU of the limbs can rapidly recognise clots in patients with suspected deep vein thrombosis, and identify gas presence in cases of anaerobic soft tissue infections (Jaovisidha et al. 2012).

Table 4. WAMS-D Ultrasonography of the Limbs

	W	A	M	S	D
Lower limb		Soft tissue infection (Jaovisidha et al., 2012)			Deep vein thrombosis (Kory et al., 2011)

CCU in Invasive Manoeuvres

In addition to the aforementioned diagnostic possibilities, CCU is consolidating its role in assisting the intensivist in the execution of invasive manoeuvres. Some such techniques are widely implemented, like ultrasound-guidance for placement of central venous catheters (Brusco et al. 2009), execution of pericardiocentesis (Matthew Fields et al. 2012), thoracentesis (Patel et al. 2012) and paracentesis (Nicolaou et al., 2007). Less common applications of CCU include the confirmation of correct endotracheal tube placement (Hsieh et al. 2004), postpyloric feeding tube placement (Hernandez-Socorro et al. 1996) and ultrasound-guided percutaneous dilatational tracheostomy (Rajajee et al. 2011a).

□

Concluding Remarks

Ultrasonography has countless applications in the intensive care unit. The fact that basic concepts are simple does not mean that the technique is necessarily easy. Primarily, we think attention should be paid on continuous training: the ultrasound machine should be taken out of the closet and each intensivist, from the student to the director, should have the opportunity to train on a daily basis.

It is the authors' opinion that excessive subjectivity in image interpretation is a major limitation at the moment; therefore, we believe that maximum efforts should be made to develop and validate a quantitative approach to ultrasonography, to reduce effects from operator inexperience, to increase resolution and to obtain a reproducible datum.

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