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Holistic ultrasound in trauma: An update

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ABSTRACT

Holistic ultrasound is a total body examination using an ultrasound device aiming to achieve immediate patient care and decision making. In the setting of trauma, it is one of the most fundamental components of care of the injured patients. Ground-breaking imaging software allows physicians to examine various organs thoroughly, recognize imaging signs early, and potentially foresee the onset or the possible outcome of certain types of injuries. Holistic ultrasound can be performed on a routine basis at the bedside of the patients, at admission and during the perioperative period. Trauma care physicians should be aware of the diagnostic and guidance benefits of ultrasound and should receive appropriate training for the optimal management of their patients.

In this paper, the findings of holistic ultrasound in trauma patients are presented, with emphasis on the lungs, heart, cerebral circulation, abdomen, and airway. Additionally, the benefits of ultrasound imaging in interventional anaesthesia techniques such as ultrasound-guided peripheral nerve blocks and central vein catheterization are described.

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Introduction

Holistic ultrasound is a total body examination using an ultrasound device aiming to achieve immediate patient care and decision making. It is performed by health care professionals of various specialties including anaesthesiologists, emergency physicians and surgeons, aiming to provide scrupulous care for injured patients. Holistic ultrasound in the hands of adequately trained physicians supplements the physical examination, without exposing patients to risks related to radiation and transportation within the emergency department and radiology department rooms; it can be performed with ultrasound devices that can be portable or even pocket-sized [15,24]. Ultrasonography has the benefit of using innocuous sound waves to produce an image, therefore, it can be performed on a routine basis at patient's admission and during the perioperative period. If ultrasound examination is ambiguous, other imaging modalities should be considered, as recommended [17,34,35,42].

In the setting of trauma, holistic ultrasound is one of the most fundamental components of care of the injured patients that may help physicians to prevent diseases or severe complications of trauma prior to becoming completely apparent with irreversible consequences for the patients. It is practically like preventing plumbing damage before pipes are totally broken and flood our space [17,34,42]. More specifically, ground-breaking imaging software allows physicians to examine various organs thoroughly, recognize imaging signs early, and potentially foresee the onset or the possible outcome of certain types of injuries [17,34,35,42].

In this paper, the findings of holistic ultrasound in trauma patients are presented, with emphasis on the lungs, heart, cerebral circulation and abdomen. Additionally, the benefits of ultrasound imaging in interventional anaesthesia techniques such as ultrasound-guided peripheral nerve blocks and central vein catheterization are described.

Transcranial ultrasound

Low frequency pulsed-wave Doppler ultrasonography (1.5–3.0 MHz) may adequately examine the cerebral arteries in trauma patients. The optimal access acoustic window is the temporal bone (thin-walled section of the skull). The anterior cerebral artery (ACA), middle cerebral artery (MCA), posterior cerebral artery (PCA) can be adequately visualized (Fig. 1). Transorbital ultrasound access can display the ophthalmic artery, and extracranial ultrasonography of major vessels including the carotid and vertebral arteries can supplement the examination. In the emergency setting, visualization of the MCA is considered the most accessible and significant of the cerebral arteries; since it

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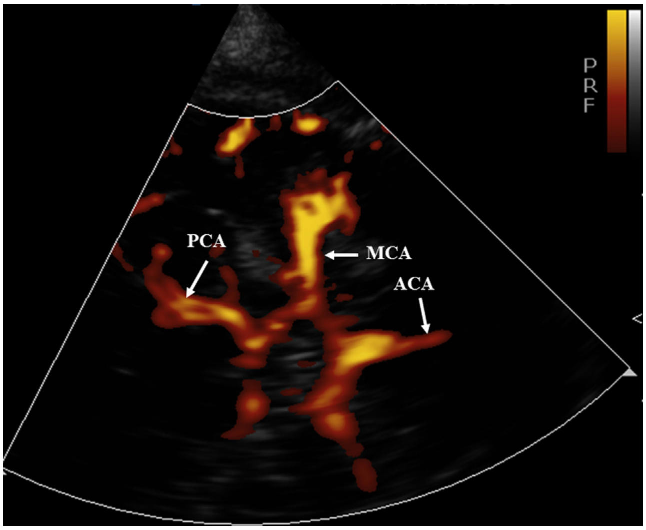

Fig. 1. Power Doppler maps of the anterior, posterior and middle cerebral arteries through the temporal bone acoustic window. (*ACA = anterior cerebral artery*; *PCA = posterior cerebral artery*; *MCA = middle cerebral artery*).

carries as much as 60%–70% of the ipsilateral cerebral blood flow. The MCA flow measured by transcranial Doppler (TCD) is easily obtained and practically reflects the blood flow of the corresponding hemisphere [5,62].

As orthopaedic trauma patients frequently suffer traumatic brain injury, TCD measurement is of paramount importance in the perioperative period. Although the majority (80%) of traumatic brain injuries are mild to moderate (Glasgow Coma Scale, 8–15), caution is necessary in the perioperative period for possible neurological deterioration [5,14,62]. Neurological deterioration often occurs from cerebral edema, expansion of cerebral hematoma, seizures, or posttraumatic hydrocephalus, which may lead to various manifestations including vasospasm and subarachnoid haemorrhage (Fig. 2), increased intracranial pressure, or even cerebral circulatory arrest (Fig. 3) [6,41,45]. Therefore, it is obvious that the use of TCD in trauma patients with brain injury may optimize the bedside management of the patients.

Chest ultrasound

Imaging of the lungs is essential for the management of trauma patients. Ultrasound compares favourably with CT scan and radiographs for the diagnosis of some acute thoracic injuries such

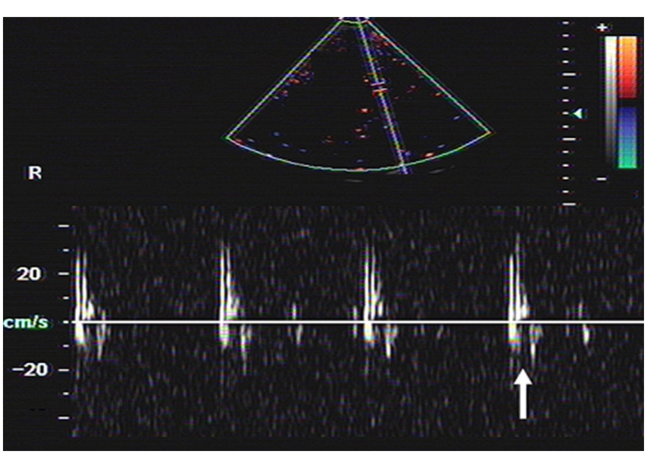

Fig. 2. (A) Early diastolic peaks in a patient with intracranial arrest of cerebral perfusion.

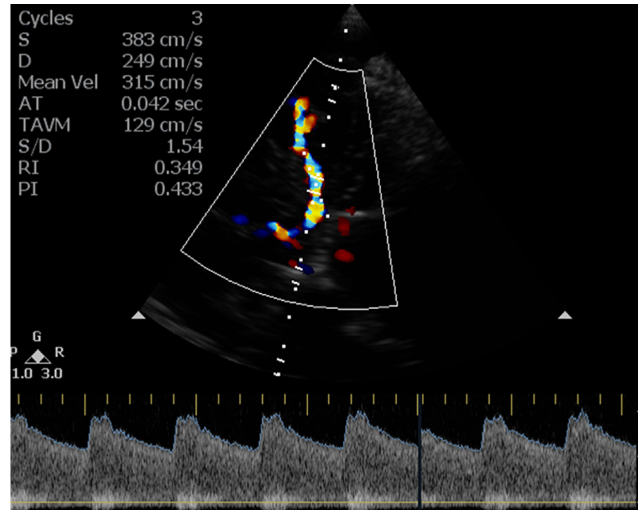

Fig. 3. Middle cerebral artery high peak systolic velocity (normal values range, 70–95 cm/sec) indicating vasospasm in a trauma patient with subarachnoid haemorrhage.

as pneumothorax and pleural effusions [36,38]. The probe is placed between two rib spaces, in a cranio-caudal orientation. Between the acoustic shadows of the adjacent ribs, a hyperechoic horizontal line (the pleural line) is visualized (Video 1). The pleural line does not represent a certain anatomical structure but an ultrasound artifact that springs from the interaction of the ultrasound beam with an interface between the visceral/parietal pleural surface (aerated tissue) and the chest wall (water-rich tissue). The pleural line shows a to-and-fro synchronous motion with respiration. This synchronous motion is called the lung sliding sign that is a dynamic sign seen on two-dimensional mode. Other common lung ultrasound artifacts are the A-lines and the B-lines. The A-lines are horizontal, hyperechoic lines parallel to the pleural line (Fig. 4A). They constitute a reverberation artifact that arises exactly below the pleural line at a distance equal to that between the skin surface and the pleural line. The B-lines are narrow based lines arising from the pleural line and extend vertically to the edge of the ultrasound screen. They represent an artifact that forms as the ultrasound beam hits a water/air interface in the subpleural interlobular septa (Fig. 4B). B-lines are frequently depicted in normal lungs; one or two B lines can be seen in 25% of healthy individuals [12,36,38]. Three or more B-lines between two ribs are called lung-rockets. More than three B-lines are associated with lung interstitial syndrome (water excess in lung). The normal lung surface in one dimensional imaging (m-mode ultrasound) has a grainy appearance called the sea-shore sign [12,36,38].

Ultrasonography of the lungs is part of the extended focused assessment sonography for trauma (FAST) that allows the examination of both lungs by applying bilateral anterior thoracic ultrasound examination to the pertinent FAST exam. This provides prompt identification of a pneumothorax and/or hemothorax [12,36,38]. Pneumothorax is recognized by the absence of the normal "lung-sliding' (Video 2) and 'comet-tail' artifacts. In m-mode ultrasound, the sea-shore sign is lost and replaced by multiple parallel grey-hued lines called the bar-code sign (Fig. 5AB).

Several recent prospective studies have validated the use of lung ultrasound in the setting of trauma patients' resuscitation; these studies have shown that ultrasound can provide an accurate estimation of the size of pneumothorax [9,37,39,40]. Although radiography and/or CT scanning is generally feasible, ultrasonography provides for immediate bedside detection of pneumothorax and guides immediate chest decompression [9,37,39,40].

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