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Updates on Role of Ultrasound in Intensive Care Unit

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Abstract

Rapid and accurate diagnosis and treatment are crucial and problematic for patients admitted to an intensive care unit. The incorrect physical examination was extensively reported when the intensive care unit was admitted. Various methods of diagnostic imaging were developed, but most lacked sensitivity, availability and portability. When a short echocardiographic study is added to extend the physical examination, the diagnostic accuracy can be increased. Ultrasound (US) has grown rapidly and has been widely accepted. In a recent study up to 36 per cent of patients admitted to a non-cardiac intensive care unit had one or more occult heart defects. Intensive patients with thoracic and abdominal pathologies often require the ultrasound examination for prompt diagnosis and treatment, and prevent deterioration or death of the patient's disease. In this review article, we discussed the role of the United States in the intensive care unit and we concluded that the critical care community has a number of application points for ultrasound in the intensive care unit. The literature advances rapidly every year. Thoracic applications, such as lung, cardiac and diaphragm ultrasound, and brain ultrasound and procedural direction are the main topics of focus. The trend of the new studies is to demonstrate the diagnostic exactness of new ultrasound treatment methods and their impact on the daily practise of critical care.

Keywords: Ultrasound, Intensive Care Unit, ICU**.**

1. Introduction

The use of ultrasound has expanded considerably in critical care research and practise in the last two decades. Despite the fact that the method has a number of inherent limitations and is largely operator dependent, it enables clinicians to diagnose unstable patients quickly and relatively inexpensively. The use of ultrasound in point-of-care applications like lung ultrasound is gradually replacing conventional imaging methods (i.e. X-rays in the thesis), while the use of ultrasound in procedural guidance has demonstrated that complications are reduced and patient safety increased [1].

Different papers in this issue showed how important ultrasound is in the intensive care unit (ICU). K. Stefanidis et al. used the ultrasound guided echogenic technology in the internal jugular vein (IJV) and the subclavian vein (SCV), respectively. Both case-control studies included intubated patients in critical care and were carried out under controlled ICU conditions. The transverse axis and cancellation of the SCV on the longitudinal axis through an infraclavicular approach were attempted to cause ultrasonic cancellation of the IJV. The use of echogenic technology improved significantly the visibility of the cannula and reduced access time and technical complexity, thus maximising ultrasound-guided central venous cancer in real time irrespective of the technique used [2].

Due to its ease of use and usefulness in critically ill patients, LUS is a key tool for intensivists. The main LUS applications for a variety of lung conditions were described as a valuable alternative to the scan of chest Computerized Tomography (CT) and chest X-rays (CXR)[3].

Over the past 15 years, lung ultrasound transthoracic (LUS) has proven one of the most revolutionary diagnostic tools in the intensive-care environment, with acute respiratory deficiencies as the most frequent cause of 33-37 percent death in hospital among those who require invasive mechanical ventilation. It is a minimally invasive success, easily repeated and easy to achieve. In addition, transthoracic LUS requires only a fast learning curve; 25 monitored tests are necessary to achieve basic knowledge[4].

In addition, in approximately 50 per cent of interventions the impact of transthoracic LUS can lead to important clinical decisions: bronchoscopy, chest tube placement, positive end-expiratory pressure (PEEP) titration, recruitment, fluid management, diuretics, antibiotic initiation/change and physiotherapy. Furthermore, early use of scores, like the "LUS scoring," helps predict the outcome of patients admitted to the ICU[5].

In future studies, advanced noninvasive hemodynamic models based on modern ultrasound techniques must be developed. Certainly, the role of echocardiography remains crucial in hemodynamic monitoring. Clinical entities like LV diastolic dysfunction are also increasingly recognised in patients with ICU[3].

The aim of the work was to change practises by using ultrasound technology in the ICU and using ultrasound at the care point. ICU

2. Methods

This is Article of a review, The research in MEDLINe, Embase, Pubmed and CINAHL Plus took place within the same time range as follows: "Ultrasound; Intensive Care Unit; Intensive Care Unit; ICU." Articles other than language are excluded from the review English.

3. Results

Point of Care Ultrasound (POCUS) enabled anesthesiologists and intensivists to decide on patient care and facilitated faster diagnostics and better treatment in intensive treatment units (ICUs), operating rooms (OR) and emergency centres. The review provides a summary of the various roles of ultrasound in the activities of health care professionals in ICU and OR [6].

During the last two decades, cardiac anesthesiologists have recognised and been skilled in the use of transesophageal echocardiography. More recently, the focus was on quickly interpreting echocardiography of transthoracic, distinguishing the noncardiogenic and cardiogenic lung edoema and diagnosis of lung embolism and cardiac tamponade. They also improved their ability to determine the importance of fluid handling by balancing liquid resuscitation and preventing fluid overload with or without POCUS in very sick patients. The IVC collapse index has become very useful for non-invasive target-directed fluid therapy in critical care units[7].

Ultrasound has become a milestone in the diagnosis and monitoring of a number of clinical problems common in ICU, including trauma, neurological emergencies, hemodynamic monitoring, airway management, brain death. Rapidity and accuracy are one of the main reasons for its popularity[8] in obtaining key information.

Procedural guidance application:

Venous and arterial cannulations guided by ultrasound

Ultrasound-guided vascular access was first described in the seventies and has developed into a highly recommended patient safety method. It has become a common practise for central venous access routinely. It is also used for the arterial cancellation and difficult peripheral vein. Residents are now commonly trained to place the lines with ultrasound. Ultrasound-guided central venous catheterization is a standard treatment which reduces the rate of complication. The evidence shows that use of UL during cannulations is associated in adult patients undergoing CVC insertion with a reduced incidence of cancellation failure, arterial punctures, hematoma, and hemothorax [9].

An ultrasound and x-ray usefulness study in the detection of CVC position and post-process pneumo thorax by ultrasound showed that the ultrasound can be used safely to detect catheter tip position and to detect complications such as pneumothorax. It can be a better alternative to routine portable x-ray chest and more precise [10].

Percutaneous tracheostomies guided by ultrasound

Intensive care patients often require long-term ventilator support with tracheostomy. The use of ultrasound has recently emerged as a simple, non-invasive instrument for bedside tracheostomies. Percutaneous tracheostomy is a common procedure done in the bedside of ICU. The surgical tracheostomy was replaced by this technique. It is less invasive, easier to master and less complicated. Ultrasound helps to detect the tracheal rings before the procedure and blood vessels on the insertion path. This helps to correctly map the place to dilate and to insert the cannula percutaneously. The use of ultrasound for dilationary percutaneous tracheostomy (PDT) is encouraging. PDT was shown to be non-inferior to bronchoscopic guided tracheostomies in critically diseased mechanically ventilated patients, using ultrasound guidance [11].

Application in hemodynamics

Ultrasound can be used to diagnose potential reversible causes for hemodynamically unstable patients. Night ultrasound is a standard treatment today in ICU. It offers insight into the key elements of the circulatory system [12].

Index of collapse of IVC (inferior vena cava)

The use of ultrasound in the assessment of inferior vena cava diameter and collapsibility indicates one of the most reliable techniques for controlling the status of intravascular volume, with accurate measurements of proper auric pressure and fluid response among critically ill patients. By measuring the distance between the front and back walls in the M mode, the maximum and minimum IVC diameters are calculated. The collapsibility index of IVC is calculated using a formula [(maximum diameter of IVC - minimum diameter of IVC)/maximum diameter of IVC]. The response to fluid therapy is positive in passively ventilated patients, where the IVC collapse rate is > 18 percent (i.e. IVC collapse index X 100)[13].

Transaortic variability of peak velocity and stroke volume

In the apical view of the 5-chamber, a continuous Doppler in mechanically ventilated patients across the peak velocity of the aortic valve with respiratory cycle has been shown to be an exact predictor of the fluid response. Stroke volume variation was also shown to be accurate after a fluid challenge. Carotid Doppler is another useful tool that can predict fluid response[14].

Application in pulmonary embolism detection

Pulmonary embolism is one of the most life-threating complications in critically ill patients. The aetiology can be diversified. The causes of ICU are few in terms of immunisation, cancer and autoimmune disease. Thus, unless contraindicated, thromboprophylaxis is a general rule. The safety, convenience, speed, low costs and easy accessibility make the diagnosis of deep venous thrombosis and pulmonary embolism essential for bedside ultrasonics. Evidence of acute pulmonary embolism can include free floating thrombus in the right heart, RV dilatation (RV/LV mid-diameter >1:1), RV systolic dysfunction, flattening interventricular septum in the LV, or evidence of deep venous thrombosis in low-end compression [15].

Echocardiography of bedside screening

The main aspects of intensivist research in critically ill patients are evidence of pulmonary embolism, ventricular systo-diastolic disease, pericardial effusion and aortic dissection (Figure 1). (Figure 1). Cardiac anesthesiologists may also use echocardiography to diagnose important heart defects that can affect perioperative diseases. outcome [16]**.**

Applications in regional anesthesia

Since anesthesiologists developed the art of giving regional perineural blocks using ultrasound guidance this has become a routine practice. Ultrasound guidance helps to accurately deposit the local anesthetic, thereby enhancing the duration and quality of the block. Moreover, ultrasound guidance might reduce the dose of local anesthetics and incidence of complications. Ultrasound is also useful in visualizing the epidural space and identifying midline structures improving the chances of placement of an epidural catheter or a spinal needle [17].

Role of Ultrasound in Neurointensive Care

Ultrasound in detecting intracranial pressure requires further research and, in the future, It might lead to changes in therapeutic management, ventilator adjustments and thereby modifying the outcome.

Application in diagnosis of intracranial hypertension

Optic nerve sheath diameter correlates with intracranial pressure. It is non-invasive and reliable in neurocritical patients. Studies have shown that sensitivity and specificity might reach 0.9 and 0.85 respectively in diagnosing the increased intracranial pressure, while the area under the summary receiver-operating characteristic curve might reach 0.94 . Raised intracranial pressure is a life-threatening complication of many central nervous system disorders namely trauma, stroke, intracranial hemorrhage, tumors or even infections [18].

Invasive monitoring of intracranial pressure has been the method of choice but has recently been debated in many conditions. Hence, any bedside non-invasive test which proves sensitive and specific might be pivotal in the future. In a study evaluating the reliability of optic nerve sheath diameter measured by ultrasound for detecting increased intracranial pressure (Fig 2), the authors found that the average cut off values of 4.6 mm and 4.8 mm, for female and males respectively, had 84.6% and 75% sensitivity in females and males in predicting intracranial pressure, whilst specificity was 100% [18].

Optic nerve sheath diameter also has been shown to be associated with results of magnetic resonance imaging. Comparing ultrasound optic nerve sheath diameter with the same MRI derived parameter, investigators have found a moderate correlation ($r = 0.02$, $p < 0.05$). These findings have strengthened the usefulness of ultrasound derived prediction of intracranial pressure [19].

Fig. (1) 2decho showing pericardial effusion, [15]

Fig. (2) ONSD measurement [19].

Brain death testing

Cerebral blood flow velocity can be monitored by transcranial Doppler and its use has spread in the operating theater, for instance, during laparoscopy and anterior open inter-vertebral spinal fusion surgery [17].

Cerebral blood flow velocity monitoring in patients with stroke and intracranial hemorrhage as an ancillary test for brain death. Meta-analyses showed 95% sensitivity and 99% specificity to detect brain death [18].

The presence of reverberation flow pattern, systolic spikes or lack of flow in basillar and in both middle cerebral arteries observed in two examinations is highly reliable for the prediction of brain death in all patients Fig. (3).

Airway assessment

Confirming endotracheal tube placement

Airway ultrasound aids in assessing the tongue, oropharynx, epiglottis, larynx, vocal cords, cricothyroid membrane, and cricoid cartilage. Ultrasound has also been used successfully in detecting the correct placement of endotracheal tube. This methodology can be an adjunct in management; however it cannot replace ETCO2 monitoring. Ultrasonography is an effective technique in confirming intubation [20].

Lung ultrasound

Detecting pneumothorax

The lung ultrasound can be used to diagnose or exclude pneumothorax, ARDS, interstitial lung disease and pleural effusions. Anesthesiologist has used ultrasound to detect pneumothorax in the anesthetized patients. This major, catastrophic life-threatening event needs to be diagnosed and treated rapidly. Traditionally chest x rays have been the main rapid tool in diagnosing pneumothorax; however it is too time consuming. Pleural sliding in combination with B lines, lung point and lung pulse are very useful in diagnosing pneumothorax [20].

Approach for detecting Pneumothorax

A pneumothorax contains air and no fluid, and therefore, will rise to the least dependent area of the chest. In a supine patient this area corresponds to the anterior region of the chest at approximately the second to fourth intercostal spaces in the mid-clavicular line. This location will identify the majority of significant pneumothoraces in the supine patient, which makes it the recommended initial area for investigation in a trauma.In contrast, air will accumulate in an apicolateral location in an upright patient [20].

Predicting difficult airway

Prediction of the difficult airway is an ongoing area of research. It has been found that measurements of anterior soft neck tissue thickness at the level of the hyoid bone and thyrohyoid membrane can be utilized in predicting difficult laryngoscopies. No significant correlation has yet been found between ultrasonographic measurements and clinical screening tests [20].

Detecting pneumonia

Lung ultrasound has high sensitivity and specificity in detecting pneumonia. Lung ultrasound has been competing with computed tomography in the monitoring of pulmonary disorders. Ventilator associated pneumonia can be diagnosed early and also can be monitored using lung ultrasound. However, there is inadequate evidence available on this argument. In a multicentric study conducted on 99 patients two dynamic linear absorbent air bronchograms produced 94% positive predictive value in diagnosis pneumonia (Fig 4). Normal aerated lung is replaced with non-aerated lung in pneumonia. The ultrasound finding in patients with this condition shows a continuous pattern of B lines with irregularities along the subpleural regions. These areas of consolidations have been shown to turn into lobar consolidations [21].

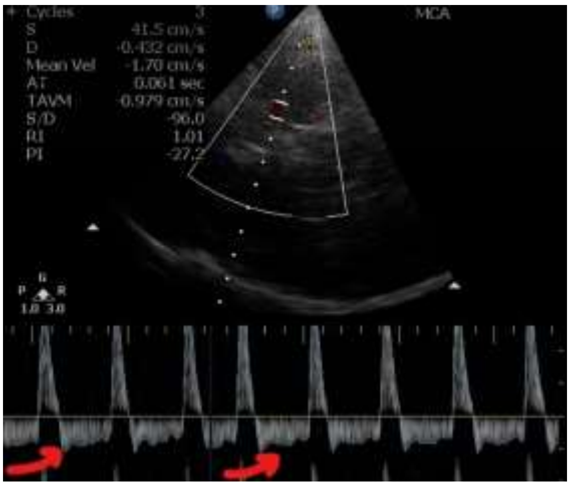

Fig. (3) TCD showing diastolic reversal in brain death [19].

Role of ultrasound in abdomen pathologies

Assessing residual gastric volume

Ultrasound has been used to detect gastric content and volume and to prevent regurgitation and aspiration

Focused assessment with ultrasonography

The role of ultrasound in critical care units in abdominal pathologies has been well documented. Diseases like Dengue fever can be suspected by the presence of ascites, gallbladder wall edema and hepatosplenomegaly. According to a study, the incidence of gall bladder wall edema > 3 mm in dengue fever is one of the most important indirect evidence of this viral infection Fig. (5).

Ultrasound has been well documented in the diagnosis of abdominal trauma. The Focused Assessment Principle of Trauma Sonography (FAST) was largely used in emergency medicine. Highly specific to hemoperitoneum is a positive ultrasound. In less urgent cases, the CT scan can be performed if the patient is stable. If other bleeding sources are sought in patients with a negative FAST, a CT scan may still be required in order to detect the cause of hypotension [23].

FAST proceeding

The FAST exam evaluates the pericardium and three potential spaces for pathological fluid within the peritoneal cavity. The right upper quadrant (RUQ) shows the liver recess, also known as Morrison's sack, the right paracolic gutter, the hepatoscopic area and the left liver lobe's caudal edge. Place the probe along the patient's flank in the sagittal orientation at 8 to 11 rib spaces. Start with your hand against the bed to ensure retroperitoneal kidney visualisation. The RUQ view is most likely to detect free fluid with 66 percent overall sensitivity. Recent retrospective evidence suggests that the area at the caudal edge of the left lobe of the liver is more sensitive than 93%. Above all, remember to evaluate each of these fields while scanning the RUQ [23].

Paracentesis of the abdomen

Ultrasound guidance has been demonstrated in patients with a previously blind technology to help doctors during paracentesis. Different other studies have shown that ultrasound-oriented paracentesis is useful to achieve a higher success rate. Hemoperitoneum is a major paracentesis complication. In a study the complication rate was reduced from 1.25% in the traditional blind cohort to 0.27% in the ultrasound cohort [24].

Fig. (4) Ultrasound lung depicting static bronchogram [21].

Fig. (5) USG abdomen showing GB wall edema [22].

4. Discussion

Rapid and accurate diagnosis and treatment Critical and problematic for intensive care admitted patients. The incorrect physical examination was extensively reported when the intensive care unit was admitted. Various methods of diagnostic imaging were developed, but most lacked sensitivity, availability and portability. When a short echocardiographic study is added to extend the physical examination, the diagnostic accuracy can be increased.

Ultrasound has grown rapidly and has been widely accepted. In a recent study up to 36 per cent of patients admitted to a non-cardiac intensive care unit had one or more occult heart defects. Intensive patients with thoracic and abdominal pathologies often require the ultrasound examination for prompt diagnosis and treatment, and prevent deterioration or death of the patient's disease.

The use of ultrasound in the intensive care unit was fully validated as it provides data that cannot be obtained by another routine methods, which is safe, accurate, rapid and repeatable at the bedside. Furthermore, diagnostic accuracy is essential in the admission of intensive care units because of the critical condition of the patient.

The use of ultrasound has expanded considerably in critical care research and practise in the last two decades. Despite the fact that the method has several intrinsic limitations and largely depends on the operator, it enables clinicians to evaluate instable patients quickly, incidentally and relatively cheaply. Point-of-care ultrasound applications such as lung ultrasound replace traditional imaging methods (i.e. chest x-rays) gradually, whilst ultrasound has been shown to reduce complications and thereby increase patient safety.

The use of ultrasound has expanded considerably in critical care research and practise in the last two decades. Although the method has a few inherent limits and is largely operator-dependent, it allows clinicians to quickly, incidentally and relatively inexpensively assess unstable patients. Point-of-care ultrasound applications such as pulmonary ultrasound replace traditional imaging methods (i.e. chest X-rays), while the use of ultrasound to guide procedures has been shown to reduce complications and increase the safety of patients.

Several papers have shown the important role of ultrasound in the intensive care unit in this issue). During ultrasound guided cannulation of both the inner jugular vein (IJV) and the subclavian vein (SCV) Stefanidis et al. used echogenic technology respectively. Both case control studies included intubated patients in critical care and were conducted in controlled intensive care unit conditions. The use of echogenic technologies significantly improved visibility of the cannula and reduced access time and technical complexity in previous studies, thus optimising central ultrasound-guided venous cancellation in real time, regardless of the technique used. Current trends promote the optimisation of two-dimensional ultrasound imaging through the use of different technologies. Advances in ultrasound software can reduce artefacts and "noises" such as spikes caused by consistent wave interference and clutters arising from the formation of beams of beams, reverberations and other acoustic phenomena, while the imagery infusion of contrast agents facilitates the interpretation of various diseases. In this sense, the application of echogenic material could optimise the application of the process ultrasound. This can be of importance, as ultrasound scans often take place in the intensive care system under suboptimal conditions and the presence of mechanical ventilation, air and / or edoema can affect the clarity of the images.

Ultrasound has become a hallmark in the diagnosis and monitoring of several common clinical problems in the Intensive Care Unit including trauma, neurological emergencies, hemodynamic monitoring, airways, brain death. Quick and accurate information collection is one of the main reasons for its popularity.

Using the traditional compartimented approach, numerous tests may be ordered including chest-contrast computed tomography, abdomen and lower extremities ultrasound studies and an echocardiogram. This approach leads to the inherent dissociation of clinical and time with advisory radiology and echocardiography. Alternatively, a critical health care physician may perform an ultrasound check on the bedside to integrate the diagnosis results and guide patient management. For more than half a century, doctors have used ultrasonography to aid diagnosis and guide procedures. Ultrasound equipment became more compact with technological progress and led to the advent of an ultrasound system, which is defined as ultrasound, brought to the patient and carried out by the provider in real time.

Realizing that doctors can see and evaluate physiological functions in real time was a turning point in critical care, and the care of patients in the intensive care unit has revolutionised. Dynamic imaging is a complete paradigm shift from the traditional approach to consultation, in which technologists and doctors who are not closely involved in patient care acquire and interpret images. This eliminates clinical and time dissociations in patient care, permits timely diagnosis and reduces exposure to radiation without potentially hazardous transport of the patient.

The advantage of target-oriented ultrasound is that it depends on the clinician. Since ultrasonography is used for the physical examination as an extension, it is naturally possible to increase the diagnostic process in a head-to-toe manner. However, it's not practical just as a daily fundoscopy check appears to be a waste of time for a patient with asthmatic intensive care unit status.

The introduction of lung ultrasound in a modern ICU has revolutionised patient care. It also showed an impact in non-ICU settings such as in ambulatory clinics for pulmonology and thoracic surgery.

Historically, ultrasound in the lung was neglected given the perceived usefulness of this method in air-filled structures. However, significant progress has been made in the last two decades in using ultrasound as a valuable tool in the evaluation of lung pathologies. Lung ultrasound has an evolving role in the ICU. Although its usefulness is not in question, it has always been an operator dependent on one of the shortcomings of ultrasound. Results from experienced centres are therefore difficult to extrapolate to other areas. The value of ultrasound in various clinical settings must be demonstrated by operators with different backgrounds to give credibility to their widespread use

Certainly, formal training is needed in the application of point of care ultrasounds in the intensive care unit. European and US residency programmes are currently taking on the responsibility of critical care fellowships responsibility.

5. Conclusion

Over the past two decades, the amount of literature on point of care ultrasound has been increasing rapidly. Nowadays, a growing body of evidence strongly supports its role in several fields with particular interest to the acute care settings. Our literature review mainly focuses on thoracic point of care ultrasound, including eight articles on lung ultrasound, six articles on echocardiography and one article on diaphragm ultrasound. In conclusion, we do not deny the life-saving contribution of medical advancement. However, evidence-based medicine through controlled clinical trials has not confirmed the benefit of mechanical ventilators, CAT scans or routine blood analysis. Yet we hold these truths to be self-evident and all intensivists must have intimate knowledge of these tools. Several applications of point of care ultrasound in the intensive care unit are of interest to the critical care community. The literature is progressing rapidly yearly. The main topics of interest are the thoracic applications, including lung, cardiac and diaphragm ultrasound, followed by brain ultrasound and procedural guidance. The trend of the new studies is the demonstration of the diagnostic accuracy of new point of care ultrasound methods and their impact in the daily practice of critical care.

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