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Evaluation of the Role of Ultrasound Use in the Emergency Department: A Literature Review

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Abstract

Background: The concept of medical ultrasound (US) was first postulated in the 1950s. Its role remained primarily experimental until the 1970s when the US started to gain recognition in the clinical settings. Point-of-care ultrasound (POCUS) is the term that is used to describe ultrasound examination within an emergency medicine setting. Point-of-care ultrasound (POCUS) should be used in a quick and focused way to identify specific US-sensitive conditions. **Objectives:** In this paper, we will review the available literature discussing the role of the US in emergency medicine. We will additionally discuss the roles of POCUS inside the emergency department. **Methodology:** We conducted the literature search within the PubMed database using the keywords: "ultrasound" and "POCUS" and "emergency medicine" and "point of care ultrasound" "echocardiography" and "FAST" between 1990 and 2020. **Review:** Cardiac US (CUS) is used in the evaluation of cardiac function through multiple US-views. For example, a parasternal long view is used to evaluate the mitral valve and the ventricle. The Focused Assessment with Sonography for Trauma (FAST) is considered an integral part of current trauma evaluation. It offers a fast assessment of free-fluid within the abdominal, pericardial, and pelvic cavities. **Conclusion:** In conclusion, ultrasound has transformed the way emergency physicians work by supplying them with an effective instrument that has allowed them to rapidly obtain data and act on it. Emergency physicians need to be aware of the vital role that the US plays which will allow them to report more useful insight to manage patients, thereby enhancing the quality of care.

Keywords: Ultrasound, POCUS, Point of care of ultrasound, Echocardiography, FAST, Emergency medicine

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Introduction

The concept of medical ultrasound (US) was first postulated in the 1950s. Its role remained primarily experimental until the 1970s when the US started to gain recognition in the clinical settings (Kendall et al., 2007). During that period, numerous researches were conducted to investigate potential clinical applications of the US. By the late 1980s, emergency medicine-related clinical research on US usage was published (Kendall et al., 2007).

A revolutionary advancement in the US started appearing by the 1990s. For example, Doppler mode employs the Doppler effect to generate a visualization of the blood movement and their relative velocity to the probe (Walcher et al., 2010). Additionally, new specialty-use probes such as the transvaginal transducer started emerging. During the same period, the American College of Emergency Physicians (ACEP) organized its first educational activity discussing the role of the US in emergency medicine (American College of Emergency Physicians). There are currently numerous applications of the US across a wide variety of medical disciplines. Table 1 shows the different applications of Point-of-Care Ultrasonography, according to medical specialty.

Point-of-care ultrasound (POCUS) is the term that is used to describe ultrasound examination within emergency medicine (EM) settings. Point-of-care ultrasound (POCUS) should be used in a quick and focused way to identify specific US-sensitive conditions. It should also be easy to learn and demonstrate recognized features (Kendall et al., 2007).

Other applications of POCUS that are being investigated include its use in pre-hospital medicine (Kendall et al., 2007). The role of POCUS is speeding access to care before hospital arrival of trauma patients by allowing early assessment and communication of significant findings. Besides, POCUS has proven a significant utility in the field of the airlift of patients, especially in remote

locations (Heegaard et al., 2010; Jakobsen et al., 2014; Press et al., 2014).

The rapid enchantments and evolution of POCUS in clinical and emergency has prioritized its role in the management of patients presenting in an emergency. Therefore, in this paper, we will review the available literature discussing the role of the US in emergency medicine. We will additionally discuss the roles of POCUS inside the emergency department including cardiac ultrasound, pulmonary ultrasound, abdominal ultrasound, renal and genitourinary tract ultrasound, aortic ultrasound, pelvic ultrasound, ocular ultrasound, deep venous thrombosis (DVT) ultrasound, soft tissue and bone ultrasound, and procedural ultrasound.

Methodology:

We conducted the literature search within the PubMed database using the keywords: “ultrasound”, “POCUS”, “Radiology”, “point of care ultrasound”, “echocardiography”, “emergency medicine”, and “FAST” between 1990 and 2020. We also used the Google Scholar database for additional literature search. After reading the abstracts, we manually selected the relevant papers for this review. In regards to the inclusion criteria, the articles were selected based on the inclusion of one of the following topics; ultrasound and emergency medicine. Exclusion criteria were all other articles that did not have one of these topics as their primary endpoint.

Review:

Overview of EM and Critical Care POCUS

Due to the inherent similarities between EM and critical care (CC) physicians, by providing prompt care to acutely ill patients, tend to utilize the US. A major application of the US is the rapid assessment of cardiopulmonary function. ER doctors use the US to guide initial management while CC doctors use the US to guide the ongoing management of the intensive care unit (Kendall et al., 2007). However, there are still contrasting elements to the EM and CC use of ultrasonography. Table 2 summarizes the differences between emergency medicine and critical care ultrasonography.

Cardiac Ultrasound

Cardiac US (CUS) is used in the evaluation of cardiac function through multiple US-views. For example, a parasternal long view is used to evaluate the mitral valve and the ventricle (Blyth et al., 2012). While the apical view is used to visualize both the atria and ventricles. Pericardial effusion is a commonly encountered acute presentation in EM. A minimal amount of fluid (i.e., 50 mL) could result in a life-threatening cardiac tamponade which requires immediate intervention (Blyth et al., 2012; Labovitz et al., 2010). A quick bedside US in the emergency department can reliably identify pericardial effusion.

Other applications of CUS which has been gaining recent attention are the additional value that is added to cases of cardiac arrest. Cardiac US (CUS) is of significant benefit in the decision making during cardiopulmonary resuscitation when it may have become fruitless. Cardiac US (CUS) that demonstrates no kinetic cardiac activity implies a probability of return of spontaneous circulation of less than 2%. In contrast, visualization of cardiac contractility in the US signifies a 50% probability of return of spontaneous circulation (Perera et al., 2014).

Pulmonary Ultrasound

In EM, pulmonary ultrasound (PUS) is usually utilized in the identification of pneumothorax. Pneumothorax results in a physical collapse of the lung, which in turn results in the loss of pleural sliding observed on PUS and is a very important sign in the evaluation of pneumothorax (Husain et al., 2012; Lyn-Kew and Koenig, 2013). A large number of straight lines in the sequence below the pleural line gives the appearance of a barcode (Stefanidis et al., 2011; Wagner et al., 2014). Compared to the classical chest x-ray, anterior lung ultrasound has good sensitivity and specificity in identifying pneumothorax (Husain et al., 2012; Wagner et al., 2014).

Further, PUS has long been used to identify pleural effusions. Pleural effusion is a condition where there is a collection of excess fluid around the lungs. Similar to pneumothorax, PUS has superior sensitivity and sensitivity in detecting clinically significant pleural effusions compared to chest radiography (Lyn-Kew and Koenig, 2013).

Abdominal Ultrasound

The Focused Assessment with Sonography for Trauma (FAST) is considered an integral part of current trauma evaluation. It offers a fast assessment of free-fluid within the abdominal, pericardial, and pelvic cavities (Jørgensen et al., 2010). The Focused Assessment with Sonography for Trauma (FAST) provides a dependable level of accuracy in detecting hemoperitoneum and hemopericardium which are significantly higher than the findings obtained by a typical physical exam (Jørgensen et al., 2010).

Ultrasound is the imagining of choice for visualization of the biliary system. In the context of POCUS, it offers quick information that can help in the decision-making algorithm. Gallstones appear as hyperechoic structures that tend to occupy space within the gallbladder (Walcher et al., 2010). If a stone inevitably becomes impacted in the gallbladder neck, an inflammation of the gallbladder could result, leading to an acute presentation of right hypochondriac pain. Among the many features that an inflamed gallbladder shows in the US are pericholecystic fluid and thickening of the gallbladder’s wall. Further, gallstones could find their way down the biliary system reaching the common biliary duct leading to choledocholithiasis (Press et al., 2014).

Renal and Genitourinary Tract Ultrasound

Pathologies of the genitourinary system, mainly the kidneys and bladder, can be assessed using the US (Saeed et al., 2018; Melnik et al., 2020; Ismail et al., 2018). One of the major applications of the US in the genitourinary system is the visualization of hydronephrosis. Hydronephrosis is a condition that occurs due to the presence of obstruction of the genitourinary system (Labovitz et al., 2010). The main US feature is a hypoechoic dilation within the renal pelvis. Causes of obstruction, such as renal stones, are seen within the kidney as hyperechoic structures that result in shadowing. Additionally, the urinary bladder could be evaluated for the post-void volume in cases of distal obstruction (Labovitz et al., 2010; Jørgensen et al., 2010).

DVT Ultrasound

Ultrasound is considered as the investigation of a choice for the primary assessment of DVT. The two-point compression study needs full collapse of the common femoral, greater saphenous vein, and of the popliteal vein. To be negative, the compressed veins should collapse to a thin line. Failure of a vein to fully collapse may be highly suggestive of DVT. Other structures in the vicinity of the veins, such as a lymph node, Baker's cyst, or pseudoaneurysm, might be mistaken for a non-compressible vessel, resulting in a false positives result (Habscheid et al., 1990).

Conclusion:

In conclusion, ultrasound has transformed the way emergency physicians work by supplying them with an effective instrument that has allowed them to rapidly obtain data and act on it. Emergency physicians need to be aware of the vital role that the US plays which will allow them to report more useful insight to manage patients, thereby enhancing the quality of care.

Table 1. Applications of Point-of-Care Ultrasonography, according to Medical Specialty

Specialty	Ultrasound Applications
Anesthesia	Guidance for Vascular Access, Regional Anesthesia, Intraoperative Monitoring of Fluid Status, and Cardiac Function
Cardiology	Echocardiography, Intracardiac Assessment
Critical Care Medicine	Procedural Guidance, Pulmonary Assessment, Focused Echocardiography
Dermatology	Assessment of Skin Lesions and Tumors
Emergency Medicine	FAST, Focused Emergency Assessment, Procedural Guidance
Endocrinology and Endocrine Surgery	Assessment of Thyroid and Parathyroid, Procedural Guidance
General Surgery	Ultrasonography of the Breast, Procedural Guidance, Intraoperative Assessment
Gynecology	Assessment of Cervix, Uterus, and Adnexa; Procedural Guidance
Obstetrics and Maternal-fetal Medicine	Assessment of Pregnancy, Detection of Fetal Abnormalities, Procedural Guidance
Pulmonary Medicine	Transthoracic Pulmonary Assessment, Endobronchial Assessment, Procedural Guidance

FAST: Denotes Focused Assessment with Sonography for Trauma

Table 2. Comparison between Emergency Medicine and Critical Care Ultrasonography

Critical Care Ultrasonography	Emergency Medicine Ultrasonography
Focused on Cardiac, Thoracic (pleura/lung), Vascular Diagnostic, Screening Abdominal, and Procedural Guidance	Includes all Critical Care Ultrasonography, Extended Abdominal, Testicular, early Obstetric, Musculoskeletal, and Ocular
Initial and Serial Examinations for Ongoing Diagnosis and Management	Typically, Single Examination for Diagnosis and Disposition
Does not Lead to Deciding to Discharge from Hospital	Frequently Leads to Deciding to Discharge from Hospital

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