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An Evaluation Of Emergency Medical Services' Use Of Ultrasonography

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ABSTRACT

In select regions of the USA and Europe, prehospital ultrasonography has been used. Medical professionals, EMTs, and flight nurses have used a range of medical and trauma ultrasound examinations to influence patient care in the field. In order to more clearly identify the potential utility of this technology for prehospital clinicians, this study will give a summary of the literature on the use of ultrasonography by emergency medical services (EMS).

Keywords: Emergency medical services, Sonography, Ultrasound, Disaster, Ultrasonography.

INTRODUCTION

Although diagnostic medical ultrasonography has been used extensively since the early 1980s, for many years its usage was restricted to hospital settings due to machine expense and weight [1]. By the middle of the 1990s, a number of manufacturers were selling lightweight portable ultrasound equipment.

Modern portable ultrasound machines have good image quality, are engineered to survive harsh climatic conditions, and are lightweight (the majority are the size and shape of a laptop computer). Numerous applications, such as focused assessment with sonography in trauma (FAST) [2-4], echocardiography [5, 6], and aorta evaluations [7], have been studied to determine how well portable machines function.

Modern ultrasound technology was initially adopted by non-radiologists in a variety of settings, including obstetrics, surgery, emergency medicine, and others, due to its increased portability and simplicity of use. These gadgets are also being used more often outside of hospitals as well. Portable ultrasound equipment have been used in the field by doctors, military medics, and emergency medical services (EMS) workers to diagnose disorders such deep venous thrombosis and pleural, peritoneal, and pericardial effusion [8–10].

In 2000, the viability of ultrasound deployment and the likelihood of avionic equipment interference were assessed [11]. In a helicopter, doctors, flight nurses, and sonographers conducted FAST exams without the ultrasound machine interfering with the avionics. Several authors have subjectively reported (but not specifically tested) the endurance of portable ultrasound devices. In a 1-year trial with 100 patients analysed, there were no mechanical issues with the use of ultrasonography during helicopter transport [9]. However, other authors

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pointed out that the use of ultrasound during flight was constrained by strong sunlight and battery failure [12]. A portable ultrasound device was employed in a field hospital in Iraq, where there was little room, a high ambient temperature and light level, and frequently battery power [13]. Portable ultrasound has "considerable value in the field or during patient transfer," according to other writers working in a comparable military setting [14].

Prehospital ultrasound experience

Germany, France, Italy, the USA, and other nations have all described the usage of ultrasound in the field [15]. Non-physician EMS teams frequently concentrate on the quick transfer of patients to emergency rooms in the USA. In some regions, healthcare professionals spend more time on-site assessing and managing patients, and doctors are frequently a part of the field team. Thus, depending on a given clinician's practise setting, the indications for and utility of point-of-care ultrasonography may vary.

In Germany, the FAST test and cardiac sonography for non-traumatic patients have been the main applications of ultrasound in the profession. Since 2002–2003, certain ground-based ambulance services (in Darmstadt and Frankfurt/Main) and the German Air Rescue Organization (Deutsche Rettungsflugwacht) have included ultrasound into their field management algorithms. The staff in these centres is made up of emergency physicians and paramedics [15]. Many French prehospital clinicians, such as SAMU (Service d'Aide Médicale d'Urgence) 93, have embraced ultrasound. The potential of mounting a portable ultrasound device on a helicopter for field exams was originally discussed by French intensivists in 1998 [16]. The FAST exam has been used in the field to assess for pericardial effusion, deep vein thrombosis, and aortic aneurysm in this area [8].

In 2005, the Italian EMS system started utilising ultrasonography for prehospital care [15]. It is being researched as a supplement to patient assessment and triage as well as for the treatment of illnesses in the field. Three important clinical indications, including cardiac arrest, torso trauma, and acute dyspnea, are being assessed in Milan by ground and helicopter teams that are both outfitted with portable ultrasonography equipment. Prehospital ultrasonography is used in this situation to assess for pericardial, intraperitoneal, and pleural fluid in trauma cases, to distinguish between pulmonary edoema and emphysema, and to distinguish between reversible sources of pulseless electrical activity (PEA). Prehospital ultrasound may have been slower to enter clinical algorithms in the USA due to the emphasis

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on quick transport and minimising on-scene time [15]. The use of ultrasound has been documented in a number of EMS helicopter projects in the USA (in Portland, Ohio, and Minnesota). The routine use of ultrasonography on ground ambulances has little experience; the first group to employ the technique was in Odessa, Texas.

EMS training in ultrasound

Portable ultrasonography has been used by a variety of practitioners (physicians, emergency medical technicians, and flight crews) in a range of professional settings, including air and ground deployment. The use of ultrasound has been training for flight crews in the USA, including flight nurses, paramedics [9, 12], and doctors [17].

In these studies, training sessions ranged from three to seven hours, and some doctors received additional scanning time that was monitored in the emergency room. In one French study, 25 initial FAST ultrasound scans and 8 hours of didactic trauma ultrasound training were provided to emergency physicians working the ground EMS system [18]. German air rescue centres and ground ambulance teams' surgeons, internal medicine doctors, and anesthesiologists have also been researched. Prior to using the equipment in the field, doctors who were unfamiliar with trauma ultrasonography in this study underwent a day of didactic and practical instruction in the FAST evaluation [10]. A medical professional with 100 hours of training in the modality was used in a portable ultrasonography study on board a Norwegian Air Rescue helicopter [19].

An ultrasound training programme for non-physician EMS providers was studied in an ongoing multicenter trial in the United States. 93 advanced life support (ALS) professionals participated in this study and successfully completed a standardised 6-hour curriculum on the FAST exam and evaluation of the abdominal aorta. The teaching methods included didactic lectures, practical scanning sessions, and observed structured clinical encounter (OSCE) scenarios.

Written test results from before and after the curriculum revealed a considerable improvement in the providers' ability to recognise images. Additionally, all 34 paramedics who underwent an OSCE three months after completing their first training successfully completed the ultrasound scanning practicum [20].

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No research has yet evaluated variances in the level of training received by each provider with the calibre of exams they are capable of conducting. Prehospital ultrasound experience to date includes both medical professionals and EMS personnel with a range of baseline ultrasound usage experiences. It is challenging to make judgments about the ideal prehospital provider training standards based on current research, particularly for people who are not tech savvy.

Indications

FAST exam

Emergency medicine literature has provided a thorough description of the FAST exam [21, 22], proving that hemoperitoneum and hemopericardium can be correctly diagnosed without the need of radiologists. It has been demonstrated that using the FAST assessment early in the patient's evaluation reduces the length of hospital stays, the cost of care, and the time until an operation is required [23]. Early diagnostic ultrasonography was one of the factors that could reduce total traumatic mortality, according to a study of battle deaths in 210 US Marines [24]. The viability of FAST tests conducted by EMS and medical professionals while flying at high speeds in constrained spaces has been investigated in preliminary experiments in helicopter transport. A complete set of sufficient pictures could not be collected in 48% of cases by EMS providers, primarily due to time restrictions, according to a prospective study of 71 patients carried by helicopter [12]. A FAST assessment conducted on a helicopter by flight surgeons revealed a sensitivity of 81.3% and a specificity of 100% for free fluid [25]. Another prospective research of 100 patients transferred by EMS via helicopter found that 90% of the time, the right upper quadrant view was adequately captured, with a sensitivity of 60% and specificity of 93% [9]. In 94% of the patients, cardiac examinations were sufficient, and the examination was 100% sensitive and specific for pericardial fluid. However, there was only one successful cardiac study in this collection. In a different research, in-flight ultrasound performed by a skilled physician (with 100 hours of ultrasound training and more than 400 prior exams) was 90% sensitive and 96% specific for detecting hemoperitoneum, pneumothorax, and pericardial effusion in 38 patients [19].

One French study on the viability of performing ultrasound exams looked at the deployment of portable ultrasonography via helicopter. The scans were carried out on patients on the ground even though a portable device was brought in and kept in the helicopter cab (at a

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desert rally). In this case, 15 patients were examined by an expert doctor who checked them for hemothorax, pneumothorax, hemopericardium, hemoperitoneum, and flattened inferior vena cava. 68 of the 75 potential views (or 90.6%) were sufficient for diagnosis. In every single instance, it was able to check for pleural and peritoneal fluid.

In less than 3 minutes, we scanned every subject. The Australian Royal Adelaide Hospital Medflight helicopter team has also investigated the viability of portable ultrasonography [26]. In this study, 38 patients underwent a FAST assessment by three retrieval doctors, with 36 receiving a full series. Two of the cases did not yield a cardiac view. Every image was captured while the aeroplane was in flight. Blinded medical reviewers found 143 of the 150 total photos to be sufficient. Technical challenges mentioned by the authors included having to get used to scanning with either hand (depending on which side of the cabin the patient was loaded), coordinating with the pilot to minimise issues with unexpected turbulence, and having little room available around fat individuals.

Sonography has been utilised by doctors on ground transport to increase the accuracy of their physical examinations, changing trauma management at the scene in one-third of cases [10]. In this study, 202 individuals were evaluated on the spot, and the average FAST assessment took less than 3 minutes to complete. Comparing the prehospital FAST evaluation to diagnoses made in the destination emergency room, it was discovered to be 93% sensitive and 99% specific. Medical professionals who scanned 302 individuals in the field discovered that their diagnostic accuracy increased in 90% of cases where there was initial diagnostic ambiguity and 67% of cases overall [8].

Cardiac evaluation and resuscitation

The effectiveness of using ultrasonography to evaluate circulation has been the subject of several research. A method for integrating bedside ultrasound into conventional advanced cardiac life support (ACLS) algorithms has recently been presented [27]. EMS providers in Germany and Italy have adopted this methodology into their prehospital cardiac examinations [15]. In a study of non-physician aeromedical crews, satisfactory examinations were obtained in 86 of 91 instances (94.5%) for cardiac activity and pericardial effusion. Although the study's sensitivity and specificity were both 100%, it was only able to identify an effusion in one patient, and no instances of cardiac standstill were noted. Regardless of the heart rhythm shown on the monitor, the absence of cardiac activity on bedside echocardiogram has been

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linked to a 100% death rate [28, 29]. In a recent case report, prehospital ultrasonography was used to identify pericardial tamponade in a victim with penetrating trauma [30]. In this case, ultrasound made clear that pericardiocentesis was necessary; spontaneous circulation resumed while the patient was being transported to the hospital. Soon after being transported to the hospital, a thoracotomy was carried out, and the patient lived. Thus, portable ultrasound may produce extra objective data that aid in prognosis and the efficient use of limited resources.

Medical illness

Numerous research have looked at the use of ultrasonography in non-traumatic sickness in addition to traumatic damage, which is still the most often investigated indication for EMS ultrasound. The effect of ultrasonography on clinical accuracy when carried out by medical professionals was investigated in a French study [8]: In this study, 169 patients underwent 302 scans, which included evaluations for pleural, pericardial, and peritoneal effusion, deep vein thrombosis, and "other" causes. Before and after utilising ultrasound on a particular patient, doctors rated their level of trust in their clinical evaluation on a visual analogue scale. To examine whether ultrasonography helped or hurt diagnostic assessment in each case, the final diagnosis (determined by confirmatory investigations following hospital evaluation) was compared to the clinical and ultrasound ratings. In the field, ultrasound evaluation was found to have a positive impact on diagnostic accuracy in 67% of cases, a negative impact in 8% of cases, and no effect in 25% of cases.

Obstetric patients being transported by air have made foetal monitoring difficult. Due to the surrounding noise, Doppler auscultation of foetal heart tones is frequently impractical during flight. The potential value of bedside ultrasound in the assessment of obstetric emergency was proven through a case series of obstetric patients being transported via helicopter. In this series, the authors discuss examples where bedside ultrasound was used to identify breech position, normal full-term gestation, and foetal distress (including bradycardic episodes and a shortage of amniotic fluid). Each time, the ultrasound changed how the patient was being managed [31].

Future directions

Mass casualty incidents

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In recent years, training for prehospital clinicians all over the world has increasingly centred on preparing for mass casualty crises (whether from natural or other disasters). It is crucial to triage casualties to the proper level of care or disposition; EMS providers frequently have to assess a large number of injured people quickly. Numerous research have looked into how ultrasonography can improve the current triage procedures used in multicasualty incidents.

Nearly 25,000 people were killed and over 150,000 were injured in an earthquake in Armenia in 1988 [32]. 750 victims were admitted to the biggest receiving hospitals in Yerevan, the capital city, within 72 hours of the incident. Many ultrasound equipment were used to perform trauma evaluations on admitted patients despite the fact that there was only one computed tomography (CT) scanner available; in this investigation, 530 ultrasound examinations were carried out on 400 patients. 96 of these patients had a pathogenic condition that was clinically meaningful. In this study, 16 patients were sent to the operating room as a result of physical examination and ultrasound results. If they were not cases of head injury, only three patients in the research underwent a CT scan as part of their evaluation; all other patients were treated using physical examination and ultrasound. The authors reported four instances of false-negative ultrasonography tests, including kidney rupture, retroperitoneal hematoma, subcapsular splenic hematoma, and an obese patient who had a hemothorax.

Another investigation into ultrasound use as a triage tool took place in the context of the 1999 earthquake in Turkey. 17,000 people were reported dead and more than 100,000 injured in this natural disaster [33]. In this investigation, nine patients with crush injury were evaluated by doctors using renal ultrasonography. Doppler ultrasonography was used to calculate the resistive index, a measurement of renal vasoconstriction. The resistance index was found to be higher in patients with acute crush injuries and to be associated with both the necessity of hemodialysis and the length of dependence on dialysis. Regarding fluid resuscitation and other treatment choices, ultrasound affected patient care.

A hand-held ultrasound device was delivered on-site by relief workers in the wake of mudslides that killed over 1,000 people in Guatemala [34]; 137 ultrasound tests were carried out on 99 patients. Numerous scans were carried out, including soft tissue, heart, thoracic, right upper quadrant, and pelvic images. According to the investigators, ultrasonography revealed an emerging problem in 12% of individuals. Ultrasound was able to rule out illness

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in 42% of individuals. Although this study was conducted during a natural disaster rescue effort, many patients were screened for non-acute illnesses; 23% of patients had illnesses that lasted less than 24 hours and 44% had illnesses that lasted longer than 14 days. As a result, it might be challenging to extrapolate all of the data to a serious multiple-casualty situation.

Injury Severity Score (ISS) was used to prioritise casualties at level I trauma centres during the Second Lebanon War [35]. In 102 out of 281 admissions with probable abdominal injuries, a FAST assessment was conducted. According to the authors, 28 hemodynamically stable patients were treated solely with ultrasound and did not undergo CT scan (based on the negative ultrasound and low suspicion for injury), while five hemodynamically unstable patients were taken for operative intervention based on a positive FAST examination. According to the authors, during multicasualty situations, ultrasonography was a helpful screening technique for choosing whether patients should be dispositioned to laparotomy, CT scan, or clinical observation. However, as the study was retrospective in nature, it should be noted that not every victim was examined with ultrasound.

Another retrospective study looked at the function of ultrasound as a supplement to the START mass casualty triage system [36]. Based on clinical factors such vital signs and the Glasgow Coma Scale, patients are classified as ambulatory (green), delayed (yellow), immediate (red), or expectant (black) in the START system. Each of the 570 patient charts from the trauma registry at a level I trauma centre was examined, and a START triage designation of yellow, red, or black was given to each patient. For 359 individuals, the results of the FAST examination were available; 27 were positive. The authors discovered that 22.2% of positive FAST examinations were false positives, which would have caused an overtriage of patients in the yellow category to the red category. 12.9% of the negative studies also contained erroneous negative results. This group would have been underutilised had we only used ultrasound.

Although it is challenging to draw conclusions from a retrospective study, the FAST assessment did not seem to be a useful tool for changing triage disposition. The number of ultrasound units needed to expedite triage judgments is a crucial concern addressing the use of ultrasonography in emergency situations [36]. When many patients were being evaluated, a single ultrasound operator would cause a triage bottleneck; as a result, many clinicians with

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multiple machines would need to be deployed in order to realise any time benefits from the technology.

The outcomes of retrospective evaluations have been inconsistent, and no controlled, prospective trials of the use of ultrasound in triage have been published. Although the technology shows potential for better field triage evaluation, it is challenging to determine the technique's utility given the most recent released data.

Telemedicine

Telemedicine, which enables doctors from distant locations (such base medical centres) to evaluate images and diagnostic data from EMS professionals on-scene or en route, is another developing field for prehospital treatment. The idea of picture data transmission from ambulances is not new; a research conducted in 1987 showed that 12-lead ECG transmission via a cellular network was feasible [37]. In the years that followed, ECG transmission, interpretation, and performance by EMS have all become customary and have been proven to improve patient care [38]. It was reported in 1996 [39] that remote assessment of in-hospital echocardiography studies relayed to laptop computers over regular telephone lines involved 187 examinations, of which 153 were abnormal and 19 had technical limitations. According to the authors, telemedicine laptop interpretation and conventional workstation interpretation agreed on 99% of the time.

In 2003, it was investigated whether real-time wireless transmission of ultrasound pictures was feasible [40]. Images from a FAST assessment were captured on an ambulance, wirelessly sent to a line-of-sight antenna, and then delivered via satellite for evaluation at a distant location. Line-of-sight (antenna) photos had comparable quality to those seen in person, according to the authors. When satellite-transmitted photos were viewed remotely, there was a 32% drop in still image quality and a 42% reduction in video clip quality.

In a different investigation, a 2.5-GHz spread-spectrum radio transmitter was used to transmit prerecorded heart images from an ambulance in the field [41]. At the base hospital, transmitted images were side-by-side compared in real time. The transmission of recorded, rather than live, images made it possible to compare image quality in a more precise manner. 32 tests were broadcast in this series while the ambulance was moving (at 50 to 75 mph). The best image quality scores were seen in the areas of left ventricular function, effusion, and

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inferior vena cava architecture (mean 97–100% equivalent to original movies). On transmitted pictures, however, the visualisation of valve structure (mean 27-60% equivalent) and wall motion evaluation (mean 13% equivalent) was poor.

In a research published in 2004 [42], echocardiograms taken in the field and transferred by wireless microwave signal to a satellite for off-site assessment, showed that image quality improved after transmission. In this investigation, formal echocardiography done using conventional, non-portable equipment as well as on-site pictures and 12 transmitted studies were compared. Technical quality (83%), left ventricle size (92%), pericardial effusion (100%), and ejection fraction (100%) received good reviews from blinded cardiologists reviewers.

CONCLUSION

We have observed a penetration of ultrasound use by non-physicians as bedside ultrasound usage moves from radiologists to non-radiologists. Applications for field ultrasonography may expand as factors like price, equipment size, and ease of use continue to advance. In order to inform treatment decisions, ultrasound may offer extra diagnostic data. Depending on how long it takes to get there and how well-trained the provider is in the ambulance or helicopter, this information may or may not be useful. Several studies are now being conducted to assess the effectiveness of prehospital ultrasonography; however, additional prospective, outcomes-based research are required to decide if prehospital ultrasound should be used more frequently.

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