ISSN: 2230-9926

Available online at http://www.journalijdr.com

IJDR

International Journal of Development Research
Vol. 10, Issue, 04, pp. 35081-35086, April, 2020

RESEARCH ARTICLE OPEN ACCESS

SYSTEMATIC REVIEW OF THE MAJOR APPROACHES TO THE USE OF PREHOSPITAL ULTRASOUND

Mariana de Almeida Lima[1], Manoel de Almeida Lima[2] and Idiberto José Zotarelli Filho[3,4*]

[1]Brazil University, Faculty of Medicine, Fernandópolis, SP, Brazil; [2]Mackenzie Evangelical College of Paraná, Medicine, Curitiba - PR, Brazil; [3]Doctor of the Zotarelli-Filho Scientific Work, São José do Rio Preto/SP, Brazil; [4]Bentham Science Ambassador, Brazil

ARTICLE INFO

Article History:
Received 19th January, 2020
Received in revised form
11th February, 2020
Accepted 26th March, 2020
Published online 29th April, 2020

Key Words:
Ergonomics; Productive efficiency; Strategic management; R&D.

****Corresponding author: Idiberto José Zotarelli Filho,***

ABSTRACT

Introduction: Point-of-Care Ultrasound (POCUS) hasbeen established as an ideal imagingmodality when used by clinicians trained in the clinical setting. Thus, sophisticated but relatively inexpensive handheld devices have also contributed to point-of-care ultrasound (POCUS) becoming the norm at the prehospital level. **Objective:** This study aimed to present, through systematic review, the main considerations about the use of ultrasound at the point of care at the prehospital level. **Methods:** The present study followed a systematic review model. After criteria of literary search using MeSH Terms, a total of 54 clinical studies were collated and submitted to the eligibility analysis and, after that, 16 studies were selected, following the rules of PRISMA. The search strategy was performed in the PubMed, Embase, Ovid and Cochrane Library, Web Of Science, ScienceDirect Journals (Elsevier), Scopus (Elsevier), OneFile databases. **Major Findings and Conclusion:** On-site ultrasound is spreading through Emergency Medicine, Critical Care, and Prehospital Care. However, there is an underlying inherited conflict with established specialties by conducting comprehensive examinations. Thus, in-service ultrasound in the light of disruptive innovation is a different perspective than ultrasound that had not been academically examined before. Therefore, it can be concluded that the ultrasound in the hospital can be implemented in several medical fields for bedside examination of patients, especially in the prehospital environment. Scientific evidence supports the fact that the addition of ultrasound technology in daily practice (portable ultrasound device), called by some 'future stethoscope', improves patient care and allows early diagnosis in a hospital setting.

Citation: ***Mariana de Almeida Lima, Manoel de Almeida Lima and Idiberto José Zotarelli Filho.*** "Systematic review of the major approaches to the use of prehospital ultrasound*", International Journal of Development Research*, 10, (04), 35081-35086.

INTRODUCTION

Point-of-Care Ultrasound (POCUS) ultrasound was established as an ideal imaging modality when used by emergency physicians trained in the clinical environment (Rooney, 2016). It can quickly and accurately diagnose many life-threatening conditions, including hemoperitoneum, pericardial effusion, cardiac tamponade, pneumothorax, and abdominal aortic aneurysm. In addition, POCUS offers portability, ease of use, speed and the provision of dynamic information in real-time without exposing patients to ionizing radiation. These attributes make POCUS an attractive tool in the prehospital setting (Vandemergel, 2019). In this sense, POCUS is especially useful in the setting of cardiac arrest. A previous study showed that all patients with cardiac arrest on the initial ultrasound die before leaving the emergency department.

Although the lack of cardiac movement has been shown to guide the interruption of resuscitation efforts in the hospital environment, no study has evaluated cardiac ultrasound in the prehospital environment (Miller, 2019). Although its application in the measurement of hemodynamics remains controversial, the technical aspects of image acquisition are not outside the limits of the skills of health professionals. Medical service providers are able to perform and interpret focused assessments with trauma ultrasound and effectively assess the lungs for pneumothorax (Quinn, 2016). In this context, in the USA today, 4% of prehospital services use ultrasound and 21% are considering their implementation. In addition, they can be used as a decision-making tool about the continuation or termination of resuscitation efforts. However, based on studies recommended by the American Heart

Association, echocardiography should be used as a complement to patient assessment. The point of service in the United States is less understood. In Europe and Australia, doctors in the prehospital environment have demonstrated the ability to identify treatable pathologies in most patients, but this is not established in the United States (De Marchi, 2017).

Thus, sophisticated, but relatively inexpensive, portable devices have also contributed to the point of care ultrasound (POCUS) becoming the norm at the pre-hospital level (Gottlieb, 2019). It was argued that ultrasound will become the next stethoscope for healthcare professionals. For this to become a reality, however, training is needed to increase familiarity with the correct use of the machine and transducers and to accurately interpret anatomy, followed by the identification of pathologies. Thus, using training sessions similar to those provided to doctors and medical students, numerous simulation studies have tested the paramedics' abilities to learn and retain US skills (Gottlieb, 2019). Therefore, POCUS is spreading through Emergency Medicine, Critical Care, and Prehospital Care. However, there is an inherited underlying conflict with established specialties, conducting comprehensive examinations. Thus, POCUS in the light of disruptive innovation is a different perspective than ultrasound that had not previously been examined academically.

Therefore, the present study aimed to present, by means of a systematic review, the main considerations about the use of ultrasound at the pre-hospital level of care.

MATERILAS AND METHODS

Study Design: The present study followed a systematic review model. After literary search criteria using the MeSH Terms that were cited in the item below on "Search strategies", a total of 64 clinical studies were compared and submitted to the eligibility analysis and, after that, 16 studies were selected (Figure 1), following the systematic review rules–PRISMA (Transparent reporting of systematic reviews and meta-analyses-http://www.prisma-statement.org/).

Search Strategy and Information Sources: The search strategy was carried out in the databases PubMed, Embase, Ovid and Cochrane Library, Web Of Science, ScienceDirect Journals (Elsevier), Scopus (Elsevier), OneFile (Gale) followed the following steps: - search by MeSH Terms: *Ultrasound. POCUS. Point-of-Care Ultrasound. Prehospital*, and the use of Booleans "and" between mesh terms and "or" among historical findings.

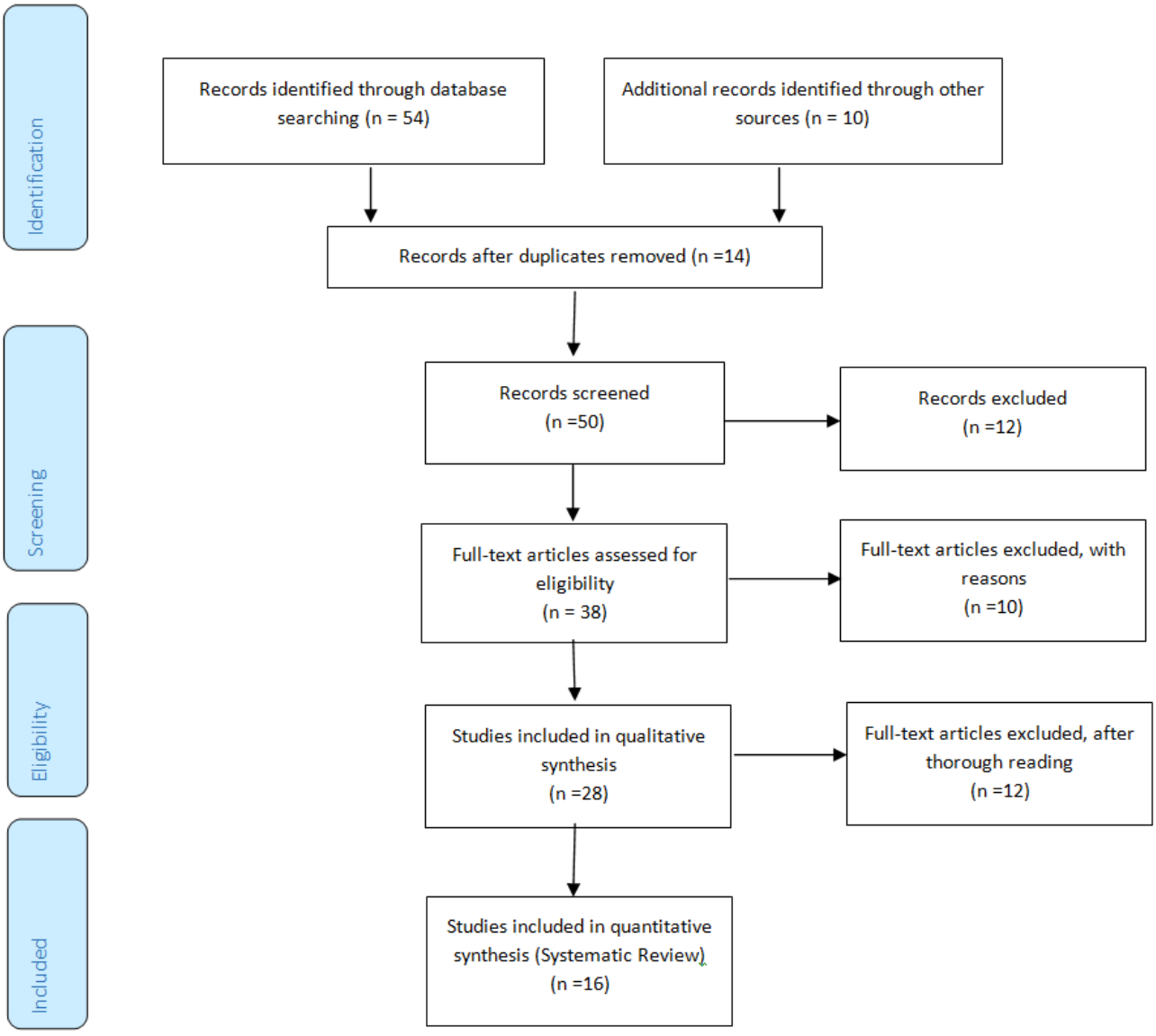

Figure 1. Flow Chart of the article selection process

Risk of Bias: According to the Cochrane model for the risk of bias in the present study, the global assessment resulted in 3 studies with a high risk of bias and 2 studies with uncertain risk. In addition, there was an absence of the funding source in 1 studies and four studies did not disclose information about the conflict of interest statement.

DEVELOPMENT AND DISCUSSION

Ultrasound is a well-established medical imaging technique, with pioneering work conducted by Professor Ian Donald and his colleagues at the University of Glasgow, starting in the mid-1950s, in terms of introduction as a diagnostic tool in the field of obstetrics and gynecology (Rooney, 2016). Since then, ultrasound has been widely used in clinical and research settings. There are few imaging techniques that have undergone such rapid and prosperous evolution since their development. Currently, diagnostic ultrasound benefits from two-dimensional (2D), three-dimensional (3D), four-dimensional (4D) and a variety of Doppler modes with technologically advanced transducers (probes) producing high anatomical fidelity images (Rooney, 2016). In the future, there may even be an ultrasound site on molecular images, allowing for microscale viewing. Ultrasound is characterized by non-invasive scanning in the real-time, relative ease of administration and lack of ionizing radiation. All of these features make ultrasound an attractive option in educational contexts for learning topographic anatomy and potentially improve future clinical practice for professional students (Vandemergel, 2019). In this context, sophisticated, but relatively inexpensive, portable devices have also contributed to making POCUS the norm for bedside and pre-hospital digitization. It was argued that ultrasound will become the next stethoscope for healthcare professionals. For this to become a reality, however, training is needed to increase familiarity with the correct use of the machine and transducers and to accurately interpret anatomy, followed by the identification of pathologies (Miller, 2019). The foregoing requires the incorporation of ultrasound teaching in undergraduate curricula, outside the field of opportunistic learning at the bedside, accompanied by ethical considerations, such as the management of accidental discoveries and a careful assessment of their pedagogical impact, transversal and longitudinally (Varsou, 2019).

In that sense, medical ultrasound has continued to spread to medical specialties and now has increasing roles in various hospital departments. This was exemplified by the rapid spread of the use of POCUS in resource-limited environments abroad. Although POCUS has been proven in numerous studies to be effective in the hands of trained physicians, it is believed that the technical aspects of imaging are easily acquired by basic health care providers and educated adults, with adequate training. Nurses, astronauts, and medical students have proven this concept in several studies (2019). In yet another study, paramedics have shown promise when learning to use POCUS in various simulation studies, however, real-world studies are scarce. British paramedics were able to obtain the technical skill of the US lungs at a threshold of fitness similar to specialist medical sonographers, with just 10 hours of training (Gottlieb, 2019). Despite these studies, there is no consensus on the use of POCUS and neither the amount of training for proficiency. One study determined whether emergency providers were able to identify cardiac anatomy and differentiate cardiac activity from cardiac arrest after just three hours of ultrasound training. Therefore, continuing education for paramedics will be necessary to continue to establish prehospital care. In addition, in patients who have critical time-sensitive conditions, POCUS may play a key role in reducing morbidity, mortality, and resources (Gottlieb, 2019). In this scenario, the major role of prehospital POCUS may be in both advanced cardiac life support and advanced trauma life support. With this, a doctor can see the patient and tangibly assess the etiology of cardiac arrest during the beginning of the intervention. Thus, adding POCUS to the clinical decision-making protocol can be useful in determining when to proceed or discontinue resuscitation based on cardiac activity (Gottlieb, 2019). Therefore, a prospective study analyzed as a primary outcome whether paramedics could perform cardiac ultrasound in the field and obtain adequate images for interpretation. A secondary endpoint was whether paramedics could correctly identify cardiac activity or lack thereof in patients with cardiac arrest. Eligible paramedics attended a 3-hour session at the point of care in the USA. Paramedics used ultrasound during emergency calls and saved tests for possible cardiac complaints, including chest pain, dyspnea, loss of consciousness, trauma or cardiac arrest. Four paramedics from two different firefighters registered a total of 19 unique patients, of which 17 were considered suitable for clinical decision-making (89%, 95% CI 67% -99%). Paramedics accurately recorded 17 cases of cardiac activity (100%, 95% CI 84% -100%) and 2 cases of cardiac arrest (100%, 95% CI 22% -100%). Therefore, with minimal training, paramedics can use ultrasound to obtain cardiac images suitable for interpretation and to diagnose cardiac arrest. More large-scale clinical trials are needed to determine whether pre-hospital ultrasound can be used to guide care for patients with cardiac complaints (Rooney, 2016). In this sense, a study evaluated the effectiveness of pulmonary ultrasound in non-traumatic respiratory failure. A case-controlled study was conducted in the most Vicentine area of ULSS 5 (Vicenza-Italy), with individuals with severe dyspnea caused by heart failure or acute exacerbation of the chronic obstructive pulmonary disease. Medication administration, oxygen delivery, and laboratory tests were compared between patients with integrated ultrasound treatment and those without ultrasound. Prehospital pulmonary ultrasonography showed high specificity (94.4%) and sensitivity (100%) for the correct identification of alveolar interstitial syndrome using B lines, while the percentages obtained with pleural effusion were lower (83.3, 53.3 %, respectively).

Patients with integrated ultrasound management received more appropriate pharmacological therapy (p 0.01), and noninvasive ventilation was used more frequently in those with acute exacerbation of chronic obstructive pulmonary disease ($p<0.011$). Laboratory tests and blood gas analysis were not significantly different between the two study groups. In a subanalysis of patients with profile A, a significantly lower concentration of PCO2 was observed in those with integrated ultrasound treatment (PCO2: 42.62 vs 52.23 p 0.049). According to the doctors' opinion, pre-hospital pulmonary ultrasound provided important information or altered therapy in 42.3% of cases, while only confirmed the physical examination in 67.7% of cases. Therefore, pre-hospital pulmonary ultrasound is easy and feasible, and the learning curve is fast. Our study suggests that heart failure and acute exacerbation of chronic obstructive pulmonary disease can be considered two indications for prehospital ultrasonography and can improve the treatment of patients with acute respiratory

failure (Zanatta, 2018). In addition, a randomized prehospital clinical study was carried out to compare two different techniques of insertion of a peripheral venous catheter (PVC) guided by ultrasound and the conventional cannulation technique in the prehospital emergency scenario, with a specific focus on the rate procedural success and in the time required to introduce the PVC. This prospective randomized controlled pre-hospital clinical trial allocated patients treated by an emergency medical service to undergo PVC insertion fully controlled by ultrasound (ultrasound guidance of the PVC tip until it penetrated the lumen, group A), partially controlled PVC insertion by ultrasound (target vein only identification, group B) or receiving PVC without ultrasound guidance (group C). The results of the study were monitored until the patient was admitted. A total of 300 adult patients were enrolled.

The success of the first attempt (group A: 88%, group B: 94%, group C: 76%, $p<0.001$) and overall success rate (A: 99%, B: 99%, C: 90%, $p <0.001$) was significantly higher in group A, followed by group B when compared to group C. The number of attempts was significantly lower (A: 1.18 ± 0.54, B: 1.05 ± 0.22, C: 1.22 ± 0.57, $p <0.001$) and the time required for the shortest procedure (A: 75.3 ± 60.6, B: 43.5 ± 26.0, C: 82.3 ± 100, 9 s, $p <0.001$) in group B compared to groups A and C. Therefore, both ultrasound-guided PVC techniques were associated with higher success rates than the conventional method. However, the insertion of PVC partially controlled by ultrasonography was superior to the complete orientation of ultrasonography in terms of the time and number of necessary cannulation attempts (Skulec, 2019). Further, a study provided a detailed review of the anatomy and an ultrasound-guided technique for placing the iliac fascia block. Recently, the placement of iliac fascia blocks has been used successfully in the emergency department of geriatric patients suffering from hip fractures through the monitoring of POCUS. This technique can be easily mastered with adequate training for use in the emergency room and in pre-hospital settings, reducing hip fracture pain and the associated risks of morbidity (Falyar, 2019). In this context, penetrating cardiac trauma to the left ventricle (LV) is a rare and serious injury. In cases of penetrating cardiac trauma, pre-hospital ultrasound by flight doctors can help identify specific pathologies. There are minimal cases reported in which pre-hospital ultrasound provided definitive diagnosis and, at the same time, provided pre-hospital blood transfusion. In 2017, in New South Wales, Australia, a new "Code Crimson" protocol was introduced to formalize a system-wide process, in which pre-hospital medical teams can streamline a direct approach (Hanley, 2019).

One study investigated whether POCUS is indeed a disruptive innovation. This is done by comparative analysis with the starting point in the theory of disruptive innovation known in the business world. Thus, it was discovered that a disruptive innovation process is taking place. This new knowledge made it possible to offer advice to interested parties in the field of ultrasound. It also made it possible to challenge the conventional knowledge pyramid used to describe different types of ultrasound. The perspective of this article was the mutual understanding of the similarities and differences between conventional ultrasound and the point of care. Only with this understanding, interested parties collaborated and used the entire spectrum of ultrasound for the benefit of the patient (Weile, 2018). Also, verifying the correct placement of the endotracheal tube (ETT) has been one of the most challenging issues of airway management in the field of emergency medicine. Early detection of esophageal intubation using a reliable method is important for emergency physicians. Thus, a prospective observational study evaluated the diagnostic accuracy of the rapid tracheal ultrasound examination (TRUE) to assess the loss of the endotracheal tube during emergency intubation. A consecutive selection of 100 patients was included. TRUE was performed for all of these patients and, subsequently, quantitative waveform capnography was performed. The subsequent test is considered the gold standard. Of the total of 100 eligible patients, 93 (93%) participants had positive TRUE results (tracheal intubation) and 7 (7%) patients had negative TRUE results (esophageal intubation). The quantitative report of the waveform capnography of all 93 (100%) patients who had TRUE positive was positive (adequate tracheal positioning). Sensitivity, specificity, positive predictive value and negative predictive value of TRUE to detect adequate ETT tracheal placement were 98.9% (95% CI, 93.3% to 99.8%), 100% (95% CI, 51 , 6% 100%), 100% (95% CI, 95.1% to 100%) and 85.7% (95% CI, 42% to 99.2%), respectively. Therefore, executing TRUE is convenient and feasible in many emergency departments and pre-hospital settings (Falyar, 2019).

Another study aimed to determine the effect of implementing POCUS using a systematic education program on image acquisition skills and the subsequent use and barriers in an anesthesiology department. Twenty-five anesthesiologists underwent a systematic education program at POCUS during the fall of 2012. A POCUS specialist evaluated baseline images and assessment tests performed on two healthy subjects as useful or not useful for clinical interpretation. In August 2016, anesthesiologists employed in the department answered a questionnaire about the use of POCUS and the perceived barriers to its use. The systematic education program increased the proportion of images useful for clinical interpretation from 0.70 (95% CI 0.65-0.75) to 0.98 (95% CI 0.95-0.99). This difference was significant when adjusted for previous courses of cardiac ultrasound, previous clinical experience of cardiac ultrasound, visualization by ultrasound and ultrasound model ($p <0.001$). After 3.5 years, 15/25 (60%) of perioperative medication providers, 22/24 (92%) of intensive care providers and 21/21 (100%) of prehospital care providers routinely used POCUS, in patients selected groups or sporadically. Therefore, the implementation of POCUS by a systematic education program increased the skills of image acquisition among anesthesiologists employed in the department. POCUS was used in the intensive care setting, in the pre-hospital setting and, to a lesser extent, in the perioperative setting. In addition, educational strategies to obtain images in difficult conditions, practical equipment, and evidence to affect patient outcomes are necessary for the complete implementation of POCUS (Bøtker, 2017).

Also in this sense, although radiography is the gold standard in the evaluation of orthopedic injuries, the use of ultrasonography at the bedside has several potential supremacies, such as avoiding exposure to ionizing radiation, availability in pre-hospital environments, being widely used. accessible and able to be used at the bedside. Thus, a prospective study, with patients aged 18 years or older, in stable hemodynamics, with a Glasgow coma scale 15 and signs or symptoms of a possible bone fracture in the extremities,

evaluated the diagnostic accuracy of ultrasound in the detection of bone fractures in ends. After the initial evaluation, ultrasonography of the suspected bones was performed by a resident trained in emergency medicine and the prevalence of true positive and false negative findings was calculated in comparison to simple radiology. 108 patients with a mean age of 44.6 ± 20.4 years (67.6% male) were studied. The analysis was carried out in 158 fracture sites, which were confirmed with simple radiography. It was suspected that 91 (57.6%) cases had a fracture (s) in the upper extremity and 67 (42.4%) had a fracture (s). The most frequent site of injuries was the forearm (36.7%) on the upper limbs and the leg (27.8%) on the lower limbs. The prevalence of true positive and false negative cases for fractures detected by ultrasound was 59 (64.8%) and 32 (35.52%) for the superiors and 49 (73.1%) and 18 (26.9%) for the lower limbs, respectively. In addition, the prevalence of true positive and false negative cases detected for intra-articular fractures was 24 (48%) and 26 (52%), respectively. Therefore, the present study shows moderate sensitivity (68.3%) of ultrasound in the detection of different bone fractures in the extremities. Ultrasonography showed the best sensitivity in detecting fractures of the femur (100%) and humerus (76.2%), respectively. However, it presented low sensitivity in detecting intra-articular fractures (Bozorgi, 2017). In addition, the use of POCUS by non-radiologists has increased dramatically. POCUS is completely different from routine radiological studies. POCUS is a physiological extension, on-site, of the clinical examination, unique and safe. A review work established the basic principles of the use of POCUS in the diagnosis of intestinal pathologies, in order to encourage doctors in intensive care to learn and master this important tool. It addressed POCUS-specific findings of the most common intestinal pathologies encountered by intensive care physicians, including acute appendicitis, epiploic appendagitis, acute diverticulitis, pseudomembranous colitis, intestinal tuberculosis, Crohn's disease, and colon tumors. Thus, a deep understanding of the basic physics of ultrasound and its artifacts is the first step in mastering POCUS. This helps to achieve an accurate diagnosis of POCUS and avoid its pitfalls. With the increase in skills, detailed and accurate POCUS results of specific intestinal pathologies can be achieved and adequately correlated with the clinical picture (Abu-Zidan, 2018).

Limitations

However, there are still few studies that evaluate the usefulness of POCUS in the prehospital environment. To date, there are no other portable imaging modalities that can achieve visualization of the heart during a cardiac arrest. Several studies have shown that POCUS minimally disrupts resuscitation efforts in critically ill patients and can potentially alter their results. Despite these advances, there is currently no widely recognized protocol that specifically addresses the immediate needs of pre-hospital service providers.

Conclusion

Therefore, it is concluded that ultrasound at the service location can be implemented in several medical fields for the patients' bedside examination, mainly in the pre-hospital environment. Scientific evidence supports the fact that the addition of ultrasound technology in daily practice (portable ultrasound device), called by some 'stethoscope of the future', improves patient care and allows for an early diagnosis in a hospital environment.

Acknowledgments and Funding: We would like to thank the Escritório Contábil Imperial of São José do Rio Preto, SP, Brazil for their encouragement and financial support.

Declaration of potential conflict of interest: The authors declare no conflict of interest.

REFERENCES

Abu-Zidan FM, Cevik AA. Diagnostic point-of-care ultrasound (POCUS) for gastrointestinal pathology: state of the art from basics to advanced. World J Emerg Surg. 2018 Oct 15;13:47. doi: 10.1186/s13017-018-0209-y. eCollection 2018.

Bøtker MT, Vang ML, Grøfte T, Kirkegaard H, Frederiksen CA, Sloth E. Implementing point-of care ultrasonography of the heart and lungs in an anesthesia department. Acta Anaesthesiol Scand. 2017 Feb;61(2):156-165. doi: 10.1111/aas.12847.

Bozorgi F, Shayesteh Azar M, Montazer SH, Chabra A, Heidari SF, Khalilian A. Ability of Ultrasonography in Detection of Different Extremity Bone Fractures; a Case Series Study. Emerg (Tehran). 2017;5(1):e15. Epub 2017 Jan 9.

De Marchi L, Meineri M. POCUS in perioperative medicine: a North American perspective. Crit Ultrasound J. 2017 Oct 9;9(1):19. doi: 10.1186/s13089-017-0075-y.

Falyar C, Tola D. Ultrasound-guided fascia iliaca blocks in the emergency department. Geriatr Nurs. 2019 Jul - Aug;40(4):441-444. doi: 10.1016/j.gerinurse.2019.07.007. Epub 2019 Jul 12.

Gottlieb M, Holladay D, Burns KM, Nakitende D, Bailitz J. Ultrasound for airway management: An evidence-based review for the emergency clinician. Am J Emerg Med. 2019 Dec 11. pii: S0735-6757(19)30816-2. doi: 10.1016/j.ajem.2019.12.019.

Hanley P, Holden J, Johnson T, Garner A, Weatherall A. Two cases of penetrating left ventricular cardiac trauma: Pre-hospital ultrasound and direct to theatre. Trauma Case Rep. 2019 Apr 13;21:100189. doi: 10.1016/ j.tcr.2019.100189. eCollection 2019 Jun.

Masoumi B, Azizkhani R, Emam GH, Asgarzadeh M, Kharazi BZ. Predictive Value of Tracheal Rapid Ultrasound Exam Performed in the Emergency Department for Verification of Tracheal Intubation. Open Access Maced J Med Sci. 2017 Jun 17;5(5):618-623. doi: 10.3889/ oamjms.2017.072. eCollection 2017 Aug 15.

Miller LE, Stoller JZ, Fraga MV. Point-of-care ultrasound in the neonatal ICU. Curr Opin Pediatr. 2019 Dec 13. doi: 10.1097/MOP.0000000000000863.

Quinn T, Price S. Where do we go with PoCUS? Resuscitation. 2017 Mar;112:A1-A2. doi: 10.1016/ j.resuscitation.2016.12.012. Epub 2016 Dec 19.

Rooney KP, Lahham S, Lahham S, Anderson CL, Bledsoe B, Sloane B, Joseph L, Osborn MB, Fox JC. Pre-hospital assessment with ultrasound in emergencies: implementation in the field. World J Emerg Med. 2016;7(2):117-23. doi: 10.5847/wjem.j.1920-8642.2016.02.006.

Skulec R, Callerova J, Vojtisek P, Cerny V. Two different techniques of ultrasound-guided peripheral venous catheter placement versus the traditional approach in

the pre-hospital emergency setting: a randomized study. Intern Emerg Med. 2019 Nov 7. doi: 10.1007/s11739-019-02226-w.

Vandemergel X. Point-of-care ultrasound (POCUS) for hospitalists and general internists. Acta Clin Belg. 2019 Dec 9:1-7. doi: 10.1080/17843286.2019.1703091.

Varsou O. The Use of Ultrasound in Educational Settings: What Should We Consider When Implementing this Technique for Visualisation of Anatomical Structures? Adv Exp Med Biol. 2019;1156:1-11. doi: 10.1007/978-3-030-19385-0_1.

Weile J, Brix J, Moellekaer AB. Is point-of-care ultrasound disruptive innovation? Formulating why POCUS is different from conventional comprehensive ultrasound. Crit Ultrasound J. 2018 Oct 1;10(1):25. doi: 10.1186/s13089-018-0106-3.

Zanatta M, Benato P, De Battisti S, Pirozzi C, Ippolito R, Cianci V. Pre-hospital lung ultrasound for cardiac heart failure and COPD: is it worthwhile? Crit Ultrasound J. 2018 Sep 10;10(1):22. doi: 10.1186/s13089-018-0104-5.

****