Research

Ultrasound applied to nursing in the Emergency Medical Service (EMS): a scoping review


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Abstract: Background. In recent years, ultrasound has represented a new field of application for nursing. Point of Care UltraSound (POCUS) has been defined as an essential skill in the pre-hospital setting. The primary objective of this scoping review is to describe what are the main ultrasound techniques applied by nurses in the pre-hospital emergency setting. The secondary objective is to identify the different training courses implemented in the various studies selected to learn the necessary ultrasound skills.

Methods. We conducted a scoping review. The following databases were consulted: PubMed, Cochrane Library, CINAHL and Google Scholar. For the extraction of useful articles, after identifying the inclusion and exclusion criteria, the PRISMA methodology was used, two authors independently analyzed the identified records, in the event of a conflict a third author intervened.

Results. The identified records were initially 815. After the duplicates removal, and screening made by the researcher for inclusion criteria, 6 articles were retrieved for qualitative analysis. The most discussed topic is the recognition of pneumothorax, two studies analyze a specific educational program on ultrasound for flight nurses, three articles evaluate the possibility of verifying the correct insertion of devices and two analyze the skills of nurses in performing ultrasound scans: nurses have an accuracy in performing ultrasound scans equal to 86%, a sensitivity between 60% and 66% and a specificity between 93% and 100%.

Conclusions. Despite the methodological differences of the selected records, the main ultrasound techniques implemented by nurses in the Emergency Medical Service (EMS) are Focused Assessment with Sonography for Trauma (FAST), Extendend Focused Assessment with Sonography for Trauma (E-FAST),
Introduction
In recent years ultrasound has represented a new field of application for nursing. The non-invasive approach, the repeatability and the low cost have allowed a rapid diffusion mainly and initially in the intra-hospital environment for the Point-of-care ultrasound (POCUS) (1), the intravenous catheters’ insertion (2) and the assessment of bladder and fluid status (3), while, again at the healthcare level, ultrasound has only recently begun to take its first steps in the Emergency Medical Service (EMS). POCUS has been defined as one of the skills on which to mainly invest in research and training in the pre-hospital setting (4). “The Emergency Medical Service’s nurses are professional whom, in possession of the requirements of current legislation, serves in the rescue team independently or in collaboration with other health professionals, members of the same team; implements interventions aimed at maintaining, restoring and supporting vital functions and provides health care using nursing intervention procedures and algorithms, guaranteeing their correct application to the patient” (5). EMS nurses must be trained and able to implement advanced interventions on the patients’ rescue aimed at restoring and maintaining their vital functions (6). In pre-hospital setting, in the delicate and often complex management of severely ill patients, there is the possibility of assessing patients using ultrasound techniques to better understand their signs and symptoms.

The literature in the EMS setting regarding ultrasound performed by nurses, is today very poor, so it is necessary to investigate in-hospital studies to have a start point. A 2010 study comparing the results obtained from the performance of different ultrasound techniques used by nurses working in Emergency Departments (ED) and physicians working in the same area showed that “nurse practitioners” can perform a focused ultrasound examination with a high degree of accuracy (7). The same accuracy in ED is found in the implementation of the Extended Focused Assessment with Sonography in Trauma (E-FAST) by nurses when compared with the medical staff (8). The care to the patient in the pre-hospital setting consists in the assessment and treatment aimed at resolving the condition that put the patient in imminent danger of life, then a continuous observation of the clinic for any new interventions or action changes. The ultrasound aid allows the healthcare professionals to increase the quality of the assistance provided, also impacting the healthcare system, reducing its costs (9). Some literature reviews stressed the importance of ultrasound in the assessment of patient in the pre-hospital setting (4, 10, 11), even if it is considered necessary to deepen the topic regarding the efficacy of assessment by ultrasound analyzing the outcome of rescued patient (12, 13). Despite EMS nurse-led sonography is poorly analyzed, there are more studies involving the execution of ultrasound scans by technical personnel (Emergency Medical technicians - EMT) or paramedics, as dedicated training courses already exist in other countries (14, 15, 16). A pilot study states that, with close supervision, paramedics can correctly obtain and interpret the Focused Assessment with Sonography in Trauma (FAST) and abdominal aortic ultrasound exams (17). Additionally, technical and paramedical staff perform chest ultrasound scans with adequate and sufficient image quality to determine whether or not pathology is present (18). Even in the case of cardio-circulatory arrest, EMTs perform a correct cardiac ultrasound to evaluate the contractile activity of the heart (19).

Aim
The primary objective of this scoping review is to describe what are the main ultrasound techniques applied by EMS nurses in the pre-hospital emergency setting. The secondary objective is to identify the different training courses that have been adopted in the various studies selected to learn the necessary ultrasound skills.

Keywords: Pre-hospital; Setting; Care; Emergency; Medical service; Nurse; Ultrasound; Sonography; Sonographer.
Methods
After a background analysis of the literature, research was conducted using the scoping review, a methodology useful for exploring a topic that has not yet been particularly developed (20, 21). The approach chosen involved the use of the PICO methodology (22), as represented in (table No. 1).

The keywords deriving from the PICO and used were the following:
- pre-hospital, setting, care, emergency, medical service;
- nurse;
- ultrasound, sonography, sonographer.

The database search included the following search engines: PubMed, Cochrane Library, CINAHL, and Google Scholar. Search limits and strings are shown in (table n° 2).

The selection of the articles, according to the PRISMA methodology (23), took place through the identification of inclusion and exclusion criteria defined below:

<table>
<thead>
<tr>
<th>Criteria</th>
<th>Description</th>
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<tbody>
<tr>
<td><strong>Inclusion Criteria</strong></td>
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<tr>
<td>Pre-hospital setting</td>
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<tr>
<td>Application of ultrasound techniques</td>
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<td>Implementation by the nurse</td>
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<tr>
<td><strong>Exclusion Criteria</strong></td>
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<tr>
<td>In-hospital setting</td>
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<td>Military setting</td>
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<td>Studies on mannequins / simulators</td>
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<tr>
<td>Execution of the ultrasound by other professional or rescue technicians</td>
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<tr>
<td>Qualitative studies</td>
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<tr>
<td>Gray literature</td>
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The consultation of the databases took place on 2 August 2021 and the review was carried out in parallel by two independent researchers. Any conflicts were analyzed and resolved by a third member of the research team.

The selected articles were then represented through the use of a table showing the following topics of interest:
- Title, author, year;
- Country where the study is conducted;
- Study methodology;
- Population performing ultrasound;
- Education;
- Ultrasound techniques described;
- Results;
- Conclusions.

<table>
<thead>
<tr>
<th>Database</th>
<th>Search Strategy</th>
<th>Limits</th>
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<tbody>
<tr>
<td>PubMed</td>
<td>(prehospital or “prehospital setting” or “prehospital care” or “prehospital emergency” or “emergency medical service”) AND (nurse or nursing or nurses) AND (ultrasound or US or sonography or sonographer)</td>
<td>Text availability: 10 years; Publication date: 10 years; English language; Full text.</td>
</tr>
<tr>
<td>Cochrane Library</td>
<td>(prehospital or “prehospital setting” or “prehospital care” or “prehospital emergency” or “emergency medical service”) AND (nurse or nursing or nurses) AND (ultrasound or US or sonography or sonographer)</td>
<td>Text availability: 10 years; Publication date: 10 years; English language; Full text.</td>
</tr>
<tr>
<td>Google Scholar</td>
<td>Prehospital and nurse and (ultrasound or sonography)</td>
<td>Text availability: 10 years; Publication date: 10 years; English language; Full text; Scientific articles.</td>
</tr>
<tr>
<td>CINAHL</td>
<td>(prehospital or “prehospital setting” or “prehospital care” or “prehospital emergency” or “emergency medical service”) AND (nurse or nursing or nurses) AND (ultrasound or US or sonography or sonographer)</td>
<td>Text availability: 10 years; Publication date: 10 years; English language; Full text.</td>
</tr>
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</table>

Table n°2
Results

As shown in table n° 2, 815 records were found, after the removal of the duplicates, they were reduced to 810 and then screened. The remaining studies and evaluated according to the eligibility criteria are 17, among these 11 articles were discarded for the following reasons:
- the population did not belong to the pre-hospital setting;
- ultrasound was not practiced by nurses.

The results are represented through the Prism Flow Diagram as in figure n° 1.

Records identified through database search
(N = 70) PubMed
(N = 57) Cochrane
(N = 632) Google Scholar
(N = 56) CINAHL

Record after removing duplicates:
(N = 810)

Records excluded by title and abstract
(N = 793)

Selected Records:
(N = 810)

Full-text articles assessed for eligibility criteria
(N = 17)

Full-text articles excluded:
Population not belonging to the pre-hospital setting (N = 3)
Ultrasound not performed by nurses (N = 8)

Studies included in the scoping review
(N = 6)

The articles selected for qualitative analysis were 6 and are represented in table No. 3.

The objectives of the records analyzed are: to evaluate if ultrasound assistance can contribute to the correct initial evaluation of the patient by helicopter rescue nurses and describe the theoretical/practical educational program (24), to implement an ultrasound program for the evaluation of pneumothorax and endotracheal intubation by helicopter rescue nurses (25), establish whether non-medical personnel could acquire lung images and interpret them with sufficient accuracy in order to identify pneumothorax in the pre-hospital setting (26),
define whether adequate use of ultrasound in the pre-hospital setting may play a key role in improving patient outcome (27), assessing accuracy in ultrasound detection for the correct positioning of the nasogastric tube (NGT) (28) and examining the use of pre-hospital ultrasound in trauma patients (11).

All the included studies analyzed nurse-led ultrasound used on patients in the pre-hospital setting.

The study by Cover et al. (24) conducted in the United States (USA) aimed at the realization of an educational program useful for the use of ultrasound in the pre-hospital setting by the flight nurse (FN), according to what the authors reported, it was done a four-months course with five didactic and practical sessions of two hours each, passing the course is determined by the ability to acquire at least 10 valid ultrasound images. The skills acquired by the FNs include the ability to recognize pericardial tamponade, the functionality of the left ventricle, the difference between pulmonary A and B lines, the caliber of the inferior vena cava and correct execution of an E-FAST. The authors conclude by saying that nurses are more likely to use ultrasound if they are unsure of the initial evaluation.

The study by Mason et al. (25), also carried out in the USA, was intended to describe the implementation of an ultrasound curriculum aimed at FNs for the identification of pneumothorax and as a guide in the tracheal tube insertion. The training course consists of 3 sessions of one hour each over two months; the course is completed by a pre-test and a post-test of 15 questions each with the aim of improving skills in the recognition of pneumothorax and the correct positioning of the Endotracheal tube (ETT). At the end of the course, the ability to answer clinical questions was improved through the use of the ultrasound.

The Scandinavian study by Ronaldson et al. (26) is intended to assess the ability of non-medical personnel to provide an accurate diagnosis of pneumothorax by ultrasound. The observational study analyzed the work of the Advance Retrieval Practitioner (ARP), a figure covered by a nurse or paramedic operating in recovery operations. ARP has 86.4% accuracy, 66.6% sensitivity and 100% specificity in using ultrasound. The authors assert that non-medical personnel are capable of acquiring ultrasound images that are valid in evaluating pneumothorax in the pre-hospital setting.

The review by Sun JT et al. (27) discusses the use of pre-hospital ultrasound, focusing on thoracic ultrasound. It was possible to identify among the sources treated the reference to a course aimed at FNs and paramedics about the use of the FAST method. This 7-hour frontal teaching course, after one year of practice, allows ultrasound performers a sensitivity and specificity of 100% in non-traumatized patients and a sensitivity of 60% and a specificity of 93% in trauma patients. The use of ultrasound in the pre-hospital setting can be fundamental in improving the patient's outcome.

The review by Lin T et al. (28) selected articles written in France, China and Korea, it is a review that summarizes the best evidence regarding the diagnostic accuracy of the ultrasound to determine the correct positioning of the NGT in adult patients. The correct positioning of the NGT used for gastric decompression in the case of cardiopulmonary resuscitation (CPR) in the pre-hospital setting, where it is not possible to perform an X-ray, can be verified through the use of the ultrasound. According to the authors, it is possible to use the technique in order to evaluate the correct positioning of the NGT, but the evidence is not such as to support this procedure.

The latest study analyzed is the one by Mercer et al. (11) which compares the use of the ultrasound by different operators on traumatic patients. The study compares multiple training programs for nurses: a one-day course on the FAST method, another 2-month course for nurses without ultrasound experience, one for FNs consisting of 8 hours didactics and 4 h of clinical practice followed by a standardized examination and the execution of 5 POCUS per month for the maintenance of skills and a last course aimed at FNs for the execution of the thorax’s ultrasound. According to Mercer et al (11), the use of ultrasound in a pre-hospital setting influences the transport and the destination hospital, without however evaluating the patient's outcome. Again, according to the author, there is no difference in the evaluation of the patient by ultrasound if it's performed by medical personnel or non-medical personnel.
<table>
<thead>
<tr>
<th>Author(s)</th>
<th>Year of publication</th>
<th>Aim</th>
<th>Country</th>
<th>Design</th>
<th>Healthcare professional using ultrasound</th>
<th>Training</th>
<th>Ultrasound techniques</th>
<th>Results</th>
<th>Conclusions/ findings</th>
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<tr>
<td>Cover et al. (2019) (35)</td>
<td>To describe the creation of a Flight Nurse (FN) US program and to evaluate whether critical care US performed by FNs in the pre-hospital and interhospital setting can clarify patient assessment</td>
<td>Michigan, United States</td>
<td>Prospective cohort study</td>
<td>Helicopter rescue nurses.</td>
<td>The nursing training course was conducted for a period of 4 months; it included 5 didactic and practical sessions of 2 hours each. Each nurse was required to obtain 10 valid ultrasound images on healthy volunteers</td>
<td>Pericardial tamponade and effusion, systolic function of the left ventricle, difference between lines A and lines B, identification of pleural slip, evaluation of the caliber of the inferior vena cava, E-FAST.</td>
<td>Over a period of 14 months, the helicopter rescue nurses evaluated 829 patients and used ultrasound on 102 patients (12.3%). It was confirmed that the use of ultrasound clarified the semeiotics in 67.4% of the transported patients</td>
<td>Helicopter rescue nurses are more likely to use ultrasound when they are not confident in their initial evaluation, especially in cases of respiratory failure, evaluation of heart function, amount of circulating blood volume.</td>
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<td>Mason et al. (2018) (36)</td>
<td>To describe the implementation of an ultrasound curriculum for the identification of pneumothorax and esophageal intubation for flight registered nurses.</td>
<td>Washington, United States</td>
<td>Prospective cohort study</td>
<td>Helicopter rescue nurses.</td>
<td>The training course was conducted for a period of 2 months, 3 training sessions of 1 hour each were planned. Nurses underwent a 15-question test before the training course and a 15-question test following it.</td>
<td>Pneumothorax assessment by ultrasound technique and esophageal ultrasound to confirm correct endotracheal tube insertion.</td>
<td>A total of 12 flight nurses participated in the study. In a test with a score of 0 to 15, the mean and median pretest scores were 6.8 and 7, respectively. For the same 15 questions, the mean and median post-test scores were 13.6 and 14, respectively. The mean pre-test corrected percentage was 45.0%, while the post-test was 90.6%. The training intervention resulted in an average percentage improvement of 45.6%, or 6.8 questions.</td>
<td>The short training session improved the flight nurses' ability to answer targeted clinical questions using ultrasound. No conclusions can be drawn about the practical abilities of ultrasound or the long-term effectiveness of education. It is believed that further research on the implementation of ultrasound in the American aviation medical system should continue.</td>
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<td>Ronaldson et al. (2020)</td>
<td>(37)</td>
<td>To assess the feasibility of nonphysicians working within a UK pre-hospital service to undertake pre-hospital ultrasound pneumothorax diagnosis in a live clinical environment, and assess the accuracy of the pneumothorax diagnosis</td>
<td>Scandinavia</td>
<td>Observational study</td>
<td>Advanced retrieval practitioners (ARP). It is a nurse or paramedic who has gained a substantial amount of experience working in primary and secondary retrieval; including critical care aeromedical transfers</td>
<td>Not specified</td>
<td>Evaluation of the pneumothorax</td>
<td>The study was conducted for a period of 13 months and a total of 87 patients were subjected to the ultrasound examination; images of 12 patients were included in the analysis. Of the 12 chosen, 50% were non-traumatic patients, and the other 50% traumatic. Overall, the study showed that ARPs had 86.4% accuracy, 66.6% sensitivity and 100% specificity compared to the expert review.</td>
<td>Non-medical personnel, including nurses, can perform appropriate ultrasound images to ascertain the presence or absence of a pneumothorax in a pre-hospital setting.</td>
</tr>
<tr>
<td>Sun JT et al. (2014)</td>
<td>(38)</td>
<td>To review and to discuss the use of prehospital ultrasound, with emphasis on trauma and chest ultrasound</td>
<td>/</td>
<td>Narrative review</td>
<td>Pre-hospital emergency nurses.</td>
<td>A revised record deals with a 7-hour training course was carried out to improve theoretical and practical skills about the FAST ultrasound.</td>
<td>Thoracic ultrasound for the recognition of pneumothorax, verification of the correct positioning of the endotracheal tube, pulmonary edema at high altitude, pericardial effusion / tamponade, pulmonary embolism, cardiac arrest, E-FAST.</td>
<td>Adequate use of prehospital US in critical patients may play a key role in improving patient outcome.</td>
<td>Adequate use of the ultrasound system in the pre-hospital setting can play a key role in improving the outcome of the critically ill patient. In addition, following the FAST training course, nurses reported 100% sensitivity and specificity in non-trauma patients and 60% sensitivity and 93% specificity in trauma patients after one year of training.</td>
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<tr>
<td>Author(s)</td>
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<td>Lin T et al.</td>
<td>(2017) (39)</td>
<td>To synthesize the best available evidence concerning the diagnostic accuracy of ultrasonography for determining NGT placement after insertion in adults.</td>
<td>France, China, Korea.</td>
<td>Systematic review and meta-analysis of observational studies.</td>
<td>Pre-hospital emergency nurses and other professionals.</td>
<td>Not specified.</td>
<td>Ultrasound in visualizing the correct positioning of the NG tube</td>
<td>Ultrasoundography diagnostic performance may be considered clinically useful to confirm correct nasogastric tube (NGT) placement, although there is insufficient evidence to suggest ultrasound as a diagnostic tool for incorrect NGT placement.</td>
<td>The ultrasound system allows professionals to confirm the correct positioning of the NG tube, even if there is insufficient evidence to suggest ultrasound as a diagnostic tool for its incorrect positioning.</td>
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<tr>
<td>Mercer et al.</td>
<td>(2020) (11)</td>
<td>To examine the use of pre-hospital ultrasound for trauma patients and the use by different provider types</td>
<td>/</td>
<td>Systematic review.</td>
<td>Pre-hospital emergency nurses and other professionals.</td>
<td>Several training courses were performed: a 1-day course of FAST was performed for nurses; 2-month training for nurses without knowledge of ultrasounds; flight crew members (nurses and paramedics) trained for the execution of the thorax US; a 4 h of clinical practice preceded by 8 h of theory for flight nurses.</td>
<td>FAST and E-FAST in the trauma patient, ultrasound evaluation of the pneumothorax and the correct positioning of the endotracheal tube. From 16 selected studies, Professionals performed ultrasound which with the following results: pre-hospital ultrasound influenced patient treatment in 23% of cases, provided additional information to the hospital in 4.6% of cases, changed the mode of transport in 0.7% of cases and changed the choice of destination in 0.7% of cases.</td>
<td>Ultrasound in the pre-hospital environment influences both the mode of transport of patients and the choice of the hospital; but it is not indicated whether this led to a change of the outcome; moreover, a study states that there is no substantial difference in the evaluation of the patient in the ultrasound performed by medical personnel compared to that performed by non-medical personnel.</td>
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The studies analyzed have substantial differences regard to the country where the study was conducted, as well as to the method of the same.

Discussion

The ability to recognize pneumothorax was addressed by 5 of the 6 analyzed records, the topic is probably so much dealt with as it is the second most frequent injury in thoracic trauma (29) and needs early recognition and treatment (27, 29). This is considered a fundamental skill for FNs, in fact the educational programs aimed at them specifically include this topic (25,26). The importance of recognizing a pneumothorax is also addressed by Ronaldson et al. (26) which concludes by saying that the correct assessment of pneumothorax improves patient safety and reduces mortality, therefore ambulance personnel must also be able to assess it. The last record to deal with the topic mentions it exclusively as an objective in the use of ultrasound, not specifying particular educational interventions for nurses (11).

Another application of the ultrasound has been identified in the evaluation of the correct devices' insertions: it is the confirmation of the correct insertion of the ETT (11, 25, 27) and the verification of the correct insertion of the NGT in the prehospital field for adequate gastric decompression in the event of CPR (28).

In three studies it is discussed EMS nurse-led FAST and E-FAST (11, 24, 27); they deal with the importance of the same in order to have additional information and choose the most appropriate destination in relation to the patients’ condition. These techniques allow to significantly reduce the hospitalization and treatment times of traumatized patients (30). Specifically, through the FAST and E-FAST method, the three articles dealt with this topic defining it of priority importance in order to be able to make a quick distinction between a critical patient and a non-critical one, in order to be able to direct him to the most suitable hospital and to early alert in-hospital trauma team (11, 24, 27). Furthermore, Storti et al. argue that certain diseases require immediate treatment on the spot and the use of ultrasound could help in early identification of the potentially reversible causes that make a critical patient as such anticipating the times of traditional diagnostics (26), also El Sayed et al. declare that adequate use of ultrasound would allow an identification of the most suitable center for treatments, in order to avoid delays of care that can often be the cause of irreversible damage (31).

It should be emphasized that this method can influence the decision-making process regarding the choice of means of transport, such as a vehicle on the ground or a vehicle in flight (32). Ultrasound is to be considered an element of the physical examination (33).

As for the explored educational programs, they remain various. The analyzed records take into consideration a small nursing population and the ability to perform accurate long-term ultrasound scans remains to be investigated. In addition, o the variable duration of trainings of 3, 7 or 10 hours (24, 25, 27), up to more articulated courses in terms of didactic and practical lessons (11), the trainings have different assessment methods: for example, the ability to obtaining valid ultrasound images in healthy patients (24) or performing ultrasound scans during clinical practice on patients with real problems, making the ultrasound more realistic (26), are some of the methods used. Since a meta-analysis was not performed, it is not possible to indicate the effectiveness of the programs and possibly which is the best in order to train nurses capable of performing valid ultrasound scans.

It is necessary to underline some limits of the study: first of all, the scarcity of articles in the literature specific to the topic of nursing ultrasound in the pre-hospital setting which, being a field of recent interest, does not allow adequate comparison, unlike what stated by Botker et al. (4) which states that the literature on pre-hospital ultrasound, carried out in this case by physicians, has seen an important increase in publications in the last decade. Secondly, the methodological differences of the selected and analyzed records represent a limit that must also be taken into consideration. A final limitation is represented by the settings from which the studies originated as the nurse professional derives and develops in different socio-political and educational contexts.

Conclusions

From what it has been possible to analyze, the authors of the identified articles tend to declare that ultrasound techniques represent a valid tool for the EMS nurses in the assessment and management of the patient rescue. The executive methodology of the individual studies is not such
as to allow a correct comparison between them, therefore it is not possible to verify the quality of the educational programs applied, especially if it is wanted to know the effectiveness of the same in the long term, a topic mostly not analyzed. Surely the nursing ultrasound in the pre-hospital setting is a novelty worthy of further study both in terms of its applicability, as well as the educational program and the improvement of patient outcome.

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References


