REVIEW ARTICLE

Current evidence on the use of pocus in the diagnosis of pneumothorax in emergency rooms: a systematic review

Fábio Flores Nani[1,2*], Silvio Oscar Noguera Servin[2,3], Ana Carolina da Costa Reis[2], Tayanne Jaques[2]

[1] Vitta Clinic- Rua José de Paula Andrade, Itatiba, São Paulo, Brazil.
[2] Postgraduate student in Emergency Medicine from the IPEMED Faculty of Medical Sciences, Brazil.
[3] Discipline of Urgency and Emergency Faculty of Medicine São Leopoldo Mandic, Araras, Sao Paulo, Brazil.

*Corresponding author: Dr. Fabio Flores Nani.
Vitta Clinic- Rua José de Paula Andrade, 137 -
CEP 13256-320 – Itatiba, São Paulo, Brazil.
E-mail: drfabionani@gmail.com

Abstract

Introduction: Point of Care Ultrasound (POCUS) is currently recognized as useful and, in some cases, mandatory, such as during invasive procedures. Its bedside application includes differential diagnosis and therapeutic management of complex clinical conditions during hemodynamic instability. The emergence of portable devices with superior image quality and their applicability in emergency rooms and intensive care units has demonstrated high diagnostic effectiveness. **Objective:** It was to highlight the use of POCUS in the diagnosis of pneumothorax in emergency rooms, through a systematic review of meta-analytic articles, systematic reviews, and observational studies from the last 11 years (2012 to 2023). **Methods:** The PRISMA Platform systematic review rules were followed. The search was carried out from October to December 2023 in the Scopus, PubMed, Science Direct, Scielo, and Google Scholar databases. The quality of the studies was based on the GRADE instrument and the risk of bias was analyzed according to the Cochrane instrument. **Results and Conclusion:** A total of 127 articles were found, 43 articles were evaluated in full and 31 were included and developed in the present systematic review study. Considering the Cochrane tool for risk of bias, the overall assessment resulted in 22 studies with a high risk of bias and 26 studies that did not meet GRADE and AMSTAR-2. Most studies did not show homogeneity in their results, with X^2=61.5%>50%. It was concluded that the POCUS method is operator-dependent and has greater sensitivity (78 to 90%) and specificity greater than 98% in chest radiography. However, when performed correctly by trained professionals, following protocols, it proved to be useful for identifying and treating pneumothorax. POCUS is a portable, fast, and low-cost bedside examination that does not involve ionizing radiation, in addition to identifying a precise location for performing thoracentesis in cases of pneumothorax, which assists clinical physicians in urgent and emergency rooms, as well as in external environments such as rescue helicopters. There is a consensus among the authors researched that, to obtain clinical evidence on the use of POCUS in the diagnosis of pneumothorax, more randomized controlled studies are necessary, which reinforce the use of this versatile equipment in different urgent and emergency scenarios.

Keywords: Pneumothorax. Ultrasound. Automated Bedside Assistance Systems.

Introduction

Ultrasonography has been used as an imaging test for more than 50 years. The diagnosis and management of respiratory diseases were limited, until recently, by the presence of air in the respiratory tract and solid structures in the rib cage, which prevented the passage of ultrasound waves and thus created image artifacts, characterizing a variety of pathologies of clinical interest [1-3]. Such artifacts are generated by the pleura, due to a difference in acoustic impedance between the air in the lung and the superficial tissues [4-6].

In an emergency room, adapting ultrasound equipment has always been a challenge, as it takes up space and usually needs to be operated by a specialist radiologist. When evaluating pleural diseases in cases of acute dyspnea, it is essential to have a rapid, bedside examination [3,4]. With the advent of Point of Care Ultrasound (POCUS) also called bedside ultrasound examination in emergency rooms comparing this method with chest radiography and computed tomography [7-10].

It is a small probe that allows easy intercostal access and the high-frequency linear array transducers (7.5 to 12 MHz) provide the highest spatial resolution, with limited penetration in obese patients or large-volume effusions. but essential in the detection of intracavitary fluid, cardiac tamponade, and detection of pneumothorax [11,12]. POCUS images can be generated on cell phone and tablet screens [13].

POCUS even favors access to specialties from other locations via telemedicine, making this bedside diagnostic method a diagnostic tool for use by any qualified doctor and not just radiologists [14,15]. The expanded use of POCUS allows for diverse interventions, in addition to urgency and emergency rooms such as rescue helicopters, where noise is a preponderant factor in the interpretation of lung auscultation [16].

Therefore, the present study highlighted the use of POCUS in the diagnosis of pneumothorax in emergency rooms, through a systematic review of meta-analysis articles, systematic reviews, and observational studies from the last 11 years (2012 to 2023).

Methods
Study Design
The present study followed the international systematic review model, following the rules of PRISMA (preferred reporting items for systematic reviews and meta-analysis). Available at: http://www.prisma-statement.org/?AspxAutoDetectCookieSupport=1. Accessed on: 10/17/2023. The methodological quality standards of AMSTAR-2 (Assessing the methodological quality of systematic reviews) were also followed. Available at: https://amstar.ca/. Accessed on: 10/17/2023.

Data Sources and Research Strategy
The databases searched followed the criteria of meta-analyses, systematic reviews, and observational studies from the last 11 years (2012 to 2023) of the search engines: PubMed, Open Journal of Emergency Medicine (OJEM), VHL, Scielo, The American Journal of Emergency Medicine (TAJED), Oxford University Research Archive (ORA), Google Scholar website and

ELSEVIER. The descriptors (MeSH Terms) were used: *"Pneumothorax. Ultrasound. Automated Bedside Assistance Systems"*, and using the Booleans "and" between MeSH terms and "or" between historical findings. The ZOTERO software was used to classify and check duplicate bibliographies [17].

Study Quality and Risk of Bias
Quality was classified as high, moderate, low, or very low in terms of risk of bias, clarity of comparisons, precision, and consistency of analyses. The most evident emphasis was on systematic review articles or meta-analyses of randomized clinical trials, followed by randomized clinical trials. The low quality of evidence was attributed to case reports, editorials, and brief communications, according to the GRADE instrument. The risk of bias was analyzed according to the Cochrane instrument by analyzing the Funnel Plot graph (Sample size versus Effect size), using the Cohen test (d).

Results and Discussion
Summary of Findings
A total of 127 articles were found that were subjected to eligibility analysis, with 31 final studies being selected to compose the results of this systematic review. The studies listed were of medium to high quality (Figure 1), considering the level of scientific evidence of studies such as meta-analysis, consensus, randomized clinical, prospective, and observational. The biases did not compromise the scientific basis of the studies. According to the GRADE instrument, most studies showed homogeneity in their results, with $X^2=61.5\% > 50\%$. Considering the Cochrane tool for risk of bias, the overall assessment resulted in 22 studies with a high risk of bias and 26 studies that did not meet GRADE and AMSTAR-2.

Figure 1. Flowchart showing the article selection process.
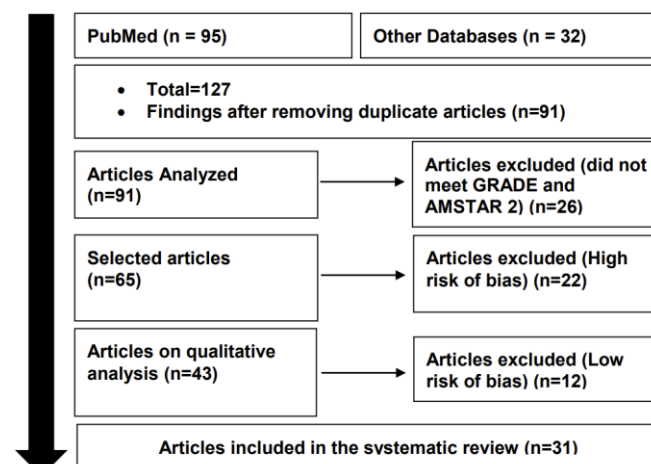
Source: Own Authorship.

Figure 2 presents the results of the risk of bias of the studies using the Funnel Plot, showing the calculation of the Effect Size (Magnitude of the difference) using the Cohen Test (d). Precision (sample size) was determined indirectly by the inverse of the standard error (1/Standard Error). This graph had a symmetrical behavior, not suggesting a significant risk of bias, both between studies with a small sample size (lower precision) that are shown at the bottom of the graph and in studies with a large sample size that are presented at the top.

Figure 2. The symmetric funnel plot suggests no risk of bias among the small sample size studies that are shown at the bottom of the plot. High confidence and high recommendation studies are shown above the graph (n=31 studies).
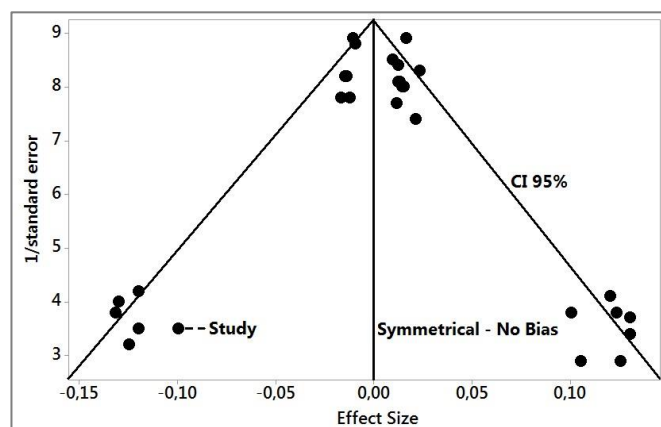
Source: Own Authorship.

Major Approaches and Results

Pneumothorax is a disease frequently observed in hospital and pre-hospital contexts and may be secondary to traumatic injury or spontaneous [18]. Tension pneumothorax is defined as the presence of air in the pleural space and can be correlated with episodes of trauma or iatrogenic events. This may be primary or spontaneous, without disease or precipitating factor, or secondary to pre-existing lung pathologies and trauma. The clinical manifestations are acute chest pain, dyspnea and the presence of asymmetric breath sounds [19].

Despite the clinical manifestations in cases of pneumothorax, diagnosis in emergency rooms, with various equipment generating noise, team members manipulating instruments, and performing maneuvers, can make the diagnosis enormously difficult for the clinical doctor, adding to the patient's instability when taking an x-ray of the chest, as a test to prove this injury, delaying the performance of a puncture [1,2].

In this way, POCUS has its great advantage, the speed in demonstrating physiological data in real-time, making it possible to consider dynamic changes carried

out due to medical treatments [19]. In intensive care units, they are extremely useful equipment [20]. Images obtained of the chest with POCUS without pneumothorax demonstrate vertical lines called B lines (uniform acoustic reverberations) and in the equipment's M mode, the "beach sign", demonstrating the sliding of the pleura.

In the event of pneumothorax, the image of the pleura loses its brightness and A lines appear (irregular acoustic reverberations) and in M mode, the granular pattern is lost, generating the stratosphere signal. Through protocols in the investigation of pneumothorax, POCUS can assist in the precise localization of thoracentesis [21]. POCUS-guided thoracentesis increases the yield of thoracentesis by reducing risks during the procedure [22].

The use of POCUS has consistently improved the sensitivity of standard diagnostic pathways for detecting congestive heart failure, pneumonia, pulmonary embolism, pleural effusion, or pneumothorax [23-25]. Specificities increased in most, but not all, studies according to the ACP (American College of Physicians). Point-of-care ultrasound can improve diagnostic accuracy in patients with acute dyspnea [26].

Previous studies have shown that the use of ultrasound for diagnosing pneumothorax in comparison with chest radiography is an effective, but operator-dependent, method [27,28]. Even clinical professionals can use POCUS to acquire images and diagnose pneumothorax in emergency rooms, with 66.6% sensitivity and 100% specificity compared to specialist radiologists [29].

In a study using POCUS to detect pneumothorax, this method showed a sensitivity of 88% and specificity of 100% of cases investigated in emergency rooms [30,31]. According to a study conducted by the European Respiratory Society, four meta-analyses suggest that the use of chest ultrasound is operator-dependent, but has better sensitivity (78 to 90%) and specificity greater than 98% in chest radiography.26 Similar results were found by authors who also raise the need for more randomized controlled studies evaluating POCUS [32].

Conclusion

It was concluded that the POCUS method is operator-dependent and has greater sensitivity (78 to 90%) and specificity greater than 98% in chest radiography. However, when performed correctly by trained professionals, following protocols, it proved to be useful for identifying and treating pneumothorax. POCUS is a portable, fast, and low-cost bedside examination that does not involve ionizing radiation, in

addition to identifying a precise location for performing thoracentesis in cases of pneumothorax, which assists clinical physicians in urgent and emergency rooms, as well as in external environments such as rescue helicopters. There is a consensus among the authors researched that, to obtain clinical evidence on the use of POCUS in the diagnosis of pneumothorax, more randomized controlled studies are necessary, which reinforce the use of this versatile equipment in different urgent and emergency scenarios.

Acknowledgement
Not applicable.

Ethical Approval
Not applicable.

Informed consent
Not applicable.

Funding
Not applicable.

Data sharing statement
No additional data are available.

Conflict of interest
The authors declare no conflict of interest.

Similarity check
It was applied by Ithenticate®.

Peer Review Process
It was performed.

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