Enhancing Emergency Fracture Diagnosis with Point-of-Care Ultrasound (Pocus) : A Rapid and Efficient Alternative

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Abstract

Introduction: Fracture diagnosis is a crucial aspect of trauma and musculoskeletal injury management, traditionally relying on imaging modalities such as X-ray, CT scan, and MRI. However, these methods have limitations, including high costs, long waiting times, radiation exposure, and limited accessibility in remote areas. Point-of-Care Ultrasound (POCUS) has emerged as a diagnostic alternative that is more portable, cost-effective, radiation-free, and provides real-time results, making it a potential solution in emergency situations or resource-limited healthcare facilities.

Methods: This study employs a literature search approach based on the PICO framework to evaluate the effectiveness of Point-of-Care Ultrasound (POCUS) in detecting fractures compared to X-ray, CT scan, and MRI. Literature sources were obtained from Scopus, ScienceDirect, Google Scholar, and PubMed using relevant keywords. Seven English-language journals were selected for further analysis.

Results and Disscussion: POCUS is a rapid, non-invasive, and effective diagnostic tool for fracture and musculoskeletal injury. It allows fracture identification within an average of 3.9 minutes, with a sensitivity exceeding 85%, reaching up to 100% in children, while its specificity exceeds 90%. Although its accuracy is still lower than that of MRI, POCUS excels in terms of speed and patient convenience.

Conclusion: POCUS serves as a safe and rapid alternative to conventional methods, particularly for children and patients with limited access to radiographic imaging. It provides

a more patient-friendly diagnostic method, especially in medical settings requiring high safety and speed. While X-ray remains the gold standard, POCUS can be utilized in emergency situations. However, its effectiveness depends on operator skill and is less optimal for detecting complex fractures.

Keywords: Point-of-Care-Ultrasound, POCUS, Fracture, Diagnosis, Medical Imaging

Introduction

The high incidence of fractures in various populations requires a rapid and accurate diagnosis. Based on the results of the 2018 Riskesdas, 5.5% of 92,976 injury cases in Indonesia experienced fractures.[1] Globally, in 2019 there were 178 million new fracture cases, an increase of 33.4% since 1990, influenced by population growth and aging.[2] These data show that fractures are not only an individual health problem, but also a significant public health burden.

Fracture diagnosis is an essential component in the management of patients with musculoskeletal trauma or injury. Traditionally, fracture diagnosis relies on physical examination and radiologic imaging such as X-ray, computed tomography (CT scan), or magnetic resonance imaging (MRI).[3] However, these methods have several limitations, such as relatively high costs, long waiting times, radiation exposure (in X-rays and CT scans), and limited access in remote areas or health facilities with limited resources.[4]

In recent years, Point of Care Ultrasound (POCUS) has emerged as a promising diagnostic tool in various fields of medicine, including emergency, intensive care, and sports medicine. POCUS offers several advantages, such as portability, relatively low cost, no radiation involved, and the ability to provide real-time results.[5] This makes POCUS an attractive alternative for diagnosing fractures, especially in emergency situations or in resource- constrained environments.

Several studies have shown that POCUS can detect fractures with high accuracy, especially in long bone fractures such as radius, ulna, tibia, and fibula.[6] In addition, POCUS can also be used to guide fracture reduction and monitor the healing process. [7] However, the application of POCUS for fracture diagnosis still requires further validation, especially in terms of its accuracy, sensitivity, and specificity compared to conventional imaging methods.

This study aims to evaluate the effectiveness of POCUS in diagnosing fractures, particularly in the context of emergencies and resource-limited settings. By understanding the

potential and limitations of POCUS, it is expected to provide recommendations for medical personnel in utilizing this technology to improve the quality of health services, especially in the management of patients with fractures.

Methods

The method used in this journal is a search of various literature sources that discuss Point of Care Ultrasound to detect fractures. The literature search used the PICO method to facilitate the search for literature used as references. PICO is composed of four parts consisting of Population, Intervention, Comparison, and Outcome.[8] The combination of several terms from the PICO framework is used to search for literature relevant to the research conducted as below:

- Population : Children and adult
- Intervention : Point of Care Ultrasound
- Comparison : X-ray, CT Scan, and MRI
- Outcome : Early detection of fractures with high accuracy.

Literature sources were obtained from Scopus, Sciencedirect, Google Scholar, and Pubmed with the source search using English. Based on the type of publication, we used relevant scientific literature with a publication limit between 2020-2025. The keywords used were "Point of Care Ultrasound" OR POCUS AND fracture. The keyword search was conducted using the Boolean Operator method. The data used based on the results of the literature search included titles, abstracts, methods, and results. A total of 13 journals were assessed as eligible which were filtered again with the inclusion and exclusion criteria of this study. The inclusion criteria were open access articles, experimental methods, point of care ultrasound, and fractures. The exclusion criteria included non-research or review journals, restricted access, and studies that discussed other than fractures. Seven English-language journals were obtained that will be used in this study.

Results and Discussion

Studies conducted using a Randomized Controlled Trial (RCT) design were conducted by Lee et al., (2020) and Snelling et al., (2024). In the first study, they examined clavicle fractures with the shortest study duration of two weeks and the smallest sample size of 10. In the second study, they examined forearm fractures with a longer study duration of 14 months and a much larger sample size of 270.[9,10] Wood et al., (2021) conducted a twelve-month

prospective pragmatic observational study of Colles fractures of the distal radius.[11] On the other hand, Pohl et al. (2024) conducted a four-month observational study of forearm fractures with a larger sample size of 106.[12] In addition, Haak et al. (2024) used a multicenter prospective cohort design with a wider scope in examining clavicle fractures in 167 patients over 11 months.[13]

The cross-sectional method was used by Ahmadi et al., 2022 and Joshi et al., (2023). Ahmadi et al., (2022) conducted a prospective cross- sectional study of acute medial meniscus injuries due to blunt trauma to the knee with a sample of 55 patients.[14] Meanwhile, Joshi et al., (2023) examined fractures of long bones such as the ulna, radius, femur, and tibia- fibula for 10 months with a larger sample size of 147 samples.[15] A prospective non-inferiority study was conducted by Troxler et al. (2022) for 53 weeks with a wide scope of upper extremity long bone fractures (humerus, elbow, forearm, metacarpal bones, and finger phalanges), and the largest sample size among all studies at 403 samples.[16] Meanwhile, the open-label feasibility study design by Lee et al., (2021) examined hip fractures in the elderly over 22 months in Toronto, Canada, with a sample size of 170.

Point of Care Ultrasound

POCUS is increasingly being used in the diagnosis of fractures and musculoskeletal injuries due to its ability to provide rapid, non-invasive imaging that is relatively easy to perform after a short training. Various studies have shown that it has a fairly high sensitivity and specificity in detecting fractures compared to standard radiographs, making it a potential tool for use in emergency departments and orthopaedic clinics.

In the POCUS examination, different types of ultrasound devices are used according to clinical needs. Some studies used Affiniti 70 and Zonare Z.One with high-frequency linear probes that can clearly capture details of the bone cortex.[12] Meanwhile, the Sonosite Turbo M device with a 7.5 MHz probe is also widely used in the diagnosis of long bone fractures in the emergency room.[15] For clavicle injuries, linear array ultrasound probes with a frequency range of 4-12 MHz are used, although device specifications may vary depending on the hospital where the study is conducted.[13]

The procedure for using POCUS in fracture diagnosis generally begins with placing the linear transducer on the suspected area of injury. The examination is performed with various angles, both longitudinal and transverse, to obtain optimal images. For example, in the diagnosis of radius and ulna fractures, imaging is performed on the dorsal, lateral, and palmar

sides to ensure there are no cortical fissures or deformities indicative of a fracture.[12] Meanwhile, in detecting meniscus injuries, a probe is placed on the medial aspect of the knee with the patient's knee bent 45-90 degrees, and the meniscus structure is observed as a hyperechoic area between the femur and tibia bones.[14]

The POCUS examination flow generally starts with patient selection based on inclusion criteria, followed by an initial physical examination. Thereafter, POCUS is performed before the patient undergoes radiography as the gold standard for diagnosis confirmation.[10,16] The results of POCUS imaging are then compared by an expert panel, which usually consists of an emergency physician, pediatric radiologist, and orthopedic surgeon, to assess the level of accuracy compared to radiographic imaging. In some cases, such as ultrasound-guided nerve block procedures, POCUS is used to identify anatomical structures before anesthetic injections are made. After the procedure, its effectiveness is evaluated by measuring the patient's pain level before and after anesthesia administration.[9]

With its various advantages, POCUS has proven to be an efficient diagnostic tool in detecting fractures and musculoskeletal injuries, especially in the pediatric population and patients with limited access to radiographic imaging. Usage POCUS can also improve the efficiency of diagnosis and treatment in the emergency department, allowing clinicians to make faster and more accurate decisions in managing patients with suspected fractures or soft tissue injuries.[12]

Diagnosis of Fracture

POCUS is used as a non- invasive, radiation-free, rapid, and effective method to help triage patients with fractures.[13] With its ability to provide *real-time* results, POCUS allows clinicians in the emergency department to immediately identify possible fractures without having to wait for radiographs. This examination only takes less than 30 minutes and the average time required is about 3.9 minutes.[9,16] POCUS has higher sensitivity, specificity, and accuracy than radiology with an average sensitivity of over 85%, and even 100% fracture detection in children. POCUS specificity averages above 90%, but when compared to MRI, POCUS only reaches 65.7%. The accuracy of the results obtained from POCUS is around 90%, but some studies do not mention the exact accuracy in numbers.

Table 1. POCUS Sensitivity, Specificity, and Accuracy

Study	Sensitivity	Specificity	Accuracy
Pohl *et al.*, 2024	100%	95.8%	99.1%
Snelling *et al.*, 2024	100%	97.9%	97.8%
Joshi *et al.*, 2023	86%	98.96%	PPV: 97.72%
			NPV: 93.2%
Haak *et al.*, 2024	93%	93%	Positive ratio: 92.5%
			Negative ratio: 91.7%
Lee *et al*., 2021	NA	NA	NA
Ahmadi *et al.*, 2022	85.0%	65.7%	PPV: 58.6%
			NPV: 88.5%
Troxler *et al.*, 2022	95%	NA	NA

Conventional Method

A comparison between conventional methods such as X-ray, CT, and MRI with POCUS in diagnosing fractures in children showed significant and promising results. Conventional methods, particularly X-ray, have a very high accuracy in detecting fractures, reaching 99.1% as reported by Pohl et al. (2024).[12] However, POCUS also showed good accuracy with a sensitivity of 86% and specificity of 98.96%. This suggests that POCUS is capable of detecting fractures well, and may even be more sensitive in some fracture types compared to X- ray, particularly in forearm fractures in children.[15]

The main advantage of POCUS compared to X-ray is the faster time to perform the examination. In studies conducted by Lee et al. (2021) and Troxler et al. (2022), the POCUS examination time was recorded to be about 3.9 minutes, while X-ray took about 16 minutes.[9,16] This suggests that POCUS is not only more effective in detection but also more efficient in execution, providing more convenience for young patients who may not endure longer diagnostic procedures.

In addition, POCUS also has an important advantage in terms of safety, as it does not use potentially harmful radiation. This makes it a safer option for children, while X- rays, although still the gold standard in diagnosis, carry risks related to the use of radiation.[13,16]

Although POCUS shows a number of advantages in some aspects, X-ray remains the primary diagnostic method due to its proven reliability. However, POCUS can serve as an alternative diagnostic tool in certain situations in the emergency room, particularly when there is a concern to minimize radiation exposure or when rapid time is critical for patient management.[9,15]

Thus, through this comparison, it is clear that POCUS has significant potential in

fracture diagnostics, offering a safe, fast, and accurate alternative to conventional methods, while still requiring confirmation with traditional methods in some cases.

Advantages and Disadvantages

POCUS has several key advantages in detecting fractures. Its sensitivity is very high, reaching 100%, so no fracture is missed.[12] Its diagnostic accuracy is also higher than radiographs in some cases, such as 'buckle' fractures.[10] In addition to that, POCUS is a non-invasive and radiation-free method, making it safer than X-ray, especially for children who are more susceptible to the adverse effects of radiation.[13]

The examination time with POCUS is shorter than with X-ray. It only takes an average of 3.9 minutes, while an X-ray takes about 16 minutes.[9] This speed allows patients to get a diagnosis and treatment faster, especially in the emergency department. In addition, POCUS is more comfortable for patients as it causes less pain than X-ray. Another advantage of POCUS is its portability and accessibility. Portable ultrasound devices can be used directly in the emergency room without the need to send the patient to the radiology department, making it more efficient in emergency conditions or in healthcare facilities with limited resources.[16]

However, POCUS has some limitations. One of the main challenges is its reliance on operator skill. The results of the examination are highly dependent on the experience and training of the doctor using it, so poorly trained doctors may have difficulty in interpretation of the results.[13] POCUS also has limitations in detecting complex fractures. Some types of fractures, such as intra- articular fractures or fractures with significant dislocation, may be more difficult to identify compared to X- ray or CT scans.[15] In addition, the specificity of POCUS in detecting certain injuries, such as the medial meniscus, is lower than that of MRI, increasing the possibility of false positive results.[14]

Although proven effective in many situations, POCUS has not been able to fully replace X-ray as the gold standard in fracture diagnosis. Its use is also limited to shallower structures, so fractures that are deeper or covered by thick soft tissue may be more difficult to detect.[16] In addition, the lack of standardization and training in the use of POCUS can be an obstacle. Not all healthcare facilities have access to ultrasound equipment or medical personnel trained in this technique, which may affect the accuracy of the results.

Conclusion

POCUS is a fast, non-invasive and efficient diagnostic tool for detecting fractures as well as musculoskeletal injuries. In addition to diagnosis, POCUS also assists in medical

procedures such as nerve blocks. Its advantages in speed and ease of access make it an effective solution in emergency departments. With real-time results, POCUS allows identifying fractures in a short time, averaging around 3.9 minutes. Its sensitivity reaches more than 85%, even in children it can reach 100%, while its specificity is above 90%, although its accuracy is still below that of MRI. POCUS is a fast, safe and accurate alternative for pediatric fracture diagnosis without radiation, making it safer than X-ray, CT or MRI. Therefore, POCUS can be a more patient-friendly diagnostic method, especially in medical environments that require high safety and speed.

Recommendation

To improve the effectiveness of POCUS in the diagnosis of fractures and musculoskeletal injuries, systematic training of medical personnel is needed, especially general practitioners, orthopedists, and emergency departments. POCUS can be the first diagnostic tool in facilities with limited radiography or MRI and used in groups vulnerable to radiation. Further studies are needed to evaluate its long-term effectiveness, while its use remains as an adjunct method in complex cases that require other imaging. Overall, POCUS is a useful diagnostic tool in detecting fractures, especially in the emergency department setting, thanks to its speed, safety and portability. However, its limitations need to be taken into account, and optimal implementation requires extensive training, standardization of procedures, and integration with other imaging methods to improve diagnostic accuracy.

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