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The diagnostic value of ultrasonography in the diagnosis of scaphoid bone fractures

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Abstract

Introduction: An assessment of small bones damages is important regarding how to choose the best invasive or non-invasive treatment approaches.
Objectives: The aim of this study was to determine the diagnostic value of ultrasonography for diagnosis of scaphoid bone fracture in comparison with radiology and CT scan.
Patients and Methods: This cross-sectional study was conducted on 224 patients with trauma to wrist and suspected to scaphoid bone fracture. Patients were evaluated with ultrasonography using a linear superficial probe on admission. Then, another radiologist who was unaware of ultrasound results, evaluated the evidence of bone fracture by radiography and CT scanning.
Results: Comparing the results of ultrasonography with CT scan as the gold standard, the sensitivity of ultrasonography was 85.2%, the specificity was 87.5%, the positive predictive value (PPV) was 81.5%, the negative predictive value (NPV) was 90.2%, and the diagnostic accuracy was equal to 86.6%. The diagnostic value of ultrasonography was slightly higher in men than in women, and in older patients than in younger subjects, and also in patients referring with a delay of more than three hours compared to earlier referring.
Conclusion: Ultrasonography can be an accurate tool as compared to other diagnostic modalities for detection of scaphoid bone fractures particularly in men, in the elderlies, and in those with delayed referring.

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Introduction

The scaphoid bone is one of eight carpal bones. The scaphoid fractures include approximately 90% of carpal bone fractures (1), and are commonly seen in men (about 85%) at the age of 15 to 30 years (2,3). Diagnosis and treatment of scaphoid's fracture remains controversial. Despite the various reports, little progress has been made in choosing the best diagnostic and therapeutic method over the last half century. Along with the clinical examination, various methods of imaging such as magnetic resonance imaging (MRI), computed tomography (CT), and bone scintigraphy have been used to evaluate and confirm or reject scaphoid fracture. The main limitations to using this tool are high costs and little access to them (4). Additionally, their accuracy is unclear in children or older ages (5). A number of recent studies have described the accuracy of ultrasonography for the detection of scaphoid bone fractures (5). Ultrasonography has important advantages over other modalities. This device is easily accessible, does not have ionizing radiation and is completely non-invasive. It also costs far less than other tools. In many articles, the physicians' desire to evaluate bone fractures through ultrasonography has been emphasized (6-12). Although some studies have shown that ultrasonography is capable of detecting scaphoid fractures, studies have also shown the relationship between this diagnostic accuracy and the experience of the physician and the operator. In total, the evidence summarized the sensitivity of 86% to 100%, the specificity of 95% to 100%, the positive predictive value (PPV) of 83% to 100%, and the negative

Core tip

As a general conclusion, ultrasonography may be an accurate tool as compared to other diagnostic modalities for detection of scaphoid bone fracture due to its high sensitivity, specificity, and diagnostic accuracy. The higher accuracy of ultrasonography in assessing scaphoid bone fracture in men, in older people, and over time will make the use of this tool more and more reliable.

predictive value of 95% to 100% for ultrasound to detect scaphoid fractures (12,13). However, there are some limitations in the detection of scaphoid bone fractures by ultrasonography. First, ultrasonography has little ability to detect scaphoid proximal pole fractures. Ultrasonography may also not be able to show the extension or fracture line (14). Additionally, scaphoid bone fractures may be mimicked by some bone anomalies or effusion due to arthritis. Finally, it seems that further evaluation seems to be needed on accuracy of ultrasonography in the diagnosis of scaphoid bone fracture, especially in different ages, and underlying etiologies that lead to fracture.

Objectives

The aim of this study was to determine the diagnostic value of ultrasonography in the diagnosis of scaphoid bone fracture in comparison with radiology and CT scan in patients referred to the emergency department.

Patients and Methods

Study design

This cross-sectional study was conducted on patients with trauma to wrist and suspected to scaphoid bone fracture. The patients with any congenital or inflammatory bone abnormalities were not included. Patients were evaluated with bedside ultrasonography (BUS) using a linear superficial probe on admission. Then, another radiologist who was unaware of ultrasound results evaluated the evidence of bone fracture by radiographic method and CT scanning. Finally, the evidence of scaphoid bone fracture in ultrasonography were compared to CT scan as the gold standard.

Ethical issues

Human rights were respected in accordance with the Helsinki Declaration 1975, as revised in 1983. The study was approved by ethics committee of Iran University of Medical Sciences (ethical code; IR.IUMS.FMD.REC1396.9411307008). The informed consent was taken from the patients as well as from parents and first relatives. This study was conducted as the residential thesis of Alireza Bahramnejad in Iran University of Medical Sciences.

Statistical analysis

For statistical analysis, results were presented as mean ± standard deviation (SD) for quantitative variables and were summarized by absolute frequencies and percentages for categorical variables. The diagnostic performance of ultrasonography compared to CT scan was assessed using the special formulas for determining sensitivity, specificity, PPV, negative predictive value (NPV), and accuracy. For the statistical analysis, the statistical software SPSS version 16.0 for Windows (SPSS Inc., Chicago, IL) was used. Accordingly, *P* values of 0.05 or less were considered statistically significant.

Results

In this study, 224 patients were enrolled. The mean age of the patients was 33.41.11 ± 11.88 years in the range of 16 to 70 years. Around 179 cases (79.9%) were male and 45 (20.1%) were female. In terms of damage mechanism, in 153 cases (68.3%) was due to vehicle accidental damages, in 60 cases (26.8%) was due to falling, and in 11 cases (4.9%) was due to wrist torsion injury. Regarding the time interval between trauma and injury, the mean time was 4.73 ± 6.90 hours in the range of 1 to 24 hours, of which 24 (10.7%) referred within 24 hours after the trauma. The average time between trauma and injury was 4.73±6.90 hours in the range of 1 to 24 hours, while 24 cases (10.7%) referred within 24 hours after the trauma.

In the CT scan, 88 cases (39.3%) had significant evidence confirming scaphoid bone fracture. In the ultrasonography, the frequency of positive cases was 92 (41.1%). Comparing the results of ultrasonography with CT scan as the gold standard, the sensitivity of ultrasonography was 85.2%, the specificity was 87.5%, the PPV was 81.5%, the NPV was 90.2%, and the diagnostic accuracy was equal to 86.6%. As shown in Table 1, the diagnostic value of ultrasonography was slightly higher in men than in women, and in older patients than in the younger, and also when referring had a delay of more than three hours compared to earlier referring. In the assessment by radiography as compared to CT scan, the results of scaphoid bone fracture were positive only in 95 cases (29.5%) yielding a sensitivity of 52.3%, a specificity of 91.2%, a PPV of 79.3%, an NPV of 74.7%, and an accuracy of 75.9%. It was finally found a good agreement between radiography and ultrasonography for detecting scaphoid bone fracture (kappa value of 0.648, $P < 0.001$).

Discussion

A detailed assessment of the small bones damages is especially important in terms of how to choose the best invasive or non-invasive treatment approaches. Evaluations are highly accurate through imaging techniques such as MRI, or CT scan, but the lack of quick and easy access to some of these tools, their high cost, the need to use radiation has led to the use of other tools that are preferable to portable, affordable and inexpensive. The diagnostic value of ultrasonography is well-understood in almost all diagnostic fields in medicine. The use of this modality is increasing day by day, but the accuracy of this tool is still unclear in evaluating hard and bony tissues, especially with regard to determining its diagnostic value in fractures of small bones. What we did in this study was to determine the diagnostic value of this instrument in the diagnosis of scaphoid bone fractures. In this study, the diagnostic accuracy of this method was evaluated in comparison with CT scan. In this study, it was found that ultrasonography has high sensitivity, specificity and diagnostic accuracy in the diagnosis of scaphoid fractures compared to both CT scan and radiography. In this regard, the sensitivity,

Table 1. The value of ultrasonography compared to CT to detect scaphoid fractures

Index	Sensitivity (%)	Specificity (%)	PPV (%)	NPV (%)	Accuracy
Total	85.2	87.5	81.5	90.2	86.6
Gender					
Male	86.5	88.6	84.2	90.3	87.7
Female	78.6	83.9	68.8	89.7	82.2
Age					
≤ 40 years	83.3	87.3	78.1	90.6	85.9
> 40 years	89.3	88.5	89.3	88.5	88.9
Trauma mechanism					
Vehicle accidents	79.5	94.4	85.4	92.0	90.2
Falling	90.7	35.3	78.0	60.0	75.0
Wrist torsion	100	100	100	100	100
Time of referring					
≤ 3 hours	81.0	89.2	79.7	90.0	86.4
> 3 hours	93.3	80.0	84.8	90.9	87.3

Abbreviations: PPV, positive predictive value; NPV, negative predictive value.

specificity, and accuracy of ultrasonography were found to be 85.2%, 87.5%, and 86.6% respectively. Therefore, with high confidence and accuracy, scaphoid bone damage can be assessed through ultrasonography. However, two points are necessary. Firstly, the experience of the sonologist and the relevant operator is very effective in determining the accuracy and sensitivity of ultrasonographic diagnosis. In other words, this diagnostic accuracy will be achieved if sufficient experience is obtained regarding the evaluation of bone tissue using this tool. Secondly, the use of ultrasonography, along with clinical presentation and physical examination (in particular, tenderness of anatomical snuffbox), will greatly increase the accuracy of ultrasonography for the diagnosis of scaphoid's fractures. In the systematic review by Kwee and Kwee, of 7 studies on the value of ultrasonographic diagnosis in the diagnosis of scaphoid bone fracture showed an ultrasonographic sensitivity between 77.8% and 100%, with a specificity of between 71.4% and 100%, which was completely consistent with our study (14). In a study by Jain et al, the accuracy of ultrasonographic diagnosis in scaphoid fractures was 98% (15). In a study by Yıldırım et al, the sensitivity and specificity of ultrasonography in scaphoid fracture were 81.7% and 100% respectively (16). In the study by Platon et al, ultrasonography had a specificity of 92% to assessing scaphoid fracture with a sensitivity of 100% to fracture confirmation (17). In a study by Herneth et al, the sensitivity was 87% for this tool (18). Finally, in the study by Christiansen et al, ultrasonography had a sensitivity of 37% and a specificity of 61% (19).

Another important point in the present study was the difference in the diagnostic accuracy of ultrasonography between two genders, different ages, different trauma mechanisms and time of referral. The reasons for these differences can be explained as follows. Firstly, regarding higher diagnostic accuracy in males than in females, the main reason was the increased accumulation of subcutaneous and visceral fat in women than men, which increased the diagnostic error in ultrasound in women. Also, higher sensitivity and accuracy of ultrasonography in older people can be due to the decrease in subcutaneous fat and visceral mass at older ages. Moreover, increasing the diagnostic accuracy of this tool over time could be due to pathological changes in the fracture area, and the formation of fibrotic and inflammatory tissue in the area over time which makes it easier to evaluate the damaged area in hours after injury. Regarding the difference in diagnostic accuracy of this tool in various mechanisms of injury, the results are not reliable because of small number of sample in the group with wrist torsion. Therefor, the study does not have sufficient power in this regard and evaluation with more sample size is needed.

Conclusion

As a general conclusion, ultrasonography may be an accurate tool as compared to other diagnostic modalities for detection of scaphoid bone fracture due to its high sensitivity, specificity, and diagnostic accuracy. The higher accuracy of ultrasonography in assessing scaphoid bone fracture in men, in older people, and over time will make the use of this tool more and more reliable.

Study limitations

Our study requires further investigation with larger samples.

Authors' contribution

CHM and BA designed the study, observed accuracy and validity of the study. KP collected the data and follow the study. CHM and BA supervised the project. CHM and BA wrote the paper. All authors edited and revised the final manuscript and accepted its publication.

Conflicts of interest

The authors declared no competing interests.

Ethical considerations

Ethical issues (including plagiarism, data fabrication, double publication) have been completely observed by the authors.

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