Ultrasonography and radiography: a comparison

Salam Musa and Paul Wilson review the role of portable ultrasound in the diagnosis and management of distal limb fractures in a minor injury unit

Abstract

Distal limb fractures are common presentations to emergency departments and minor injury units (MIUs). The authors conducted a study of the usefulness and efficiency of portable ultrasound in detecting the presence of minor fractures in patients presenting to Cirencester Hospital's MIU. Patients above two years of age about whom there was a high clinical suspicion of a closed fracture of the distal forearm or wrist, or the lower limb, were included in the study. After initial clinical assessments, the patients were referred for X-ray, as is usual for such patients, and also for ultrasound imaging of their injured sites. The ultrasound and radiograph images were subsequently compared for injury and presence of fracture, and this article discusses the results.

Keywords

Ultrasound, ultrasonography, X-rays, radiograph, fractures, forearm, wrist, lower limb

ULTRASOUND IS a high-pitched sound wave generated at a frequency of more than 20,000Hz, or 20kHz, in air, although the frequency changes depending on the density of the objects through which it passes. Sound waves at such frequencies are inaudible to humans (Connolly 2004).

Ultrasonography, or the use of ultrasound, has proven to be useful in many fields of care, including rheumatology and cardiology. It is used to undertake interventions, such as drain insertions (Ziswiler 2002), and to identify cartilage problems. It is also used to detect soft-tissue masses, foreign bodies (Kaplan et al 1990) and bone diseases, such as osteomyelitis. In emergency care, and in military emergency medicine, ultrasonography is used to detect injuries in adults with abdominal trauma (Panyadath and Sneed 2014). For these reasons, the authors considered that ultrasonography could also become part of the standard examination process for diagnosis of distal limb fractures by clinicians in minor injury units (MIUs).

During daily practice at the authors’ MIU, staff sometimes encounter subtle minor injuries to patients’ distal upper and lower limbs that lead them to question whether X-rays are needed to identify whether or not fractures are present. If ultrasonography were to prove as useful as X-rays in diagnosing fractures, it could be used when radiology departments are closed or otherwise unavailable.

In addition, patients would be able to avoid attending radiology departments unnecessarily, which would be more convenient for them and, in line with the principles of ‘as low as reasonably achievable’ (Slovis 2003), reduce their exposure to radiation.

Study

Aim In light of these findings, the authors decided to conduct a study of the efficiency of portable ultrasound in an MIU in confirming possible fractures in the forearm, compare the results of ultrasonography with those of radiography, and to determine whether a protocol to ensure fewer patients undergo radiological investigations can be developed.

Participants All people who presented to the MIU and about whom there was a high clinical suspicion of closed fracture were asked to take part in the study except for those who:

- Presented with injuries other than those to the distal limbs.

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Were children below the age of two years because nurses in the unit are not permitted to assess or request X-rays for these patients.

Had lacerations or were bleeding near the fracture site because of the associated difficulties in using ultrasound and risk of infection.

Had obvious clinical deformities because their involvement may have delayed their treatments or caused them distress, and so was considered inappropriate.

Over the 12 months in which the study was conducted, 97 patients with suspected minor closed fractures volunteered to participate in the study. About 30% or the sample were under the age of 16.

Ethical considerations The authors sought and obtained approval for their study from a local research ethics committee. Patients were advised of the study at their first point of contact with the MIU’s receptionists, emergency nurse practitioners (ENPs) or doctors. The patients were given copies of an information sheet and an invitation to take part in the study. The information sheet explained that participants would be given normal clinical examinations there and then, and that those who required X-rays would also be given ultrasound. If the patients were young adolescents, the study was also discussed with their parents or guardians in line with Lord Fraser’s ruling on Gillick v West Norfolk & Wisbech Area Health Authority [1985]. All patients, carers and guardians were given time to consider in private whether they wished to participate.

The clinical assessment of children with distal limb fractures in MIUs can be especially challenging because the patients are often frightened by the pain of the injury and the unfamiliarity of their surroundings (Kennedy and Luhmann 1999). Consequently, specific rooms and trained staff were allocated to the younger patients to ensure they were as comfortable as possible during their treatment (Royal College of Emergency Medicine 2013).

Equipment and training A bedside portable ultrasound device was used for the study so that there would be no need for patient transfer, and to enable quick and efficient diagnoses that would be comfortable for the patients concerned.

Representatives of the ultrasound device’s manufacturer trained all of the ENPs and doctors in the MIU in its use and in interpretation of ultrasound scans in three two-hour initial training sessions. Staff also took part in several episodes of practice involving patients with normal and abnormal X-rays of specific sites. These patients were not involved in the study but had been informed that they were participating in a staff-training exercise. The trainers came to the MIU on several occasions to assess the ability of staff members to use the ultrasound equipment before confirming that they were competent in assessing the kinds of patients who would be involved in this study.

During the study it became clear that patients found the use of bedside ultrasonography convenient and time saving, while staff found ultrasound images straightforward to interpret.

Method The study involved identification of suspected fractures in the distal fibula, distal radius or ulna, fingers or thumb, metacarpals, metatarsals, proximal forearm or toes. Fractures to the carpal bones were excluded because, due to their specific alignment and anatomy, they are difficult to interpret without more intensive training.

Each patient’s ultrasound images were produced by one ENP, and collected and assessed by another and by the MIU’s doctors, while the patient concerned was still in the unit.

In each case, images, details of type of injury, and confidential patient identification data, such as patient date of birth, gender and name, were stored on a computer. The same written data were also recorded in a book that was kept in a locked cabinet in the MIU, in line with local standard operating procedures. The patients whose data were stored were given different numbers so that they could not be identified by name.

The patients were then referred to the radiology department and standard anterioposterior and lateral radiographs of the relevant sites were obtained. Each patient’s X-rays, details of type of injury and identification data were stored on a different

<table>
<thead>
<tr>
<th>Site of injury</th>
<th>Number of patients</th>
</tr>
</thead>
<tbody>
<tr>
<td>Finger or thumb</td>
<td>26</td>
</tr>
<tr>
<td>Distal radius or ulna</td>
<td>24</td>
</tr>
<tr>
<td>Distal fibula</td>
<td>23</td>
</tr>
<tr>
<td>Metacarpal</td>
<td>12</td>
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<tr>
<td>Metatarsal</td>
<td>5</td>
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<tr>
<td>Proximal forearm</td>
<td>4</td>
</tr>
<tr>
<td>Toe</td>
<td>3</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>97</strong></td>
</tr>
</tbody>
</table>
computer from that on which the ultrasound data were stored so that they could not be correlated with the ultrasound images, and written data were also kept securely in the MIU.

After the patients concerned had left the MIU, their ultrasound images and X-rays were reviewed by a third ENP and a doctor, who followed a double-blind process so that none was aware of the others’ interpretation of the data.

Results Of the 97 patients who took part in the study, 60 (62%) had fractures confirmed by normal routine X-ray assessment. This result is in line with those in previous studies, such as Puckridge et al (2010). It may appear that too many patients had been referred for X-ray, but it should be borne in mind that patients with obvious fracture, for whom X-rays would have been unnecessary, were excluded from the study. The numbers of these patients with injuries in specific sites are shown in Table 1.

Analysis showed that, of the 60 patients whose fractures were confirmed by X-ray, 51 (85%) had injuries that had been detected through ultrasonography. Twenty four patients had distal radius or ulna fractures and, of these, 21 (87%) had injuries that had been detected through ultrasonography. Analysis of ultrasound images for these fractures produced five (8% of 60) true negatives and three (5% of 60) false negatives, all of which were considered subtle fractures and unlikely to cause major clinical problems for the patients concerned. There were no false positives, which shows excellent correlation with radiography. These results are shown in Table 2.

Further analysis revealed that, of the 60 patients with fractures, 45 (75%) had injuries in one of only three sites: the finger or thumb, the distal radius or ulna, or the distal fibula. The numbers of patients with injuries at each of these sites were similar, but the numbers whose injuries had been detected through ultrasonography varied by site, from 50% of fractures of the distal fibula to 100% of fractures of the distal radius or ulna. The reason for such variation in the detection rate may be that injuries at some sites, such as the distal fibula, are more subtle and difficult to interpret without radiological intervention than injuries at others sites. A typical ultrasound scan of the metacarpophalangeal joint is shown in Figure 1.

All of the results were reported to the local clinical governance group in line with local policy.

Limitations The authors were unable to exploit ultrasonography to its full potential during their study because staff trained to use the equipment were not available seven days a week.

Discussion The study is one among several (Brenchley et al 2000) that indicate the potential for further and more widespread use of ultrasound in emergency care settings, thereby challenging the dominant role of X-ray in managing subtle fractures. The study suggests that ultrasonography is a reliable way to detect fractures of the distal radius or ulna and it is reasonable to conclude that portable ultrasound devices will play an increasingly significant role in the assessment of patients with suspected minor or even subtle fractures in emergency care settings.

Ultrasonography has many advantages over radiography. It is easy to perform at the bedside on initial presentation of a patient and so can be a useful adjunct to clinical examination in specific cases. The patients who took part in the study said that it is more convenient, and less painful and distressing that radiography, and so should be especially useful for use with children who have suspected simple fractures.
Because it does not involve irradiation, ultrasonography can be used to compare right and left limbs without concern about multiple exposure, especially in children and women who are or may be pregnant.

Ultrasonography training is minimal (Marshburn et al 2004) and, unlike radiology training, can be tailored to the specific needs of emergency clinicians. For example, while the staff involved in the authors’ study could rely on their knowledge of the appropriate anatomical sites, and their ability to interpret normal and abnormal X-rays, to interpret ultrasound images, radiographers require a more extensive knowledge of anatomy to interpret X-rays. Nevertheless, as the study demonstrates, emergency clinicians can rule in fractures by studying ultrasound images but ruling out fractures is still the job of radiologists. Consequently, if clinicians do not find fractures in ultrasound images but remain suspicious that they are there, they should request the input of the radiology department.

In the long term, as more patients are included in studies similar to this one and other bony injuries are assessed, the skills of device operators should be enhanced.

The use of ultrasound should also save money for emergency care settings. Although there is an initial, one-off payment for ultrasound equipment, which varies according to equipment and supplier, there is a potential reduction in the number of X-rays required. X-rays cost about £36 each in addition to the cost of the time spent by radiographers, and by porters taking patients to and from the radiology department. Patients given ultrasound would also spend less time in EDs and MIUs, and receive quicker and better overall care. Initial outlay would be recouped more easily in larger departments in which more patients with similar conditions are seen. Meanwhile, the ultrasound devices can be used in different departments so that initial costs can be shared.

References


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Conflict of interest

None declared