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ORIGINAL ARTICLE

# Effectiveness of Ultrasound as a Triage Tool in Ruling out Fractures among Non-Critical Emergency Department Patients

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## *ABSTRAK*

*Penggunaan mesin ultrasound telah menjadi lebih meluas dengan peredaran masa di Jabatan Kecemasan. Penyelidikan ini bertujuan menilai kebolehan alat ultrasound untuk mengenalpasti kepatahan tulang berbanding dengan mesin X-ray di dalam situasi berbeza seperti di kawasan triaj. Penyelidikan ini adalah di satu pusat dengan kaedah keratan rentas. Dalam tempoh Ogos 2014 hingga November 2014, sejumlah 46 pesakit menyertai penyelidikan ini menghasilkan 75 imej. Bagi pesakit yang memberi kebenaran, siasatan ultrasound dilakukan, dan kemudian dibanding dengan laporan X-ray mengenai kewujudan patah tulang. Analisa SPSS digunakan untuk menentukan tahap kepekaan (sensitivity) dan pengkhususan (specificity) alat ultrasound berbanding mesin X-ray. Kepekaan ultrasound adalah 72%(95% CI, 50.6% - 87.9%) dan pengkhususan ultrasound adalah 80% (95%CI: 66.3 – 90%) berbanding alat X-ray untuk mengenalpasti patah tulang. Analisa kappa menunjukan bahawa persetujuan antara pemerhati adalah sederhana (0.5). Penyelidikan ini menunjukkan bahawa penggunaan alat ultrasound sebagai alat triaj untuk menghantar pulang pesakit dari kawasan triaj Jabatan Kecemasan tidak sensitif dan perlu kepada penilaian dan pertimbangan selanjutnya.*

*Kata kunci: ultrasound, triaj, kepatahan, kecemasan*

## ABSTRACT

The popularity of ultrasound for acute diagnosis of fractures in the Emergency Department (ED) has increased over the recent years. This present study aimed to determine the sensitivity and specificity of ultrasound use for detection of fractures in a different environment, which is at the triage area of the ED. We compared the results of bedside ultrasound in detecting non-critical fractures to the current

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gold standard of X-rays in the triage area. The design was a single centered cross-sectional study. From August 2014 till November 2014, a total of 46 patients were recruited, creating 75 image pairs. Following consent, a bedside ultrasound was performed and subsequently compared with X-ray reporting regarding the presence or absence of fractures. SPSS analysis was used to determine the sensitivity and specificity of ultrasound in diagnosing fracture as compared to X-rays. Ultrasound had a sensitivity of 72% (95% CI, 50.6% - 87.9%) and a specificity of 80% (95%CI: 66.3 – 90%) when compared to X-rays in fracture diagnosis. The kappa analyses showed moderate inter observer agreement (0.5) between ultrasound and X-rays in diagnosing fractures. This study suggests that the use of ultrasound as a triage tool yet has unacceptable sensitivity and needs further evaluation and consideration.

Keywords: emergency, fractures, triage, ultrasound

## INTRODUCTION

Since 1993, ultrasound has been an accepted tool for detection of life threatening intra-abdominal bleed among trauma patients in the ED (Sippel et al. 2011). With the inclusion of bedside ultrasound in the emergency master's curriculum (Bahner et al. 2013), the Emergency Physicians should be expected to perform ultrasound in the ED. Work by Fenkl et al. (1992) showed the ability of ultrasound to pick up sternal fractures. Bitschnau et al. (1997) showed good correlation between ultrasound and X-rays in detecting rib fractures.

Triage zone is the doorway entry to the ED. It aims to direct and ensure that patients are treated in the order of their clinical urgency. Triage also allows for the allocation of the patient to the most appropriate assessment and treatment area (Australian College for Emergency Medicine 2013). Ultrasonography is performed mostly in the critical and semi critical areas in the ED. However, the use of ultrasound is suboptimal in the triage area where we sort, direct and give initial treatment to patients in which critical initial diagnosis matters the most.

Triage area is unique and different from the rest of the ED where it plays a role as a front gateway. The triage environment has a limited space and time contact with patients. Previous studies assessed patients in the other areas of the ED or wards where space and time do not count as a critical issue in comparison to the triage area. The literature review conducted did not show any study specifically looking at ultrasound use as a triage tool in the triage environment of the ED.

The aim of the present study was to assess the effectiveness of ultrasound to diagnose fractures in the triage area compared to plain radiographs. Musculoskeletal related complaints are seen quite common among the non-critical patient who present to the ED. A study in Switzerland found that non-critical patients to the ED commonly had trauma related musculoskeletal complaints. Up to 32.7% of non-critical patients in the Swiss ED involved in their study had injuries related to the musculoskeletal system (Chmiel et al. 2011).

Ultrasound usage by non-radiologists has been increasing over the years. Specialties such as surgery, orthopedics, and anesthesiology have started to use ultrasound in their practice for diagnoses and in guiding procedures (Blankstein 2011; Lindelius et al. 2008; Sites & Antonakakis 2009). Ultrasound use has been explored in extreme environments like the international space station (Law & Macbeth 2011). The ultrasound also shown promising results as an imaging modality using telemedicine – this has applications in rural areas, space medicine and disaster scenarios (Pian et al. 2013).

Ultrasound use has been explored in various body parts of the trauma patient. Investigators have explored ultrasound use to diagnose facial bone and nasal bone fractures in the trauma patient (Friedrich et al. 2003; Javadrashid et al. 2011). In fact, low dose pulsed ultrasound has been investigated as an agent to accelerate bone healing during fracture with mixed results (Busse et al. 2009). In the future, the Emergency Physician should be able to perform a comprehensive musculoskeletal assessment of the trauma patient, as advanced ultrasound skills enable the identification of ligament injuries, muscle tear (Lee & Healy 2004) and fracture involving cartilaginous growth plates in children (Warkentine et al. 2014).

An evidence based review of bedside ultrasound stated that 50-95% of limb X-rays can be avoided in limb injured patients without missing fractures. This statement was based on studies by authors such as (Heyworth 2003) which showed that only 15% of ankle injured patients had objective fractures in X-rays. Another study by Stiell et al. (1992), showed a fracture rate of only 4.3% mid foot and 9.3% malleolar in those who presented with ankle injuries. The use of ultrasound could be an adjunct to clinical decision rules in avoiding unnecessary X-rays in the patients such as those studied by Heyworth and Stiell above.

Clinician-performed bedside ultrasonography is emerging as a useful diagnostic tool for healthcare providers in resource-limited settings (Sippel et al. 2011). A recent study in Sweden showed that operators with minimal training were able to rule out ankle fractures using ultrasound (Hedelin et al. 2013).

In an earlier study, it was shown that Emergency Physicians with merely one hour of training, were able to achieve a sensitivity of 92.9% and specificity of 83.3% in diagnosing fractures of the humerus (Marshburn et al. 2004).

Another study showed that Pediatric Emergency Medicine Physicians with a one hour training were able to achieve a sensitivity of 73% (95% confidence interval [CI], 58%-84%), and specificity of 92% (95% CI, 86%-95%) in diagnosing long bone fractures of paediatric patients, defined as ages 1 – 25 years (Weinberg et al. 2010).

Fracture can be diagnosed by ultrasound as the bony cortex reflects sound waves, so the outer cortex and periosteum are well seen by ultrasound. A fracture shows up as a disruption of the cortical outline, hematoma at point of fracture, or avulsion fragments (Cross 2011).

The use of ultrasound in trauma is currently focused on Extended Focused Assessment of Sonography in Trauma (EFAST). If enough evidence accumulates, it will be justified to equip the triage area with an ultrasound machine to rule out fractures.

The present study aimed to assess the efficiency of ultrasound in diagnosing a fracture in the triage area as compared to X-rays. The gold standard in fracture diagnosis were the X-ray findings and the ultrasound diagnosis of the presence or absence of fracture which were compared to the X-ray findings. Increased use of ultrasound holds the promise of lower cost, faster time, and avoidance of the ionizing radiation present in X-rays.

## MATERIALS AND METHODS

This was a prospective cross sectional study. The location was within the triage area, Emergency Department, Universiti Kebangsaan Malaysia Medical Centre (UKMMC). The study was carried out for a period of three months.

### INCLUSION CRITERIA:

1. Patient showing any clinical signs and/or symptoms (swelling, tenderness, deformity, limited range of motion) of closed fracture.
2. Age above 18 years.

### EXCLUSION CRITERIA:

1. Open fracture.
2. Old fracture at site.
3. Deformed bone.

### DATA COLLECTION:

Non-critical patients presenting to the triage area of the emergency department with musculoskeletal complaints requiring imaging were selected. The study was explained to them with the assistance of the patient information sheet. If the patient was interested in participating in the study, they underwent the usual triage assessment, with the addition of ultrasound examination of the affected body area. The patient then underwent an X-ray and received the routine treatment as appropriate.

### DATA ANALYSIS:

Data that was collected was analyzed using SPSS 12.0 for Windows [Release 12.0.0 (4 September 2003)].

### ETHICAL ASPECTS:

Ethical approval was obtained from the Ethics Committee (Ethics Committee/ IRB ref no: UKM 1.5.3.5/244/FF-2014-311) of UKMMC. This study commenced once ethical approval was obtained. The established ethical principles were followed to ensure no harm would be caused to the participants. The researcher ensured adequate communication with the participants regarding the intention of the study.

### ULTRASOUND METHODS:

Following was the standardized technique for assessing efficiency of fracture by ultrasound. Initially the procedure was explained to the patients and consent was taken. Patient details were recorded on data collection sheet. The linear ultrasound probe was covered with ultrasound gel and the probe was traced along the length of the suspected site of fracture. Positive or negative finding by ultrasound probe was recorded onto the data collection sheet. Scanned body part was cleaned of any leftover gel, and patient is sent for X-ray. Fracture was detected in the presence of these ultrasonographic features, which were disruption of bony cortical outline, presence of avulsion fracture fragments and hematoma at point of fracture. Figure 1 shows the ultrasonographic picture of fracture. One could observe the discontinuation of the cortical bone, and hematoma formation (anechoic-black colour) above the fracture. Figure 2 shows X-ray view.

Flow chart of data collection is depicted in Figure 3.

Sample size calculation (Kish, L. 1965):

$$ss = \frac{Z^2 * (p) * (1-p)}{(S.E)^2}$$

Where:

Z = Z value (e.g. 1.96 for 95% confidence level)
p = percentage picking a choice, expressed as decimal (.5 used for sample size needed)
S.E: standard error

Z = 1.96
P = prevalence of event, is estimated to be at 81% (Barata et al. 2012)

Confidence interval = percentage of acceptable error

$$SS: \frac{1.96 \times 1.96 \times 0.81 \times 0.19}{0.1 \times 0.1} = 59 \text{ images}$$

## RESULTS

A total of 48 patients were chosen on a voluntary basis during the data collection period. Two images were rejected by Radiologist for technical reasons (incomplete X-ray images)


Figure 1: Ultrasoud image of fracture


Figure 2: X-ray image of a fracture

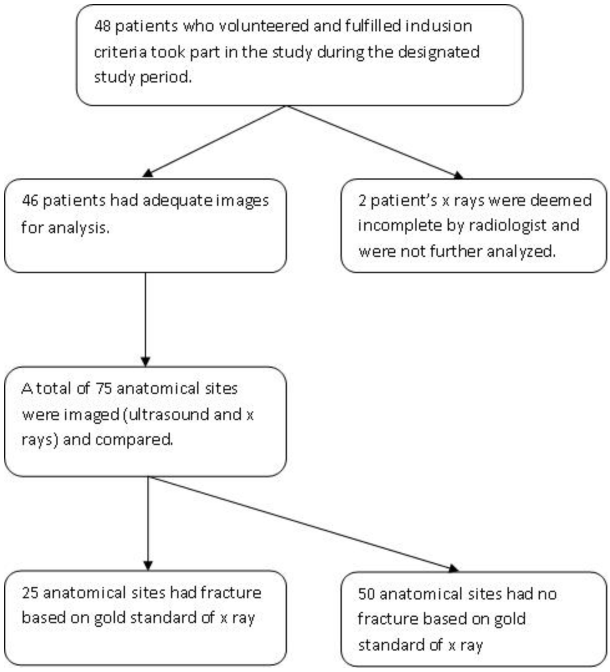


Figure 3: Data collection over the designated data collection period

leaving 46 patients and 75 anatomical sites with comparison images (Figure 2).

The demography of the patients was listed in Table 1, 2, and 3. A majority of that (69.6%) were males, with a male female ratio of 2:1. The Malays made up 65.2% of studied patients, followed by Chinese patients (19.6%), Indians (6.5%), foreigners (6.5%) and other Malaysian race (2%).

Regarding age, 58.7% were between 18 to 40 years, 28.3% were between 41 to 60 years, and 13% were more than 60 years of age. Out of the anatomical sites analyzed, 69.3% were lower limb areas, and 21.2% represented upper limb areas. The patella was the commonest site imaged (24%), followed by the femur (17.3%). Chest (ribs) and clavicle made up 9.3% of anatomical areas studied (Table 4).

The kappa measure of agreement showed that agreement was moderate between ultrasound and X-ray (kappa of 0.41 to 0.6 was considered moderate agreement; above 0.80 was an almost perfect agreement). This mean that the agreement in the ultrasound diagnosis by the investigator and the X-ray diagnosis by the Radiologist was not merely due to chance. The table above shows that specificity of ultrasound is high for patella but sensitivity is lacking for this anatomical site. Due to irregularity of the patellar cortical outline when compared to the long bone surfaces, false positive findings of fracture occured. In femur ultrasound scanning, fractures proximal to the shaft, at the intertrochanteric or neck regions lay deeper and were more difficult to scan. This could lead

Table 1: Gender

| Gender | Number of patients | Percent |
|---|---|---|
| Male | 32 | 69.6 |
| Female | 14 | 30.4 |
| Total | 46 | 100.0 |

Table 2: Race

| Race | Number of patients | Percent |
|---|---|---|
| Malay | 30 | 65.2 |
| Chinese | 9 | 19.6 |
| Indian | 3 | 6.5 |
| Other (Dayak) | 1 | 2.2 |
| Foreigner | 3 | 6.5 |
| Total | 46 | 100% |

Table 3: Age distribution

| Age | Number of patients | Percentage |
|---|---|---|
| 18 - 40 | 22 | 58.7 |
| 41 - 60 | 13 | 28.3 |
| > 60 years old | 6 | 13.0 |

Table 4: Fracture Sites

| Fracture Sites | n (N = 75) | Percentage, % |
|---|---|---|
| Patella | 18 | 24.0 |
| Femur | 13 | 17.3 |
| Tibia | 11 | 14.7 |
| Clavicle | 6 | 8.0 |
| Hand | 7 | 9.3 |
| Foot | 5 | 6.7 |
| Ankle | 5 | 6.6 |
| Wrist | 3 | 4.0 |
| Humerus | 3 | 4.0 |
| Chest | 1 | 1.3 |
| Elbow | 1 | 1.3 |
| Radius | 2 | 2.6 |
| Total | 75 | 100 |

to missed fractures of the proximal femur. The drawback of the patellar bone was its irregular appearance with cortical outline, and the femur was its proximal part positioned deeper in the pelvis. Superficial long bones such as tibia, clavicle, hand and foot bones showed minimal to zero false positive or false negative findings. Ultrasound findings in these anatomical sites were more reliable.

Regarding the sensitivity and specificity of ultrasound in the detection of fractures, there was 72% sensitivity (95% confidence interval [CI], 50.6% - 87.9%) and 80% specificity (95% CI, 66.3% - 90.0%), respectively, and the positive and negative predictive values were 64.3% positive predictive value (95% CI, 44.1% -81.4%) and negative predictive value 85.1% (95% CI, 71.7% - 93.8%), respectively. The positive likelihood ratio was 3.6 (95%CI, 1.96 – 6.6), and the negative likelihood ratio was 0.35 (0.184 – 0.666), with the odds ratio being 10.3 (95% CI 3.43 – 30.8).

## DISCUSSION

The triage area is the place in ED where the medical personnel assesses the severity of the patient's condition and allocates them to the appropriate zones of treatment. Triage also involves the 'see and treat' concept where patients with mild disease conditions are given simple treatments and sent home (Cooke et al. 2003). A survey of adults attending the ED estimated that 13% of non urgent attenders could be directed away from the ED to self care (Coleman et al. 2001). The most frequent reason given by non urgent patients seeking care in the ED was their belief that X-rays were necessary (Coleman et al. 2001).

In terms of demography, the expected patterns were found. Patients presenting with suspected fractures were commonly males, usually in the age range of 20 to 40. This demographic group represented the more active members of society who were very productive, economically. Ability to quickly triage and discharge this group of patients will minimize disruption to their daily earning capacity. In terms of racial composition, the patient pool reflected the demography of the country with the Malay population forming a majority of the patients.

In the present study, the comparative accuracy of ultrasound versus X-ray in the triage environment was assessed. The use of mobile ultrasound, in addition to clinical decision rules and clinical judgment could reduce waiting time and eliminate the over utilization of X-rays in the ED. Out of the 75 images, ultrasound correctly identified fractures in 18 out of the total 25 identified with X-rays, and correctly ruled out fractures in 40 out of the total 50 identified with X-rays, thereby showing a sensitivity of 72% and specificity of 80%. The sensitivity and specificity of bedside ultrasound in this study were acceptable as compared to the gold standard of X-ray fracture diagnosis as reported by a Radiologist. A kappa inter-rater agreement found moderate agreement in the diagnosis of fracture by ultrasound in the ED as compared to fracture diagnosis using X-rays by Radiologist.

## CONCLUSION

In conclusion, the findings of this study showed that the bedside ultrasound is a viable tool to triage away non-critical patients who present to the ED. Further large multi-centre studies are needed to add on symptoms and clinical decision rules to bolster the accuracy of ultrasound findings in sending patient home. Patient and doctor perception of the ultrasound method, and time-cost analysis would strengthen the argument to replace X-rays with ultrasound to triage away non-critical patients with minor trauma in the future.

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