The Ultrasound Detection of Simulated Long Bone Fractures by U.S. Army Special Forces Medics

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Abstract

Introduction: U.S. Army Special Forces Medics (18Ds) operate in austere environments where decisions regarding patient management may be limited by available resources. Portable ultrasound may allow for the detection of fractures in environments where other imaging modalities such as radiography are not readily available or practical. **Objective**: We used a simulation training model for the ultrasound diagnosis of long bone fractures to study the ability of 18Ds to detect the presence or absence of a fracture using a portable ultrasound. **Methods**: The fracture simulation model is composed of a bare turkey leg bone that is mechanically fractured and housed in a shallow plastic container within an opaque gelatin base solution. Five fracture patterns were created: transverse, segmental, oblique, comminuted, and no fracture. After a brief orientation session, twenty 18Ds evaluated the models in a blinded fashion with a SonoSite M-Turbo portable ultrasound device for the presence or absence of a fracture. **Results**: 18Ds demonstrated 100% sensitivity (95% CI: 94.2% to 100%) in fracture detection and an overall specificity of 90% (95% CI: 66.8-98.2%) due to two false positive assessments of the no fracture model. **Conclusions**: Using a portable ultrasound device, 18Ds were able to correctly detect the presence or absence of a simulated long bone fracture with a high degree of sensitivity and specificity. Future studies are needed to investigate the clinical impact of this diagnostic ability.

Introduction

U.S. Army Special Forces Medics (18Ds) commonly operate in austere environments where decisions regarding patient management may be limited by available resources. In deployed or training settings, diagnostic equipment and evaluations commonly found in the hospital or clinic environment such as radiography or blood analysis may not be readily available. This lack of the preferred diagnostic tools may create a barrier to the assessment of a patient when the presence of a long bone fracture is being considered. However, newer generations of lightweight portable ultrasounds may allow for the detection of fractures in environments where other imaging modalities are impractical.

Ultrasound has demonstrated usefulness in the detection of long bone fractures. Cortical bone is not penetrated by ultrasound and can be differentiated from surrounding soft tissue. Sonographic discontinuities in the normally smooth cortical bone may indicate a fracture site.[1] The sonographic evaluation of long bones for the presence of a fracture can be accomplished by personnel with minimal ultrasound training and has the advantage of immediate clinical correlation during examination of the area of interest.[2,3] Because the ability to detect sonographic evidence of fractures is thought to increase over time and with practice, a recent fracture simulation training model was developed and evaluated by physicians.[4] We utilized this novel training model to evaluate the ability of 18Ds with minimal prior exposure to ultrasound to sonographically detect the presence or absence of simulated long bone fractures.

Methods

Simulation Model

The fracture simulation model was prepared as previously described and was composed of a bare turkey leg bone housed in a shallow plastic container within a firm gelatin matrix.[4] The bony diaphysis of each model was approximately 15cm in length and 1.5cm in diameter. A semi-opaque transverse fracture training model was prepared that allowed visualization of the underlying bone (Figure 1). Additionally, five study models made completely opaque by the addition of black food coloring to the gelatin were prepared with differing fracture patterns: no fracture, segmental fracture, transverse fracture, oblique fracture, and comminuted fracture (Figure 1). At each fracture site there was approximately 3mm to 5mm of bony cortex displacement.

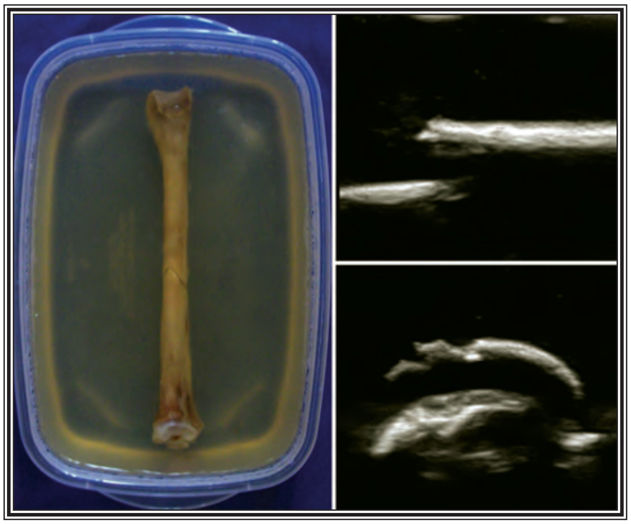

Figure 1: *The semi-opaque fracture detection training model (left) with corresponding longitudinal (top right) and transverse (bottom right) ultrasound images of the fracture site.*

Figure 2: *Fracture detection of the opaque study model via the SonoSite M-Turbo portable ultrasound.*

Model Evaluation

This study was granted exemption from continuing review by our study site institutional review board. A convenience sample of twenty 18Ds was consecutively enrolled to participate in two study sessions at Fort Lewis, WA. Participants reported no or minimal previous familiarity with the practical use of ultrasound. Participants received a three minute standardized orientation and training session to familiarize them with the study protocol and the use of ultrasound for fracture detection. During this study session they practiced fracture detection via sonographic examination of the semi-opaque fracture model or a selected opaque study model. They then sonographically evaluated the five completely opaque models with a SonoSite M-Turbo portable ultrasound device (Sonosite, Inc., Bothell, WA) equipped with a 10-5 MHz transducer head (Figure 2). Participants were blinded to the true identity of the underlying fracture pattern and were presented the study models in an identical order. They were allowed an unlimited amount of time to complete their sonographic assessment and recorded their ultrasound impression of the presence of a bony fracture after examination of each study model.

Results

The sonographic evaluation of all five study models was completed by participants in five to ten minutes. All 18Ds correctly identified the presence of a fracture in the four fractured models and two false positive assessments of the non-fractured model were made. Across all fracture patterns, a final sensitivity of 100% (95% confidence interval: 94.2-100%) and a specificity of 90% (95% confidence interval: 66.8-98.2%) was observed in our study (Table).

Discussion

It is not uncommon for U.S. Army Special Forces Medics to provide medical care in austere environments. The ability for an 18D to make accurate diagnoses for difficult decisions such as the initiation of patient evacuation can be challenging. Ultrasound may be a useful tool to assist in decision making in chal-

Table: *The correct identification of the presence or absence of a fractured model based on sonographic examination by 20 Special Forces Medics (with 95% confidence intervals of overall results shown in brackets).*

Fracture Model	Number correctly identified
No fracture	18/20 = 90%
Segmental fracture	20/20 = 100%
Transverse fracture	20/20 = 100%
Oblique fracture	20/20 = 100%
Comminuted fracture	20/20 = 100%

Overall sensitivity = 100% [94.2-100%]
Overall specificity = 90% [66.8-98.2%]

lenging environments that exist beyond the traditional hospital or clinic. Ultrasound has been used by non-physician providers such as 18Ds and paramedics in such ways as to detect the presence of a pneumothorax and assess the abdomen for intraperitoneal blood.[5,6] Sonography can also be used to identify the presence of long bone fractures and to visualize the successful reduction of long bone fractures.[6,7] Recent experience from Operations Iraqi Freedom and Enduring Freedom regarding extremity injuries has illustrated the frequent occurrence of long bone fractures.[8] Portable ultrasound has been shown to change the disposition of patients in austere environments.[9] While it is unknown what the clinical or operational impact of early sonographic diagnosis of a fracture may be, the opportunity for such an intervention certainly exists.

The cortical discontinuity that is seen on ultrasound and is suggestive of a fracture does not appear to be difficult to appreciate after a brief orientation to the architecture of the sonographic image. However, there is a paucity of literature describing the ability of non-physician providers to use ultrasound to detect fractures as well as a lack of knowledge as to how this ability may alter patient care. The ability to detect fractures with ultrasound does appear to increase with practice and it is possible that simulation models such as the one used in this study may offer relevant practice in this skill. Our study population of 18Ds demonstrated a high degree of both sensitivity and specificity in this skill as evaluated by this previously investigated training model using a portable ultrasound device. The unknown degree to how this skill may carry over to an actual injured patient warrants further investigation.

Notable limitations to our study do exist. The fracture model used in this study contained a larger degree of standard cortical displacement than the 1mm that may be suggestive of a fracture site, and it is possible that 18Ds may have been less proficient at identifying more subtle fractures. As not all participants practiced sonography on the semi-opaque model during the brief orientation portion of the study, it is conceivable that the learners who did utilize these semi-opaque models may have benefitted from additional learning due to the ability to correlate the sonographic image with the underlying fracture site. Also, an order effect may have also been present as participants were not presented the study models in a randomized fashion. Our population of study models also had a high prevalence of fractures with only one fracture-free model, and therefore it is possible that our results were biased toward the identification of abnormalities. The ultrasound probe and the ultrasound model are typical of the small, battery powered modern devices that are commonly used both in the hospital and in austere environments. However, it is possible that our results may be somewhat limited to the model of ultrasound machine that we investigated.

The differential consideration of a closed long bone fracture versus less severe musculoskeletal trauma can pose a diagnostic and evacuation dilemma for the austere provider such as a U.S. Army Special Forces medic. In our study, 18Ds demonstrated an accurate ability to detect simulated long bone fractures using a previously investigated training model and a practical portable ultrasound device. A training program for 18Ds in the use of emergent ultrasound in combat and non-combat conditions has been proposed.[10] Future ultrasound applications by 18Ds may include training to detect long bone fractures and future studies may assess how this sonographic ability effects patient care and supports the challenges of operational medicine.

Disclaimer

The authors have no conflicts of interest or financial relationships with SonoSite to disclose. The views expressed herein are solely those of the authors and do not represent the official views of the Department of Defense, the Army Medical Department, or the Journal of Special Operations Medicine.

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