

Ultrasound in Emergency Medicine

BEDSIDE ULTRASOUND FOR THE DETECTION OF SOFT TISSUE FOREIGN BODIES: A CADAVERIC STUDY

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Abstract—The objective of this study was to evaluate the sensitivity and specificity of bedside ultrasound, as performed by emergency physicians with typical equipment, in detecting small, soft tissue foreign bodies, using a cadaveric model. This was a prospective study, using 6 unembalmed human cadavers and 6 ultrasound-credentialed, emergency medicine residency-trained physicians as sonographers. Incisions were made in 150 total sites of the extremities and each site was randomly assigned one of five groups: wood, metal, plastic, glass, or no foreign body. All foreign bodies were 2.5 mm³ in total volume or less, no longer than 5 mm in any dimension, and inserted to a depth of up to 3 cm. Ultrasound was performed with a SonoSite TITAN[®] (SonoSite, Inc., Bothell, WA) ultrasound system using a L38/10-5 broadband linear array transducer. Sonographers were blinded to the number, type, and location of foreign bodies. A total of 900 ultrasound examinations were recorded. Overall sensitivity of ultrasound for foreign body detection was 52.6% (95% confidence interval [CI] 48.9%–56.2%), and overall specificity was 47.2% (95% CI 39.9%–54.5%). Positive predictive value was 79.9% (95% CI 76.3%–83.5%), and negative predictive value was 20.0% (95% CI 16.2%–23.7%). Sensitivity for individual sonographers ranged from 40.8% to 72.3% (average 52.6% ± 13.3%), and specificity ranged from 30% to 66.7%

(average 47.2% ± 15.1%). Inter-observer reliability was poor. In our model, bedside ultrasound performed by emergency physicians was neither sensitive nor specific for the presence of small soft tissue foreign bodies. © 2009 Published by Elsevier Inc.

Keywords—ultrasound; foreign body; soft tissue; emergency medicine; musculoskeletal; cadaveric

INTRODUCTION

Ultrasound (US) has gained increasing favor in the Emergency Department (ED) over the past decade and has been employed in a myriad of clinical diagnostic and procedural applications (1). Multiple studies have been performed to determine the utility of US in excluding or identifying soft tissue foreign bodies (FB) (2–5). These studies achieved mixed results. Many physicians are using US as an adjunct to careful wound exploration and plain radiography for excluding soft tissue FB in appropriate settings. However, the reliability of ultrasound for this purpose is still the subject of debate. If ultrasound were demonstrated to be highly sensitive for the detection of foreign bodies, it could replace more expensive and time-consuming radiographic techniques such as computed tomography. It could also be used in out-of-hospital settings where other imaging techniques are impractical or unavailable.

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Our goal was to determine whether ultrasound examinations, done by emergency physicians (EPs) with standard equipment, are sensitive and specific for the detection of small soft tissue foreign bodies, the likes of which might be missed on physical examination of a traumatic wound. For our experimental model, we chose human cadaveric tissue as the medium, ultrasound equipment commonly used in EDs, and four types of small, radiopaque and radiolucent foreign bodies. To our knowledge, this is the largest study of its type to date. If proven reliable, ultrasound might be the method of choice to decrease the incidence of unidentified FB in wounds (4,6,7).

METHODS

Study Design

This was a prospective, cadaveric study. The study was approved by the Institutional Review Board of the sponsoring institution in an expedited review.

Study Setting and Population

The six sonographers in this study were all ultrasound-credentialed, EM residency-trained physicians, practicing at a 65,000-visits-per-year community hospital ED, where ultrasound is used widely for all typical EM applications. All physicians had attended a 2-day local ultrasound course given at the beginning of their tenure at the hospital, and had completed the minimum number of supervised examinations in each of the core EM-ultrasound categories, as delineated by the 2001 American College of Emergency Physicians policy for proficiency (8). Additionally, all had also attended at least one national EM ultrasound course. Although soft tissue ultrasound was taught in both ultrasound courses, and was actively practiced by these physicians in the ED, no specific number of prior soft tissue examinations was required for credentialing of these physicians or for participation in this study. Six unembalmed human cadavers were used as the tissue model.

Study Protocol

Incisions were made using a number 15 scalpel blade at a total of 150 extremity sites among the 6 cadavers: 18 left upper arm, 12 left forearm, 15 right upper arm, 10 right forearm, 30 left thigh, 18 left calf, 29 right thigh, and 18 right calf. Each site was then randomly assigned one of five categories: wood, metal, plastic, glass, or no

foreign body. A total of 30 sites were designated for each of these groups. Foreign bodies were inserted into the incision, using hemostats, to depths up to 3 cm. All FBs were 2.50 mm³ in total volume or less, and were no longer than 5 mm in any dimension. Ultrasound examinations were done with a SonoSite TITAN[®] ultrasound machine and a L38/10-5 broadband linear array transducer (SonoSite, Inc., Bothell, WA) set to "resolution" mode (up to 10 mHz). Sonographers were blinded to the overall number, type, and location of the foreign bodies. Each was shown a known positive and negative foreign body site, and then was told to scan each of the 150 experimental sites in two planes, without the use of a step-off pad, and state whether a foreign body was present or not. All decisions by sonographers were made in real time, and no images were retained for subsequent review. Physicians were encouraged to scan as they usually would clinically, and were allowed to manipulate the controls of the ultrasound machine as desired to optimize their views. Data were recorded on standardized data collection sheets.

Data Analysis

Sensitivity, specificity, positive and negative predictive values, and likelihood ratios were calculated for each sonographer's set of examinations, and for the group as a whole. The sensitivity of ultrasound for each type of foreign body, and sensitivity and specificity of ultrasound at each anatomical site were calculated. Inter-observer reliability was assessed by average kappa statistic, computed over all pairs of observers. Confidence intervals were determined using the Wald Equation. All computations were done using Microsoft Office Excel 2003-SP2 software (Microsoft Corporation, Redmond, WA).

RESULTS

A total of 900 ultrasound examinations were recorded. The overall sensitivity of ultrasound for detection of a foreign body was 52.6% (95% confidence interval [CI] 48.9%–56.2%), and overall specificity was 47.2% (95% CI 39.9%–54.5%). The positive predictive value was 79.9% (95% CI 76.3%–83.5%), and the negative predictive value was 20.0% (95% CI 16.2%–23.7%). Positive and negative likelihood ratios were 1.00 (95% CI 0.81–1.24) and 1.00 (95% CI 1.28–0.80), respectively. Sensitivity for the individual sonographers ranged from 40.8% to 72.3% (average 52.6% $\pm$ 13.3%), and specificity ranged from 30% to 66.7% (average 47.2% $\pm$ 15.1%). For all observer pairs, average kappa was 0.140

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