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BRIEF REPORT

Novel Approach to the Diagnosis of Fractures in an Austere Environment Using a Stethoscope and a Cellular Phone

Brett A. Matzek, MD; Phillip T. Fivecoat, DO; Reis B. Ritz, MD

From the Department of Emergency Medicine, Carl R. Darnall Army Medical Center, Fort Hood, TX.

Background.—Fracture diagnosis in the austere environment where radiographic tests are not available can be a challenge. In the past, a diagnostic technique has been described using a tuning fork and stethoscope to assess decreased sound conduction in the fractured extremity. In this study, we evaluate the use of a cellular phone's vibrate function and a stethoscope to limit equipment carried by expeditionary practitioners.

Objective.—The purpose of this study was to evaluate the accuracy of fracture diagnosis using a cellular phone and stethoscope.

Methods.—This is a pilot study to assess the usefulness of the above technique before clinical implementation. In 3 cadavers, we created fractures of the humerus and femur. Twenty-seven emergency medicine residents and an attending physician performed the diagnostic technique.

Results.—Overall, the use of the cellular phone and stethoscope resulted in a sensitivity of 73% (95% confidence interval [CI]: 0.64 to 0.81) and a specificity of 83% (95% CI: 0.77 to 0.88), with a positive predicted value of 68% (95% CI: 0.59 to 0.77) and a negative predicted value of 86% (95% CI: 0.81 to 0.90). Positive likelihood ratio was 4.3, and negative likelihood ratio was 0.32.

Conclusions.—The use of a cellular phone and stethoscope may be a useful tool for the diagnosis of fractures in the austere environment. However, further study is needed to validate these findings in the clinical environment.

Key words: fracture, auscultation, tuning fork, diagnosis, wilderness medicine, austere medicine, combat medicine

Introduction

Healthcare providers practicing outside of the hospital setting, such as those participating in expeditionary, sports, or battlefield medicine, are often presented with diagnostic dilemmas. One such dilemma is the accurate diagnosis and disposition of musculoskeletal injuries. These practitioners have a wide range in skill levels and often work in remote locations where they must independently make evacuation and treatment decisions under challenging conditions. They are in constant need of simple, effective, and easily learned diagnostic techniques.

The views expressed in this case study are those of the authors and do not represent the official policy or position of the Department of Defense, the Department of the Army, or the United States Government.

Corresponding author: Brett Matzek, MD, Department of Emergency Medicine, 36000 Darnall Loop, Fort Hood, TX 76544 (e-mail: brett.a.matzek@us.army.mil).

The evaluation of fractures rests mostly on the physical examination. However, beyond the traditional examination, it is sometimes taught that a fracture can be detected using a 128 Hz tuning fork and a stethoscope. The technique involves placing the vibrating tuning fork distal to the injury and auscultating proximally. Bone with cortical disruption results in a decrease in the sound propagation. Several studies have demonstrated the value of this technique.[1–4] To minimize the equipment carried by practitioners in an austere environment, we propose changing the vibration source to a more commonly carried tool, a cellular telephone. In this pilot study, we demonstrate a novel approach to the diagnosis of fractures in the humerus and femur using a cellular phone and stethoscope.

Methods

Using 2 cadavers, fractures were made in 1 humerus and 1 femur each. One additional body was used as a control.

Figure 1. Femur auscultation site at the pubis. (Personal protective equipment excluded for demonstration purposes.)

Fractures were produced with the combined use of a bone saw, hammer, and chisel. A variety of fracture sizes and types were produced including transverse, oblique, and comminuted. Fractures of the humerus were done at the surgical neck whereas the femur fractures were produced just distal to the lesser trochanter. All limbs had the same incision made, to blind the participants. A convenience sample of 27 emergency medicine residents and 1 emergency medicine attending physician performed the diagnostic examination.

The participants had never used the study technique nor had they used the tuning fork technique before their participation in this study. There were no known hearing deficits among the participants. For the femur, participants were asked to auscultate at the pubic symphysis and decide which side was decreased: left, right, or neither (Figure 1). For the humerus, participants were asked to auscultate at the anterior shoulder and decide which side was decreased: left, right, or neither (Figure 2). The researcher held the vibrating cell phone to the patella for the lower extremities (Figure 3) and to the lateral epicondyle for the upper extremities (Figure 4). The sites of vibration and auscultation resemble previous studies done with the tuning fork technique. Duration of contact was approximately 3 s per side. The participants were able to request repeats on either side until confident in their examination. To limit amplitude variability, the phone was applied without a case, flush against the bony prominence, with no downward or lateral pressure. The participants were blinded as to which limbs were fractured.

For this study, we used the Apple iPhone 3S (Apple, Cuppertino, CA) and the Littmann Master Classic II Stethoscope (3M Health Care, St. Paul, MN). To make the phone vibrate repeatedly, the iVibe application was used (Robot Mouse, West Chester, PA). Measures of diagnostic accuracy were calculated using GraphPad Prism version 5.04 for Windows (GraphPad Software,

Figure 2. Humerus auscultation site at the anterior shoulder. (Personal protective equipment excluded for demonstration purposes.)