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BRIEF REPORT

Negative Predictive Value of Excluding an Embedded Snake Foreign Body by Ultrasonography

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Objective.—Numerous reputable sources for healthcare providers advocate routine imaging to rule out an embedded tooth or fang after a snake bite. The objective of this study was to determine whether these foreign bodies can be reliably excluded by bedside ultrasonography.

Methods.—All emergency medicine (EM) residents and faculty at a single institution were invited to participate. Two sets of 5 ultrasound gel phantoms were prepared using a method previously validated to have the same density as human tissue. In the first set of 5 phantoms, 1 snake fang was embedded to simulate a retained foreign body. Similarly, in the second set of 5 phantoms, 1 snake tooth was also embedded. Participants were asked to identify the presence or absence of a foreign body in each phantom using bedside ultrasonography. Year of training and confidence in excluding a snake foreign body were also recorded.

Results.—Each participant ($n = 27$) performed ultrasound imaging on 10 phantoms for a total of 270 samples. Range of experience included postgraduate year 1 (25.9%), postgraduate year 2 (29.6%), postgraduate year 3 (33.3%), and graduates of EM residency (11.1%). The sensitivity and negative predictive value for ruling out an embedded fang was 92.6% and 98.1%, respectively. The sensitivity and negative predictive value for ruling out an embedded tooth was 77.8% and 93.7%, respectively. Among all the phantoms, there was a sensitivity of 85.2% and a negative predictive value of 96%.

Conclusion.—Bedside ultrasonography performed by an EM physician is a feasible option to rule out embedded foreign bodies after a snake bite if imaging is warranted.

Key words: snake, pit vipers, ultrasound, foreign body, emergency medicine

Introduction

The care of patients with snake bites is standard practice for an emergency physician. In 2011 there were 6630 snakebite cases reported to the American Association of Poison Control Centers.[1] Currently, the prevalence of a retained snake tooth or snake fang in human tissue remains unknown, and there is a paucity of literature on retained snake foreign bodies; only two English case reports were found that detailed a retained snake tooth or fang.[2,3] A review of one poison center's experience with 1679 pit viper (*Crotalinae)* bites reported over a 10-year period found no evidence of a retained snake tooth or fang.[4] Nevertheless, many healthcare providers continue to order routine imaging as part of wound management after a snake bite. They are not alone; several reputable guidelines for healthcare providers advocate for imaging to rule out a retained foreign body after snake bite.[5–7]

Recently, other investigators have promoted bedside ultrasonography as a viable alternative to radiography to exclude several types of foreign bodies.[8] The advantage of ultrasonography lies in its lack of ionizing radiation and availability at the bedside. Many soft tissue foreign bodies appear hyperechoic on sonography and may produce either shadowing or a reverberation artifact that allows them to be identified even when radiolucent on radiography. Furthermore, ultrasound guidance may play a role in removing the foreign body.[8] The objective of this study was to determine whether embedded foreign bodies, such as a fang or tooth, can be reliably excluded by bedside ultrasonography in a simulated snake bite scenario.

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Methods

All emergency medicine (EM) residents and faculty at a single tertiary care center with a census of approximately 60,000 visits per year were invited to participate in this study. The study was approved by the University of Virginia's Institutional Review Board. Written consent was waived by the Board as there was minimal risk to study participants. Because the true incidence of a retained snake foreign body remains unknown, a priori we assumed a 20% prevalence with the understanding that this would likely underestimate our negative predictive value (NPV).

Two sets of 5 ultrasound gel phantoms were prepared using a method previously validated to have the same density as human tissue that has been used in other ultrasonography research.[9,10] A gelatin and water suspension was made, after which psyllium-based fiber was introduced to act as a scattering agent to approximate the characteristics of human tissue. Blue dye was added to the model to obscure direct visualization of an inserted object.

In the first set of 5 phantoms, a snake fang was embedded approximately 1 cm deep in 1 of 5 phantoms to simulate a retained foreign body after a venomous snake bite. In the second set of 5 phantoms, a snake tooth was similarly placed approximately 1 cm deep in only 1 phantom. Both snake tooth and fang were obtained from a *Crotalinae* species. The fang measured 0.75 cm long and the tooth was 0.2 cm long. On each phantom, the approximate location of the snake bite was identified with a red mark, as bites in actual patients are usually apparent owing to puncture wounds, ecchymosis, and bullae.

Participants were informed that the incidence of retained foreign bodies is low, and they were then asked to identify the presence or absence of a foreign body in each phantom using a SonoSite M-Turbo (SonoSite, Bothell, WA, USA) bedside ultrasound system. They were explicitly blinded to the knowledge that only 1 phantom in each set had a retained snake tooth or fang. Before the study, participants were shown an image of a fang (Figure 1) and tooth as seen on ultrasonography, but no other training was given. Each participant was allowed to scan at his or her own speed, determine the appropriate lighting, and choose either the high frequency or low frequency ultrasound probe. All work was done individually, and each phantom was scanned one at a time in random succession. Year of training, completion of a formal ultrasonography course in residency, and confidence in excluding a foreign body were also recorded.

STATISTICAL ANALYSIS

Each participant's set of 10 responses indicating the presence or absence of a foreign body was recorded on paper then entered into a Microsoft Excel spreadsheet. These responses were graded for accuracy, thereby identifying cumulative values of true positives, true negatives, false positives, and false negatives across all participants.

Ultrasonography test characteristics measured in this study included sensitivity (proportion of gels containing foreign bodies that were correctly identified), specificity (proportion of gels without foreign bodies that were correctly identified), positive predictive value (proportion of gels identified as having a foreign body that truly had a foreign body), and NPV (proportion of gels identified as not having a foreign body among those that truly had no foreign body). In addition to overall

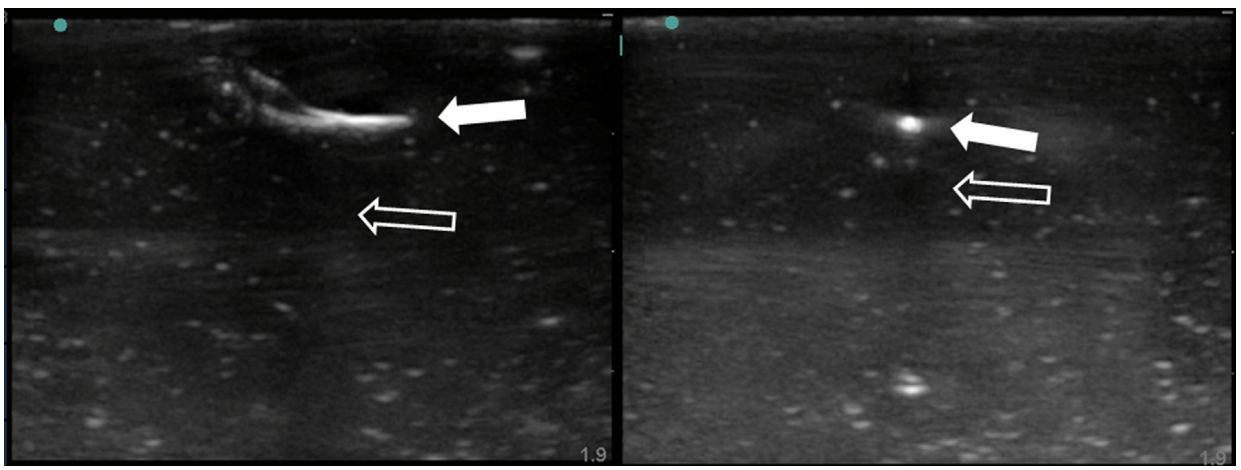

Figure 1. Sagittal (left) and transverse (right) views of *Crotalinae* fang. The hyperechoic fang is represented by the white arrows. Posterior acoustic shadowing is indicated by the hollow arrows.