A simplified training method for soft tissue foreign body detection using ultrasound in emergency medicine residency program

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Abstract

Using ultrasound for detecting soft tissue foreign bodies seems to be the preferred choice with minimum invasion and easy availability at the bedside in emergency departments. In this study, a workshop (1 hour of lecture presentation and 3 hours of interactive hands-on) was designed to evaluate the efficacy of a short course of simple interactive training to improve the ability of emergency medicine residents to detect foreign bodies with ultrasound. Eight pieces of fresh full thickness (10 × 10 × 10 cm) lamb leg muscle were used in this study. Five different types of foreign bodies, including: a piece of glass (5 × 5 × 4 mm), wood (5 × 5 × 4 mm), gravel (5 mm diameter), plastic (5 × 5 × 2 mm) and a nail (25 mm in length) were placed deep inside each lamb leg. An ultrasound machine with a 7.5 MHz linear probe was used in this study. 35 emergency medicine residents (12 PGY1, 11 PGY2 and 12 PGY3) were enrolled in this study. Pretest and post-test results were compared and analyzed. Among all 35 participants in the training session, foreign body detection was significantly improved after the workshop ($p < 0.001$). Overall sensitivity and specificity for differentiating the presence and absence of a foreign body with 95% confidence were 60% (75% for PGY3) and 85.7% (91.7% for PGY3), respectively. The overall accuracy increased from 20.2% to 72.8% due to this session. This study supported the possibility of using ultrasound to detect foreign bodies by emergency physicians with a very short training course. This is highly beneficial for overcrowded emergency departments.

Keywords: Ultrasound, foreign body, emergency medicine, residents' training

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Introduction

Almost 2% of soft tissue injuries are due to retained foreign bodies.¹ These injuries result in seeking medical care in overcrowded emergency departments. In addition, delayed removal could result in morbidities due to pain, inflammation and infection.^{1,2} The vast majority of foreign bodies are radiolucent;³ therefore, simple X-ray would not be able to detect them and these foreign bodies might go undetected in 38% of cases.¹ Among the non-invasive methods for detecting non-radiopaque foreign bodies, ultrasound seems to be the preferred choice with minimum invasion and easy availability at the bedside in emergency departments.^{4–7} It could also be used as a guide to remove foreign bodies and lower the costs by reducing the need for exploratory surgeries.⁸ However, the detection of foreign bodies by using ultrasound is operator-dependent and needs additional training. In this study, we evaluate the improvement of ultrasound-guided soft tissue foreign body

detection after a short training session among emergency medicine residents, who have not been trained for such a task before.

Methods

35 emergency medicine residents from our program were enrolled in this training session. The emergency residents consisted of 12 PGY1, 11 PGY2 and 12 PGY3. None of the residents had previously attended any course on soft tissue ultrasound. The scientific content of the lecture, which was a concise adoption of the American College of Emergency Physicians (ACEP) Guideline for Emergency Ultrasound⁹ was validated by the Panel of Faculties of Radiology and Emergency Medicine of the Tehran University of Medical Sciences. The 4-hour training session was divided into an hour of lecture followed by 3 hours of hands-on.

Experimental subject preparation

In this study, eight pieces of fresh full thickness ($10 \times 10 \times 10$ cm) lamb leg muscle were used. Five different types of foreign bodies including: a piece of glass ($5 \times 5 \times 4$ mm), wood ($5 \times 5 \times 4$ mm), gravel (5 mm diameter), plastic ($5 \times 5 \times 2$ mm) and a nail (25 mm in length) were placed deep inside the samples. Each lamb leg was incised from behind to keep its surface clean and neat. In order to simplify the study and minimize the confounding factors, the foreign bodies were inserted at a depth of less than 20 mm from the anterior surface and were placed horizontally inside the muscle (Figure 1). The remaining samples were left without foreign bodies (Figure 2). In order to keep the tissue fresh, the models were prepared an hour before the training session and they were all identical parts of lamb leg. A portable Fukuda Denshi UF 750 ultrasound machine with a 7.5 MHz linear probe with the preset of soft tissue was used in this study.¹⁰

Study procedure

At the beginning of the training session, after collecting the participation consent, all residents took part in a blinded hands-on pretest for 1 hour on eight pieces of lamb leg muscles. They were allowed to hold the transducer, alter the pressure, use as much gel as necessary and change the gain, depth and magnification on the ultrasound machine in order to have an optimal view. However, they were not able to touch the samples, since touching the samples could have revealed the presence of the foreign body and its location. They wrote their answers on separate answer sheets.

Then, an emergency medicine faculty member gave an hour lecture, consisting of a brief introduction on “basic physics and how to use an ultrasound.” However, the main emphasis of the lecture was on pattern recognition in which ultrasound patterns related to each kind of foreign body were shown to the residents and they were encouraged to memorize these patterns (Figures 1 and 2). After the presentation, a 3-hour interactive hands-on session began. The content of each sample was revealed and the residents started to examine all pieces overtly and as many times as they wished, to master the technique and memorize

Figure 2 Ultrasound scan of lamb leg muscle without any foreign body

Figure 1 Ultrasound scans of different foreign bodies placed deep in lamb leg muscle

Table 1 Complete result of the pretest and post-test and the McNemar's analysis

FB	Pretest/Post-test	PGY1 12 (n)	PGY2 11 (n)	PGY3 12 (n)	All 35 (N)
Plastic	Before	2 (16.6%)	3 (27.2%)	3 (25%)	8 (22.8%)
	After	11 (91.6%)	10 (90.9%)	11 (91.6%)	32 (91.4%)
	<i>p</i> Value	0.004	0.01	0.008	0.006
Glass	Before	1 (8.3%)	2 (18.1%)	4 (33.3%)	7 (20%)
	After	4 (33.3%)	6 (54.5%)	7 (58.3%)	17 (48.5%)
	<i>p</i> Value	0.1	0.05	0.04	0.002
Metal	Before	1 (8.3%)	3 (27.2%)	4 (33.3%)	8 (22.8%)
	After	5 (41.6%)	6 (54.5%)	7 (58.3%)	18 (51.4%)
	<i>p</i> Value	0.1	0.2	0.3	0.006
Wood	Before	2 (16.6%)	2 (18.1%)	3 (25%)	7 (20%)
	After	4 (33.3%)	8 (72.7%)	9 (75%)	21 (60%)
	<i>p</i> Value	0.03	0.03	0.03	<0.001
Gravel	Before	1 (8.3%)	2 (18.1%)	3 (25%)	6 (17.14%)
	After	7 (58.3%)	8 (72.7%)	11 (91.6%)	26 (74.2%)
	<i>p</i> Value	0.03	0.03	0.008	<0.001
Blank	Before	3 (25%)	2 (18.1%)	2 (16.6%)	7 (20%)
	After	9 (75%)	10 (90.9%)	11 (91.6%)	30 (85.7%)
	<i>p</i> Value	0.03	0.008	0.004	<0.001

Table 2 Final results before and after workshop for all residents and PGY3 in particular with 95% of CI

	Accuracy (before)	Accuracy (after)	Sen (before)	Sen (after)	Spe (before)	Spe (after)	PPV (before)	PPV (after)	NPV (before)	NPV (after)
All 35 (95% CI)	20.2% (19.3–21.1)	72.8% (71.7–73.9)	20.6% (19.7–21.5)	60.0% (58.6–61.3)	20.0% (19.1–20.9)	85.7% (85.0–86.4)	20.5% (19.6–21.4)	80.8% (80.0–81.7)	20.1% (19.2–21.0)	68.2% (67.0–69.4)
PGY3 12 (95% CI)	22.5% (19.6–25.3)	92.5% (91.4–93.6)	28.3% (25.0–31.6)	75.0% (72.0–78.1)	16.7% (14.4–19.0)	91.7% (90.4–92.9)	25.3% (22.2–28.4)	90.0% (88.5–91.5)	18.9% (16.4–21.4)	78.5% (75.7–81.2)

Sen: sensitivity; Spe: specificity; PPV: positive predictive value; NPV: negative predictive value.

different patterns of artifact with ultrasound. Finally, they were notified that a post-test would be taken in two months, exactly similar to the pretest. All residents took part in the post-test. Meanwhile, during the 2-month interval, none of the residents used ultrasound to detect foreign bodies at the Emergency Department and did not have the chance to practice this method on their own.

Data collection and analysis

In order to collect the data, each participant had a paper sheet in which they had mentioned whether a foreign body was detected or not in each sample. All data from the pretest and post-test were gathered confidentially and were blinded before analysis. The data were then analyzed using SPSS 15.¹¹ We used McNemar's test to find any significant difference ($p < 0.05$) between pretest and post-test.

Results

In this study, there were 35 emergency medicine residents, consisting of 12 PGY1, 11 PGY2 and 12 PGY3. According to the overall analysis, foreign body detection was significantly improved among all trainees after the workshop ($p < 0.001$). Plastic, wood and gravel detection among all

residents improved significantly after the workshop (Table 1). However, although overall nail detection by all residents improved significantly after the workshop ($p = 0.006$), detection of the nail among each subgroup of residents of PGY1, PGY2 and PGY3 did not improve significantly after the workshop ($p = 0.1$, $p = 0.2$ and $p = 0.3$, respectively). Moreover, glass detection did not improve significantly in the PGY1 subgroup ($p = 0.1$) compared to the overall improvement ($p = 0.002$) (Table 1).

Overall, the concise workshop significantly ($p < 0.001$) improved the ability of all participants in identifying foreign bodies or determining their absence in blank pieces (Table 1). The accuracy, sensitivity, specificity, positive predictive value (PPV) and negative predictive value (NPV) for detection of each radiolucent foreign body increased significantly after the training session (Table 2). The estimated overall sensitivity and specificity with 95% confidence interval were 60% (75% for PGY3) and 85.7% (91.7% for PGY3), respectively. The overall accuracy increased from 20.2% to 72.8% (Table 2).

Discussion

In this study, a 1-hour lecture followed by a 3-hour hands-on session using the concise ACEP guideline for emergency

ultrasound was used to train emergency residents. The results of our study were comparable to a similar study done by Orlinsky *et al.*¹² In that study, 16 hours of combined didactic and practical hands-on training adopted from the Society of Academic Emergency Medicine (SAEM) Guideline for Emergency Ultrasound revealed a sensitivity and specificity of 74% and 87% for emergency physicians (PGY3) without previous training. However, the performance of our third-year residents (PGY3) after two months was almost similar with sensitivity of 75% and specificity of 91.7%. Another study done in New Zealand showed an overall 85.7% sensitivity and 89.2% specificity of foreign body detection among six consultant emergency physicians and 14 emergency medicine PGY3-10 with major differences in exposure to soft tissue ultrasound techniques.¹³ The participants in that study had previously attended an exclusive ultrasound course for 1 to 5 days. Then, they all attended 20 minutes of hands-on training on different artifacts from different soft tissue foreign bodies. When comparing the above study with our study, our trainees were residents who had never been officially trained for soft tissue ultrasound and had no prior experience. Moreover, in our study, a pretest and a post-test after two months were used to evaluate the training session and its sustainability.

The trained residents improved their ability to detect wood splinters, plastic, glass and gravel in soft tissue by the use of ultrasound. Although the overall nail detection in all residents was improved significantly after the workshop, in each subgroup of residents (PGY1, PGY2 and PGY3) there was not a significant improvement in nail detection. This might be due to the limited number of participants in each subgroup. As a result, when pooling of participants was done, the improvement became significant. Moreover, although the nail was not too small to be detected (25 mm length and 2 mm diameter), the residents' experience and the need to align the probe longitudinally exactly parallel to the nail could be another reason for this failure in each subgroup.

With regard to the PGY1 glass detection, which did not improve significantly after the workshop, previous clinical use of ultrasound for performing FAST (Focused Assessment with Sonography in Trauma) by PGY2 and PGY3 could be an explanation. As a result, the background knowledge and experience for using ultrasound could be a confounding factor in this study.

This study supported the possibility of using ultrasound to detect radiolucent foreign bodies by emergency physicians with a very short training course. This is highly beneficial for overcrowded emergency wards in which radiologists are always busy with other procedures. This could result in bedside diagnosis and treatment of patients in the emergency department.

Factors that should be considered in future studies are as follows: In this study, an immediate post-test was not done. If we had an immediate post-test, we could have compared the result of it with our long-term evaluation after two months. All the foreign bodies were placed horizontally

and only one foreign body was placed in each lamb leg. Other studies could be done to evaluate the performance of trainees based on the position and number of foreign bodies. It is highly suggested to have a revalidating strategy in which residents will be re-evaluated on a six-month basis by consultant radiologists to determine the maintaining competence. As this training is based on ultrasound pattern recognition, training ED and triage nurses could be the main aspect of further studies. Last but not least, it is recommended to increase the sampling size in further studies to minimize its effect on the results.

DECLARATIONS

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Contributorship: SM and SF researched literature and conceived the study. SF and ZK designed the study. SF, SBH, HBG and MS participated in training and evaluation sessions. SF, SBH and ZK did the data analysis. MS and MA wrote the first draft of the manuscript. SBH wrote the final version of the manuscript. All authors reviewed and approved the final version of the manuscript. SF was the project supervisor and the department clinical lead.

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