ORIGINAL ARTICLE

Role of ultrasound simulators in the training for Focused Assessment with Sonography for Trauma (FAST)

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ABSTRACT

BACKGROUND: The present study aims to investigate the efficacy of ultrasound simulators in the training of the health staff working in the emergency department of a university hospital on Focused Assessment with Sonography for Trauma (FAST).

METHODS: This study was conducted on emergency medicine residents, medical interns and paramedics of the emergency department of Selçuk University Medical Faculty, prospectively. The participants were given theoretical and practical training on FAST using the SonoSim® USG simulator. At the end of the training, all participants were requested to perform FAST for the pre-selected scenarios for five patients to find the ideal diagnostic window for each patient and declare the diagnosis.

RESULTS: This study included 60 participants, including emergency medicine residents, medical interns and paramedics, each having 20 members. The rate of obtaining the correct image was 99.5%, and the rate of diagnosing correctly was 94% among resident physicians. For interns, these rates were 98.5% and 88%, respectively. For paramedics, the rates were 98% and 81.5%, respectively.

CONCLUSION: It was observed that the theoretical knowledge level of the trainees did not affect the ability to obtain a correct image in the simulator. However, the skills of the trainees for correctly diagnosing via FAST were directly proportional to their theoretical knowledge levels. Our findings suggest that a short theoretical training followed by a simulator-guided practice would easily provide a sufficiency for FAST for the health workers.

Keywords: Education; emergency department; FAST; trauma; ultrasound simulator.

INTRODUCTION

Trauma is the fourth most common cause of death among all age groups worldwide, whereas it is the most common cause of death among the adult population below 40 years of age, who are expected to have a long life expectancy.[1] Patients brought to emergency departments with trauma are evaluated in accordance with an experimental algorhythm; however, in case of multi-traumas or severely poor general condition, this algorhythm may not always be kept up with. In cases requiring emergency surgery, diagnostic methods should immediately be performed. Otherwise, the mortality risk of a patient with intraabdominal bleeding and shock is increased by 1%, with every three minutes having passed.[2] In particular, in hemodynamically unstable patients, the bleeding foci should be detected and controlled.

Patients considered to have intraabdominal bleeding according to physical examination may be examined invasively with diagnostic peritoneum lavage (DPL) or non-invasively with methods, such as ultrasonography (USG) or computed tomography (CT). Selection of the method depends on the condition of the patient. Recently, the use of USG in the emergency department to detect intraabdominal bleeding has been increased. The USG used for this purpose has been defined as Focused Assessment with Sonography for Trauma (FAST). FAST has been recommended as an effective diagnostic method for swift detection of bleeding in patients with

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trauma both before and after the hospitalization.[3] FAST is extremely important in the evaluation of unstable patients with trauma in the emergency departments due to its bedside applicability and rapid nature, cost-efficiency and high sensitivity.[4] The FAST protocol investigates the presence of any pericardial or intraperitoneal fluid (perihepatic, perisplenic and pelvic). In addition, hemothorax and pneumothorax may also be investigated in the Extended FAST (EFAST) protocol.

FAST is a practical, bedside, non-invasive diagnostic method. However, the practitioner should be trained on USG to perform FAST. In the literature, volunteers, standardized patients, hand-made models and real patients have been used for USG training. It is difficult to convince volunteers and real patients for training. The cost for standardized patients is high since they are hourly priced. Hand-made models are expensive and generally do not provide realistic images. Therefore, a more sustainable and realistic solution is needed to provide a larger-scaled and long-term USG training.[5]

Due to many reasons, simulations have been believed to be ideal for bedside USG training and evaluation. Simulation may be used in bedside USG training due to the repeatability of the clinical scenarios and the presence of the possibility to meet life-threatening clinical findings in a safe environment. Simulation-based training can protect the patients from mistakes and the sequelae caused by these mistakes, as well as provide training in low-stress environment for occasionally observed high-risk injuries.[6]

The present study aims to investigate the efficacy of USG simulators in the training of the health staff working in the emergency department of a university hospital on FAST.

MATERIALS AND METHODS

This study was conducted prospectively on emergency medicine residents, medical interns and paramedics of the emergency department of Selçuk University Medical Faculty after approval of the ethical board of Selçuk University (date: 07.07.2015, no: 2015/231).

The SonoSim® Ultrasound Training Simulator was used in this study. This simulator is made up of two pieces as a computer, including the software and the imaginary probe (Fig. 1). Imaginary patients formed by modeling the real USG images of normal or pathological patients are used in this simulator. The program includes 10 FAST cases consisting of a wide range of cases, from those with no free fluid to those with massive fluid. The trainee calibrates the probe according to its position on the imaginary patient on the monitor, and as he/she moves the probe, the USG image obtained from a real patient on the monitor moves correlated with the hand movements of the trainee. In this way, the trainee tries to catch the site to be visualized by moving the probe to the desired direction.

Figure 1. The SonoSim® Ultrasound Training Simulator.

The trainees were first given theoretical information on USG and FAST through the internet site http://sonosim.ttlms.com. They were then given practical USG and FAST training using the simulator. The training was continued until the attendees gave consent for sufficient adaptation to the simulator and progressing to the test scenarios.

Following the completion of the training, all attendees were asked to apply FAST on scenarios for five pre-selected patients included in the SonoSim® Ultrasound Training Simulator to detect the ideal diagnostic window and declare the diagnosis. In addition, an experienced specialist was asked to score whether the correct diagnostic window was obtained or not during FAST and whether the diagnosis was correct or not.

During FAST, among the skills of detecting the correct image and correct diagnosing in each of the four quadrants evaluated, each quadrant was scored as 1 point. Each attendant evaluated five scenarios. Thus, two different skills were evaluated over 20 points each. This examination was conducted under the supervision of two lecturers with USG certification.

Statistical Analysis

Before statistical analyses, distributional properties of the data were tested using the Anderson-Darling normality test. The descriptive statistics for continuous variables were expressed as median (minimum–maximum) for non-normally distributed variables. The scores obtained by the attendees for the images obtained and diagnosing were compared between the groups. The Kruskal-Wallis test was used for multiple group comparisons and the Mann-Whitney U test was used to define the different group or groups. A p-value of <0.05 was accepted as statistically significant.

RESULTS

This study included 60 participants, including emergency medicine residents, medical interns and paramedics, each having 20 members. The median age was 27 (range: 23–41). Among them, 39 were male and 21 were female. The median

Table 1. Descriptive statistics for ages (as year) according to occupations*

Groups	n	Male	n	Female	n	Overall
Resident physicians	17	30 (26–40)	3	29 (25–31)	20	30 (25–40)
Intern students	11	24 (23–26)	9	24 (23–25)	20	24 (23–26)
Paramedics	11	29 (23–41)	9	31 (23–34)	20	30 (23–41)

*Data are presented as median (minimum–maximum).

Table 2. Descriptive statistics for the duration of seniorities of the participants according to groups and genders

Groups	Male	Female	Overall
Resident physicians	43 (4–56)	36 (2–43)	39.5 (2–56)
Intern students	10 (8–10)	10 (7–10)	10 (7–10)
Paramedics	108 (36–264)	132 (60–144)	126 (36–264)

*Data recorded as a month and presented as median (minimum–maximum).

age among male participants was 28 (range: 23–41), and the median age among female participants was 25 (range: 23–34). The median ages among resident physicians, intern students and paramedics were 30 (range: 25–40), 24 (range: 23–26) and 30 (range: 23–41), respectively (Table 1).

Duration of professional experience was evaluated among the participants, which were 39,5 (range: 2–56), 10 (range: 7–10) and 126 (range: 36–264) months for resident physicians, intern students and the paramedics, respectively (Table 2).

Primarily, the ability to obtain the correct image on the USG simulator was evaluated on four anatomic regions of five tested cases (right and left upper quadrant, pericardium and pelvis). The participants were not expected to make a diagnosis in this step, but whether they could obtain the correct image or not was scored. Each anatomic region was scored with 1 point, and each participant was evaluated for over 20 points score for five cases. The percentages of obtaining the correct image were 99.5%, 98.5% and 98% for resident physicians, intern students and paramedics, respectively (Fig. 2a). In this step, all participants obtained the correct image with almost absolute success (Fig. 2a). No statistically significantly difference was observed between the study groups (p=0.26).

Secondly, the participants were asked to report any pathology they had observed in the sites they had obtained the correct images on the USG simulator and evaluated for correct diagnosis. In this step, the participants who had not obtained the ideal images were evaluated as wrong diagnosers. Each region was calculated over 1 point, and each participant was evaluated over a total score of 20 points for five cases. Among all participants, no significant difference was observed between the males and females about the correct diagnosis (p=0.24). A statistically significantly difference was observed between the study groups about concerning the correct diagnosis (p<0.001) (Fig. 2b). The percentages of correct diagnosis were 94%, 88% and 81,5% for resident physicians, intern students and paramedics, respectively. The inter-group comparison revealed a significant difference between both resident physicians and intern students (p=0.005) and between the resident physicians and paramedics (p<0.001). No significant difference was observed between the intern students and paramedics (p=0.08).

Following the evaluation of the differences between the groups, the success of the groups for correct diagnosis in four anatomical regions evaluated for FAST were compared (Table 3). A significant difference was observed between the resident physicians and the paramedics for each of the four anatomical regions.

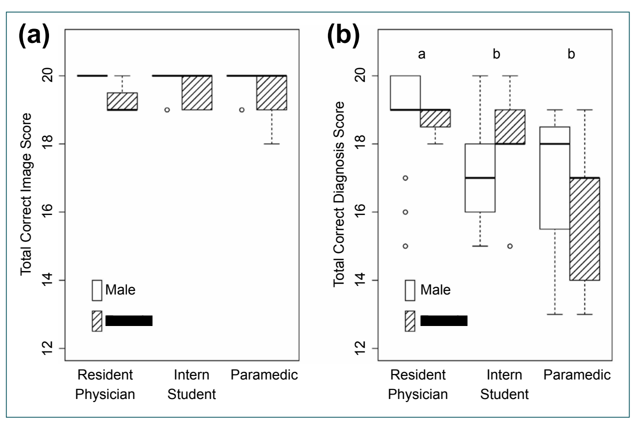

Figure 2. Boxplots of total scores for: **(a)** correct image, and **(b)** making a correct diagnosis obtained by the participants groups. Groups not sharing the same letter are significantly different from each other (p<0.01).

Table 3. Descriptive statistics and results from the comparison of the groups about making a correct diagnosis according to the images the participants obtained for the four anatomical regions undergoing FAST*

Region	Groups		
	Resident physicians	Intern students	Paramedics
Right upper quadrant	5 (3–5)[a]	5 (3–5)[a]	4 (3–5)[b]
Pelvis	5 (3–5)[a]	4 (3–5)[b]	4 (1–5)[b]
Left upper quadrant	5 (4–5)[a]	4 (3–5)[b]	4 (2–5)[b]
Pericardium	5 (4–5)[a]	5 (4–5)[a]	5 (3–5)[b]

*Data are presented as median (minimum–maximum)
Group medians, not sharing the same letter are significantly different from each other (p<0.05).

In the final step of this study, the participants were classified into three groups according to seniorities for each profession type. Since all intern students belonged to the same group, no such classification was carried out for them. Among the resident physicians, those who had been residents for 0–24 months were grouped as "low seniority", those with 25–48 months were grouped as "moderate seniority" and those who had been residents for >48 months were grouped as "high seniority". Among the paramedics, those who had a 0–60 month experience were grouped as "low seniority", those who had 61–120 months of experience were grouped as "moderate seniority" and those who had an experience of more than 120 months were grouped as "high seniority".

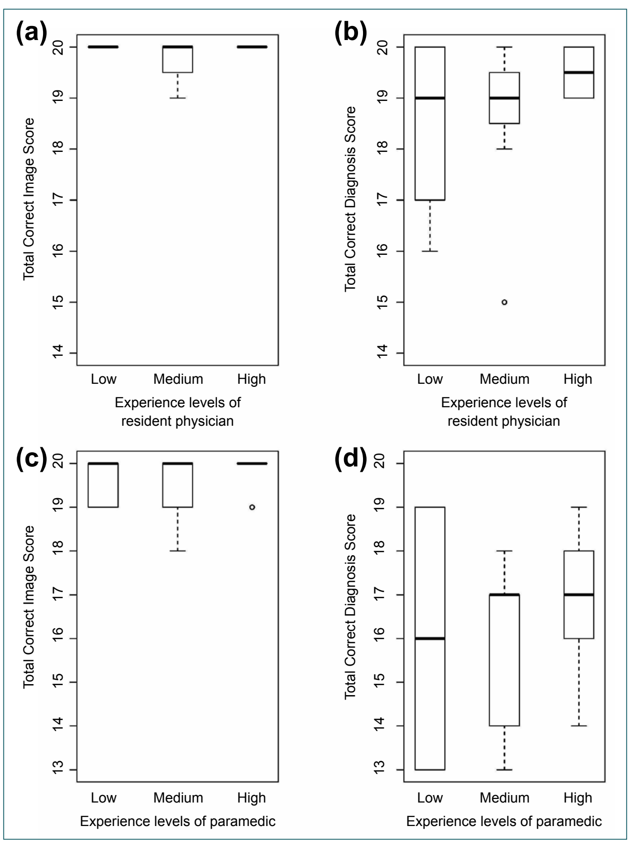

Figure 3. Boxplots of total scores according to the seniority groups for: **(a)** correct image by a resident physician, **(b)** making a correct diagnosis by resident physician **(c)** correct image by paramedic, and **(d)** making a correct diagnosis by the paramedic.

Following the classification of resident physicians and paramedics, in-group comparison was performed according to obtaining the correct image and correct interpretation of the images for each group, which revealed no significant difference between the seniority groups (obtaining the correct image; p=0.20 and p=0.68, respectively) (correct diagnosis; p=0.41 and p=0.66, respectively) (Fig. 3).

DISCUSSION

FAST is a facilitative searching method for the clinician in the bedside evaluation of intraabdominal free fluid. Using this examination, intraperitoneal free fluid has been investigated in hemodynamically unstable patients to evaluate the intraabdominal injury. However, although it is an effective method in evaluating the presence of free fluid, it cannot localize the damage. Besides, FAST has been observed to be insufficient in evaluating the retroperitoneal bleedings that do not lead to hemoperitoneum, which may be related to serious blood loss. Furthermore, false-positive results may be observed in patients with unexpected ascites in the abdomen.[7]

In a study evaluating 633 patients brought to the trauma center due to abdominal trauma and undergoing FAST, FAST was observed to have a negative predictive value of 96%, the positive predictive value of 63%, the sensitivity of 29% and specificity of 99% in predicting intraperitoneal injury.[8] These data suggested that FAST was useful in the first evaluation of intraperitoneal injuries; however, a negative FAST outcome would not eliminate an intraabdominal injury since its sensitivity was low. FAST is not a routine pathological examination via USG, and only a limited version of it is used as planned for the evaluation of the free fluid.[9] In an international meeting on the subject, a consensus was made on the recommendation that FAST should be repeated twice with a six hour interval in patients with abdominal trauma in order not to miss any organ injury and that clinical examination should be repeated frequently in the meanwhile.[10]

FAST has many advantages; however, one of the most important disadvantages is that the practitioner should be trained on basic USG to perform FAST. Training on FAST includes didactic training (USG physics, indications and technique), practical training and actual clinical training on patients with trauma.[11,12] Important technical factors, including the description of sonographic artifacts, should be considered during the training.[13] In a study, the trainees who were given only eight hours of didactic and practical FAST training were requested to perform FAST on patients admitted with blunt abdominal trauma. In that study, the sensitivity, specificity, and accuracy of FAST were observed to be 81%, 99.3% and 98%, respectively.[14]

FAST trainers use different models in the training of the physicians to perform FAST on patients with trauma. Models, including didactic imaginary presentation, video presentation of actual patients, animal models, simulator models, cadavers, normal healthy individuals, or peritoneal dialysis models, have been used in training.[11,15] Some studies have shown that skills on FAST may be developed by attending regular USG training and positive examination experiences.[16]

Due to many reasons, USG simulators are believed to be ideal for bedside USG training and evaluation. Bed-side USG training necessitates repeatable clinical scenarios, measurable performances of the trainees, and the opportunity for the trainees to meet abnormal or critical findings in a safe environment and standardized manner. Simulators provide the opportunity of FAST in a wide range of cases from those with no free fluid to those with massive fluid. Simulation provides the trainees a practical approach before performing FAST on patients with trauma.[17] Using simulation models prevents experiencing the method on actual patients who already have a critical condition. Furthermore, they provide training in a low-stress environment for rarely observed high-risk injuries.[6]

In a systemic review conducted on 52 studies evaluating FAST training, it was determined that normal individuals were most frequently used in FAST training (65%), which was followed by patients with peritoneum dialysis (27%). The least frequently used methods were animal models (4%) and cadavers (2%). Simulators were used at a rate of 14.5%. As a result, it was mentioned that USG training should include a minimum of two steps, the first including theoretical and the second including animal models simulator-guided practical training.[17] In our study, all participants were given theoretical information online, which was followed by simulator-guided practical training, in accordance with that study.

In a study, the trainees were classified into two groups; the first group was trained on patients receiving peritoneal dialysis, and the second was trained on the simulator, and the satisfaction scores and success of the trainees were compared. It was reported that the trainees were both satisfied by the peritoneum dialysis model and the simulator. The scoring, on the other hand, revealed that intraperitoneal free fluid imaging was important. In that study, although high satisfaction scores were obtained with peritoneal dialysis models, no significant difference was observed compared to that of the simulators.[18]

Simulators are advantageous since they are present in the training program whenever they are needed, provide the trainees a high variability about sonographic findings, and carry no patient privacy problem.[11] Simulators are believed to be preferred in the future since it has the ability to provide a standardized training, and allows direct comparison of sonographic performances of the trainees in the test stage. In our study, the healthcare-givers with no USG experience at all had high success in visualizing the free fluid following the theoretical and practical training, which supports this data. In particular, paramedics and intern students with no USG experience at all showed a rate of over 95% in obtaining the ideal image and a diagnosing rate of between 80% and 90%, which is promising in FAST to become widespread in the next decades for the use of the method in many fields, including the pre-hospital period.

Although use of bedside USG is becoming increasingly widespread, students of medical faculties are not experienced with USG. In medical faculties, generally, direct X-Rays and electrocardiogram methods have been taught for long hours; however, training on USG is not sufficient. These imaging methods would facilitate the approaches of the students to anatomy, physiology and pathology, as well as improving their integration to the hospital. In a study conducted on USG in Canada, 12 students of the medical faculty were given theoretical information, which was followed by practical training using the USG simulator. Then, an examination was performed using six different scenarios. Comparison of the scores of the students before and after the examination revealed that the scores obtained after the examination were significantly higher.[19] In another study conducted to evaluate whether USG training would be sufficient for the medical faculty training before graduation or not, USG training was given to the students in emergency medicine internship and a survey was performed subsequently. Among the students, 98% mentioned that they had received a qualified education, and 100% mentioned that their education on USG had improved and that they would recommend the training.[20] In another study, 5th-year students of the medical faculty were given theoretical and practical education on USG, and they were examined on actual patients. Values of obtaining acceptable correct images were 73.8% for the cardiovascular region and 93.5% for the whole abdomen. A 100% success was obtained in patients examined for free abdominal fluid only.[21] In our study, an exam was performed after the intern doctors were given FAST training via USG simulators, and a rate of 99% was obtained for obtaining a correct image and a rate of 88% was obtained for correct interpretation of the images in accordance with the literature. These results suggest that with the advances in technology, in addition to conventional methods, such as examination using the stethoscope and direct X-Rays, students of medical faculties should be given USG training to contribute to their education.

In a well-operating pre-hospital triage system, patients suspected to have major traumatic injury are bought to the emergency department of a previously determined trauma center by ambulance. Before arrival, the hospital is informed about the situation. On arrival at the emergency department, trauma is evaluated and primary or secondary examination is performed according to the hemodynamic situation and FAST is performed. A pre-hospital FAST performed may accelerate the diagnosis and treatment of the patient. In a study conducted in the USA, a team, including nine paramedics, were given FAST training, and they were examined on 10 cases, including patients receiving peritoneal dialysis and normal individuals. The evaluation revealed 67% sensitivity, 56% specificity and 60% accuracy.[22] In another study conducted in Australia, nurses and paramedics were given FAST training and checked for sensitivity and specificities. In this study, including 242 paramedics and nurses, sensitivity, specificity and accuracy rates were measured to be 84.4%, 98.4%, and 95%, respectively.[23] In a study conducted on 127 patients in Turkey, paramedics were given four hours of theoretical and four hours of practical training, and the trainees were asked to perform FAST; the sensitivity and specificity rates were observed to be 84.6% and 97.3%, respectively.[24] In our study, the sensitivity and specificity rates were not measured; however, obtaining the correct image and correct evaluation of the image were 98% and 82% for paramedics, respectively. These results are generally close to those observed in the literature and demonstrate that FAST training is easy and successful using USG simulators. The presence of trained paramedics on FAST would accelerate the diagnostic and treatment processes of the patients both in the pre-hospital period and in the hospital and reduce the workload in the hospital.

We observed no significant difference between the three occupational groups about obtaining the correct image in FAST. However, resident physicians were observed to be significantly more successful in interpreting the images correctly compared to intern students and paramedics. Comparison of diagnostic success between the occupational groups about the region in which FAST was performed revealed no significant difference between resident physcians and intern students for the right upper quadrant and pericardium, whereas the success of paramedics was significantly lower. For the left upper quadrant and pelvis, no significant difference was observed between the intern doctors and paramedics, whereas resident physicians were observed to be significantly more successful compared to these two groups. In the light of these data, it may be concluded that a basic anatomical education is sufficient for obtaining the correct image in FAST, whereas emergency medicine education and experience are required to correctly interpret the image.

Following the classification of resident physicians and paramedics according to their seniorities, participants of the same occupation were compared about their abilities to obtain the correct image and correct interpretation of the image according to their seniorities, and no significant difference was observed. These data demonstrate that no seniority level is necessary for FAST training, and all healthcare-givers meeting the patient with trauma may be given FAST training easily using USG simulators.

Conclusion

With the developing technology, USG simulators have gained importance in FAST training. The use of USG simulators in FAST training was observed to improve the skills of participants in obtaining an image in USG and to interpret this image. Theoretical knowledge of the trainees was observed not to affect the skills of obtaining the correct image in the simulator. However, it was observed that the theoretical information level of the trainees and skills of correctly diagnosing using FAST and simulator were directly proportional. Furthermore, seniorities of the trainees did not affect the rates of obtaining the correct image and the ability to diagnose correctly. Our findings suggest that with a short theoretical education followed by practical training via the simulator, healthcare -givers may easily obtain sufficiency regarding FAST.

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ORİJİNAL ÇALIŞMA - *ÖZET*

Travmada Sonografi ile Odaklanmış Değerlendirme (FAST) eğitiminde ultrason simülatörlerinin rolü

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AMAÇ: Bu çalışmanın amacı, bir üniversite hastanesi acil servisindeki sağlık çalışanlarına FAST eğitimi verilmesinde ultrason simülatörlerinin etkinliği incelenmesidir.
GEREÇ VE YÖNTEM: Bu çalışma, Selçuk Üniversitesi Tıp Fakültesi Hastanesi Acil Tıp Kliniği'nde çalışan acil tıp asistanı, stajyer doktor ve paramedikler üzerinde ileriye yönelik olarak yapıldı. Katılımcılara SonoSim® USG simülatörü ile teorik ve pratik FAST eğitimi verildi. Eğitim tamamlandıktan sonra tüm katılımcılara sırayla simülatör içeriğinde yer alan önceden seçilmiş beş hasta senaryosu için FAST uygulaması, her bir hasta için ideal tanısal pencereyi bulması ve tanıyı söylenmesi istenmiştir.
BULGULAR: Çalışmamıza, herbiri 20 kişiden oluşan acil tıp asistanları, stajyer doktorlar ve paramedik gruplarının yer aldığı 60 katılımcı alındı. Asistan doktorlar için doğru görüntüyü elde etme oranı %99.5, doğru tanı koyma oranı %94 olarak hesaplandı. Stajyer doktorlar için doğru görüntüyü elde etme oranı %98.5, doğru tanı koyma oranı %88 olarak, paramedikler için ise doğru görüntüyü elde etme oranı %98, doğru tanı koyma oranı %81.5 olarak hesaplandı.
TARTIŞMA: Kursiyerlerin teorik bilgi düzeyinin simülatörde doğru görüntüyü elde etme becerilerini etkilemediği görülmüştür. Ancak eğitime katılan kursiyerlerin teorik bilgi düzeyleriyle, simülatörde FAST uygulayarak doğru tanı koyma becerilerinin doğru orantılı olarak etkilendiği görülmüştür. Bu çalışma, kısa bir teorik eğitim ve arkasından yapılacak simülatör eşliğinde pratik eğitimle sağlık çalışanlarının FAST konusunda yeterlilik sağlayabileceklerini göstermiştir.
Anahtar sözcükler: Acil tıp; eğitim; FAST; travma; ultrason simulatörü.

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