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Evaluation of Diagnostic Value of FAST in Patients with Multiple Trauma Referring to a Trauma Center in Northern Iran

Iraj Baghi [1], Mohammadsadegh Mousavi [1] *, Arghavan Malekshahi [1], Mohammadreza Mobayen [1]

[1] Guilan Road Trauma Research Center, Guilan University of Medical Sciences, Rasht, Iran

* **Corresponding author:** Mohammadsadegh Mousavi. Guilan Road Trauma Research Center, Poursina Hospital, Namjoo Street, Rasht, Iran. **Email:** Mmobayen@gmail.com

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Abstract

Background: Abdominal injuries are among the most common causes of death in trauma patients, one-third of whom develop abdominal trauma. Focused assessment with sonography is a part of the initial examination for emergency care of patients with abdominal blunt trauma.

Objectives: This study aimed to investigate trauma patients with positive FAST under laparotomy surgery in a Trauma Center.

Methods: This cross-sectional study was conducted on 180 patients with abdominal trauma admitted to Poursina Hospital, Rasht, Iran between 2016 and 2017. On admission, they were examined with FAST and divided into positive and negative. The patients underwent laparotomy/CT after physical examinations, and their results were mentioned as negative/positive.

Results: Sensitivity, specificity, positive and negative predictive values of FAST compared with CT-scan in all patients were 60%, 52.4%, 23.3% and 84.4%, respectively. Seventy-eight out of 90 patients with positive FAST underwent laparotomy and 19 patients with negative FAST underwent laparotomy. Low blood pressure, GCS, and the hospital arrival time had a significant relationship with the likelihood of false positives of FAST compared to CT scans, whereas the significant relationship was reported only in false-negative cases in age. There was a relationship between false-positive cases of the FAST compared with laparotomy in blood pressure. This relationship was significant in the case of false-negative cases in age ($P<0.05$).

Conclusion: Implementing FAST by surgical assistants does not have high sensitivity and specificity. Therefore, it is recommended to use other diagnostic methods such as CT-scan along with FAST, besides paying attention to sufficient training of surgical assistants in performing FAST.

Keywords: Diagnostic value, Multiple trauma, Surgery.

Introduction

Trauma is the leading cause of death in the world,[1] and is more common in patients under 40 years of age.[2] Given to industrialization, urbanization, and technological development in human societies, accidents are currently one of the most important threats to public health, and leading to high mortality and morbidity.[3-5]

Abdominal injuries are one of the most common causes of death in trauma patients.[3] About one-third of trauma patients have abdominal trauma.[6] The abdomen is the third most vulnerable area in trauma, requiring surgery in 15-20% of cases, and non-penetrating abdominal injuries are still the most common mechanism of abdominal injury.[7,8] One of the important points in reducing the mortality rate of trauma patients is the rapid and timely diagnosis of organic injuries. Clinical examination is not reliable in the precise evaluation of trauma patients, and acceptable standard gold methods such as computed tomography (CT) scan and diagnostic peritoneal lavage (DPL) are time-consuming and invasive.[7]

Ultrasound can be used, given its major advantages in diagnostic accuracy, it is an important step to reduce the time and cost of examining trauma patients.[9,10] Ultrasound is commonly used as a diagnostic method in many countries around the world for abdominal injuries.[9] Focused Assessment with Sonography for Trauma patients (FAST) is a part of the initial examination as well as a valuable aid for emergency care of patients with

abdominal blunt trauma.[11] After spending a short training course, emergency physicians can use FAST to make an initial assessment of trauma patients.[12] Nowadays given to technological advances, ultrasonography can be used as a portable apparatus during emergencies and at the patient's bedside. Unlike radiography or CT scans, ultrasound can be performed with resuscitation measures simultaneously in a trauma room to detect life-threatening injuries without any delay or even interruption.[12] FAST has been widely used in the last 3 decades. Prior to FAST, invasive methods such as DPL and laparotomy were used.[13] FAST is a bedside ultrasound protocol that can be used as a screening tool to identify lesions within the peritoneum, and is performed by surgeons and radiologists with the same reliability. FAST is usually recommended in the primary survey of traumatic patients in the circulatory stage and in an unstable patient with abdominal trauma to examine intra-abdominal and pericardial fluid.[14]

FAST ultrasound has many advantages in assessing early trauma patients and is useful as a screening test, especially in patients who are unable to have a CT scan due to unstable hemodynamics. The presence of free fluid in the FAST with unstable hemodynamics that does not respond to resuscitation measures indicates the need for immediate surgery.[15] In recent years, FAST ultrasound in emergency centers has been utilized increasingly due to its portability and ease of use, as well as the lack of the need for a skilled radiologist.[16] Given that the test is performed at the patient's bedside with no need to transfer of patient, it can be very useful in acute care,[17] so it is necessary to use this technique and evaluate the diagnostic accuracy, limitations, and capabilities of it to assess patients with non-penetrating abdominal trauma in emergency centers.

Objectives

This study aimed to investigate trauma patients with positive FAST under laparotomy surgery referring to a trauma center.

Methods

This was a cross-sectional study conducted on 180 patients with abdominal trauma admitted at Poursina Educational and Medical Center in Rasht, Iran between September 2016 and September 2017. The patients were entered into the study by census method. The samples were patients 12 years of age and older who suffered from high-energy trauma following multiple trauma. The patients underwent physical examination and diagnostic FAST as soon as they entered the emergency department by a fourth-year surgical assistant and were divided into positive and negative FAST groups based on the results. In the next step, the patients underwent laparotomy if there have signs of generalized peritonitis or hemodynamic instability. The patients underwent CT scans if there were no peritoneal stimulation symptoms or evidence of hemodynamic instability. The results were reported as negative or positive.

The data required for this study were collected in a checklist including age, gender, the time interval between occurring trauma and laparotomy, mechanism and type of trauma, preoperative physical findings, and mortality rate.

Statistical analysis

The data were analyzed using descriptive statistical tests such as mean, standard deviation, and multiple logistic regression analysis using SPSS Version 21. By drawing a cross table, the sensitivity and specificity of FAST and its positive and negative predictive values were calculated. A statistical difference of less than 0.05 was considered significant.

Ethical considerations

Informed consent was obtained from all individual participants included in the study. The study has been approved by the ethics committee of Guilan University of Medical Sciences.

Results

In the present study, 151 (83.89%) patients were male and 29 (16.11%) female. The mean age of the samples was 34.4±13.8 years old, with the range of 14-74 years. The mean hospital arrival time was 2.8±0.8 hours. The mean GCS of patients was 13.05, with a range of 3-15. The mean systolic and diastolic blood pressure was 103.1±16.4 and 68.3±8.7 mm Hg, respectively. Also, the pulse rate was 99.5±18.9 beats per minute.

Among trauma mechanisms, traffic accidents were the most common (93%). Falls from a height (5%) and falling from the same level ranked second and third, respectively (Figure-1).

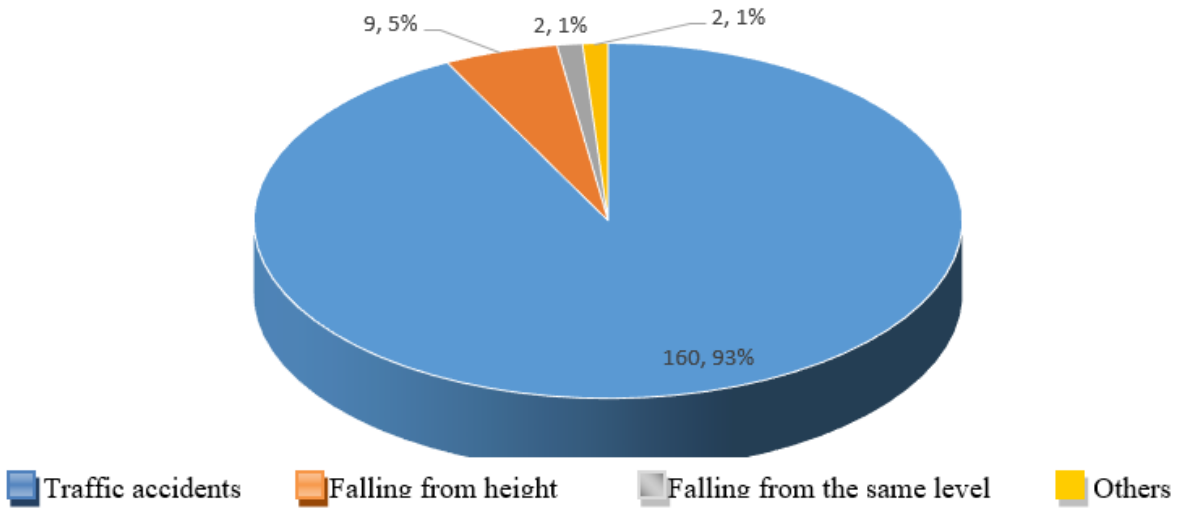

Figure-1. The frequency of multiple trauma patients referred to Poursina hospital in terms of mechanism of injury (n=180)

As shown in Table-1, the sensitivity, specificity, positive and negative predictive values of the FAST test were 60%, 52.4%, 23.3% and 84.4%, respectively, compared to CT scan in all samples. Out of 90 patients with positive FAST, 78 patients underwent laparotomy, and 19 patients with negative FAST underwent laparotomy. The results of the FAST test in patients undergoing laparotomy indicate that the sensitivity, specificity, positive and negative predictive values of this test were 85.5%, 46.1%, 91.02%, and 33.3%, respectively, compared to laparotomy.

Table-1. Sensitivity, specificity, positive and negative predictive value of fast test compared to CT-scan and laparatomy in patients with multiple trauma (n=180)

		FAST Test Result			
		-	+		
Sensitivity	60%	14	21	+	CT sacn
Specificity	52.4%	76	69	-	
		84.4%	23.3%		
		Negative Predictive Value	Positive Predictive Value		
		-	+		
Sensitivity	85.5%	12	71	+	Laparatomy
Specificity	46.1%	6	7	-	
		33.3%	91.02%		
		Negative Predictive Value	Positive Predictive Value		

The age and sex had no statistically significant relationship with the probability of false positives. When the GCS and the hospital arrival time increase, the chances of false positives of FAST test rise and decrease, respectively. On the other hand, low blood pressure had direct and significant relationship with a false positive FAST test result. This means that patients with low blood pressure had three times more likely developed false positives. The significant relationship between variables and false negatives of the FAST test report only for age, so that increasing one year of age raises likelihood of false negatives of FAST result about 5% (Table-2).

Table-2. The relationship between the study variables and False Positives and Negatives of FAST test compared to CT-scan

	Variable	Odds Ratio	Standard Deviation	Z Statistics	p-value	Low Limit	High Limit
False Positive	Age	0.9865615	0.012222	-1.09	0.275	0.962895	1.010809
	Sex (Male)	2.139638	1.230412	1.32	0.186	0.693189	6.604336
	GCS	0.8529356	0.052029	-2.61	0.009	0.756821	0.961257
	Low Blood Pressure	3.049138	1.600501	2.12	0.034	1.089881	8.530512
	Hospital Arrival Time	0.4397471	0.095949	-3.77	0.000	0.286733	0.674416
	Constant Coefficient	35.23151	44.64998	2.81	0.005	2.93885	422.3623
False Negative	Age	1.05643	0.0211552	2.74	0.006	1.015769	1.098718
	Sex (Male)	0.4938877	0.3363624	-1.04	0.3	0.12999	1.87646
	GCS	1.20243	0.1949531	1.14	0.256	0.87509	1.652218
	Low Blood Pressure	0.86448094	0.747017	-0.17	0.866	0.159095	4.700922
	Hospital Arrival Time	0.7761242	0.2632834	-0.75	0.455	0.39919	1.508978
	Constant Coefficient	0.0029537	0.0081795	-2.1	0.035	0.000013	0.672316

The CT scan findings indicate that there is a statistically significant relationship between evidence of solid organ injury and the false negatives of the FAST test. No significant relationship was found between existing free fluid and the false negatives of the FAST test. The odds ratio of this variable was 19.96, that is, if there is solid organ injuries evidence, the probability of being false negative of FAST test increases 19 times.

Also, the results related to the relationship between the site of free fluid and being false positive of FAST test showed that the presence of free fluid in Right Upper Quadrant (RUQ) and Left Upper Quadrant (LUQ) has a significant and direct relationship with false positives cases. If the free fluid is detected in these areas, the probability of being false positive of the test is 7 and 9 times higher, respectively (Table-3).

Table-3. The Relationship between Free Fluid Observation Site and False Positives of FAST Test

Variable	Odds Ratio	Standard Deviation	Z Statistics	p-value	Low Limit	High Limit
Age	0.996412	0.01457	-0.25	0.806	0.968261	1.025381
RUQ Free Fluid	7.214308	3.132648	4.55	0.000	3.080207	16.89699
LUQ Free Fluid	9.114021	4.137861	4.87	0.000	3.743308	22.19037
Suprapubic Free Fluid	3.436072	3.625541	1.17	0.242	0.434435	27.17691
Interloop Free Fluid	0.138737	0.202616	-1.35	0.176	0.007926	2.428365
Pelvic Free Fluid	0.206378	0.228927	-1.42	0.155	0.023467	1.814971
Constant Coefficient	0.178599	0.106119	-2.9	0.004	0.055733	0.572325

In the present study, the relationship between the study variables and the false positives of FAST test compared with laparotomy was investigated. The results of logistic regression model show that age, sex, GCS, and emergency medical system (EMS) arrival time don't have a significant relationship with the probability of false positive results, while low blood pressure had a direct and significant relationship with false positive FAST test result. This means that patients with low blood pressure were eight times more likely to develop false positive results. Also, the analysis of the relationship between variables and false negative results of FAST test compare to laparotomy shows that except for the age variable, the other variables did not have a significant relationship with false negative results of FAST test (Table-4).

Table-4. Relationship between the study's variables and false positives and negatives of the FAST test compared to laparotomy

	Variable	Odds Ratio	Standard Deviation	Z Statistics	p-value	Low Limit	High Limit
False Positive	Age	0.997949	0.028008	-0.07	0.942	0.944536	1.054382
	Sex (Male)	0.132561	0.176979	-1.51	0.13.	0.009683	1.814827
	Hospital Arrival Time	1.025904	0.575508	0.05	0.964	0.341667	3.080426
	GCS	1.103905	0.148811	0.73	0.463	0.847591	1.43773
	Low Blood Pressure	8.73714	8.316765	2.28	0.023	1.352453	56.44384
	Constant Coefficient	0.06063	0.150965	-1.13	0.26	0.000461	7.982455
False Negative	Age	1.057749	0.022183	2.68	0.007	1.015153	1.102133
	Hospital Arrival Time	1.303351	0.560593	0.62	0.538	0.560977	3.028151
	GCS	1.162666	0.179316	0.98	0.328	0.859361	1.57302
	Low Blood Pressure	1.284331	1.050399	0.31	0.76	0.258533	6.380252
	Constant Coefficient	0.001068	0.002787	-2.62	0.009	6.42E-06	0.177764

Discussion

In the present study, the most important trauma mechanism was road traffic accidents, followed by falling down. The frequency of trauma is most common in men with a mean age of 34.5 years old. Various studies are consistent with our study.[13,18,19]

Our study showed that the sensitivity, specificity, positive and negative predictive values of the FAST test compared to CT scan were 60%, 52.4%, 23.3% and 84.4%, respectively. Also, the sensitivity, specificity, positive and negative predictive values of the FAST test compared to laparotomy were 85.5%, 46.1%, 91.02% and 33.3%, respectively. The higher sensitivity of FAST in laparotomy compared to CT scan can be due to the clinical status of these patients and the observation of free fluid in the Morrison space by the ultrasound operator. Maylon et al., reported the sensitivity and specificity of FAST at 85% and 96%, respectively.[20] Over the past few decades, various studies have reported different percentages for sensitivity and specificity of FAST for the diagnosis of intra-abdominal injury.[21-23] One of the possible reasons for this variability is the test to which FAST is compared with it. In some studies, only patients with CT-scan, DPL, or laparotomy as confirmatory tests were included,[24,25] while others studied only patients under clinical supervision were surveyed.[26,27-29] FAST indications also vary from center to center. For example, some centers use FAST for almost all of their injured patients, while others use it selectively.[21] Ultrasound apparatuses and their required standards may also differ.[2,4,7] Also, the organizational experience of FAST is very different among various centers.[28,30] FAST is performed by a radiologist in some centers [26,28] and experienced ultrasound technicians,[27,29] while it is performed by physicians or emergency surgeons in other centers.[22,30]

The comparison of the FAST test with CT scan in the present study showed that the age variable has a significant relationship with false negative results of this test. Sheng et al., showed that younger patients underwent ultrasounds more than older patients. This study using univariate and multivariate Logistic regression showed that the tendency to use CT-scan and FAST remained statistically significant after the patients' age was controlled.[31]

Previous studies show that various factors affect the predictive power of sensitivity and specificity of FAST to determine intra-abdominal hemorrhage. One of these variables is blood pressure. Rowell et al., reported that 22% of patients who underwent therapeutic laparotomy during the first 6 hours of admission had negative FAST results. They suggested that physicians should still be highly suspicious of significant abdominal hemorrhage in

patients with low blood pressure with negative FAST.[32]

In our study, the FAST false-positives results were increased. One of the possible reasons for the high false positive results is the low skill of operators. Therefore, the training of operators is so important factor. There is no international agreement on the duration or number of operating FAST tests to become experts. For example, the American College of Emergence Physicians' ultrasound guidelines recommends performing 25 to 40 FAST tests under supervision,[33] while some other studies consider doing more than 40 FAST tests to be necessary.[34,35] Fukuda et al., recommend a 4-hour theory program, a 4-hour practical program, and doing 200 supervised tests is enough to become expert in performing FAST.[36]

Our study showed that hospital arrival time had an inverse relationship with the false positive FAST result. The results of other studies are consistent with our findings.[24,28] The interval time between trauma occurrence and doing FAST is an important measurement for promoting the sensitivity and specificity of this diagnostic test, because the accumulation of sufficient blood volume in the peritoneal cavity requires time for diagnosis by FAST.[13] Therefore, FAST serial scans may be helpful in cases where the initial FAST is negative or in patients suffering blunt trauma with persistent hemodynamic status.[37-39]

Other results of the present study showed that patients with reduced levels of consciousness were more likely to show false positives, while false-negatives rise with increasing age. It is maybe due to the accumulation of gas in the intestines resulting from low mobility,[18] or their inability to hold a full bladder during an ultrasound, because an empty bladder limits the assessment of free fluid in the pelvis.[40] The findings also showed that the observation of free fluid in the RUQ and LUQ spaces (7 and 9 times, respectively) was associated with more false positive results. Therefore, it seems necessary to perform a CT scan in these groups. In various studies, these factors have been suggested as indications for CT scans.[35,41]

Given the results of the present study and other similar studies, it can be stated that FAST is useful in patients with abdominal trauma and unstable hemodynamic status because the implementation of this method reduces the time required to perform treatment measurements, length of hospital stay, therapeutic costs, and radiation exposure.[13,42-44] On the other hand, the negative results of FAST do not rule out the possibility of intra-abdominal injuries in patients with blunt trauma due to its low sensitivity and specificity, as this test is not able to clearly show solid parenchyma injury, posterior peritoneum, or diaphragmatic defects. It also works insufficiently in detecting intestinal damage. Therefore, other diagnostic methods such as CT scans should be performed for patients with negative FAST to rule out other injuries.[19] Although a CT scan has high sensitivity and specificity for detecting intra-abdominal injuries, it takes about 30 minutes to perform and is not suitable for patients with unstable hemodynamics status and pregnant women.[18] However, a CT scan should be performed as a confirmatory test for screening patients with negative FAST who seems to be at high risk for intra-abdominal hemorrhage.[32]

Our study has several limitations. The sample size was small. Also, there is a selection bias due to being retrospective nature of the study, which may affect the results, because only patients with proven abdominal injuries were examined in this study. Furthermore, our study was designed to determine the characteristics of the FAST test for any amount of free bleeding, regardless of its clinical significance.

Conclusions

The present study showed that the implementation of FAST by surgical assistants does not have high sensitivity and specificity. Therefore, it is recommended to use other diagnostic methods such as CT-scan along with FAST, as paying attention to sufficient trainings of operators.

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Competing interests

The authors declare that they have no competing interests.

Abbreviations

Focused Assessment with Sonography for Trauma patients

(FAST); computed tomography (CT); diagnostic peritoneal lavage (DPL); Right Upper Quadrant (RUQ); Left Upper Quadrant (LUQ); emergency medical system (EMS).

Authors' contributions

All authors read and approved the final manuscript. All authors take responsibility for the integrity of the data and the accuracy of the data analysis.

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Availability of data and materials

The data used in this study are available from corresponding author on request.

Ethics approval and consent to participate

Institutional review board of Guilan University of Medical Sciences approved this study.

Consent for publication

By submitting this document, the authors declare their consent for the final accepted version of the manuscript to be considered for publication.

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