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Evaluation of the diagnostic value of FAST in patients with multiple trauma referring to a trauma center in northern Iran

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Abstract

Background: Abdominal injuries are among the leading causes of death in trauma patients, with one-third developing abdominal trauma. Focused Assessment with Sonography in Trauma (FAST) is a crucial component of the initial evaluation for emergency care of patients with abdominal blunt trauma.

Objectives: This study aimed to investigate the accuracy of FAST in identifying occult abdominal injuries in trauma patients who underwent laparotomy surgery at our center.

Methods: This cross-sectional study included 180 patients with abdominal trauma admitted to Poursina Hospital in Rasht, Iran, from 2016 to 2017. All patients underwent FAST upon admission and were categorized as either positive or negative based on the findings. Those with a positive FAST underwent laparotomy, while those with a negative FAST underwent a CT scan.

Results: The sensitivity, specificity, positive predictive value, and negative predictive value of FAST compared to a CT scan in all patients were 60%, 52.4%, 23.3%, and 84.4%, respectively. Of the 90 patients with positive FAST, 78 underwent laparotomy, while 19 patients with negative FAST underwent laparotomy. Low blood pressure, Glasgow Coma Scale (GCS), and hospital arrival time were significantly associated with false-positive FAST results, while age was significantly related to false-negative cases.

Conclusion: While implementing FAST by surgical assistants has some limitations, its use can be complementary to other diagnostic methods like CT scans, especially when combined with proper training and consideration of patient factors.

Keywords: Diagnostic value, Multiple trauma, Surgery, Focused Assessment with Sonography in Trauma (FAST).

Introduction

Trauma is the leading cause of death globally, and it affects a larger proportion of younger people (under 40 years old).[1,2] Industrialization, urbanization, and technological advancements in human societies have contributed to an increase in accidents as a major threat to public health, resulting in high mortality and morbidity rates.[3-5]

Abdominal injuries are one of the most common causes of death in trauma patients.[3] Approximately one-third of trauma patients experience abdominal trauma.[6] The abdomen ranks as the third most susceptible area to injury in traumatic events, necessitating surgical intervention in approximately 15-20% of cases. Non-penetrating abdominal injuries remain the most frequent cause of abdominal harm.[7,8] One of the key factors in reducing mortality rates among trauma patients is the prompt and accurate diagnosis of organic injuries. While clinical examination can be unreliable in evaluating trauma patients, established standards like computed tomography (CT) scans and diagnostic peritoneal lavage (DPL) are time-consuming and intrusive.[9,10] Ultrasound can be used due to its significant advantage in diagnostic accuracy, making it a crucial step towards reducing the time and cost of examining trauma patients. It is widely utilized as a diagnostic tool in numerous countries globally for

assessing abdominal injuries.[9] Focused Assessment with Sonography in Trauma (FAST) is a crucial component of the initial examination and a valuable tool for emergency care of patients with abdominal blunt trauma.[11] After completing a brief training program, emergency physicians can utilize FAST to quickly evaluate trauma patients. Nowadays, due to technological advances, ultrasonography can be used as a portable device during emergencies and at the patient's bedside. Unlike radiography or CT scans, ultrasound can be performed alongside resuscitation measures in a trauma room to detect life-threatening injuries without any delay or interruption.[12] FAST has been widely used for the past three decades. Before FAST, more invasive methods like DPL and laparotomy were commonly used.[13] FAST is a bedside ultrasound protocol that serves as a screening tool to detect lesions within the peritoneum. Both surgeons and radiologists can conduct it with comparable precision. Fast is usually recommended in the primary survey of traumatic patients during the circulatory phase and in unstable individuals with abdominal trauma to assess for intra-abdominal and pericardial fluid.[14]

FAST ultrasound has numerous advantages in evaluating early trauma patients and serves as a valuable screening tool, particularly for individuals who cannot undergo a CT scan due to unstable hemodynamics. The detection of free fluid on FAST imaging in combination with unstable hemodynamics that do not improve following resuscitation efforts signifies the urgent need for surgical intervention.[15] In recent years, FAST in emergency departments has been utilized increasingly due to its portability and ease of use, as well as the lack of need for a skilled radiologist.[16] Given that the test is performed at the patient's bedside without the need for patient transfer, it can be very useful in acute care,[17] making it essential to employ this technique and evaluate its diagnostic accuracy, limitations, and capabilities when assessing patients with non-penetrating abdominal trauma in emergency departments.

Objectives

This study aimed to investigate trauma patients with positive FAST findings after laparotomy surgery who were referred to a trauma center.

Methods

This was a cross-sectional study conducted on 180 patients with abdominal trauma admitted to Poursina Educational and Medical Center in Rasht, Iran, between September 2016 and September 2017. Patients aged 12 years or older who experienced high-energy trauma and had multiple injuries were included in the study using a census approach. The patients underwent a physical examination and rapid sequence fluid challenge immediately upon arrival in the emergency department by a fourth-year surgical resident. Based on the FAST results, the patients were categorized into two groups: those with positive and those with negative findings. If the patient showed signs of generalized peritonitis or hemodynamic instability during the FAST, they underwent laparotomy. Additionally, CT scans were performed if there were no peritoneal signs or evidence of hemodynamic instability. The data collected for this study included age, gender, time interval between trauma occurrence 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 this study, 151 (83.89%) patients were male, while 29 (16.11%) were female. The average age of the sample was 34.4±13.8 years old, ranging from 14 to 74 years. The average hospital arrival time was 2.8±0.8 hours. The average GCS score of patients was 13.05, with scores ranging from 3 to 15. The average systolic and diastolic

blood pressures were 103.1±16.4 and 68.3±8.7 mmHg, respectively. Additionally, the pulse rate was 99.5±18.9 beats per minute. Traffic accidents were the leading cause of injury, accounting for 93% of cases. Falling from a height (5%) and falling from the same level (3%) ranked second and third, respectively [Figure 1].

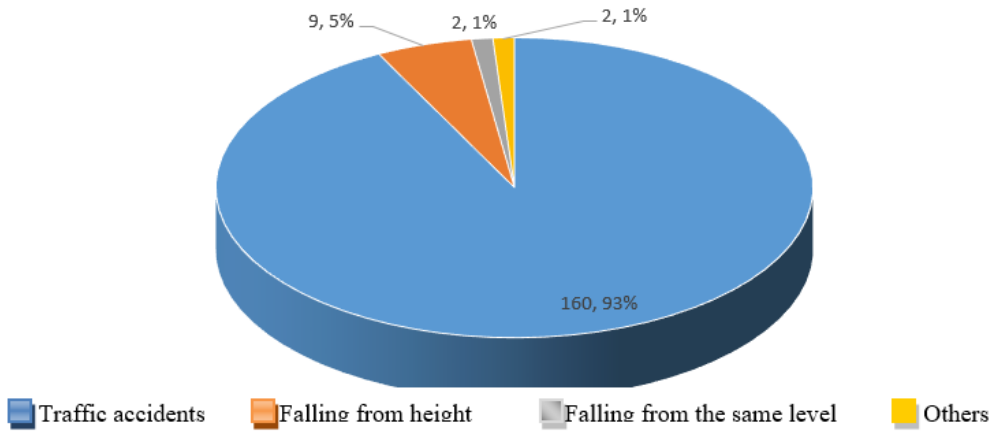

Figure-1. The frequency of multiple trauma patients referred to Poursina hospital in terms of mechanism of injury (n=180)

As shown in Table 1, the sensitivity, specificity, positive predictive value, and negative predictive value of the FAST test were 60%, 52.4%, 23.3%, and 84.4%, respectively, compared to CT scans in all samples. Of the 90 patients with positive FAST findings, 78 underwent laparotomy, while 19 patients with negative FAST findings also underwent laparotomy. The performance of the FAST test in patients who underwent laparotomy showed an 85.5% sensitivity, 46.1% specificity, 91.02% positive predictive value, and 33.3% negative predictive value, 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		

Age and sex did not have a statistically significant relationship with the probability of false positives. When the GCS and hospital arrival time increased, the chance of false positives on the FAST test rose and decreased, respectively. Conversely, low blood pressure was found to have a direct and significant relationship with a false positive FAST test result, indicating that patients with low blood pressure were three times more likely to develop false positives. Interestingly, there was a significant relationship between variables and false negatives of the FAST test only for age, such that an additional year of age resulted in a 5% increase in the likelihood of false negatives [Table 2].

Table-2. The relationship between the study variables and False Positives and Negatives of the 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

CT scans' findings indicate that there is a statistically significant relationship between evidence of solid organ injury and false negatives of the FAST test. No significant relationships were found between existing free fluid and the false negatives of the FAST test. The odds ratio of this variable is 19.96, indicating that if there is solid organ injury evidence, the likelihood of a false negative result on the FAST test increases by 19 times. Additionally, the results relate to the relationship between the site of free fluid and being false-positive. The FAST test shows that the presence of free fluid in the right upper quadrant (RUQ) and left upper quadrant (LUQ) has a significant and direct relationship with false-positive cases. When free fluid is detected in these areas, the likelihood of a false positive result on the test is 7 and 9 times greater, 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 this current study, the relationship between the study variables and the false positives of the FAST test compared to laparotomy was investigated. The results of the logistic regression model reveal that age, sex, GCS, and EMS arrival time do not have a significant relationship with the likelihood of false positive results, whereas low blood pressure has a direct and significant association with false positive FAST test outcomes. Specifically, patients with low blood pressure are eight times more likely to exhibit false-positive results. Furthermore, an assessment of the association between factors and FAST test false negatives in contrast to laparotomy revealed that only the age variable failed to establish a significant link with false negative findings [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

Road traffic accidents were the most common trauma mechanism in this study, followed by falls. The frequency of trauma is most common in men, with a mean age of 34.5 years old. Various studies are consistent with our findings.[13,18,19]

Our study demonstrated that the sensitivity, specificity, positive predictive value, and negative predictive value of the FAST test compared to CT scans were 60%, 52.4%, 23.3%, and 84.4%, respectively. Additionally, the sensitivity, specificity, positive predictive value, and negative predictive value of the FAST test compared to laparotomies were 85.5%, 46.1%, 91.02%, and 33.3%, respectively. FAST's increased sensitivity in laparotomies compared to CT scans may be related to these patients' clinical condition and the observer-dependent identification of free fluid in the Morrison space during ultrasound inspection.[20] Over the past few decades, various studies have reported different percentages for the sensitivity and specificity of FAST in the diagnosis of intra-abdominal injuries.[21-23] One of the possible reasons for this variability is the test used to compare FAST. In some studies, only patients who had a CT scan, DPL, or laparotomy as a confirmatory test were included,[24,25] while others examined only patients under clinical observation.[26,27-29] FAST indications can vary from center to center. For instance, some centers utilize FAST for most of their injured patients, whereas others employ it selectively. 21 Ultrasound equipment and its associated standards may also vary. 2,4,7 Additionally, the organizational experience of FAST varies significantly among different centers.[28,30] In certain centers,[26,28] FAST is conducted by a radiologist and skilled ultrasound technologists, but in others,[22,30] it is performed by doctors or emergency surgeons.

The comparison of the FAST test with a CT scan in the present study showed that the age variable had a significant relationship with false negative results for this test. According to Sheng et al., younger patients were found to undergo ultrasounds more frequently than older patients. This study, which used both univariate and multivariate logistic regression analysis, demonstrated that the tendency to use CT-scan and FAST remained statistically significant even after controlling for patients' age.[31] Previous studies have shown that various factors influence the predictive power of the sensitivity and specificity of FAST in determining intra-abdominal hemorrhage. One of these variables is blood pressure. Rowell et al. reported that approximately 22% of patients who underwent therapeutic laparotomy within the first six hours of admission had negative FAST results. They suggested that clinicians should remain highly suspicious

of significant abdominal hemorrhage in patients with low blood pressure despite negative FAST findings.[32]

In our study, the FAST false-positive rates increased. One of the possible reasons for the high false positive rate is the low skills of operators. Therefore, operator training is a crucial factor. There is currently no international agreement on the length of time or number of FAST tests required to achieve expertise. For instance, the American College of Emergency Physicians' ultrasound guidelines recommend performing 25 to 40 FAST tests under supervision,[33] while other studies suggest that more than 40 FAST tests may be needed.[34,35] Fukuda et al., recommend a 4-hour theoretical program, a 4-hour practical program, and completing 200 supervised tests as sufficient to become an expert in performing FAST.[36]

Our study demonstrated that hospital arrival time has an inverse relationship with false-positive FAST results. The findings of other studies are consistent with ours.[24,28] Because adequate blood volume buildup in the peritoneal cavity takes time to be identified by FAST, the delay between trauma onset and performing a FAST examination is an essential parameter for enhancing the sensitivity and specificity of this diagnostic test.[13] Therefore, FAST serial scans may be helpful in cases where the initial FAST is negative or in patients experiencing blunt trauma with persistent hemodynamic instability.[37–39]

Other findings from this study revealed that individuals with decreased levels of consciousness were more prone to displaying false positives, whereas false negatives increased with advancing age. This may be attributed to the buildup of gas in the intestines as a result of reduced mobility[18] or the inability to maintain a fully filled bladder during the ultrasound examination, which hinders the evaluation of free fluid in the pelvic area.[40] The data also revealed that seeing free fluid in the RUQ and LUQ spaces (7 and 9 times, respectively) was linked to more false positive outcomes. 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]

Based on the current study's findings and other relevant research, it is possible to conclude that FAST is beneficial for patients with abdominal injuries and unstable vital signs because of its ability to streamline treatment assessments, reduce hospitalization duration, lower medical expenses, and reduce radiation exposure.[13,42–44] On the other hand, the negative findings of FAST do not necessarily exclude the possibility of intra-abdominal injuries in patients with blunt trauma, despite its relatively low sensitivity and specificity. This is because FAST is unable to clearly visualize a solid parenchyma injury, posterior peritoneum, or diaphragmatic defects. Additionally, it may not provide sufficient information on intestinal damage. As a result, other diagnostic techniques, like CT scans, are often used in conjunction with FAST to rule out other potential injuries in patients with negative FAST results.[19] Although a CT scan has high sensitivity and specificity for detecting intra-abdominal injuries, it takes approximately 30 minutes to perform and is not suitable for patients with unstable hemodynamic status or pregnant women.[18] However, a CT scan should be performed as a confirmatory test for screening patients with negative FAST findings who seem to be at high risk for intra-abdominal hemorrhage.[32]

Our study has several limitations. Firstly, the sample size was small. Additionally, there is a selection bias due to the retrospective nature of the study, which may impact the results since only patients with proven abdominal injuries were included in this study. Moreover, our study aimed to identify the characteristics of the FAST test for any amount of free bleeding rather than focusing on its clinical significance.

Conclusions

The present study revealed that the implementation of FAST by surgical assistants lacks high sensitivity and specificity. Consequently, it is advisable to utilize alternative diagnostic techniques such as CT scans in conjunction with FAST while prioritizing adequate training for operators.

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Competing interests

The authors declare that they have no competing interests.

Abbreviations

Focused Assessment with Sonography in Trauma (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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