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# Clinical utility of performing FAST scan in hemodynamically stable patients presenting with blunt abdominal trauma in level one trauma center

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## ABSTRACT

**Background:** Focused assessment with sonography for trauma (FAST) has a role in the rapid screening of hemodynamically unstable patients to decide on management, however, its role in hemodynamically stable patients remains equivocal.

**Objectives:** This study aimed to determine the sensitivity and specificity rate of FAST for intra-abdominal injury (IAI) in hemodynamically stable blunt abdominal trauma patients. Secondary outcomes like Glasgow coma score, length of hospital stays (LOS), head injury, and mortality were also examined for their association with FAST scan results.

**Settings and Design:** A retrospective cross-sectional study was conducted in level-one trauma center in Bahrain.

**Methods:** This study was conducted from January 2019 to October 2020. A total of 191 trauma codes were activated during this period, however, only 112 patients were included based on the inclusion criteria.

**Results:** FAST scan in hemodynamically stable patients was found to have a higher specificity (96.7%) than sensitivity (30%) in this study. A higher negative predictive value (NPV) (86.4%) compared to a positive predictive value (66.6%) and a high accuracy rate (84.8%) was observed. LOS showed significant association only with FAST diagnostic accuracy.

**Conclusion:** In hemodynamically stable patients; FAST is better at ruling in intra IAI when compared to ruling out and its high NPV supports it being a good screening tool. The results do not support the use of FAST as the sole diagnostic tool without performing computed tomography scan.

**Keywords:** FAST, haemodynamically stable, trauma, blunt, abdomen.

## Introduction

Injury due to trauma is one of the leading causes of death, especially in those under the age of 45 years. Blunt trauma accounts for almost 80% of traumatic injuries, in which most fatalities are secondary to hypovolemic shock. This highlights the significance of early detection of intraperitoneal bleeds, which occur in 12% of blunt abdominal traumas [1].

One of the well-documented ways to achieve this, is the focused assessment with sonography for trauma (FAST) scan, which is considered an integral part of the resuscitation algorithm of trauma patients; given that its part of the advanced trauma life support (ATLS) course and its current incorporation has been done by greater than 96% of level one trauma centers [1].

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The role of FAST in managing hemodynamically unstable patients has been well supported, however, there have been unsettled opinions regarding its clinical utility in hemodynamically stable patients [2]. Previous studies have reported a low sensitivity and a higher specificity of FAST scan to detect intraperitoneal fluid in hemodynamically stable patients [2]. It was also reported that patients with severe head injuries are more likely to have a false negative (FN) FAST result given the difficulty of performing an accurate scan in such patients due to physician's distraction and patient non-cooperativity [3-7]. Furthermore, it is hypothesized that FN FAST results are associated with patient's adverse outcomes such as longer length of hospital stay (LOS) and increased mortality [3,7].

The objective of this study was to determine FAST sensitivity, specificity, positive predictive value (PPV) and negative predictive value (NPV), and accuracy rates in hemodynamically stable blunt abdominal trauma patients. Secondary outcomes in this study included examining the association of variables like Glasgow coma score (GCS), head injury, LOS, and mortality with FAST scan diagnostic outcome.

## Subjects and Methods

A retrospective cross-sectional study was performed in a level-one trauma center in Bahrain from January 2019 to October 2020. As per hospital protocol, any patient who met the criteria for trauma code activation would initially have a FAST scan done in the trauma bay. If hemodynamically stable, the decision to proceed with computed tomography (CT) scan was based on the discretion of the trauma team leader [8].

To establish FAST test characteristics, FAST results were compared against abdominal contrast-enhanced CT (CECT) scan findings, given that it's the gold standard for detecting intra-abdominal injuries (IAI) [1,9]. This study design was implemented in various prior studies that examined FAST scan characteristics [2,10-23].

A convenience sample was derived through an obtained list from the trauma code registry that included all activated trauma codes between the above-mentioned outlined period. This provided a list of 191 patients, whose scanned trauma sheet records were reviewed for meeting the eligibility criteria defined as age ≥18 years, blunt abdominal trauma, systolic blood pressure (SBP) ≥90. However, exclusion criteria were defined as anyone who did not have a FAST scan performed or had an inconclusive finding of the scan, and abdominal CT scan absent or unreported. Patients with missing records were also eliminated as outlined in the CONSORT diagram (Figure 1).

A true positive (TP) FAST is the finding of IAI confirmed by CT or laparoscopy/laparotomy. A false positive (FP) FAST means a positive FAST without confirmed IAI by CT or laparoscopy/laparotomy. A true negative (TN) FAST involves a negative FAST in the absence of IAI by CT or laparoscopy/laparotomy. Whereas, a FN FAST involves a negative FAST in the presence of IAI by CT or laparoscopy/laparotomy.

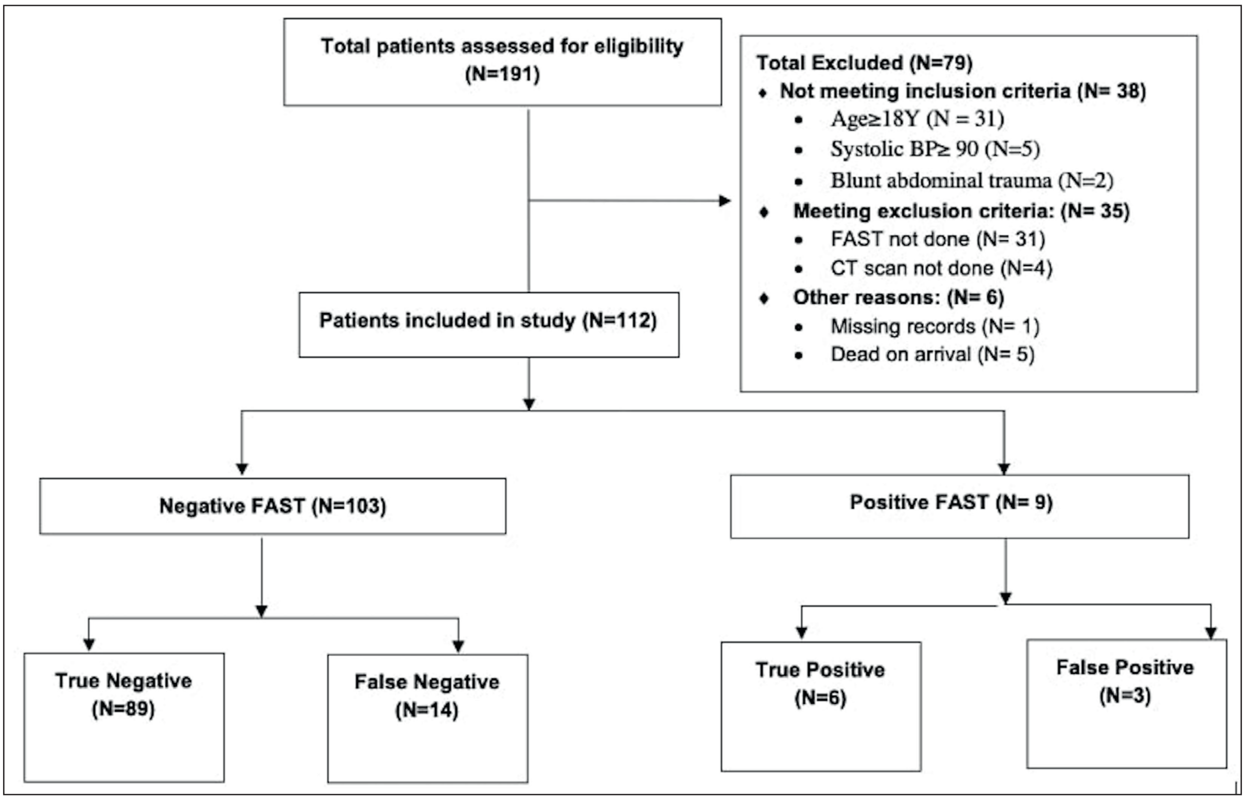


***Figure 1.*** *CONSORT diagram showing the selection of study participants.*

Data were obtained from trauma sheet records and used to fill a standardized data collection instrument. Recorded information included medical record number, patient age and gender, mechanism of trauma, initial vital signs, FAST scan result as either positive or negative, CECT abdomen findings as either negative or positive with the specified finding, intra-operative findings if patient proceeded to laparoscopy/laparotomy, GCS, LOS, presence of head injury on brain CT, and mortality.

FAST was done by ATLS-certified emergency residents and was reported in the trauma sheet as either positive or negative only, without necessarily documenting which area was positive. All data on CT scan findings were obtained from official attending radiologists' reports. Efforts to minimize potential bias involved a blind data collection process, as two independent data retrievers were used with one limited to collecting FAST scan results only and another limited to CT scan results. An important effect modifier was the time frame between performing the FAST and CT scan which was unrecorded.

The study data were expressed as mean and standard deviation (SD) or frequencies, except for LOS, which was expressed as median (25th, 75th percentiles). To assess FAST scan diagnostic yield, sensitivity, specificity, PPV and NPV, accuracy, and 95% confidence intervals (CI) were calculated using MedCalc's free statistical calculators. To investigate associations between FAST scan diagnostic outcome and continuous variables, different tests were used depending on normality. Student *t*-test was used for all the variables, except for age, respiratory rate (RR), GCS, and LOS, for which Mann–Whitney U-test was used. Kruskal Wallis test was used for LOS. Kruskal wallis test was used for LOS in Table 2. For categorical variables, which were outlined as percentages; Fishers Exact test was used. McNemar's test was used to compare the performance of FAST and CECT scan. $p$-value < 0.05 was considered statistically significant. All analyses, besides FAST diagnostic yield measures, were performed using a statistical package for the social sciences version 25.0.

## Results

After applying the set inclusion and exclusion criteria, a total of 112 patients were included in the analyses. Almost 94.6% of them were males ($N$ = 106). The ages of the participants ranged from 18 to 71 years, with mean and SD of 33 ± 10.9 years. The most common mechanisms of injury were motor vehicle crash (40.2%), falling from height (28.6%), and pedestrian (10.7%), followed by motorbike accident (9.8%). Thus, 60.7% of the injuries were caused by road accidents. LOS varied greatly, it ranged from 0 to 103 days. For three patients, LOS was not calculated; one of them was still admitted at the time of data collection, and the other two were transferred to another hospital for unknown reasons (Table 1).

Those with a positive FAST scan had in general a lower SBP mean, a higher RR mean, and a lower GCS mean (all of which reflect hemodynamic compromise) when compared to the negative FAST scan group. However, none of these three variables' results had statistical significance. The percentage of accuracy for positive FAST and for negative FAST was not significantly different, although negative FAST group results were slightly more accurate. This accuracy is embodied in the CT findings which showed a statistically significant

***Table 1.*** *Patients' characteristics stratified by FAST results.*

| Variable | Positive FAST ($N$ = 9) | Negative FAST ($N$ = 103) | $p$-value |
|---|---|---|---|
| Age (Mean ± SD) | 39.3 ± 17.0 | 32.9 ± 10.1 | 0.314 |
| Gender (%)<br>Male<br>Female | <br>9 (100%)<br>0 | <br>97 (94.2%)<br>6 (5.8%) | >0.05 |
| SBP (Mean ± SD) | 120.8 ± 30.8 | 135.5 ± 20.3 | 0.194 |
| Diastolic blood pressure (Mean ± SD) | 72.1 ± 22.5 | 80.1 ± 14.99 | 0.146 |
| HR (Mean ± SD) | 98.4 ± 15.9 | 96.7 ± 20.5 | 0.808 |
| HR ≤100 (%)<br>HR >100 (%) | 4 (44.4%)<br>5 (55.6%) | 63 (61.2%)<br>40 (38.8%) | 0.480 |
| RR (Mean ± SD) | 27.6 ± 9.9 | 21.5 ± 5.7 | 0.085 |
| Glasgow coma scale (Mean ± SD) | 11.8 ± 4.4 | 13 ± 3.3 | 0.397 |
| Mild (13-15) (%)<br>Moderate (9-12) (%)<br>Severe (3-8) (%) | 6 (66.7%)<br>0<br>3 (33.3%) | 78 (75.7%)<br>11 (10.7%)<br>14 (13.6%) | 0.265 |
| LOS [Median (25%, 75%)] | 13 (6, 76.5) | 5 (2, 10) | 0.014[a] |
| Accuracy (%)<br>True<br>False | <br>6 (66.7%)<br>3 (33.3%) | <br>89 (86.4%)<br>14 (13.6%) | 0.137 |
| CT finding (%)<br>Positive<br>Negative | <br>6 (66.7%)<br>3 (33.3%) | <br>14 (13.6%)<br>89 (86.4%) | 0.001[b] |
| Head injury (%)<br>Yes<br>No | <br>5 (55.6%)<br>4 (44.4%) | <br>37 (35.9%)<br>66 (64.1%) | 0.292 |
| Mortality (%)<br>Alive<br>Dead | <br>9 (100%)<br>0 | <br>101 (98.1%)<br>2 (1.9%) | >0.05 |

[a]Less than 0.05, [b]Less than 0.01.

association with FAST scan results. Nevertheless, McNemar's test result showed that FAST performed significantly poorer than CT ($p$-value = 0.013).

Furthermore, the overall accuracy of FAST was 84.8% [95% CI: (76.8, 90.9)%]. FAST was positive in nine patients, six of them only had IAI [sensitivity 30 (11.9, 54.3) %]. FAST was negative in 103 patients, of which 14 had IAI [specificity 96.7 (90.8, 99.3) %]. The prevalence of IAI in our sample was 17.9%. Out of 20 positive IAI on CT scans, 85% ($N$ = 17) had solid organ injuries; of which 47% ($N$ = 8) were hepatic injuries and 47% ($N$ = 8) were splenic injuries, with one case that had both injuries together 5.8% ($N$ = 1) (Figure 2).

The percentage of tachycardiac patients in TP group was 66.7% ($N$ = 4) while 61.7% ($N$ = 55) of TN group had a heart rate (HR) ≤100, however, no statistical significance was found between HR and FAST diagnostic accuracy. Nonetheless, it is important to highlight confounding factors of tachycardia, such as pain and anxiety, that were difficult to eliminate in a trauma code setting. LOS showed the only significant association with FAST diagnostic accuracy, so Mann–Whitney U-test was applied as *post-hoc* to find where the difference lies exactly for this variable. It was found that for TP LOS is significantly longer than TN, FP, and FN ($p$-value = 0.001, 0.020, and 0.043, respectively). Also, LOS for FN is significantly longer than TN as initially hypothesized ($p$-value = 0.017) (Table 2).

This study found no statistically significant association between FAST diagnostic accuracy and the presence of head injury ($p$-value = 0.597), or its severity as reflected by the GCS score ($p$-value = 0.164). This is contrary to the hypothesis regarding those with severe head injuries being more likely to have an FN result as only 35.7% of this group had a head injury, which was almost the same as TN (35.9%) and FP (33.3%) groups. However, the highest rate of head injury was in the TP group (66.7%) and this explains why this group had the longest median LOS (38 days). The mortality rate in this study was 1.8% (2/112), with one being in the TN group and one in the FN group. This mortality is partly explained by the fact that those two cases had significant intracranial haemorrhage (ICH) with low GCS score (3-4). No statistically significant association was found between mortality and FAST diagnostic accuracy.

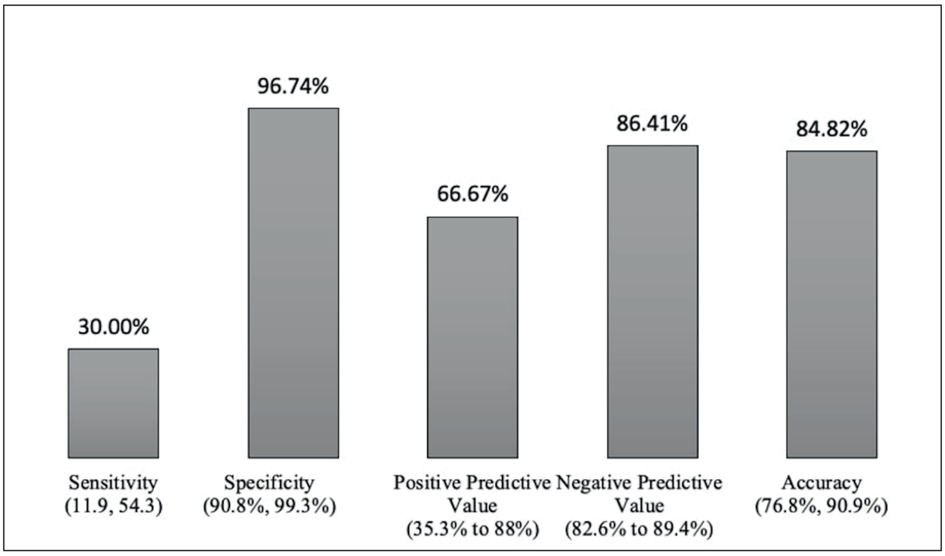


***Figure 2.*** *Fast scan sensitivity%, specificity%, PPV%, NPV%, and accuracy% (95% CI).*

***Table 2.*** *Association between FAST diagnostic accuracy and different variables. (N = Number).*

| | TP ($N$ = 6) | TN ($N$ = 89) | FP ($N$ = 3) | FN ($N$ = 14) | $p$-value |
|---|---|---|---|---|---|
| HR >100 ($N$) | 4 | 34 | 1 | 6 | 0.563 |
| HR ≤100 ($N$) | 2 | 55 | 2 | 8 | |
| Glasgow coma scale ($N$) | | | | | 0.363 |
| Mild | 3 | 67 | 3 | 11 | |
| Moderate | 0 | 9 | 0 | 2 | |
| Severe | 3 | 13 | 0 | 1 | |
| Head injury ($N$) | | | | | 0.500 |
| Yes | 4 | 32 | 1 | 5 | |
| No | 2 | 57 | 2 | 9 | |
| LOS [(Median (25%, 75%)] | 38(13.3, 83.8) | 4 (2, 9) | 6 (4, 6) | 9 (6, 20.8) | 0.001[a] |
| Mortality ($N$) | 0 | 1 | 0 | 1 | 0.370 |

[a]Less than 0.01.

## Discussion

The results of this study supported good FAST performance for ruling in IAI in hemodynamically stable patients as reflected by its high specificity (96%) and low FP rate (3.3%). Nevertheless, given the small group of positive FAST (*N* = 9) found in this study population, it would be difficult to make a robust conclusion regarding its performance in ruling out IAI, however, current results showed a low sensitivity (30%) with a high FN rate (70%).

The NPV (86.41%) was found to be higher than the PPV (66.67%) which supports FAST being a good screening test for IAI. Furthermore, even though a high diagnostic accuracy (84.8%) was found in this study, given its variance based on disease prevalence, it should always be interpreted with other measures, especially predictive values [24].

This study results were in concordance with prior studies that evaluated the diagnostic yield of FAST scan in blunt abdominal trauma and hemodynamically stable patients only. Six studies were found between (2002 and 2019), accumulatively they reported a sensitivity range between 22% and 92.68%, a specificity range between 97.4% and 99%, NPV range between 93% and 95%, PPVs between 67% and 94%, and accuracy range between 92% and 96% [2,10-14].

The latest studies in literature, published over the last 3 years (2019-2021) looked at the diagnostic accuracy of eFAST instead of FAST, two of these studies were meta-analysis [15,16]. Accumulatively, they reported sensitivities that ranged between 70% and 94.8%, and specificity ranged between 94.07% and 100% [15-19]. These studies, however, as opposed to the present study's inclusion criteria, included chest injuries, hemodynamic instability, and some included pediatric age groups. Only one of the two meta-analysis reported isolated values for eFAST sensitivity (76%) and specificity (98%) in detecting intra-abdominal free fluid in normotensive adults [16]. Other recent studies conducted in between 2018 and 2020 looked at FAST in blunt abdominal trauma regardless of hemodynamic status. They found a sensitivity range between 76.1% and 91.9% and a specificity range between 84.2% and 100% [20-23].

The general pattern of results seen in all the above studies supports a higher specificity than the sensitivity of FAST and eFAST. Also, the NPVs were always higher than the PPVs and the accuracy was always found to be high. The variance of the actual values of these accuracy measures reported in different studies is due to the different inclusion and exclusion criteria implemented by each, in addition to some studies comparing FAST against CT scan only, exploratory laparotomy only, and some against both.

Several factors might account for the observed low sensitivity of FAST in this study, one of which being that out of 20 positive IAI on CECT scans, 85% (*N* = 17) had solid organ injuries, of which only 17.6% (*N* = 3) had associated free fluid on CT. Only 35% (6 of 17) of solid organ (live and spleen) injuries were detected by FAST in this study. This low detection rate is explained by FAST being known for its limited ability in detecting solid organ injuries in the absence of free fluid as previous studies had reported low sensitivities ranging between 38.5% and 44% [25,26]. The prevalence of organ injury without associated free fluid ranges from 5% to 37% [10]. This highlights one of FAST weaknesses as a sole diagnostic tool.

Furthermore, the amount of free fluid required to be detected by FAST is one of its limitations. The minimum amount required varies according to which pouch is being examined and in what position the patient is lying. It was found that a mean minimum of 619 ml of diagnostic peritoneal lavage (DPL) fluid is needed in Morrison's pouch and that the sensitivity of FAST increases with larger volumes of free fluid [26]. This volume correlates with class I of hemorrhage, which clinically would manifest with hemodynamic stability [10]. It was also found that a median minimal volume of 100 ml of DPL fluid was required for detection in the pelvic views of FAST [26]. However, following bladder emptying with Foley's, studies have found limited ability to detect small amounts of free pelvic fluid [26]. It was also shown that in comparison to FAST done in a supine position; the trendelenburg position facilitated the detection of lesser amounts of hepatorenal free fluid (median, 400 *vs.* 700 ml) [26]. Moreover, since the collection of free intraperitoneal fluid would be affected by any pathologic structures or postoperative adhesions and scars; this would influence the sensitivity of FAST [27]. In the CT reports reviewed in this study, the presence of free fluid on CT was mentioned without any documentation of the amount which would've been important to correlate with FAST diagnostic ability. Also, given the setting and fast pace of trauma code, it is assumed that most FAST scans were done in the supine position, however, no section of the trauma sheet states the position in which FAST was done.

The FN rate (70%) was high in this study, to which various factors might contribute. One of those factors includes patients with delayed presentations, where the hemorrhage has clotted and caused mixed echogenicity instead of the black appearance of fluid or fresh blood [1]. Another factor is the time between doing FAST and CT which might have varied between each case, especially since this time gap wasn't documented, and it is suggested that during this period, detectable quantities of free fluid might form and lead to a higher FN rate [25].

LOS showed the only significant association with FAST diagnostic accuracy as part of secondary outcomes. LOS in the FN group was significantly longer than TN which supports the hypothesis of FN results predisposing to adverse patient outcomes, however, no association with mortality was found in this study. On the contrary, a prior study had found no association between LOS and mortality rate with a FN FAST [3,7]. As opposed to prior studies, no association was found between FN results and the presence of head injury or GCS Score, however, most prior studies used the abbreviated injury scale which is more specific to head injury than GCS [3,6].

It is important to highlight the fact that all positive IAI was based on the findings of CT scans and that none was confirmed by surgical exploration as no case in the study sample proceeded further. Even though the one mortality case in the FN group had significant IAI on CT besides significant ICH, it was not surgically explored based on the discretion of the trauma surgeon. The sensitivity of CT scans for injury diagnoses in blunt abdominal trauma is reported between 92% and 98% [11]. It is also known for its ability to detect as little as 100 cc of intraperitoneal fluid [1]. However, surgical exploration would still be considered the most ideal reference point to truly reflect the diagnostic accuracy of FAST scans by comparing the findings of both.

In this study, the reporting of CT scans was always done by consultant radiologists, however, the fact that each CT was reported by a different consultant who might interpret things differently, carries the risk of observer bias causing variations in the results and affecting the overall sensitivity of FAST. This risk should be minimal since it is reported by physicians of similar levels of qualifications.

The performance of FAST is limited by various factors like the clinical setting, patient body habitus, surgical emphysema, bowel gas interference, pneumoperitoneum, pneumomediastinum. All these could make FAST scans difficult to interpret and without an experienced operator there's a potential for misinterpretations with misdiagnosis, in fact, even experienced practitioners can miss small amounts of free fluids [25]. This was a limitation of this study, as there are possibly variations in the level of FAST training between different emergency residents, especially since no specific FAST training was conducted. Hence, this might partially explain the observed low sensitivity of FAST in this study.

One of the limitations of this study was retrospective data collection which relies on documented data in patient records regardless of its accuracy or completeness. It is important to highlight the lack of FAST scan images record, especially in the Middle East, which creates a major obstacle in accurately conducting studies. Another limitation might be the chosen criteria of SBP ≥90 to reflect hemodynamic stability as it is debatable whether to depend on one parameter or a combination of vitals including HR to define hemodynamic stability [2].

Several areas in this study design can be improved to obtain a more reliable and externally valid conclusion. Those related to the FAST scan procedure include documenting which areas of the FAST scan are positive for better correlation with the CT findings. Also, to increase the sensitivity of the FAST scan, serial scans could be performed, and all scans might be done by physicians with common FAST training to aim to standardize the interpretation. Several studies have reported increased sensitivity and lower FN rates associated with serial scans [28,29]. Moreover, the time between performing FAST and CT scans should also be standardized to reduce the FN rates. Lastly, the CT reports did not contain any estimate of free fluid quantity, which would've been important to correlate with FAST diagnostic ability.

## Conclusion

The results of this study support good FAST performance for ruling in IAI in the hemodynamically stable patients as reflected by its high specificity (96%). Given the small group of positive FAST found in this study population, it would be difficult to make a robust conclusion regarding its performance in ruling out IAI, however, current results showed a low sensitivity (30%), which does not support the use of FAST as a sole diagnostic tool without performing CT scan. A higher NPV (86.4%) compared to PPV (66.6%) and a high accuracy rate (84.8%), all support FAST being a good screening tool.


## Acknowledgment

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**List of Abbreviations**

| | |
|---|---|
| ATLS | Advanced trauma life support |
| CECT | Contrast enhanced computed tomography |
| CI | Confidence intervals |
| CT | Computed tomography |
| FAST | Focused assessment with sonography for trauma |
| FN | False negative |
| FP | False positive |
| GCS | Glasgow coma score |
| HR | Heart rate |
| IAI | Intra-abdominal injuries |
| LOS | Length of hospital stay |
| NPV | Negative predictive value |
| PPV | Positive predictive value |
| RR | Respiratory rate |
| SBP | Systolic blood pressure |
| SD | Standard deviation |
| TN | True negative |
| TP | True positive |


**Conflict of interest**

The authors declare that there is no conflict of interest regarding the publication of this article.

**Funding**

None.


**Consent to participate**

Given the retrospective nature of the study, all data were obtained retrospectively from patient records and anonymized with no identifying data used. Therefore, no informed consent was obtained, and this was approved by the hospital ethical committee.

**Ethical approval**

This study was approved by the hospital body ethics committee (Research & Research Ethics committee at Bahrain defence force -Royal medical services) via letter number: 2019-478. Dated: 27th September 2020.


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