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Developing a model for predicting intra-abdominal injuries following blunt trauma: a cross-sectional study

Saeed Safari[1,2], Seyed Hadi Aghili[1,3,4]*, Hamed Maneshi[5]*, Shahram Paydar[5], Zahra Shayan[6], Mehri Farhang Ranjbar[1,7]

1. Research Center for Trauma in Police Operations, Directorate of Health, Rescue & Treatment, Police Headquarter, Tehran, Iran.
2. Men's Health and Reproductive Health Research Center, Shahid Beheshti University of Medical Sciences, Tehran, Iran.
3. Neurosurgery Department, Imam Khomeini Hospital Complex, Tehran University of Medical Sciences, Tehran, Iran.
4. Department of Neurosurgery, Valiasr Hospital, Tehran, Iran.
5. Trauma Research Center, Shahid Rajaee (Emtiaz) Trauma Hospital, Shiraz University of Medical Sciences, Shiraz, Iran.
6. Department of Biostatistics, School of Medicine, Trauma Research Center, Shiraz University of Medical Sciences, Shiraz, Iran.
7. Department of Medical Surgical Nursing, School of Nursing and Midwifery, Tehran University of Medical Sciences, Tehran, Iran.

***Corresponding authors:** Hamed Maneshi; **Email:** hamed76maneshi@gmail.com
Seyed Hadi Aghili; **Email:** dr.seyedhadi.aghili@gmail.com

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Abstract: **Objective:** Finding the associated factors of traumatic intra-abdominal injuries (IAIs) and designing a predictive model could minimize the unnecessary use of computed tomography (CT) scans. This study aimed to develop a risk stratification model in this regard.

Methods: This prospective cross-sectional study was conducted at the emergency department (ED) of a level III trauma center. In this study, we thoroughly examined the association between demographic details, physical examinations, laboratory tests, and ultrasonography with abdominopelvic CT scan results regarding the presence of intra-abdominal injuries following blunt abdominal trauma, trying to develop a risk stratification model in this regard.

Results: A total of 472 blunt trauma patients with a mean age of 39.06±18.49 (range: 15-96) were investigated (81.1% male). 47 intraabdominal damages in 45 (9.5%) patients were diagnosed. Based on logistic regression analysis, presence of abdominal pain (odds ratio [OR]: 39.60; 95% CI: 9.42,166.35), positive focused assessment sonography in trauma (FAST results (OR: 46.93; 95% CI: 14.79,148.89), and injury severity index (ISS)≥25 (OR: 6.43; 95% CI: 2.07,19.90) were significantly correlated with the presence of intraabdominal injuries in blunt trauma patients. The area under the ROC curve of the model was 0,865 (95% Cl: 0.805,0.926) with 86.67% sensitivity and 86.41% specificity.

Conclusion: Being accurate and user-friendly alongside broader criteria compared to similar studies makes our risk stratification model a reliable decision-making tool to optimize CT scan usage in the emergency department.

Keywords: Abdominal Injuries; Blunt Injuries; Clinical Decision Rule; Injury Severity Score; Tomography, X-ray Computed

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1. Introduction

Traumatic injuries have been one of the leading causes of morbidity and mortality around the world for decades (1). The usual causes are vehicle collisions, falls, assaults, or self-harm (2). The absence of adequate care results in high mortality rates and long-term morbidity, especially in elderly groups (3,4). Blunt abdominal trauma, a significant subgroup of trauma, continues to be a leading cause of death and morbidity among trauma patients that can be effectively treated (5). There are several tools available to identify abdominal injuries, including physical examination, focused assessment sonography for trauma (FAST), x-ray graphs, and abdominopelvic computed tomography (CT) scan with IV/oral contrast. No other method can match the accuracy of a CT scan despite some limitations, such as recognizing injuries to the gastrointestinal lumen (6-8). Therefore, CT scan remains the primary method for detecting intra-abdominal injuries (IAIs) due to the high sensitivity and specificity (8,9). Excessive and inappropriate use of CT scans contributes to various health issues and financial burdens for patients and hospitals while also causing confusion within healthcare facilities (10,11). Identifying patients at a higher risk is a suggested approach to reduce the use of CT scans, but the lack of reliable methods has sparked controversy over their use (12-14).

Finding the probable factors associated with IAIs and designing the predictive model could minimize unnecessary use of CT scans. The most efficient predictive model would be provided, to assist the decision-making of ED physicians. This study aimed to develop a risk stratification model for predicting at-risk patients for intra-abdominal injuries following blunt abdominal trauma.

2. Methods

2.1. Study design & setting

This prospective cross-sectional study was conducted at the emergency department (ED) of Emtiaz Hospital, a level III trauma center in Shiraz, Iran, from November 2022 to September 2023. In this study, we thoroughly examined the association between demographic details, physical examinations, laboratory tests, and ultrasonography with abdominopelvic CT scan results regarding the presence of intra-abdominal injuries following blunt abdominal trauma, trying to develop a risk stratification model in this regard.

This research was approved by the Ethics Committee of Shahid Beheshti University of Medical Sciences (IR.SBMU.TEB.POLICE.REC.1402.025) and researchers honored the principle of the Helsinki Declaration (15). Informed consent was obtained from all patients participating in the study, ensuring that their treatment remained unchanged and incurred no additional costs.

2.2. Participants

During the study period, all patients aged 15 or above who had suspected blunt abdominal trauma with a clinical indication for an abdominopelvic CT scan with intravenous (IV)/oral contrast media with no penetrating injuries were carefully monitored for potential IAIs. In our study, all patients underwent an abdominopelvic CT scan as the gold standard of diagnosis. Despite limitations in abdominal injury diagnosis due to high sensitivity and specificity, CT scan remains the cornerstone of diagnosis. Participants who did not meet the age criteria, were pregnant, had doubtful physical examination due to any reason (low Glasgow coma scale (GCS), ...), or declined to participate were excluded from the study.

2.3. Data gathering

The data was collected through patient interviews and by reviewing their electronic records at Shiraz Trauma Registry (STR) as a branch of the National Trauma Registry of Iran (NTRI). An emergency medicine physician collected demographic information, and vital signs (including systolic blood pressure (SBP), and pulse rate (PR)), performed an abdominal physical examination (checking for abdominal pain, tenderness, and abdominal guarding), and obtained FAST sonography results. FAST sonography was conducted and interpreted by the emergency medicine physician in charge, in the patient's first examination. We collected data on duration of hospitalization and intensive care unit (ICU) admission, mortality rates, laboratory results (including complete blood count and international normalized ratio), as well as the findings of abdominopelvic CT scans and X-rays. Two blinded radiologists reported findings of the patients' abdominopelvic CT scans and X-ray graphs separately; any disagreement was resolved by consensus.

The abdominopelvic CT scan was performed using an 8-slice device, covering the area from the diaphragm to the pelvic outlet with 1 cm intervals between each cut. FAST, was conducted using a Honda 2000 device and a 3.5 MHz probe. Abdominopelvic CT scan and FAST results were considered positive if fluid was present in four areas of the abdominal cavity and if injuries to internal organs, hollow viscera, and vascular structures were identified without any evidence of bone fractures. The thoracic injury was defined as the presence of rib fracture, sternum fracture, pneumothorax, hemothorax, signs of diaphragm damage, and lung contusion in x-ray graphs. The pelvic fracture was defined as the fracture of the bony component of the pelvic ring in X-ray graphs. We determined the abbreviated injury scale (AIS) of different regions by analyzing the patient's clinical characteristics, paraclinical data, and surgical notes after hospitalization. The computation was performed following AIS guidelines released in 2008. Subsequently, we computed each subject's injury severity score (ISS) and incorporated it into the dataset.

2.4. Statistical analysis

The required number of participants for this investigation was determined to be 231 patients, with 43 positive results (corresponding to a rate of 6.07 events per predictor parameter). Building upon previous efforts to develop BATSS scores in comparable environments, the prevalence of IAIs among patients with blunt abdominal trauma (BAT), power (shrinkage), and the area under the curve (AUC) was determined to be 0.184, 0.9, and 0.95, respectively. In addition, we considered seven parameters as the pillars of this model (16,17).

To make the final model more usable, the quantitative variables were transformed into group measures. The systolic blood pressure and pulse rate were categorized, based on the likelihood of shock (for blood pressure, patients were divided into three classes of normal SBP, probability of stage and shock, and presence of stage or hemorrhagic shock). The severity of anemia was categorized based on hemoglobin level. ISS categories were also used to define the severity of injury. Other lab data were categorized by the hospital lab references.

SPSS version 27 was utilized for all calculations and illustrations. Quantitative variables were presented as mean with standard deviation or median with interquartile range (IQR) and categories were presented as count with percentage. Comparison between patients with and without IAIs was per-

Table 1 Comparing the baseline characteristics of the studied case between patients with and without traumatic intraabdominal injury (IAI) based on abdominopelvic CT scan findings as a reference test

Characteristics	Intraabdominal injury		Total (n: 472)	P
	Without (n: 427)	With (n: 45)		
Age (years)				
Mean ± SD	39.58±18.38	34.11±19.01	39.06±18.49	0.059
Sex				
Female	83 (19.4)	6 (13.3)	89 (18.9)	0.319
Male	344 (80.5)	39 (86.6)	383 (81.1)	
Type of injury				
Direct blunt trauma	47 (11.0)	3 (6.6)	50 (10.6)	0.053
Motor vehicle collisions	275 (64.4)	37 (82.2)	312 (66.1)	
Fall	105 (24.5)	5 (11.1)	110 (23.3)	
Hospital residency (days)				
Median (IQR)	5.0 (3.0-9.0)	6.0 (4.0-10.0)	5.0 (3.0-10.0)	0.061
ICU residency (days)				
Median (IQR)	0.0 (0.0-3.0)	3.0 (1.0-6.0)	0.0 (0.0-4.0)	<0.001
Discharge status				
Transport to another hospital	9 (2.1)	0 (0.0)	9 (1.9)	0.056
Recovered	377 (88.2)	42 (93.3)	419 (88.8)	
Leave AMA	32 (7.4)	1 (2.2)	33 (6.9)	
Mortality	9 (2.1)	2 (4.4)	11 (2.3)	
Abdominal pain				
Absence	421 (98.5)	24 (53.3)	445(94.3)	<0.001
Presence	6 (1.4)	21 (46.6)	27 (5.7)	
Abdominal tenderness				
Absence	422 (98.8)	27(60.0)	449 (95.1)	<0.001
Presence	5 (1.1)	18 (40.0)	23 (4.9)	
Abdominal guarding				
Absence	426 (99.7)	39 (86.6)	465 (98.5)	<0.001
Presence	1 (0.2)	6 (13.3)	7 (1.5)	
Thoracic injury				
Absence	235 (55.0)	16 (35.5)	251 (53.2)	0.013
Presence	192 (44.9)	29 (64.4)	221 (46.8)	
Pelvic fracture				
Absence	359 (84.0)	32 (71.1)	391 (82.8)	0.028
Presence	68 (15.9)	13 (28.8)	81 (17.2)	
FAST sonography				
Negative	417 (97.6)	16 (35.5)	433 (91.7)	<0.001
Positive	10 (2.3)	29 (64.4)	39 (8.3)	
SBP (mmHg)				
≥110	381 (89.2)	38 (84.4)	419 (88.8)	0.152
110 >, ≤ 90	41 (9.6)	7 (15.5)	48 (10.2)	
<90	5 (1.1)	0 (0.0)	5 (1.1)	
PR (bpm)				
Normal (≤100)	332 (77.7)	38 (84.4)	370 (78.4)	0.299
Tachycardia (>100)	95 (22.2)	7 (15.5)	102 (21.6)	
Hemoglobin (g/dl)				
>14	125 (29.5)	7 (15.5)	132 (28.2)	0.139
< 14, ≥ 8	290(68.5)	37 (82.2)	327 (69.9)	
<8	8 (18.9)	1 (2.2)	9 (1.9)	
Hematocrit (%)				
39%-53%	208 (50.4)	14 (34.1)	222 (49.0)	0.046
<39%	204 (49.5)	27 (65.8)	231 (51.0)	
RDW-CV (%)				
Normal (11.6 – 14.6)	335 (79.7)	26 (59.0)	361 (77.8)	0.002
Abnormal (< 11.6)	85 (20.2)	18 (40.9)	103 (22.2)	
INR				
Normal (≤1.1)	113 (54.0)	5 (27.7)	118 (52.0)	0.032
Delayed (> 1.1)	96 (45.9)	13 (76.4)	109 (48.0)	

Table 1 Comparing the baseline characteristics of the studied case between patients with and without traumatic intraabdominal injury (IAI) based on abdominopelvic CT scan findings as a reference test

Characteristics	Intraabdominal injury		Total (n: 472)	P
	Without (n: 427)	With (n: 45)		
ISS				
Minor injury (<9)	147 (34.4)	3 (6.6)	150 (31.8)	<0.001
Moderate injury (>8, <16)	145 (33.9)	8 (17.7)	153 (32.4)	
Severe injury (<25, >15)	91 (21.3)	15 (33.3)	106 (22.5)	
Very severe injury (>24)	44 (10.3)	19 (42.2)	63 (13.3)	

Data are presented as mean ± standard deviation, median (IQR: interquartile range), or frequency (%). AMA: Against medical advice; FAST: Focused assessment sonography for trauma; GCS: Glasgow coma scale; SBP: Systolic blood pressure; PR: Pulse rate; RDW-CV: Red cell distribution width - coefficient of variation; INR: International normalized ratio; ISS: Injury severity score

Table 2 The logistic regression analysis of independent predictors of intraabdominal injury following blunt abdominal trauma based on the abdominopelvic CT scan findings as a reference test

Factor	OR (95% CI)	Score (β)	P value
Abdominal pain	39.60 (9.42 to 166.35)	3.67	< 0.001
FAST sonography	42.69 (14.79 to 148.89)	3.84	< 0.001
Severe injury ISS	6.43 (2.07 to 19.90)	1.86	< 0.001

OR: Odds ratio; CI: Confidence interval; ISS: Injury severity score. P value significant at < 0.05.

Table 3 Intraabdominal injury distribution based on risk stratification model

Model		Total	Intraabdominal injury		Sensitivity	Specificity
			Without	With		
Predictive model	High risk	97 (20.5)	58 (12.2)	39 (8.2)	0.86	0.86
	Low risk	375 (79.4)	369 (78.1)	6 (1.2)		
Total		472 (100.0)	427 (100.0)	45 (100.0)		

Data are presented as a number (%) of cases

formed using the chi-squared, independent sample T and Mann-Whitney U tests for proportions.

A prediction model for IAIs was developed by deriving factors with significant associations in the chi-squared test into logistic regression. Four hundred and seventy-two patients were studied in forward stepwise logistic regression analysis. Afterward, we developed a model based on the odds ratio for every factor in logistic regression. ROC curve for this model using CT scan data as the reference test was then created (P-value regarded as significant at < 0.05).

3. Results

3.1. Baseline characteristics of participants

A total of 621 patients were studied. 149 patients were excluded due to failure to meet the criteria and missing data. The remaining 472 patients with a mean age of 39.06±18.49 (range: 15-96) years were closely observed for potential IAIs. Of the patients, 81.1% were male with an average age of 37.75±17.69 years, while 18.9% were female with an average age of 44.69±20.79 years.

The primary cause of trauma was motor vehicle accidents, accounting for 66.1% of cases (n=312), followed by falls accounted for 23.3% (n=110), and direct abdominal trauma accounted for 10.6% (n=50) of the cases. Based on abdominopelvic CT scan results, IAIs were detected in 9.5% of the patients (n=47). The distribution of injuries among different organs was as follows: liver in 44.6% (n=21), spleen in 38.2% (n=18), bladder in 4.2% (n=2), colon in 6.3% (n=3), duodenum in 2.1% (n=1), pancreas in 2.1% (n=1), and kidney in 2.1% (n=1) of cases (some patients had multiple organ damage, resulting in a total of 47). All patients with the final diagnosis of IAIs had definitive findings or clues on the abdominopelvic CT scan.

3.2. Comparison between patients with and without IAIs

The mortality rate was 4.2% in patients with IAIs and 2.1% in others. The median duration of hospitalization was 6.0 (IQR: 4.0-9.0) days and 5.0 (IQR: 3.0-9.0) days for the IAI+ group and IAI- group, respectively (P=0.061). The IAI- group had a shorter ICU residency duration with a median of 0.0 (IQR: 0.0-3.0) days in comparison to the IAI+ group with a median of 2.0 (IQR: 0.0-5.0) days (P< 0.001).

The detailed comparison between the two groups is presented in table 1. Patients with IAIs based on CT scan findings had more abdominal pain (P<0.001), abdominal tenderness (P< 0.001), abdominal guarding (P<0.001), positive FAST results (P<0.001), pelvic fracture (P=0.028), thoracic injury (P=0.013), low hematocrit level (P=0.046), abnormal RDW-CV (P=0.002), abnormal INR (P=0.032), and high ISS score (P<0.001).

Factors with significant differences were inserted into logistic regression analysis (Table 2). Accordingly, factors with independent significant association to IAIs were the presence of abdominal pain (odds ratio [OR]: 39.60; 95% CI: 9.42,166.35), positive FAST results (OR: 46.93; 95% CI: 14.79,148.89), and ISS ≥ 25 (OR: 6.43; 95% CI: 2.07,19.90) respectively.

3.3. Predictive model

A model was developed to predict the possibility of IAIs by utilizing the odds ratio of the detected factors. The presence of abdominal pain, positive FAST, and severe injury (ISS≥25) were pillars in this model. The final prediction model is based on the presence of the mentioned factors. Based on our model, patients were divided into high-risk and low-risk groups to predict the possibility of IAIs. Any patients with abdominal pain or tenderness, positive FAST sonography results, or ISS score exceeding 25 were considered high risk, and the rest were considered low risk. The risk of IAIs increases with the combination of the mentioned factors. The distribution of patients with and without IAIs is presented in table 3 and figure 1. Table 3 displays the risk stratification model's diagnostic performance. The area under the curve for the designed model is 0,865 (95% Cl: 0.805,0.926). The sensitivity, specificity, negative predictive value, and positive predictive value of the model in predicting the presence of IAI were 86.67% (95% CI: 73.20%,94.94%), 86.417% (95% CI: 82.79%,89.52%), 98.40% (95% CI: 96.68%,99.23%), 40.20% (95% CI: 34.02%,46.71%).

4. Discussion

In this study, we aimed to identify potential predictors and examine their impact on the diagnosis of IAIs following blunt abdominal trauma. Our analysis revealed three primary factors that strongly predict IAIs. After excluding other variables, a model was developed that utilized three key factors: the presence of abdominal signs and symptoms, the severity of the trauma, and the results of the para clinic FAST sonography. The utilization of our model, which demonstrated a remarkable sensitivity and negative predictive value of 86.67 % and 98.4%, respectively, effectively minimized the unnecessary use of CT scans in the patients involved in this study despite two missing patients. The analysis highlighted the irreplaceable role of CT scans, as supported by findings in various studies.

Based on advanced trauma life support (ATLS), recording vital signs, physical exams, and FAST sonography results will be performed for each traumatic patient upon arrival into the ED. Our analysis shows if a traumatic patient had no abdominal signs or symptoms, negative FAST sonography results, and ISS score less than 25 (ISS<25), positive findings on abdominal CT scan are remote, and the dysregulation of vital signs and laboratory results might not be due to IAIs. However, in every phase of treatment, the emergence of the mentioned factors should be considered alarming for the presence of IAIs.

When it comes to predicting IAIs, certain factors like FAST sonography, abdominal signs and symptoms, and multiple trauma (that included abdominal trauma) involving pelvic ring, femur, and head fractures have proven to be highly predictive. While the lack of the three factors mentioned reduces the likelihood of IAIs, it may still be challenging to completely rule out IAIs with absolute certainty. According to our analysis, shock at any grade, acute anemia, and abnormal coagulation tests (INR) should be approached cautiously when considering the possibility of IAIs. In order to address the issue of ensuring accuracy in an uncertain population, one potential solution involves utilizing repeated predictors such as repeated FAST sonography and abdominal physical examination. This approach can help identify and rule out IAIs or utilize minor predictors.

In addition to our study, we examined three other prospective observational studies (18-20). Our research, along with other studies, consistently found that motor vehicle accidents were the primary cause of trauma. The study population was 3435 individuals (39.8 years mean age) in the Holmes et al. study, 1040 individuals (37.0 years mean age) in Denuk et al. study, 472 individuals (39.06 years mean age) in our study, and 261 individuals (20-30 years mean age) by Shojaee et al. study as reported in their documents (17-119). Every study was a prospective observational study in a different country and at a different time. The study conducted by Holmes et al. was performed in the USA from 2002 to 2004, while the survey by Denuk et al. was conducted in the Netherlands in 2010. Similarly, Shojaee et al. and our study were performed in Iran in 2012 and 2023, respectively (17-19).

The occurrence of IAI was documented as 29.7%, 18.4%, 9.5%, and 9% in the studies conducted by Denuk et al., Shojaee et al., our study, and Holmes et al., respectively (17-19). The variations in the percentage of outcomes were due to the specific criteria used to include or exclude participants in each study. The Holmes et al. study excluded individuals under the age of 18, pregnant individuals, and those who experienced cardiac arrest (19). Similarly, the Denuk et al. study excluded individuals under the age of 16, pregnant individuals, and those in stage or of hemorrhagic shock (18). The Shojaee et al. study outlined specific criteria for exclusion, including individuals under the age of 18, pregnant women, those with unreliable physical examination results, patients using warfarin, and individuals with penetrating trauma (17). In our study, exclusion criteria were broader in comparison to the previous studies. They encompassed factors such as age below 15, doubtful physical examination, patient unwillingness to participate, and pregnancy.

The mortality rate was reported as 5.5%, 3.9%, and 2.3% in the Denuk et al., Holmes et al., and our study, respectively, while it is not reported in the Shojaee et al. study. While not documented in other studies, mortality attributable to brain injuries predominated in the research of Holmes et al. and Denuk et al (17-19). Each study developed an algorithm or scoring system to identify patients at risk of IAI. Next, the models were evaluated by calculating their sensitivity and specificity.

The study by Deunk et al. introduced an algorithm that utilizes nine parameters to assess various medical conditions. These parameters included low systolic blood pressure, abnormal physical examination findings in the lumbar spine, abdomen, or pelvis, extremity fracture, Base excess < -3 meq/L, abnormal chest X-ray results, abnormal pelvic X-ray results, abnormal lumbar spine X-ray results, and the use of FAST sonography (18).

Holmes et al. developed an algorithm that considers seven different parameters, including a GCS score of less than 14, costal margin tenderness, abdominal tenderness, femur fracture, hematuria level greater than or equal to 25 red blood cells/high powered field, hematocrit level less than 30%, and abnormal chest radiograph result (19).

Shojaee et al. developed a scoring system known as BATSS. This system takes into account seven different parameters, such as systolic blood pressure below 100 mmHg, pulse rate higher than 100 bpm, the presence of abdominal pain, abdominal tenderness, pelvic fracture, thorax injury, and the results of FAST sonography. Considering these factors, the scoring system aims to provide a comprehensive assessment. Patients were categorized into three groups based on their risk levels: high risk, medium risk, and low risk (17).

Our study introduced a model that considered three key factors: the existence of abdominal pain or tenderness, the results of FAST sonography, and the ISS.

It is evident in all models that including abdominal examination and combined traumas played a crucial role in identifying IAI, while the other parameters showed some variation across the models.

While working in a clinical setting, it is important to consider the use of para clinics like CT scans in the ED when calculating ISS. Although ISS cannot be calculated in the emergency department and needs comprehensive data, our analysis shows using ISS helps ensure that we do not overlook patients with IAIs who may also have other serious injuries but show no abdominal signs or symptoms. The ISS receives more attention compared to other factors used in various studies to indicate the severity of trauma, such as pelvic fractures, femur fractures, and chest wall signs. It highlights the significance of the severity of trauma rather than solely focusing on its location. For instance, a patient with a high ISS (such as a simultaneous fracture of the cranium and the shaft of the femur) is susceptible to IAI despite the absence of direct abdominal trauma. In order to make it practical to use ISS in the ED, we may use other scores that resemble the severity of trauma like revised trauma score (RTS), or like other studies, use a combination of other body part's injuries as an indicator for the severity of trauma (like the presence of pelvic, femur, cranium fracture and ....)

In various studies, the models displayed different levels of sensitivity and specificity. For instance, the sensitivity ranged from 96.8% to 99.3%, while the specificity varied from 27.4% to 98.2%. These findings highlight the variability in the performance of the models across different studies. Shojaee et al. reported a 100% sensitivity and specificity in the low-risk group. However, our study did not achieve the intended goal using the BATSS scoring method.

With our comparable sensitivity among other studies besides acceptable specificity, we aim to regulate the utilization of CT scans. In order to achieve this objective, it is necessary to identify individuals who will not benefit from CT scans. However, despite all attempts, the necessity for a CT scan remains unavoidable (20).

Despite numerous efforts, achieving a model with absolute accuracy is challenging due to variations in abdominal cavity structures. Consequently, the necessity of a CT scan remains unavoidable. However, considering our predictors (abdominal pain or tenderness, FAST sonography, and ISS) and their high sensitivity and NPV we can prioritize patients to use abdominopelvic CT scans in advance in a crowded emergency department. As proposed in figure 2, individuals who have at least one of the mentioned factors may benefit from earlier utilization of CT scans, while those with no mentioned factors can consider alternative methods such as minor predictors, serial physical examination, and repeated FAST sonography to manage patients and minimize unnecessary CT scan usage effectively.

5. Limitations

First, not all blunt abdominal trauma patients undergo a CT scan for diagnosis. Some patients due to hemodynamic situations, may experience immediate laparotomy or other invasive procedures. On the other hand, CT scans will not be considered for many trauma patients due to physician opinion. In this study, we only observed those who underwent abdominopelvic CT scans with IV/oral contrast.

Second, due to physician a few patients' electronic files due to laboratory faults, decisions, some patients did not require certain laboratory tests, which resulted in missing data. Moreover, due to laboratory faults, some parts of CBCs were missed in a few patients' electronic files. Third, researchers were not blind to the aim of this study.

6. Conclusion

Our risk prediction model's accuracy and user-friendliness, combined with broader criteria compared to similar studies, make it a reliable decision-making tool for optimizing CT scan usage in the emergency department.

7. Declarations

7.1. Acknowledgement

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7.2. Authors' contribution

study concept: SS, HM; Methodology: SS, SP, HM; Data collection: HM, SP; Data analysis: ZS, HM; Manuscript writing: HM; Manuscript editing: all authors. All authors read and approved the final manuscript.

7.3. Conflict of interest

The authors certify that there is no conflict of interest with any financial organization regarding the material discussed in the manuscript.

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7.5. Artificial intelligence usage

The authors used Quillbot for the language edition. AI outputs were supervised and re-checked by the authors.

7.6. Data availability

The datasets collected and analyzed during this study are available upon reasonable request.

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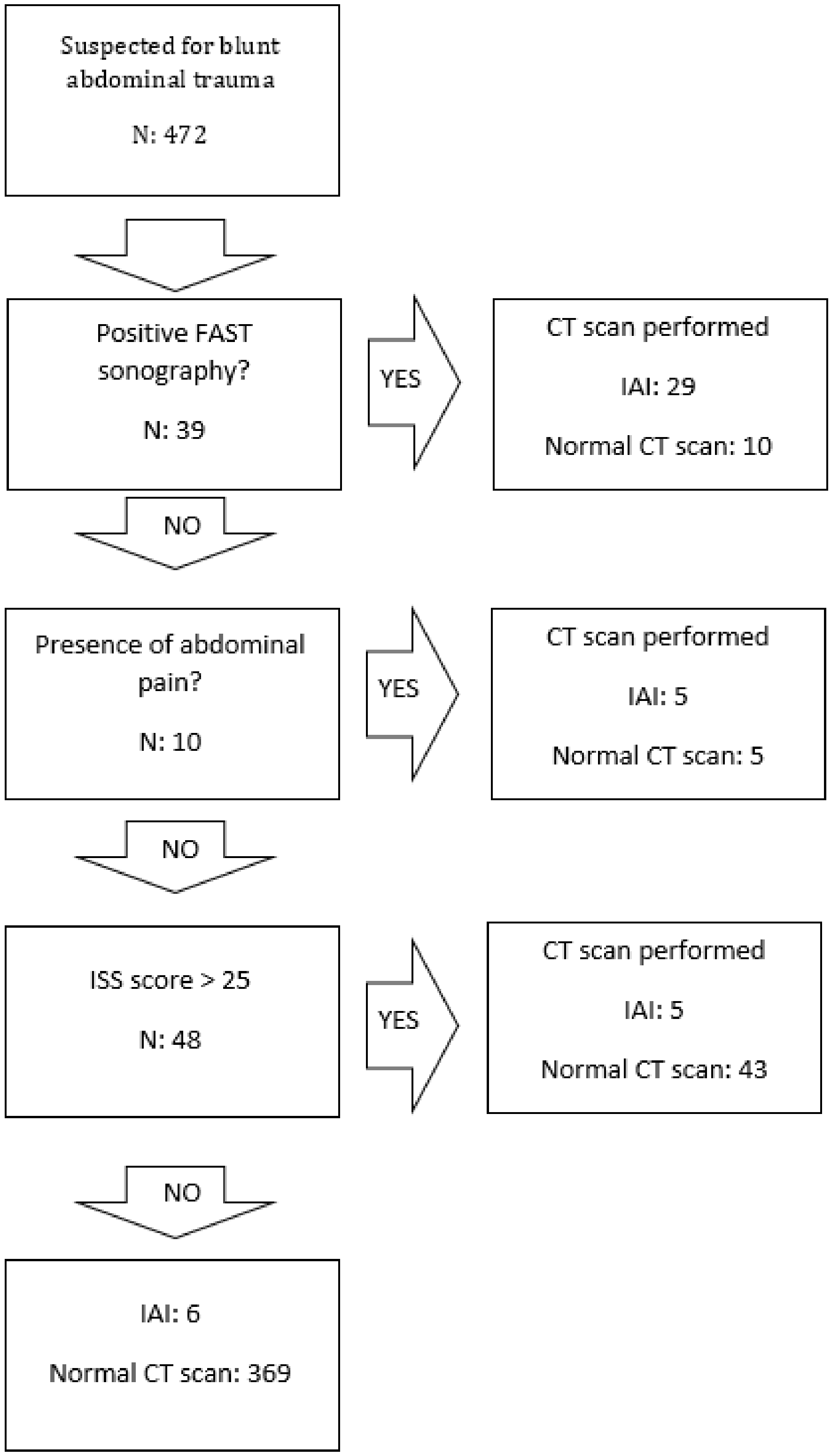

Figure 1 Distribution of study population based on prediction model parameters. ISS: Injury severity score; FAST: Focused assessment sonography in trauma; IAI: Intraabdominal injury

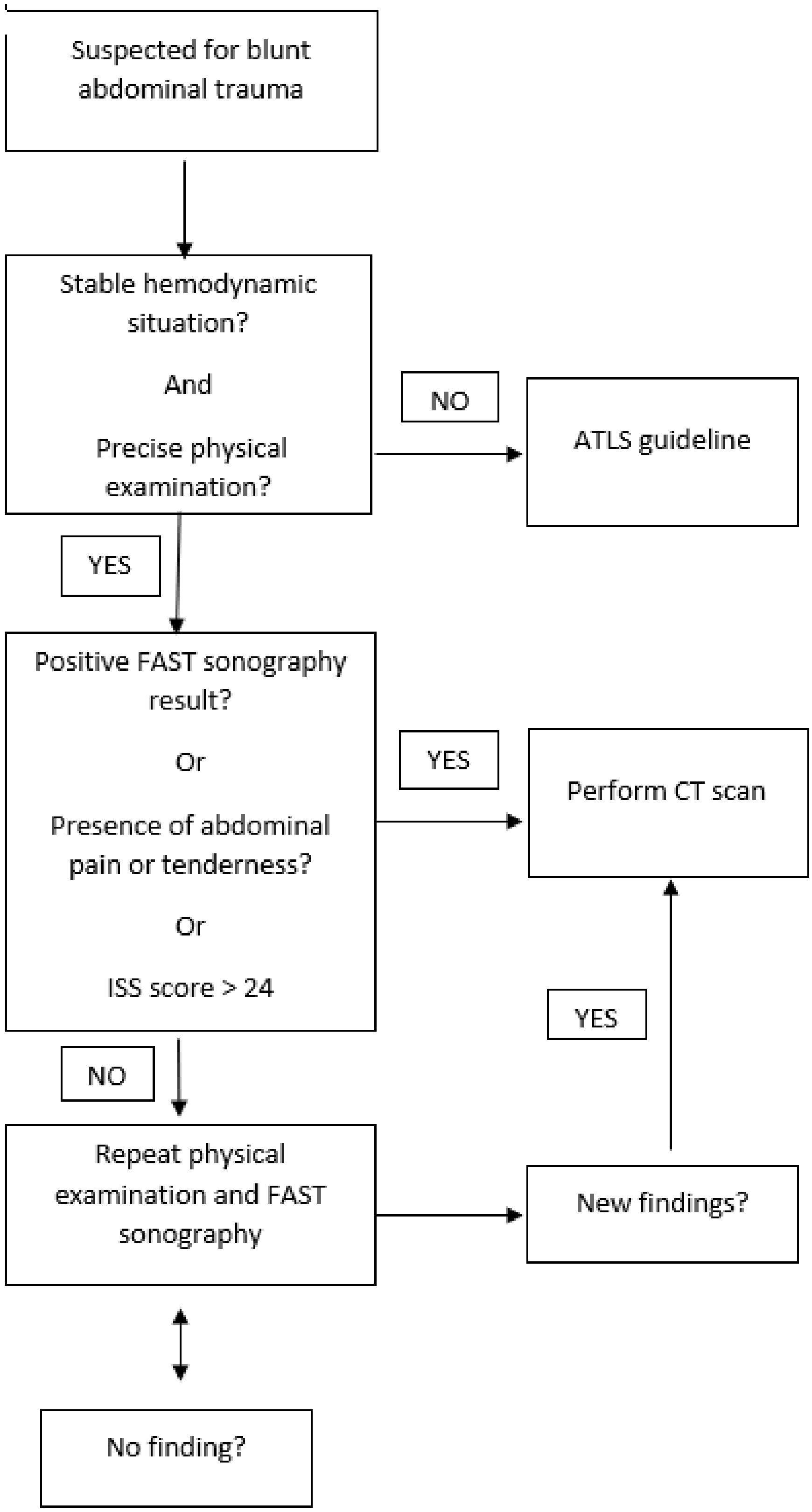

Figure 2 Proposed flowchart based on prediction model for IAI following blunt abdominal trauma. ISS: Injury severity score; ATLS: Advanced trauma life support; FAST: Focused assessment sonography in trauma