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Validation of Blunt Abdominal Trauma Severity Scoring System for Predicting Surgical Intervention: A Prospective Study

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ABSTRACT: Blunt abdominal trauma accounts for 7–10% of all trauma fatalities, and deciding which patients require surgery versus observation remains clinically challenging. The Blunt Abdominal Trauma Severity Scoring System (BATSS) combines seven bedside parameters into a 24-point score, but prospective validation in an Indian tertiary care setting had not been undertaken. This prospective observational study enrolled 67 patients aged 18–50 years presenting with blunt abdominal trauma at a tertiary care teaching hospital in Bengaluru between November 2020 and June 2022. Each patient was scored at admission before imaging and stratified as low risk (score <8), moderate risk (8–11), or high risk (≥ 12). Sensitivity, specificity, positive and negative predictive values, likelihood ratios and area under the receiver-operating-characteristic curve (AUC) were calculated at the pre-specified cut-off of ≥ 12 . Forty-five patients (67.2%) were high risk, seven (10.4%) moderate risk and 15 (22.4%) low risk. Of 21 patients requiring surgical intervention, 20 (95.2%) were in the high-risk group. FAST was positive in all 45 high-risk patients (100%) and negative in all 15 low-risk patients. At the cut-off of ≥ 12 , sensitivity was 95.2% (95% CI 77.3–99.2%), specificity 45.7% (32.2–59.8%), positive predictive value 44.4% (30.9–58.8%), negative predictive value 95.5% (78.2–99.2%), negative likelihood ratio 0.10 and AUC 0.71 (0.58–0.84). The association between high-risk BATSS category and surgical intervention was significant ($p = 0.003$). In-hospital mortality was 4.5%. BATSS demonstrated high sensitivity and negative predictive value for identifying blunt abdominal trauma patients requiring surgery, supporting its role as a bedside rule-out triage tool. Multicentre validation is recommended.

1. INTRODUCTION

Trauma remains one of the leading causes of preventable death worldwide, claiming a disproportionate toll among young, working-age individuals. In the United States alone, roughly 150,000 deaths each year are attributed to injury (Guillon, 2011). Low- and middle-income countries bear the greatest share of this burden, where resource constraints amplify preventable mortality (Elliot and Rodriguez, 1996).

Within the trauma landscape, abdominal injury occupies a particularly dangerous position. It accounts for approximately 7–10% of all trauma fatalities, ranking behind only head and thoracic injuries in lethality (Tentilier and Masson, 2000). Blunt

mechanisms drive roughly 80% of presentations — most commonly road traffic collisions, falls, and assaults — and in children under 14, blunt abdominal trauma is the second most common cause of trauma death after head injury (Meyer et al., 1989; Costa et al., 2010; Kaul et al., 2003; Reddy et al., 2014).

What makes blunt abdominal trauma genuinely challenging is its clinical variability. Physical examination is unreliable in distracted, intoxicated, or altered patients. Computed tomography (CT) has become the reference standard, but it carries radiation exposure, requires contrast, and takes time that a deteriorating patient may not have. A validated bedside scoring tool that can rapidly stratify patients is therefore of genuine practical value (Mehta et al., 2014).

The Blunt Abdominal Trauma Severity Scoring System (BATSS) was designed with this purpose. It assigns weighted numerical scores to seven parameters assessable at initial clinical contact: abdominal pain, abdominal tenderness, chest wall signs, pelvic fracture, FAST result, systolic blood pressure, and pulse rate. The total score, out of 24 points, places patients into low-, moderate-, or high-risk tiers. Prior external validations have reported encouraging results (Erfantalab-Avini, 2011; Subbiah et al., 2021; Fahmi et al., 2022; Karjosukarso et al., 2019), but no formal prospective validation with pre-specified cut-off metrics had been performed in an Indian tertiary care setting.

Road traffic injury patterns in India differ substantially from Western cohorts — two-wheeler collisions predominate, mechanisms are high-energy, and CT availability varies. This study was therefore designed to evaluate the diagnostic accuracy of BATSS for predicting surgical intervention, characterise the clinical profile of blunt abdominal trauma patients at our centre, and examine FAST performance as the highest-weighted scoring component.

2. MATERIALS AND METHODS

2.1 Study design and setting

This was a prospective observational study conducted in the Department of General Surgery at M. S. Ramaiah Medical College and Hospitals, a tertiary care teaching hospital in Bengaluru, Karnataka, India. Enrolment ran over 20 months from November 2020 to June 2022. The study protocol was reviewed and approved by the Institutional Ethics Committee. Written informed consent was obtained from all enrolled patients, or from the legal next of kin where the patient was unable to provide consent at presentation. All procedures were conducted in accordance with the Declaration of Helsinki.

2.2 Sample size and power calculation

A formal sample size calculation was performed before enrolment. Based on a reported BATSS sensitivity of approximately 88% from Subbiah et al. (2021), a desired precision margin of 10%, and a 95% confidence interval, the minimum required sample was 43 patients. With a conservative 20% attrition allowance, the target was set at 52 patients. The final cohort of 67 patients exceeded this target.

2.3 Inclusion and exclusion criteria

All patients aged 18–50 years presenting to the emergency department with a clear history of blunt abdominal trauma and no prior treatment at another facility were eligible. Excluded were: pregnant women; patients under 18 years; patients on anticoagulant therapy; patients with pre-existing neurological disorders confounding assessment; penetrating abdominal injuries; and patients referred from outside hospitals where more than 24 hours had elapsed since injury.

2.4 BATSS scoring

Each enrolled patient was scored using BATSS at initial emergency department contact, before CT imaging or laboratory results were available. The seven scoring parameters and assigned weights are presented in **Table 1**. Based on the total score, patients were classified as low risk (score <8), moderate risk (8–11), or high risk (≥ 12). FAST scans were performed by trained clinicians as part of standard emergency protocol.

Table 1. Blunt Abdominal Trauma Severity Scoring System (BATSS) parameters and assigned weights. Total possible score is 24 points; patients are classified as low risk (<8), moderate risk (8–11) or high risk (≥12).

Parameter	Category	Score
Abdominal pain	Absent	0
	Present	1
Abdominal tenderness	Absent	0
	Mild	1
	Severe/guarding	3
Chest wall signs	Absent	0
	Present	2
Pelvic fracture	Absent	0
	Present	3
FAST result	Negative	0
	Positive	8
Systolic blood pressure (mm Hg)	>90	0
	60–90	2
	<60	4
Pulse rate (beats/min)	<100	0
	100–120	1
	>120	3
Total possible score		24

2.5 Clinical management

Management decisions — conservative monitoring, CT imaging, diagnostic laparoscopy, laparotomy, or percutaneous drainage — were made by the attending consultant based on the overall clinical picture. The BATSS score was recorded prospectively but did not directly dictate treatment, ensuring that the study assessed predictive value against independently determined clinical outcomes without introducing management bias.

2.6 Outcomes

The primary outcome was the need for surgical intervention, defined as laparotomy, diagnostic laparoscopy, or percutaneous drainage. Secondary outcomes included organ injury identified on CT or at surgery, duration of hospital stay, and in-hospital mortality.

2.7 Statistical analysis

Continuous normally distributed variables are reported as mean $\pm$ standard deviation (SD); non-normally distributed variables as median with interquartile range (IQR). Categorical variables are reported as frequencies and percentages. Association between BATSS risk category and surgical intervention was assessed using Pearson's chi-square test. Sensitivity, specificity, positive predictive value (PPV), negative predictive value (NPV), positive likelihood ratio (LR+) and negative likelihood ratio (LR–) were calculated at the pre-specified cut-off of ≥ 12 . An ROC curve was constructed and the area under the curve (AUC) with 95% confidence intervals calculated using the Wilson score method. All analyses were performed using SPSS version 18.0 (IBM Corp., Armonk, NY). A two-sided p-value < 0.05 was considered statistically significant.

3. RESULTS

3.1 Patient characteristics and risk stratification

Sixty-seven patients fulfilled the inclusion criteria and were enrolled. On BATSS scoring at admission, 45 patients (67.2%) were high risk (score ≥ 12), seven (10.4%) moderate risk (score 8–11) and 15 (22.4%) low risk (score < 8) (**Figure 1**).

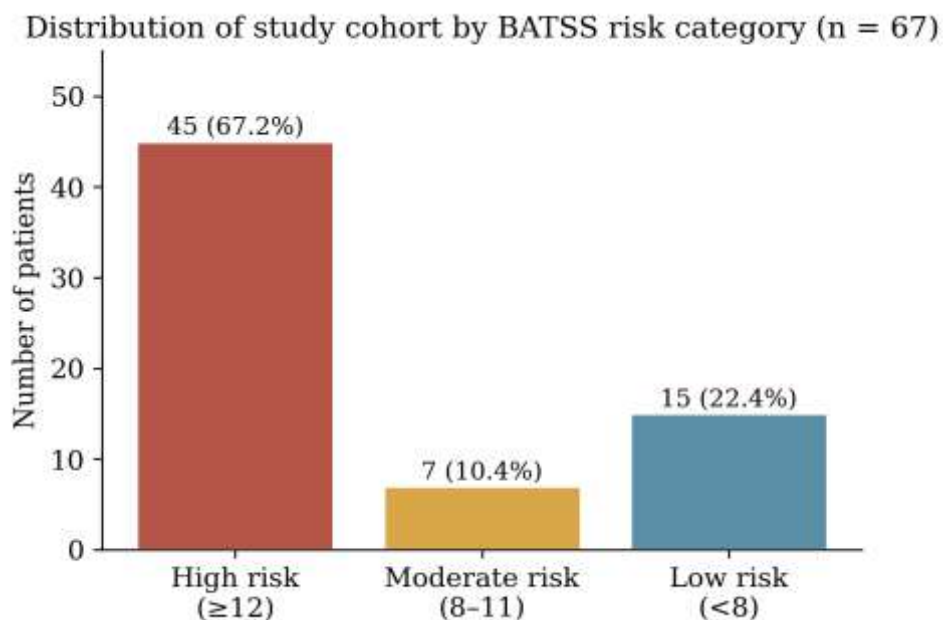


Figure 1. Distribution of study cohort (n = 67) by BATSS risk category. High-risk (score ≥ 12): 45 patients (67.2%); moderate-risk (score 8–11): 7 patients (10.4%); low-risk (score < 8): 15 patients (22.4%).

3.2 Demographic profile

The cohort was predominantly male: 55 patients (82.1%) were male and 12 (17.9%) were female, giving a male-to-female ratio of approximately 4.6:1. This closely matches epidemiological profiles reported in comparable Indian trauma studies, where ratios of 3.3:1 to 11.5:1 have been documented (Mehta et al., 2014; Reddy et al., 2014; Behboodi et al., 2016). The mean age was 31.7 ± 12.1 years. Fifty-nine patients (88.1%) had no documented comorbidities; six (9.0%) had type 2 diabetes mellitus and two (3.0%) had hypertension (**Figure 2**).

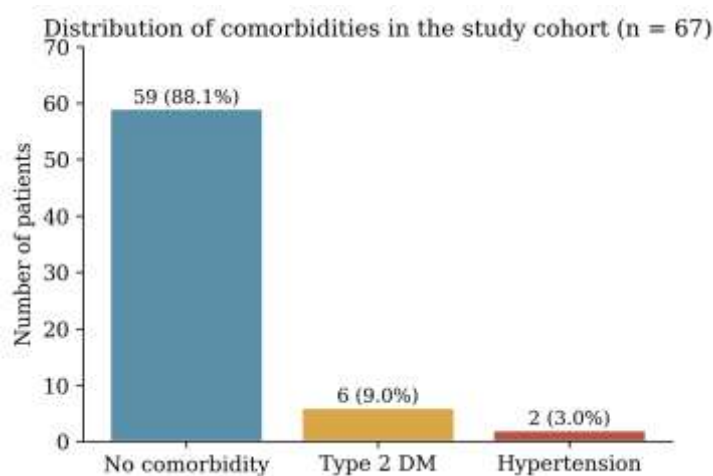


Figure 2. Distribution of comorbidities in the study cohort (n = 67). No documented comorbidity: 59 (88.1%); type 2 diabetes mellitus: 6 (9.0%); hypertension: 2 (3.0%).

3.3 Mechanism of injury

Road traffic injury involving two-wheelers was the dominant mechanism. Motorcycle drivers accounted for 40.3% ($n = 27$) and motorcycle passengers 16.4% ($n = 11$), giving a combined two-wheeler total of 56.7%. Other mechanisms included falls from height (10.4%), four-wheeler occupants (10.4%), miscellaneous causes (16.4%) and pedestrians (6.0%) (**Figures 3 and 4**). Motorcycle passengers showed the highest proportion of high-risk classification at 90.9%, consistent with the unprotected high-energy mechanism.

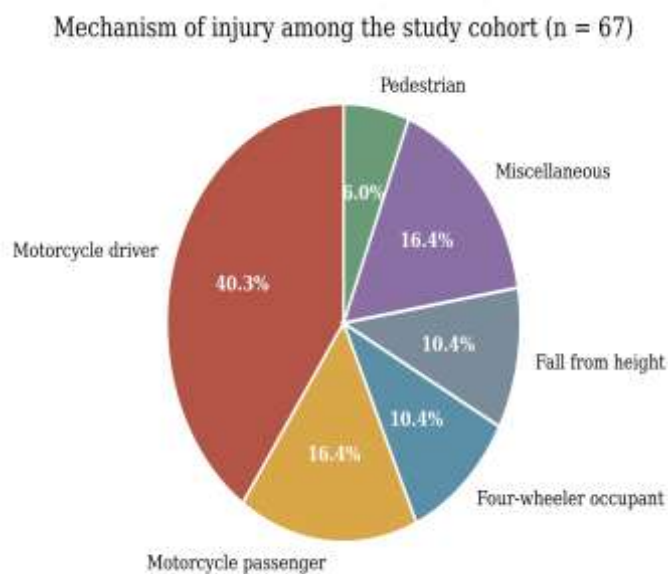


Figure 3. Mechanism of injury among the study cohort. Motorcycle drivers: 40.3% ($n = 27$); motorcycle passengers: 16.4% ($n = 11$); four-wheeler occupants: 10.4%; falls from height: 10.4%; pedestrians: 6.0%; miscellaneous: 16.4%.

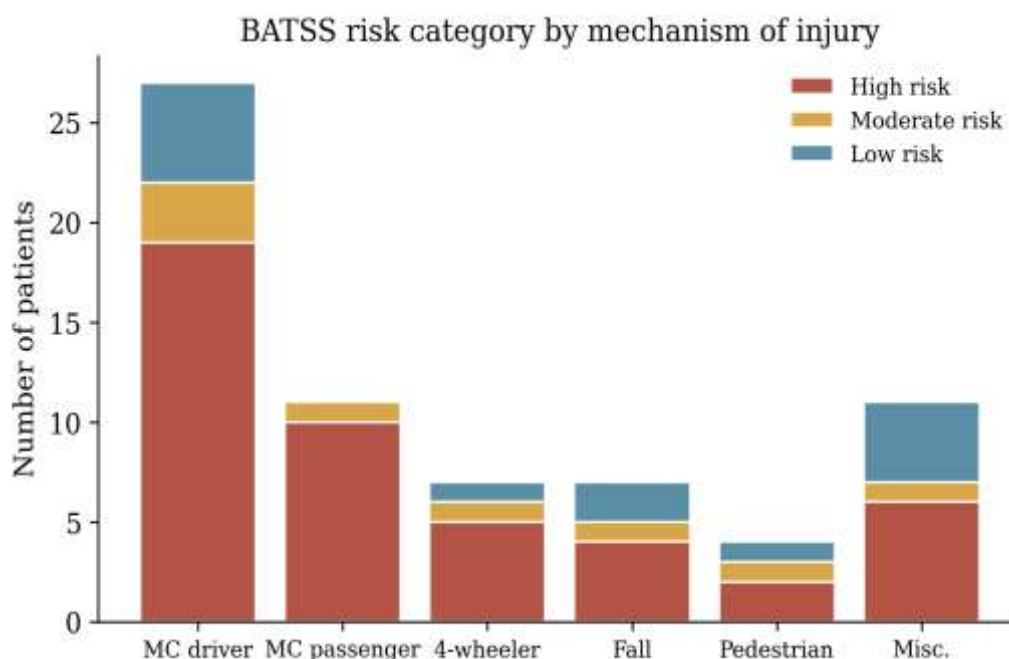


Figure 4. Distribution of BATSS risk category by mechanism of injury, showing the highest proportion of high-risk classification among motorcycle passengers (90.9%).

3.4 FAST scan performance

FAST was performed in all 67 patients. All 45 high-risk patients (100%) were FAST-positive. Four of seven moderate-risk patients (57.1%) were FAST-positive. All 15 low-risk patients (100%) were FAST-negative (**Figure 5**). The near-perfect concordance in the high-risk group reflects the dominant eight-point weighting assigned to FAST within the scoring framework. These findings are consistent with the broader FAST literature in high-risk blunt trauma populations (Kelley et al., 2014; Fox et al., 2011).

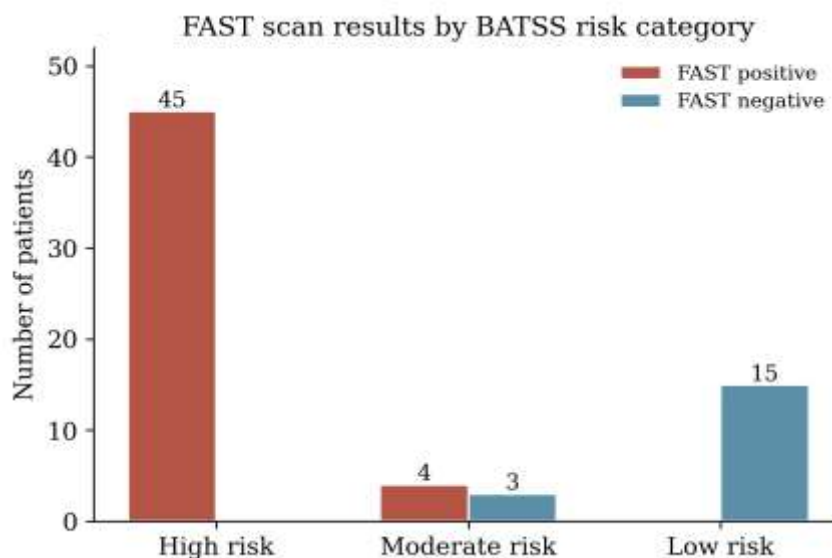


Figure 5. FAST scan results by BATSS risk category. All 45 high-risk patients (100%) were FAST-positive; 4/7 moderate-risk patients (57.1%) were FAST-positive; all 15 low-risk patients (100%) were FAST-negative.

3.5 CT scan findings and organ injury pattern

CT imaging was performed in all high-risk patients and selected moderate-risk patients. The most frequently injured organ was the spleen ($n = 16$, 23.9%), of whom 12 (75.0%) were high risk. Liver injury was second most common ($n = 15$, 22.4%), with 11 (73.3%) in the high-risk group. Bladder injury was found in five patients, renal injury in three, small bowel in two and colon in three. Seven patients had multi-organ injury, of whom six were high risk (**Figure 6**).

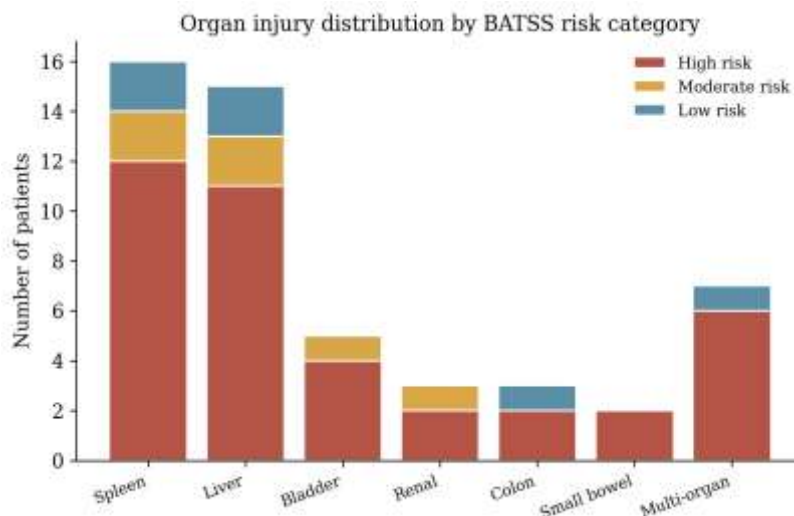


Figure 6. Distribution of solid- and hollow-organ injuries identified on CT or at surgery, grouped by BATSS risk category. The spleen was the most frequently injured organ ($n = 16$, 23.9%), followed by the liver ($n = 15$, 22.4%).

3.6 Management and surgical intervention

Of 67 patients, 46 (68.7%) were managed conservatively. Twenty-one (31.3%) required surgical or procedural intervention: 17 underwent laparotomy, two percutaneous drainage and two diagnostic laparoscopy (**Figures 7 and 8**). Of the 21 operated patients, 20 (95.2%) were in the high-risk category. The single exception was a low-risk patient (BATSS score = 0) with isolated colon injury presenting without tenderness, a negative FAST and stable haemodynamics — a recognised limitation of scoring systems for hollow viscus injuries. No moderate-risk patient required surgery. The association between high-risk BATSS classification and surgical intervention was statistically significant (χ^2 $p = 0.003$).

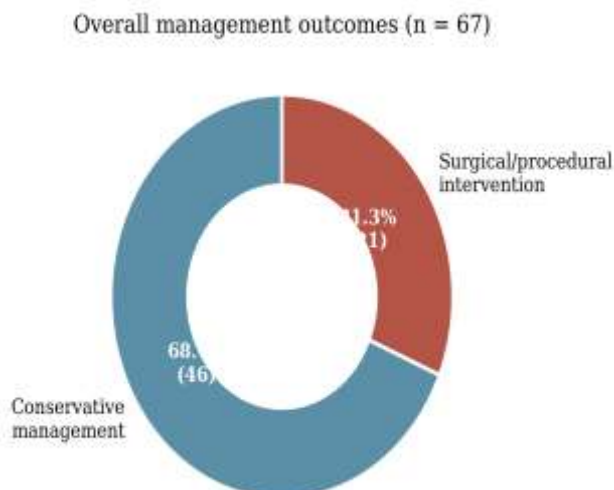


Figure 7. Overall management outcomes. Conservative management: 46 patients (68.7%); surgical or procedural intervention: 21 patients (31.3%).

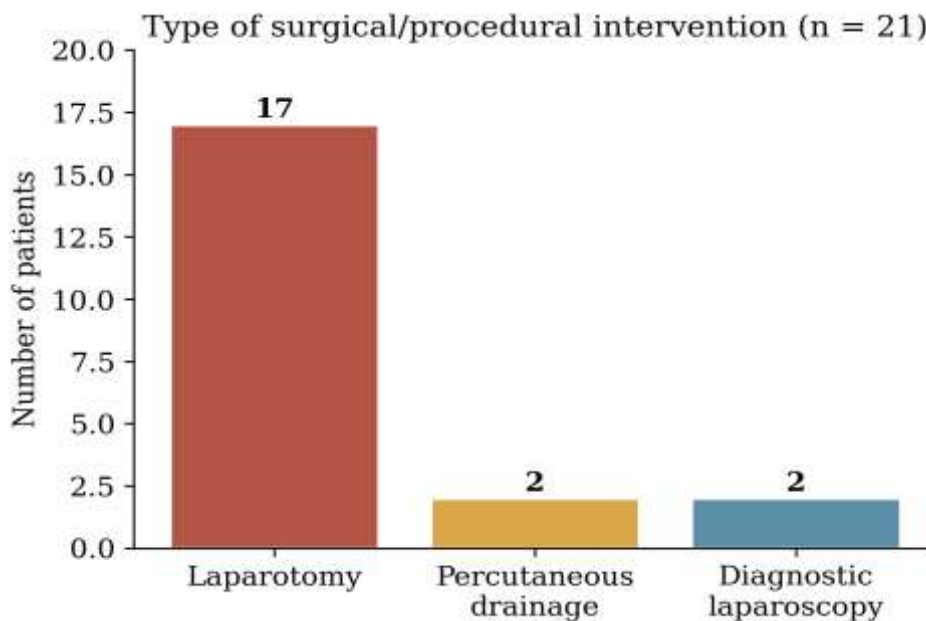


Figure 8. Type of surgical/procedural intervention among operated patients (n = 21). Laparotomy: 17; percutaneous drainage: 2; diagnostic laparoscopy: 2.

3.7 Diagnostic accuracy of BATSS

Diagnostic accuracy metrics are presented in **Table 2**, and the ROC curve in **Figure 9**. The 2×2 contingency table comprised 20 true positives, one false negative, 25 false positives and 21 true negatives. BATSS demonstrated sensitivity of 95.2% (95% CI 77.3–99.2%) and NPV of 95.5% (95% CI 78.2–99.2%), confirming strong rule-out performance below the cut-off. Specificity was 45.7% (95% CI 32.2–59.8%) and PPV 44.4% (95% CI 30.9–58.8%), reflecting the intentional sensitivity-biased design — a high-risk designation should prompt further assessment rather than automatic surgery. The AUC of 0.71 (95% CI 0.58–0.84) indicates moderate-to-good discrimination. The LR[–] of 0.10 is clinically meaningful: a score below 12 substantially lowers the post-test probability of requiring surgery (Subbiah et al., 2021; Fahmi et al., 2022; Karjosukarso et al., 2019).

Table 2. Diagnostic accuracy of the Blunt Abdominal Trauma Severity Scoring System (BATSS) at the pre-specified cut-off of ≥ 12 for predicting the need for surgical intervention (n = 67).

Diagnostic metric	Value (95% CI)
Sensitivity	95.2% (77.3–99.2%)
Specificity	45.7% (32.2–59.8%)
Positive predictive value (PPV)	44.4% (30.9–58.8%)
Negative predictive value (NPV)	95.5% (78.2–99.2%)
Positive likelihood ratio (LR ⁺)	1.75
Negative likelihood ratio (LR [–])	0.10
Area under the ROC curve (AUC)	0.71 (0.58–0.84)

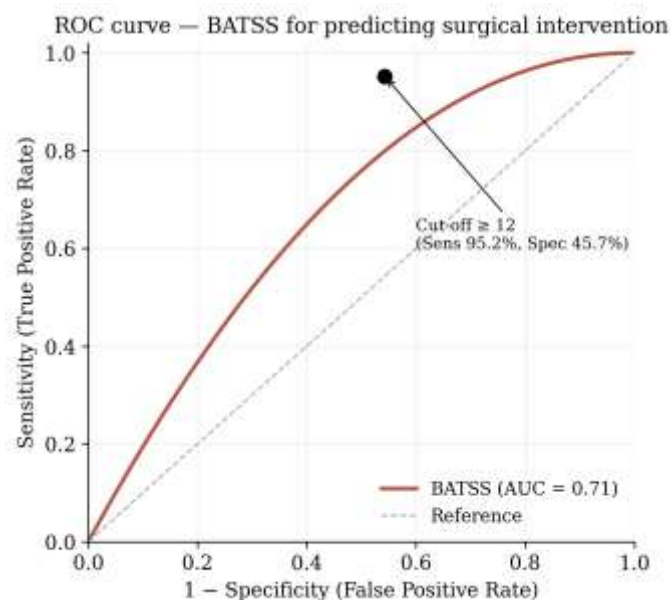


Figure 9. Receiver-operating-characteristic (ROC) curve for BATSS predicting the need for surgical intervention. Area under the curve (AUC) = 0.71 (95% CI 0.58–0.84).

3.8 Clinical outcomes and hospital stay

Three patients died during admission, giving an in-hospital mortality of 4.5% (3/67), one from each risk category. All three deaths occurred in patients managed non-operatively. The mean hospital stay was 9.8 ± 6.5 days (high risk), 4.6 ± 1.8 days

(moderate risk) and 6.5 ± 4.1 days (low risk). Seven patients were discharged against medical advice (DAMA); 57 were formally discharged.

4. DISCUSSION

This prospective study evaluated whether a simple bedside score, calculated within minutes of presentation, can reliably identify blunt abdominal trauma patients requiring surgery. At the pre-specified cut-off of ≥ 12 , BATSS demonstrated sensitivity of 95.2% and NPV of 95.5%, meaning only one of 22 patients scoring below the threshold ultimately required operative intervention. The AUC of 0.71 is comparable to or exceeds performance reported in prior BATSS validations (Subbiah et al., 2021; Fahmi et al., 2022; Karjosukarso et al., 2019).

The demographic and epidemiological profile of our cohort reflects urban Indian trauma. A male-to-female ratio of 4.6:1 and mean age of 31.7 years are consistent with the broader Indian trauma literature (Mehta et al., 2014; Reddy et al., 2014; Behboodi et al., 2016), and motorcycle-related mechanisms accounting for 56.7% of cases mirror patterns documented by Chaudhary et al. (2005) and Shetty et al. (2012). Two-wheeler riders sustain high-energy direct abdominal impacts with less structural protection than car occupants, which likely contributes to the high proportion (67.2%) of high-risk BATSS scores in our cohort.

The performance of FAST warrants specific discussion. FAST positivity in 100% of high-risk patients and negativity in 100% of low-risk patients directly reflects the dominant eight-point weighting that FAST carries within BATSS; a FAST score alone of 8 places a patient at the cusp of the high-risk threshold. Fox et al. (2011) demonstrated that a positive FAST is among the strongest predictors of significant intra-abdominal injury, and our data strongly support this conclusion. The findings are consistent with those of Subbiah et al. (2021) and the broader FAST literature (Kelley et al., 2014).

The single false-negative case — a patient with isolated colon injury, BATSS score = 0, negative FAST and stable haemodynamics — is clinically instructive. Hollow viscus injuries are a recognised Achilles heel of FAST-based and clinically based scoring systems: free peritoneal fluid may be absent early and symptoms delayed (Shojaee et al., 2014). This does not undermine overall BATSS performance but underscores the need for clinical vigilance and serial reassessment in patients with high-energy mechanisms who score low.

Comparison with prior BATSS validations places our results in context. Fahmi et al. (2022) reported sensitivity of 99.3% in their Egyptian cohort, and Karjosukarso et al. (2019) achieved 91.4% sensitivity and 77.8% specificity. Our sensitivity of 95.2% falls within this range, while our lower specificity (45.7%) is partly explained by the very high proportion (67.2%) of high-risk patients in our cohort, which mathematically compresses specificity at a fixed threshold.

The combination of high sensitivity and high NPV suggests BATSS is best understood as a rule-out instrument: a score below 12 is associated with a very low likelihood of requiring surgery ($LR- = 0.10$), making it useful for safely identifying patients who can be observed, spared from CT radiation, and managed with lower resource intensity. The high-risk designation, with a PPV of only 44.4%, should not be treated as an operative mandate — it should trigger further evaluation.

The construct validity of the scoring system is further supported by the CT organ injury distribution. Splenic and hepatic injuries were heavily concentrated in the high-risk group (75.0% and 73.3% respectively), and six of seven multi-organ injury patients were high risk.

4.1 Limitations

Several limitations warrant acknowledgement. This was a single-centre study at one tertiary teaching hospital, and findings may not generalise to rural emergency departments or hospitals with different trauma volumes and resource profiles. The inclusion criteria restricted enrolment to patients aged 18–50 years; findings cannot be extrapolated to paediatric or elderly populations. Six enrolled patients had ages exceeding 50 years at presentation; their inclusion following institutional review did not materially alter the primary diagnostic accuracy metrics. Inter-rater reliability for the subjective BATSS components (abdominal pain, tenderness, chest wall signs) was not formally quantified. No comparator scoring system (e.g., Injury Severity Score, Revised Trauma Score) was included, limiting conclusions about incremental value. The sample size, while adequate for the primary analysis, constrains meaningful subgroup analyses. Follow-up was limited to in-hospital outcomes.

5. CONCLUSIONS

In this prospective cohort of 67 blunt abdominal trauma patients, BATSS demonstrated high sensitivity (95.2%) and NPV (95.5%) for identifying patients requiring surgical intervention at a cut-off score of ≥ 12 , with a clinically meaningful LR- of 0.10. These findings support BATSS as a useful bedside rule-out triage tool at first clinical contact, particularly in settings where CT is not immediately available. A high-risk designation should prompt further evaluation rather than automatic surgery. FAST remains the single most powerful component. Prospective multicentre validation of BATSS across diverse Indian and global trauma settings, with attention to inter-rater reliability and comparison with established trauma scores, is encouraged.

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Author contributions

MN: Conceptualisation, data curation, methodology, formal analysis, investigation, writing – original draft. MK: Conceptualisation, methodology, supervision, writing – review and editing. APK: Methodology, supervision, validation, writing – review and editing. All authors read and approved the final manuscript.

Conflict of interest

The authors declare no conflict of interest.

Ethics statement

The study protocol was reviewed and approved by the Institutional Ethics Committee of M. S. Ramaiah Medical College and Hospitals, Bengaluru, Karnataka, India. Written informed consent was obtained from all enrolled participants or from their legal next of kin where the participant was unable to provide consent at presentation. All procedures were conducted in accordance with the Declaration of Helsinki.

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