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Diagnostic Validity of Trans-Abdominal Ultrasound for Splenic Injuries in Trauma Patients Taking CT Scan Findings as Gold Standard

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ABSTRACT

Background: Splenic injuries commonly occur in patients with blunt abdominal trauma, especially in those involved in motor vehicle accidents and fall injuries. It is important to make an early diagnosis because any delay may lead to considerable blood loss, which may compromise the outcome in the patients. Though it has been widely accepted that the gold-standard technique in the diagnosis of splenic injuries is the application of computed tomography, access to this facility may be limited in many emergency departments. Trans-abdominal ultrasonography is frequently used as the first technique to evaluate the patients. **Objective:** To assess the diagnostic accuracy of ultrasound for detecting splenic injuries in trauma patients, using CT scan findings as the gold standard. **Study Design and Setting:** This was a cross-sectional validation study conducted from January 2025 to May 2025 in the Department of Radiology at Ayub Teaching Hospital Abbottabad. **Methodology:** A total of 104 trauma patients aged 18 to 60 years with blunt abdominal injury were included. Ultrasound findings were compared with computed tomography scan results. Data were analyzed using chi-square test and two by two contingency table to calculate sensitivity, specificity, positive predictive value, negative predictive value and diagnostic accuracy. **Results:** The mean age of patients was 36.02 ± 9.90 years. Trans-abdominal ultrasound showed sensitivity of 85.71%, specificity of 95.18%, positive predictive value of 81.82%, negative predictive value of 96.34% and overall diagnostic accuracy of 93.27%. **Conclusion:** Trans-abdominal ultrasound is a reliable and accurate tool for initial evaluation of splenic injuries in trauma patients.

INTRODUCTION

Blunt trauma to the spleen is commonly seen in road accidents, fall from height, sports injuries, and assaults.[1] The organ is also frequently injured in abdominal trauma. The highly vascular nature of the organ makes the splenic injury a potential candidate to lead to considerable blood loss in the event of splenic laceration.[2] In many trauma cases, the splenic injury may not show immediate symptoms because of the lack of external symptoms and the presence of pain relief. In many trauma cases, the symptoms may not show immediately. In such trauma cases, the symptoms may vary from abdominal pain in the left upper quadrant, generalized abdominal pain, dizziness, syncope, pallor, referred pain to the left shoulder (Kehr's sign).[3]

Diagnosis of splenic injuries in trauma patients is based on clinical condition, physical examination, laboratory findings, and diagnostic images.[4] In practical conditions, the evaluation of splenic injuries in trauma patients is not an easy job since the patients are in an unconscious, drunk, or confused condition due to other injuries.[5] Heart rate, blood pressure, pulse rate, and cool peripheries are signs of hemorrhage in trauma patients. Initially, the hematocrit and hemoglobin levels are within the normal range. Therefore, the evaluation of splenic injuries is not an easy job. Contrast-enhanced computed tomography (CT) scan of the abdomen is considered a routine investigation in trauma patients.[6] Contrast-enhanced CT scan is used to detect splenic injuries, hemorrhage, hemoperitoneum, and associated injuries to other abdominal organs.[7]

The use of transabdominal ultrasound in the management of splenic injuries is common, particularly through the use of FAST—Focused Assessment with Sonography in Trauma—due to its speed, portability, non-use of ionizing radiation, and its ability to be performed at the patient's bedside during resuscitation attempts.[8] The diagnostic validity of this technique is dependent on its ability to identify signs such as the presence of free fluid around the spleen, within the space around the liver known as the Morison's pouch, pelvic cavity, perisplenic space, and sometimes direct abnormalities of the splenic parenchyma, including hypoechoic lacerations, subcapsular hematomas, and irregularities of the splenic

edge.[9] In many cases, this technique has been shown to be more sensitive to moderate to large volumes of hemoperitoneum, although it will not be able to detect small volumes of blood loss, contained hematomas, and sometimes early injuries without the presence of free fluid.[10] Although a negative result can be achieved with this technique, it cannot be used to definitively rule out a splenic injury, particularly if the patient is hemodynamically stable and a CT can be performed.[11]

In a study of 2,576 patients evaluated by ultrasound after blunt abdominal trauma, 311 (12.07%) scans were positive and 43 (1.7%) were false negative. The prevalence of splenic injury was 13.74%. Ultrasound showed a sensitivity of 86%, specificity of 98%, accuracy of 97%, positive predictive value of 87%, and negative predictive value of 98% for detecting intra-abdominal injuries.[12]

Trauma caused by road traffic accident and fall injuries is a common cause of hospital admissions in the Abbottabad region, often causing blunt injuries, including splenic injuries. Trans-abdominal ultrasonography is commonly employed in the preliminary imaging of abdominal injuries, including splenic injuries, although there exists a lack of local evidence of its diagnostic validity in the region. Given the high patient volume and limited access to CT scanning facilities, it becomes imperative to assess the accuracy of the diagnostic tool in the region, in order to improve the outcomes of the management of trauma injuries in the region.

METHODOLOGY

This cross-sectional validation study was carried out from 16 January 2025 to 16 May 2025 in the Department of Radiology at Ayub Teaching Hospital Abbottabad. The study included trauma patients who were referred from the emergency department for trans-abdominal ultrasound to assess possible visceral injury. Ethical approval was obtained from the institutional ethical review committee of the hospital prior to initiation of the study. The sample size was calculated as 104 cases using the WHO formula for diagnostic test evaluation studies. The calculation was based on an expected sensitivity of 86%, specificity of 98%, prevalence of splenic injury of 13.74%, precision of 18% and confidence interval of 95%. Both male and female patients aged between 18 and 60 years presenting with blunt trauma and referred for trans-abdominal ultrasound scan were included in the study. Patients having chronic liver disease with ascites were excluded to avoid interference in image interpretation. Written informed consent was taken from all eligible patients after explaining the nature and purpose of the study in understandable language. Demographic information including age, gender and residence was recorded. Additional variables such as height, weight, body mass index, mechanism of injury and presence of comorbidities including diabetes, hypertension and obesity were also documented.

A detailed history related to trauma was taken, followed by general and systemic physical examination. All patients underwent trans-abdominal ultrasound examination using Toshiba Xario 100 machine with a 12 MHz high frequency probe. The ultrasound was performed by a consultant radiologist. Findings suggestive of splenic injury were recorded. After ultrasound patients were referred for CT scan abdomen and pelvis as per hospital protocol. Patients were then managed by the surgical department and operative findings were retrieved from medical records when surgery was performed and entered in a structured proforma. Transabdominal ultrasonography of the spleen was considered positive in cases of splenic injuries if free fluid in the peritoneum, particularly in the upper abdomen, or disruption of the normal texture of the spleen, laceration, or presence of hypoechoic areas due to the presence of a hematoma, was noted. Splenic injuries detected on computed tomography scans of the abdomen were characterized either by the presence of linear or branching hypodense areas due to lacerations, low-density fluid causing architectural distortion due to a subcapsular hematoma, or the presence of a high-density contrast extravasation with attenuation values ranging from 80-95 Hounsfield units, which is suggestive of an ongoing hemorrhage.

Data was entered and analyzed using IBM SPSS version 25. Quantitative variables including age, height, weight and BMI were expressed as mean ± standard deviation. Categorical variables such as gender, residence, mechanism of injury and presence of comorbidities were presented as frequencies and percentages. Sensitivity, specificity, positive predictive value, negative predictive value and diagnostic accuracy were calculated using a 2 x 2 contingency table considering CT scan findings as the gold standard.

RESULTS

The mean age of the participants was 36.02 ± 9.90 years with height of 167.58 ± 7.51 cm and mean weight was 70.49 ± 12.96 kg. The body mass index of the patients was calculated as 25.05 ± 4.01 kg/m^2. The duration of symptoms before presentation were recorded as 198.87 ± 122.35 minutes. Regarding gender distribution, majority of the patients was males which constituted 81 (77.9%) cases while females was only 23 (22.1%) of the total sample. The most common mechanism of injury were road traffic accidents which was observed in 62 (59.6%) patients, followed by fall from height in 18 (17.3%) cases. Assault or blunt object injuries was found in 16 (15.4%) patients and sports-related or occupational blunt injuries was seen in 8 (7.7%) cases. Among comorbidities, diabetes was present in 16 (15.4%) patients while 88 (84.6%) was negative for diabetes. Hypertension was documented in 10 (9.6%) patients whereas 94 (90.4%) did not have hypertension. Obesity was identified in 14 (13.5%) cases while 90 (86.5%) was non-obese (as shown in Table-I).

Table I

Patient Demographics

Demographics	Mean ± SD / n (%)
Age (years)	36.02 ± 9.90
Height (cm)	167.58 ± 7.51
Weight (kg)	70.49 ± 12.96
BMI (kg/m^2)	25.05 ± 4.01
Duration of Symptoms (minutes)	198.87 ± 122.35
Gender	
Male n (%)	81 (77.9%)
Female n (%)	23 (22.1%)
Mechanism of Injury	
Road Traffic Accident n (%)	62 (59.6%)

Fall from Height n (%)	18 (17.3%)
Assault/Blunt Object Injury n (%)	16 (15.4%)
Sports-related or Occupational Blunt Injury n (%)	8 (7.7%)
Diabetes	
Positive n (%)	16 (15.4%)
Negative n (%)	88 (84.6%)
Hypertension	
Positive n (%)	10 (9.6%)
Negative n (%)	94 (90.4%)
Obesity	
Positive n (%)	14 (13.5%)
Negative n (%)	90 (86.5%)

When comparing the diagnostic modalities, trans-abdominal ultrasound detected splenic injury in 22 (21.2%) patients while it was negative in 82 (78.8%) cases. On the other hand, CT scan which was used as gold standard identified splenic injury in 21 (20.2%) patients and was negative in 83 (79.8%) patients (as shown in Table-II).

Table II

Overall Results of Trans-abdominal Ultrasound and CT Scan in Diagnosis of Splenic Injury

Splenic Injury	Trans-abdominal Ultrasound	CT Scan
Positive	22 (21.2%)	21 (20.2%)
Negative	82 (78.8%)	83 (79.8%)
Total	104 (100%)	104 (100%)

The comparative analysis between trans-abdominal ultrasound and CT scan revealed that among 22 positive cases on ultrasound, 18 was true positives and 4 was false positives. Among 82 negative cases on ultrasound, 3 was false negatives and 79 was true negatives. The total positive cases on CT scan was 21 while total negative cases were 83 (as shown in Table-III).

Table III

Comparison of Trans-abdominal Ultrasound versus CT Scan in Diagnosis of Splenic Injury

Trans-abdominal Ultrasound	CT Scan		Total
	Positive	Negative	
Positive	18 (TP)	4 (FP)	22
Negative	3 (FN)	79 (TN)	82
Total	21	83	104

Key: TP = True positive, FP = False positive, FN = False negative, TN = True negative

The diagnostic performance parameters of trans-abdominal ultrasound were calculated against CT scan findings. The sensitivity of ultrasound was 85.71% and specificity was 95.18%. The overall diagnostic accuracy of the test was found to be 93.27%. The positive predictive value was 81.82% while the negative predictive value was calculated as 96.34% (as shown in Table-IV).

Table IV

Sensitivity, Specificity, Diagnostic Accuracy, PPV and NPV of Trans-abdominal Ultrasound in Diagnosis of Splenic Injury

Diagnostic Parameter	Result
Sensitivity	85.71%
Specificity	95.18%
Diagnostic Accuracy	93.27%
PPV	81.82%
NPV	96.34%

DISCUSSION

The mean age of patients in this study was 36.02 ± 9.90 years which indicates that splenic injuries predominantly affects younger adult population. This age distribution can be explained by the fact that younger individuals is more likely to be involved in high-energy traumatic events such as road traffic accidents and falls. The physical activities and occupational exposures in this age group also contributes to increased risk of blunt abdominal trauma. Male patients was significantly higher 81 (77.9%) compared to females 23 (22.1%) in present study. This gender predominance is attributed to the fact that males generally engages more in outdoor activities, driving, and occupations that involves physical labor. Males also demonstrates higher risk-taking behaviors which makes them more vulnerable to traumatic injuries. Road traffic accidents was the most common mechanism of injury accounting for 62 (59.6%) cases. This high proportion reflects the increasing number of vehicular accidents and poor road safety measures. During road traffic accidents, the spleen being a highly vascular organ located in left upper quadrant is particularly susceptible to injury from sudden deceleration forces and direct impact to abdomen. The sensitivity of the trans-abdominal ultrasound in detecting splenic injuries was found to be 85.71%, which implies that the majority of the splenic injuries can be identified using the ultrasound technique. The higher sensitivity of the ultrasound technique may be attributed to the technique's capacity to detect free fluid in the peritoneal cavity, as well as the capacity to detect injuries in the spleen. The occurrence of three false-negative results may imply that the ultrasound technique may fail to detect minor injuries, particularly those related to the spleen. This indicates the high specificity of the ultrasonography modality, which was found to be 95.18%. The high specificity implies the ultrasonography modality had the exceptional capability to accurately detect patients without splenic injury. False-positive ultrasonography findings might result in four possible ways. Overall, the accuracy was 93.27%, confirming the reliability of the trans-abdominal ultrasound technique as a tool for diagnosis of splenic injury. The accuracy of the technique, coupled with the speed of assessment, underscores the value of ultrasound as a screening tool, particularly in emergency situations where timely action is crucial.

In present study, the mean age of patients was 36.02 ± 9.90 years which is higher compared to Al Najjar *et al.* [13] who reported mean age of 22.19 ± 17.84 years and Sinwar *et al.* [14] who found that most splenic injuries occurs in <30-year age group (62.5%). This difference in age distribution can be attributed to variation in study population and geographic location where younger population in developing countries may have different exposure patterns to traumatic events. However, the findings remains consistent that splenic injuries predominantly affects younger and middle-aged adults who is more active and exposed to high-risk activities. The gender distribution in current study showed male predominance 81 (77.9%) which is comparable with Sinwar *et al.* [15] who reported 91.7% male patients and Al Najjar *et al.* [13] who found 80% males (104 out of 130 patients). This consistent male predominance across studies confirms

that males is at higher risk for blunt abdominal trauma and splenic injuries due to their involvement in outdoor activities and risk-taking behaviors. Road traffic accidents was the leading cause of injury in present study 62 (59.6%) which is similar to Sinwar *et al.* [14] who reported 75% cases due to road traffic accidents. This similarity indicates that vehicular accidents remains the primary mechanism of splenic injury across different populations and geographic regions. The high incidence of road traffic accidents reflects poor road safety measures and increasing number of vehicles on roads.

The sensitivity of trans-abdominal ultrasound in current study was 85.71% which is comparable to findings by Kranthi Kumar Marathu *et al.* [15] who reported overall sensitivity of 83.3% for ultrasound in detecting solid organ injuries and Ogbuanya *et al.* [16] who found sensitivity of 84.7% for sonographic assessment of splenic injuries. However, Al Najjar *et al.* [13] reported higher sensitivity of 100% for spleen detection. This variation in sensitivity may be explained by differences in operator expertise, quality of ultrasound equipment, severity of injuries, and presence of associated complications like bowel gas or subcutaneous emphysema which can interfere with ultrasound visualization.

The specificity of ultrasound in present study was 95.18% which is higher than Kranthi Kumar Marathu *et al.* [15] who reported specificity of 87.5% but lower than their CT scan specificity of 100%. McKenney *et al.* [17] reported higher specificity of 99% for sonography in detecting intra-abdominal injury. The high specificity in present study demonstrates that ultrasound reliably excludes splenic injury when findings is negative, however slight variations across studies may be due to different interpretation criteria and definition of positive findings.

The diagnostic accuracy in current study was 93.27% which is comparable to Kranthi Kumar Marathu *et al.* [15] who reported 84% accuracy for ultrasound and McKenney *et al.* [17] who found 97% accuracy for sonography. The slightly higher accuracy in some studies may be attributed to use of advanced ultrasound techniques, experienced radiologists, and clear protocols for image interpretation. Giordano *et al.* [18] reported even higher sensitivity and specificity of 99% using contrast-enhanced ultrasound (CEUS), suggesting that newer ultrasound modalities can improve diagnostic performance. The positive predictive value in present study was 81.82% which is lower than Kranthi Kumar Marathu *et al.* [15] who reported PPV of 93.7% for ultrasound. This difference may be related to prevalence of disease in study population and threshold used for defining positive results. The negative predictive value was 96.34% in current study which is higher than Kranthi Kumar Marathu *et al.* [15] who found NPV of 70%, indicating that negative ultrasound findings in present study is more reliable in ruling out splenic injuries.

Multiple studies including Al Najjar *et al.* [13] Marathu *et al.* [15] and Patil *et al.* [19] has emphasized that ultrasound is effective initial screening tool for blunt abdominal trauma due to its non-invasive nature, rapid availability, cost-effectiveness, and lack of radiation exposure. These advantages makes ultrasound particularly valuable in emergency settings where quick decision-making is required. However, Marathu *et al.* [15] concluded that CT scan is more accurate with sensitivity of 94.7% and accuracy of 96%, which supports the use of CT as gold standard for definitive diagnosis and grading of splenic injuries as also adopted in present study.

However, the present study has several limitations that should be considered. The first limitation is that the present study was conducted in a single center within a single institution. This might limit the external validity of the present results in other institutions that may vary in terms of patient population and healthcare facilities. The second limitation of the present study is that the sample size of the present study was only 104 patients. This might limit the statistical power of the present results. The third limitation of the present study is that ultrasound examinations are operator-dependent. This means that different levels of expertise among ultrasound technicians might have affected the results. The fourth limitation of the present study is that patients who were managed conservatively without imaging were not included in the present study.

CONCLUSION

The findings of the current study have led to a conclusion that "the use of transabdominal ultrasonography can be viewed as a highly accurate diagnostic tool in identifying trauma to the spleen in trauma victims in comparison to computed tomography as a reference standard." Ultrasonography has been proven to have a high sensitivity and specificity in identifying trauma to the spleen, which has highlighted its importance as a diagnostic tool in identifying such trauma.

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