Original Article

Multimodality imaging approach to blunt abdominal trauma in a tertiary care center in North India

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Abstract

Background: Evaluating patients who have sustained blunt abdominal trauma (BAT) remains one of the most challenging and resource-intensive aspects of acute trauma care. This study was conducted to evaluate the correlation of ultrasonography (USG) and computed tomography (CT) in detecting the visceral injuries with the assessment of their diagnostic indices. X-ray was done in cases of suspected bowel injuries.

Materials and Methods: This prospective cross-sectional study was conducted in the Department of Radiodiagnosis, Imaging and Interventional Radiology, at CSS Hospital, Subharti Medical College, Meerut, Uttar Pradesh, India, for 2 years. Eighty-two patients of BAT were evaluated using investigations such as X-ray (wherever required), USG, and CT scan during the study.

Results: Majority of the patients were from the age group of 21 to 40 years with predominance of male (69.5%). Hemoperitoneum associated with visceral injuries were the major findings detected by both USG (70.7%) and CT (81.7%). Sensitivities of USG for the detection of spleen, liver, kidney, and pancreatic injuries were 95%, 94%, 66.6%, and 40%, respectively, while the sensitivity of CT for the detection of liver, spleen, kidney, and pancreas was 100%.

Conclusion: CT is highly sensitive, specific, and accurate in detecting the presence or absence of injury in BAT and defining its extent. However, USG still remains the initial investigation of choice.

Keywords: Blunt abdominal trauma, computed tomography, ultrasonography

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INTRODUCTION

Abdominal trauma contributes to 10% of overall trauma mortality and morbidity. It could be blunt or penetrating. Blunt trauma occurs in approximately two-third of abdominal injury patients.[1] Assessing patients of blunt abdominal trauma (BAT) remains one of the most challenging and tools-intensive aspects of trauma care.

Ultrasonography (USG) is the preliminary investigation of choice in the assessment of BAT. USG in the form of focused assessment with sonography for trauma (FAST) is highly sensitive for the identification of free intraperitoneal fluid, though it is operator dependent and lacks specificity with high false-negative results and uncertain sensitivities.[2]

However, for stable trauma patients, computed tomography (CT) has become the definitive imaging modality of choice. The radiological images may help to quantitate the sum of blood in the abdomen and can reveal injuries to individual organs with precision.[3]

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The present study is planned to evaluate the role of imaging modalities in the evaluation of BAT and to access their diagnostic indices.

MATERIALS AND METHODS

This observational study was carried out on 82 patients of BAT of all ages meeting the inclusion criteria who visited to the Department of Radiodiagnosis under the aegis of N. S. C. B. Subharti Medical College, Meerut, Uttar Pradesh, India. Informed consent was obtained from all patients before the patient was subjected for evaluation.

Inclusion criteria

Patients with a clinically suspected BAT were included in the study.

Exclusion criteria

Patients who had been previously investigated or explored and managed, pregnant women, and hemodynamically unstable patients were excluded from the study.

Study design

Study design was prospective cross-sectional study. Eighty-two patients fulfilled the criteria and their detailed history and physical examinations were performed and recorded on predesigned patient pro forma.

Radiological examinations

All 82 patients were subjected to imaging modality for the confirmation of diagnosis. Plain X-ray of the abdomen, if required was performed. USG/FAST scanning was performed using SAMSUNG MEDISON USG Accuvix 30 unit. Noncontrast and contrast-enhanced CT scan was performed and axial sections were taken. Coronal and sagittal reformatting was done with the help of multidetector CT (MDCT): Philips ingenuity core-128 slice.

Computed tomography technique

All examinations were done on MDCT with patients in supine position. Noncontrast followed by contrast studies were done using arterial, venous, and delayed phases.

Ultrasonography technique

The referred patient was taken for USG examination, done with patient lying in supine position. Examinations were performed using 3.5 MHz convex probe or if required high frequency 7.5 MHz linear probe is used.

FAST scans involve scanning for free fluid in perihepatic space, perisplenic space, pericardium, and pelvis. Extended FAST allows examination of the lungs for pneumothorax.

Statistical analysis

Data were analyzed using the Statistical Package for the Social Sciences, version 23 (SPSS Inc., Chicago, IL, USA). Results for continuous variables were recorded as a mean ± standard deviation, whereas results for categorical variables were recorded as number (percentage). The level $P < 0.05$ was considered as the cutoff value for statistical significance. True positive, false negative, true negative, and false positive were calculated from comparing the results of the modalities (USG and CT) with surgical findings. The severity of visceral injuries was graded on CT using the American Association for the Surgery of Trauma (AAST).

RESULTS

Majority of patients were in the age group of 21–40 years (53.6%), and 69.5% were male in our study [Table 1].

The most common symptoms were abdominal pain observed in 85.3% of the studied patients, followed by abdominal distension (76.8%), chest pain (36.5%), and vomiting (34%). The most common signs were abdominal tenderness (79.2%) and guarding-rigidity (48.7%).

Road traffic accident (RTA) (50%) was the most common mode of injury followed by fall from height (29.3%) [Table 1]. Of the studied patients, 36.5% were anemic (hemoglobin <12 mg/dl) and 63.5% were normal [Table 1].

Hemoperitoneum with visceral injury (solid organ, hollow viscus, and mesentery) were detected by USG in 70.7% cases and by CT in 81.7% cases, only visceral injury without hemoperitoneum in 12.2% cases in each, only hemoperitoneum was detected in 13.4% cases on USG and in 2.4% cases on CT, and 3.7% patients were normal on both CT and USG.

Table 1: Demographic profile of studied patients

	Frequency (*n*=82), *n* (%)
Age (years)	
<20	25 (30.5)
21-40	44 (53.6)
40-60	13 (15.9)
Gender	
Male	57 (69.5)
Female	25 (30.5)
Mode of abdominal injury	
RTA	41 (50.0)
Physical violence	11 (13.4)
Fall from height	24 (29.3)
Others	6 (7.3)
Anemia (mg/dl)	
Anemia (Hb <12)	30 (36.5)
Normal (Hb >12)	52 (63.5)

Hb – Hemoglobin; RTA – Road traffic accident

The most frequently injured organ was the spleen (54.8%), followed by the liver (37.8%) and kidney (11%) [Figure 1], and the least injured organs were the diaphragm (1.2%) and adrenal glands (1.2%). In 73% cases, single organ was injured, whereas in 23% cases, polytrauma was detected. According to the AAST injury scale, majority in liver, spleen injuries were of grade 3 severity [Figure 2], pancreatic injuries were of Grade 4 severity [Figure 3], renal injuries were of Grade 2 severity and urinary bladder injuries were also of grade 3 severity [Figures 4 and 5]. The most common associated injury was rib fracture (18.2%) followed by lung injury (12.1%). Of all studied patients, 50% were conservatively managed and the remaining 50% required surgery.

Sensitivity, specificity, and diagnostic accuracy of USG were 62.5%, 75%, and 63.3%, respectively, whereas CT was 92.6% sensitive, 100% specific, and 93% accurate in detecting all solid injuries.

On the basis of inter-rater agreement (kappa value) between USG and surgical management, 100% findings were positive for liver and it was found statistically highly-significant association among them ($P < 0.001$). Similarly, 70.3%, 92.1%, 54.2%, and 70.1% findings were positive for kidney, spleen, pancreas, and urinary bladder injuries, respectively, and it was found statistically highly significant ($P < 0.001$) association between USG and surgery [Table 2].

However, for CT and surgical management, all each 100% findings were positive for liver, kidney, spleen, pancreas, and urinary bladder injuries, respectively. All inter-rater agreement between USG and CT findings with surgical management was found to be statistically highly significant ($P < 0.001$) [Table 2].

Sensitivities of USG for the detection of spleen, liver, kidney, pancreatic, urinary bladder, and bowel injuries were 95%, 94%, 66.6%, 40%, 40%, and 0%, respectively. Sensitivity of CT for the detection of liver, spleen, kidney, pancreas, and urinary bladder was 100% and for bowel injuries was 66.6%. Sensitivity for the detection of mesentery was 0% on both USG and CT.

DISCUSSION

Abdominal trauma is a common cause of mortality and morbidity and thereby requires prompt imaging and intervention.

The demographic profile of the patients in our study was in accordance with the study done by Suman *et al*.[4] and Kumar *et al*.,[5] Maske and Deshmukh,[6] Mukhopadhyay,[7] Shah *et al*.,[8] and Enderson *et al*.,[9] which also concluded that

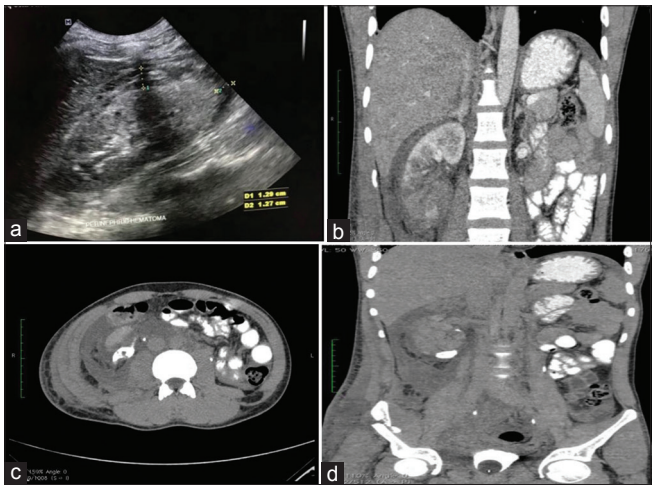

Figure 1: (a) Ultrasonography image shows contusion of lower pole of the right kidney with surrounding perinephric hematoma. (b) Coronal contrast-enhanced computed tomography shows laceration-contusion complex in the lower pole of the right kidney with perinephric hematoma. (c) Delayed axial contrast-enhanced computed tomography shows focal area of contrast extravasation adjacent to lower pole calyx of the right kidney suggestive of focal rupture of pelvicalcyeal system laceration-contusion injury with contrast extravasation. (Grade IV according to the American Association for the Surgery of Trauma grading). (d) Delayed coronal contrast-enhanced computed tomography shows focal area of contrast extravasation adjacent to lower pole calyx of the right kidney suggestive of focal rupture of pelvicalcyeal system laceration-contusion injury with contrast extravasation. (Grade IV according to the American Association for the Surgery of Trauma grading)

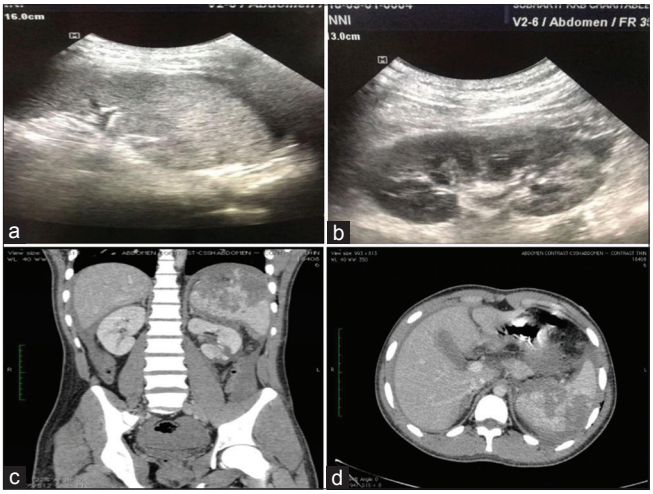

Figure 2: (a) Ultrasonography shows large laceration contusion complex in the superior medial aspect of the spleen with adjacent perisplenic hematoma. (b) Ultrasonography image shows contusion of lower pole of the left kidney with adjacent minimal perinephric fluid. (c) Coronal contrast-enhanced computed tomography image shows multiple lacerations involving lower and middle pole of the left kidney. On delayed scan, no contrast extravasation noted (Grade III according to the American Association for the Surgery of Trauma grading). (d) Axial contrast-enhanced computed tomography image shows a large nonenhancing laceration contusion complex involving middle and superior aspect of the spleen (Grade III according to the American Association for the Surgery of Trauma grading)

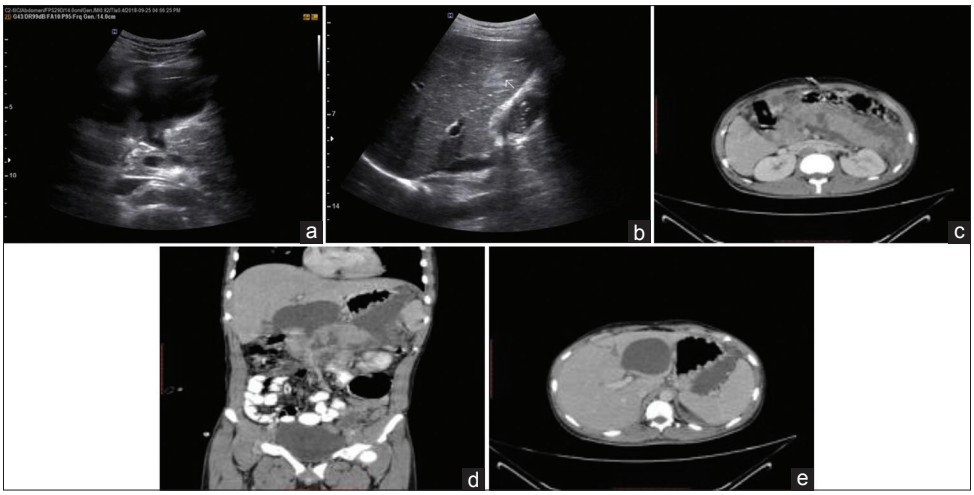

Figure 3: (a) Shows pancreatic transection through the entire thickness with suspected involvement of pancreatic duct and associated collection in lesser sac. (b) Ultrasonography shows associated laceration in the liver. (c) Axial contrast-enhanced computed tomography images show pancreatic transection with the involvement of pancreatic duct and associated peripancreatic fluid (Grade IV according to the American Association for the Surgery of Trauma grading). (d) Coronal contrast-enhanced computed tomography images show pancreatic transection with the involvement of pancreatic duct and associated peripancreatic fluid (Grade IV according to the American Association for the Surgery of Trauma grading). (e) Axial contrast-enhanced computed tomography shows associated laceration in segment V and collection in the lesser sac

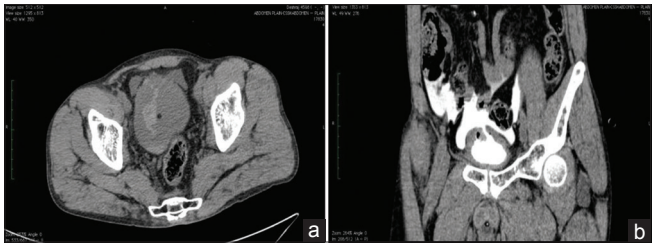

Figure 4: (a) Plain axial computed tomography scan shows hyperdense clot within the lumen. (b) Coronal contrast-enhanced computed tomography shows rent in the dome of bladder with contrast extravasation into the peritoneal cavity outlining bowel loops intraperitoneal rupture (Grade III according to the American Association for the Surgery of Trauma grading)

majority of patients were in the age group of 21–40 years with male preponderance. However, few studies like Gioffrè-Florio *et al*.[10] observed that geriatric patients are more prone to abdominal injury, with a definite female preponderance.

RTA (50%) was the most common mode of injury; since our hospital is located on a major highway, majority of cases were due to RTA. Maske and Deshmukh,[6] Shah *et al*.,[8] Kulkarni *et al*.,[11] and Nnamonu *et al*.[12] also concluded similar results.

The most common symptoms were abdominal pain (85.4%), abdominal distension (76.8%), chest pain (36.5%), and vomiting (34%). Abdominal tenderness (79.2%) was the most common sign followed by guarding-rigidity found in 49%. Mehta *et al*.,[13] Shah *et al*.,[8] Maske and Deshmukh,[6] and Panchal and Ramanuj[14] also concluded similar results in their studies.

In the present study, the spleen (54.8%) was the most injured organ, followed by the liver (37.8%) and kidney (11%), whereas the least organs affected were the diaphragm, mesentery, and adrenal glands with 1.2% each. Mehta *et al*.[13] in their study also observed that the spleen (51%) followed by the liver 25 (35%) were the most common organs affected. Similar findings were also reported by various national and international studies as conducted by Maske and Deshmukh,[6] Kulkarni *et al*.,[11] Srihari *et al*.,[15] Manohar and Ramanaiah,[16] and Awe and Am.[17] Although the spleen is relatively protected under the ribcage, injury due to rapid deceleration, such as occurs in motor vehicle crashes, direct blows to the abdomen in domestic violence, or leisure and play activities such as bicycling, frequently result in a variety of splenic injuries.

In the present study, 84% patients of organ injury were associated with hemoperitoneum and 16% were not associated with hemoperitoneum. Ku YK *et al*.[18] and Drasin *et al*.[19] reported their study that hemoperitoneum is commonly associated with organ injury. Soto and Anderson,[20] however, studied that small pockets of low-attenuation fluid can be found in 3%–5% of male blunt trauma patients; in the absence of any hollow and solid organ injury, these patients require close clinical observations and follow-up. In female patients of reproductive age group, isolated free fluid can be explained by normal menstrual cycle. Shanmuganathan *et al*.[21] studied 575 abdominal visceral injuries, in which no hemoperitoneum was observed in 157 (34%) of patients with abdominal visceral injuries.

Table 2: Inter-rater agreement between visceral injuries detected by ultrasonography and computed tomography with surgery

Visceral injuries	USG findings	CT findings	Surgery	USG and surgery		CT and surgery	
				Kappa %, *P*	Sensitivity (%)	Kappa %, *P*	Sensitivity (%)
Liver	17	17	17	100.0, <0.001	100	100.0, <0.001	100
Kidney	4	6	6	70.3, <0.001	72.6	100.0, <0.001	100
Spleen	21	22	22	92.1, <0.001	96.5	100.0, <0.001	100
Pancreas	2	5	5	54.2, <0.001	40.0	100.0, <0.001	100
Urinary bladder injury	2	5	5	70.1, <0.001	36.0	100.0, <0.001	100

USG – Ultrasonography; CT – Computed tomography

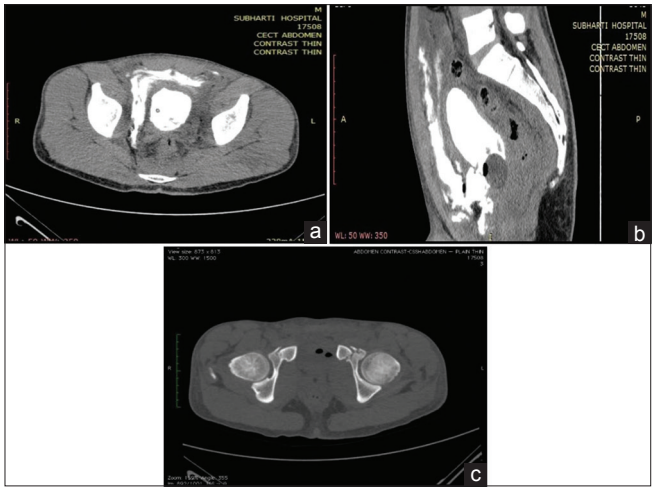

Figure 5: (a) Axial contrast-enhanced computed tomography shows discontinuity in the lower half of the anterior wall of the bladder with extravasation of the contrast in the prevesical space, anterior preperitoneal space extraperitoneal bladder rupture. (Grade III according to the American Association for the Surgery of Trauma grading). (b) Coronal contrast-enhanced computed tomography shows discontinuity in the lower half of the anterior wall of the bladder with extravasation of the contrast in the prevesical space, anterior preperitoneal space extraperitoneal bladder rupture. (Grade III according to the American Association for the Surgery of Trauma grading). (c) Axial computed tomography (bone window) shows associated bilateral pubic rami fractures

Fifty percent of patients were managed conservatively, whereas remaining 50% required surgical management. The management depends on the clinical and hemodynamic stability of the patient. Raza *et al*.[22] in their study concluded that nonoperative management for BAT injuries was found to be highly successful in 89.98% of the patients.

Sensitivity, specificity, and diagnostic accuracy of USG for detecting intraabdominal organ injury were 62.5%, 75%, and 63.3%, respectively, similar to studies conducted by Shah *et al*.[8] and Nnamonu *et al*.[12] CT was 92.6% sensitive, 100% specific, and 93% accurate in detecting all solid injuries similar to the studies conducted by Shah *et al*.[8] and Hamidi *et al*.[3]

Sensitivities of USG for the detection of liver, spleen, renal, pancreas, urinary bladder, and bowel injuries were 94%, 95%, 66.6%, 40%, 40%, and 0%, respectively. Ravindernath and Reddy[23] concluded lower sensitivity of USG due to overlying bowel gases, surgical emphysema, and empty bladder. Doody *et al*.[24] suggested that hematomas demonstrate echogenicity equal to or slightly greater than parenchyma and retain this appearance for approximately 48 h until lysis begins. The echogenic phase usually corresponds to the time when imaging is performed in most acute circumstances, and hence, early splenic injuries can be missed on USG. Körner *et al*.[25] studied pancreatic injuries are masked because of superimposed bowel gas. In the study by Shah *et al*.,[8] Grade 4 or higher pelvicalyceal injuries and ureteric injuires were not obvious on early scans without significant urinary leak. Mohammadi and Ghasemi-Rad[26] studied that bowel injuries are frequently missed, but repeat USG scans can facilitate its diagnosis. Sensitivity of CT for the detection of the liver, spleen, kidney, pancreas, and urinary bladder injuries was 100% and for bowel was 66.6%. Sensitivity for the detection of mesenteric injury was 0% on both USG and CT. Hamidi *et al*.[3] also observed that CT is notoriously inadequate for the diagnosis of mesenteric injuries and may also miss hollow visceral injuries. A negative CT scan in such a patient cannot reliably exclude intra-abdominal injuries. Salimi *et al*.[27] and Fakhry *et al*.[28] also showed similar results.

We thereby conclude that USG/FAST is a noninvasive, readily available method of detection of free fluid in a trauma patient and allows selection of patient for CT. Repeat USG can sometimes be beneficial for stable patients if findings were initially missed. CT is the initial examination of choice for hemodynamically stable patients because it is highly sensitive, specific, and accurate in detecting the presence and absence of injury and defining its extent.

CONCLUSION

CT is highly sensitive, specific and accurate in detecting pressence or absence of injury in BAT and defining its extent. However, USG still remeians the initial investigation of choice

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Nil.

Conflicts of interest

There are no conflicts of interest.

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