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Usefulness of ultrasonography in diagnosing abdominal trauma compared to computed tomography scan

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ABSTRACT

Background: Abdominal trauma following road traffic accident is a leading cause of morbidity and mortality among all age groups. Imaging such as ultrasonography (USG) and computed tomography (CT) scan plays a critical role in the evaluation of these patients. The accuracy of CT scan in hemodynamically stable blunt trauma patients has been well-established. **Aims and Objectives:** Assessment of usefulness of USG in diagnosing abdominal trauma with reference to involvement of different organs in terms of sensitivity, specificity, and predictive accuracy compared to CT scan. **Materials and Methods:** It is a hospital-based cross-sectional study was conducted on 87 patients in imaging and sonology room under the Department of Radiodiagnosis, Bankura Sammilani Medical College and Hospital, Bankura, West Bengal with a time frame of years. **Results:** In this study, the sensitivity of USG in detecting hemoperitoneum as compared to CT was found out to be 88.8%. USG had sensitivity – 79.3%, specificity – 98.2%, positive predictive value (PPV) – 95.8%, negative predictive value (NPV) – 90.4%, and predictive accuracy – 91.9% for splenic injury. For liver injury, USG had a sensitivity – 80%, specificity – 98.5%, PPV – 94.1 %, NPV – 94.2 %, and predictive accuracy – 94.25%. For renal injury, USG had sensitivity – 83.3%, specificity – 98.6%, PPV – 90.9%, NPV – 97.3%, and predictive accuracy – 96.5%. The sensitivity, specificity, PPV, NPV, and predictive accuracy of USG for pancreatic injury in comparison to CT were 100%. **Conclusion**: When the findings of abdominal injury on USG were compared to CT scan, which was taken to be the gold standard, it was observed that USG was fairly sensitive in detecting hemoperitoneum and solid organ injury (especially when the grades of injury was higher), but it showed less sensitivity in detecting lower grades of solid organ injuries and hollow visceral injuries (such as injury to the bowel and bladder). These cases, which were missed on USG were detected on CT scan and CT scan also helped in better grading of the visceral injuries. CT also helped in better detection of other associated findings such as pelvic fractures and pneumoperitoneum.

Key words: Abdominal trauma; Hemoperitoneum; Solid organ injury; Hollow visceral injury

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INTRODUCTION

Abdominal trauma is a leading cause of morbidity and mortality among all age groups. Blunt injury occurs most frequently with motor vehicle collisions.[1] Road traffic crashes kill 1.2 million people annually around the world, 90% of these days are in low- or middle-income countries.

Many of these patients have multisystem injuries resulting from high velocity mechanisms. Identification of serious intra-abdominal pathologies is often challenging. When assessing the status of an abdominal trauma patient on arrival to the emergency department, clinical history and physical examination are often unreliable and even misleading. Clinical diagnosis can be challenging due to lack of specific physical findings in many patients.[2]

Imaging plays a critical role in the evaluation of patients with blunt abdominal trauma (BAT). Computed tomography (CT) scan as the sole modality enables evaluation of

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other associated injuries in addition to global evaluation of abdominal trauma. Routine use of CT scan for the evaluation of BAT was not initially viewed with overwhelming enthusiasm. CT requires a cooperative, hemodynamically stable patient. In addition, the patient must be transported out of the trauma resuscitation area to the radiographic suite.

CT scanners are now available in most trauma centers, and with the advent of helical scanners, scan time has been significantly reduced. As a result, CT has become an accepted part of the traumatologist's armamentarium. In blunt injuries, the solid organs – spleen, kidney, and liver – are damaged most often, followed by the intestines.[3] No diagnostic modality outperforms CT in the evaluation of intraperitoneal as well as retroperitoneal injuries.[1]

The accuracy of CT scan in hemodynamically stable blunt trauma patients has been well-established. Sensitivity between 92% and 97.6% and specificity as high as 98.7% has been reported in patients subjected to emergency CT scan.[4,5]

Aims and objectives

General: Assessment of usefulness of USG in diagnosing abdominal trauma as an alternative of CT.

Specific:
1) To describe the sonological and CT findings among the patients sustaining abdominal trauma
2) To analyze sonographic and CT findings and their correlation.
3) To evaluate the efficacy of USG in diagnosing abdominal trauma with reference to involvement of different organs in terms of sensitivity, specificity and predictive accuracy compared to CT scan.

MATERIALS AND METHODS

The present study was a cross-sectional study conducted in imaging and sonology room under the Department of Radiodiagnosis, Bankura Sammilani Medical College and Hospital, Bankura, West Bengal with a time frame of 18 months from ethical approval.

Study population

All the patients referred to the department of radio diagnosis from department of surgery with the provisional diagnosis of abdominal injury in cases with history of trauma to the abdomen. Ultrasonography (USG) followed by CT scan was done in all the patients.

Sample size

Sample size for the proposed study was calculated based on the formulae used for evaluation study of a diagnostic test. It is $n=(Z^2\ sn[100-sn])/l^2p$

Putting these values n=87.

Inclusion criteria

The following criteria were included in the study:
1. All patients with abdominal trauma with provisional diagnosis of abdominal injury.
2. Cases are included irrespective of age and sex.
3. Penetrating abdominal injured patients.

Exclusion criteria

The following criteria were excluded from the study:
1. Pregnant women.
2. Psychiatric patients.
3. Patients who are in hypovolemic/hemorrhagic shock.
4. Patient with a previous known history of complication due to dye administration.

Statistical plan for data analysis

Data were tabulated in Microsoft Excel and were analyzed by appropriate statistical methods. Proportion and percentages will be used for categorical variables. Data display was done by tables and various charts. Sensitivity, specificity, and predictive values along with Kappa test were done. Statistical software like statistical package for Social Science (SPPSS) version 22 was utilized, when required.

RESULTS

Considering true positives – positive on both USG and CT, True negatives – negative on USG and CT, False negative – negative on USG but positive on CT, False positive – positive on USG but negative on CT, we got following results.

In our study of 87 patients, USG is found to be 88.8% sensitive and 96.9% specific for detecting hemoperitoneum. Positive predictive value (PPV), negative predictive value (NPV), and predictive accuracy are 97.87%, 84.2%, and 89.6%, as shown in Table 1.

For splenic injury, USG is found to be 79.3% sensitive and 98.2% specific. PPV, NPV, and predictive accuracy are

Table 1: USG versus CT in diagnosing hemoperitoneum

Total patients studied – 87			
USG	CT		
	Positive	Negative	Total
Positive (49)	48	1	
Negative (38)	6	32	
Total	54	33	87

True positives – 48, false positives – 1, true negatives – 32, false negatives – 6.
USG: Ultrasonography, CT: Computed tomography

95.8%, 90.4%, and 91.9%, as shown in Table 2.

In our study, USG is to be 80% sensitive and 98.5% specific for detecting liver injury. PPV, NPV, and predictive accuracy are as 94.1%, 94.2%, and 94.25%, as shown in Table 3.

As shown in Table 4, USG is found to be 83.3% sensitive and 98.6% specific for detecting renal injury. PPV, NPV, and predictive accuracy are as 90.9%, 97.3%, and 96.5%.

USG is found to be 100% sensitive and 100% specific for detecting pancreatic injury. PPV, NPV, and predictive accuracy are all of 100%, as shown in Table 5.

Table 2: USG versus CT in diagnosing splenic injury

Total patients studied – 87			
USG	CT		
	Positive	Negative	Total
Positive (24)	23	1	
Negative (63)	6	57	
Total	29	58	87

True positives – 23, false positives – 1, true negatives – 57, false negatives – 6.
USG: Ultrasonography, CT: Computed tomography

Table 3: USG versus CT in diagnosing hepatic injury

USG	CT		
	Positive	Negative	Total
Positive (17)	16	1	
Negative (70)	4	66	
Total	20	67	87

True positives – 16, false positives – 1, true negatives – 66, false negatives – 4.
USG: Ultrasonography, CT: Computed tomography

Table 4: USG versus CT in diagnosing renal injury

Total patients studied – 87			
USG	CT		
	Positive	Negative	Total
Positive (11)	10	1	
Negative (76)	2	74	
Total	12	75	87

True positives – 10, false positives – 1, true negatives – 74, false negatives – 2.
USG: Ultrasonography, CT: Computed tomography

Table 5: USG versus CT in diagnosing pancreatic injury

Total patients studied – 87			
USG	CT		
	Positive	Negative	
Positive (1)	1	0	
Negative (86)	0	86	
Total	1	86	87

True positive – 1, true negative – 86, false positive – 0, false negative – 0.
USG: Ultrasonography, CT: Computed tomography

Three cases of bladder injuries were detected on CT, while none of these bladder injuries were detected on USG.

Four cases of bowel injury were detected in this study and all of them were detected on CT scan and none were detected on USG.

DISCUSSION

In recent years, CT and USG have replaced all other modalities of investigation up to a great extent. USG was done in all patients, followed by a CT examination and the time gap between the two examinations was tried to be kept to a minimum as far as possible.

In this study, splenic trauma was the most common injury detected on both USG and CT; this is in accordance with standard surgical description of more common splenic injuries. Pancreatic, bowel, and mesenteric injuries and urinary bladder trauma were low in frequency in accordance with literature; hepatic injuries were also common and were second most common injuries detected after splenic trauma on both USG and CT. Hemoperitoneum is quite high in incidence probably derived from multiple sources. Few cases of pelvic fractures were also detected mainly by CT.

Spleen was the most commonly injured organ in this study. There were 24 cases of splenic injury detected on USG in this study, which is 45.2 % among all injuries detected by USG in this study. CT detected 29 cases of splenic trauma which is 40.84 % among all the injuries that were detected on CT in this study. CT had detected six cases of splenic trauma which missed on USG. All those injuries that were detected on USG and CT were graded using organ injury scale. Of 24 cases which were detected on USG, three cases were of Grade 1 (12.5%), eight cases were of Grade II (33.3%). Nine cases of Grade III injury (37.5 %) and four cases of Grade IV injury (16.6 %). In this study, CT detected 29 cases of splenic trauma compared to USG which detected 24 cases, out of these cases four cases were of Grade I-, 11 cases were of Grade II, nine cases were of Grade III, five cases were of Grade IV, no cases of Grade V splenic injuries were noted on this study. Of the six6 additional cases detected on CT, three were of Grade – I and three were of Grade II injury. One case which was graded as Grade I on USG was found to be Grade II, 1 case graded as Grade II on USG turned out to be of Grade III on CT, and one case which was graded as III on USG was graded as Grade IV on CT. USG had sensitivity – 79.3%, specificity – 98.2%, PPV – 95.8%, NPV – 90.4%, and predictive accuracy – 91.9%.

Liver was the second most commonly injured organ on this study. In this study, USG had detected 17 cases of trauma to the liver which was 32% among all the organ injuries that were detected on USG and it detected 21 cases of liver injury on CT scan which was 29.5% among all organ injuries detected on CT. All the cases that were detected on USG were graded using organ injury scale, there were three cases that had Grade – I liver injury – 17.6 %, six cases had Grade – II liver injury – 35.2%, six cases had Grade III liver injury – 35.2 %, and two cases had Grade IV liver injury – 11.7%. The injuries that were detected on CT were also graded, there were three cases of Grade – I injury – 14.2%, nine cases of Grade – II injury – 42.8%, seven cases of Grade III injury – 33.3%, and two cases of Grade IV injury – 9.5 %. No cases of Grade V and Grade VI hepatic injuries were found on this study. CT had detected four cases of hepatic trauma that were missed on USG, having Grades I and II liver injuries; also, CT helped in better grading of the lesions, two cases which were graded as Grade – I on USG but was given a higher grade as Grade II on CT, one case which was graded as Grade II on USG, was graded as III on CT. USG had a sensitivity – 80%, specificity – 98.5%, PPV – 94.1 %, NPV – 94.2 %, and predictive accuracy – 94.25 %.

This study was in accordance with the several studies performed earlier which had mixed results.

Yoshii et al.,[7] reported sensitivities of 92% and 90% for the ultrasound detection of liver and spleen injuries, respectively.

Goletti et al.,[8] demonstrated a slightly lower sensitivity for liver injuries (80%) but a higher sensitivity for spleen injuries (93%).

In contrast to the prior studies, McGahan et al.,[9] reported detection rates of 14% for liver injuries and 69% for spleen injuries. The same group later demonstrated higher sensitivities for both liver and spleen injuries, but this was most pronounced in injuries that were either Grade III and higher.

Our study is in accordance with the above-mentioned studies, our study also accounts for the relatively low sensitivities of USG in detecting liver and splenic injuries for the lower grades of injuries as mentioned in the study by McGahan et al.[9]

Kidneys were the third most commonly injured organ in this study. There were 11 cases of renal injury detected on USG in this study, which is 20.7% among all injuries detected by USG in this study. CT detected 13 cases of renal trauma which is 18.3% among all the injuries that were detected on CT in this study. CT had detected two cases of renal trauma which were missed on USG. All those injuries that were detected on USG and CT were graded using organ injury scale. Of 11 cases which were detected on USG three cases were of Grade 1 – 27.27%, four cases were of Grade II – 36.3 %. Three cases of Grade III injury – 27.27% and one cases of Grade IV injury – 9.09 %. In this study, CT detected 13 cases of renal trauma compared to USG which detected 11 cases, out of these cases, two cases were of Grade I – 15.38%, six cases were of Grade II – 46.1%, four cases were of Grade III – 30.76%, one case was of Grade IV – 7.69%, and no cases of Grade V renal injuries were noted on this study. Of the two additional cases detected on CT, one case was graded as Grade I and another as Grade II. CT also helped in better grading of the renal injuries as two cases which were reported as Grade I and II were graded as II and III respectively on CT.

Jalli et al., correlated sonography with CT in identifying and grading renal trauma and found that, overall sensitivity and specificity of sonography in detection of renal injuries were 48% and 96%, respectively, with a 0.8 PPV, a NPV of 0.57, and an overall accuracy of 79%. Signs of parenchymal hematoma, perinephric hematoma, and pelvicaliectasis associated with internal echogenicity were the most prevalent ultrasound findings. During our study, we observed that sonography can identify renal injury, but CT is more accurate both in identifying and in staging of renal trauma. McGahan et al.,[9] noted that injuries of the kidney are often associated with significant splenic, hepatic, diaphragmatic, or bowel trauma. These concomitant injuries may result in the presence of free fluid in the abdomen.

Sclafani et al.,[6] also considered that CT is the method of choice for renal injuries and confirmatory angiography unnecessary.

There was one case of pancreatic injury in this study, which was Grade – II and was detected both on USG and CT. The sensitivity, specificity, PPV, NPV, and predictive accuracy of USG in comparison to CT were 100%.

This result was in accordance with the study done by Lv et al.,[10] where it was found that CEUS findings can be used to provide a reliable diagnosis for blunt pancreatic trauma. CEUS is thus promising in the assessment of blunt pancreatic trauma, especially in institutions where emergency CEUS is used as an initial diagnostic instrument.

Four cases of bowel injuries were detected on this study, all were detected on CT scan, USG was unable to detect any of these cases of bowel injury. Based on this study, USG was not found to be sensitive in the detection of bowel injuries.

The study conducted by Mohammadi and Ghasemi-Rad[11] found that in patients with isolated gastrointestinal injury, the sensitivity of FAST was 38.5%.

Yoshii et al.,[7] reported 19 false negative results, on USG for the detection of abdominal visceral injuries, of which 11 had gastrointestinal injuries.

Nnamonu et al.,[12] had ten false negative results on USG when scanning for the visceral parenchymal injury. Out of these patients, six had gastrointestinal injury.

Nural et al.,[13] had five false negative results on USG for the detection of abdominal visceral injuries, three of whom had gastrointestinal injuries.

This study had three cases of bladder injury, out of which two extraperitoneal and one intraperitoneal. All cases of bladder injuries were associated with pelvic fractures. All of these cases of bladder injury was detected on CT scan. USG was unable to detect any of the bladder injuries. The reason for this may be the non-distention of the bladder either with or without catheterization, this may have caused the limitation of USG in detecting any wall defect or discontinuity on USG accurately.

Hemoperitoneum

In this study, free fluid was noted in 49 cases of abdominal trauma on USG. Out of these 49 cases, associated visceral injuries were present in 41 cases (83.6%), eight cases (14.4%) were not associated with any visceral injuries on USG. On CT scan, six more additional cases of hemoperitoneum were detected, leading to detection of 54 cases of hemoperitoneum on CT in this study. This was most likely as a result of the amount of the collections in these patients was smaller than might are detected sonographically. Intestinal obstruction related to the immediate post-trauma could have compromised the sonographic detection of hemoperitoneum in these patients. This can be thanks to the accumulated gut gas within the presence of intestinal obstruction serving as a structural interface that distorts the sonographic image. Furthermore, the sonographic window was restricted, once patients had skin abrasions and dressings on the anterior wall. There was additionally a restricted area for maneuvering the livid patients thanks to pain.

Out of these 54 cases, 51 cases (94.4%) were associated with visceral injuries, while three cases (5.6 %) of isolated hemoperitoneum were found on CT. Six cases were noted, which were having visceral injuries on CT scan, but hemoperitoneum was not detected. The sensitivity of USG in detecting hemoperitoneum as compared to CT was found out to be 88.8%.

Nnamonu et al.,[12] reported the sensitivity of US for detecting intra-abdominal injury when scanning for hemoperitoneum to be 96%.

Yoshii et al.,[7] reported a sensitivity of 94.6% of USG in detecting hemoperitoneum.

The number of false positives in this study was lower as compared to similar studies reviewed in the literature. While this study showed 1 false positive(2%) when scanning for intra-peritoneal fluid, Nural et al.,[13] in their study, which involved 454 patients, had 19 (4%) FP results. Yoshii et al.,[7] studying 1239 patients had 44 (4%) FP results.

This study like the others reviewed shows that ultrasound scan for intra-peritoneal fluid has a high diagnostic accuracy.

Six cases (9.83%) of visceral injuries without evidence of hemoperitoneum was detected on CT scan in this study. This is lower in comparison to the findings noted by Sherbourne et al.,[14] where a total of 246 abdominal injuries were identified in 196 patients. Fifty (26%) patients with abdominal visceral injuries diagnosed by admission CT scan had no evidence of hemoperitoneum.

Limitations of the study

In spite of every sincere effort our study has lacunae.

The notable short comings of this study are:

1. The sample size was small. Only 87 cases are not sufficient for this kind of study.
2. The study has been done in a single center.
3. The study was carried out in a tertiary care hospital, so hospital bias cannot be ruled out

CONCLUSION

Based on the findings of this study, following conclusions were arrived upon:

1) CT is the imaging modality of choice for diagnosing abdominal injury.
2) USG is fairly sensitive in detecting hemoperitoneum and solid organ injuries (especially of higher grades).
3) Spleen is the most commonly injured organ in abdominal trauma.
4) USG is relatively less sensitive in detecting bowel and bladder injuries.
5) Since, majority of patients detected negative for abdominal injury on USG were also negative on CT scan, hence clinically stable patients, negative on USG could be followed up with serial clinical examinations and USG when necessary without the absolute need of undergoing a CT examination.

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BP- Manuscript preparation, data collection and literature search; **SSK**- Conceptualised the study, literature search, data analysis and interpretation; **AN**- Literature search and Prepare first draft; and **KK**-Concept and design of study, review the Literature and Revision of manuscript.

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