



## Comparative Study of CT and Ultrasonography in Blunt Abdominal Trauma

Author

**Dr Shailja Srivastava**

Assistant Professor Radiology, OMC, Hyderabad

### Abstract

**Background:** *Patients with abdominal trauma present a frequent diagnostic dilemma because of low accuracy of physical examination and clinical diagnosis. Clinical findings are often unreliable and have low sensitivity for diagnosis of intra peritoneal injuries following blunt trauma. It is challenging, even for an experienced trauma surgeon to determine the extent of abdominal injuries and the need for surgical intervention on the basis of clinical presentation alone. Hence there is a need for an accurate imaging modality. In the recent years there is growing trend of conservatism in closed injuries, where the role of imaging becomes even more paramount for the safe practice of such surgical restraint*

**Aims and Objectives:** *To study the various radiology findings associated with blunt abdominal trauma. To analyze the efficacy of ultra sound and CT in the diagnosis of blunt abdominal trauma; and to compare individual merits and demerits and their superiority in the diagnosis.*

**Materials and Methods:** *In this prospective study 50 cases of blunt abdominal trauma were evaluated by US and CT in the Department of Radiology & Imageology, OGH, Hyderabad between September 2016 to December 2017. All the cases were admitted in the Department of General Surgery, OGH, Hyderabad, where clinical follow - up done.*

*In this study 50 patients of blunt abdominal trauma were assessed for injuries to various organs using organ injury scale, both USG and CT and the results were compared and the sensitivity and specificity of USG in comparison with CT were calculated and the positive predictive value and negative predictive value of USG for individual organs was calculated.*

**Result:** *In this study hepatic trauma was the most common injury detected on both USG and CT; this is a variation from standard surgical description of more common splenic injuries. The reason might be that surgically occult liver lesions are picked up more with the use of abdominal CT. Pancreatic and urinary bladder trauma were low in frequency in accordance with literature; spleen injuries were also common and were second most common injuries detected after hepatic trauma on both USG and CT.*

*Haemoperitoneum is quite high in incidence probably derived from multiple sources. Few cases of retroperitoneal injuries, abdominal and pelvic fractures were also detected mainly by CT.*

**Conclusion:** *Clinical examination fails to accurately diagnose many intra abdominal injuries in blunt abdomen and hence there is a well rounded need for a good imaging technique. USG and CT satisfy this to a great extent. With minimum technical limitations and a short time for examination USG and CT become extremely useful in guiding the trauma surgeon.*

*NECT combined with CECT is a highly useful imaging modality for diagnosis of blunt abdominal trauma. However USG can be used as a useful initial modality. CT is excellent in picking up clinically unsuspected trauma especially involving liver, kidney and bowel.*

**Keywords:** *Blunt abdominal trauma, CT, Hemoperitoneum, USG.*

**Aims and Objectives**

To study the various radiology findings associated with blunt abdominal trauma. To analyze the efficacy of ultra sound and CT in the diagnosis of blunt abdominal trauma; and to compare individual merits and demerits and their superiority in the diagnosis. To reduce the investigation time and to facilitate early management of the patient to reduce morbidity associated with blunt abdominal trauma.

**Material and Method**

In this prospective study 50 cases of blunt abdominal trauma were evaluated by US and CT in the Department of Radiology & Imageology, OGG, Hyderabad, between September 2016 to December 2017. All the cases were admitted in the Department of General Surgery, OGH Hyderabad, where clinical follow - up done.

No of cases in this study: 50

Male: Female ratio 47:3

**Age:**

<20Y	20-40Y	>40Y
8	34	8

Patients were selected based on following:

**Inclusion Criteria**

Abnormal physical examinations.

Macroscopic hematuria.

Unconscious or altered consciousness with suspected abdominal injury.

Delayed symptoms like:

- (i) Progressive abdominal distention
- (ii) Delayed abdominal pain and tenderness
- (iii) Delayed hematuria.
- (iv) Falling vitals.

**Exclusion Criteria**

Patients in shock

Patients with spinal injuries were excluded from this study.

All patients underwent both Ultrasound and CT and the time gap between the two was tried to be kept a minimum

All patients chosen where hemodynamically stable and had no overt life threatening neurological, thoracic or abdominal injury .in the presence of shock such patients went directly to the surgeons table, Abnormal physical examination findings where in the form of

- Localized are generalized tenderness/guarding.
- Local bruise / wounds.

**Machine Parameters**

Ultrasound was performed using GE ESOATE SCANNER with SECTOR, CURVILINEAR and LINER PROBE

CT was performed using: TOSHIBA spiral CT, single slice

CT scanning protocols:

- 120 KV 240 MAS
- Slice thickness – 7mm and 5mm
- Reconstruction of 2.5mm.
- First non-enhanced CT (NECT) followed by contrast enhanced CT (CECT) was performed.
- 70ml of I/V contrast was given.
- Pre scan delay of 22 sec for arterial and 48 sec for venous phase was given.
- 7mm slice thickness from diaphragm to the pubic symphysis.
- Additional inter slices if required.
- 5 minute delay was given in cases of renal injuries.
- No routine sedation was done.

All images were viewed in soft tissue as well as lung window settings besides bone window.

**Observations & Analysis**

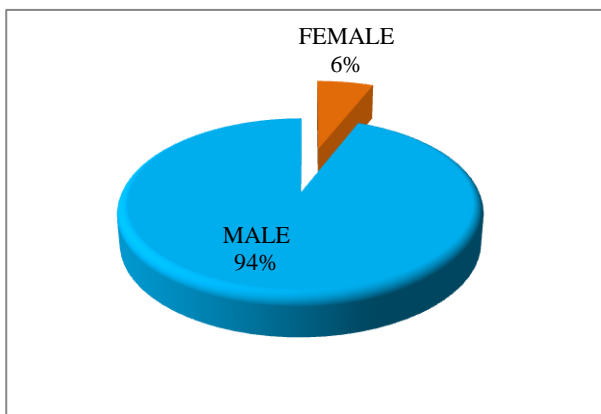
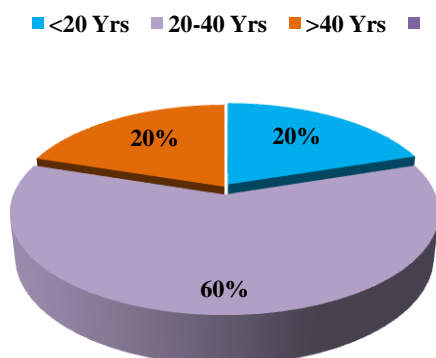
In this study 50 patients of blunt abdominal trauma were assessed for injuries to various organs using organ injury scale using both USG and CT and the results were compared and the sensitivity and specificity of USG in comparison with CT were calculated and the positive predictive value and negative predictive value of USG for individual organs was calculated.

Total number of patients – 50

Age & Sex Distribution

<20 Yrs	20-40 Yrs	>40 Yrs
8	34	8

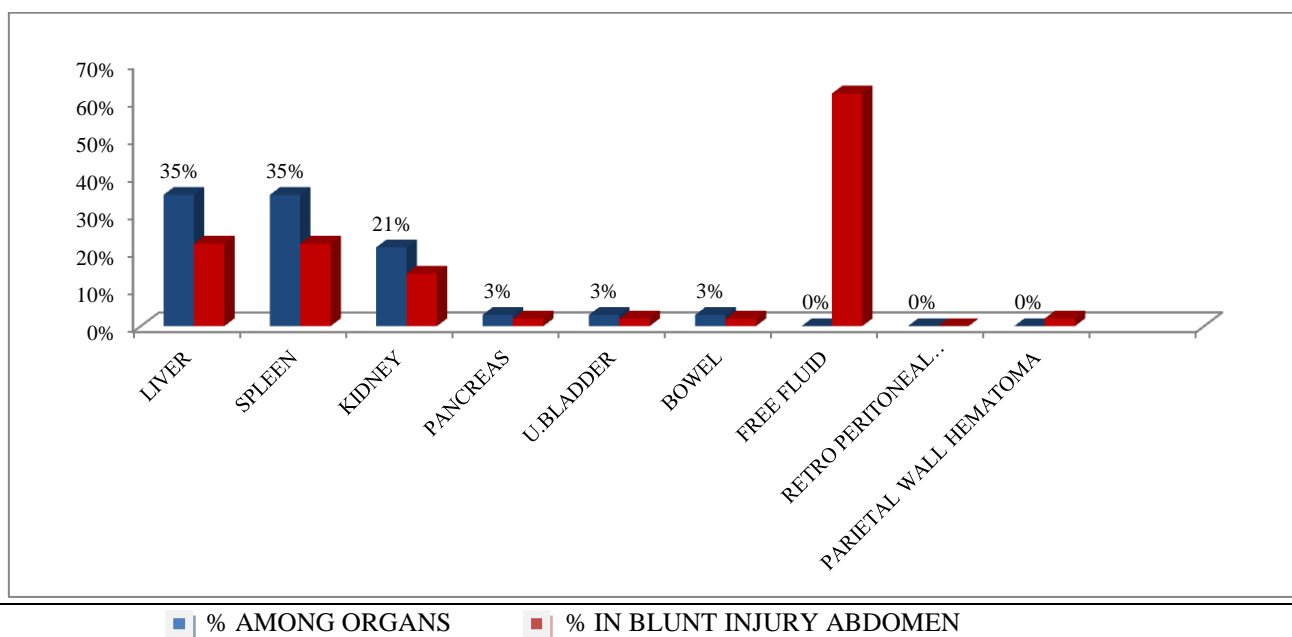
MALE	FEMALE
47	3



Intra Abdominal Organ Injury

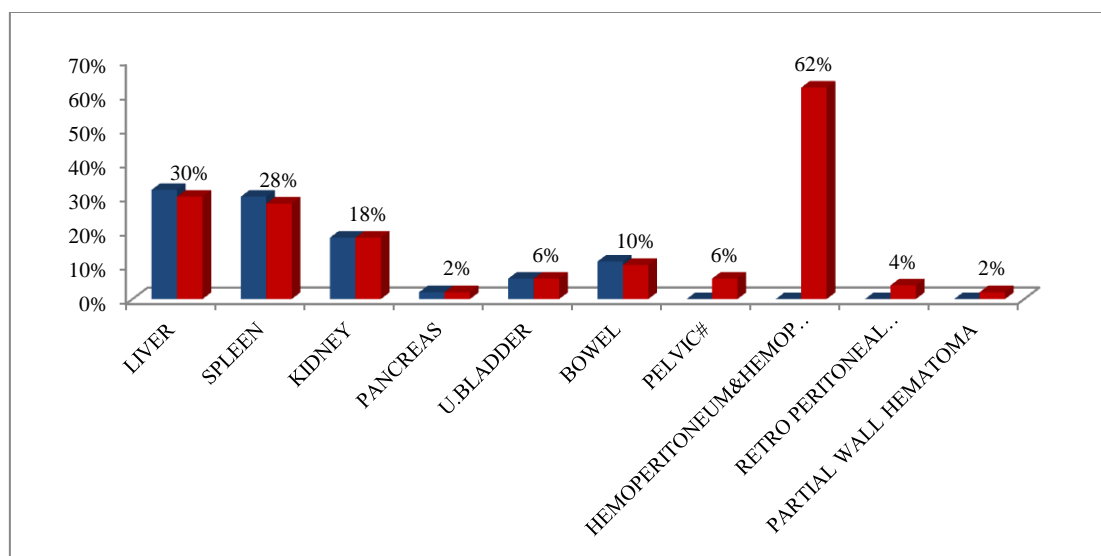
Table 1: Distribution Detected by USG

ORGAN	NO.OF CASES	% AMONG ORGANS	% IN BLUNT INJURY ABDOMEN
LIVER	11	35%	22%
SPLEEN	11	35%	22%
KIDNEY	7	21%	14%
1	1	3%	2%
U.BLADDER	1	3%	2%
BOWEL	1	3%	2%
FREE FLUID	31	0%	62%
RETRO PERITONEAL HEMORRHAGE	0	0%	0%
PARIETAL WALL HEMATOMA	1	0%	2%



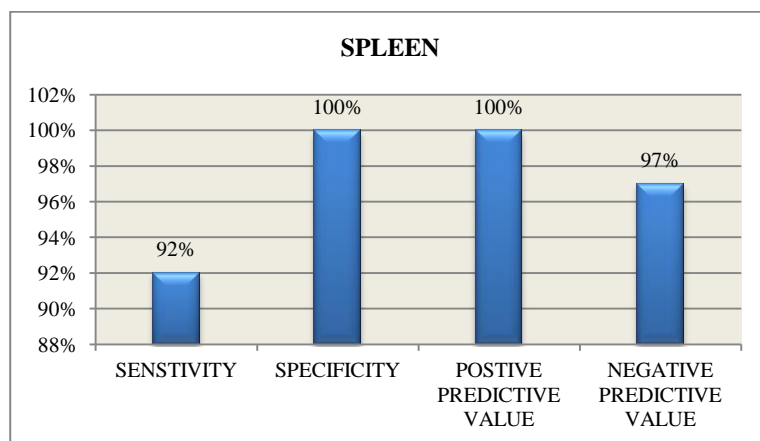
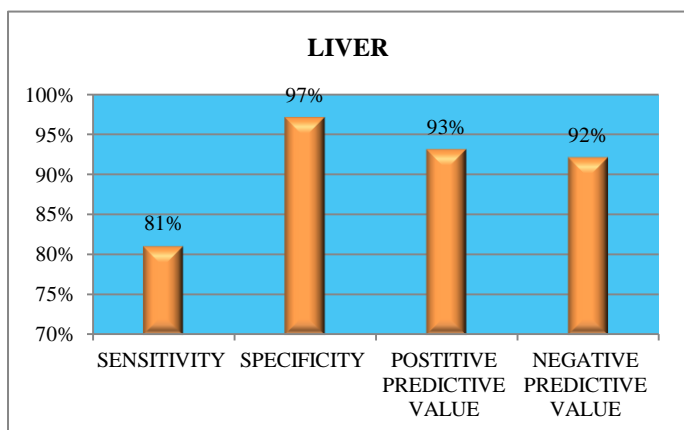
**Table-2: Distribution Detected by CT**

ORGAN	NO.OF CASES	% AMONG ORGANS	% IN BLUNT INJURY ABDOMEN
LIVER	15	32%	30%
SPLEEN	14	30%	28%
KIDNEY	9	18%	18%
PANCREAS	1	2%	2%
U.BLADDER	3	6%	6%
BOWEL	5	11%	10%
PELVIC#	3	0%	6%
HEMOPERITONEUM & HEMOPNEUMOPERITONEUM	31	0%	62%
RETRO PERITONEAL HEMORRRHAGE	2	0%	4%
PARIETAL WALL HEMATOMA	1	0%	2%

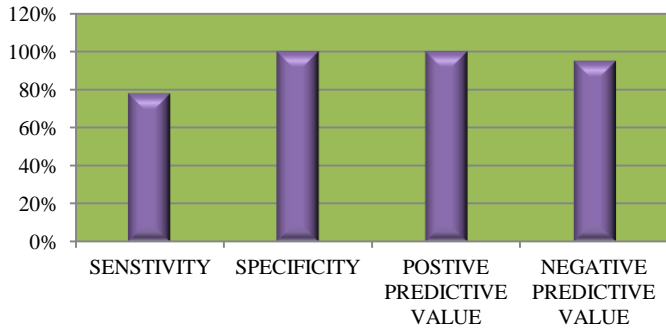


■ % AMONG ORGANS      ■ % IN BLUNT INJURY ABDOMEN

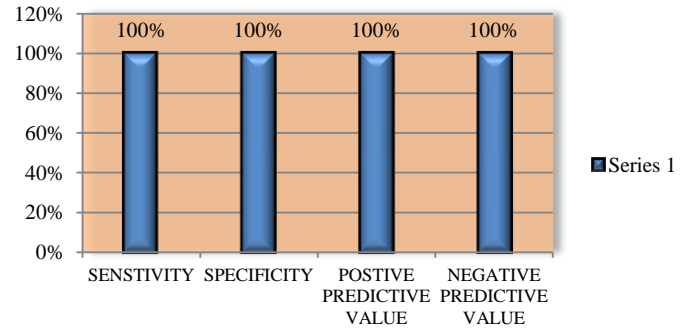
**Sensitivity, Specificity, Positive Predictive Value and Negative Predictive Value of Ultra Sound When Compared with CT**



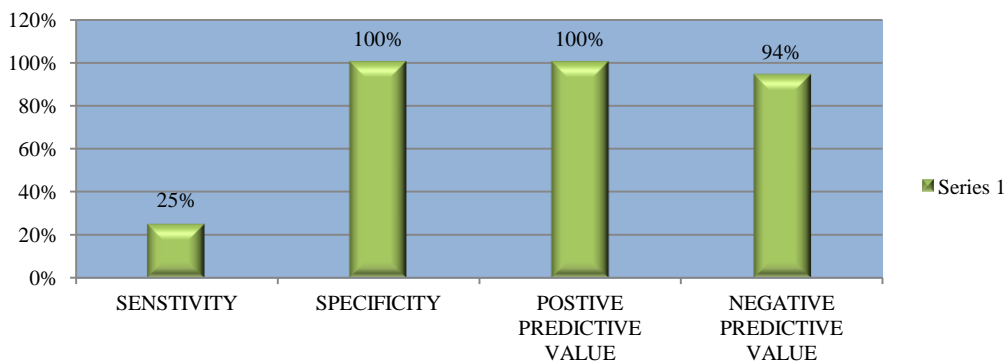
**KIDNEY**



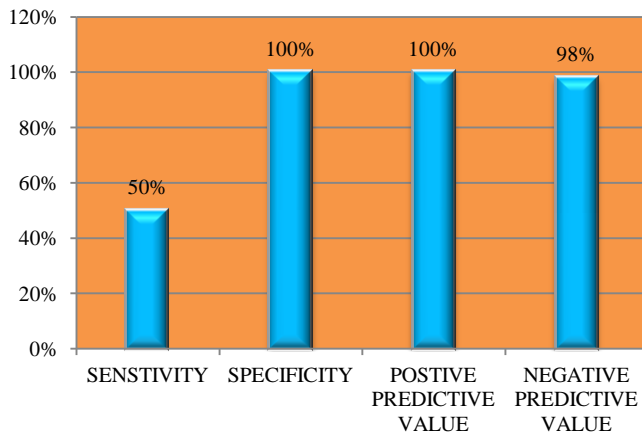
**PANCREAS**



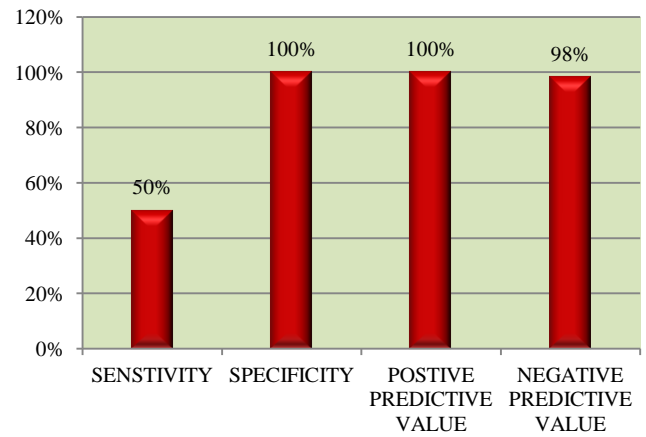
**URINARY BLADDER**

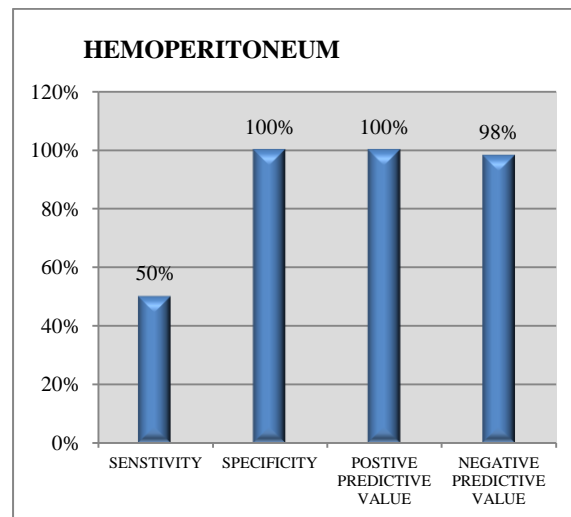
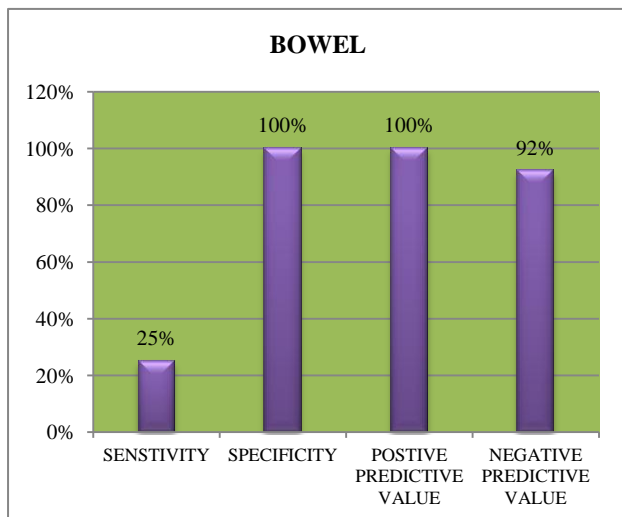


**RETROPERITONEAL HEMORRHAGE**



**PELCVIC WALL HEMATOMA**





### Discussion

The challenge in the imaging of abdominal trauma is to accurately identify injuries early exploration and at the same time avoid unnecessary operative intervention in cases that can be managed conservatively.

In recent years CT and USG have replaced all other modalities of investigation up to a great extent. Blunt trauma in this series, as elsewhere in the world was found to be affecting the relatively younger age group (20-40 years) (68%) and much more common in the male population (94%). A direct abdominal hit or run over accidents are more likely to cause serious internal damage.

Routine USG was done in all patients which was followed by a CT and the time gap between the two examinations as far as possible was tried to be kept to a minimum.

Omission of oral contrast agents in suspected bowel injury cases was not to be of any significant disadvantage in this series as all the five bowel injuries were confirmed on surgical exploration and all bowel injuries were correctly diagnosed in this series thus agreeing with Clancy et al<sup>22</sup> that bowel opacification is not a must.

Few of these patients had associated injuries and needed neurological, thoracic or pelvic screening by CT and hence all these examinations along with abdominal scan on a single sitting did not add much to the extra time required. This is to be remembered in this context of observations of shoemaker et al<sup>10</sup> that greatest risk of CT is the

time delay added onto by the procedure. The average time for a dedicated abdominal study was not more than twenty minutes.

### Individual Organ Trauma

In this study hepatic trauma was the most common injury detected on both USG and CT; this is a variation from standard surgical description of more common splenic injuries. The reason might be that surgically occult liver lesions are picked up more with the use of abdominal CT. Pancreatic and urinary bladder trauma were low in frequency in accordance with literature; spleen injuries were also common and were second most common injuries detected after hepatic trauma on both USG and CT.

Hemoperitoneum is quite high in incidence probably derived from multiple sources. Few cases of retroperitoneal injuries, abdominal and pelvic fractures were also detected mainly by CT

### Liver Trauma

USG had detected 11 cases of trauma to the liver which was 35% among all the organ injuries that were detected on USG and 22% among all cases of blunt injury to the abdomen which was 32% among all organs injuries detected on CT and 30% among all the cases of blunt injury to the abdomen in this study.

All the cases that were detected on USG were graded using organ injury scale there were 9 cases that had grade- I liver injury – 82%, 1 case had

grade – II liver injury -9% , one case had grade III liver injury -9%

The injuries that were detected on CT were also graded there were 12 cases of grade – I injury - 82% , 1 case of grade – II injury -6% , 1 case of grade III injury-6% and one case of grade IV injury -6%

CT had detected four cases of hepatic trauma that were missed on USG and most of them were grade – I injuries and also CT helped in grading the lesion better in one case which was graded as grade – II but was given a higher grade as grade III on CT. However most of these patients were managed conservatively which did not significantly alter the final outcome in most of these pts. USG had a sensitivity -81.2%, specificity 97% , ppv-93%,npv-92%.

Parameters of the study	Comparable studies
Incidence 32%	Oldham et al <sup>32</sup> 1986(28%)
Conservative management 100% no late haemorrhages	Oldham et al <sup>34</sup> 1995(56%) Meredith et al <sup>34</sup> 1994(97%)
Higher grades managed conservatively	Boone et al <sup>36</sup> 1995(56%)
Surgery in most instances Were for other involved Organs	Medredith et al <sup>34</sup> 1994
NECT must before CECT	Kelly J.et al <sup>28</sup> 1989

### Splenic Trauma

There were 11 cases of splenic trauma detected on USG which is 35% among all injuries detected by USG and 22% among all the cases of blunt injury to the abdomen in this study. CT detected 14 cases of splenic trauma which is 30% among all the injuries that were detected on CT and 28% among all the cases of blunt injury to the abdomen in this series. CT had detected 3 cases of splenic trauma which missed on USG all those injuries that were detected on USG and CT were graded using organ injury scan.

Of 11 cases which detected on USG 6 cases were of grade I-54%,4 cases were of grade III -36% and 1 case of grade IV injury -10%.Of the 14 cases that were of grade –I – 57% , cases were grade – III – 29% , 2 cases were of grade IV – 14%

In this study CT detected 14 cases of splenic trauma compared to USG which detected only 11 cases, of the 3 additional cases detected on CT two were of grade – I and one was a grade IV injury. one case which was graded as grade I on USG was found to be grade III, USG had sensitivity- 92%, Specificity-100%, ppv-100%, npv-97%

Parameters in this study	Comparable studies
Incidence 18%	Schwartz105 (19%)
Conservative management for lower grades	Rescinti et al <sup>46</sup> 1998(37%) Scatamaachia et al <sup>44</sup> 1989
High correlation of CT operative findings	Boiloi et al <sup>41</sup> 1993

### Renal Trauma

There were 7 cases of renal trauma which were detected on USG which was 21% among all the organ injuries detected on USG and 22% among all the cases of blunt injury to the abdomen I this series.

There were 9 cases of renal trauma detected by CT and 18% among all the cases of blunt injury to the abdomen in this series. CT had detected two cases of renal trauma missed by US and all these cases were graded using organ injury scale.USG detected 3 cases of grade I injury -42% of all renal injuries that were detected on USG,1 case of grade II injury -14% and 3 case of grade III -42% of all renal injuries detected on USG.

CT detected 4 cases of grade I injury -44% of all renal injuries detected on CT and 5 cases of grade III injury -56.

USG detected only 7 cases of renal trauma where CT could detect 9 cases of renal trauma. Of this one case which was graded as grade I on USG was given a higher grade on CT i.e. grade III. In another case which case graded as grade II on USG was given a grade of III on CT. USG had sensitivity –78%, specificity -100%,ppv-100%, npv-95%.

Parameters in this study	Comparable studies
CT invaluable in categorization And hence In management.	Baumann et al 1992
CT can detect vascular injuries Even Segmental involvement	Lupetin et al 641989
Conservative management in most of the cases.	Change et al 631994 (81%).

### Pancreas

In this study there was one case of injury to the pancreas which was detected on USG which is 3% among all the organ injuries that were detected on USG and 2% among all the cases of blunt injury to the abdomen. CT also detected only one case of pancreatic trauma which is 2% among all the organ injuries that were detected on CT and 2% among all the cases of blunt injury to the abdomen in this study.

Both CT and USG detected only one case of pancreatic injury in the form of pancreatic laceration.

Generally it is low in incidence which is 2% on CT and 3% on USG among all other injuries. Clinical diagnosis of pancreatic trauma is a difficult problem. Pancreatic trauma shows only subtle signs on USG and CT. The infrequent and subtle nature is comparable to many a series 50,51,52,53 & 54 but most closely to rescorla F.J.et al 54 where five out of six pancreatic lacerations were missed on CT. This is disappointing in the light of severe mortality of such injuries if not intervened surgically. Being deep seated pancreatic injury to the pancreas needed no surgical intervention and was managed conservatively.

If not carefully searched for especially with other midline injuries pancreatic trauma can be missed in CT since it has a low sensitivity for the same. USG had sensitivity -100%, specificity -100%. ppv 100%, npv-100%.

### Urinary Bladder Trauma

There was only one case of urinary bladder trauma detected on USG which was 3% among all organ injuries detected on USG and 2% among all the cases of blunt injury to the abdomen.

CT detected 3 cases of urinary bladder trauma which is 6% among all the organ injuries detected on CT and 6% among all the cases of blunt injury to the abdomen.

In this study CT detected 2 cases which were missed on USG. The reason for this could be due to partially filled bladder and also CT CYSTOGRAPHY was done when ever there was a doubt on NECT.

However the incidence of urinary bladder trauma was low in this study 3% on USG and 6% on CT could detect one case of rupture which was confirmed on surgery. CT could also help us detect the source of hematuria. USG had sensitivity -25%, specificity-100% ,ppv-100%, npv-92%.

### Bowel Injury

USG detected one case of bowel injury which was 3% among all the injuries detected on USG and 2% among all the cases of blunt injury to the abdomen.

CT detected 5 cases of bowel injury which was 11% among all he organ injuries detected on CT and 10% among all the cases of blunt injury to the abdomen.

CT could pick up 4 cases of bowel injury which was missed on USG. The overall incidence of bowel injuries was 3% on USG and 11% on CT of all the organ injuries detected. Bowel injuries were common in the small bowel than in the colon in this study and agrees with the usual pattern of involvement.

In most of the cases accurate prediction of bowel injury was possibly on CT based on pneumoperitoneum which should be searched for in lung window settings. Another associated finding was peritoneal fluid without any obvious solid organ injury.

Though accurate localization was not possible, pneumoperitoneum was found to be highly specific for bowel injuries in the form of perforation. Hemopneumoperitoneum adds to the evidene. Majority of cases were not associated with chest injury which may cause dissection of



air from pleural cavity to the peritoneum and hence a false positive pneumoperitoneum. Without bowel opacification itself CT is highly sensitive and specific for bowel injury in the form of perforation in this study. USG had sensitivity - 94%, specificity -94%, ppv-97%, npv-89%.

Comparable studies	Parameters in this series
Incidence	Mc Cortt et al <sup>10</sup> 69%
Pneumoperitoneum highly specific	Albanese et al <sup>73</sup> 1996
Despite subtle findings CT is accurate at diagnosis	Nghiem et al <sup>70</sup> 1993 Jamieson et al <sup>74</sup> 1996

This study disagrees with reported false negative rates found in Wisner et al<sup>68</sup> series.

### Hemoperitoneum and Hemopneumoperitoneum

In this study there were 31 cases of haemoperitoneum which were detected on USG. CT also detected 31 cases of haemoperitoneum and hemopneumoperitoneum which is 62% among all the cases of blunt injury to the abdomen.

Overall 1 incidence in this series 62% (31). Hemoperitoneum was very common with liver, spleen and bowel injuries. Liver injuries were the most common source. CT diagnosis of hemoperitoneum was highly accurate with an average value of >30 HU. However values below this cannot be dismissed as absence of hemoperitoneum – since this was shown to exist with a HU of 14 in one of the cases confirmed by needle aspiration. False negative diagnosis encountered can be explained by late hemorrhage that takes place during the time interval between scan and laparotomy which may run into hours. When associated with pneumoperitoneum bowel was the source as were provided in three cases.

Even high grades of hemoperitoneum were managed conservatively successfully and most were hepatic injuries.

Besides important role in diagnosis and management CT helps locate possible source of bleed by picking up ‘sentinel clots’. Approximate quantification was also possible on visualization of a pelvic hemoperitoneum

where more than 500ml can be expected. So the role of CT in detecting hemoperitoneum is extremely important. Ultrasound though capable of detecting hemoperitoneum is less sensitive in solid organ trauma diagnosis. Since the dictum of hemoperitoneum of more than 250-500ml as an indication for laparotomy is no longer acceptable and increased tendency towards conservatism alone will not serve the purpose and hence the prime role for CT in blunt injury abdomen.

Parameters in this study	Comparable studies
High sensitivity and specificity	Federal et al <sup>79</sup> 1983
High incidence with liver and spleen injuries (91%)	Brick et al <sup>30</sup> 1987 (75%)
Approximate quantitative prediction	Meredith et al <sup>90</sup> 1988
Patients undergone laparotomy were those with higher volume of hemoperitoneum.	Levine et al <sup>80</sup> 1995.

### Retroperitoneal Hemorrhage

There were no cases of retroperitoneal hemorrhage detected on USG. There were two cases of retroperitoneal hemorrhage detected on CT. CT was better at detecting retroperitoneal hemorrhage which had detected two cases which were missed on USG.

Overall incidence was only 4% (2) in this series. This agrees with the High accuracy rate in retroperitoneal hemorrhage by CT reported by Meredith et al 90 and undermines a major advantage CT has got over DPL as observed by Spencer et al 43. USG had sensitivity – 100% specificity – 98%, ppv – 0%, npv – 94%

### Abdominal Wall Injuries

There was one case of parietal wall hematoma that was detected on both USG and Ct. This is 2% of all the injuries detected on Ct and USG.

Due to tenderness and appearance these are misleading in certain instances and were found to be unassociated with any serious internal injuries so the role of CT on such a differentiation is extremely useful in a given clinical context and agree with Hill S.A et al 91.

**Other Injuries**

CT also picks up spine fractures. It is particularly excellent in depicting pelvic fractures. Major central vessel injuries were not encountered in this

study, The reason may be that such lesions are exsanguinating and patients are unstable on arrival and hence proceed directly for laparotomy.

**Organ Injury Grade****Liver Trauma**

Grade	USG	%	C.T	%
Grade I	9	82%	12	82%
GradeII	2	18%	1	6%
Grade III	0	0	1	6%
Grade IV	0	0	1	6%
Grade- V	0	0	0	0

**Splenic Trauma**

Grade	USG	%	C.T	%
Grade I	6	54%	8	57%
GradeII	0	0	0	0
Grade III	4	36%	4	29%
Grade IV	1	10%	2	14%

**Renal Trauma**

Grade	USG	%	C.T	%
Grade I	3	42%	4	44%
GradeII	1	14	0	0
Grade III	3	42%	5	56%
Grade IV	0	0%	0	0

**Conclusion**

Clinical examination fails to accurately diagnose many intraabdominal injuries in blunt abdomen and hence there is a well rounded need for a good imaging technique.USG and CT satisfy this to a great extent.

With minimum technical limitations and a short time for examination

USG and CT become extremely useful in guiding the trauma surgeon.

NECT combined with CECT is a highly useful imaging modality for diagnosis of blunt abdominal trauma. However USG can be used as a useful intial modality.

USG and CT grading though of not much impact in the management of liver trauma, is however extremely useful in the decision making of renal trauma and to a lesser extent in splenic injuries.

CT is excellent in picking up clinically unsuspected trauma especially involving liver, kidney and bowel.

Retroperitoneal hemorrhage and hemopneumoperitoneum are two situations where CT is better than USG.

USG along with CT has a very vital role in accurate diagnosis, source localization, quantification and management decision making in hemoperitoneum.

Compared with USG, CT is extremely accurate and valuable in predicting occult bowel injuries in the form of traumatic perforations even without the use of contrast opacification of bowel.

Compared to USG, CT has a better potential to diagnosis other hollow viscous injuries like urinary bladder trauma.

CT is excellent in diagnosis of associated injuries of spine, pelvis, skeleton and hence a single sitting complete examination technique for trauma patient.

**To Conclude**

CT is a superior diagnostic modality in the diagnosis of abdominal trauma.

USG can be valuable initial investigation. however ,USG can miss crucial injuries and may lead to inappropriate management in some patients.

Hence it is imperative that all USG positive cases should be followed by CT.

Similarly CT must also be performed in symptomatic patients with negative US scans and in patients with suboptimal US scans.

Although a higher USG or CT scoring of hemoperitoneum increases the chances of surgical management, hemodynamic stability and accurate imaging diagnosis are the main determinants which dictate the type of management strategies.

It appears that asymptomatic patients with normal clinical examinations and US scans can be followed up without CT scan or indoor admission, restricting CT for US positives, US negative symptomatic and unsatisfactory US examinations.

However as the diagnostic yields in most reported studies are relatively low, large clinical trials are required to find out whether such protocols can be safely followed.

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