



IGM Publication

Journal of Medical Science and Clinical Research

Volume||1||Issue||5||Pages236-251||2013

Website: [www.jmscr.igmpublication.org](http://www.jmscr.igmpublication.org) ISSN (e): 2347-176X

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## ROLE OF ULTRASONOGRAPHY AND COMPUTED TOMOGRAPHY IN EVALUATION OF BLUNT ABDOMINAL TRAUMA

**\*R. PARTHASARATHI A, DR.GAUTHAM M, \*\*DR. KISHOR V H**

\*DEPARTMENT OF RADIODIAGNOSIS, RAJARAJESWARI MEDICAL COLLEGE AND HOSPITAL, MYSORE ROAD,  
BANGALORE, KARNATAKA, INDIA 560074

\*\*DEPARTMENT OF RADIODIAGNOSIS, NARAYANA MEDICAL COLLEGE, CHINTAEDDY PALEM, NELLORE,  
ANHRA PRADESH, INDIA – 524002

E-mail: [dr.pathu@gmail.com](mailto:dr.pathu@gmail.com)

E-mail: [dr.gautampes@gmail.com](mailto:dr.gautampes@gmail.com)

### ABSTRACT

*The Study was conducted to compare the role of ultrasound and computed tomography in patients presenting with blunt trauma. Patients with blunt trauma abdomen were evaluate with both ultrasonography and computed tomography and there organ injuries were assessed using organ injury scale for both USG and CT and the results were compared and the sensitivity and specificity of ultrasound compared with CT. Positive predictive value and negative predictive value of ultrasound for individual injured organs was calculated. The study was performed from October 2009 to September 2012 on 50 patients with blunt abdominal trauma. Our study shows CT is a superior diagnostic modality in the diagnosis of abdominal trauma. Hence it is imperative that all USG positive cases should be followed by CT abdomen. Similarly CT must also be performed in symptomatic patients with negative USG scans and in patients with suboptimal USG scans.*

**KEYWORDS:** *Computed tomography, ultrasound, laceration, contusion*

### INTRODUCTION:

Accident trauma affects a high proportion of younger age group individuals each year and hence results in loss of productive years of life. Though the major cause for mortality and morbidity in this setting are due to neurological injury and hemorrhage, along with chest trauma, blunt trauma of the abdomen or closed abdominal injuries are also major contributors especially if the situation remains unrecognized due to

overshadowing of other injuries. Clinical examination fails to diagnose internal injury in blunt injury abdomen in many instances and hence there is a need for an accurate imaging modality. In the recent years there is a growing trend of conservatism in closed injuries where the role of imaging becomes even more paramount for the safe practice of such surgical restraint.

With blunt trauma of abdomen a large number of patients are stable with no evidence of abdominal injury. Small proportions are unstable. Both these categories are not usually asked for imaging assistance. Only a small proportion with overt evidence of abdominal injury or unreliable abdominal examination reaches the radiology department. Added onto this, only a minority of these undergo surgical treatment and hence confirmation of imaging findings. Noninvasive modalities like ultrasound and computed tomography throw maximum light into area of major concern and dilemma of the trauma surgeon.

In this study the USG findings were correlated with CT findings and the outcomes were verified with operative findings, in those who underwent laparotomy. In those cases where CT was positive and surgery deferred, clinical follow up was the yardstick.

#### **MATERIALS AND METHODS:**

Fifty cases were studied irrespective of age and sex. In this prospective study patients were selected based on the following

**Inclusion Criteria:** All patients with history of blunt abdominal trauma who shows

- 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,
- Associated spinal injuries,
- Penetrating abdominal injury.

Contraindication for CECT imaging like hypersensitivity, increased serum creatinine, pregnancy etc.

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

All patients chosen were hemodynamically stable and had no overt life threatening neurological, thoracic or penetrating abdominal injury. In the presence of shock & suspicious of massive solid organ injury, such patients went directly to the surgeons table.

Abnormal physical examination findings were in the form of

- Localized or generalized tenderness/guarding.
- Local bruises/wounds.
- Free fluid in the abdomen.

Ultrasonography performed using 3 – 5 MHz curvilinear and 3 – 12 MHz linear probes

#### **CT Scanning Protocols:**

Contrast enhanced CT was performed with 50 ml of Intravenous iodinated contrast, 8-10mm thick slices were taken from domes of diaphragm to the pubic symphysis. Additional thin slice sections were taken where ever required. Early and 5 minutes delay was taken in cases of renal injuries. No oral contrast was given this was avoided since blunt injury abdomen patients were potential candidates for emergency surgery and hence general anesthesia.

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

#### **REVIEW OF LITERATURE:**

Road traffic accidents (RTAs) are the commonest cause and account for up to 50% of trauma related deaths. Abdominal trauma contributes 10% of overall mortality and considerably more in terms of morbidity<sup>1</sup>. Trauma most often results from traffic accidents, falls (mainly on the work site), recreational accidents & violence accounting for the other causes<sup>2</sup>

The mechanisms of internal injury in blunt injury abdomen are:

1. Direct compression of organs against bony prominences e.g. pancreatic trauma.
2. Structures normally attached to bones via fascia or ligaments getting torn following fracture e.g. urinary bladder trauma.
3. Deceleration injuries e.g. renal trauma.

The mainstay for radiological evaluation in blunt injury abdomen prior to the invent of CT were:

1. Plain abdominal radiograph.
2. Intravenous urography.
3. Angiography.

4. Radionuclide studies.

5. Ultrasonography.

Danne P.D<sup>3</sup> stated that the practice of making diagnosis in blunt injury abdomen by repeated clinical examinations over prolonged periods of time is to be condemned and that CT is the best organ imaging technique. His observation that an initial clinical examination may fail to detect many abdominal injuries also found support from Mackersie et al<sup>4</sup>. Consistent unreliability is observed on clinical examination of pancreatic and retroperitoneal injury-Lang EK et al<sup>5</sup>.

A.R Padhani et al<sup>6</sup> series of a retrospective analysis of role of CT in blunt injury abdomen, his indications for CT were

1. Abnormal abdominal physical examination.
2. Hematuria.
3. Multiple injuries.
4. Unreliable physical examination due to unconsciousness.
5. Unexplained hypotension.
6. Abnormal chest/abdominal radiograph.
7. Falling hematocrit.
8. Positive or equivocal peritoneal lavage.
9. Delayed abdominal symptoms.
10. Abnormal ultrasound examinations.
11. Postoperative evaluation.

Diagnostic peritoneal lavage (DPL) is a technique, which is being extensively studied in comparison with CT regarding its usefulness as an indicator for open surgery. Conflicting views exist regarding this. DPL involves aspiration as well as washing of the peritoneal cavity with saline and subsequent biochemical and microscopic examinations. Four-quadrant aspiration involves aspiration alone and is an inferior technique compared to DPL. Hawkins et al<sup>7</sup> justifies continued use of DPL since it avoids disruption of patient care that might result in the radiology suite. However DPL increases the incidence of non-therapeutic laparotomies (15.5%) compared to CT (0.8%) according to Meredith J.W. et al<sup>8</sup>. The greatest risk is the delay in time that CT adds to the performance of a needed laparotomy-Shoemaker et al<sup>9</sup>. Minor complications and false negative are also reported with DPL –Orwig DS<sup>10</sup>. Kane M. et al<sup>11</sup> pointed out that a post lavage CT leaves residual fluid or even air which makes a subsequent CT diagnosis difficult. Overall the CT results were inferior during the 1980s but have improved considerably in the 1990s due to

accumulation of experience and improvement of equipment. Recent reports suggest complementary roles for both CT and DPL i.e. CT for organ specific identification in the presence of a positive DPL-Baron B.J<sup>12</sup>.

### **ULTRASOUND SCANNING TECHNIQUE:**

Emergent sonography for trauma is performed simultaneously with physical assessment, resuscitation, and stabilization within minutes of a patient's arrival. The primary goals of this initial rapid examination are to detect hemoperitoneum and determine the need for immediate laparotomy. With this approach, the examination can be performed in approximately 5 minutes.

The patient is scanned in the supine position using a 3.5-MHz sector transducer (2 MHz for large patients) to allow intercostal scanning of the upper abdomen. The examination generally begins by checking for adequate bladder distention. If the bladder is empty, saline is injected through the indwelling Foley catheter. Because peritoneal fluid tends to accumulate in dependent areas, a systematic sequence then follows scanning the various peritoneal reflections to detect free intraperitoneal fluid as an indication of intra-abdominal injury. Hard copy documentation is obtained for both longitudinal and transverse planes of the right upper quadrant including the subphrenic space and Morison's pouch, left upper quadrant including the subphrenic and perisplenic areas, and the pelvis<sup>13</sup>.

A new scanning method called focused assessment with sonography for trauma (FAST) was devised with a primary objective of developing a procedure that could detect intraperitoneal fluid and could be used easily, after training for brief periods, by surgeons and emergency medicine physicians with limited experience in ultrasonography. Numerous reports have appeared in which the usefulness of FAST has been studied.

These scans are designed to look for free fluid in the pericardium, perihepatic area, perisplenic region, paracolic gutters & cul-de-sac. The urinary bladder is filled with saline before or during the scan to allow visualization of the cul-de-sac, solid organs are not evaluated for the evidence of injury – SS Lingawi<sup>14</sup>

Generally, such FAST examinations have been performed to detect free fluid in patients with abdominal trauma, and computed tomography (CT) has been performed to detect parenchymal injuries as well as free fluid. Hemodynamically stable patients with positive or indeterminate FAST results undergo CT scanning. Hemodynamically stable patients with negative FAST results are followed by clinical observation and repeated FAST to confirm the absence of injury because organ injuries are not necessarily accompanied by hemoperitoneum. In hemodynamically unstable patients, a positive FAST result leads to an emergency laparotomy, and an indeterminate FAST result leads to a diagnostic peritoneal lavage (DPL) or a CT scan. Abdomen distended with extensive bowel gas limits the usefulness of ultrasound according to Ivancev et al<sup>15</sup>.

Inaccuracy of USG in diagnosis of solid organ injuries was shown by Akgur F.M<sup>16</sup>. However its value in detecting hemoperitoneum was highlighted by Boulanger et al<sup>17</sup>. Liu M et al<sup>18</sup> reported low accuracy for USG (92.4%) against CT (96.4%).

Intravenous contrast opacification is accepted as it improves resolution of small lesions and some lesions are detected only on CECT according to Bulas et al<sup>19</sup>. Miyakawa et al<sup>20</sup> emphasizes the need for NECT prior to CECT since some lesions like high attenuation hematomas were observed to become inconspicuous in CECT. A R Padhani et al<sup>6</sup> series recommends dynamic study with 50ml bolus followed by 50-100 ml drip infusion. They also recommended bowel opacification.

While Federle et al<sup>21</sup> recommends oral contrast, Clancy T.V et al<sup>22</sup> found that omission of bowel opacification was not a disadvantage. Padhani et al<sup>23</sup> suggested that when examination is concentrated on abdomen the proportion of unsatisfactory studies were much lower. Hence there is no place for a 'poorly supervised quick look' at the abdomen following a cranial or thoracic study.

### **RECENT TRENDS:**

Brody AS et al<sup>24</sup> reports that Ultrafast CT has advantage over conventional CT mainly in the form of reduced respiratory and movement artifacts and improved accessibility for support personnel.

McGehee et al<sup>25</sup> in a series where CECT was compared with MRI in blunt injury abdomen reported T2 images were equal to CECT in judgment of extent and conspicuity of lesions where T1 and GRE were judged inferior. They concluded that no significant advantage exists over CT by MRI.

### **DISCUSSION:**

#### **LIVER TRAUMA:**

USG had detected 11 cases of trauma to the liver which is approx. 35% among all the organ injuries that were detected on USG and 22% among all cases of blunt injury to the abdomen in this study. CT had detected 15 cases of blunt injury to the abdomen, which is approx. 32% among all the organ 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 which is approx. 82% & 2 cases had grade II liver injury which is approx. 18%.

The injuries that were detected on CT were also graded there were 12 cases of grade I injury approx. 81%, 1 case of grade II injury approx. 6%, 1 case of grade III injury approx. 6% and one case of grade IV injury approx. 6%.

CT had detected three 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 IV 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 Sensitivity -73%, Specificity-100%.

**TABLE 1:GRADING OF HEPATIC TRAUMA-AMERICAN ASSOCIATION FOR THE SURGERY OF TRAUMA**

<b>GRADE</b>	<b>CRITERIA</b>
I	Capsular avulsion, Superficial laceration(s)(<1cm deep), subcapsular hematoma (<1cm thick), Isolated peritoneal hemorrhage or tracking.
II	Parenchymal laceration (s) 1-3cm deep, central/subcapsular hematoma(s) 1-3cm.
III	Laceration (s)>3cm. deep, central/Subcapsular hematoma(s) >3cm.
IV	Massive central or subcapsular hematoma (>10cm) Lobar destruction(maceration) or devascularisation.
V	Bilobar tissue destruction (maceration) or devascularisation.

**SPLenic TRAUMA:**

There were 7 cases of splenic trauma, which were detected on USG which is approx. 21% among all the organ injuries detected on USG and 14% among all the cases of blunt injury to the abdomen in this series. There were 9 cases of splenic trauma detected by CT, which was 19% among all the injuries that were detected on CT and 18% among all the cases of blunt injury to the abdomen in this series.

USG detected 3 cases of grade I injury which is approx. 43% of all splenic injuries that were detected on USG, 1 case of grade II injury which is approx. 14% and 3 case of grade III injury which is approx. 43% of all splenic injuries detected on USG. CT detected 4 cases of grade I injury which is approx. 44% of all splenic injuries detected on CT and 5 cases of grade III injury which is approx. 56% all splenic injuries detected on CT.

USG detected only 7 cases of splenic trauma where CT could detect 9 cases of splenic 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 was graded as grade II on USG was given a grade of III on CT. USG had sensitivity-78%, specificity-100%.

**TABLE 2: GRADING OF SPLEEN TRAUMA- AMERICAN ASSOCIATION FOR THE SURGERY OF TRAUMA**

GRADE	TYPE	CRITERIA
I	Hematoma	Subcapsular, less than 10% surface area
	Laceration	Capsular tear, less than 1 cm parenchyma depth
II	Hematoma	Subcapsular, 10% to 15% surface area; intraparenchymal less than 5cm in diameter
	Laceration	1 to 3 cm parenchymal depth; does not involve a trabecular vessel.
III	Hematoma	Subcapsular, > 50% surface area or expanding; ruptured subcapsular or parenchymal hematoma.
	Laceration	Greater than 3cm parenchymal depth or involved trabecular vessel.
IV	Laceration	Laceration involving segmental or hilar vessels & producing major devascularization
V	Laceration	Completely shattered spleen
	Vascular	Hilar vascular injury that devascularizes spleen.

**RENAL TRAUMA:**

There were 11 cases of renal trauma detected on USG which is approx. 35% among all organ injuries detected by USG and 22% among all the cases of blunt injury to the abdomen in this study. CT detected 14 cases of renal trauma which is approx. 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 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, 6 cases were of grade I which is approx. 54%, 4 cases were of grade III which is approx. 36% and 1 case of grade IV injury which is approx. 10%. Of the 14 cases that were detected on CT, 8 cases were of grade I which is approx. 57%, 4 cases were of grade III which is approx. 29%, 2 cases were of grade IV which is approx. 14%.



In this study CT detected 14 cases of renal trauma compared to USG which detected only 11 cases. Of the 3 additional cases detected on CT, 2 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-78.5%, specificity-100%.

**TABLE 3: GRADING OF RENAL TRAUMA- AMERICAN ASSOCIATION FOR THE SURGERY OF TRAUMA**

GRADE	DESCRIPTION
I	Renal contusion or subcapsularhaematoma with intact capsule
II	Superficial cortical laceration that does not involve the deep renal medulla or collecting system or nonexpanding perinephrichaematoma
III	Deep laceration(s) with or without extravasation of urine
IV	Lacerations extending into the collecting system with contained urine leak
V	Shattered kidney, renal vascular pedicle injury, devascularized kidney

**PANCREAS:**

In this study there was one case of injury to the pancreas which was detected on USG which is approx. 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 approx. 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. Being deep seated, pancreatic injury is usually associated with other visceral injuries. Traumatic injury to the pancreas needed no surgical intervention and was managed conservatively.

**URINARY BLADDER TRAUMA:**

There is only one case of urinary bladder trauma detected on USG which is 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 are missed on USG .The reason for this could be due to partially filled bladder and also CT CYSTOGRAPHY is done whenever there was a doubt on NECT.

However the incidence of urinary bladder trauma is 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%.

### **BOWEL INJURY:**

USG detected one case of bowel injury which is 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 is approx. 11% among all the 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 are missed on USG.

The overall incidence of bowel injuries is 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 agree with the usual pattern of involvement. In most of the cases accurate prediction of bowel injury is possible on CT based on pneumoperitoneum which should be searched for in lung window settings. Another associated finding is peritoneal fluid without any obvious solid organ injury.

Though accurate localization is not possible, pneumoperitoneum is found to be highly specific for bowel injuries in the form of perforation. Hemopneumoperitoneum adds to the evidence. Majority of cases are 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-16%, specificity-100%.

### **HEMOPERITONEUM AND HEMOPNEUMOPERITONEUM:**

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

Overall incidence in this series 62% (31). Hemoperitoneum is very common with liver, spleen and bowel injuries. Liver injuries were the most common source.CT diagnosis of hemoperitoneum is highly accurate with an average value of >30 HU. However values below this cannot be dismissed as absence of hemoperitoneum, since this is 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 is the source as were provided in three cases.

## RETROPERITONEAL HEMORRHAGE

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

## ABDOMINAL WALL INJURIES:

There is one case of parietal wall hematoma that is detected on both USG and CT. This is 2% of all the injuries detected on both CT and USG. Due to tenderness and appearance these are misleading in certain instances and are 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 agrees with Hill S.A. et al<sup>98</sup>.

**TABLE 4: INTRA ABDOMINAL ORGAN INJURY DISTRIBUTION DETECT BY USG**

Organ	No	% Among Organs	% IN Blunt Injury Abdomen
Liver	11	35%	22%
Spleen	7	21%	14%
Pancreas	1	3%	2%
Kidney	11	35%	22%
U. Bladder	1	3%	2%
Bowel	1	3%	2%
Hemoperitoneum	31	-	62%
Retro peritoneal hemorrhage	-	-	-
Parietal wall hematoma	1	-	2%

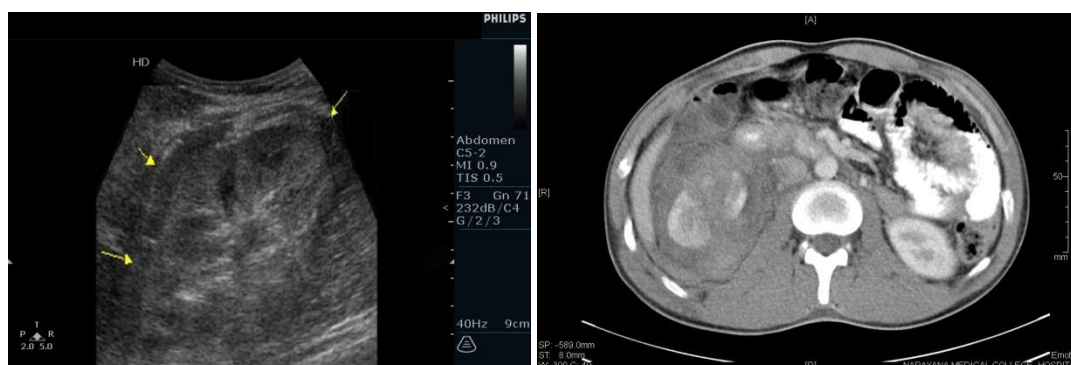
**TABLE 5: INTRA ABDOMINAL ORGAN INJURY DISTRIBUTION DETECT BY CT**

Organ	No	% Among Organs	% IN Blunt Injury Abdomen
Liver	15	32%	30%
Spleen	9	19%	18%

Pancreas	1	2%	2%
Kidney	14	30%	28%
Urinary Bladder	3	6%	6%
Bowel	5	11%	10%
Hemoperitoneum	31	0	62%
Retroperitoneal hemorrhage	2	0	4%
Parietal wall hematoma	1	0	2%

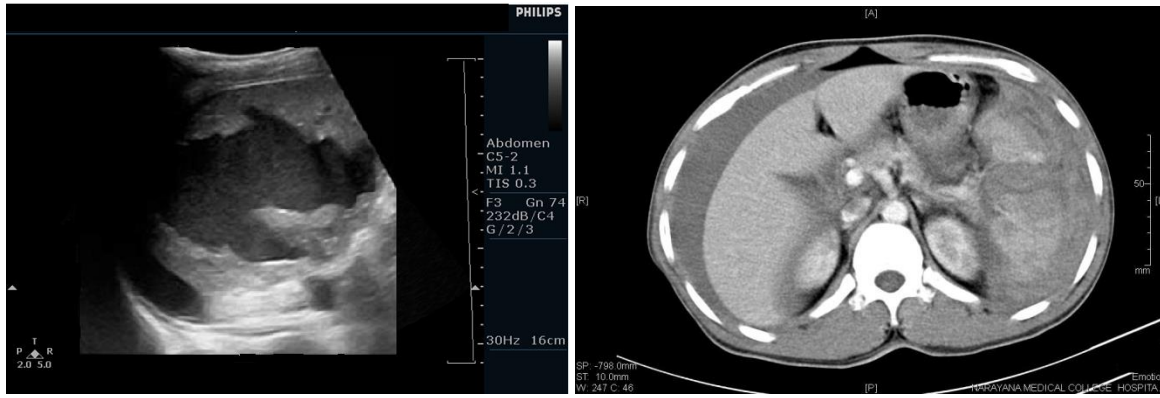


**FIG 1.USG and CT abdomen- showing gross amount of free fluid in patient with blunt injury abdomen**



**FIG 2.USG and CT abdomen showing Grade IV kidney laceration with large perinephric hematoma on right side in patient with blunt injury abdomen**

**Case 7 : USG and CT abdomen- showing gross amount of free fluid in patient with blunt injury abdomen**



**FIG 3.USG and CECT abdomen showing splenic laceration with perisplenic and perihepatic collection**

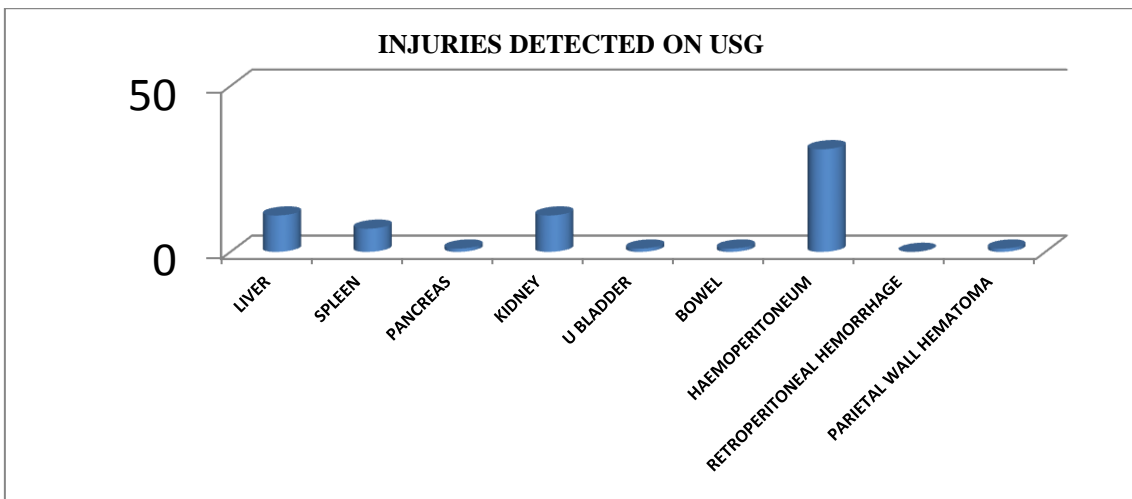


**FIG 4. USG and CECT abdomen showing pancreatic laceration with thin peripancreatic collection**

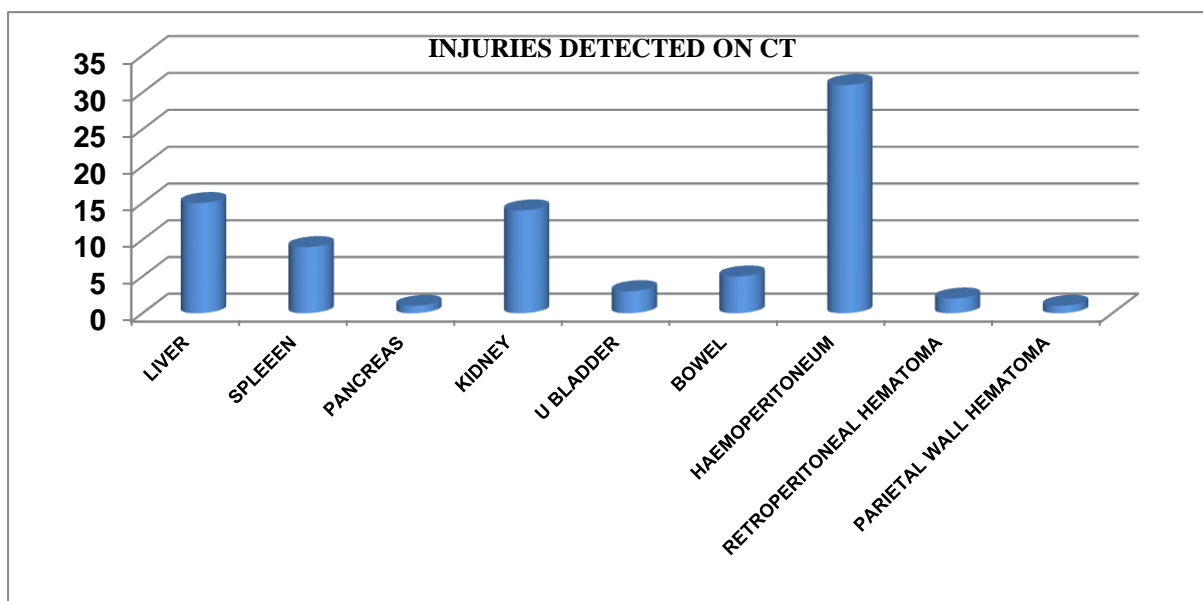
**OTHER INJURIES:**

CT also picks up spine fractures. It is particularly excellent in depicting pelvic fractures. Major central vessel injuries are 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.

**GRAPH 1: INJURIES DETECTED ON ULTRASOUND**



## GRAPH 2: INJURIES DETECTED ON CT



### CONCLUSION:

CT is a superior diagnostic modality in the diagnosis of abdominal trauma. USG can be a valuable initial investigation. 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 USG scans and in patients with suboptimal USG scans. It appears that asymptomatic patients with normal clinical examination and USG scans can be followed up without CT scan or indoor admission, restricting CT for USG positives, USG negative symptomatics and unsatisfactory USG examinations.

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