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ORIGINAL ARTICLE

COMPARATIVE STUDY OF ULTRASOUND AND COMPUTED TOMOGRAPHY IN THE EVALUATION OF ABDOMINAL TRAUMA

G. V. Prasad[1], A. Sarvottam[2], Ranadheer Singh[3]

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ABSTRACT: BACKGROUND AND OBJECTIVE: The role of imaging in abdominal trauma is to rapidly and reliably determine the presence or absence of intra-abdominal injury and to triage the patients for appropriate management as trauma is a time sensitive malady. Ultrasonography (US) and computed tomography (CT) have found an increasingly important role in the evaluation of abdominal trauma. The present study was to done to compare the relative roles of ultrasound and computed tomography in the evaluation of trauma and to effectively use these modalities in appropriate settings. **METHODOLOGY:** Patients presenting at the casualty department of SVRR Govt. General Hospital, following injury and suspected to have abdominal trauma were investigated. Forty three patients who were stable to undergo both US and CT examination and had at least one of these studies interpreted as positive were included in this study. US scans were performed to detect presence of free fluid in the abdomen and pelvis, in addition to assessment of individual organs. Contrast enhanced CT scans was performed. Free fluid with attenuation value >30 Hounsfield Units (HU) was labeled as hemoperitoneum. Patients undergoing conservative management were clinically followed up. Surgical findings were noted in those undergoing laparotomy. The outcome of surgical or conservative management was correlated with US and CT findings and the overall imaging findings were analyzed for their role in guiding the therapeutic options. Sensitivity, specificity, and accuracy of US and CT were calculated. **RESULTS:** Out of the total 43 patients, in 27 patients US and CT showed similar findings. In 40 patients US showed either intra-abdominal free fluid or organ injury or both. In three patients US did not reveal any abnormality. Two of these had retroperitoneal hematomas and one had bowel injury. These injuries were later detected on CT. US had an overall sensitivity of 93%, specificity of 100% and accuracy of 93%. US detection of free fluid intraperitoneal fluid had a sensitivity of 92.6%, specificity of 100% and an accuracy of 97%. A total of 23 patients had surgical management including two cases of non-therapeutic laparotomy. The remaining 20 were managed conservatively. Of the two patients without any detectable fluid on US or CT, one was treated surgically for traumatic small bowel hernia and the other patient was treated conservatively for retroperitoneal hematoma. In 9 patients CT detected additional finding or provided additional information but did not change the management. In 7 patients CT was decisive for management or surgical planning. **INTERPRETATION AND CONCLUSION:** Based on our study and on reviewing the literature, we can conclude that US is a valuable initial modality in patients with abdominal trauma. CT is required in most US positive patients to delineate the exact extent of injury and to exclude any other significant injuries. Symptomatic patients should have a CT even if US is negative. Serious intra-abdominal injury is unlikely in the group with normal US and a normal abdominal examination, and CT may be avoided in this group

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of patients during initial work-up. Any deterioration or subsequent abnormality should lead to further work-up.

KEYWORDS: Abdominal trauma, Ultrasound, Computed tomography**.**

INTRODUCTION: Trauma can be aptly labeled as an 'unsolved epidemic' of modern society. Estimated loss of life from trauma equals that from cardiovascular disease and cancer combined. In fact trauma is the leading cause of death in people younger than 40 years. Trauma is a 'time sensitive disease'. Prevalence of intra-abdominal injury varies widely, ranging from 7.7% to 65%. Clinical examination does not always provide enough information about the extent of abdominal injuries. Therefore, a diagnostic tool is needed that rapidly and reliably determines the presence or absence of intra-abdominal injuries.

Ultrasonography for blunt abdominal trauma was first described in1971, and it is currently the primary screening examination for blunt abdominal trauma in most trauma centers. Its main application is the detection of free abdominal fluid, and it plays an important role in the evaluation of pleural and pericardial fluid. Focused assessment sonography in trauma (FAST), is limited to evaluation for free intra-abdominal fluid, without organ assessment. This method is regarded as a rapid diagnostic examination in the triage of victims of blunt abdominal trauma that can lead to a reduction in the number of abdomino-pelvic computed tomographic (CT) and deep peritoneal lavage procedures performed. The advantages of US are: It is non-ionizing, non-invasive, relatively inexpensive, portable, rapid and accurate in excluding intra peritoneal fluid without interrupting resuscitation and does not require shifting the patient out of the trauma resuscitation area.

The introduction of CT following US has been hailed as a major advance in trauma care. In a hemodynamically stable patient a single test, i.e. CT enables global evaluation of abdomen and retroperitoneum, gives functional status of kidneys and detects associated skeletal injuries. CT by its localizing nature helps in deciding surgical approach or conservative management in appropriate clinical setting. CT is however relatively insensitive to early detection of intestinal, mesenteric and pancreatic injury. The need to shift a potentially unstable out of the trauma care area, the time required to prepare the patient, and limited availability are its main disadvantages.
The purpose of our study is to evaluate the role of US and CT for the depiction of organ injury indirectly (by means of analysis of free fluid) and directly (including parenchymal analysis) in patients with blunt abdominal trauma, and compare the findings of these two frequently used modalities so that their optimal use can be maximised.

AIMS AND OBJECTIVES:

- To assess the relative role of US and CT in evaluation of patients with abdominal trauma.
- To evaluate the common causes of blunt abdominal trauma.
- To evaluate the role of imaging in the management of trauma.

METHODOLOGY: Patients presenting at the casualty department of SVRR Govt. General Hospital, following injury and suspected to have abdominal trauma were investigated. The time, cause and mode of injury was obtained whenever possible. Forty three patients who were stable

to undergo both US and CT examination and had at least one of these studies interpreted as positive were included in this study. Whenever possible, US preceded CT and the time gap between the two studies was kept to the minimum to make the studies comparable. Both US and CT scans were performed in all 43 patients. Diagnostic peritoneal tapping was performed in all the patients with free fluid to confirm the presence of hemoperitoneum.

ULTRASONOGRAPHY: US scans were performed on "ESOATE My Lab 50" machine, with 2.5-6.5 and 7.5-12 Mhz curvilinear and linear probes. Particular attention was paid to the detection of free fluid in the abdomen and pelvis, in addition to assessment of individual Organs. Visceral organs were evaluated for parenchymal abnormalities consisting of intraparenchymal masses, hematomas, lacerations, and/or geographic zones of echotextural heterogeneity.

CT TECHNIQUE: CT scans were performed on; "TOSHIBA ASTEION S4" helical sub second (0.75 Sec) scanner. Helical CT of the entire abdomen was done from the level of dome of diaphragm upto the inferior aspect of ischium.

Scan Parameters & Technique:

Slice Collimation	7mm.
Table Speed	7mm/sec.
Pitch	1:1.
KV	120.
MA	180-240.

Images were reconstructed at 5 mm intervals using standard reconstruction kernel and 180 degrees linear interpolation.

Contrast Material: Routine oral contrast was not given to the patients. All patients received IV contrast material administered with an automated Medrad Power Injector after the initial pilot scan via a large-bore (18-20 G) peripheral venous line. A total of 120 ml, 60% non -ionic iodinated contrast was given intravenously at a rate of 2-4 ml per second. Scanning was initiated 70-90 seconds after the start of contrast infusion. Delayed CT scans were also incorporated whenever there was suspicion of kidney or urinary tract injury. Lung and bone window exposures were also obtained in addition to standard soft tissue window whenever required. Free fluid with attenuation value > 30 Hounsfield Units (HU) was labeled as hemoperitoneum. Follow up US or CT scans were obtained as dictated by the clinical course of the patients.

Patients undergoing conservative management were clinically followed up. Surgical findings were noted from the operative notes in those undergoing laparotomy. Injury to different organs was staged by organ injury scaling (OIS) system developed by Organ Injury Scaling Committee of the American Association for the Surgery of Trauma (AAST), Moore et al. (1995). Hemoperitoneum detected on US was scored as described by Huang et al.

Similarly hemoperitoneum on CT was graded as described by Federle and Jeffrey et al. The outcome of surgical or conservative management was correlated with US and CT findings and the overall imaging findings were analyzed for their role in guiding the therapeutic options. Sensitivity, specificity, and accuracy of US and CT were calculated.

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Scoring System to Estimate the Amount of Intra-abdominal Free Fluid on US followed in this study.

Site	Quantity	Points
Morison's pouch	Significant*	2
	Minimal+	1
Douglas's pouch	Significant*	2
	Minimal+	1
Perisplenic space		1
Paracolic gutter		1
Floating intestinal loops		2

Table 1

*More than 2 mm of free fluid✞ Less than or equal to 2 mm of free fluid Intra–abdominal free fluid is at least 1000 ml, when US score > 3.

Scoring System to Estimate the Amount of Intra-abdominal Free Fluid on CT followed in this study.

Location of hemoperitoneum.

1. Perisplenic space.
2. Perihepatic space.
3. Morison's pouch.
4. Left paracolic gutter.
5. Cul-de-sac of pelvis.

Estimates	Approximate Amount	Description
1. Small	(100-200 ml)	Fluid in only one space
2. Moderate	(250-500 ml)	Fluid in two or more spaces
3. Large	(>500 ml)	All spaces are well distended with fluid or Pelvic fluid extends anterior superior to bladder

Table 2

OBSERVATION AND RESULTS: Forty-three patients with a history of abdominal trauma were evaluated by both US and CT.

Age and sex distribution is as shown below:

Age group	No. of patients	Males	Females	Percentage
0-12	02	02	0	4.6%
13-20	08	08	0	18.6%
21-30	14	12	2	32.6%
31-40	13	11	2	30.2%

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41-50	03	03	0	7%
51-60	02	01	1	4.6%
61-70	01	01	0	2.3%

Table 3

The following table shows the cause of injury:

Mode of trauma	No. of patients	Percentage
Road traffic accidents	28	65%
Fall from height	10	23.2%
Assault	5	11.6%

Table 4

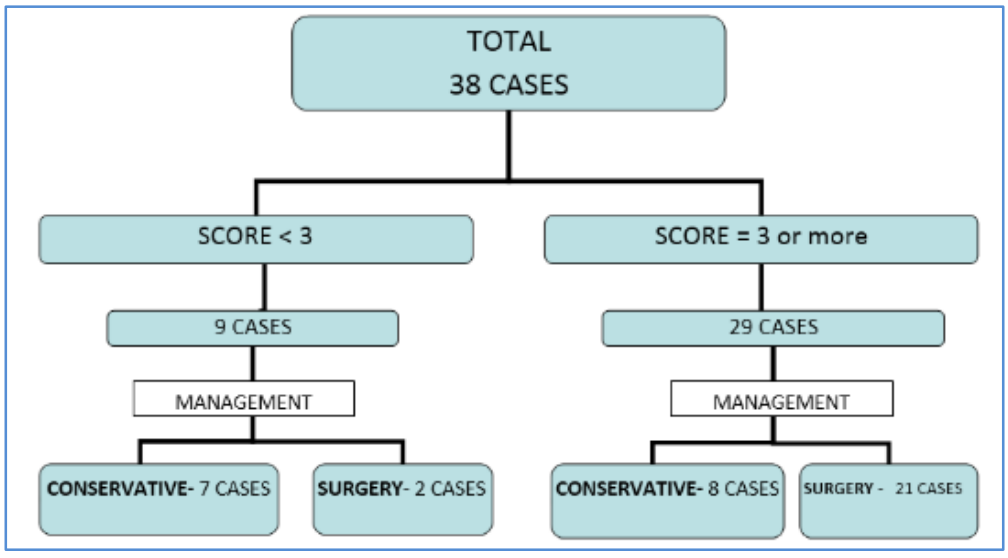
Hemoperitoneum detected on US was scored according to the scoring system developed by Huang et al. (1994).[1] In the group with US score less than 3, only two out of nine patients required a therapeutic laparotomy, that is 22% probability of needing a laparotomy. In contrast twenty-one out of twenty-nine required operative management i.e. 72.4% probability of needing a laparotomy in the other group with US score 3 or more.

Forty-one patients detected to have hemoperitoneum on CT were classified as small (n=9), moderate (n=21), and large (n=11), according to the system described by Federle and Jeffrey. Outcome of these three groups was analyzed.

Eight out of nine patients with 'small' free fluid on CT were successfully managed conservatively and all eleven patients with 'large' free fluid were surgically managed. Eleven out of twenty-one patients with 'moderate' free fluid were surgically managed. The rate of laparotomy in this group with 'moderate' fluid was 52.3%.

US detection of free fluid intraperitoneal fluid thus had a sensitivity of 92.6%, specificity of 100% and an accuracy of 97%.

Outcome of patients with suspected hemoperitoneum on US:



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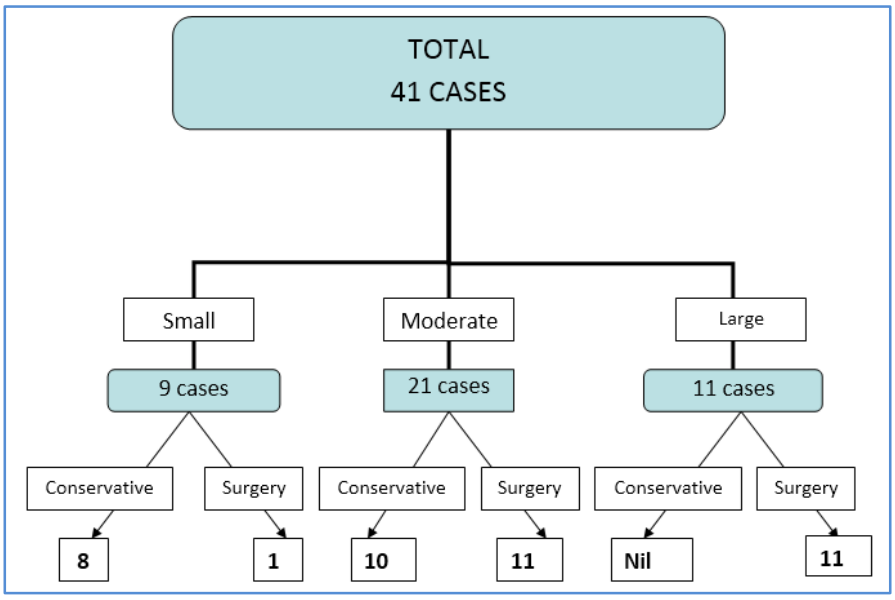

A total of 23 patients had surgical management including two cases of non-therapeutic laparotomy. The remaining 20 were managed conservatively. Of the two patients without any detectable fluid on US or CT, one was treated surgically for traumatic small bowel hernia and the other patient was treated conservatively for retroperitoneal hematoma.

ORGAN INJURIES: Distribution of organ injuries.

Organ	No. of Patients	Percentage
Spleen	14	32.5%
Liver	13	30.2%
Kidneys	08	18.6%
Bowel and mesentery	12	28%
Pancreas	02	4.6%
Urinary bladder	01	2.3%
Diaphragm	02	4.6%

Table 5

Note: The number of patients is more because some showed multi-organ injuries.

Thirteen patients had multiorgan injuries. Individual organ injuries were graded according to Organ Injury Scaling (OIS) system (Moore et al[2]., 1995), which is an amalgamation of radiological, surgical and pathological correlates.

Out of the total 43 patients, in 27 patients US and CT showed similar findings. In 9 patients CT detected additional finding or provided additional information but did not change the management. In 7 patients CT was decisive for management or surgical planning. However in all of them US showed the presence of free fluid.

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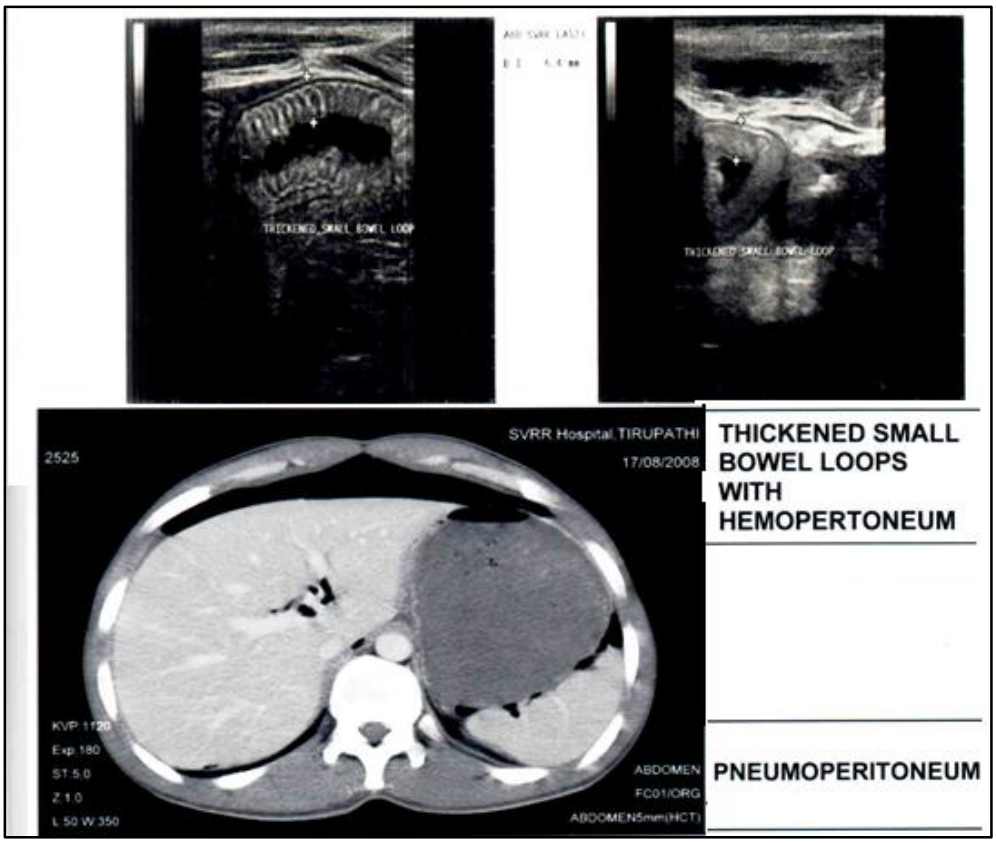
In 40 patients US showed either intra-abdominal free fluid or organ injury or both. In three patients US did not reveal any abnormality. Two of these had retroperitoneal hematomas and one had bowel injury. These injuries were later detected on CT. US had an overall sensitivity of 93%, specificity of 100% and accuracy of 93%.

Organ injury	Ultrasound		
	Sensitivity	Specificity	Accuracy
Spleen	83%	100%	95%
Liver	84%	100%	95%
Kidneys	62.5%	100%	93%
Bowel and mesentery	58%	100%	88%

Table 6

CT detected either intra-abdominal free fluid or organ injury or both in all the patients and thus showed an overall sensitivity, specificity and accuracy of 100%. CT showed distinct advantage in patients with overlying subcutaneous emphysema which prevented normal visualization of underlying structures on US. Both these patients had splenic injuries. CT was useful in detecting associated injuries such as pneumothorax, lung contusions, rib and vertebral fractures, thereby providing additional information in guiding the initial mode of management of such patients.



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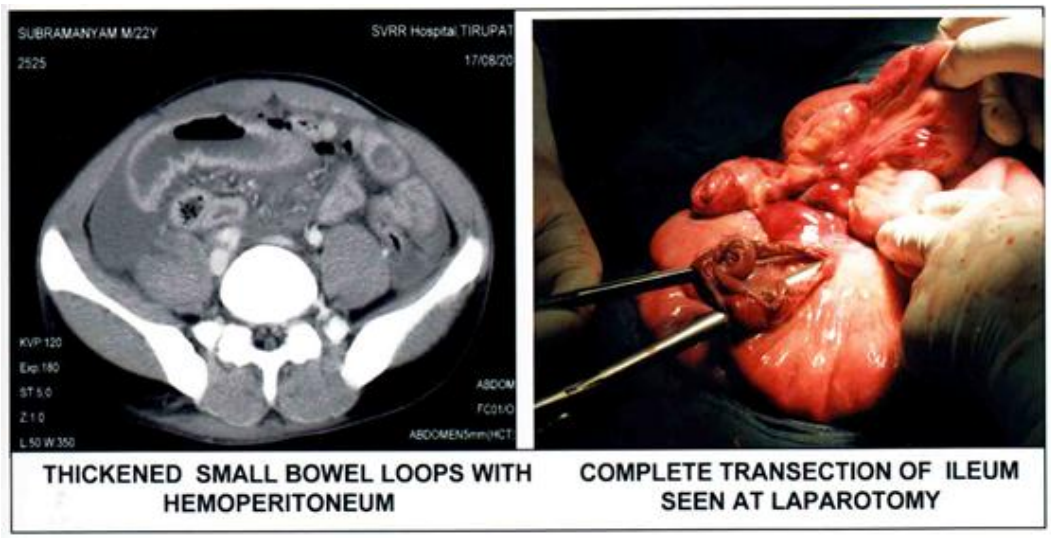

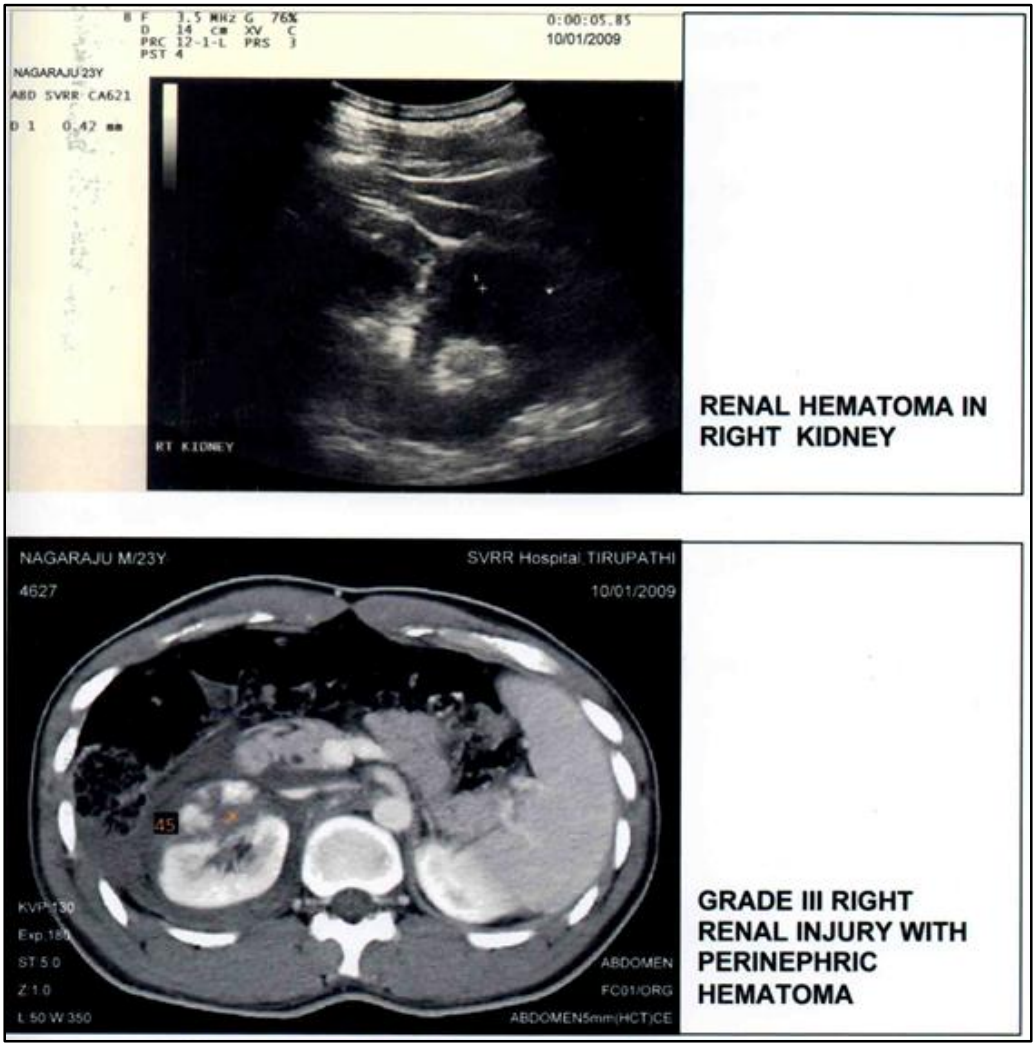

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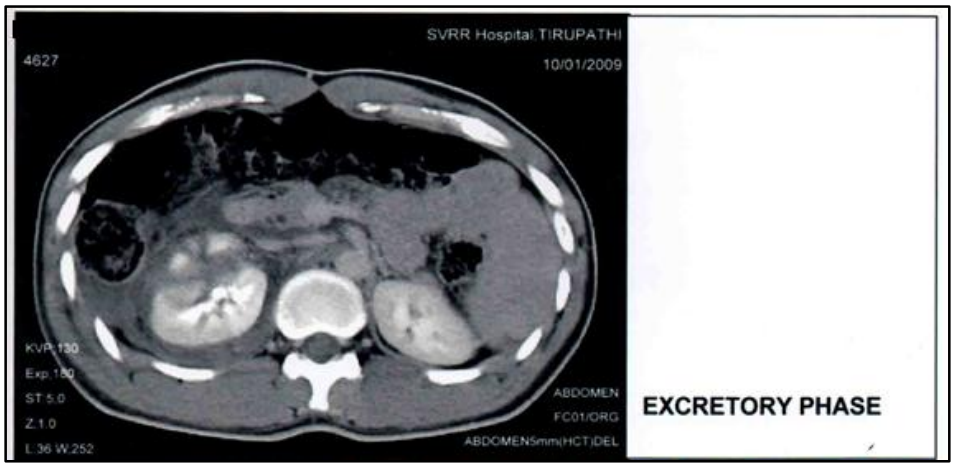

DISCUSSION:

In most studies, the major mechanisms of injury are road traffic accidents (RTA), followed by fall[3] In the present study RTA accounted for 65% of injuries and 23% of patients sustained injuries due to fall from height. The prevalence of trauma was more in males (88.3%) as reported in earlier studies.

Hemoperitoneum is cited to be the most frequent sign of abdominal injury. Out of the total 43 patients in our study, hemoperitoneum was detected in 41 patients on CT (95.3%). Thirty-eight cases were detected on us. US thus had a sensitivity of 92.6%, specificity of 100% and an accuracy of 97% in the detection of hemoperitoneum.

Most of the studies show a high specificity of US in the detection of intraperitoneal free fluid. The results in our study are similar to that of Mallik et al.(2000).

References	Year	Sensitivity	Specificity	Diagnostic Reference
Shackford et al[4]	1999	69%	98%	Laparotomy, DPL, CT, Observation
Mallik et al.	2000	90%	100%	Laparotomy, Observation
Kirkpatrick et al[5]	2005	77%	99%	CT, laparotomy, serial examinations
Brenchley et al.[6]	2006	78%	99%	DPL, laparotomy, CT, autopsy

Comparision of Free Intraperitoneal Fluid Detection on US by Various Studies

US could correctly detect the source of hemoperitoneum in 27 out of 38 patients with free fluid on US (71%). CT detected the source of hemoperitoneum in all but two of the 41 patients (sensitivity of 95%). Both patients had a small mesenteric tear detected on surgery.

SPLEEN: Spleen is the most common intra-abdominal organ injured in blunt abdominal trauma. Splenic injuries account for about 40% of all intra-abdominal injuries. The presence of pulp tissue and poorly developed mesenchymal supporting structure predisposes spleen to injury. In our study spleen was the commonest organ injured with an incidence of 32%.

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On US, the specificity of 100% in our study is similar to that found by Mallik et al[3](100%). However, our study had a higher sensitivity of 83% compared with 73% in their study. Asher et al[1]. Showed a sensitivity of 80% in their study of splenic injuries on US. In our study two patients were falsely negative on US. Out of the two false negative cases, one patient had injury to the left hemidiaphragm and one case had a small wedge shaped subcapsular hematoma in the upper pole of spleen which was later detected on CT. All the patients had intra-abdominal free fluid on US.

All the 14 patients of splenic injuries were correctly diagnosed by CT including two patients in whom US visualization of spleen was not possible due to overlying surgical emphysema. There were no cases of false-positive splenic injury either on US or on CT.

LIVER: The liver is the second most frequently injured organ in blunt abdominal trauma, and the most common abdominal injury leading to death. Liver was the second most frequently injured organ in our study with an incidence of 30%. On US the sensitivity, specificity and accuracy were 84%, 100% and 95%. It has been observed that US is better at diagnosing liver injuries compared to splenic injuries. Goletti et al.[7] also found 80% sensitivity and 100% specificity in diagnosing liver injuries. Mallik et al.[3] retrospectively diagnosed' all cases of liver injury on US in their study. It was observed that injuries located near dome of diaphragm in right lobe of liver may be difficult to locate.

CT showed good depiction of liver injuries in all of the 13 patients and all of them were managed conservatively.

KIDNEYS: The third commonest injured organ was the kidney (18%). The US detection of renal injury had a sensitivity, specificity and accuracy of 62.5%, 100% and 93%. The specificity and accuracy are comparable to previous studies done by Mallik et al.[3] who reported a sensitivity of 67%, 100% and 100%. Both the kidneys were injured in one patient and it was accurately detected on both US and CT.

CT diagnosed all the cases correctly in addition to accurately showing the extent of injury in all cases. All the cases which were false negative on US were managed conservatively. Seven out of eight patients with kidney injury had multi-organ injuries. Spleen was the most frequently associated organ injured followed by the liver. Hepatic injury was often localized to segments V and VI. In one patient with right kidney injury which was not visualized on US, an associated injury involving the head of pancreas and pneumoperitoneum due to perforation of hepatic flexure was detected on CT.

PANCREAS: Pancreatic injuries are not common in abdominal trauma; they account for 3-12% of all abdominal injuries. There were two patients with pancreatic injury in our study (4.5%). US was able to detect free fluid in both the patients but in neither of these, pancreas could be visualized on US. In one patient free fluid was seen in the Morison's pouch with an associated hepatic injury. In the other patient free fluid was noted in all spaces with dilated bowel loops secondary to perforation of hepatic flexure of colon. An associated right renal injury, was detected on CT. Both these patients were correctly diagnosed on CT. One of the two patients

showed linear hypodensity at the junction of head and neck of pancreas. The other patient showed hypodensity within the head of pancreas.

The difficulty in US and CT diagnosis of pancreatic injury has been observed by other authors also. Because of delay in appearance of signs, a second CT in 12-24 hours has been advocated when the possibility of pancreatic trauma persists despite an initial normal CT.

BOWEL: Bowel injuries are reported to occur in 3% to 5% of blunt trauma cases. Our study showed an incidence of 28%. Several studies have reported high accuracy of CT in detecting bowel injuries. Our study showed an accuracy of 97% for CT. Current studies report sensitivities of CT for the diagnosis of bowel and mesenteric injuries ranging from 64% to 96%. Our study showed a sensitivity of 66% with US and 91.6% with CT. These results are comparable to the study of Joshua W. Stuhlfaut et al[9] who reported a sensitivity of 82%, specificity of 99%, positive predictive value of 64% and negative predictive value of 99% with multi-detector row CT for identification of bowel or mesenteric injury without the use of oral contrast.

In a study reported by Liu et al.[9] CT missed only one of the seven bowel injuries whereas as many as three were missed on US. They concluded that in the context of organ injuries, overall, CT and US had a similar sensitivity, specificity and accuracy but differed mainly in respect of detection of isolated small bowel perforation and retroperitoneal hematomas.

BLADDER: The single patient of bladder rupture in our study could be detected on CT. CT showed extavasation of contrast from the bladder on delayed images. Most authors have observed that CT was more sensitive than cystography in detection of small amount of contrast extravasation and simply clamping the Foley's catheter before starting the scan may be adequate for all significant injuries. In the single patient in our study with a 1.5cm sagittal laceration in the posterior wall, extravasation was seen through the small laceration (grade II) from the collapsed bladder with clamped Foley's catheter.

DIAPHRAGM: Diaphragm rupture occurs in approximately 5% of patients with blunt abdominal trauma and 65% to 85% of diaphragmatic ruptures are on the left side. There were two patients with diaphragmatic injuries involving the left hemi-diaphragm (4.5%). On US, in one patient bowel loops were visualized in the thorax whereas in the other patient associated subcutaneous emphysema due to rib fractures prevented visualization of underlying structures. Both these patients were correctly diagnosed on CT. Both patients· had associated injuries to the spleen which were missed on US.

RETROPERITONEAL HEMATOMAS: In our study 10 patients had retroperitoneal hematomas. Seven patients had retroperitoneal hematoma associated with pelvic fractures. Four out the seven retroperitoneal hematomas were detected on US. Three patients had retroperitoneal hematoma in the absence of pelvic fracture which was detected on CT in two patients and on both US and CT in the other. Liu et al.[9] detected three out of six retroperitoneal hematomas on US and all six on CT in their study. Mallik et al.[3] reported that in their study, out of five patients with pelvic

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fractures three had retroperitoneal hematoma on CT whereas US could not detect even a single case. CT detected all the retroperitoneal hematomas correctly in our study.

References	Year	Sensitivity	Specificity	Diagnostic Reference
Lingawi et al[10]	2000	94%	98%	CT, US observation
Richards et al[11]	2004	69%	98%	Laparotomy, DPL, CT
Nural et al	2005	87%	95%	CT, DPL, laparotomy
Atif et al	2008	93%	85%	CT

Comparision of Results of US in Different Studies in Patients with Abdominal Trauma

Taking free intra-peritoneal fluid or organ injury or both as positive, the overall sensitivity, specificity and accuracy of US was 93%, 100% and 93%. This is similar to other studies, describing US as a valuable modality.

The presence of free fluid in the abdomen is one of the frequent markers of significant intra-abdominal injury. However unlike Huang et al.[1] in our study the decision for laparotomy was based on clinical assessment and overall imaging work-up.

In our study, in the group with scores less than 3, only 22% required therapeutic laparotomy, whereas in the group with scores 3 or more, 72% required therapeutic laparotomy. These figures are significantly different from the corresponding figures of 38% and 96% found by Huang et al.[1] This could be due to several factors.

- Firstly, the patients with 3 or more scores on US were subjected to routine laparotomy by Huang et al[1].
- Secondly, it is known that parenchymal bleeds from liver or spleen , especially the former, frequently stops spontaneously and may be conservatively managed even with moderate to large hemoperitoneum.

Our study shows that scores of less than 3 have very high chance of being amenable to conservative treatment. Although a significant number of patients even with 3 or more scores may be managed conservatively, the majority will require surgery. As US cannot differentiate hemoperitoneum from urine, bile or enteric fluid, it has been suggested that US guided aspiration of fluid may lead to detection of unsuspected bladder, biliary or bowel injuries which are not usually detected on US.[7] In our study as many as 8 out of 29(27.5%) patients with scores more than 3 were managed conservatively based on their hemodynamic status. This validates the frequent observations made by several workers that the hemodynamic stability is the main consideration in deciding the approach.

We have quantified free intraperitoneal fluid detected on CT into small, moderate and large according to Federle and Jeffrey system,[12] We found a very good correlation with the ultimate therapeutic outcome. All the patients showing large collections needed operative management and all but one patient with small collection were managed conservatively. Half of the patients with moderate free fluid underwent exploration and the rest could be managed conservatively.

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Two patients in our study did not have free fluid either on US or CT. One patient was treated surgically for traumatic abdominal wall hernia and the other patient was managed conservatively for retroperitoneal hematoma.

The rate of non-therapeutic laparotomy is an important yardstick of the effectiveness of various diagnostic modalities. Goletti et al.[7] reported an incidence of 2.4% (1 in 43) of non-therapeutic laparotomy. Mallik et al.[3] have reported an incidence of 8.5% (1 in 12 patients). Other authors have reported an incidence of 0.8% to 15.4% of non-therapeutic laparotomies compared to the rate of 8.3% (2 in 24 patients) in our study. A reduction in the incidence of non-therapeutic laparotomy should be one of the goals of imaging to avoid associated morbidity from an unnecessary laparotomy. However "an unnecessary laparotomy is preferable to an undiagnosed critical injury".[11]

In 28 patients (65%) in our study, similar findings were observed both on US and CT. In 11 patients (25%) CT detected additional finding or provided additional information but did not change the management. In 4 patients (9.3%) out of a total of 43, CT was decisive for management planning. In two patients bowel injury was diagnosed on CT. In one patient it detected the source of free fluid which led to surgical intervention. In yet another patient CT influenced the extent of surgery by detecting additional lesions (renal injury). If US would have been the only modality used in our patients, the 15 false negative results in our study would have led to 4 cases of missed injuries requiring surgery (11 cases were conservatively managed). Significant hemoperitoneum was not however missed on US. The missed injuries were four splenic, one liver, two pancreatic, four renal injuries, two bowel and mesenteric injuries, one diaphragmatic injury and bladder injury and two retroperitoneal hematoma. (Note: the no. of organs injured is more because some patients showed multi-organ injuries.)

Different workers have tried to predict the need for surgical management based on the grades of organ injury. In our study there was a relatively good correlation of CT grades of splenic injuries with the need for surgical or conservative management. All the patients with grade I injuries were managed conservatively. One patient with grade II injury required surgery because of multi-organ injury and all the patients with grade III and IV injuries required surgery. Regarding liver injuries all the patients (grade I to III) were managed conservatively. This is in agreement with the observations made by Boone et al.[13] (1995) that major hepatic injury can be usually managed without surgery In hemodynamically stable patients. The grading of renal injuries was not helpful in predicting the outcome in our study.

CONCLUSION: Finally based on our study and on reviewing the literature, following conclusions could be drawn: -

- US is a valuable initial modality for evaluation of patients with abdominal trauma.
- CT is required in most US positive patients to delineate the exact extent of injury and to exclude any other significant injuries. Also, in a small but significant group CT may change the management approach.
- Symptomatic patients or patients with unexplained findings should have a CT even if US is negative.

- Inadequate US evaluation in the presence of gaseous distension or overlying surgical emphysema should be followed by CT.
- Serious intra-abdominal injury is unlikely in the group with normal US and a normal abdominal examination, and CT may be avoided in this group of patients during initial work-up. Any deterioration or subsequent abnormality should lead to further work-up.

US or CT quantification of hemoperitoneum or grading of injury does not always dictate whether the management should be conservative or surgical. However they reflect the severity of injury and injuries of severe grade with large free fluid are more likely to require a laparotomy.

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AUTHORS:

1. G. V. Prasad
2. A. Sarvottam
3. Ranadheer Singh

PARTICULARS OF CONTRIBUTORS:

1. Associate Professor, Department of Radiology, S. V. Medical College.
2. Resident, Department of Radiology, S. V. Medical College.
3. Resident, Department of Radiology, S. V. Medical College.

NAME ADDRESS EMAIL ID OF THE CORRESPONDING AUTHOR:

Dr. G. V. Prasad,
Flat No. 201, V. V. Plaza,
Reddy and Reddy Colony,
Tirupathi-517501,
Andhra Pradesh.
E-mail: g_v789@yahoo.com

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