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ORIGINAL ARTICLE

COMPARATIVE ROLE AND EVALUATION OF ULTRASOUND AND MULTISLICE COMPUTED TOMOGRAPHY IN THE GRADING OF HEMOPERITONEUM IN PATIENTS WITH ACUTE BLUNT ABDOMINAL TRAUMA AND ITS CORRELATION WITH THE GRADING OF ORGAN INJURY

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ABSTRACT: AIMS AND OBJECTIVES: 1. To assess the role of Ultrasound (US) and Multislice Computed Tomography (MSCT) in detecting hemoperitoneum in patients with acute blunt abdominal trauma. 2. To study the use of US and MSCT in grading of hemoperitoneum in blunt abdominal trauma patients. 3. To compare the US and MSCT grading of hemoperitoneum with the grading of organ injury.4. To compare and statistically analyze the spectrum of findings observed in each modality. **MATERIAL AND METHODS:** The study was conducted at advanced diagnostics and institute of imaging, Amritsar. The study comprised of 50 patients who were stable enough to undergo both US and CT scans.US was preceded by MSCT in most of the patients and the time gap between the imaging modalities was less than 1 hour to make the study comparable. **TECHNIQUES ADOPTED:** 1. US was performed on Versa plus (Siemens) and Xario (Toshiba) with Cardiac, 3.5-5 Mhz-Convex and 5-7.5 Mhz-Linear probes. Particular attention was paid to the amount of free fluid in the abdomen and pelvis. 2. MSCT was performed with MSCT Volume Zoom (Siemens Forchheim Germany AG). 500-1000cc of water orally or through nasogastric tube was given 15-20 minutes before the study, followed by 120cc I/V contrast at the rate of 2-3ml/second using power injector. Parameters used: Single breath hold; A. 165 mAs. B. 120 kvp. C. Scan delay-40 seconds. D. Collimation-4x2.5mm. E. Pitch-5mm. Following findings were observed: a. Presence of peritoneal fluid. B. Any tear or hematoma in the solid abdominal organs like spleen and liver. C. Status of hollow viscera like small bowel, large bowel and urinary bladder. Hemoperitoneum was scored on both US and MSCT. Visceral injuries were graded according to O.I.S grading system. Score was correlated with the underlying organ injury and the management of the patient. US scoring (Table A) and MSCT quantification of hemoperitoneum was done. (Table B) Location of hemoperitoneum. A. Perisplenic space. B. Perihepatic space. C. Morison's pouch. D. Left paracolic gutter. E. Cul-de-sac in pelvis. Data analysis was done using stasticial package (Analyse it Leeds U.K.). Sensitivity and specificity of each modality was observed along with cost analysis. Chi square test was performed to determine the statistical significance of the above results followed by ROC analysis to compare the sensitivity and specificity of both the modalities.

KEYWORDS: US, MSCT, Hemoperitoneum.

INTRODUCTION: One of the big challenges facing the emergency room medical team is how to establish non-invasively the presence and extent of internal injury in a patient presenting with blunt abdominal trauma. Evaluating patients with blunt abdominal trauma (BAT) remains one of the most challenging and resource-intensive aspects of acute trauma care. Missed intra-abdominal injuries continue to cause preventable deaths. Physical examination findings are notoriously unreliable for several reasons; a few examples are the presence of distracting injuries, an altered mental state and drug and alcohol intoxication in the patient.[1]

US is a rapid, repeatable, readily accessible modality, easily integrated into the resuscitation of patients with trauma without a delay of therapeutic measures especially in hemodynamically unstable patients.[2] It is now the primary examination used in several trauma centers. Unlike diagnostic peritoneal lavage, US is noninvasive and has no associated morbidity.

There has been a learning curve within the literature, and this examination has changed appropriately. The main focus of the examination has been on detection of free fluid within the abdomen of patients with acute trauma. One original description of the use of US in BAT was to obtain a single view of the Morrison pouch to detect free fluid.[3] However, that examination has been abandoned in favor of a more comprehensive examination, which has been well described in the literature.[4] This examination has been named Focused Abdominal Sonography for Trauma (FAST).[5]

FAST usually includes US of the right upper quadrant, including the hepatorenal fossa, the left upper quadrant, including the perisplenic region; the right and left paracolic gutters, and the pelvis, performed to detect free fluid. Free fluid will gravitate to the most dependent portion of the pelvis and as such, free fluid in the pelvis may be missed if the patient has an empty bladder.[4] In some cases an examination of the epigastrium to check for free fluid, free air or both is also done.

The CT remains the criterion standard for the detection of solid organ injuries. CT unlike DPL or FAST examinations has the capability to determine the source of hemorrhage. In addition to retroperitoneal injuries, CT provides excellent imaging of the pancreas, duodenum, and genitourinary system. The images can help quantitate the amount of blood in the abdomen and can reveal individual organs with precision.

CT scanning is done from the dome of the diaphragm above to the pelvis below. CT is also useful for assessment of bony structures of the vertebral column and pelvic girdle when there is suspected fracture in these patients.[6] CT is important to determine the location, type and volume of both intra and extra peritoneal fluid. It can detect the presence of haemoperitoneum and has the advantage over US of accurate characterization of hemoperitoneum through its Houndsfield unit (HU).

Improved scan speed in MSCT enables not only better coverage in single breath hold, but provides a significant reduction in patient movement artifacts and encourages better use of contrast media. Spiral CT has gone a step further with its ability to produce three dimensional (3-D) images of bony structures and blood vessels making demonstration of fractures and vascular injuries easier. Computed tomography angiography (CTA) using multislice CT (MSCT) technology is capable of demonstrating the abdominal aorta as well as the iliac arteries and their branches in a single reformatted image.

Recent advances in CT imaging now make it possible to identify bleeding vessels using this modality. Active hemorrhage in patients after blunt abdominal trauma is most frequently visible as a jet of extravasated contrast agent on multidetector CT. When extravasation is detected, immediate surgical or angiographic therapy is required,[7] Although ultrasound can be used in the initial screening of patients with blunt abdominal trauma, CT remains the imaging modality of choice for detecting intra-abdominal lesions in stable patients. But CT too has limitations like radiation hazards, high financial cost and its limited availability at some places restricts its wide spread use in every case.

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The present study is aimed to redefine the role of imaging using us and msct in the grading of hemoperitoneum in patients with acute blunt abdominal trauma and its correlation with the grading of organ injury. To study the cost effectiveness and compare and discuss the results of both the modalities in these patients.

OBSERVATIONS AND RESULTS: The study comprised of 50 patients with history of acute BAT of duration less than 24 hours who came to our institute for imaging evaluation. Out of these, there were 7 female and 43 male patients. Mean age being 27.31+/-16yrs. (males-26.03+/-16.17 yrs and females—35.14+/-13.31yrs) [Chart 1]. 8 patients were of pediatric age group (up to 12 yrs of age) and 4 patients were above 50 yrs of age.

RTA was the commonest cause in 47 patients and fall from height in 3 patients. Out of these, commonest injury was liver injury in 16 patients followed by splenic and renal injuries in 15 and 10 patients respectively.

2 patients had normal US and CT findings, while 10 patients had more than 1 organ injury.

Both US and MSCT abdomen were done in all the patients with less than 1 hour interval between the two investigations and results were compared and analyzed statistically

Hemoperitoneum was the commonest finding seen in 31 patients on MSCT.US also detected hemoperitoneum in 29 patients.2 patients were false positive on US and MSCT due to bladder rupture and gut perforation. On US hemoperitoneum was seen as anechoic in 20/29 patients and showed internal echoes in 9/29 patients. On MSCT attenuation was hypodense in 26(83.33%), hyperdense in 1(3.33%) and mixed attenuation in 4(13.33%) patients.1 patient with mixed attenuation hemoperitoneum had active liver bleeding, while rest of the 3 patients had shattered kidneys. Patient with dense hemoperitoneum had grade III splenic injury. 2 false positive cases showed anechoic fluid in 1 and with internal echoes in the other. So US showed sensitivity, specificity and accuracy of 93.55%, 89.47% and 92% respectively in detecting hemoperitoneum with 2 false positive and 2 false negative cases. [Chart 2] MSCT showed overall sensitivity, specificity and accuracy of 100%, 90.47% and 98% respectively [Chart 3].

Regarding the sites, 16/29 patients showed fluid in the pelvis and rest in the perihepatic, perisplenic, right paracolic gutter and perinephric spaces. Depending upon the site of involvement and depth of fluid, hemoperitoneum was scored on US ranging from1-6. Similarly MSCT scoring for hemoperitoneum was done as mild, moderate and marked. For calculating correlation coefficient, MSCT scoring was converted into ordinal scale as 1-mild, 2-moderate, 3-marked.Hemoperitoneum scores were compared on US and CT and significant correlation was found ($r<0.819$ and p value of <0.001). [Table A]

Liver: Liver injury was seen in 16 patients and the commonest presentation (75%) was history of pain and tenderness in right hypochondrium. Associated hemoperitoneum was detected in 14 patients on MSCT and US detected it in 12 patients with sensitivity, specificity and accuracy of 85.71%, 100% and 87.50% respectively. US findings revealed heterogenous 7938 chogenicity in the hepatic parenchyma and hypodensity on CECT. One patient had active bleeding and was managed with hepatic artery ligation. MSCT scoring was 3 in this case (Fig. 1a & b).

Spleen: Splenic injury was detected in 15 patients.11 patients (73.33%) presented with pain and tenderness in left lower chest. US detected injury in 8 patients and MSCT in all 15 patients. All patients were managed conservatively for splenic injury as hemoperitoneum scoring was 2 on US and 1 on MSCT. One patient had thrombus in the splenic vein with no hemoperitoneum but was managed with spleenectomy due to grade V injury. (Fig. 2 a, b & c)

Pancreas: Pancreatic injuries were seen in 2 patients. Both the patients had complaint of pain and tenderness in the epigastrium. Neither of the injuries was detected on US. One patient had RTA and another had fall from height with history of injury by some blunt object in the epigastrium. MSCT showed transaction of neck of pancreas.US scoring was 2 and MSCT scoring was 2. (Fig3 a & b)

Renal: Renal injuries were seen in 10 patients who had complaint of pain in the lumbar region.5 patients had hematuria. Echo texture was heterogenous in 3 patients, hyper echoic in 1 patient and thin streak of anechoic fluid was seen in the perinephric space in 1 patient on US. On MSCT lesions were non-enhancing in 4 patients. Associated hemoperitoneum was detected in 8 patients on MSCT and US detected it in 7 patients with a sensitivity, specificity and accuracy of 87.50%, 100% and 90% respectively. Shattered kidneys were seen in 2 patients. (Fig. 4a-b). Perinephric hematoma was seen in 4 patients, as hypodense in 3 and hyperdense in 1 patient.

Urinary Bladder: Urinary bladder injury was observed in 2 patients. US showed only free peritoneal fluid in the pelvis. It could not tell the site and extent of injury, so US showed poor sensitivity. MSCT detected injury in both the patients and also categorized them.US false positively detected hemoperitoneum in 1 patient with scoring of 2 which on MSCT was proved as extravasated intraperitoneal contrast and not hemoperitoneum. In patient with intraperitoneal injury urinary bladder neck repair was done. (Fig. 5a-b).

It was found that grades of hemoperitoneum correlated well with the underlying visceral injury and the management of the patient. Patients with US score of 1 and 2 had underlying low grade visceral injury. Patients with scores of 3 and above had underlying grade IV and V injuries. 2 patients with scores of 5 and 6 had underlying grade V injuries.1 patient with grade V injury had US score of 1, because this patient had thrombus in the splenic vein and no parenchymal disruption was seen.Similarly patients with MSCT score of 1 had low grade injuries, with score 2 had higher grades, whereas patients with score of 3 had underlying grade V injuries. [Table B].

With US score of 1and 2, 14 out of 20 (70%) patients were managed conservatively. With score of 3 and 4, 6 out of 9 (66.66%) patients underwent surgery.2 patients had US scores of 5 and 6 and both (100%) patients underwent surgery. Similarly on MSCT 12 out of 15(80%) patients with score 1 were managed conservatively.7 out of 14 patients (50%) with score 2 were managed conservatively, whereas both patients (100%) with score 3 underwent surgery. [Table C]
ROC curves were plotted for hemoperitoneum, which showed area under curve of 0.915 and 0.975for US and MSCT respectively. (Curves 1 and 2)

DISCUSSION: BAT causes an estimated 10% of worldwide deaths and is the third commonest cause of death after malignancy and vascular diseases. RTA is the commonest cause and account for up to 50% of trauma related deaths.

The challenge in the imaging of abdominal trauma is to accurately identify injuries that require early exploration and at the same time avoid unnecessary operative intervention in cases that can be managed conservatively. In recent years CT and US have replaced all other modalities of investigation to a great extent. But both have their limitations. In spite of diagnostic superiority, availability of CT is still limited and it also requires stable patients. On the other hand, major limitations of US are its inability to consistently detect pancreatic, bowel and mesenteric injuries and inability to functionally assess the kidneys and frequent interference by gaseous distension and associated bone or soft tissue injuries.[8]

Hemoperitoneum is the most common finding seen in blunt abdominal trauma patients. In present study, it was detected in 31 patients.US showed sensitivity, specificity and accuracy of 93.55%, 89.47% and 92% respectively in detecting hemoperitoneum with 2 false positive and 2 false negative cases. The negative predictive value and positive predictive values were 89.47% and 93.55% respectively. MSCT showed sensitivity, specificity, negative predictive value, positive predictive value and accuracy of 100%, 95%, 100%, 96.77% and 98% respectively.

Goletti O et al[9] (1994) studied role of US in blunt abdominal trauma in 250 consecutive cases and showed similar results with overall sensitivity of US in detecting free fluid collection being 98% with a specificity of 99% and a positive predictive value of 100%.

The results in the present study were better than the results of the study conducted by J. P. Mc Gahan et al[4] (1997) for use of US in the patient with acute abdominal trauma who showed the sensitivity of US in detecting hemoperitoneum to be 63%, specificity 95% with accuracy of 85%.

Mallik Kshitishet al[2] (2000) studied the comaparative role of US and CT in blunt abdominal trauma. The sensitivity and specificity of US in detecting hemoperitoneum was 90.47% and 100% respectively. They correlated the US and CT scoring of hemoperitoneum with the management outcome of the patient. They found that in patients with US scoring of <3, only 11% required surgery and with score >3, 60% underwent surgery. While in the present study 30% of cases with US score<3 underwent surgery. The reason was that in the present study 3 patients had score 1 hemoperitoneum, but had intraperitoneal bladder injury, small gut perforation and splenic vein thrombosis. So surgery was required in these patients. With score >5, 100% underwent surgery. Regarding CT scoring, none of the patients with mild hemoperitoneum required surgery in their study.In the present study 20% patients with mild hemoperitoneum got operated.50% of the patients with moderate hemoperitoneum and100% patients with marked hemoperitoneum underwent surgery. These results were similar to the study by Mallik Kshitish et al. The specificity in their study was in the range of 98% to 100%, compared with the prent study which showed it to be 89.47%. The reason is due to detection of 2 false positive cases of hemoperitoneum on US and 1 false positive case on MSCT in the present study.

Similar results were observed by various other researchers like Damir et al [10] (1999), Tas F et al[11] (2004) and Susan B. Promes[12] (2004).

The present study revealed that while doing US and MSCT scoring of hemoperitoneum, it had a good correlation and predictive value to suggest the underlying organ injury especially with scores of 3 and above with r<0.8199 and p<0.001.To our knowledge, no direct correlation had been done in any other study. Similarly patients with hemoperitoneum scores of 5 and above suggest a strong likelihood of severe underlying organ injury. The scoring also influences patient's management and the present study showed that 70% patients can be managed conservatively with scores <2, while those with higher scores, 66.66% underwent surgical management. While in study by Mallik Kshitish et al[2] (2000) 80% patients with score <3 were managed conservatively and 60% patients with score >3 were managed surgically. Although the total number of patients were significantly small in study by Mallik Kshitish et al as compared to the present study, yet the results observed were similar.

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CONCLUSION: US is highly sensitive in detecting hemoperitoneum. When positive for hemoperitoneum, US alarms to the presence of underlying visceral injury. But at the same time, absence of hemoperitoneum on US does not exclude the underlying injury. MSCT accurately grades the injury and can change the management outcome of the patient.US is cost effective in initial evaluation of trauma and detection of hemoperitoneum. But overall MSCT is more cost effective in detecting and accurately grading the solid as well as hollow visceral injury in blunt abdominal trauma patients.US has very high sensitivity in detecting and scoring hemoperitoneum and the results are similar to that of MSCT.

LOCATION	THICKNESS OF FLUID	POINTS
Morison's Pouch	>2cm	2
	<2cm	1
Douglas Pouch	>2cm	2
	<2cm	1
Perisplenic space	+	1
Paracolic gutter	+	1
Floating bowel loops	+	2

Table A: US Scoring of Hemoperitoneum

Description	Estimates	Approximate amount
Fluid in only one space	Small	100-200 ml
Fluid in two or more spaces.	Moderate	250-500 ml
Fluid in all spaces or pelvic fluid anterior /superior to urinary bladder.	Large	> 500 ml

Table B1: MSCT Scoring of Hemoperitoneum

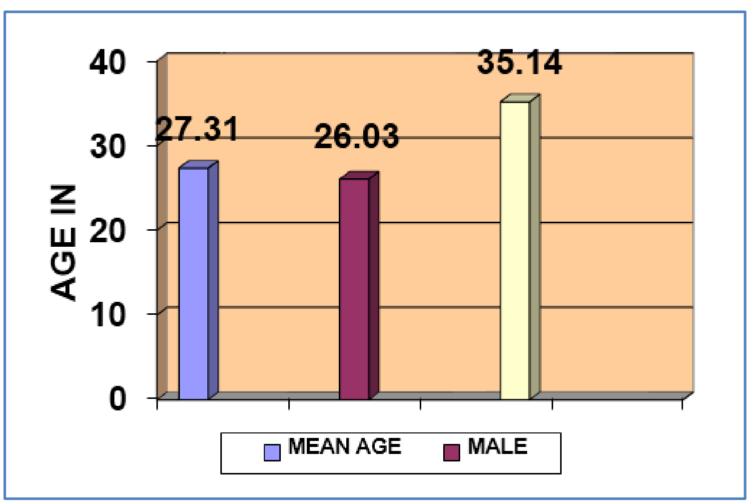

CHART 1: Age Distribution in Years

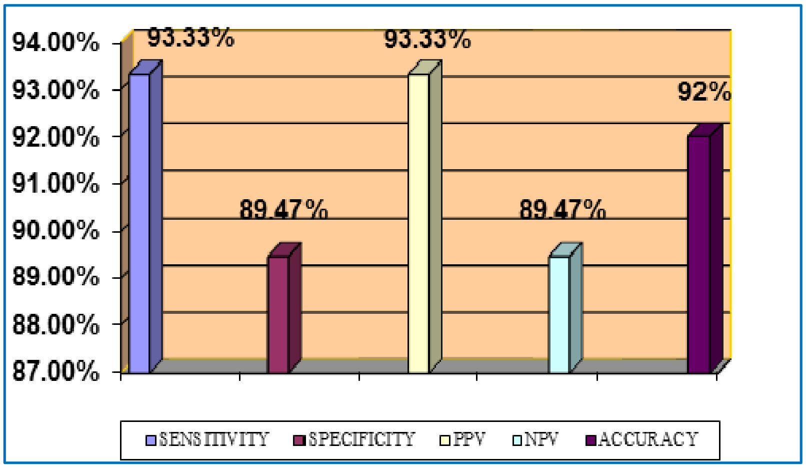

CHART 2: Sensitivity, Specificity, PPV, NPV and Accuracy of us in Hemoperitoneum

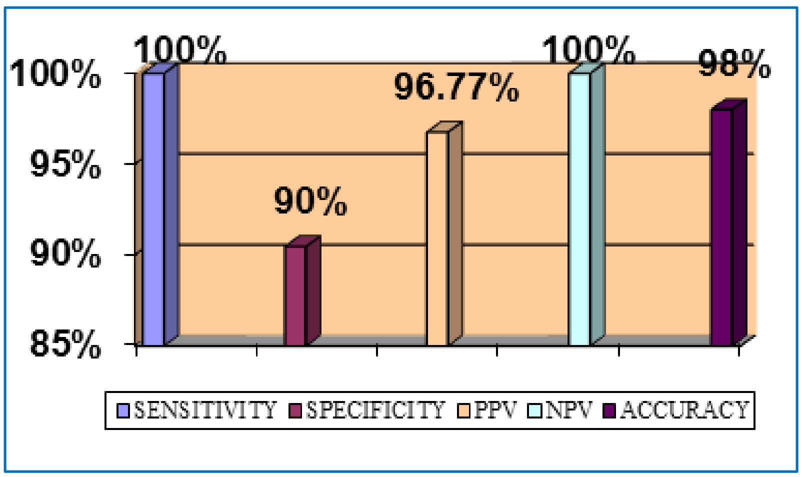

CHART 3: Sensitivity, Specificity, PPV, NPV and Accuracy of MSCT in Detecting Hemoperitoneum

NO.	US	MSCT	SCORE ON US	SCORE ON MSCT
1	Y	Y	3	2
2	Y	Y	2	1
3	Y	Y	6	3
4	Y	Y	2	1
5	Y	Y	1	1
6	Y	Y	1	1
7	Y	Y	1	1
8	Y	Y	1	1
9	N	Y	0	1
10	N	Y	0	1
11	Y	Y	1	1
12	Y	Y	2	2

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13	Y	Y	2	1
14	Y	Y	3	2
15	Y	Y	1	1
16	Y	Y	3	2
17	Y	Y	4	2
18	Y	Y	3	2

TABLE A 1: US and MSCT Scores of Hemoperitoneum

19	Y	Y	2	2
20	Y	Y	2	2
21	Y	Y	3	2
22	Y	Y	2	1
23	Y	Y	1	1
24	Y	Y	2	2
25	Y	Y	1	1
26	Y	Y	5	3
27	Y	Y	1	1
28	Y	Y	4	2
29	Y	Y	3	2
30	Y	Y	1	1
31	Y	Y	2	2
32	Y	Y	2	1
33	Y	Y	3	2
r=0.8199		p<o.oo1		highly significant

TABLE A 2: US and MSCT Scores of Hemoperitoneum and Correlation Coefficient

FIG. 1 (A): AXIAL CECT Shows a Large Hypodense non-Enhancing Area in the Right Lobe of LIVER (ARROW)

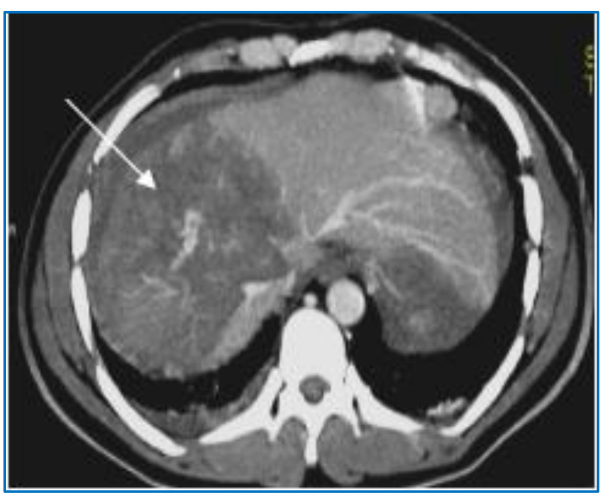

Fig. 1A

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FIG. 1(B): Coronal Cect Shows a Large Hypodense Non-Enhancing Area in the Right Lobe of Liver with Evidence of Active Bleed and Hyperdense Hemoperitoneum [ARROW].

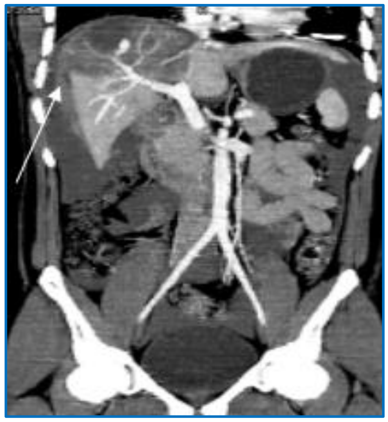

Fig. 1B

FIG. 2 (A): US Shows Markely Hypoechoic Spleen with an Echogenic Thrombus in the Splenic Vein (ARROW).

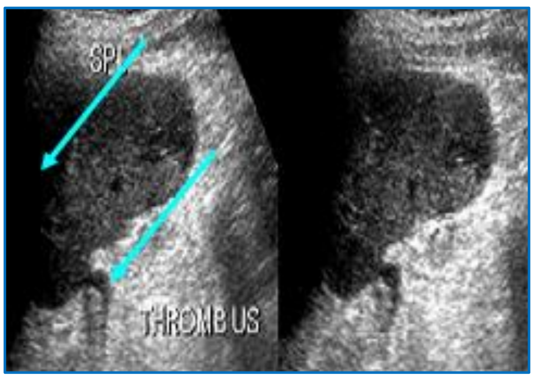

Fig. 2A

FIG. 2 (B): Color Doppler Shows Normal Flow in the Splenic Artery.

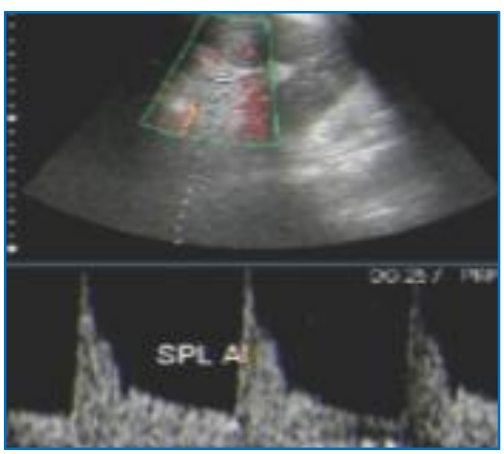

Fig. 2B

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Fig. 2 (C): CECT Axial Section and Magnified View Shows Non Enhancing Area in the Splenic Parenchyma with Intraluminal Hypodense Filling Defect in the Splenic Vein Consistent with Thrombus (Arrow).

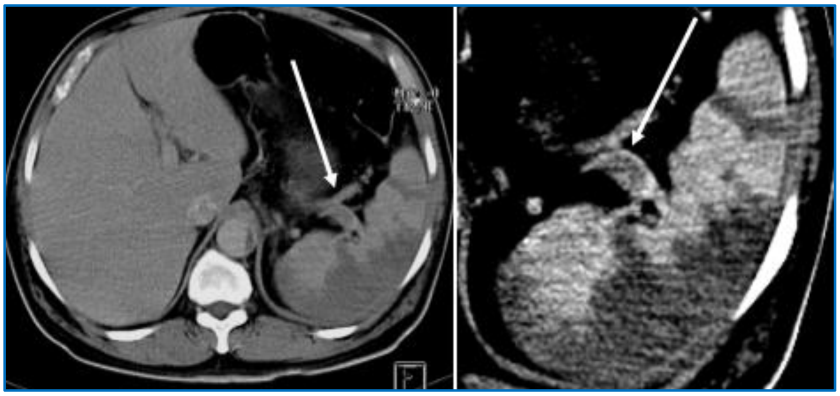

Fig. 2C

FIG. 3 (A): US Shows Normal Size and Echotexture of Pancreas.

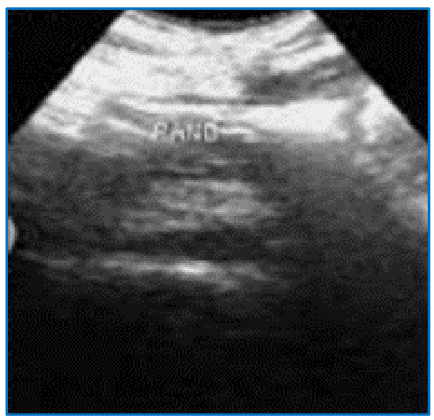

Fig. 3A

FIG. 3 (B): MSCT Shows Transection of Neck of Pancreas [Arrow] With Surrounding Fluid.

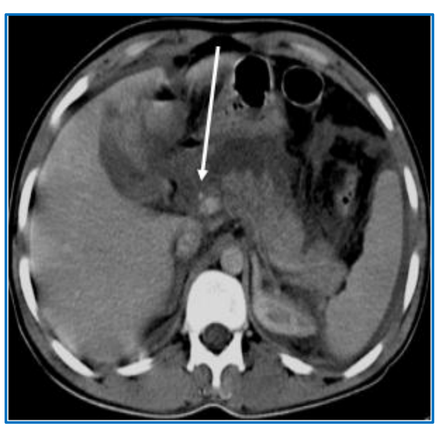

Fig. 3B

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FIG. 4 (A): Shows Enlarged Right Kidney with Heterogenous Echotexture with Anechoic Perinephric and Subcapsular Fluid.

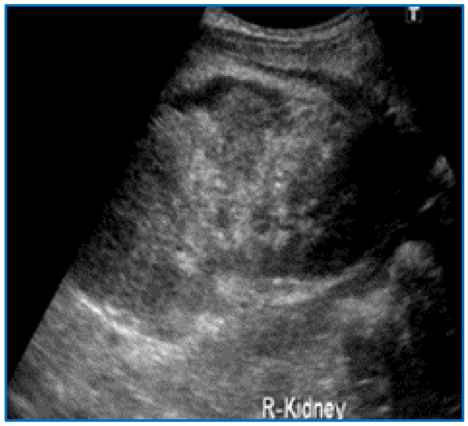

Fig. 4A

FIG. 4 (B): CECT Shows Shattered Right Kidney with Hyperdense Perinephric Hematoma and Hypodense Fluid.

Fig. 4B

FIG. 5: (A): US Shows Free Peritoneal/Pelvic Fluid.

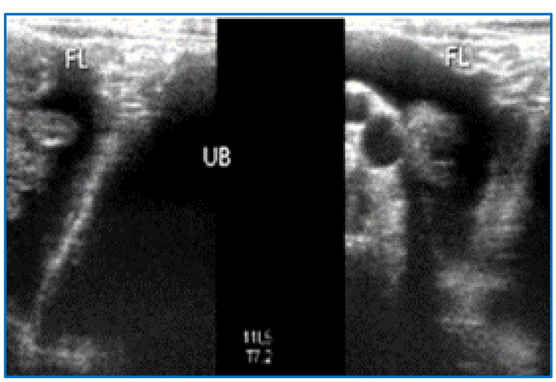

FIG. 5A

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FIG. 5 (B): CT cystography saggital section shows bladder Tear (blue arrow) with intraperitonal extravasation of the contrast (white arrow).

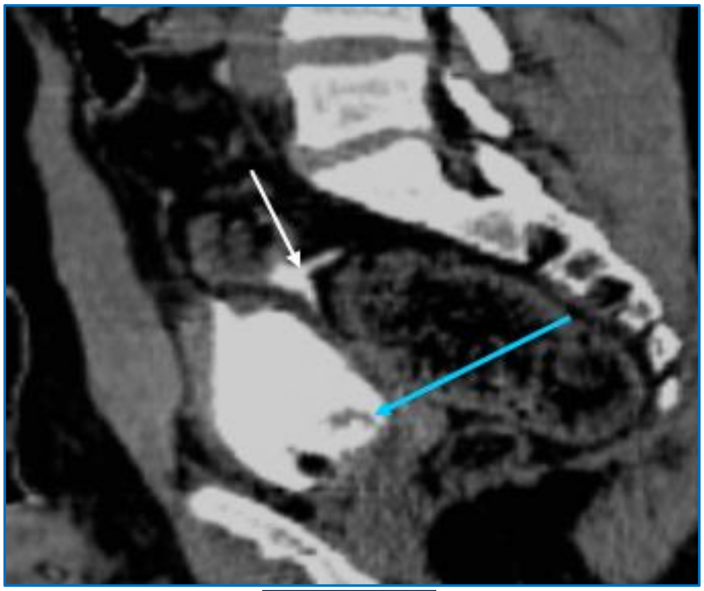

Fig. 5 B

US SCORE	ORGAN INJURY			MSCT SCORE	ORGAN INJURY		
	A	B	C		A	B	C
1, 2	7	1	1	1	10	3	1
3, 4	2	3	2	2	4	6	4
5, 6	0	0	2	3	0	0	2

TABLE B2: Correlation Between Hemoperitoneum and Underlying Organ Injury (a-mild, b-moderate, c- severe)

SCORE ON US	CONSERVATIVE	SURGERY
1 AND 2	70%	30%
3 AND 4	33.33%	66.66%
5 AND 6	0%	100%
SCORE ON MSCT	**CONSERVATIVE**	**SURGERY**
1	80%	20%
2	50%	50%
3	0%	100%

TABLE C: US and MSCT Scoring of Hemoperitoneum and Effect on Management of the Patient

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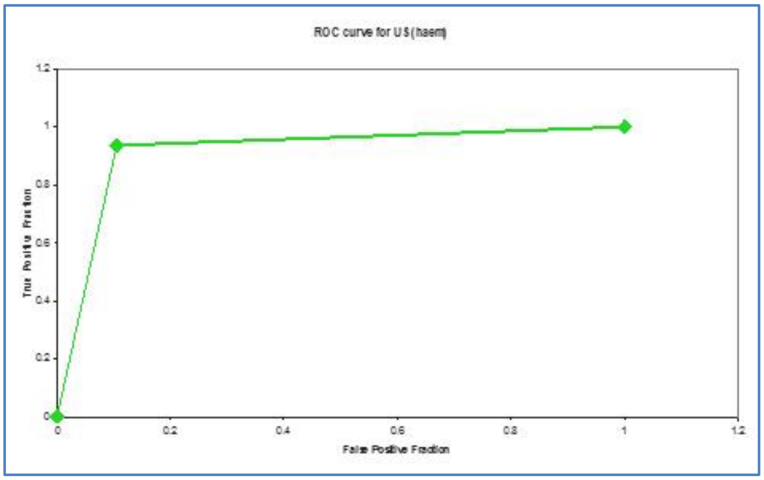
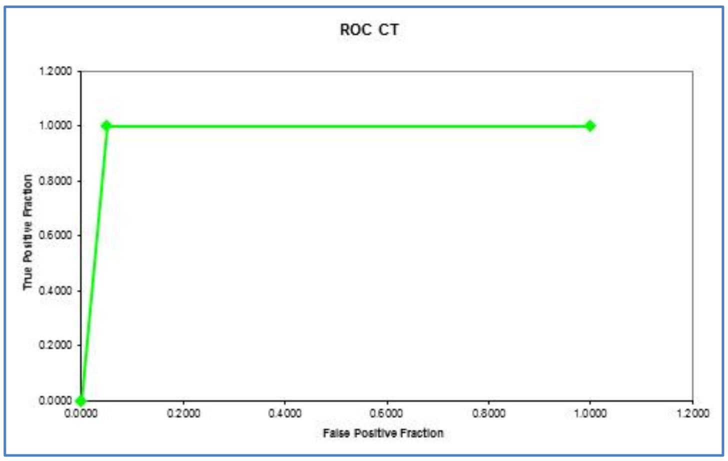


Curve 1: ROC Curve Us for Hemoperitoneum



Curve 2: ROC Curve MSCT for Hemoperitoneum

ABBREVATIONS:

US	ULTRASONOGRAPHY
MSCT	MULTISLICE COMPUTED TOMOGRAPHY
BAT	BLUNT ABDOMINAL TRAUMA
FAST	FOCUSED ABDOMINAL SONOGRAPHY FOR TRAUMA
CT	COMPUTED TOMOGRAPHY
DPL	DIRECT PERITONEAL LAVAGE
HU	HOUNDSFIELD UNIT
ROC CURVE	RECEIVER OPERATING CHARACTERISTIC CURVE
OIS	ORGAN INJURY SCALE

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