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Role of Ultrasonography and Computed Tomography Scan in Abdominal Trauma and Correlation with Intra Operative Findings

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Abstract

Introduction: Trauma is a 'time sensitive disease'. Prevalence of intra-abdominal injury varies widely, ranging from 7.7% to 65% [5]. Physical examination alone may not always yield sufficient information regarding the extent of abdominal injuries. Therefore, there is a need for a diagnostic tool that can rapidly and reliably assess the presence or absence of intra-abdominal injuries. In cases of blunt abdominal trauma, relying solely on clinical assessment can lead to diagnostic delays and the potential oversight of intra-abdominal injuries due to neurological impairment caused by the trauma itself. In the contemporary approach to managing blunt abdominal trauma non-operatively, even in cases involving solid organ injuries, imaging plays a crucial role. The detection of abdominal trauma is a frequent diagnostic problem in patients with multiple injuries. Focused assessment sonography in trauma (FAST) specifically targets the detection of intra-abdominal free fluid, though it does not provide detailed organ assessment. This approach is widely recognized as a rapid diagnostic tool during the initial assessment of blunt abdominal trauma victims, potentially reducing the need for abdomino-pelvic computed tomographic (CT) scans and deep peritoneal lavage procedures. Computed tomography (CT) is considered the preferred diagnostic modality for assessing abdominal injuries resulting from blunt trauma in hemodynamically stable patients. CT scans offer a quick and precise evaluation of abdominal organs, retroperitoneum, skeletal injuries, and the

abdominal wall. Additionally, abdominal CT scans are valuable for detecting associated thoracic injuries and unexpected spinal and pelvic fractures.

Objective

- Identification of various types of internal injuries in abdominal trauma using USG.
- Identification and grading of various types of internal injuries in abdominal trauma using CT scan.
- Correlation of USG and CT findings with surgical/ operative findings.

Methods: Conducted as a longitudinal and analytical at Gandhi Medical College and Hamidia Hospital, Bhopal, India, from September 2022 to December 2023, this research included adult patients with history of blunt abdominal trauma.

Results

- Most of the participants belonged to the age group of 21 to 30 years (31%) with the mean age of 27.5 ± 11.7 years.
- Majority of the patients were male (86%) while 14% were females.
- On USG, majority (87%) of the participants had hemoperitoneum. Among solid organ injuries, spleen was the most commonly affected organ (34%) which was followed by involvement of Liver (28%) > Kidney (17%) > Pancreas (4%) > Bladder (3%) > Pericardium (1%).
- On CT, majority (89%) of the participants showed extraperitoneal fluid involvement. Among solid organ injuries, spleen was most commonly injured (45%) which was followed by Liver (33%) >Bone/Spinal injury (32%) > Kidney (29%) >Retro peritoneum (8%)>Pancreas (7%)> Bladder (6%) > Pneumoperitoneum (6%) > Pericardium (1%).
- On CT based AAST grading of splenic injury, majority cases (18/29 i.e. 62.1%) were of grade IV followed by Grade III (27.6%), Grade II (6.9%) and Grade V (3.4%).
- On CT based AAST grading of liver injury, majority cases (4/7 i.e. 57.1%) were of grade III followed by Grade IV (28.6%) and Grade II (14.3%).
- On CT based AAST grading of renal injury, majority cases (4/6 i.e. 66.7%) were of grade III followed by Grade IV (33.3%).
- On CT based AAST grading of pancreatic injury, majority cases (23/47 i.e. 48.9%) were of grade III followed by Grade IV (42.6%), Grade II (6.4%) and Grade V (2.1%).
- On CT based AAST grading of bladder injury, majority cases (16/31 i.e. 51.6%) were of grade IV followed by Grade III (35.5%), Grade II (6.5%) and Grade V (6.5%).
- On surgical observation, majority (99%) of the participants had hemoperitoneum which was followed by involvement of Spleen (44%) > Liver (30%) > Kidney (27%) > Pancreas (8%) > Bladder (6%) > Bowel mesentery (3%).
- For splenic injury detection, USG was found to have sensitivity, specificity, PPV, NPV and accuracy of 77.3%, 100%, 100%, 84.8% and 90%, respectively. Kappa value of 0.792 indicates substantial agreement in detecting the condition.
- For hepatic injury detection, USG was found to have sensitivity, specificity, PPV, NPV and accuracy of 80%, 94.3%, 85.7%, 91.7% and 90%, respectively. Kappa value of 0.757 indicates substantial agreement in detecting the condition.
- For renal injury detection, USG was found to have sensitivity, specificity, PPV, NPV and accuracy of

63%, 100%, 100%, 88% and 90%, respectively. Kappa value of 0.713 indicates substantial agreement in detecting the hepatic injury on USG.

- For pancreatic injury detection, USG was found to have sensitivity, specificity, PPV, NPV and accuracy of 37.5%, 98.9%, 75%, 94.8% and 94%, respectively. Kappa value of 0.472 indicates moderate agreement in detecting the condition.
- For bladder injury detection, USG was found to have sensitivity, specificity, PPV, NPV and accuracy of 50%,100%, 100%, 96.9 % and 97%, respectively. Kappa value of 0.653 indicates substantial agreement in detecting the condition.
- For splenic injury detection, CT was found to have sensitivity, specificity, PPV, NPV and accuracy of 97.7%, 96.4%, 95.6%, 98.2% and 97%, respectively. Kappa value of 0.939 indicates perfect agreement in detecting the condition.
- For hepatic injury detection, CT was found to have sensitivity, specificity, PPV, NPV and accuracy of 96.7%, 94.3%, 87.9%, 98.5% and 95% respectively. Kappa value of 0.884 indicates perfect agreement in detecting the condition.
- For renal injury detection, CT was found to have sensitivity, specificity, PPV, NPV and accuracy of 100%, 97.3%, 93.1%, 100% and 98%, respectively. Kappa value of 0.950 indicates perfect agreement in detecting the condition.
- For pancreatic injury detection, CT was found to have sensitivity, specificity, PPV, NPV and accuracy of 87.5%, 100%, 100%, 98.9% and 99%, respectively. Kappa value of 0.928 indicates perfect agreement in detecting the condition.
- For bladder injury detection, CT was found to have sensitivity, specificity, PPV, NPV and accuracy of 100% each. Kappa value of 1.000 indicates perfect agreement in detecting the condition.

Conclusion: CT is the superior diagnostic modality in the diagnosis of abdominal trauma. In a nutshell, a multipronged multimodality approach employing combination of USG and CT in evaluating trauma cases can be fairly useful and accurate in early diagnosis as well as management of organ injuries from abdominal trauma with high sensitivity and specificity resulting in reduction of morbidity and mortality.

Keywords: Bladder, Liver, Renal Injury, Pericardium

Introduction

As the population in India is on the rise, there is increase in incidence of RTA and violent trauma. Trauma can be appropriately labelled as an ‘unsolved epidemic’ of modern society. Estimated loss of life from trauma nearly equals that from cardiovascular disease and cancer combined together. Abdominal trauma includes those cases where there is injury to one or more viscera with or without any obvious external penetrating injury. Today the most common causes of abdominal trauma are due to: road traffic accidents accounting for 75-80% of cases followed by sport injuries, accidental fall, fall of heavy objects over abdomen, crush and burst injuries. The most frequently injured organs are the spleen, liver, small bowel, retroperitoneum, bladder, kidneys, diaphragm and pancreas. Trauma is the primary cause of death among individuals younger than 40 years old, with abdominal injuries accounting for 10% of these fatalities. Indian data indicate a higher incidence of such injuries among the younger demographic, particularly those aged 15-25 years. The fatality rates for trauma are 20 times more in India than that for developed countries. Of this, the deaths that can be prevented are about 30%. Trauma is a ‘time sensitive disease’. Prevalence of intra-abdominal injury varies widely, ranging from 7.7% to 65% [5].

Physical examination alone may not always yield sufficient information regarding the extent of abdominal injuries. Therefore, there is a need for a diagnostic tool that can rapidly and reliably assess the presence or absence of intra-abdominal injuries. In cases of blunt abdominal trauma, relying solely on clinical assessment can lead to diagnostic delays and the potential oversight of intra-abdominal injuries due to neurological impairment caused by the trauma itself. In the contemporary approach to managing blunt abdominal trauma non-operatively, even in cases involving solid organ injuries, imaging plays a crucial role. Detection of abdominal trauma is a frequent diagnostic problem in patients with multiple injuries. Delay in diagnosis and treatment of abdominal trauma substantially increases mortality and morbidity in trauma patients due to bleeding from solid organs or vascular injury or infection resulting from perforation of a hollow viscus.

In 1971, ultrasonography was first introduced as a diagnostic tool for blunt abdominal trauma and has since become a standard primary screening method in trauma centers. Its primary utility lies in detecting abdominal free fluid and evaluating pleural and pericardial effusions [10]. Focused assessment sonography in trauma (FAST) specifically targets the detection of intra-abdominal free fluid, though it does not provide detailed organ assessment. This approach is widely recognized as a rapid diagnostic tool during the initial assessment of blunt abdominal trauma victims, potentially reducing the need for abdomino-pelvic computed tomographic (CT) scans and deep peritoneal lavage procedures. The advantages of US are: It is non-ionizing, non-invasive, portable, rapid, relatively inexpensive and accurate in excluding intra peritoneal fluid without interrupting resuscitation procedure and does not necessitate shifting the patient out of the trauma resuscitation area [11].

Computed tomography (CT) is considered the preferred diagnostic modality for assessing abdominal injuries resulting from blunt trauma in hemodynamically stable patients. CT scans offer a quick and precise evaluation of abdominal organs, retroperitoneum, skeletal injuries, and the abdominal wall. Additionally, abdominal CT scans are valuable for detecting associated thoracic injuries and unexpected spinal and pelvic fractures [12].

Most trauma centers are now equipped with CT machines and with the advent of helical scanners, time required for scanning is reduced significantly. The accuracy of CT in hemodynamically stable blunt abdominal trauma patient has been well established with sensitivity ranging between 92% & 97.6% and specificity as high as 98.7% has been reported in patients subjected to emergency. The introduction of CT following ultrasonography has been hailed as one of the major advances in trauma care. In a patient who is hemodynamically stable, a single test, i.e. CT enables global evaluation of abdomen and retroperitoneum, provides functional status of kidneys and detects associated skeletal injuries. In appropriate clinical setting, CT by its localizing nature can help in deciding conservative management or surgical approach. CT however is relatively insensitive to early detection of mesenteric, intestinal and pancreatic injury. The need to shift a potentially unstable patient out of the trauma care area, the time required to prepare the patient, and limited availability of CT are its main disadvantages. The most important preoperative management of patients with abdominal trauma is to ascertain the requirement for laparotomy. Therefore, the screening test must be quick and highly sensitive. It is a very clear advantage to the operating surgeon if the same test is sensitive enough for citing the organ of injury, especially when there is popularization of a conservative approach towards trauma in today’s time. This study highlights the role of ultrasound and CT in identifying and assessing blunt abdominal trauma, aiding surgeons in making accurate diagnoses and effectively managing trauma cases.

Materials and Methods

A longitudinal and analytical study study was conducted to evaluate abdominal trauma patients using ultrasonography and computed tomography (CT) with comparison of intraoperative findings.

The study was done in the Department of Radio-diagnosis at Gandhi Medical College and Hamidia Hospital, Bhopal, from September 2022 to December 2023.

Patients referred to the Department of Radio-diagnosis with history of abdominal trauma were included in the study.

Inclusion criteria

- Patients referred from Department of Surgery with history of abdominal trauma.

Exclusion criteria

- Hemodynamically unstable patients.
- Patients with adverse reaction to CT (IV) contrast agents.

Sample size: The sample size of 100 patients were taken.

Imaging Procedures: After confirming the patient with inclusion and exclusion criteria as described above, a brief history was taken from each patient. The history included mode of injury, site of trauma, history of abdominal distension, hematemesis, hematuria, vomiting and any other relevant significant clinical history.

USG: The patient was scanned under USG machine quadrant wise to look for any fluid or internal organ injury. The initial scanning followed the FAST protocol under which the pelvic, subhepatic, peri splenic and pericardial cavity were looked by using high frequency linear probe (7-12MHz). In addition to this, bilateral CP angles were observed for any fluid. After the initial assessment, Low frequency curved probe (3-5 MHz) was used to assess for solid organ injury. The report was given according to the findings observed in the scan.

CT: Patients underwent Contrast Enhanced Computed Tomographic abdominal scan on a Hitachi 128 slice helical CT scan machine in Department of Radiodiagnosis, Hamidia Hospital, Bhopal. A plain scan was taken initially followed by a contrast scan. Patients received 1.1 mL/kg of non-ionic contrast at the rate of 2.5 mL/second. Arterial phase was taken at 15 seconds. It was followed by Porto-venous phase taken at 45-50 seconds from the time of beginning of contrast injection. The slice thickness was kept at 5 mm. Delayed phase of 8 minutes was done in patients suspected of renal, ureteric or bladder trauma. In patients with pelvic injuries, CT cystography was performed with due consent to look for urinary bladder injuries. Dilute water-soluble contrast with dilution ratio of 1:10 was instilled into the bladder via Foleys catheter until patient feels urge to void. Upto 300ml was instilled in all cases. Scanned images were studied to look for fluid as well as solid organ injuries. Grades of organ injury were assigned according to American Association for the Surgery of Trauma (AAST) organ injury scale. In addition, bone window was used to assess bony/ spinal injuries in patients. Reconstructed & reformatted images were acquired using the maximum intensity projection (MIP) and MPR techniques when sagittal and coronal images were required.

Surgical findings

They were collected from the clinical notes of the respective patient after the surgical/ medical management.

Statistical Analysis

- All the variables were grouped into (as per their mathematical transformation) nominal/ ordinal/

interval & ratio. Further point estimates with dispersion measures will be calculated with the help of MS Excel and other statistical software.

- The agreement between the two modalities in assessing imaging findings was evaluated using Cohen's kappa coefficient.
- The diagnostic performance of USG and CT in detecting blunt abdominal injuries was assessed by calculating sensitivity, specificity, positive predictive value (PPV), and negative predictive value (NPV).
- Extent of type one error was measured with parametric analysis. Z test was applied for proportion and T-test to find out any significant difference among detected proportion and mean.

Results

Chart 1: Age wise distribution of study participants

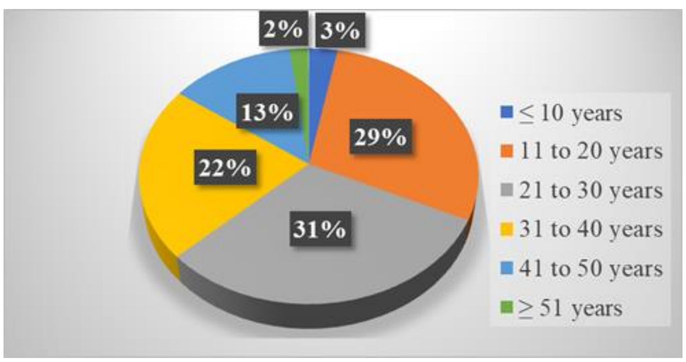
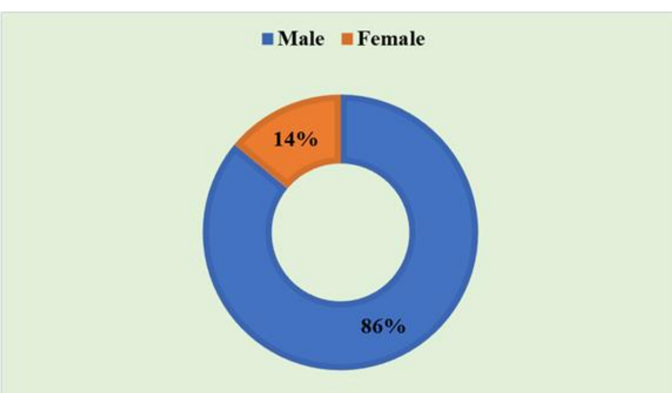
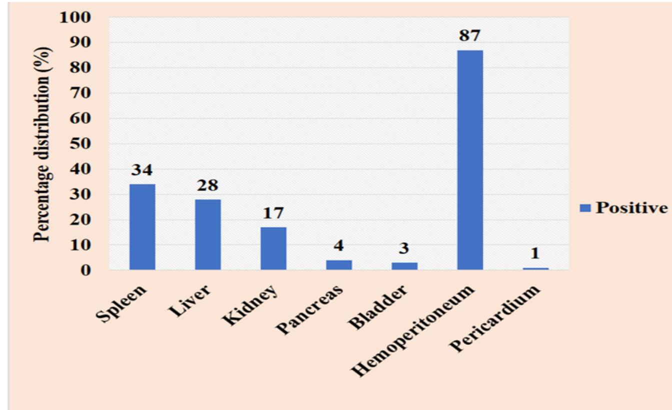


Chart 2: Distribution of study participants on the basis of their gender



USG findings among study participants

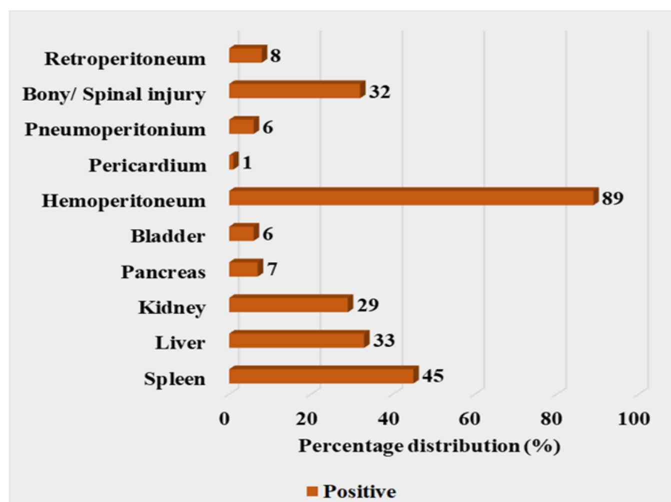
Graph 1: Distribution of injuries in USG



Graph 1: Displays injuries involved in ultrasonography. Majority (87%) of the participants had extraperitoneal fluid on ultrasonography. Among the visceral injuries, Spleen was involved in maximum (34%) cases which was followed by involvement of Liver (28%) > Kidney (17%) > Pancreas (4%) > Bladder (3%) > Pericardium (1%).

CT findings among study participants

Graph 2: Distribution of findings in CT



Majority (89%) of the participants demonstarted extraperitoneal fluid. Among solid organ injuries, Spleen was the most commonly injured (45%) organ followed by Liver (33%)> Bone/Spinal injury (32%)> Kidney (29%)> Retroperitoneum (8%)> Pancreas (7%)> Bladder (6%)> Pneumoperitoneum (6%) > Pericardium (1%).

Table 1: CT based AAST Grading of structures involved

Structure involved	AAST Grading				
	Grade II	Grade III	Grade IV	Grade V	Total
Spleen	2 (6.9%)	8 (27.6%)	18 (62.1%)	1 (3.4%)	29 (100%)
Liver	1 (14.3%)	4 (57.1%)	2 (28.6%)	0 (0%)	7 (100%)
Kidney	0 (0%)	4 (66.7%)	2 (33.3%)	0 (0%)	6 (100%)
Pancreas	1 (14%)	4 (57%)	2 (29%)	0 (0%)	7 (100%)

Table 1 depicts CT based AAST grading of various organ involvement.

Splenic injury was detected in 29 out of 100 patients. According to figure 5, majority cases (18/29 i.e. 62.1%) had grade IV injury followed by Grade III (27.6%), Grade II (6.9%) and Grade V (3.4%).

Hepatic injury was detected in 7 out of 100 patients. According to figure 6, majority cases (4/7 i.e. 57.1%) were of grade III followed by Grade IV (28.6%) and Grade II (14.3%).

Renal injury was detected in 6 out of 100 patients. According to figure 7, majority cases (4/6 i.e. 66.7%) were of grade III followed by Grade IV (33.3%).

Pancreatic trauma was detected in 7 out of 100 patients. According to figure 8, majority cases (4/7 i.e. 57%) were of grade III followed by Grade IV (29%) and Grade II (14%).

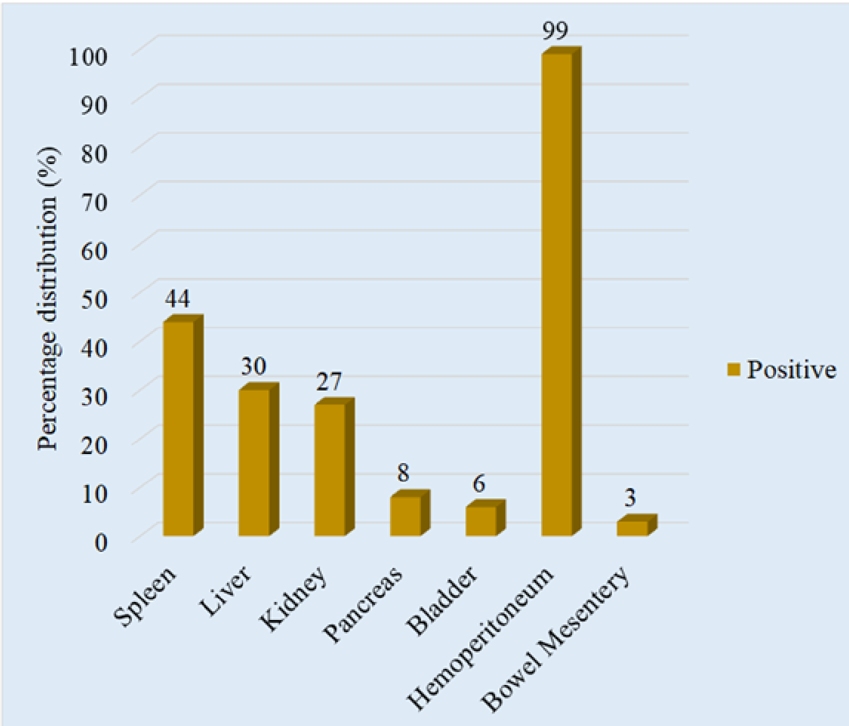
Surgical/ Intraoperative findings among study participants

Table 2: Distribution of structures involved surgically

Sn.	Surgical/ Intraoperative Findings	Positive		Negative		Total	
		N	%	N	%	N	%
1	Spleen	44	44.0	56	56.0	100	100.0
2	Liver	30	30.0	70	70.0	100	100.0
3	Kidney	27	27.0	73	73.0	100	100.0
4	Pancreas	8	8.0	92	92.0	100	100.0
5	Bladder	6	6.0	94	94.0	100	100.0
7	Hemoperitoneum	99	99.0	1	1.0	100	100.0
8	Bowel/ Mesentery	3	3.0	97	97.0	100	100.0

Majority (99%) of the participants had hemoperitoneum which was followed by involvement of Spleen (44%)> Liver (30%)> Kidney (27%)> Pancreas (8%)> Bladder (6%)> Bowel mesentery (3%).

Graph 3: Distribution of structures involved surgically



Comparison of USG diagnosis vs Surgical/ Intra Operative findings in solid organ injuries

Table 3: Comparison of USG diagnosis vs Surgical/ Intra Operative findings in splenic injury

Spleen		Surgical/ Intraoperative findings			Kappa value, p value
		Positive	Negative	Total	
USG	Positive	34 (TP)	0 (FP)	34	0.792, <0.001
	Negative	10 (FN)	56 (TN)	66	
	Total	44	56	100	
Sensitivity	Specificity	PPV	NPV	Accuracy	
77.3%	100.0%	100.0%	84.8%	90.0%	

*TP- True Positive, FP- False Positive, FN- False Negative, TN- True Negative, PPV- Positive Predictive Value, NPV- Negative Predictive Value.

Out of 44 surgically detected splenic injuries, only 34 were observed on USG indicating sensitivity to be 77.3%. Similarly, Specificity of USG in detecting splenic trauma is found to be 100% with ZERO False Positive cases. PPV, NPV and Accuracy of USG in detecting the condition is found to be 100%, 84.8% and 90.0% respectively. Kappa value of 0.792 indicates substantial agreement in detecting the condition.

Graph 4: Comparison of USG diagnosis vs Surgical/ Intra Operative findings in splenic injury

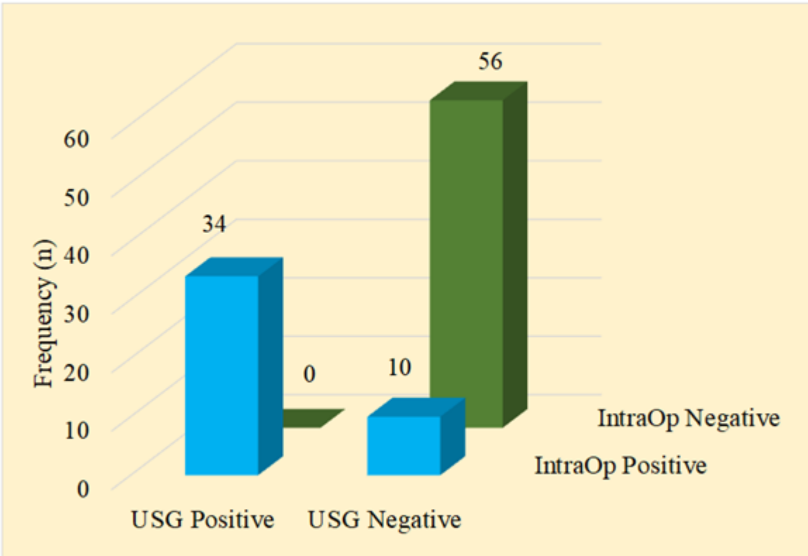


Table 4: Comparison of USG diagnosis vs Surgical/ Intra Operative findings in hepatic injury

Liver		Surgical/ Intraoperative findings			Kappa value, p value
		Positive	Negative	Total	
USG	Positive	24 (TP)	4 (FP)	28	0.757, <0.001
	Negative	6 (FN)	66 (TN)	72	
	Total	30	70	100	
Sensitivity	Specificity	PPV	NPV	Accuracy	
80.0%	94.3%	85.7%	91.7%	90.0%	

Out of 30 surgically detected hepatic injuries, only 24 were observed on USG indicating sensitivity to be 80.0%. Similarly, Specificity of USG in detecting hepatic trauma is found to be 94.3% with 4 False Positive cases. PPV, NPV and Accuracy of USG in detecting the condition is found to be 85.7%, 91.7% and 90.0% respectively. Kappa value of 0.757 indicates substantial agreement in detecting the condition.

Graph 5: Comparison of USG diagnosis vs Surgical/ Intra Operative findings in hepatic injury

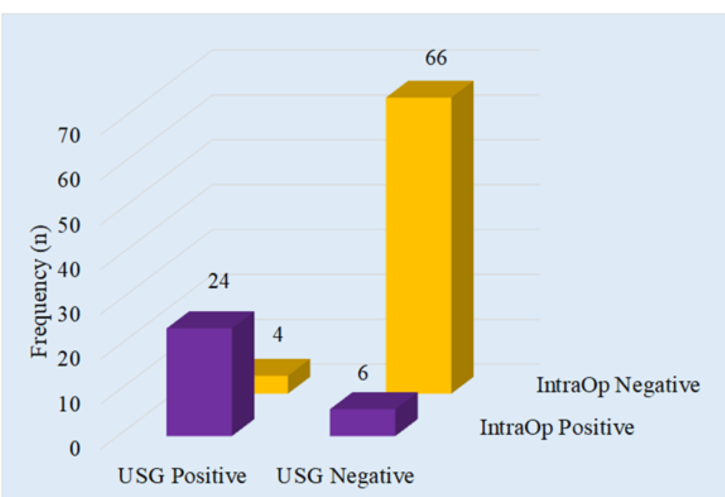


Table 5: Comparison of USG diagnosis vs Surgical/ Intra Operative findings in renal injury

Kidney		Surgical/ Intraoperative findings			Kappa value, p value
		Positive	Negative	Total	
USG	Positive	17 (TP)	0 (FP)	17	0.713, <0.001
	Negative	10 (FN)	73 (TN)	83	
	Total	27	73	100	
Sensitivity	Specificity	PPV	NPV	Accuracy	
63.0%	100.0%	100.0%	88.0%	90.0%	

Out of 27 surgically detected renal injuries, only 17 were observed on USG indicating sensitivity to be 63.0%. Similarly, Specificity of USG in detecting renal trauma is found to be 100.0% with ZERO False Positive cases. PPV, NPV and Accuracy of USG in detecting the condition is found to be 100.0%, 88.0% and 90.0% respectively. Kappa value of 0.713 indicates substantial agreement in detecting the condition.

Graph 6: Comparison of USG diagnosis vs Surgical/ Intra Operative findings in renal injury

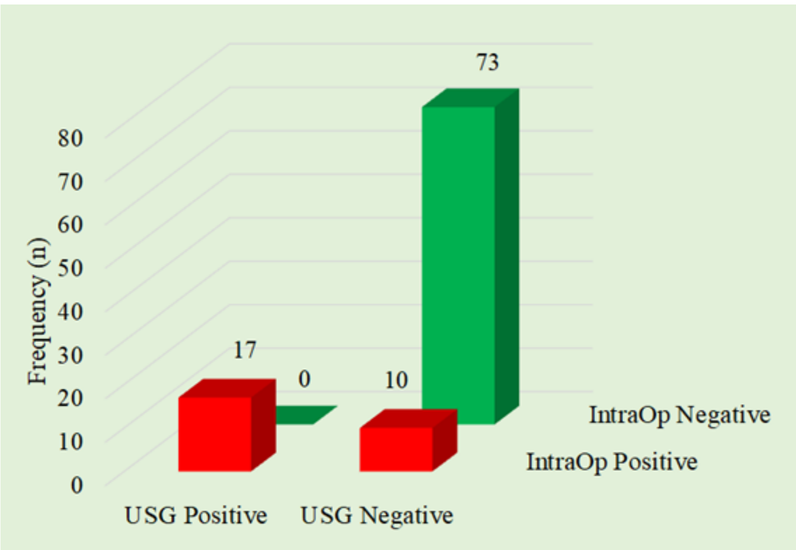


Table 6: Comparison of USG diagnosis vs Surgical/ Intra Operative findings in pancreatic injury

Pancreas		Surgical/Intraoperative findings			Kappa value, p value
		Positive	Negative	Total	
USG	Positive	3 (TP)	1 (FP)	4	0.472, <0.001
	Negative	5 (FN)	91 (TN)	96	
	Total	8	92	100	
Sensitivity	Specificity	PPV	NPV	Accuracy	
37.5%	98.9%	75.0%	94.8%	94.0%	

Out of 8 surgically detected pancreatic injuries, only 3 were observed on USG indicating sensitivity to be 37.5%. Similarly, Specificity of USG in detecting pancreatic trauma is found to be 98.9% with ONE False Positive case. PPV, NPV and Accuracy of USG in detecting the condition is found to be 75.0%, 94.8% and

94.0% respectively. Kappa value of 0.472 indicates moderate agreement in detecting the condition.

Graph 7: Comparison of USG diagnosis vs Surgical/ Intra Operative findings in pancreatic injury

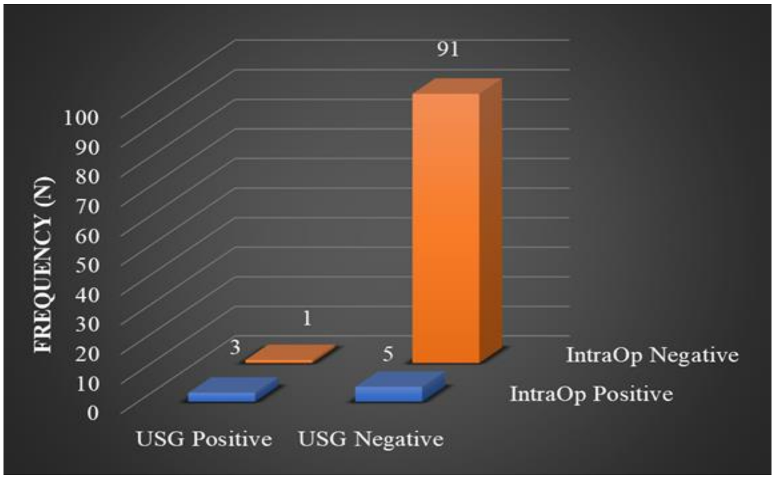
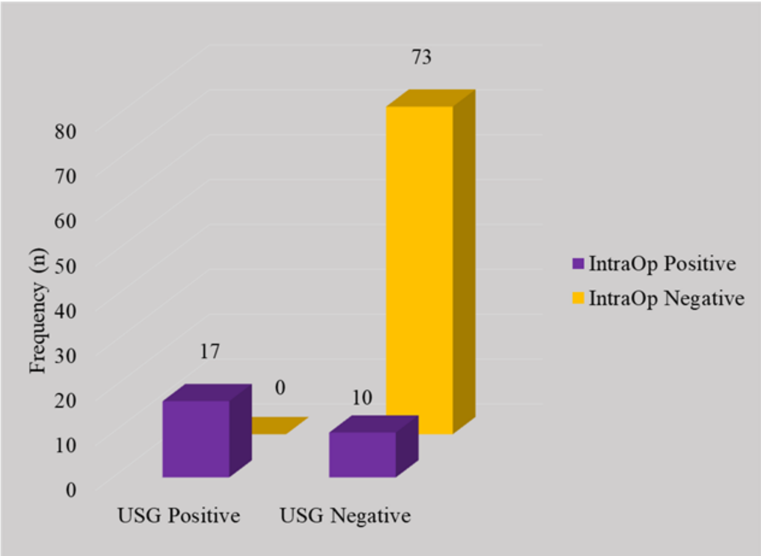


Table 7: Comparison of USG diagnosis vs Surgical/ Intra Operative findings in urinary bladder injury

Bladder		Surgical/Intraoperative findings			Kappa value, p value
		Positive	Negative	Total	
USG	Positive	3 (TP)	0 (FP)	3	0.653, <0.001
	Negative	3 (FN)	94 (TN)	97	
	Total	6	94	100	
Sensitivity	Specificity	PPV	NPV	Accuracy	
50.0%	100.0%	100.0%	96.9%	97.0%	

Out of 6 surgically detected bladder injuries, only 3 were observed on USG indicating sensitivity to be 50.0%. Similarly, Specificity of USG in detecting bladder trauma is found to be 100.0% with ZERO False Positive case. PPV, NPV and Accuracy of USG in detecting the condition is found to be 100.0%, 96.9% and 97.0% respectively. Kappa value of 0.653 indicates substantial agreement in detecting the condition.

Graph 8: Comparison of USG diagnosis vs Surgical/ Intra Operative findings in urinary bladder injury



Comparison of CT diagnosis vs Surgical/ Intra Operative findings

Table 8: Comparison of CT diagnosis vs Surgical/ Intra Operative findings in splenic injury

Spleen		Surgical/ Intraoperative findings			Kappa value, p value
		Positive	Negative	Total	
CT	Positive	43 (TP)	2 (FN)	45	0.939, <0.001
	Negative	1 (FN)	54 (TN)	55	
	Total	44	56	100	
Sensitivity	Specificity	PPV	NPV	Accuracy	
97.7%	96.4%	95.6%	98.2%	97.0%	

Out of 44 surgically detected splenic injuries, 43 were observed on CT indicating sensitivity to be 97.7%. Similarly, Specificity of CT in detecting splenic trauma is found to be 96.4% with 2 False Positive cases. PPV, NPV and Accuracy of CT in detecting the condition is found to be 95.6%, 98.2% and 97.0% respectively. Kappa value of 0.939 indicates perfect agreement in detecting the condition.

Graph 9: Comparison of CT diagnosis vs Surgical/ Intra Operative findings in splenic injury

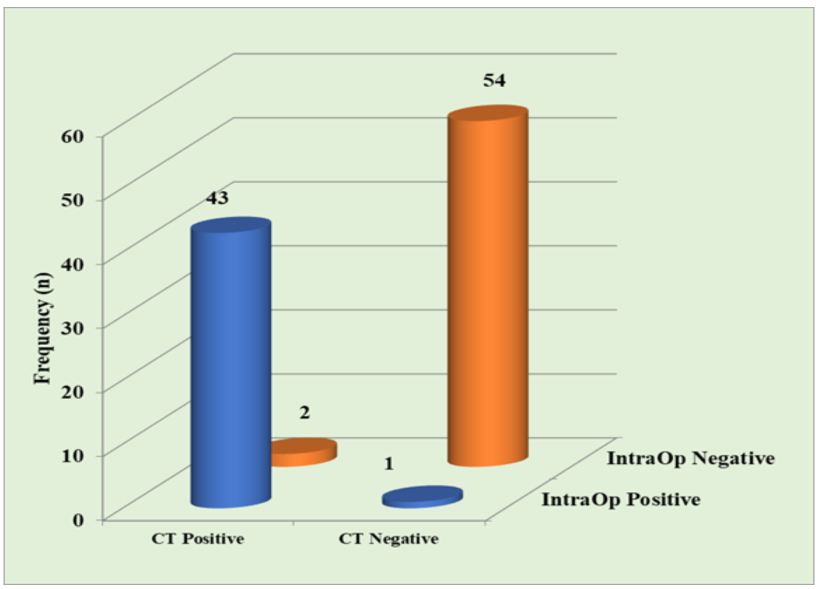


Table 9: Comparison of CT diagnosis vs Surgical/ Intra Operative findings in hepatic injury

Liver		Surgical/ Intraoperative findings			Kappa value, p value
		Positive	Negative	Total	
CT	Positive	29 (TP)	4 (FP)	33	0.884, <0.001
	Negative	1 (FN)	66 (TN)	67	
	Total	30	70	100	
Sensitivity	Specificity	PPV	NPV	Accuracy	
96.7%	94.3%	87.9%	98.5%	95.0%	

Out of 30 surgically detected hepatic injuries, 29 were observed on CT indicating sensitivity to be 96.7%. Similarly, Specificity of CT in detecting hepatic trauma is found to be 94.3% with 4 False Positive cases. PPV, NPV and Accuracy of CT in detecting the condition is found to be 87.9%, 98.5% and 95.0% respectively. Kappa value of 0.884 indicates perfect agreement in detecting the condition.

Graph 10: Comparison of CT diagnosis vs Surgical/ Intra Operative findings in hepatic injury

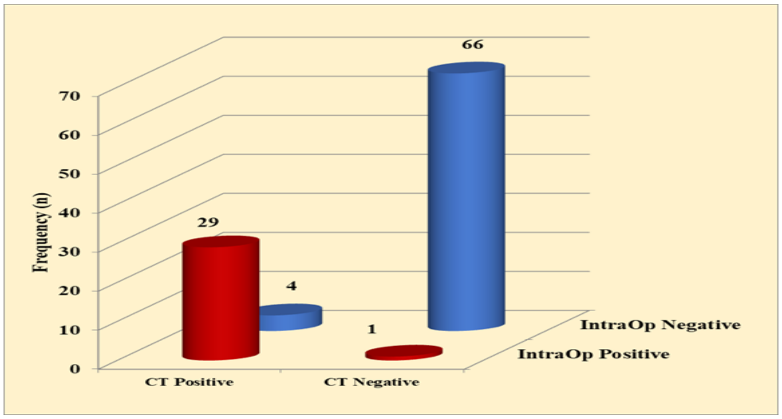


Table 10: Comparison of CT diagnosis vs Surgical/ Intra Operative findings in renal injury

Kidney		Surgical/ Intraoperative findings			Kappa value, p value
		Positive	Negative	Total	
CT	Positive	27 (TP)	2 (FP)	29	0.950, <0.001
	Negative	0 (FN)	71 (TN)	71	
	Total	27	73	100	
Sensitivity	Specificity	PPV	NPV	Accuracy	
100.0%	97.3%	93.1%	100.0%	98.0%	

Out of 27 surgically detected renal injuries, all 27 were observed on CT indicating sensitivity to be 100.0%. Similarly, Specificity of CT in detecting renal trauma is found to be 97.3% with 2 False Positive cases. PPV, NPV and Accuracy of CT in detecting the condition is found to be 93.1%, 100.0% and 98.0% respectively. Kappa value of 0.950 indicates perfect agreement in detecting the condition.

Graph 11: Comparison of CT diagnosis vs Surgical/ Intra Operative findings in renal injury

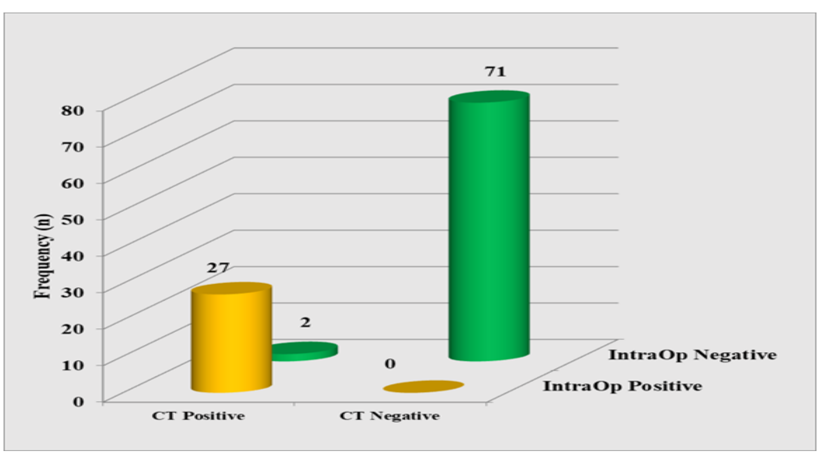


Table 11: Comparison of CT diagnosis vs Surgical/ Intra Operative findings in pancreatic injury

Pancreas		Surgical/ Intraoperative findings			Kappa value, p value
		Positive	Negative	Total	
CT	Positive	7	0	7	0.928, <0.001
	Negative	1	92	93	
	Total	8	92	100	
Sensitivity	Specificity	PPV	NPV	Accuracy	
87.5%	100.0%	100.0%	98.9%	99.0%	

Out of 8 surgically/ intraoperatively detected pancreatic injuries, 7 were observed on CT indicating sensitivity to be 87.5%. Similarly, Specificity of CT in detecting pancreatic trauma is found to be 100.0% with ZERO False Positive case. PPV, NPV and Accuracy of CT in detecting the condition is found to be 100.0%, 98.9% and 99.0% respectively. Kappa value of 0.928 indicates perfect agreement in detecting the condition.

Graph 12: Comparison of CT diagnosis vs Surgical/ Intra Operative findings in pancreatic injury

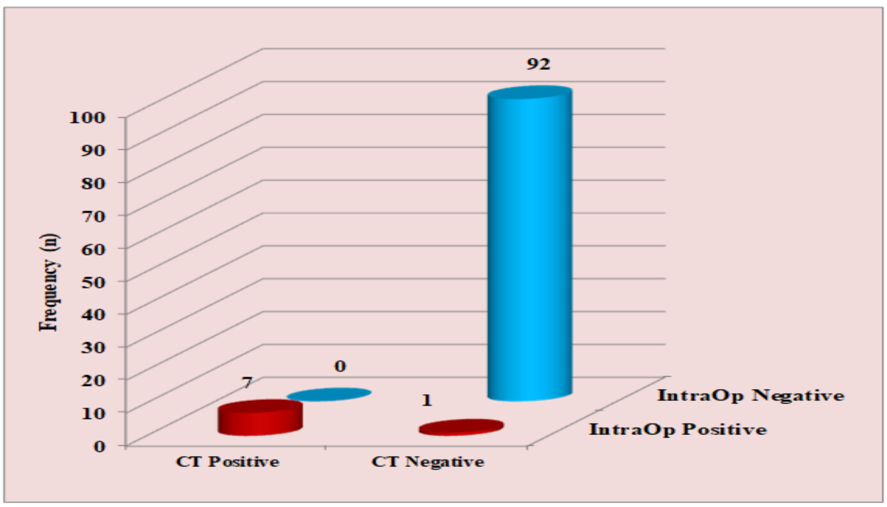
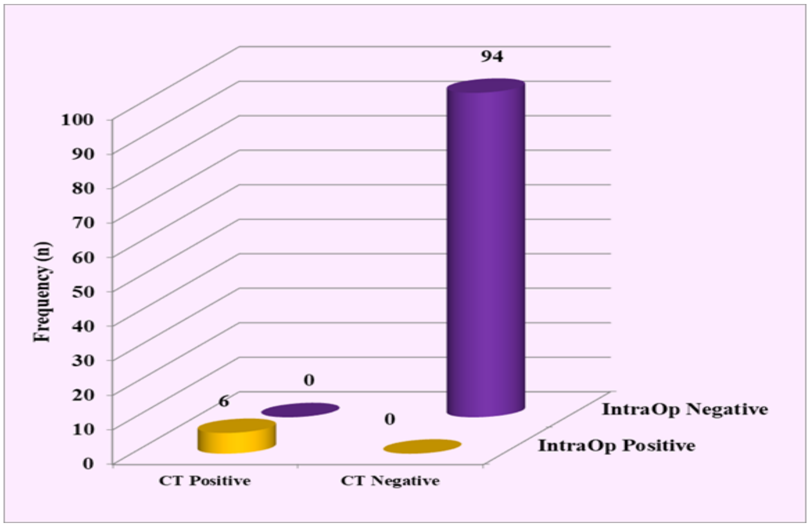


Table 12: Comparison of CT diagnosis vs Surgical/ Intra Operative findings in urinary bladder injury

Bladder		Surgical/ Intraoperative findings			Kappa value, p value
		Positive	Negative	Total	
CT	Positive	6 (TP)	0 (FP)	6	1.000, <0.001
	Negative	0 (FN)	94 (TN)	94	
	Total	6	94	100	
Sensitivity	Specificity	PPV	NPV	Accuracy	
100.0%	100.0%	100.0%	100.0%	100.0%	

Out of 6 surgically detected bladder injuries, all 6 were observed on CT indicating sensitivity to be 100.0%. Similarly, Specificity of CT in detecting bladder trauma is found to be 100.0% with ZERO False Positive case. PPV, NPV and Accuracy of CT in detecting the condition is found to be 100.0%, 100.0% and 100.0% respectively. Kappa value of 1.000 indicates perfect agreement in detecting the condition.

Graph 13: Comparison of CT diagnosis vs Surgical/ Intra Operative findings in urinary bladder injury



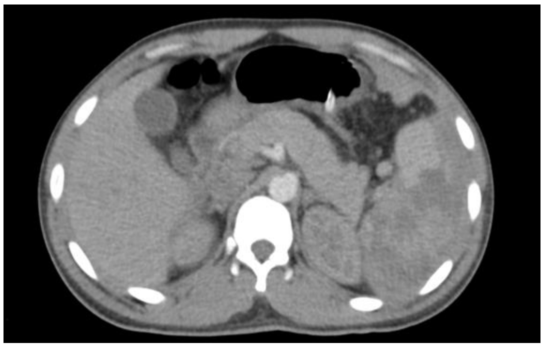


Image 1.1: CT scan in a 34-year-old male showing multiple hypodense areas within the splenic parenchyma representing lacerations and contusions. Patient had Grade IV Splenic injury.

Image 1.2: Greyscale ultrasound in the same patient shows a linear hypodense area, reaching upto capsule (representing laceration). Also noted is the gross hemoperitoneum.

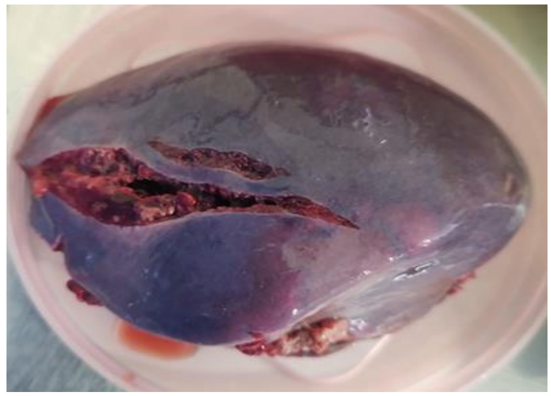


Image 1.3: Post operative splenectomy specimen of the same patient. He had grade IV splenic injury. Gross hemoperitoneum was also drained.

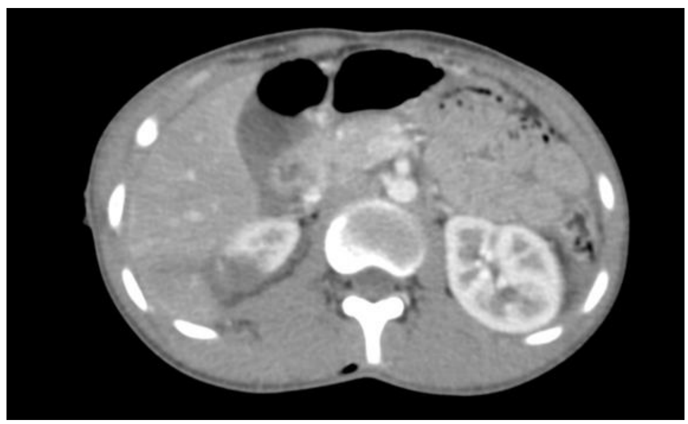


Image 2.1: A 41-year-old male who had a blunt abdominal trauma underwent a CT scan. It shows a wedge-shaped hypodense area in interpolar region of right kidney consistent with AAST Grade III renal injury.

Image 2.2: A 27-year-old patient with road traffic accident having multiple liver lacerations (grade IV) demonstrating gross hemoperitoneum.

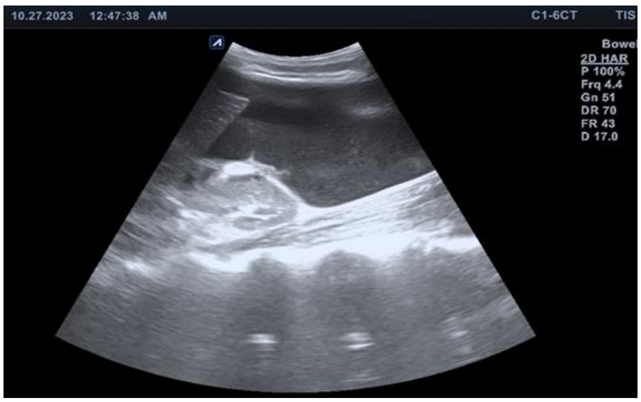


Image 2.3: Ultrasound image of the same patient demonstrating anechoic fluid with internal echoes in peritoneal cavity including hepatorenal (Morrisons) pouch consistent with gross hemoperitoneum.

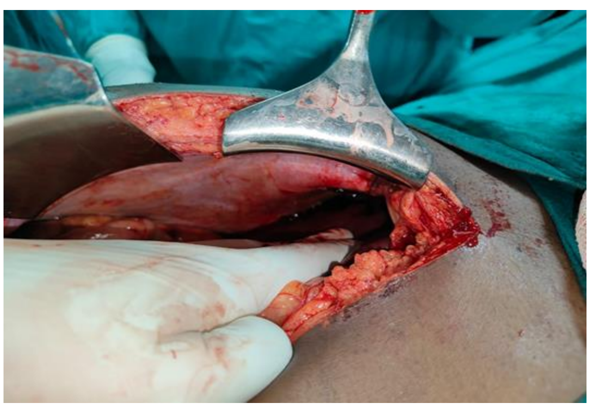


Image 2.4: Intra operative image of the same above-mentioned patient whose CT demonstrated grade IV liver injury with hemoperitoneum. Image shows exploration of the peritoneal cavity with drainage of hemoperitoneum. Segment VI of liver is visible.

Image 3.1: A 40-year-old male patient with a motor vehicle accident showing a large hypodense area in segments VII & VI of liver with multiple lacerations & contusions consistent with grade IV liver injury.

Image 3.2: Grey scale ultrasound in the same shows an ill-defined hypodense area in right lobe of the liver with adjacent hyper echogenicity. Hemoperitoneum was also found.

Image 3.3: The intra operative image of the same patient shows lacerations in the liver parenchyma. The patient had grade IV liver injury with moderate hemoperitoneum. Perihepatic packing with insertion of abdominal drain was done.

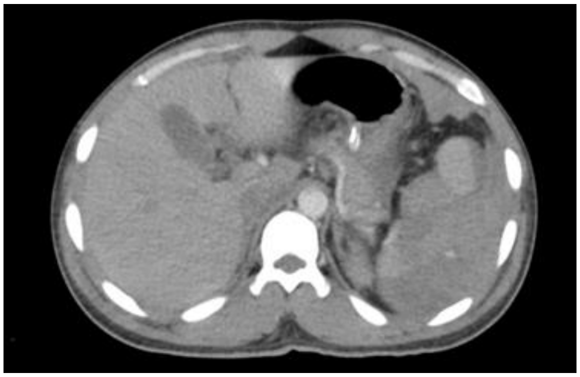


Image 4.1: CT scan in a 26-year-old female showing near completely shattered spleen (Grade V) with multiple contusions & lacerations reaching upto hila. The patient also had left sided 9^{th}, 10^{th} & 11^{th} rib fractures.

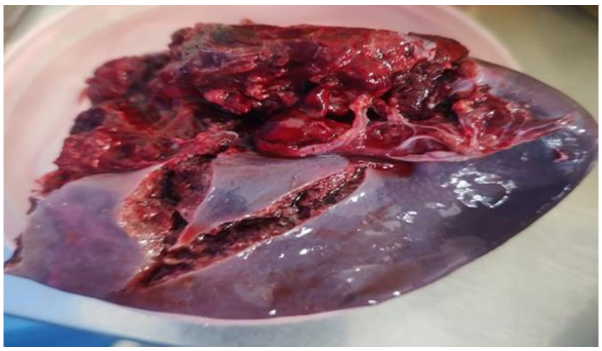


Image 4.2: Post operative splenectomy specimen of the same patient with grade V splenic injury showing shattered spleen.

Image 5.1: A 35-year-old male with fall from a height suffered injury over abdomen. Segment VIII shows hypodense area with mild active extravasation of contrast. Also noted is the hemoperitoneum in subdiaphragmatic space.

Image 5.2: The axial image of a 22-year-old male who had a history of assault followed by blunt abdominal trauma shows a large air locule in peritoneal cavity with gross hypodense fluid consistent with hemopneumoperitoneum. Patient also had grade III splenic injury.

Image 5.3: Sagittal image of the same patient shows air locule anterior to the liver surface. Fluid in the pelvic & peritoneal cavity can also be seen.

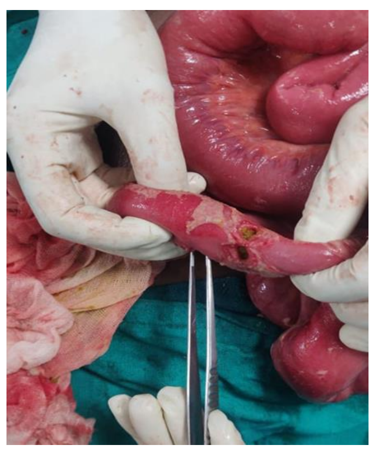


Image 5.4: Intra operatively it was revealed that the patient had jejunal perforation which is demonstrated in the above image. Pneumo hemoperitoneum was drained

and resection with anastomosis of the perforated segment was done.

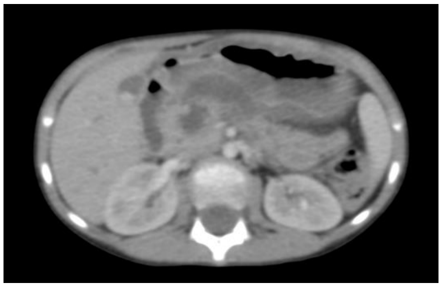


Image 6: CT scan of a 6-year-old female who had bicycle accident shows hypodense area in pancreatic head region (representing laceration) consistent with grade IV injury. Peripancreatic fluid in lesser sac is also noted.

Image 7: CT of a 47-year-old male with abdominal trauma demonstrating multiple liver lacerations (grade III) and renal contusions (grade III). Moderate hemoperitoneum was also noted in the same patient.

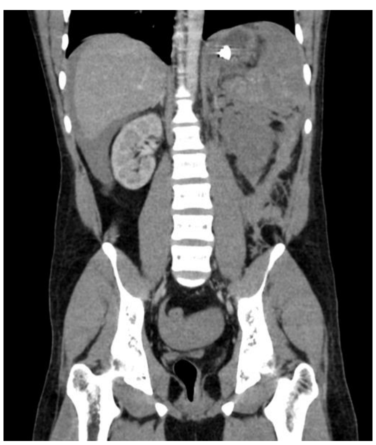


Image 8: A 19-year-old female with a motor vehicle accident. Coronal CT scan image shows completely shattered spleen (grade V). Also noted is multiple left renal contusions & lacerations and gross hemoperitoneum. The patient had left 10th, 11th & 12th rib fractures. The patient underwent splenectomy.

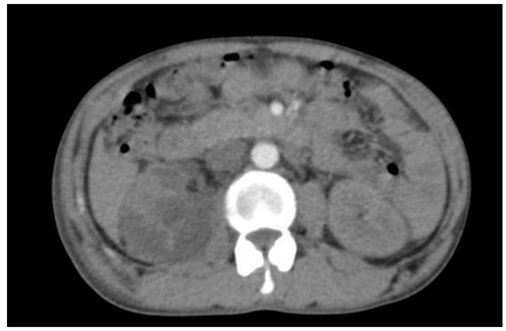


Image 9: A 38-year-old male with multiple right renal lacerations with perinephric collection. Patient had Grade IV renal injury.

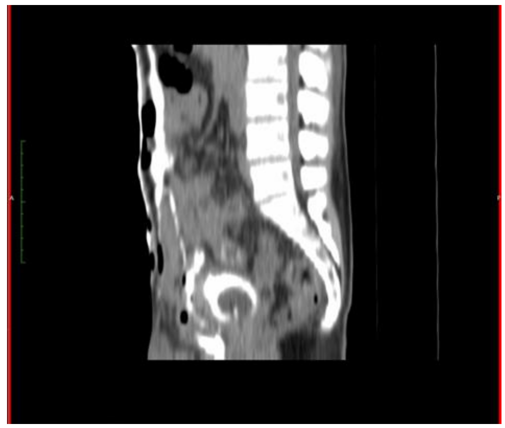


Image 10.1: A 34-year-old male who fell from a height suffered pelvic fractures. Patient presented with hematuria & urinary incontinence. Reconstructed sagittal image of a CT cystogram shows contrast extravasation into the extraperitoneal perivesical space. It is also seen extending along the anterior abdominal wall. Images are consistent with extraperitoneal bladder injury. CT also showed fracture of superior pubic rami.

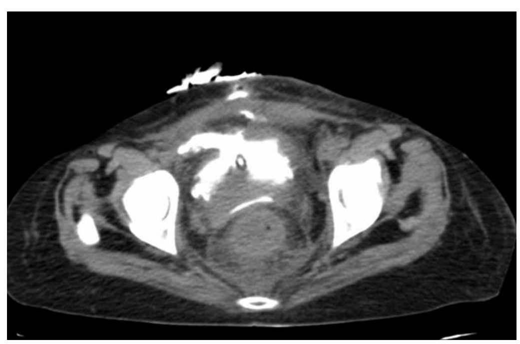


Image 10.2: Axial CT images in the same patient shows a defect in the anterior wall of urinary bladder through which contrast is possibly extravasating.

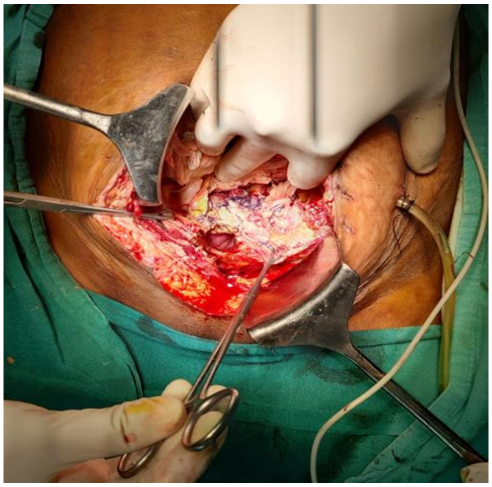


Image 10.3: Intraoperative image showing ongoing repair of the urinary bladder defect of the same patient.

Discussion

The study was conducted on 100 patients referred to the Department of Radio-Diagnosis, Gandhi Medical College, with clinically suspected abdominal trauma, matching inclusion criteria in a period from 2022 to 2023.

Most of the participants were in the age group of 21 - 30 years (31%) followed by the age group of 11- 20 years (29%). Mean age of the participants was 27.5 ± 11.7 years. Manikandan et al.,(2021) [1] from India had similar finding of the most patients belonged to 21-30 years of age group (30%). Madhu et al., (2019) [2] (India) evaluated 50 patients and found majority of patients were of 21-40 year age group (64%). Khan et al., (2019) [3] from Pakistan, studied 88 patients and evidenced mean age of 35.83±14.02 years, slightly higher than that of our study. Most frequent age group was 15–30 years (40.9%). Another Indian study, Marathu et al., (2019) [4] observed the mean age of 33.05±11.85 years. Three other Indian studies, Srivastava et al., (2018)[5], Ravindernath et al., (2017) [6] and Prasad et al., (2015) [7] reported most common age group of 20-40 years (60%), 18-25 years (33.8%) and 21-30 years (32.6%), respectively. Young people have more chances of getting trauma due to more exposure to out-door and violence activities.

86% of the patients were male in our study. Other studies supported our finding and showing male predominance among their patients i.e. Manikandan et al., (2021) [1] (70%), Madhu et al., (2019) [2] (84%), Khan et al., (2019) [3] (85%), Marathu et al., (2019) [4] (72%), Srivastava et al., (2018) [5] (94%), Ravindernath et al., (2017) [6] (78.5%) and Prasad et al., (2015) [7] (88.4%). It is because of involvement of males in more out-door and violence activities.

On USG examination, we found that majority (87%) of the participants had hemoperitoneum. The most common involved organ, detected on USG, was spleen (34%) followed by liver (28%) and kidney (17%).On USG, Khan et al., (2019) [3] reported intra-abdominal free fluid (>200ml) in 55.7% of the patients. They also evidenced spleen (32.7%) to be mostly involved followed by liver (30.6%), in accordance with our findings. Srivastava et al., (2018) [5] detected free fluid in 62% of the patients on USG. Incidence of involvement of both spleen (35%) and liver (35%) was same among solid organ injury, in their study. Ravindernath et al., (2017) [6] and Madhu et al., (2019) [2] evidenced hemoperitoneum in 83.9% and 54% of the cases, respectively.

On CT examination, majority (89%) of the participants had extra-peritoneal fluid. The most common organ involvement detected on CT was spleen (45%) followed by liver (33%) and Bone/Spinal injury (32%). On CT, Khan et al., (2019) [3] reported intra-abdominal free fluid (>200ml) in 67% of the patients. However, liver (40.7%) was mostly involved organ followed by spleen (25.4%), which defers our findings. Srivastava et al., (2018) [5] detected free fluid in 64% of the patients, on CT. In contrast to our findings, liver (30%) was most commonly involved organ followed by spleen (28%), on CT.

Ravindernath et al., (2017) [6] and Madhu et al., (2019) [2] evidenced hemo-peritoneum in 100% and 56% of the cases, respectively.

On CT based AAST grading of splenic injury, majority cases were of grade IV > Grade III. For liver, majority cases were of grade III > Grade IV . Majority cases were of grade III > Grade IV on AAST grading of renal injury. For pancreas injury, majority cases were of grade III > Grade IV. Madhu et al., (2019) [2] observed most common grades for different organ injury on MDCT as follows: splenic (grade II> III), liver (grade II > III), and renal (grade III > IV). Srivastava et al., (2018) [5] observed grade I (57%) to be the most common for splenic injury followed by grade III (29%). Other injured organs with their AAST grading on CT were:- liver [grade I (82%)> grade II (6%)=grade III (6%)= Grade IV (6%)] and renal [grade III (56%) > I (44%)].

On surgical observation, we confirmed that majority (99%) of the participants had hemo-peritoneum. Surgically, splenic injury was the most common followed by liver. However, Verma et al., (2024) [8] reported liver to be most common found injured organ followed by spleen, intra-operatively. We compared the intra operative findings with USG and CT findings for the solid organs.

We documented sensitivity, specificity, PPV, NPV and accuracy of USG to detect splenic injury was 77.3%, 100%, 100%, 84.8% and 90% respectively with substantial agreement in detecting the condition (k = 0.792). CT was found to have more sensitivity (97.7%) but lesser specificity (96.4%). PPV, NPV and accuracy for CT was 95.6%, 98.2% and 97% respectively perfect agreement in detecting the condition (k = 0.939).Verma et al., (2024) [8] documented 100% sensitivity and 92.8% specificity for splenic injury on USG, which differs our findings. They also noted 83.3% sensitivity and 100% specificity on CT. In contrast to our findings, they observed USG to be more sensitive and less specific than CT to detect splenic injury.

For detecting hepatic injury, sensitivity, specificity, PPV, NPV and accuracy of USG was observed to be 80%, 94.3%, 85.7%, 91.7% and 90%, respectively and found to be in substantial agreement in detecting the condition (k = 0.757). CT was found to have more sensitive (96.7%) but same specificity (94.3%) than USG for detecting hepatic injury. PPV, NPV and accuracy for CT was 87.9%, 98.5% and 95% respectively with perfect agreement in detecting the condition (k = 0.884). Verma et al., (2024) [8] reported higher sensitivity (100%) and lesser specificity (92.3%) on USG and higher sensitivity (100%) as well as specificity (100%) on CT when compared to our finding for detecting hepatic injury.

For renal injury detection, USG had 63% sensitivity but 100% specificity with 100% PPV, 88% NPV and 90% accuracy. Kappa value of 0.713 indicates substantial agreement in detecting the hepatic injury on USG. CT had more sensitivity (100%) but lesser specificity (97.3%) than USG with 93.1% PPV, 100% NPV and 98% accuracy. CT had perfect agreement in detecting the condition (k = 0.950). Verma et al., (2024) [8] showed higher sensitivity (100%) and same specificity (100%) on USG and also same sensitivity (100%) and higher specificity (100%) on CT for detecting renal injury when compared to our study.

USG had very less sensitivity (37.5%) but higher specificity (98.9%) for detecting pancreatic injury with 75% PPV, 94.8% NPV and 94% accuracy. Kappa value of 0.472 indicates moderate agreement in detecting the condition. CT had more sensitivity (87.5%) and specificity (100%) than USG with 100% PPV, 98.9% NPV and 99% accuracy with perfect agreement (k = 0.928). Verma et al., (2024) [8] documented higher sensitivity (50%) and higher specificity (100%) on USG and also higher sensitivity (100%) but same specificity (100%) on CT for detecting pancreatic injury when compared to our study.

For bladder injury, detection by USG had 50% sensitivity and 100% specificity with 100% PPV, 96.9 % NPV and 97% accuracy and with substantial agreement in detecting the condition (k = 0.653). CT was found to be perfect than USG for detecting bladder injury with 100% of each sensitivity, specificity, PPV, NPV as well as accuracy with kappa value 1. Kumar et al., (2005) [9] reported 50% sensitivity of CT to detect bladder injury.

Various other studies also supported our findings correlating the USG and CT findings for organ injury with intra operative findings. Madhu et al., (2019) [2] reported higher sensitivity (92.3%), specificity (75%) and PPV (96%) but lesser NPV (60%) on CT than USG [sensitivity (78.57%), specificity (71.42%) and PPV (84.61%) and NPV (62.50%)] for detecting the organ injury in blunt abdominal trauma. Marathu et al., (2019) [4] also evidenced higher sensitivity (94.7%), specificity (100%) and PPV (100%), NPV (87.5%) as well as accuracy (96%) on CT than USG[sensitivity (83.3%), specificity (87.5%) and PPV (93.7%), NPV (70%) and accuracy (84%)] for organ injury detection.

The variations in results of ultrasound in these studies are may be subjected to several factors, the operator's experience, including the examination technique and extent of sonography, as well as the reference tools used (patient's course, or CT and laparotomy etc.).

Conclusion

High degree of suspicion and prompt screening of patients should be done to rule out any intra-abdominal injury. Ultrasonography may be used as the initial diagnostic or screening modality for suspected abdominal injury. The chance of detecting peritoneal fluid was more than USG. CT was found to be more sensitive and accurate than USG for detecting the organ injuries. However, specificity of CT for detecting splenic and renal injury was lesser than that of USG but same for hepatic as well as bladder injury and more for pancreatic injury. CT was able to detect retroperitoneal injury and pneumoperitoneum which was missed by USG. Additionally, CT was able to detect even the smallest of bony/ spinal injuries which cannot be detected by USG.

Thus, the present study concluded that CT is the superior diagnostic modality in the diagnosis of abdominal trauma. In a nutshell, a multipronged multimodality approach employing combination of USG and CT in evaluating trauma cases can be fairly useful and accurate in early diagnosis as well as management of organ injuries from abdominal trauma with high sensitivity and specificity resulting in reduction of morbidity and mortality.

References

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