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Original Article

Role of multi detector computed tomography (MDCT) in evaluation and management of blunt abdominal trauma.

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Abstract

Background: The majority of all blunt and penetrating body injuries are abdominal injuries. Computed tomography is a significant and quick technology that provides information on the kind of abdominal damage quickly and aids in patient care in accordance with that information. The current study's objectives were to assess the value of Multidetector Computed Tomography (MDCT) in identifying intra-abdominal injuries in patients with acute abdominal trauma and to give knowledge that might precisely guide therapy decisions (non- operative versus operative). and to compare the computed tomography (CT) results to either clinical observation, a further CT scan (if necessary), or the results of surgery (wherever applicable).
Objectives: To examine the utility of multidetector computed tomography (MDCT) in detecting intra-abdominal injuries in patients with blunt abdominal trauma and providing information to define the role of therapy (operative versus conservative).
Materials and Methods: This two-year prospective study looked at 50 patients who had suffered blunt abdominal trauma. The MDCT findings were compared to clinical outcomes, follow-up CT scans (if needed), and surgical outcomes (whichever applicable).
Results: Motor vehicular accidents were the commonest cause of abdomen blunt injury (68%). Abdominal injury was present in 38 (76%) patients and hemoperitoneum was seen on CT scan in 33 patients (85.8%). In 27 patients, hemoperitoneum was associated with solid organ injury. The commonest injury was splenic injury. In 6 patients (15.8%) who underwent surgery, CT findings of hemoperitoneum and solid organ injury were verified, and bowel injury was shown to be the origin of isolated hemoperitoneum in two cases. The CT scan was 100% accurate in detecting hemoperitoneum. During the follow-up period, all conservatively handled cases recovered without incident. As a result, OIS grading appeared to predict care methods in the majority of patients in this study's overall analysis of solid organ injuries, with the exception of those with bowel and mesenteric injuries.
Conclusion: In the diagnosis and management of blunt abdominal trauma, CT is the imaging modality of choice.
Keywords: Computed tomography; Blunt Abdominal Trauma; Organ Injury Scaling (OIS); splenic injury; liver injury, road traffic accidents.

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Introduction

Blunt abdominal trauma is one of the primary causes of morbidity, mortality and is most commonly associated with motor vehicle collisions (MVCs).[1]

Globally, MVCs account for 1.2 million deaths annually (3242 people a day).[2] Multisystem injuries are common in high velocity injuries. Identification of intra-abdominal pathology during initial evaluation can be challenging as clinical history and examination findings may be unreliable or even deceptive. In many cases neurological damage may also be difficult to determine due to underlying influence of intoxicating agents. Existence of related injuries can mask underlying serious abdominal trauma thereby limiting optimal assessment.[3] In this context, imaging plays an important role in assessment of blunt abdominal trauma. CT has been shown to play an important role evaluation of trauma. In blunt injuries, kidney, spleen, and liver commonly affected, after that the intestines.[4] CT is considered an initial standard evaluation tool for detecting intraperitoneal and retroperitoneal injuries.[1] Because of the near proximity of highway, which is prone for high speed MVCs, we decided to investigate the significance of MDCT in assessment of blunt abdominal trauma and to assess, whether CT findings can play a definitive role in management of these patients.

Materials and Methods

Source of data: The study's data was gathered from patients attending/referred to the department of Radio-Diagnosis, Sri R L Jalappa Hospital and Research Centre attached to Sri Devaraj Urs Medical College, Tamaka, Kolar with abdominal blunt trauma.

Method of collection of data: A descriptive correlational study was undertaken in 50 patients with acute abdominal trauma who were referred for contrast enhanced CT abdomen over an eighteen-month period (January 2013-June 2014). They were scanned with a sixteen-slice Multidetector Computed Tomography scanner (SIEMENS SOMATOM EMOTION 16), and the results were compared to clinical follow-up, CT scans (if necessary), and surgical results (whichever applicable). The technique created by Federle and Jeffrey[4] was used to quantify free fluid, which was categorised as small, moderate, or big (Table 1). Individual organ injuries were rated using the Organ Damage Scaling (OIS) system and the Mirvis et al[5] injury severity grades, as well as the American Association for the Surgery of Trauma (AAST) guidelines[6] (Tables 2 through 6).

Intra-abdominal injury was diagnosed in patients who had hemoperitoneum, abdominal visceral injury, or both. Intra-abdominal injury was ruled out in patients who had no visceral injury or hemoperitoneum.

Table 1. Quantification of hemoperitoneum on CT

Hemorrhage location	Quantification on CT	Approximate quantity
Fluid in one	Small	100-200 ml
Fluid in more than one	Moderate	250-500 ml
Fluid in all spaces or pelvic fluid	Large	>500 ml
* Hemorrhage in a single location: perisplenic or perihepatic/ Morrison's		

Table 2: AAST OIS (Organ Injury Scaling) for liver

Grade *	Type of Injury	Description of injury
I	Hematoma	Subcapsular, <10% surface area
	Laceration	Capsular tear,<1cm parenchymal depth
II	Hematoma	Subcapsular, 10% to 50% surface area: intraparenchymal<10cm in diameter
	Laceration	Capsular tear 1-3 parenchymal depth, <10cm in length
III	Hematoma	Subcapsular, >50% surface area of ruptured subcapsular or parenchymal hematoma: intraparenchymal hematoma >10 cm or expanding
	Laceration	>3 cm parenchymal depth
IV	Laceration	Parenchymal disruption involving 25% to 75% hepatic lobe or 1-3 Couinaud's segments
V	Laceration	Parenchymal disruption involving>75% of hepatic lobe or >3 Couinaud's segments within a single lobe
	Vascular	Juxtahepatic venous injuries; ie. retrohepatic vena cava/central major hepatic veins
VI	Vascular	Hepatic avulsion

*Advance one grade for multiple injuries up to grade III

Table 3: AAST OIS (Organ Injury Scaling) for Pancreas.

Pancreas Injury Scale

Grade*	Type of Injury	Description of Injury	ICD-9	AIS-90
I	Hematoma	Minor contusion without duct Injury	863.81-863.84	2
	Laceration	Superficial laceration without duct Injury		2
II	Hematoma	Major contusion without duct injury or tissue loss	863.81-863.84	2
	Laceration	Major laceration without duct injury or tissue loss		3
III	Laceration	Distal transection or parenchymal injury with duct injury	863.92/863.94	3
IV	Laceration	Proximal [a] transection or parenchymal injury involving ampulla	863.91	4
V	Laceration	Massive disruption of pancreatic head	863.91	5

*Advance one grade for multiple injuries up to Grade III. *863.51,863.91-head:863.99,862.92-body; 863.83,863.93-tail. [a] Proximal pancreas is to the patients' riaht of the superior mesenteric vein.

Table 4: AAST OIS (Organ Injury Scaling) for Spleen

Spleen injury scale (1994 revision)

Grade*	Injury type	Description of injury
I	Hematoma	Subcapsular,<10% surface area
	Laceration	Capsular tear, <1cm parenchymal depth
II	Hematoma	Supcapsular, 10%-50% surface area: intraparenchymal, <5cm in diameter
	Laceration	Capsular tear, 1-3cm parenchymal depth that does not involve a trabecular vessel
III	Hematoma	Subcapsular, >50% surface area of expanding; ruptured subcapsular or parenchymal hematoma; intraparenchymal hematoma ≥ 5cm or expanding
	Laceration	>3cm parenchymal depth or involving trabecular vessels
IV	Laceration	Laceration involving segmental or hilar vessels producing major devascularzation (>25% of spleen)
V	Laceration	Completely shattered spleen
	Vascular	Hilar vascular injury with devascularizes spleen

*Advance one grade for multiple injuries up to grade III.

Table 5: AAST OIS (Organ Injury Scaling) for Kidneys.

Kidney injury scale

Grade*	Type of injury	Description of Injury
I	Contusion	Microscopic or gross hematuria, urologic studies normal
	Hematoma	Subcapsular, nonexpanding without parenchymal laceration
II	Hematoma	Nonexpanding perirenal hematoma confirmed to renal retroperitoneum
	Laceration	<1.0 cm parenchymal depth of renal cortex without urinary extravagation
III	Laceration	<1.0 cm parenchymal depth of renal cortex without collection system rupture or urinary extravagation
IV	Laceration	Parenchymal laceration extending through renal cortex, medulla, and collecting system
	Vascular	Main renal artery or vein injury with contained hemorrhage
V	Laceration	Completely shattered kidney
	Vascular	Avulsion of renal hilum which vascularizes kidney

* Advance one grade for bilateral injuries up to grade III

Table 6. Grading of bladder injury

Classification System for Bladder Injury Based on Findings at CT Cystography	
Type of Injury	**Finding**
1	Bladder contusion
2	Intraperitoneal rupture
3	Interstitial bladder injury
4	Extraperitoneal rupture A. Simple extraperitoneal rupture B. Complex extraperitoneal rupture
5	Combined bladder injury

Statistical Methods

The current study used descriptive statistical analysis, and the results are reported as mean SD (min to max) for continuous variables and number (percent) for categorical data. The correlation of CT scan was discovered using diagnostic data such as sensitivity, specificity, PPV, NPV, and accuracy.

Results and Observations

The youngest patient in this study was three years old, and the oldest was eighty. The bulk of the patients were between the ages of 21 and 30 (28 percent). (Table 7).

Table 7. Patient age distribution.

Age (in years)	Number	Percentage (%)
0 day – 10	4	8
11 – 20	8	16
21 - 30	14	28
31 - 40	12	24
41 - 50	7	14
51 - 60	3	6
61 - 70	1	2
71 - 80	1	2
Total	**50**	**100**
Mean age	**31 years**	

As expected there was a male preponderance (74%) with abdominal blunt injury compared with female patients (26%) (Table 8). MVCs/motor vehicle accidents (MVA) were the leading cause of abdominal trauma in both men and women, followed by falls from great heights and assault (Table 9). This is unsurprising given our hospital's proximity to a major highway, where high-velocity MVAs are common.

Table 8: Patients gender distribution

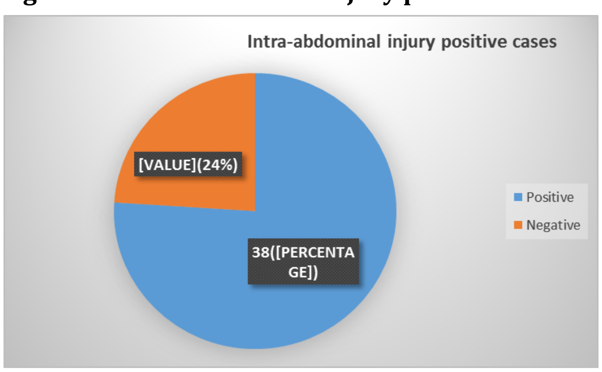
Gender	Number	Percentage (%)
Male	37	74
Female	13	26
Total	**50**	**100**

Table 9: Mode of abdominal blunt injury.

Mode of Injury	Male	Female	Total Patients
MVA / RA	27 (72.9)	7 (53.8)	**34 (68.0)**
Fall from height	6 (16.2)	4 (30.8)	**10 (20.0)**
Assault	4 (10.8)	2 (15.4)	**6 (12.0)**
Total	**37 (100.0)**	**13 (100.0)**	**50 (100.0)**

In our study, 76 percent (38 patients) of the patients had abdominal damage, while only 24 percent (12 patients) did not (Figure 1). All of the parameters reported by both radiologists had high inter-observer agreement, with no deviations.

Figure 1: Intra-abdominal injury positive cases.



86.8% (33 patients) of the 38 patients who tested positive for intra-abdominal injury had hemoperitoneum, while 13.2% (5 patients) had visceral injury without hemoperitoneum (Table 10). 71 percent (27 patients) of patients with hemoperitoneum had accompanying solid organ injury, and 15.8% (6 patients) had isolated hemoperitoneum (Figure 2).

Table 10: Positive Intra-abdominal Injuries: Distribution.

Positive Intra-abdominal injuries	Number of cases	Percentage (%)
Solid organ injury with Hemoperitoneum	27	71
Hemoperitoneum free visceral injuries	5	13.2
Hemoperitoneum Isolated	6	15.8
Total	**38**	**100**

Figure 2: Positive Intra-abdominal Injuries distribution.

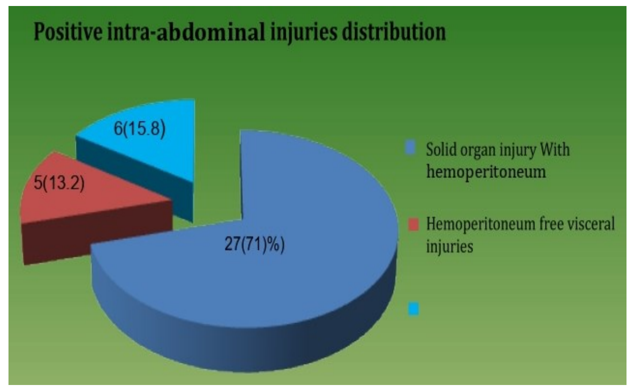
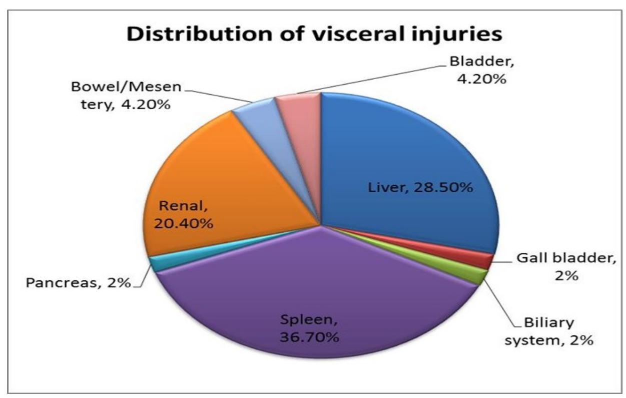


Figure 3: Visceral Injuries Distribution.



The commonest organ injured in this study was spleen (Figure 3) seen in 18 patients (out of 33 with hemoperitoneum). Majority of them (11 patients; 61.1%) were grade three injuries. All splenic injury cases were managed conservatively and did well on follow-up.

There were 14 cases of liver damage, with the majority (8 patients, or 57 percent) being grade III. There was one incidence of gall bladder injury with limited haemorrhage into the lumen of the gall bladder and one case of intrahepatic biliary duct injury with several bilomas. On follow-up, these individuals had no stomach pain, fever, or jaundice, thus they were treated conservatively. There was just one case of grade V liver injury and none of grade VI. Hepatic damage was treated conservatively in all cases.

The third most common injuries were renal injuries (10 cases) with 40% of these being grade IV injuries. Renal injury cases were managed conservatively and did well on follow up.

There was just one case of pancreatic injury (complete transection of pancreas at the neck) that was managed surgically.

CT observations of pneumoperitoneum and intestinal wall thickening were used to diagnose two cases of bowel damage. In addition, two incidences of intestinal damage were discovered. Intraoperatively in cases of isolated hemoperitoneum taken up for surgery that are clinically unstable. Only 50% of bowel cancer was detected in this investigation (2 out of the 4 cases). Pneumoperitoneum without a known cause, intramural/intra-mesenteric/retroperitoneal air without a known source, direct gut wall discontinuity, and extra luminal faeces are all direct CT indicators of bowel injury. Indirect CT indicators include intestine wall thickness greater than 4 mm, retroperitoneal fluid, particularly anterior para renal fluid, fluid between mesentery folds, and uneven bowel wall enhancement. Bowel injuries without overt CT features may be difficult to detect in CT study.[8]

There were two cases of bladder injuries (one extraperitoneal and one intraperitoneal). All bladder injury cases were associated with pelvic fractures. The case with intraperitoneal bladder injury was taken up for surgery.

Table 11: Number of Cases Operated Along with Indication for Surgery.

	Number of detected cases by CT	**Number of cases Operated**	**Cases with Additional Injuries detected on Surgery**
Isolated Hemoperitoneum	6	2	Bowel injury present in both cases
Bowel Injuries	2	2	
Bladder Rupture (Intra-peritoneal)	1	1	
Pancreatic Injuries	1	1	
Renal Injuries	10	0	
Liver	14		
Spleen	18		
Total Operated Cases		**6**	

In our study, there were 6 cases of hemoperitoneum isolated, of whom 2 were unstable clinically and hence were operated upon. It was determined Bowel injury as the cause of isolated hemoperitoneum in these 2 cases. Patients with bowel injuries, intraperitoneal bladder rupture and pancreatic injury were operated upon. Any of the patients with liver, spleen and renal injuries were operated. This probably suggests that in patients with blunt abdominal trauma, bowel injuries, intraperitoneal bladder rupture and pancreatic rupture are perhaps of concern for the surgeon and that these areas should be focused upon by radiologists while evaluating blunt abdominal trauma.

In this study, 12 cases (24%) were found to be free of intra-abdominal damage and discharged based on CT findings. All of these patients had an uneventful outpatient follow-up.

In this investigation, the sensitivity was assessed based on how accurate CT findings were in directing patient therapy (Operative vs Conservative). Surgical therapy was recommended for four of the 38 patients who had intra-abdominal damage based on CT results. In these four patients who had laparotomy, all CT findings were associated. As a result, CT was 100 percent accurate. Two patients with isolated hemoperitoneum (who had been given a period of observation based on CT findings) developed clinically worsening symptoms and required laparotomy. These two cases both suffered intestinal injuries that were not seen on CT images. As a result, there were four intestinal injuries in this study, only two of which were confidently diagnosed by CT scan.

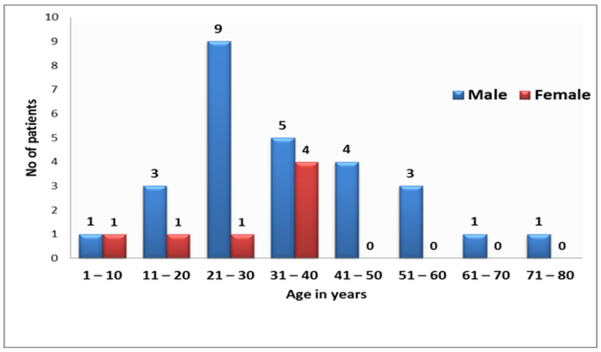
In this investigation, the total sensitivity and specificity of CT findings used to guide patient therapy were 66.7 percent and 100 percent, respectively. Only the examples that were operated were used to calculate the sensitivity. Because the majority of the cases in our study were handled cautiously, the overall sensitivity is likely to be higher. This study had a 100% positive predictive value, a 94.1 percent negative predictive value, and a 94.7 percent accuracy.

Discussion

Male patients (74%) had blunt abdominal injuries compared to female patients (26%), and male patients outnumbered female patients in all forms of injury (Table 8).

The majority of male patients involved in motor vehicle accidents were between the ages of 21 and 30, with age groups 31-40 and 41-50 following in decreasing order (Figure 4).

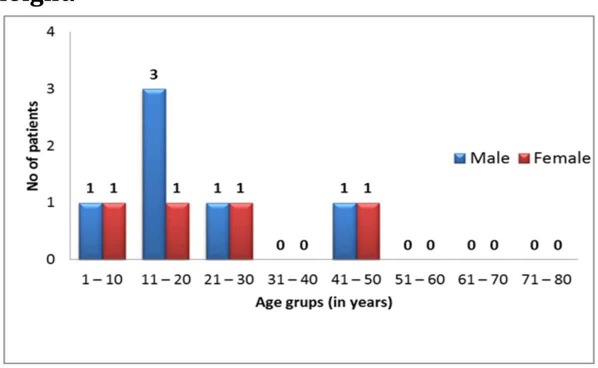
Figure 4: Gender-wise distribution in motor vehicle collisions.



When the pattern of mode of injury was analyzed according to gender-wise distribution, it was seen that most of the patients were victims of MVA/RA, which accounted more than 2/3rd of all cases of trauma, with a male preponderance (27 males vs 7 females).

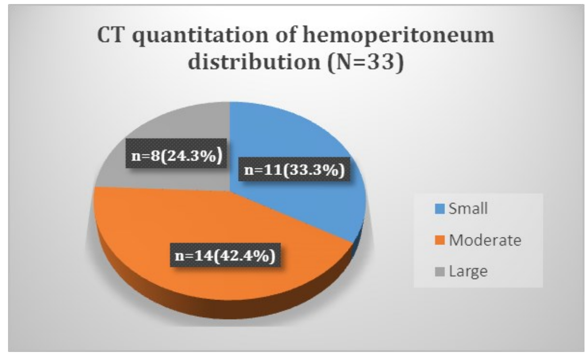
The gender-wise distribution of patients who sustained injuries due to fall from height showed that maximum cases were seen in age group of 11-20 years (3 males and 1 females). However, there were very few cases, outside this age group, with no cases being recorded in patients aged >50 years (Figure 5).

Figure 5: Gender-wise distribution in fall from height.



In this study, 76 percent (38 patients) of the 50 patients tested positive for abdominal damage, while only 24 percent (12 patients) tested negative. Polytrauma occurred in the majority of the patients, with injuries affecting multiple viscera or systems. In this investigation, one patient died as a result of concomitant brain injuries.

Figure 6: CT quantitation of hemoperitoneum distribution (N=33)



On CT, 33.8 percent (11 patients) had little hemoperitoneum, 42.4 percent (14 patients) had moderate hemoperitoneum, and 24.3 percent (8 patients) had big hemoperitoneum (Figure 6). Furthermore, surgery was required in 37.5 percent (3 patients) of those with extensive hemoperitoneum and 27.3 percent (3 patients) of those with little hemoperitoneum. The surgical team determined if surgery was necessary based on a variety of factors such as the patient's hemodynamic status and CT findings, among others, before deciding on a conservative or surgical strategy. Thus, in this investigation, Federle and Jeffrey et al[4] CT quantification was not a reliable predictor for operative management. Our findings differ from those of Mallik K et al[9], who reported a strong link between CT measurement of hemoperitoneum and therapeutic strategy. Mallik K et al[9] studied patients with minor hemoperitoneum.

Figure 7: A 13 year old male patient with isolated heamoperitoneum. Axial CECT image showing minimal pelvic collection without associated visceral injury.

A study observed that the isolated finding of free intraperitoneal fluid in males with blunt trauma is approximately 3% of patients.[10] In our study all cases of hemoperitoneum were managed conservatively (27 cases; 81.8%) a n d had uneventful recovery during clinical observation or follow up period. CT was 100% sensitive in detecting hemoperitoneum.

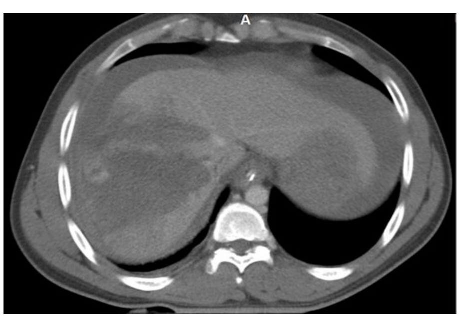
Splenic injuries (figure 8) have been found to be more common and seen in more than one-third of patients, which is similar to the rates observed in our study. Although more than 60% of these injuries (11 out of 18) were grade III injuries, they were managed conservatively.

Our results are in agreement with another study[11], which has shown that CT findings in splenic trauma cannot be used to determine reliably the need for surgical/conservative management. Patients with CT grade III, IV, and V splenic parenchymal injuries have been effectively managed conservatively if the clinical situation is adequate, however patients with low CT grades can still have delayed splenic rupture.[11] The decision between operational and non-operative splenic trauma care should be based on both clinical and CT results, rather than just CT findings.

Consistent with literature reports[12], which suggest that CT staging for liver injuries (Figure 9) has little therapeutic implications, all liver injury cases were managed conservatively in our study, questioning the CT role in staging for liver injury.

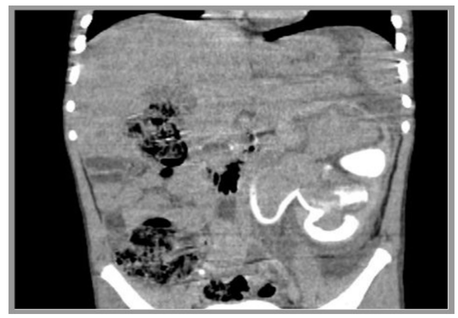
Figure 8: 16 year old male patient with grade III liver & grade II splenic injuries. Axial CECT image showing linear non enhancing hypodensities involving segment V & VI of liver and upper pole of spleen, suggestive of lacerations.

Figure 9: A23 year old male patient with grade IV liver injury. Axial CECT image showing liver lacerations involving segment VII & VIII with moderate perihepatic collection.



The third most usually injured organ in this investigation was the kidney (20.4 percent, 10 cases). Grade II and IV injuries accounted for 40% (4 out of 10) of the total (figure 10). All of the instances were handled cautiously and followed up on carefully. CT was found to be effective in directing the management of renal damage in this investigation. Literature has shown mixed results with CT imaging for detecting renal trauma.[13,14,15] Nonetheless in our study we were able to successfully determine outcomes based on CT findings.

Figure 10: 56 year old male patient with grade IV renal injury. Coronal reformatted CECT image showing laceration in left kidney upper pole with hemmorhagic areas in the dilated pelvicalyceal system and with peripheral pooling of IV contrast.



In this investigation, there was one incidence of pancreatic damage with total pancreas transection at the neck. This patient had surgery right away. We can't properly deduce the accuracy of CT in pancreatic injuries based on just one case in this study because we only had one case of pancreatic injury that was discovered on CT. According to research, CT may not be useful in determining pancreatic injury. [16,17,18,19]

Based on CT findings, two cases of intestinal injury were recognised in this investigation. In addition, in clinically unstable patients of isolated hemoperitoneum taken up for surgery, two occurrences of intestinal damage were discovered. As a result, only 50% of bowel and mesenteric lesions were detected in this investigation (2 out of the 4 cases). For intestinal injuries, CT demonstrated a sensitivity of 50%. There are inconsistent findings on the diagnosis of intestine and mesenteric injuries[16], and given the small number of patients with bowel injuries, we cannot extrapolate on the sensitivity of CT for evaluating bowel injuries.

There are two bladder injuries in our study, one extra peritoneal and one Intraperitoneal. Every case of bladder injury was linked to a pelvic fracture. Surgery was scheduled for the Intraperitoneal bladder damage.

All of the bladder damage cases were correctly detected using CT. Thus, in this study's overall CT examination of visceral injuries, OIS grading in isolation appeared to predict therapeutic procedures in the majority of patients, with the exception of intestinal injuries (CT sensitivity for bowel injuries was only 50 percent in this study). Other research have come to the same conclusion.[9]

In this investigation, the total sensitivity and specificity of CT findings used to guide patient therapy were 66.7 percent and 100 percent, respectively. This study had a 100% positive predictive value, a 94.1 percent negative predictive value, and a 94.7 percent accuracy. Similar findings have been seen in other studies.[15] CT's poorer sensitivity in detecting intestinal injuries was fully responsible for the lower overall sensitivity. In this investigation, CT was extremely accurate in detecting additional visceral lesions, with 100% sensitivity in detecting hemoperitoneum.

Adult age group patients with blunt torso trauma and normal abdominal CT scans are at low risk for subsequently identified intra-abdominal injury. Thus, hospitalization for evaluation of possible intra-abdominal injury after a normal abdominal CT scan is unnecessary in most cases.[20]

Our study has some limitations. Firstly our study was limited to a sample size of 50 patients. A larger sample size would have provided more robust data for our study however our results are consistent with other studies conducted elsewhere. Moreover, RTAs accounted for most of the abdominal injuries in our study. Our study was not sufficiently powered to analyze types of injury sustained based on mode of injury and therefore most of the results are from MVA -related injury. Although in our hospital, RTAs are common, these results may be different in places where assault and trauma due to fall may be associated with greater frequency. Thirdly, most of patients in our study were from younger age group. Therefore, we have limited data on how the intra-abdominal injuries may behave in elderly individuals.

Nonetheless, our study highlighted the CT role in management of intra- abdominal trauma with excellent correlation compared to existing data.

Conclusion

In imaging abdominal trauma, the difficulty is to reliably detect injuries that require early exploration while avoiding unnecessary operational intervention in situations that may be handled conservatively.

Intra-abdominal injury was found in 76 percent of the cases (38 of 50), and the majority of the patients were polytrauma patients with injuries to multiple viscera or systems. CT was able to diagnose related injuries to the head, chest, spine, and limbs in these patients.

The CT scan was 100% accurate in detecting hemoperitoneum. Only 50% of intestinal and mesenteric injuries were detected in this investigation. In intestinal and mesenteric injuries, CT scan findings can be faint and non-specific. In individuals who have multiple questionable CT scan findings for bowel or mesenteric damage, surgical exploration should be explored. Because no single diagnostic modality has been shown to be superior in reliably diagnosing bowel injuries, a multi-modal approach is required, taking into account the mechanism of injury, clinical status, serial physical examination, pertinent laboratory data, and the appropriate diagnostic imaging modalities.

Except for individuals with intestinal injuries, OIS grading in isolation appeared to predict care regimens in the majority of our patients in our study's overall examination of visceral injuries.

A negative CT scan is just as valuable as a positive one since it prevents unneeded admission or abdominal exploration. This is especially relevant in patients who have numerous injuries, such as serious cranial or extremities injuries, and who might benefit from avoiding the added stress of stomach surgery. Finally, in the diagnosis and management of acute abdominal trauma, CT is a superior diagnostic method.

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