Panacea Journal of Medical Sciences 2024;14(3):741–747

Content available at: https://www.ipinnovative.com/open-access-journals

Panacea Journal of Medical Sciences

Journal homepage: http://www.pjms.in/

Original Research Article

Evaluation of the role of helical CT in blunt abdominal trauma

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ARTICLE INFO

Article history:
Received 17-11-2023
Accepted 28-02-2024
Available online 21-12-2024

Keywords:
Blunt abdominal trauma
Helical CT
CT scan

ABSTRACT

Background: The majority of injuries are the result of blunt trauma. For these individuals, CT has emerged as the main diagnostic tool. The development of computer technology and slip ring gantry design has made it possible to scan much faster thanks to the availability of helical or spiral CT scanners. These advancements have also made rapid picture reconstruction possible with faster microprocessors.
Aim: the aim of the study was to assess the role of helical CT in evaluation of patients with blunt abdominal trauma.
Materials and Methods: Total 39 patients after taking written informed consent were studied with Helical CT Scanner using GE, Hi-Speed CT/i Scanner. (General Electric) at tertiary care district hospital of Jammu.
Results: A total of 39 patients with mean age of 34 years were studied. The CT examination was conducted at an average of 2.6 days after sustaining blunt trauma. The accuracy of CT was confirmed by surgical, clinical and radiological follow up for an average period of 7.9 months. The major cause of injury in our study was road traffic accident. The most frequently involved viscera in our study were kidneys which comprised 33.33%. This was followed by bowel/mesentery 15.15%, liver 8.24%, spleen 8.24% pancreas, 8.24%, urinary bladder 8.24% and diaphragm 3.03%.
Conclusion: Helical CT has become a major advancement to assess the trauma patients, because of fast scans and also image reconstruction time have reduced patient turn-around time for abdominal trauma. CT having the advantage over other imaging methods like excretory urography, sonography, and radionuclide imaging because superior contrast resolution and ability to visualize all organs as well as simultaneously the peritoneal cavity and retroperitoneum can be visualized.

1. Introduction

The majority of injuries, known as blunt trauma or wide impact trauma, are caused by energy exchange between an object and the human body rather than by skin penetration. CT has supplanted radionuclide imaging and abdominal aortography as the principal diagnostic technique in hemodynamically stable trauma patients, thereby obviating the necessity for exploratory laparotomy and reducing diagnostic uncertainty. The development of the helical or spiral CT scanner in slipring gantry design and computer technology has made scanning faster. Rapid image reconstruction is made possible by faster microprocessors, which allows acutely injured patients to be examined without requiring a significant amount of time. Spiral CT with a rapid power-bolus IV contrast material injection has become the standard of care for hemodynamically stable blunt trauma patients. It is used to evaluate the thoracic and abdominal organs as well as vascular structures, particularly the aorta. Spiral CT provides 3D pictures of blood arteries and bone structures, simplifying the display of vascular damage and fractures. With thinner slices and higher spatial resolution, the most recent generation of

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https://doi.org/10.18231/j.pjms.2024.132
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multidetector-row scanners enables better patient coverage and scans in less than a second during a single breath-hold. CT angiography in trauma has gained popularity due to faster scanning methods that can separate and optimize venous and arterial phase images more accurately. The intrathoracic abdomen, pelvic abdomen, retroperitoneal abdomen, and true abdomen are the four arbitrary divisions of the abdomen. Advanced Trauma Life Support (ATLS) guidelines state that abdominal or pelvic organ damage cannot be clinically ruled out. When the trauma team and emergency radiologist work together, patients can receive "expectant management" on time, which includes surgery, angiographic intervention, or observation. Helical CT can be used for a quick work-up of patients who are brought to the emergency room and are hemodynamically stable. The following considerations must be taken regarding these patients: is urgent surgery required, and if not, is a period of observation required, or can the patient be safely discharged? Helical CT can provide precise results and quantify all organs together with any visible injuries or ongoing bleeding, therefore it can provide answers to both of these issues. More diagnostic data can be obtained from a helical CT scan than from a full US test or diagnostic peritoneal lavage. Thus, fast process helical CT may alter the course of treatment for some trauma patients who are minimally unstable. Contrast enhanced spiral CT is crucial for the examination and evaluation of injuries in hemodynamically stable patients. Furthermore, angiography combined with embolization of current hemorrhage identified by helical CT scan has demonstrated significant potential in halting bleeding while maintaining organ function, namely in the pelvis and spleen.

CT is useful in cases of further abdominal injuries that call for more details.

A follow-up CT scan can be helpful in evaluating postoperative problems or in supporting clinical decision-making when taking a cautious strategy. To identify a ruptured diaphragm, helical CT scans, sagittal, and coronal reconstruction pictures are helpful.

MRI has been shown to be nearly as accurate as CT in the accurate assessment of individual organ injuries, although there are drawbacks such as restricted access to patient monitoring and resuscitation and the requirement for MRI-compatible equipment. An assessment of the entire abdomen and pelvis requires multiple sequences, which increase the total image time and are more expensive and frequently unavailable.

This study was undertaken with the aim and objective to assess the role of helical CT in evaluation of patients with blunt abdominal trauma with special attention to the following:

1. To determine the role of helical CT in detection and characterization of intra-abdominal injuries or active bleeding.
2. To demonstrate the extent of injury or rule out other concomitant injuries.
3. To assess the role of helical CT in planning the management of patient.
4. To know the significance of helical CT in follow up after treatment.

An attempt was made to compare helical CT findings with operative findings in cases where surgery was done.

2. Materials and Methods

The study was conducted in the patients who sustained blunt trauma to the abdomen referred to the Department of Radiodiagnosis, Government Medical College Jammu for helical CT by various departments during the period of study. The study was started only after the permission from the institutional ethical committee. After obtaining informed consent, total 39 patients were observed for the study. A detailed enquiry was made regarding the possibility of any contraindication to radiological contrast material like idiosyncratic anaphylactoid reactions, severe renal insufficiency etc.

Demographic data with detailed history and routine blood investigations were done. Also different appropriate investigations were also done like X-ray chest standing PA view, plain X-ray abdomen Supine, four quadrant diagnostic peritoneal tap, intravenous Urography (IVU), ultrasonography (USG)wherever applicable abdomen and all the patients under study were imaged on Helical CT Scanner using GE, Hi-Speed CT/i Scanner. (General Electric).

2.1. *Preparation*

Dilute (2-5%) water soluble oral contrast material, gastroscan (Meglumine and Sodium Diatrizoate), total dose of 500–750 ml was administered 5–40 minutes prior to CT scanning orally or via a nasogastric tube to opacify the bowel.

For Helical CT Examination:

1. Patient were be counselled to reduce swallowing and snoring movements and to reduce head motion.
2. Stomach was decompressed via nasogastric tube to prevent air-fluid artifact.
3. Nasogastric tube was withdrawn into the distal esophagus immediately before scanning to prevent artifact.
4. All extraneous objects such as ECG leads, intravenous lines and other monitoring and support apparatus was repositioned out of the scanning field whenever possible.
5. Patients' arms were, if possible, positioned out of scan field.

2.2. Scanning technique

Nonionic intravenous contrast material 60-75% e.g. ultravist 300 (Iopromide 62.3%) total dose of 2-3ml/kg body weight was administered as a single bolus into the median anticubital vein.

A scan delay of 70-90 seconds was being used from the time of onset of injection of contrast material to the initiation of scanning to allow for peak organ enhancement. Extent of scan covered from inferior lungs to inferior edge of ischia.

A collimation of 5-7mm was used with reconstruction increment 5-7 mm with a pitch of 1-2. Scan parameters were 250mAs at 120KVp.

The helical exposure duration was 20-30 seconds i.e. during a single breath hold. FOV 27-37 cm, Acquisition Matrix 512 x 512 or 256 x 256. Delayed scans were taken wherever necessary.

Helical sections were reconstructed retrospectively for multi-planner reformations and 3D reconstructions whenever necessary.

All CT images were reviewed at multiple window settings viz lung, bone, standard soft tissue.

Films were obtained on attached multiformat dry view laser camera.

Radiological diagnosis was confirmed with operative findings wherever possible.

3. Results

Total number of cases studied was 39, out of which 36 were males and 3 were females. The average age of our patients was 34 years with a range of 5-70 years. Maximum number of patients were between 10-30 years old i.e. 23 (58.9%). The major cause of injury in our study was road traffic accident which comprised 48.7% of our cases followed by fall from height 33.3%, Assault 10.2% and others 7.6%.

CT examination of patients was performed at an average of 2.6 days with a range of 05 hrs-10 days. Most of the patients were examined within one day i.e. 28 patients (71.7%).

The patients were followed up to confirm the CT findings by surgical, clinical and radiological means for an average of 7.9 months with a range of 03-12 months.

The most frequently involved viscera in our study were kidneys which comprised 33.33%. This was followed by bowel/mesentery 15.15%, liver 8.24%, spleen 8.24% pancreas, 8.24%, urinary bladder 8.24% and diaphragm 3.03%.

Total 21 cases with hemoperitoneum were there, among them 12(57.14%) were associated with visceral injury while 9(42.85%) were isolated cases.

According to this quantification, 05 small, 06 moderate and 10 large cases with hemoperitoneum were noted.

3.1. Diaphragm

Only one case of Diaphragmatic injury was reported in our series.

4. Discussion

Total 39 patients of blunt abdominal trauma were evaluated by helical CT. The average age of our patients was 34 years. Male to female ratio was 36:3.

The cause of injury in nearly half of the patients (48.7%) was road traffic accident, which account for the majority and similar to the study done by Kmar et al(73%).

The mean interval between injury and CT examination was 2.6 days with a range of 5 hrs – 10 days with maximum patients scanned within a day.

The accuracy of CT was confirmed by surgical, clinical and radiological follow up for an average of 7.9 months with a range of 03 – 12 months.

Patients were deemed positive for intra-abdominal injury if they had hemoperitoneum, visible abdominal visceral injury, or both. Patients were deemed negative for intraabdominal damage if their examinations did not show hemoperitoneum or visceral injury. Out of the 39 individuals in the current investigation, 35 were classified as positive and 4 as negative.

Out of 35 patients reported, hemoperitoneum was detected in 21 patients, visceral injury in 33 patients, in 2 patients one had abdominal wall injury and the other had lumbosacral spine injury without visceral injury.

Among the visceral injuries kidney was the most common organ involved in (33.33%) followed by bowel/mesentery, liver and spleen which is against Kumar et al 2005[7] whose series showed spleen 36% as most commonly involved organ, followed by Liver. These differences are probably due to inclusion of only acutely injured patients in his series.

According to Federle et al.[8] 19838, CT quantification of the hemoperitoneum was performed for these instances, and the results were categorized as mild, moderate, and big. Hemoperitoneum patients were treated with a laparotomy as a result of this measurement. In present study the cases of hemoperitoneum showed a density of about 40-50 Hounsfield units (HU), except in two cases where the density was about 25-30 HU, one case was perforation of small bowel and in another CT was done more than 48 hours after sustaining the injury. Following laparotomy three case of isolated hemoperitoneum showed gut injury and three cases showed urinary bladder injury, rest of the cases were managed conservatively. Thus, CT was 100% sensitive in detecting hemoperitoneum.

There were 33 incidences of visceral damage reported in the current investigation. There were one or more viscera involved in these injuries. Hemorperitoneum was linked to 21 out of 33 instances, meaning that 63.63% of patients with

Table 1: CT quantification of hemoperitoneum as determined by Federle and Jeffrey in 1983.[1]

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 and anterior/superior to urinary bladder	Large	>500 ml

Table 2: Distribution of patients according to the pattern of Splenic Injury as graded by Mirvis et al 1989 in the study.[2]

Grade	Criteria	No. of cases
I	Capsular avulsion, superficial laceration (s), or subcapsular hematoma < 1 cm maximal thickness.	01
II	Parenchymal laceration (s)1-3 cm deep, central/subcapsular hematoma (s) < 3 cm	02
III	Lacerations > 3 cm deep, central/ subcapsular hematoma (s) > 3 cm in diameter	01
IV	Parenchymal fragmentation into two or more sections	00
V	Intraparenchymal contrast blush or extravasation beyond capsule; progression of injury by follow up CT; devascularized (non-enhancing) spleen	00
Total		04

Table 3: Distribution of patients according to the pattern of Hepatic Injury as graded by Mirvis in the study.[3]

Grade	Criteria	No. of cases
I	Caspular avulsion, superficial lacertion (s) < 1cm deep, subcapsular hematoma < 1 cm maximal thichness.	01
II	Laceration (s) 1-3 cm in diameter, central/subcapsular hematoma (s) 1-3cm in diameter	00
III	Lacerations > 3 cm deep, central/subcapsular hematoma >3 cm in diameter	03
IV	Laceration > 10 cm deep; central/cubcapsular hematoma> 10 cm; lobar maceration or devascularisation; injury extending into major hepatic vein.	00
V	Bilobar tissue maceration; parenchymal contrast “blush” arterial contrast extravasation beyond capsule.	00
Total		04

Table 4: Distribution of patients according to the pattern of Renal Injury as graded by Moore 1989 in the study.[4]

Grade	Criteria	No. of cases
I	Contusion or non-expanding subcapsular hematoma without laceration.	03
II	Non-expanding perirenal hematoma or cortical laceration (<1cm) without urinary extravasation.	03
III	Laceration (>1cm) without urinry extravasion;larger perinephric hematomas.	03
IV	Laceration through the corticomedullary junction and into collection system or segmental renal artery or vein with contained hemorrhage.	01
V	Shattered kidney or avulsion of the renal pedicle.	01
Total		11

Table 5: Distribution of patients according to the pattern of Pancreatic Injury as graded by Moore 1990 in the study.[5]

Grade	Criteria	No. of cases
I	Minor contusion or laceration without duct injury	00
II	Major contusion or laceration without duct injury or tissue loss.	01
III	Distal transaction or parenchymal injury with duct injury.	01
IV	Proximal transaction (to the right of mesecteric vein) or parenchymal injury involving impulla.	00
V	Massive disruption of pancreatic head.	00
Total		02

Table 6: Mirvis's Computed Tomography signs of Bowel injury was adopted for Blunt Bowel Injury in the study (Mirvis et al 1992).[6]

Diagnostic	Suspicious
Pneumoperitoneum without known source	Bowel wall thickening > 4mm
Intramural, intramesenteric, retroperitoneal air without known source	Retroperitoneal fluid especially anterior paranenal
Direct bowel wall discontinuity	Fluid between folds of mesentery (triangles)
Extraluminal feces	Irregular bowel wall enhancement.

Table 7: Distribution of Bowel and Mesenteric Injury in the study.

Type of injury	Diagnosed	Missed	Total	Percentage of diagnosis
Bowel perforation	01	01	02	50%
Mesenteric injury	02	01	03	66%
Total	03	02	05	60%

Table 8: Distribution of patients according to the pattern of Urinary Bladder Injury as graded by Moore et al 1990.[5]

Grade	Description of Injury	No. of cases
I	Contusion, Intramural hematoma Partial thickness	00
II	Extraperitoneal bladder wall laceration < 2cm	01
III	Extraperitoneal (>2cm) or intraperitoneal (<2cm) bladder wall laceration	03
IV	Intraperitoneal bladder wall laceration >2cm	00
V	Intraperitoneal or extraperitoneal bladder wall laceration extending into the bladder neck or ureteral orifice (trigone)	00
Total		04

visceral damage also had hemoperitoneum.

In this study four cases of splenic injury were reported, which constituted 8.24% of visceral injury. All splenic injuries were accurately detected by CT (Jeffrey et al 1981, Federle 1983).[8] Splenic injury was graded according to grading by Mirvis et al 1989,[3] two cases belonged to Grade II, one case to Grade I and one case to Grade III. Three out of four cases were associated with hemoperitoneum, (75%), same as Kumar et al 2005.[7]

For each of these patients, a CT-based score developed in 1988 by Resciniti et al. was also used. It was discovered that those who had conservative management had scores lower than three, which is in line with the findings of Resciniti et al. 19889 and Kumar et al. 2005.[7,9]

Total 4 cases of hepatic injury, constituting 8.24% of visceral injuries were reported. CT findings accurately depicted all kinds of liver injury (Foley et al 1987 and Moon et al 1983).[10] Three out of four cases were associated with hemoperitoneum (75%) as against 100% in series of Kumar et al 2005.[7] Hepatic injuries were graded according to Mirvis et al 1989.[3] Three cases were graded as Grade IV and one case as Grade I, all the cases of Grade IV were operated & CT findings were confirmed.

Total eleven cases of renal injury and constituted 33.33% which was most commonly involved viscera were found in the present study. CT findings of renal parenchymal injury were same as other solid visceral organs except that delayed scan showed extravasation of contrast material suggestive of disruption of collecting system as in Grade III injuries (Sandler et al 1981).[11] The injuries were graded according to Moore et al 1989,[4] Sandler et al 1981.[11] Three cases in each of Grade I and Grade II, three cases graded as Grade III, one case in each of Grade IV and Grade V which were operated and underwent nephrectomy. Most of renal injuries in the study fell into Grade I and Grade II which accounted for majority of cases (75%) Wolfman et al 1992. All cases of renal injuries were detected in the series thus proving CT highly specific and sensitive in detecting renal injury (Sandler CM et al 1981).[11]

Our series had four cases of pancreatic injuries which constituted 8.24% of visceral injuries. Pancreatic injuries were graded according to Moore et al 1990.[5] One case was graded as Grade III and another was graded as Grade II, findings of both were confirmed later on surgery. Two cases with pseudocysts were managed conservatively. In the present series all the four cases of pancreatic injury were detected so Sensitivity of 100% as against Jeffrey et al 1983[12] and Federle 1983 whose series showed 84.6%. This difference probably resulted due to increased interval between the time of injury and CT scan in our series.

In our series five cases of bowel and mesenteric injury were reported constituting 15.15% of visceral injury. In the series three out of five cases of bowel and mesenteric injury were correctly diagnosed and two cases were missed, hence the sensitivity for detection of bowel injury and of mesenteric injury was 50% and 66% respectively and overall sensitivity of 60% as against the series by Butela et al 2001 (64%), Udekwo et al 1996[13] (41%), Kumar et al 2005[7] (50%), Nolan et al 1995[14] (50%).

One case of diaphragmatic injury was reported in our series which constituted 3.03% of visceral injury which was later proved by surgery. The CT findings of diaphragmatic injury were intrathoracic herniation of abdominal viscera, non-visualization of diaphragm, dependent viscera sign, shift of mediastinum towards contralateral side. (Vichimi et al 2005, Cantwel et al 2006, Bergin et al 2000).[15] Sagittal and coronal reformations was more useful in detecting diaphragmatic injury (Killeen et al 1999).[16]

There were four cases of Urinary bladder injuries in our study which constituted 8.24% of visceral injuries. Three out of four cases (70%) were associated with pelvic fractures (70%) Robert et al 1996.[17] CT, features of Bladder injury were, free fluid in pelvis, extravasation of contrast material in the extraperitoneal pelvis, anterior abdominal wall and thigh in two cases (Deck et al 2000)[18] which indicated extraperitoneal bladder rupture which were later proved by surgery. The other two cases were intraperitoneal rupture, one case of intraperitoneal rupture was missed in our series. The sensitivity of detecting urinary bladder injury in our series was 75% as against Chan et al showing sensitivity of 100%. The discordance may be due to inability to perform CT Cystography as one patient become hemodynamically unstable in our series. Thirteen cases of visceral damage were conservatively handled, whereas eighteen cases underwent laparotomy. During the follow-up period, all cases that were conservatively handled recovered without incident.

With no case requiring surgery out of all the ones that were reported as negative, CT had 100% accuracy when reporting a negative scan. It is therefore a very focused inquiry. These patients underwent unremarkable follow-up before being released from care. The accuracy of Wing et al. (1985),[19] Udekwu et al. (1996)[13] (96.6%), and Kumar et al. (2005)[7] (100%) was strongly associated with our study.

35 out of 39 individuals who had blunt abdominal trauma evaluated were found to be positive; three cases were overlooked. Consequently, we found that in our series, CT had a sensitivity of 93% for the detection of visceral lesions and hemoperitoneum, compared to 100% specificity for Peitzman et al. 198620,[20] Sriussadapom et al. 1993;[21] Udekwu et al.1996;[13] and Kumar et al. 2005.[7] Additionally, CT showed to be useful in predicting whether trauma patients would require surgery. The surgeon's decision on patient care was aided by the organ injury grading and CT quantification of the hemoperitoneum.

Due to its accessibility and ease of use, ultrasonography (US) is typically the primary imaging modality utilized to evaluate blunt abdominal injuries. But since quicker scanning and image reconstruction durations have shortened the time it takes to evaluate trauma patients, helical CT has emerged as a significant development in the treatment of abdominal trauma. The main benefits of CT over radionuclide imaging, sonography, and excretory urography are its higher contrast resolution and its capacity to simultaneously view the retroperitoneum, the peritoneal cavity, and all organs. Nonetheless, there is a tendency toward the non-operative therapy of solid parenchymal injury, in part because to CT's capacity to determine the amount of the damage and track its progressive repair.

When hemodynamically stable patients are suspected of having blunt abdominal trauma, it is advised that US be used as the first screening modality. CT should then be used to further define and characterize the extent of injury and further plan the management of these patients.

5. Source of Funding

None.

6. Conflict of Interest

None.

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Cite this article: Shaikh FI, Shah DD. Evaluation of the role of helical CT in blunt abdominal trauma. *Panacea J Med Sci* 2024;14(3):741-747.