ORIGINAL ARTICLE

# The Role of Multislice Computed Tomography (MSCT) in the Detection of Blunt Traumatic Intra Abdominal Injury: Our Experience in Hospital Tengku Ampuan Afzan (HTAA), Kuantan, Pahang

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**SUMMARY**

**Multislice computed tomography (MSCT) is the imaging modality of choice in assessing clinically stable patients with blunt abdominal trauma. This study assessed the role of MSCT in the detection of intra abdominal injury caused by blunt trauma in our centre within a two-year-period (2008-2009). A total of 151 patients had MSCT abdomen for blunt abdominal trauma within this study period. Positive scan were seen in 126 patients (83.4%). Out of these positive scans, liver, spleen and renal injuries were seen in 42.1% (n=53), 34.9% (n=44) and 30.0% (n=34) of cases respectively. Laparotomies were performed in 45 patients. Out of these 45 laparotomies, 10 patients had surgically significant injuries that were missed on CT scan findings. The injuries were bowel perforation (n=4), serosal tear of bowel (n=1), mesenteric injuries with active haemorrhage (n=3), spleen injury (n=1) and liver injury (n=1).**

**KEY WORDS:**
*Computed Tomography, Blunt Abdominal Trauma, Injuries*

## INTRODUCTION

Blunt abdominal injuries are often difficult to be accurately evaluated clinically[1]. It can cause multiple injuries and these injuries may be masked by other more marked external injury. MSCT has been accepted as the diagnostic imaging of choice for the evaluation of blunt abdominal trauma in haemodynamically stable patients[2]. Previous studies had shown its high sensitivity, specificity, and accuracy in the detection and extent of abdominal injuries[3,4].

The use of CT in blunt trauma has influenced the current trends in the management of solid organ injuries towards non-operative managements[4,5]. Even though the decision for operative intervention is usually based on clinical criteria rather than on imaging findings, CT information frequently increases the diagnostic confidence of the surgeons and influences clinical management decision and plays an important role in decreasing the rates of unnecessary exploratory laparotomy[6,7].

This study assessed MSCT detection of intra abdominal injury following blunt trauma and we presented our results in this report.

## MATERIALS AND METHODS

The institutional review board approved this study. We retrospectively traced images and reports of all patients who underwent MSCT for suspected blunt traumatic intra-abdominal injuries in a two-year period at our institution. A total of 151 patients were collected from January 2008 until December 2009.

For all patients, the scans were performed using a four-row MSCT scanner; Somatom Siemens Volume Zoom (Siemens Medical Systems, Erlangen Germany) with slice width of 10mm, 2.5 mm collimation, 0.75s rotation time, table feed of 15 mm and 3 mm reconstruction interval. The CT performed from the dome of the diaphragm to the symphysis pubis. Pre- and post-contrast scans were routinely performed and patients received 2ml/kg of intravenous contrast medium (Iohexol 300 mg I/ml). Oral contrast was not routinely administered in our patients. The contrasted CT scans were acquired during portal venous phase, approximately 80 seconds after contrast injection. Additional delayed images were performed when investigating genitourinary tract trauma. When necessary, sagital and coronal images were reconstructed using multiplanar reconstruction (MPR) technique.

The existence of clinically important injuries was verified either during laparotomy or with clinical notes during hospital stay. All patients that were managed conservatively were traced on follow up notes and outcome of patients at the end of follow-up. The imaging diagnosis was compared with the operative findings where applicable. Positive scan was defined as CT scan study that showed any solid organ injury, bowel and mesenteric injury or retroperitoneal injury. Presence of isolated free fluid in the peritoneum is not considered as positive scan. Free fluid quantification was done according to system given by Federle et al. and was graded as small, moderate or large8. Individual organ injuries were graded according to American Association for the Surgery of Trauma (AAST) classification.

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**RESULTS**

From the 151 patients, 122 (80.8%) patients were male and 29 (19.2%) patients were female. Majority of the patients were Malays (74.2%). Age ranges from 2 to 84 years with mean age of 26.4 years. Motor vehicle accidents were the most common cause of trauma comprising of 82.8%, followed by home injury (6.6%) and industrial accidents (4.6%). The rest were sports injury and assault cases, 2.0% and 4.0% respectively. MSCT were performed within 24 hours of trauma in 86% and after 24 hours in 14% of cases.

Positive scans were detected in 83.4% (n=126) of cases and negative study in 16.6% (n=21). From the 126 patients with positive MSCT, 42 (33.3%) patients were operated. Two patients died (day 2 and day 3 days post operation) due to multiple injuries sustained and the rest 40 patients recovered fully on subsequent follow up. The other 84 (66.7%) patients with positive MSCT were managed conservatively. Clinical notes of 9 patients in this group were incomplete and 79 others had uneventful complete recovery. In 21 patients with negative CT scan, 3 patients subsequently had laparotomy; two of which confirming the absence of significant injury and one patient had small bowel perforation that required surgical repair (false negative). The other 18 patients were managed conservatively. Two patient's record were incomplete, the rest 16 patients showed no clinical features to suggest that traumatic injuries were missed on subsequent follow up (Figure 1).

Laparotomies were performed in 45 patients that confirmed the MSCT findings in 35 patients (77.8%). From these 35 cases, additional injuries were noted in 9 cases during the operation. However, these injuries were mild and didn't require surgical intervention. The injuries were pancreatic contusions (n=4), bowel wall contusions (n=4) and mesenteric tear with no active bleeding (n=1). Ten of 45 patients who underwent laparotomies had undetected surgically significant injuries (Table I). All these patients had concomitant more than one organ injuries except one case with isolated massive haemoperitoneum (false negative). A coincidence of positive CT findings and negative laparotomies has not been observed; therefore no false positive CT was detected. Statistical analysis showed significant correlation between grades of injury and type of management. Those with high grade organ injuries were more likely to have operation compared to those with low grade organ injuries (Table II).

*Visceral injuries*

Out of 126 cases of positive scans, 92 cases demonstrated one-organ injury, 23 cases with two-organ injuries, 3 patients with three-organ injuries, 1 patients with more than three organ injuries and 7 patients had retroperitoneal soft tissue injury without associated organ injuries. The commonest visceral injuries were liver, spleen and renal which comprised of 42.1% (n=53), 34.9% (n=44) and 30.0% (n=34) of cases in relation to positive scans respectively. The frequency of visceral injuries and the grading distribution of the injuries were illustrated in Table III, Table IV, Table V and Table VI.

From 53 patients with liver injury, 35 cases (66.0%) demonstrate liver injury alone and the rest were associated with kidney injury (n=6), spleen injury (n=5), adrenal (n=1) and multiple organ injuries (n=6). Liver injuries were managed conservatively in 77.4% (n=41) and operatively in 22.6% (n=12). One liver injury was missed on MSCT as proven by laparotomy.

From 44 patients with spleen injury, 29 cases (65.9%) demonstrate spleen injury alone and the rest were associated with kidney injury (n=7), liver injury (n=5), pancreas (n=1) and multiple organ injuries (n=2). Spleen injuries were managed conservatively in 50% of the patient and operatively in the remaining 50%. One spleen injury was missed on MSCT as proven by laparotomy.

From 34 patients with renal injury, 16 cases (47.1%) demonstrated renal injury alone and the rest were associated with liver injury (n=6), spleen injury (n=7), pancreas (n=1) and multiple organ injuries (n=4). Renal injuries were managed conservatively in 67.6% (n=23) and operatively in 32.4% (n=11).

From 7 patients with urinary bladder injury, 4 cases were extraperitoneal and 3 cases were intraperitoneal injuries. Operations were done in all 3 cases of intraperitoneal urinary bladder injuries. All patients with extraperitoneal injuries were managed conservatively. Associated pelvic fractures were seen in 57.1% (n=4) of cases.

Pancreatic injuries detected with MSCT were seen in 5 cases. In 3 patients the MSCT was performed more than 24 hours after initial trauma. All these three patients had complete transections of the pancreas on MSCT and one of the cases was complicated by pseudocyst formation that required percutaneous drainage while the other 2 cases recovered fully after conservative management. In the 2 cases where MSCT were done on the same day of trauma, scan revealed pancreatic contusion in both cases. These two patients had laparotomies done for other organ injuries; one patient with bowel perforation and the other patient had multiple injuries involving the liver, spleen and kidneys. There were 4 cases of pancreatic contusions missed on CT scan review and noted during operation for other organ injuries.

Adrenal injuries were seen in 5 cases and in 3 cases it was associated with other intra abdominal organ injuries. In the other 2 cases the patients had adrenal injuries without other visceral injuries. However ribs fractures and lung contusions were seen in these 2 cases.

One case of urethral injuries diagnosed on MSCT had comminuted pelvic fractures. The balloon's of Foley's catheter was abnormally located making the diagnosis of urethral injuries straightforward and it was confirmed with ascending urethrogram performed later.

*Bowel and mesenteric injuries*

MSCT detected bowel injuries in 5 patients and in all these patients operation confirmed the CT findings. All these cases demonstrated free extraluminal air.

There were 8 cases of surgically significant undiagnosed bowel and mesenteric injuries found during laparotomy.

**Table I: Undetected injuries by MSCT as proved by laparotomy**

| Organ injuries | Number |
|---|---|
| Liver | 1 |
| Spleen | 1 |
| Bowel perforation or transection | 4 |
| Serosal tear of bowel | 1 |
| Mesenteric injury with active haemorrhage | 3 |

**Table II: Correlation of severity of organ injuries with management**

| Injuries | Conservative | Operation |
|---|---|---|
| Grade 1-3 | 76.0% | 24.0% |
| Grade ≥ 4 | 42.3% | 57.7% |
| Pearson Chi-Square Test p≤0.001 | | |

**Table III: Distribution of injuries according to MSCT findings**

| Organ injuries | Number | % |
|---|---|---|
| Liver | 53 | 33.1 |
| Spleen | 44 | 27.5 |
| Renal | 34 | 21.3 |
| Urinary bladder | 7 | 4.4 |
| Pancreas | 6 | 3.7 |
| Adrenal | 5 | 3.1 |
| Bowel and mesentery | 3 | 1.9 |
| Retroperitoneum | 7 | 4.4 |
| Urethra | 1 | 0.6 |
| TOTAL | 160 | 100% |

**Table IV: Grading of liver injuries as demonstrated on MSCT**

| Grade | Number of cases | % |
|---|---|---|
| Grade 1 | 14 | 26.4 |
| Grade II | 21 | 39.6 |
| Grade III | 8 | 15.1 |
| Grade IV | 9 | 17.0 |
| Grade V | 1 | 1.9 |
| Grade VI | 0 | 0 |
| Total | 53 | 100 |

**Table V: Grading of spleen injuries as demonstrated on MSCT**

| Grade | Number of cases | Percentage |
|---|---|---|
| Grade 1 | 12 | 27.3 |
| Grade II | 9 | 20.4 |
| Grade III | 11 | 25.0 |
| Grade IV | 4 | 9.1 |
| Grade V | 8 | 18.2 |
| Total | 44 | 100 |

**Table VI: Grading of renal injuries as demonstrated by MSCT**

| Grade | Number of cases | Percentage |
|---|---|---|
| Grade 1 | 4 | 11.8 |
| Grade II | 16 | 47.0 |
| Grade III | 8 | 23.5 |
| Grade IV | 4 | 11.8 |
| Grade V | 2 | 5.9 |
| Total | 34 | 100 |

Seven of the cases demonstrated co-existence other organ injuries; urinary bladder injuries (n=2), liver injuries (n=2), spleen injuries (n=2) and kidney injury (n=1).

*Retroperitoneal soft tissue injuries*

Retroperitoneal soft tissue injuries were seen in 34 cases. In majority of the cases, the retroperitoneal injuries were associated with other injuries such as renal, adrenal, pancreas and liver injuries (n=27). In 7 cases, no other visceral injuries were present but patients had pelvis fracture.

*Haemoperitoneum*

Haemoperitoneum was seen in 66.2% (n=100) of the cases reviewed; minimal (n=44), moderate (n= 31) and massive (n=25). There were 4 cases of haemoperitoneum with negative scan. One was the false negative case with laparotomy-proven bowel injury. The other 3 cases recovered uneventfully after conservative management without any blood transfusion or clinical features suggestive of missed intra abdominal injury.

There were 30 cases of positive MSCT with no haemoperitoneum. The organ injuries in these cases were liver (n=10), renal (n=8), spleen (n=3), liver and renal (n=1), extraperitoneal urinary bladder injury (n=1) and retroperitoneal injuries (n=7). Majority of these patients had Grade I or Grade II organ injuries. Only three patients from this group had Grade III renal injuries and two of them were operated. The rest had uneventful recovery after conservative management.

Contrast extravasation suggestive of active hemorrhages was seen in 6.3% (n=8) of the positive cases reviewed. Organ injuries associated with contrast extravasations were liver (n=5), spleen (n=2) and kidney (n=1). Seven cases with contrast extravasations identified on MSCT were operated. In all of these seven cases, active haemorrhage was confirmed intraoperatively. One patient with contrast extravasation and kidney injury detected on MSCT was managed conservatively. A repeat CT 3 weeks later showed functioning right kidney with residual perirenal haematoma [Figure 2(a) and (b)].

## DISCUSSION

Abdominal injury from blunt trauma posed a challenge to clinicians in giving accurate diagnosis. Many of these patients were the victims of multiple injuries and the clinical signs and symptoms of the intra abdominal injury may be masked by more obvious or compelling injuries elsewhere[1]. However, MSCT can provide a rapid, accurate appraisal of the status of the abdominal viscera, retroperitoneum and abdominal wall[2,3].

The use of MSCT has influenced the current trends in the management of blunt intraabdominal injuries towards non-operative managements9-11. Even though the decision for operative intervention was usually based on clinical criteria rather than on imaging findings, MSCT information frequently increases the diagnostic confidence of the surgeons and plays an important role in decreasing the rates of unnecessary exploratory laparotomy[6,7,12,13].

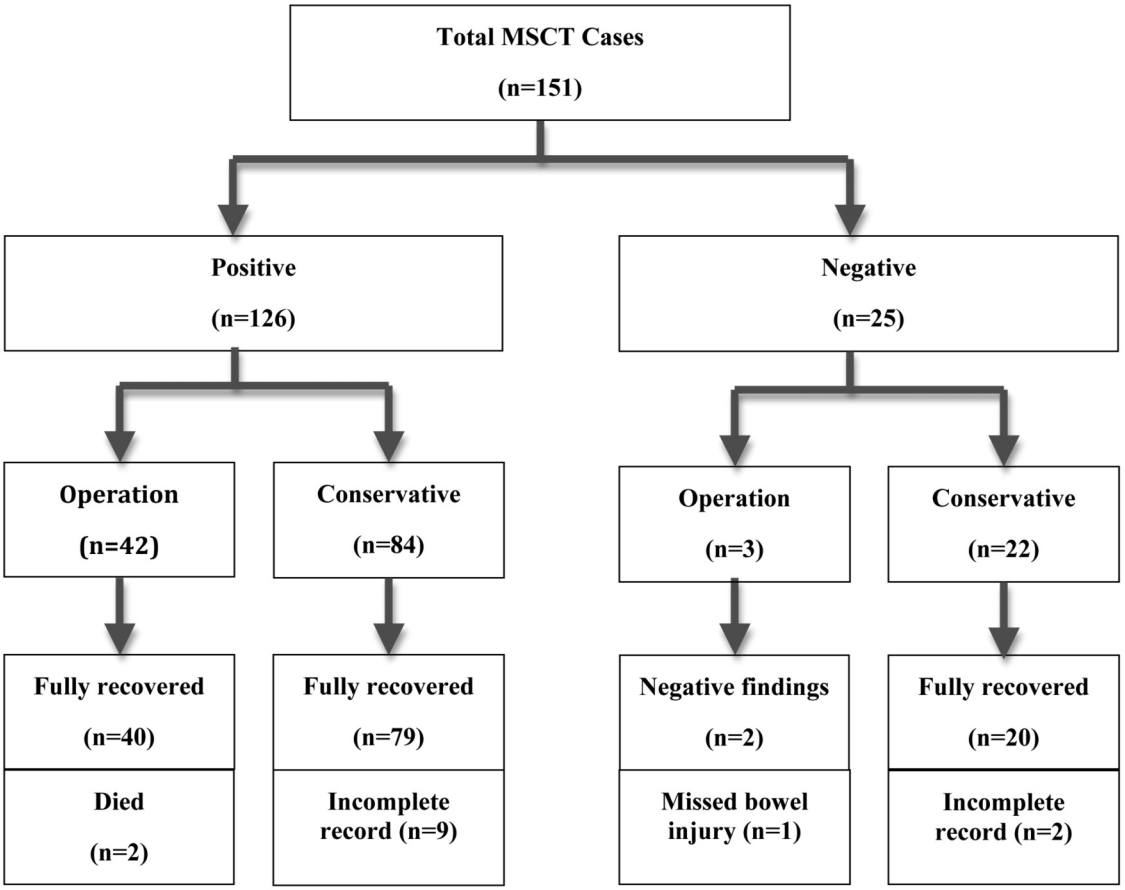


**Fig. 1:** Schematic diagram showing summary of the cases reviewed.

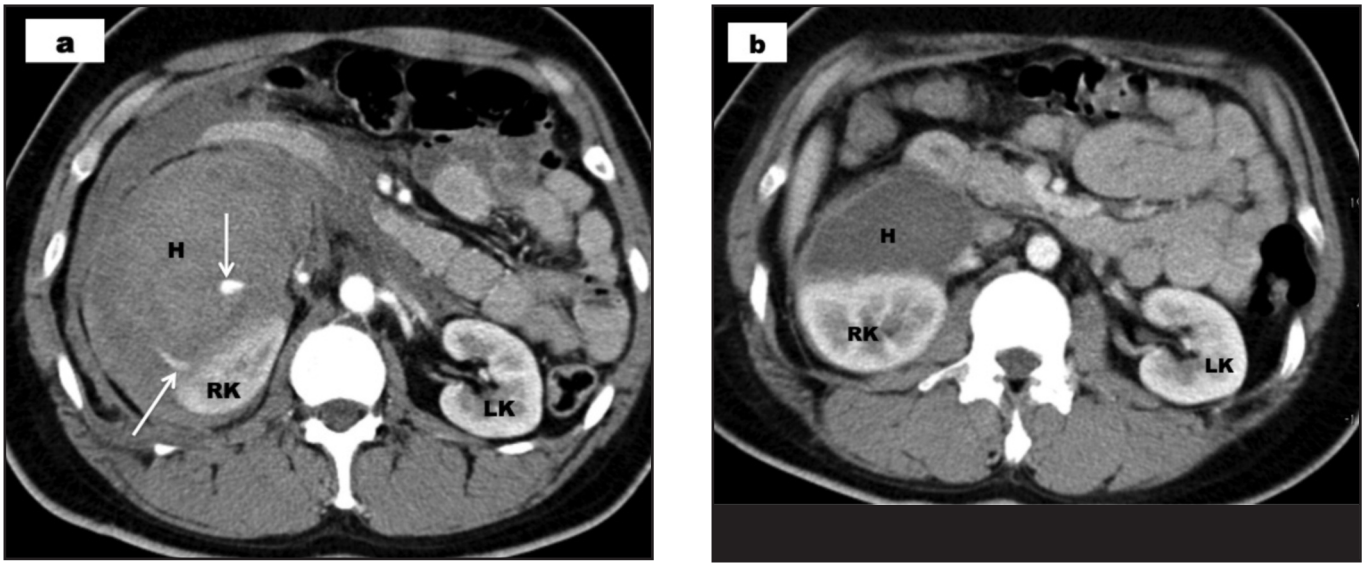


**Fig. 2:** Axial MSCT, post contrast in a 32-year old man whose motorcycle skidded. (a) MSCT on the day of accident showed contrast extravasations (arrows) with huge perirenal haematoma (H). (b) MSCT repeated 3 weeks later showed residual perirenal haematoma. RK=right kidney, LK=left kidney.

**Fig. 3:** Coronal reformatted MSCT in a 23-year old man who fall from motorcycle showed Grade IV liver injury (arrow). He was successfully managed conservatively.

In 83.4% of our cases, MSCT were positive and revealed substantial abdominal injury, retroperitoneal haematoma or pelvis fractures. The positive MSCT in previous reported series widely ranged from 26% to 89%[4,14]. This can be due to different definition of positive scan by various authors. For example, some studies did not include pelvis fracture and haemoperitoneum as criteria for positive CT scan while others classified presence of minimal free fluid without definite organ injury as positive scan. An international consensus would be required in the future to improve the accuracy and consistency of reporting trauma cases. In our study, even though isolated haemoperitoneum without identifiable organ injuries is not classified as positive scan, the percentage of positive scan is still high. Good selection of patients by the surgeons is the possible explanation for the high positive scans.

Many previous studies reported spleen as the most common organs injured in blunt abdominal trauma[14-16]. Distribution of organ injuries in our study slightly differs with liver injuries being more common than spleen injuries. Liver as the only organ injury were seen in 35.1% of cases, however total liver injuries including those involving multiple organ injuries were as high as 40.8% of cases. This is higher than previous report that stated up to 25% of patients had liver injuries detected if whole-body CT scan is performed as initial diagnostic procedure in severely injured blunt trauma

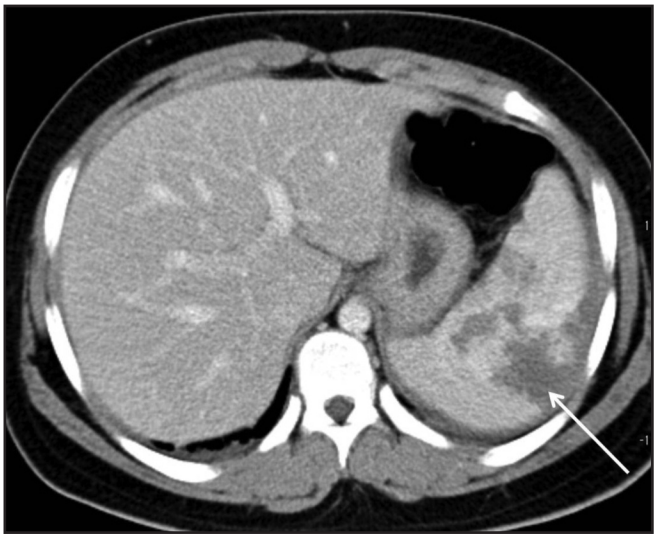

**Fig. 4:** Axial MSCT, post contrast in a 15-year old man with Grade III spleen injury (arrow) which was confirmed intraoperatively. He had active bleeding from the injury and splenectomy was performed.

patients [17]. This is an important fact as liver injury is associated with significant morbidity and mortality despite advances in surgical treatment[17].

Our result showed that operations were more common in higher grade organ injuries. Conservative management was successful in 77.4% of liver injuries and 50% of splenic injuries. This is lower compared to other reported series with successful conservative management of solid organ injuries ranged from 80 to 95% of cases[9,18,19]. One of the possible reasons for this difference is due to unavailability of interventional radiologist in our centre to perform angiogram and embolization as part of non-operative management of organ injuries during the study period.

Pancreatic injuries were difficult to be diagnosed by imaging as illustrated in our cases. Total of 9 pancreatic injuries and only 5 cases were detected on MSCT while 4 cases were missed on CT review. Three of 5-pancreatic injuries detected on MSCT had the scan performed more than 24 hours after the trauma due to its nonspecific presentation and delayed clinical diagnosis. All three cases were pediatric patients injured by handlebar of bicycle and MSCT revealed transected pancreas. The difficulty in establishing a diagnosis of pancreatic injury has been stressed by various authors[20,21]. Clinical, laboratory and radiographic findings are highly variable and nonspecific[22,23]. One of the reasons was due to elastic nature of pancreatic tissue that can bounce back to its normal architecture after an injury[24]. In patients with clinically suspicious of pancreatic injury, repeat CT scan after few hours after an initial negative CT scan can be helpful[25,26]. CT scan has proved to be extremely helpful in identifying complications related to pancreatic injury including pseudocyst and abscess[25].

Free intra-peritoneal fluid was a common finding in our study as previously noted by other authors[5,14,27]. It is positive in 66.2% of our cases (n=100). There were 4 cases of haemoperitoneum with negative scan. One was moderate

haemoperitoneum that was the false negative case with laparotomy-proven bowel injury. The other 3 cases were minimal haemorperitoneum recovered uneventfully after conservative management without any blood transfusion or clinical features suggestive of missed intra abdominal injury. This findings supported statements from previous study that small amount of intraperitoneal fluid as the sole abnormality shown by CT can be treated conservatively but larger amount of fluids have a higher likelihood of being associated with bowel or mesenteric injury[28].

In our patients, there were 24% of positive MSCT with no haemoperitoneum (n=30). This is higher compared to previous study which reported 11% of liver and 12% of spleen injuries had no free fluid visible on CT scan [29]. The importance of this fact is to the emergency and surgical team as these are the cases that can be missed based on diagnostic peritoneal lavage and focused abdominal sonography in trauma (FAST) assessment.

Contrast extravasation is an important finding on MSCT of blunt abdominal trauma[30,31]. It is suggestive of active haemorrhage and was reported in 6.5% to 43% of patients [32-34]. Contrast extravasation was seen in 6.3% (n=8) of the positive cases reviewed in this study. Out of these 8 cases, 7 cases had operation and active haemorrhage was documented. One patient was successfully managed conservatively (Figure 1). Even though contrast extravasation was previously reported as a strong predictor of unsuccessful nonoperative management, a recent study reported no association between contrast extravasation and the need for transfusion, mortality or splenectomy. Patients with contrast extravasation can still be treated without surgery based on the clinical condition[19 ,32].

Bowel and/or mesenteric injuries were the commonest injury missed in our study. There were 8 cases of significant bowel and/or mesenteric injuries and 5 cases of non-significant bowel and/or mesenteric injuries, which were missed. Re-review of MSCT images revealed changes suggestive of bowel and mesenteric injuries in all cases except one false negative MSCT. Extraluminal air was missed in 2 of 8 significant bowel and/or mesenteric injuries. The findings were subtle. The sensitivities and specificities of MSCT in the detection of bowel injuries ranged from 64-95% and 48-84% respectively[3,14,35]. The reliance on presence of free air to diagnosed bowel perforation was the main reasons for the high percentage of missed bowel and mesenteric injuries in our series. The low sensitivity and high specificity of this sign is well-documented3. Review of the reports revealed that abnormality suggestive of these injuries was described in the findings however the diagnosis of bowel and/or mesenteric injuries was not given as a conclusion. The signs of bowel and mesenteric injuries are abnormal bowel enhancement, bowel wall defect, bowel dilatation, bowel wall thickening, abrupt termination of mesenteric vessel, vessel beading, extravasation of contrast from mesenteric vessels and focal mesenteric haematoma.

## CONCLUSION

MSCT is a useful tool for the evaluation of blunt abdominal trauma especially in the detection of solid organ injuries and retroperitoneal haematoma. However assessment of bowel and mesenteric injury was not similarly effective in our study. Radiologists should diligently search for not only the characteristic free air sign which can be subtle but for other signs suggestive of bowel and mesenteric injury to increase interpretation accuracy and ability to detect significant bowel and mesenteric injuries based on CT examination. It is also important to note that absence of haemoperitoneum does not exclude intra abdominal injury but minimal haemoperitoneum as isolated findings may be safely managed conservatively. However, final decision should be based on clinical assessment rather than radiological findings.

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## REFERENCES

1. Rodriguez A, DuPriest Jr., Shatney CH. Recognition of intra-abdominal injury in blunt trauma victims. A prospective study comparing physical examination with peritoneal lavage. Am Surg 1982; 48: 457-59.
2. Rozycki G, Root HD. The diagnosis of intraabdominal visceral injury. J Trauma 2010; 68(5): 1019-23.
3. Atri M, Hanson JM, Grinblat L, Brofman N, Chughtai T, Tomlinson G. Surgically important bowel and/or mesenteric injury in blunt trauma: accuracy of multidetector CT for evaluation. Radiology 2008; 249(2): 524-33.
4. Ruess L, Sivit CJ, Eichelberger MR, Gotschall CS, Taylor GA. Blunt abdominal trauma in children: impact of CT on operative and nonoperative management. AJR Am J Roentgenol 1997; 169(4): 1011-4.
5. Becker CD, Mentha G, Terrier F. Blunt abdominal trauma in adults: role of CT in the diagnosis and management of visceral injuries. Part 1: liver and spleen. Eur Radiol 1998; 8(4): 553-62.
6. Neish AS, Taylor GA, Lund DP, Atkinson CC. Effect of CT information on the diagnosis and management of acute abdominal injury in children. Radiology 1998; 206(2): 327-31.
7. Uranüs S, Pfeifer J. Nonoperative treatment of blunt splenic injury. World J Surg 2001; 25(11): 1405-7.
8. Federle MP, Jeffrey Jr RB. Hemoperitoneum studied by computed tomography. Radiology 1983; 148(1): 187-92
9. Kozar RA, Moore FA, Moore EE, et al. Western Trauma Association critical decisions in trauma: nonoperative management of adult blunt hepatic trauma. J Trauma 2009; 67(6): 1144-8.
10. Taviloglu K, Yanar H. Current Trends in the Management of Blunt Solid Organ Injuries. Eur J Trauma Emerg Surg 2009; 35(2): 90-4.
11. Kristoffersen KW, Mooney DP. Long-term outcome of nonoperative pediatric splenic injury management. J Pediatr Surg 2007;42(6):1038-41.
12. Haan JM, Bochicchio GV, Kramer N, Scalea TM. Nonoperative management of blunt splenic injury: a 5-year experience. J Trauma 2005; 58(3): 492-8.
13. Schwab CW. Selection of nonoperative management candidates. World J Surg 2001; 25(11): 1389-92.
14. Kailidou E, Pikoulis E, Katsiva V *et al*. Contrast-enhanced spiral CT evaluation of blunt abdominal trauma. JBR-BTR 2005; 88(2): 61-5.
15. Federle M, Goldberg H, Kaiser J, Moss A, Jeffrey Jr R, Mall J. Evaluation of abdominal trauma by computed tomography. Radiology 1981; 138(3): 637-44.
16. Asuquo M, Etiuma A, Bassey O *et al*. A Prospective Study of Blunt Abdominal Trauma at the University of Calabar Teaching Hospital, Nigeria. Eur J Trauma 2010; 36(2): 164-68.
17. Matthes G, Stengel D, Seifert J, Rademacher G, Mutze S, Ekkernkamp A. Blunt liver injuries in polytrauma: results from a cohort study with the regular use of whole-body helical computed tomography. World J Surg 2003;27(10):1124-30.
18. Badger SA, Barclay R, Campbell P, Mole DJ, Diamond T. Management of Liver Trauma. World J Surg 2009; 33(12): 2522-37.
19. Marmery H, Shanmuganathan K, Alexander MT, E.Mirvis S. Optimization of selection for nonoperative management of blunt splenic injury: comparison of MDCT grading systems. American Journal of Roentgenology 2007; 189: 1421-27.

20. Sutherland I, Ledder O, Crameri J, Nydegger A, Catto-Smith A, Cain T *et al*. Pancreatic trauma in children. Pediatr Surg Int 2010; 26(12): 1201-06.
21. Phelan HA, Velmahos GC, Jurkovich GJ, Friese RS, Minei JP, Menajer JA *et al*. An evaluation of multidetector computed tomography in detecting pancreatic injury: results of a multicenter AAST study. J Trauma 2009; 66(3): 641-6; discussion 46-7.
22. Hoff WS, Holevar M, Nagy KK, Patterson L, Young JS, Arrillaga A, et al. Practice management guidelines for the evaluation of blunt abdominal trauma: the East practice management guidelines work group. J Trauma 2002; 53(3): 602-15.
23. Matsuno WC, Huang CJ, Garcia NM, Roy LC, Davis J. Amylase and lipase measurements in paediatric patients with traumatic pancreatic injuries. Injury 2009; 40(1): 66-71.
24. Rekhi S, Anderson S, Rhea J, Soto J. Imaging of blunt pancreatic trauma. Emergency radiology 2010;17(1): 13-9.
25. Linsenmaier U, Wirth S, Reiser M, Korner M. Diagnosis and classification of pancreatic and duodenal injuries in emergency radiology. Radiographics 2008; 28: 1591-601.
26. Gross JA, Vaughn MM, Johnston BD, Jurkovich G. Handlebar injury causing pancreatic contusion in a pediatric patient. American Journal of Roentgenology 2002; 179: 222.
27. Shuman WP. CT of blunt abdominal trauma in adults. Radiology 1997; 205: 297-306.
28. Levine CD, Patel UJ, Wachsberg RH, Simmons MZ, Baker SR, Cho KC. CT in patients with blunt abdominal trauma: Clinical significance of intraperitoneal fluid detected on a scan with otherwise normal findings. American Journal of Roentgenology 1995; 164: 1381-85.
29. Ochsner MG, Knudson MM, Pachter HL, Hoyt DB, Cogbill TH, McAuley CE *et al*. Significance of minimal or no intraperitoneal fluid visible on CT scan associated with blunt liver and splenic injuries: a multicenter analysis. J Trauma 2000; 49(3): 505-10.
30. Vu M, Anderson S, Shah N, Soto J, Rhea J. CT of blunt abdominal and pelvic vascular injury. Emergency radiology 2010;17(1):21-29.
31. Yao DC, Jeffrey RB, Mirvis SE, Weekes A, Federle MP, Kim C, et al. Using contrast-enhanced helical CT to visualize arterial extravasation after blunt abdominal trauma: incidence and organ distribution. AJR Am J Roentgenol 2002;178(1):17-20.
32. Davies DA, Ein SH, Pearl R, Langer JC, Traubici J, Mikrogianakis A, et al. What is the significance of contrast "blush" in pediatric blunt splenic trauma? Journal of Pediatric Surgery 2010;45(5):916-20.
33. Anderson SW, Varghese JC, Lucey BC, Burke PA, Hirsch EF, Soto JA. Blunt splenic trauma: delayed phase CT for differentiation of active hemorrhage from contained vascular injury in patients. Radiology 2007;243:88-95.
34. Fang JF, Wong YC, Lin BC, Hsu YP, Chen MF. Usefulness of multidetector computed tomography for the initial assessment of blunt abdominal trauma patients. World J Surg 2006;30(2):176-82.
35. Butela ST, Federle MP, Chang PJ, Thaete FL, Peterson MS, Dorvault CJ, et al. Performance of CT in detection of bowel injury. AJR Am J Roentgenol 2001;176(1):129-35.