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Computed tomography has an important role in hollow viscus and mesenteric injuries after blunt abdominal trauma

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ABSTRACT

Introduction: Computed tomographic (CT) scans have become invaluable in the management of patients with blunt abdominal trauma. No clear consensus exists on its role in hollow viscus injuries (HVI) and mesenteric injuries (MI). The aim of this study was to correlate operative findings of HVI and MI to findings on pre-operative CT.

Methods: All patients treated for blunt abdominal trauma at Tan Tock Seng Hospital from January 2003 to January 2008 were reviewed. CT scans were only performed if the patients were haemodynamically stable and indicated. All scans were performed with intravenous contrast using a 4-slice CT scanner from 2003 to December 2004 and a 64-slice CT scanner from January 2005 onwards. All cases with documented HVI/MI that underwent both CT scans and exploratory laparotomy were analysed.

Results: Thirty-one patients formed the study group, with median age of 40 (range, 22–65) years and a significant male (83.9%) predominance. Vehicular-related incidents accounted for 67.7% of the injuries and the median Injury Severity Score (ISS) was 13 (4–50).

The 2 commonest findings on CT scans were extra-luminal gas (35.5%) and free fluid without significant solid organ injuries (93.5%). During exploratory laparotomy, perforation of hollow viscus (51.6%) occurred more frequently than suspected from the initial CT findings of extra-luminal gas. Other notable findings included haemoperitoneum (64.5%), and mesenteric tears (67.7%). None of our patients with HVI and MI had a normal pre-operative CT scan.

Conclusion: Our study suggests that patients with surgically confirmed HVI and MI found at laparotomy were very likely to have an abnormal pre-operative CT scan. Unexplained free fluid was a very common finding in blunt HVI/MI and is one major indication to consider exploratory laparotomy.

Introduction

Computed tomographic (CT) scans have become invaluable in the management of patients with blunt abdominal trauma.[13] Multiple reports had documented the accuracy of CT scans in assessing the severity of solid organ injuries. Unfortunately, diagnosis of hollow viscus injuries (HVI) and mesenteric injuries (MI) has been suboptimal using CT scans.[3]

With an increasing proportion of patients with solid organ injuries being managed conservatively[12] the importance of CT scans in excluding HVI/MI is of paramount importance. Missed diagnosis of HVI/MI would delay the appropriate management and often result in significant morbidity and mortality.[5]

The main goal of this study was to correlate operative findings of HVI and MI with abnormal findings on pre-operative CT to determine the usefulness of using CT in the evaluation of HVI and MI.

Methods

Study population

All patients in this study were treated at Tan Tock Seng Hospital (TTSH) from January 2003 to January 2008. Tan Tock Seng Hospital is a 1300-bed hospital in Singapore that provides medical care to over 1.5 million people. It handles the highest number of trauma patients in Singapore and admits over a thousand serious trauma patients yearly (ISS 9 and above). Over 96% of these patients were reviewed for blunt injuries, with 40% of the trauma admissions having an Injury Severity Score (ISS) of more than 15.

All trauma patients with suspected intra-abdominal injuries were reviewed at the Emergency Department by the trauma team on duty. Focussed assessment with sonography for trauma (FAST) was performed, and if the patient remained haemodynamically stable and possess no immediate indication for surgical interven-

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Table 1
Characteristics of the 31 patients with hollow viscus and mesenteric injuries that underwent CT scan prior to their surgery.

	n (%)
Median age (years)	40 (22–65)
Gender	
Male	26 (83.9)
Female	5 (16.1)
Mechanism of injuries	
RTA	21 (67.7)
Assault	4 (12.9)
Fall	3 (9.7)
Others	3 (9.7)
Median haemoglobin level (g/dL)	14.0 (7.5–17.0)
Median GCS	15 (8–15)
Median ISS	13 (4–50)
Median length of hospital stay (days)	16 (5–127)
Outcome	
Alive	31 (100.0%)
Death	0 (0%)

tion, CT scan was performed subsequently. Ever since 2005, all CT scans were performed using a Siemens SOMATOM Sensation 64-slice CT scanner (Siemens AG, Wittelsbacherplatz, Muenchen, Germany). Prior to 2005, a Toshiba Aquilion 4-slice CT scanner (Toshiba Medical Systems Corporation, Otawara, Tochigi, Japan) was used. Intravenous contrast was given to all patients. Oral contrast was not used in our patients. The scans would then be read immediately by a trained radiologist and the trauma surgeon.

A retrospective review of all patients with HVI/MI that underwent CT scans and subsequent exploratory laparotomy from January 2003 to January 2008 was performed. Patients were excluded if they suffered penetrating injuries or were operated for the management of severe solid organ injuries with the HVI/MI found incidentally. The indications to perform surgery in these patients were based on the findings from the CT scans and/or the corresponding clinical signs.

The CT findings recorded included unexplained free fluid in the absence of solid organ injuries, extra-luminal air, bowel wall thickening; mesenteric haemorrhage, and mesenteric haematoma. Fluid on CT scan is an objective finding and can be easily and reliably identified.[10] To diagnose unexplained free fluid, patients must not have any diagnostic peritoneal lavage, underlying disease that could result in ascites or substantial solid organ injury. Free fluid is typically located in the Morrison's pouch, peri-hepatic space, peri-splenic space, paracolic gutters, and in the pelvis.[10] In our institution, all patients with unexplained free fluid in the absence of solid organ injuries were subjected to an exploratory laparotomy.

The surgical observations included haemoperitoneum; perforation of hollow viscus; gangrenous or ischaemic bowel; partial thickness tear of bowel; bowel edema; mesenteric tear; mesenteric haemorrhage; mesenteric haematoma and solid organ injuries.

Information such as patient's age, gender, mechanism of injury, initial Hb level, Glasgow Coma Scale (GCS) score, Injury Severity Score (ISS), CT scan findings, laparotomy observations, and the eventual outcome were recorded. All trauma patients were managed by the only dedicated surgical trauma team in the institution.

Results

Study population

During the study period, there were 406 patients who presented to the TTSH emergency department after sustaining blunt abdominal trauma. From this group of patients, there were 62 (15.3%) patients with HVI/MI who were admitted. Twenty-one (5.2%) patients had their HVI/MI diagnosed during exploratory laparotomy without any prior CT scans, while another 10 (2.5%) patients had their HVI/MI treated non-operatively after CT scans. Hence, only 31 (7.6%) patients formed the study group.

Table 2
CT scan findings of the 31 patients with HVI and MI.

CT scan findings	*n* (%)
Extra-luminal gas	11 (35.5)
Active mesenteric haemorrhage	3 (9.7)
Unexplained free fluid in the absence of significant solid organ injuries	29 (93.5)
Bowel thickening	9 (29.0)
Mesenteric haematoma	2 (6.5)

The median age of the study group was 40 (range, 22–65) years and with a significant male (83.9%) predominance. Vehicular-related incidents accounted for 67.7% of the injuries. The median GCS score and ISS were 15 (range, 8–15) and 13 (4–50), respectively. FAST was positive in 17 (54.8%) patients in the emergency department. The median length of hospital stay was 16 (range, 5–127) days. Table 1 illustrates the characteristics of the study group.

CT scan findings

The median time taken from the alleged injury, as described by the paramedics to the time the CT scan being performed was 248 min (range, 91–1161 min). Unexplained free fluid in the absence of significant solid organ injuries was seen in 29 (93.5%) patients. The other significant CT findings included extra-luminal gas ($n = 11$, 35.5%) and bowel thickening ($n = 9$, 29.0%). For mesenteric injuries, active mesenteric haemorrhage was seen in 3 (9.7%) patients while mesenteric haematoma was present in 2 (6.5%) patients. Table 2 summarises the various CT findings.

Most of the patients ($n = 29$, 93.5%) had surgery within 6 h after the CT scans. The remaining two patients had their injuries initially managed conservatively as the haemoperitoneum on CT scan using the 64-slice CT scanner was attributed to solid organ injury (1 liver and 1 spleen). They subsequently underwent surgery the following day because of clinical deterioration. Intra-operatively, one had significant haemoperitoneum from a small bowel mesenteric laceration, while the other had a jejunal perforation necessitating bowel resection and primary anastomosis. Both the liver and splenic lacerations were managed conservatively.

Surgical observations

As shown in Table 3, perforation of hollow viscus was present in 16 (51.6%) patients, while 11 (35.5%) had gangrenous or ischaemic bowel. Haemoperitoneum and mesenteric tears were the commonest findings in 20 (64.5%) and 21 (67.7%) patients, respectively. Coexisting solid organ injuries was present in 9.7% for which they were all managed conservatively (Table 3). All patients in the study group had abnormal CT scan findings. Interestingly, among those patients with perforated hollow viscus, only 11 (68.8%) of them had extra-luminal gas on CT scan. The rest had only free intra-peritoneal fluid.

Surgical intervention and outcome

Fifteen (48.4%) patients underwent bowel resection with primary anastomosis, with another 10 (32.3%) undergoing simple repair of the bowel injuries. Haemostasis of mesenteric haemorrhage was achieved in 4 (12.9%) patients. The remaining 2 (6.5%)

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Table 3
Surgical findings of the 31 patients with HVI and MI.

Surgical findings	*n* (%)
Perforation of hollow viscus	16 (51.6)
Gangrenous or ischaemic bowel	11 (35.5)
Partial thickness tears of the bowel	8 (25.8)
Bowel edema	14 (45.2)
Haemoperitoneum	20 (64.5)
Active mesenteric haemorrhage	8 (25.8)
Mesenteric tears	21 (67.7)
Mesenteric haematoma	8 (25.8)
Coexisting solid organ injuries	3 (9.7)

Table 4
Surgical intervention and operative outcome in our series.

	n (%)
Surgical intervention	
Bowel resection with primary anastomosis	15 (48.4)
Simple repair of bowel tears	10 (32.3)
Haemostasis of mesenteric haemorrhage	4 (12.9)
Non-therapeutic laparotomy	2 (6.5)
Outcome	
Discharged well with no significant complications	20 (64.5)
Superficial wound infection	4 (12.9)
Intra-abdominal collection	3 (9.7)
Anastomosis leak	1 (3.2)
Others	3 (9.7)

patients had non-expanding mesenteric haematoma diagnosed intra-operatively and were managed conservatively. Table 4 highlights the various surgical intervention and their outcomes.

Most of the patients (64.5%) were discharged well with no significant complications. Superficial wound infection was the commonest complication in 12.9%, followed by intra-abdominal collection in 9.7%. One patient had an anastomotic leak which required an emergency Hartmann's procedure. There was no mortality in our series.

Discussion

Although HVI and MI account for less then 5% of all injuries after blunt abdominal trauma,[1] the consequences of missed or delayed diagnosis are significant. Higher morbidity and mortality ensued should surgical intervention be delayed.[5] These complications include systemic sepsis, intra-abdominal collections, peritonitis, bowel strictures and wound dehiscence.[5]

In the past, exploratory laparotomy was frequently performed to assess intra-abdominal injuries after blunt trauma, but numerous reports supporting the benefits of non-operative management has resulted in a paradigm shift.[12] But for non-operative management of solid organ injuries to be consistently safe, HVI and MI must be reliably excluded by non-invasive means.

Though FAST is highly sensitive and specific for intra-abdominal fluid, it is unable to yield any information on the types and details of the injuries sustained.[11] It is also user-dependent. However, FAST is still an important screening tool in blunt abdominal trauma, particularly looking for significant haemoperitoneum. If present in a patient who is haemodynamically unstable, emergent laparotomy would be warranted.

Apart from FAST, diagnostic peritoneal lavage (DPL) has been advocated by some trauma surgeons.[8] However, the authors felt that the role of DPL may be actually limited in the diagnosis of HVI/MI in certain situations. Unquestionably, the presence of bowel content clearly indicates the presence of bowel perforation, but this is usually not evident early. In addition, the presence of blood on DPL may indicate a solid organ injury or a false positive from a significant pelvic fracture for which conservative management may suffice. In addition, the introduction of air and fluid from DPL will confuse subsequent CT scan if the clinical condition of the patient merits further radiological evaluation.

In view of all the above limitations, CT scan has gained much popularity among trauma surgeons in the evaluation of blunt abdominal trauma. It is non-invasive and allows immediate and specific information on the intra-abdominal, retroperitoneal and bony structures. Helical CT, which is being used in our institution, further reduces the time taken for the procedure and hence has less respiratory and cardiovascular artefacts. In addition, studies of multiple areas can be timed to obtain data during periods of ideal vascular and parenchymal opacification, and high-resolution multi-planar two-dimensional and three-dimensional reconstructions of the viscera can be performed. All these allow improved diagnostic accuracy in the presence and extent of injuries in patients with blunt abdominal trauma. But the main disadvantage of CT is the time required for the procedure to be performed, which may be critical in a trauma patient.[9] The usefulness of CT in evaluating solid organ injuries is beyond doubt, but no clear consensus exists in its usage in HVI/MI. Several reports have quoted the effectiveness of CT in diagnosing HVI/MI to be from unreliable to very accurate.[1,2,4]

Some of the CT scan findings that mandate exploratory laparotomy include extra-luminal gas, extravasation of oral contrast, disruption of bowel wall and active intravenous contrast extravasation.[6] Other findings suggestive of HVI/MI would include bowel wall thickening, mesenteric fat stranding, haematoma and isolated free fluid without solid organ injuries.[6] Mesenteric injuries are especially difficult to characterise before surgery, as the finding of focal mesenteric haematoma can be present in patients who require immediate surgery or in those that can be managed conservatively.

In our study, we found that extra-luminal gas and active intravenous contrast extravasation only accounted for 45.2% of the patients who underwent surgical intervention for HVI and MI. If we had only depended on these 2 CT findings, we would have missed the majority of patients in whom surgical interventions were necessary.

The commonest CT finding in our series was the presence of unexplained free fluid in the absence of significant solid organ injuries. These patients were subsequently diagnosed to have either mesenteric injuries or perforated viscus. There are considerable variations in the literature with regards to the recommended management of free fluid without solid organ injury on CT scan. While some have advocated laparotomy in situations with unexplained free fluid, especially in the absence of solid organ injuries, others have suggested close observation.[10,14] In our institution, we routinely perform exploratory laparotomy in patients who possessed unexplained free fluid in the absence of significant solid organ injuries after blunt abdominal trauma. The authors recognised the issues of non-therapeutic laparotomies and their potential complications.[15] But this must be balanced with the morbidity and mortality associated with missed injuries, which can be even more devastating.

Perhaps the most important finding in our study was none of our patients with HVI/MI had a normal CT scan. This is fairly consistent with other recent studies for which specificity of up to 99.6% has been reported on the role of CT scans in diagnosing HVI/MI.[1,3,7] However, in those series, some of the patients who were deemed to have normal CT scan had actually small amount of unexplained intra-abdominal fluid.

Though the authors acknowledged that our results could be skewed by the usage of 2 different CT scanners during the study period, the accuracy of even a single slice helical CT has been reported to be as high as 94%.[9] In view of the small number in our

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series, the authors did not attempt to compare the accuracy between the 4-slice and 64-slice CT scanner. This is one of the major limitations of our study. However, a recent study illustrated no difference in the accuracy between the 4-slice and the 16-slice CT scanner in HVI/MI.[3] Furthermore, it would be impossible to perform any prospective comparison in our institution as only the 64-slice CT scanner is used currently.

The usage of oral contrast in CT imaging in trauma patients has been controversial. Though its usage has been shown to be useful for depicting bowel injuries of the duodenum and proximal jejunum, as well as mesenteric injuries, it is not without its complications.[1] In the trauma setting, the risk of vomiting and aspiration is sizeable, especially in patients with decreased consciousness. Furthermore, the potential delay in diagnosis and the lack of substantial benefits for detection of bowel and mesenteric injury[1] are some of the underlying rationale explaining our institution's protocol of performing CT scans without oral contrast in the trauma setting.

Other limitations included this being a single institution's experience with a small number of patients. The patient population was a selected group with confirmed HVI/MI by surgery and retrospectively reviewed. The exclusion of patients who were managed conservatively or had no pre-operative CT scans was a major limitation as this removes the possibility of determining the accuracy of CT scans in the detection of HVI/MI.

However, as our main aim was to verify the CT scan findings with the actual surgical observations in patients with HVI/MI, the exclusion of these patients was necessary. This also contributed to the small study group. As CT scans were only performed in patients who are haemodynamically stable, the outcome is not a true reflection of our institution's experience in managing HVI/MI.

The authors recognised that despite the continual advances in our diagnostic armamentarium, missed injuries of HVI/MI will persist if we are solely dependent on the findings from the various imaging modalities. A thorough and continual clinical assessment, aided by repeated imaging or even surgical intervention would be required to minimise the implications of missed injuries. However, our study remained important as it again highlighted that CT scan is extremely useful in the diagnosis of HVI/MI as all our patients with surgically confirmed HVI/MI had abnormal CT scan. The presence of unexplained free fluid in the absence of significant solid organ injuries was the commonest finding.

Conclusion

Our study suggests that patients with surgically confirmed HVI and MI found at laparotomy were very likely to have an abnormal pre-operative CT scan. Unexplained free fluid was a very common finding in blunt HVI/MI and is one major indication to consider exploratory laparotomy.

Conflicts of interest statement

There are no financial or other interests with regard to the submitted manuscript that might be construed as a conflict of interest. All the authors of this research paper have directly participated in the planning, execution or analysis of the study, and are aware of and agree to the content of the paper and their being listed as an author on the paper.

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