Free fluid accumulation following blunt abdominal trauma: potential for expansion of the FAST protocol

鈍性腹部創傷後釋出液體的積聚：擴大「集中評估創傷超聲波檢查法」方案的潛力

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Objective: To determine sites of free intra-peritoneal fluid collection following blunt abdominal trauma, with a view to refinement of the Focused Assessment by Sonography for Trauma (FAST) protocol. ***Methods:*** This was a retrospective observational study of CT scans of subjects who had suffered blunt abdominal trauma and had free intra-peritoneal fluid detected on CT scan within 24 hours. The depth from the skin and amount of fluid at 14 abdominal sites were determined. ***Results:*** CT scans of 105 patients were examined: 68 (64.8%) were male, mean age 36.7±18.4 years, mean injury severity score 25.4±11.6. Fluid collected most commonly at three sites: right mid-axillary line at the level of the xiphisternum (52 patients, 49.5%), lateral margin of the right rectus muscle at the level of the anterior superior iliac spine (49 patients, 46.7%) and right mid-axillary line at the level of the umbilicus (40 patients, 38.1%). Mean depth of fluid at these sites were 3.6, 3.6 and 4.2 cm, respectively. ***Conclusions:*** Free fluid collects commonly in the area of the right iliac fossa following blunt abdominal trauma. The inclusion of this site in the FAST protocol may increase the ultrasonographic detection of free fluid in the acute trauma setting. (*Hong Kong j.emerg.med.* 2009;16:70-75)

目的：確定鈍性腹部創傷後腹腔內釋出的液體聚集的位置，希望改良「集中評估創傷超聲波檢查法」的方案。**方法：**這是一個回顧性觀察的電腦掃描研究。對象為鈍性腹部受傷而在24小時內電腦掃描偵察到腹腔內有釋出液體的病人。在14個腹部位置確定液體的份量及離開皮膚的深度。**結果：**共檢查了105名病人的電腦掃描：68名男性（64.8%），平均年齡36.7±18.4歲，平均傷勢嚴重性得分為25.4±11.6。液體最普遍聚集在3個位置：劍突水平的右腋窩中線（52名病人，49.5%），髂前上棘水平的右直肌外側邊緣（49名病人，46.7%）及肚臍水平的右腋窩中線（40名病人，38.1%）。在這些位置，液體的平均深度分別為3.6、3.6及4.2厘米。**結論：**鈍性腹部創傷後，釋出的液體普遍聚集於右髂窩的區域內。如「集中評估創傷超聲波檢查法」的方案包括這位置在內，在急性創傷環境下以超聲波偵察釋出的液體或可有所增加。

Keywords: Abdomen, ultrasonography, wounds and injuries, X-ray computed tomography

關鍵詞：腹部，超聲波檢查法，傷口與創傷，X光電腦掃描

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Introduction

The diagnosis of intra-abdominal injury in the setting of blunt abdominal trauma is difficult.[1] Clinical symptoms and signs are unreliable and the presence of distracting injuries and/or an altered conscious state often make examination unreliable or misleading. Computed tomography (CT) is a common modality used in the setting of blunt abdominal trauma in the emergency department (ED). CT is both sensitive and specific in the detection of intra-abdominal injuries and free fluid in the setting of major trauma.[2] However, CT may be remote from the ED trauma reception area, it can be time consuming and it may be associated with risk in the unstable trauma patient.

Focused Assessment by Sonography for Trauma (FAST) ultrasound (U/S) scanning is increasingly used as a precursor, adjunct, and even alternative to CT scanning.[3] A number of studies have concluded that FAST is a quick, cheap and reliable test. Additionally, it is portable, can be undertaken by ED staff, and does not involve radiation or contrast.[4] FAST has been shown to impact upon the management of patients with blunt abdominal trauma. A prospective study of 1671 patients showed that it correctly identified all patients requiring emergency laparotomy.[5] The corollary was that FAST could be used to differentiate those requiring immediate surgery and those who required further diagnostic workup.[6] The sensitivity and specificity of FAST in the detection of free intra-abdominal fluid have been reported at 84-88%[5-7] and 96-100%,[7] respectively, and it has been suggested that as little as 100 ml of free fluid can be detected. This accuracy of FAST has led to it largely replacing diagnostic peritoneal lavage in the diagnostic algorithm.

The FAST protocol targets four sites: the right and left upper quadrants, pelvis and pericardium. However, our experience suggests that free fluid (as detected by CT scan) collects commonly at other abdominal sites. We aimed to determine where fluid collects following blunt abdominal trauma. The findings indicate the need for further research aiming to revise the targeting of FAST and improve its detection accuracy. This may refine the practice of centres that use abdominal U/S in the setting of blunt abdominal trauma.

Methods

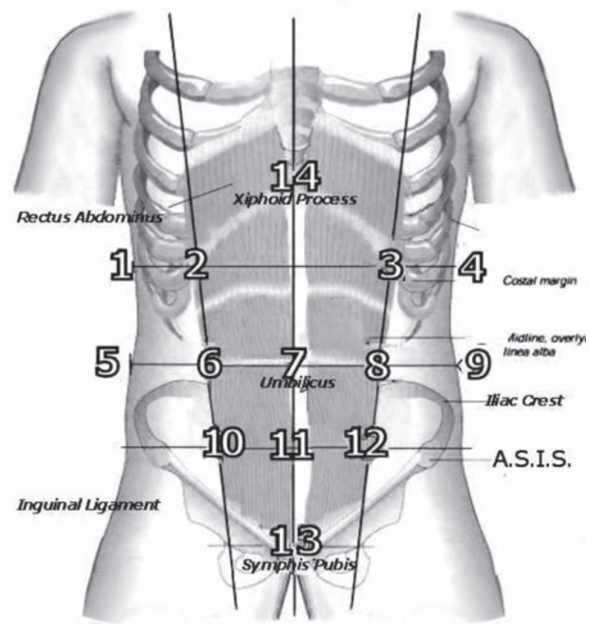
This was a retrospective, observational study of patients admitted to an inner city, adult trauma centre (annual patient census 55,000) between 1999 and 2003, inclusive. The study was authorised by the hospital's Human Research and Ethics Committee.

Potential cases were identified through the hospital trauma database. Cases were included if they had sustained blunt abdominal trauma, had undergone a CT scan within 24 hours of presentation, and had CT findings of free intra-abdominal fluid. Cases were excluded if they had CT evidence of conditions likely to produce intra-abdominal fluid other than blood (e.g. cirrhosis, intraperitoneal dialysis catheters), if the CT film series did not cover the entire abdomen and pelvis, if there was penetrating trauma, or if the scan was not performed in the supine position. All CT scans were performed on a GE Lightspeed 4-slice scanner incorporating 5 mm slices. Oral and intravenous contrasts were used in the majority of cases. Axial slices were used for data analysis.

All hard copy CT scans of patients meeting the entry criteria were retrieved. The principal investigator (NS) analysed all scans under the supervision of a specialist trauma radiologist (PP). Initially, scans were analysed in tandem. A single investigator (NS) analysed the remaining scans following the establishment of accuracy of interpretation. Sample sets of the remaining films were also analysed in tandem. Additionally, specialist radiologists had reported on all scans and these reports were used for comparison. A single investigator (NS) further examined the hospital trauma database to determine patient demographics, details of the mechanism and nature of the injury.

The primary endpoint was the location of free intra-abdominal fluid, presumed to be blood, after confounders such as severe renal and liver disease had been excluded. For standardisation of the primary endpoint, the abdomen was divided into 14 sites based upon surface anatomy (Figure 1). Each site was examined separately for free fluid.

Secondary endpoints were the mean depth of the free fluid from the skin, and the antero-posterior (AP) dimensions of the fluid collections. Measurements were taken of the AP distance from the internal abdominal wall to the superficial aspect of the fluid collection, and the AP diameter of the fluid collection itself. Measurement was performed manually, to the nearest 1 mm.



Site descriptions:
- 1, 4: **mid-axillary lines** at the level of **sites 2 and 3**
- 2, 3: **costal margins** at **lateral rectus** margin
- 5, 9: **mid-axillary lines** at the level of the **umbilicus**
- 6, 8: **lateral rectus** margin at the level of the **umbilicus**
- 7: **umbilicus**
- 10, 12: **lateral rectus** margin at the level of the **anterior superior iliac spine**
- 11: **midline** at the level of the **anterior superior iliac spine**
- 13: immediately superior to the **pubic symphysis**
- 14: **xiphisternum**

A.S.I.S. = anterior superior iliac spine

Figure 1. The 14 abdominal sites examined for free fluid collection (courtesy of Dr. Craig Castle FACEM, Epworth Hospital, Victoria).

All patients who met the study criteria during the study period were examined. Most findings are reported descriptively with 95% confidence intervals (CI) fitted around simple proportions using EpiCalc statistical software.[8]

Results

A total of 105 cases were identified (68 [64.8%] male, mean age 36.7 SD18.4 years, mean Injury Severity Score 25.4 SD11.6). The mechanism of injury is shown in Table 1. The most commonly injured organs were the liver, spleen and bowel (Table 2).

Fluid collected most frequently at sites 1, 10, 5, 4 and 13 and rarely at midline sites (Table 3). The mean depth of fluid from the skin also varied (Table 3). Fluid at sites 1 and 10 was relatively shallow (3.6 cm) while fluid at site 5 was deeper. In the pelvis (site 13), fluid accumulated at a much greater depth. The mean AP diameter of the fluid collections ranged from 1.4 to 2.6 cm.

For each of sites 1, 10, 5 and 4, free fluid was present in more than 30% of cases. Fluid was present in at least one of the FAST sites (1, 4 or 5) in 84% of cases. The addition of a single non-FAST site (site 10, right iliac fossa) would have added 8 collections, to a total of 92% of all fluid collections.

Table 1. Mechanism of injury

Mechanism	**Number of patients**	**(%, 95%CI)**
MVA-front seat passenger	46	(43.8, 34.3-53.8)
Motorbike accident	13	(12.4, 7.0-20.6)
Pedestrian	13	(12.4, 7.0-20.6)
MVA-back seat passenger	10	(9.5, 4.9-17.2)
Fall	10	(9.5, 4.9-17.2)
Cyclist	9	(8.6, 4.2-16.1)
Blunt trauma	3	(2.9, 0.7-8.7)
Crush	1	(1.0, 0.1-6.0)
Total	**105**	**(100)**

MVA = motor vehicle accident

Table 2. Organ injury sustained (n=105)

Organ injured	Number of patients	(%, 95%CI)
Liver	40	(38.1, 28.9-48.1)
Spleen	31	(29.5, 21.2-39.3)
Bowel	24	(22.9, 15.5-32.3)
Kidney, right	14	(13.3, 7.7-21.7)
Kidney, left	10	(9.5, 4.9-17.2)
Bladder/ureter	8	(7.6, 3.6-14.9)
Pancreas	5	(4.8, 1.8-11.3)
Others	5	(4.8, 1.8-11.3)
Gynaecological organs	1	(1.0, 0.1-6.0)

Table 3. Frequency and amount of fluid found at each abdominal site (n=105)

Site	No. (%, 95%CI) of patients where fluid was observed	Mean depth from skin to fluid collection (cm)	Antero-posterior diameter of fluid collection (cm)
1	52 (49.5, 39.7-59.4)	3.6	1.5
2	18 (17.1, 10.7-26.0)	2.6	1.4
3	10 (9.5, 4.9-17.2)	3.4	1.5
4	34 (32.4, 23.8-42.3)	2.9	1.9
5	40 (38.1, 28.9-48.1)	4.2	1.8
6	14 (13.3, 7.7-21.7)	6.5	1.6
7	12 (11.4, 6.3-19.5)	5.9	1.7
8	10 (9.5, 4.9-17.2)	4.9	2.3
9	28 (26.7, 18.7-36.3)	4.3	1.6
10	49 (46.7, 37.0-56.6)	3.6	1.7
11	11 (10.5, 5.6-18.4)	5.3	2.3
12	19 (18.1, 11.5-27.1)	3.5	1.6
13	30 (28.6, 20.4-38.4)	6.3	2.2
14	5 (4.8, 1.8-11.3)	5.6	2.6

The liver was the most commonly injured organ, and free fluid in the right iliac fossa (site 10), was most closely associated with collections in the right upper quadrant (site 1).

Discussion

A number of studies have documented the sensitivity and specificity of FAST examination as it is conventionally performed.[9] A lesser amount of research, however, has investigated the location of fluid on CT scanning in the setting of blunt abdominal trauma, and whether other locations accumulate fluid with clinically significant frequency. Current FAST scanning practice certainly has its limitations, particularly in the areas of closed renal trauma, pelvic fractures and duodenal injuries.[10]

The trauma cases were managed at an Australasian adult trauma service and had a range of ISS and organ injury patterns. The results show that fluid accumulates in predictable regions following blunt abdominal trauma. The most common site of fluid accumulation is in the right upper quadrant. This is consistent with the anatomical location of the most commonly injured organ (the liver) and previous research guiding the target locations for FAST examination.[3] Moderate frequencies of fluid collecting in the left upper quadrant, and pelvis also provide support for current trauma ultrasound practice and are consistent with the reported literature.[4]

Our finding of numerous, relatively shallow, fluid accumulations in the right iliac fossa (site 10) may be important (Figure 2). This site, if added to the FAST protocol, has the potential to increase the detection rate of free intra-abdominal fluid, and therefore FAST fluid detection, in blunt abdominal trauma. The site is easily accessible for U/S examination and is examined in cases of suspected appendicitis. However, bowel gas and a poorly defined interface between solid organs and potential fluid collections may limit its usefulness for fluid detection by U/S in blunt abdominal trauma. These barriers may be transient, given the rapid evolution of ultrasound technology.

Further research is required to determine whether current U/S can reliably detect free fluid in the right iliac fossa. If this reliability can be demonstrated, this site could be added to the existing FAST protocol. The revised protocol would, in turn, need to be evaluated to determine if it provides greater accuracy than the traditional FAST protocol.

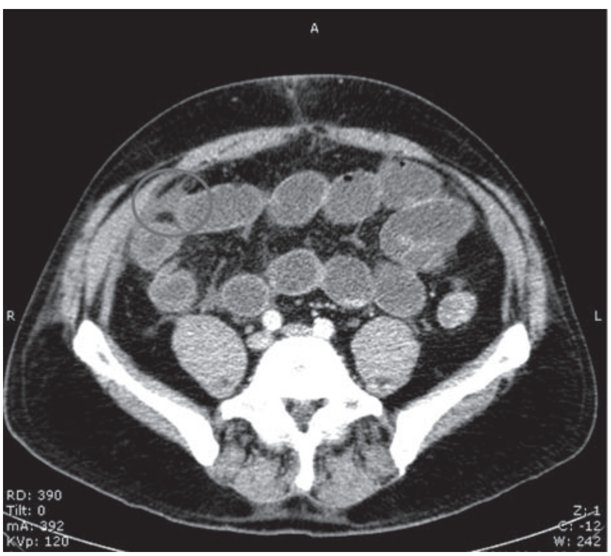


Figure 2. Superficial free fluid in the right iliac fossa (circle).

This study was performed prior to the implementation of electronic radiology at the trauma centre. As such, measurement was performed manually, though this is unlikely to have significantly affected accuracy. In some cases, parts of a subject's film series were incomplete, and these subjects were excluded from analysis. While this decreased the sample size it is unlikely to have introduced significant selection bias. Measurement bias related to CT reporting was unlikely due to close supervision of the principal investigator, ongoing film co-analysis with a trauma radiologist and correlation with the formal radiologist report.

All subjects undergoing CT scanning were deemed haemodynamically stable, to the extent that they could be safely transported to and from the scanner. This may affect the generalisability of this study to an unstable trauma population who undergo FAST scanning as a primary investigation.

Conclusion

Fluid accumulates in a range of intra-abdominal sites following blunt abdominal trauma. The traditional FAST protocol examines most abdominal sites where fluid commonly collects. However, fluid also collects commonly in the right iliac fossa, a site not traditionally scanned during FAST examination. Further research is required to determine if free fluid in the right iliac fossa can be reliably detected by existing U/S technology. If so, there is the potential for the FAST protocol to be expanded, through the inclusion of this site, and for its accuracy to be increased.

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