Diagnostic Value of Abdominal Ultrasonography in Patients with Blunt Abdominal Trauma

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ABSTRACT

Background: Various investigative modalities are used to detect intra-abdominal injury requiring surgical intervention. Ultrasonography (US) is a cheap, readily available, safe and non-invasive investigation used in the evaluation of patients with blunt abdominal trauma. Patients are subjected to no added risk of radiation. **Aims:** The aim of this study was to evaluate the diagnostic value of US in patients with blunt abdominal trauma. **Materials and Methods:** Patients who had US for blunt abdominal trauma were prospectively evaluated from 1 January 2006 to 31 December 2007. A total of 57 patients were included is this study. US results in each patient were classified as true positive (TP), false positive (FP), false negative (FN) or true negative (TN) by comparing with findings at either diagnostic peritoneal lavage or surgery. Sensitivity, specificity, positive and negative predictive values (NPV) and diagnostic accuracy of US in detecting free fluid and in detecting the visceral parenchymal injury were calculated using two by two tables. The Epi Info statistical software version 3.4.1 was used for data analysis. **Results:** By scanning to detect free fluid, TPs were 46, FPs three, FNs two and TNs six. Sensitivity, specificity, positive and NPV and the diagnostic accuracy were 96%, 67%, 94%, 75% and 91% respectively. By scanning to detect the parenchymal injury, TPs were 24, FPs 15, FNs 10 and TNs 8. Sensitivity, specificity, positive and NPV and diagnostic accuracy were 71%, 35%, 62%, 44% and 56% respectively. **Conclusion:** US has a high diagnostic value in the screening of patients with blunt abdominal trauma. Scanning for the presence of free fluid yields better results than scanning for the visceral parenchymal injury.

KEYWORDS: Injuries, intra-abdominal fluid, ultrasonography

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INTRODUCTION

Whereas the diagnosis of penetrating abdominal injury presents little if any problems, blunt abdominal injury creates a scenario where diagnostic investigations must be used to good effect, in order to determine, which patients need to be operated on, with a view to achieving the best possible outcome.[1]

Unlike in the developing world, in the developed world, there is a preponderance of available diagnostic tools. Most of the authors would regard computed tomography scans, laparoscopy, diagnostic peritoneal lavage (DPL) and abdominal ultrasonography (US) as key tools in the evaluation of the patient with blunt abdominal trauma.[2,3] However, there is a difference in the opinion as to the usefulness and diagnostic value of abdominal ultrasound scan.[4-6] While some hold the view that it only finds use in rapid evaluation for the detection of hemoperitoneum in the increasingly popular focused assessment sonography for trauma, others opine that it could, in addition, also identify significant parenchymal injuries. Some posit that it has a limited diagnostic accuracy and could engender undue delay in intervention in some patients who turn out to be false negatives (FNs).[5] Interestingly, sonography is the only readily available facility in many centers in the developing world. It is also affordable and there are portable machines.[7]

MATERIALS AND METHODS

This was a prospective study carried out at the Jos University Teaching Hospital over a period of 24 months, from 1 January 2006 to 31 December 2007. Approval of the Ethical Committee of the Hospital was obtained. All patients recruited into the study were required to give a written consent administered by the admitting doctor. Consent was obtained from relatives when the injured patients were unable to give informed consent.

The study population consisted of adult patients 17 years and above, admitted into the Jos University Teaching Hospital during the study period with clinical features of blunt abdominal trauma and who had US as well as a procedure for verifying the US findings. During the study period, 57 patients who had ultrasound evaluation for blunt abdominal trauma were studied.

Children, patients who did not have abdominal US and patients in whom neither DPL nor laparotomy were performed, were excluded from the study.

All patients had routine resuscitation and treatment appropriate for their presentation. This followed the advanced trauma life support module. Initial resuscitation was done in the casualty department and included maintenance of the airway with control of the cervical spine, ensuring adequate breathing and maintenance of the circulation with intravenous normal saline and blood transfusion when necessary.

All patients studied had abdominal US done in the ultrasound scan room in the radiology department. A 3.5 MHz convex probe was used. DPL was performed in the casualty department. All patients who had clear-cut features of peritonism with US features of free intra-peritoneal fluid had laparotomy performed. Patients with hemodynamic instability and generalized abdominal tenderness had surgery without having DPL performed as surgery was absolutely necessary. The outcome of scan, DPL and surgery were all entered into the proforma.

The findings at US were compared with the findings at surgery. In patients who did not have surgery, the findings at US were compared with the findings at DPL. Patients were thus categorized as true positives (TP), false positives (FP), FN and true negatives (TN) on assessment of free intra-peritoneal fluid and on assessment of visceral parenchymal injury.

The TPs, FPs, FNs and TNs were entered into 2 × 2 tables. The sensitivity, specificity, positive predictive value (PPV), negative predictive value (NPV) and diagnostic accuracy based on detection of free intra-peritoneal fluid and on detection of parenchymal injuries were calculated. The Epi Info statistical software version 3.4.1 was used for data analysis. Chi-square test and $P < 0.05$ were used as tests of significance.

Results

There were 45 males and 12 females (M:F = 3.8:1). Ages ranged from 18 years to 62 years. The mean age of patients studied was 35 ± 13.4 years.

As shown in Figure 1, all 57 patients had US, 38 had surgery without DPL and nine had DPL without surgery. In 10 patients, both surgery and DPL were performed.

As shown in Figure 2, the highest number of patients, 22 (39%) were in the 18-26 year age group while the lowest, 4 (7%) was in the 38-46 year age group. There were 39 patients (69%) who were below 38 years. There were 45 (79%) males and 12 (21%) were females.

A total of 23 patients (40%) suffered motor vehicle injuries, 14 (25%) were victims of motorcycle injuries, 11 pedestrians (19%) were knocked down by cars while 5 patients (9%) fell from heights. These are shown in Figure 3.

A total of 49 patients (86%) had a positive finding of free intra-peritoneal fluid on US [Figure 4]. 46 (81%) of these were confirmed at laparotomy. One patient (2%) who had a negative

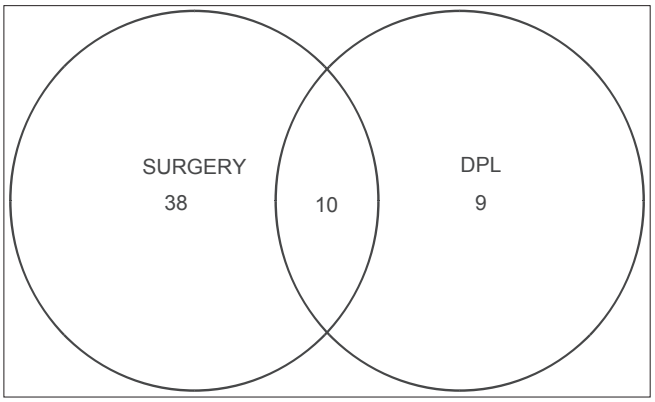

Figure 1: Investigation and management of 57 patients with blunt abdominal trauma

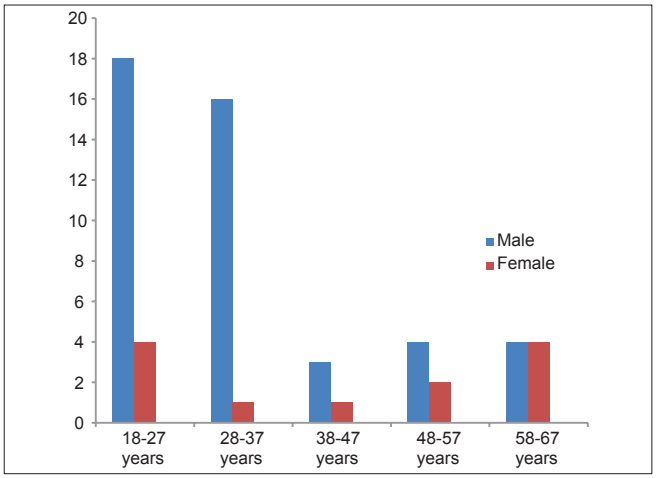

Figure 2: Bar chart showing the age and sex distribution of 57 patients with blunt abdominal trauma

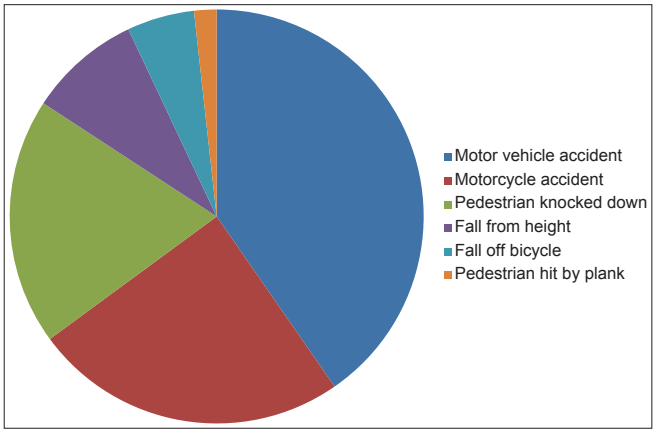

Figure 3: Pie chart showing mechanism of injury in 57 patients with blunt abdominal trauma

DPL was managed non-operatively and improved. In two patients (3%), there was no blood in the peritoneal cavity at surgery.

In eight patients (14%), hemoperitoneum was absent at US. Six of them (11%) were TN as shown by a negative DPL. They showed steady improvement and did not have surgery. In two patients (3%), the DPL finding was positive. These patients were considered as FN, but the absence of clinical features guided the decision to manage them non-operatively and they were all discharged in good condition within one week of admission. This was entered into a two by two table as shown in Table 1.

In 24 patients (42%), the visceral injuries picked up at sonography were confirmed at surgery. In 15 (26%) of these patients, only the spleen was injured. In seven (12%) of these patients, the injury involved only the liver while two (4%) had renal injuries.

Furthermore, the results showed that 15 patients (26%) were FP. Of these, nine (16%) had surgery with the organ injuries reported at US not confirmed. Six patients (10%) had a negative DPL and improved on conservative treatment.

There were 10 patients (17%) in whom no visceral injury was shown at sonography, but who were found to have visceral injuries at surgery (FN). Of these, six (10%) had intestinal injury while four of them (7%) had splenic injury.

There were eight patients (14%) who were TNs. In these patients, US showed no parenchymal injury. In five patients (9%), no parenchymal injury was seen at surgery while three patients (5%) had a negative DPL and were managed non-operatively and discharged within one 1 week of admission. This was entered into a two by two table as shown in Table 2. The summary of all the results is shown in Table 3.

A total of 38 patients (68%) had single organ injuries: Spleen 17 (30%), liver 8 (14%), bowel 7 (13%) of which small bowel 5 (9%), large bowel 2 (4%) and one each (2%) for pancreas, kidney and diaphragm [Table 4]. Three patients (5%) had retroperitoneal hematoma.

Moreover, 8 (14%) patients had multiple injuries. They included 2 (4%) patients who had liver injury associated with other injuries. In 4 (7%) patients, small and large bowel injuries were associated with other injuries: 2 (4%) patients had splenic injury, 1 (2%) of them had associated diaphragmatic rupture and the other retroperitoneal hematoma [Table 5]. 5 (9%) of the 6 (11%) patients seen with retroperitoneal hematomas in this study had upper midline (Zone 1) hematomas, which were neither pulsating nor expanding and so were not explored. In 1 (2%) patient, the hematoma extended across Zones 1, 2 (lateral) and 3 (pelvic), but was not explored as it was neither pulsating nor expanding.

Figure 4: Abdominal ultrasound scan showing free fluid in the peritoneal cavity

Discussion

US is used in the assessment of patients presenting with blunt

Table 1: Two by two table on scanning for intra-abdominal fluid

True positives	46
False positives	3
False negatives	2
True negatives	6

Sensitivity=(46/46 + 2)×100%=(46/48)×100%=96%, Specificity=(6/3 + 6)×100%=(6/9) ×100%=67%, Positive predictive value=(46/46 + 3)×100%=(46/49)×100%=94%, Negative predictive value=(6/2 + 6)×100%=(6/8)×100%=75%, Accuracy=(46 + 6/46 + 3 + 2 + 6)×100%=(52/57)×100%=91%, $\chi 2 = 24.54$, $P = 0.0000007$(<0.05 significant)

Table 2: Two by two table on scanning for visceral parenchymal injuries

True positives	24
False positives	15
False negatives	10
True negatives	8

Sensitivity=(24/24 + 10)×100%=(24/34)×100%=71%, Specificity=(8/15 + 8)×100% =(8/23)×100%=35%, Positive predictive value=(24/24 + 15)×100%=(24/39)×100% =62%, Negative predictive value=(8/10 + 8)×100%=(8/18)×100%=44%, Accuracy=(24 + 8/24 + 15 + 10 + 8)×100%=(32/57)×100%=56%, $\chi 2 = 0.18$, $P = 0.67$(>0.05 not significant)

Table 3: Summary of results in 57 patients with blunt abdominal trauma

Results	US	DPL	SURG	TP	FP	FN	TN	SENS %	SPEC %	PPV %	NPV %	ACC %
Intraperitoneal fluid	57	19	48	46	3	2	6	96	67	94	75	91
Visceral injury	57	19	48	24	15	10	8	71	35	62	44	56

US: Ultrasonography, DPL: Diagnostic peritoneal lavage, SURG: Surgery, TP: True positives, FP: False positives, FN: False negatives, TN: True negatives, SENS: Sensitivity, SPEC: Specificity, PPV: Positive predictive value, NPV: Negative predictive value, ACC: Accuracy

abdominal trauma. It is readily available, accessible and is a non-invasive procedure with high patient acceptability. However, the ultrasound results are operator dependent. This may alter the reliability of ultrasound in the evaluation of blunt abdominal trauma. In this study, the ultrasound scans were mostly carried out by the hospital consultant radiologists and by two surgeons in the hospital who have been certified as sonographers and hold post-graduate diplomas in US.

In this study, the sensitivity of US for detecting intra-abdominal injury when scanning for hemoperitoneum is very good at 96%, bearing much similarity to the findings of Yoshii *et al.*[8] who reported a sensitivity of 94.6%. In the retrospective study carried out on 2,693 patients by Brown *et al.*,[9] the sensitivity was reported as 85%, which is lower than 96% found in this study and perhaps a reflection of the observer-dependent nature of US and the size of the sample evaluated.

Out of 48 patients (84%) who had intra-abdominal fluid, 46 (81%) were correctly identified at US. The 2 patients (3%) in whom free intra-peritoneal fluid was not identified at sonography, had a positive DPL. However, they were successfully managed non-operatively. This was probably because the volume of the collections in these patients was smaller than could have been detected sonographically. Ileus associated with the immediate post-trauma period may equally have compromised the sonographic detection of hemoperitoneum in these patients. This is as a result of the increased bowel gas in the presence of ileus serving as a structural interface that distorts the sonographic image.[10]

Table 4: Single organ injuries in 38 patients with blunt abdominal trauma

Organ injured	Number	Percentage
Spleen	17	30
Liver	8	14
Pancreas	1	2
Small bowel	5	9
Large bowel	2	4
Kidney	1	2
Diaphragm	1	2
Retroperitoneal hematoma	3	5
Total	38	68

Challenges encountered in the course of US imaging in this study included the limitation of the sonographic windows when patients had skin abrasions and dressings on the anterior abdominal wall. There was also a limited room for maneuvering the injured patients due to pain.

On the other hand, when scanning was done for specific visceral parenchymal injury, the sensitivity dropped to 71%. There were 34 patients (60%) who had visceral injuries, which were identified at surgery. Only 24 of these (42%) were correctly identified at sonography while in 10 patients (18%), injuries were missed. In six of these patients (11%), the injury was in the intestine. In all six patients, ultrasound scan correctly identified the presence of free intra-peritoneal fluid, necessitating laparotomy in these patients. In the other four patients (7%), the injury was in the spleen. Hemoperitoneum was correctly detected, but the splenic injury was not detected sonographically. Hence, ultrasound scanning still served as an appropriate investigation, correctly detecting the presence of intra-abdominal injury, but was poor at localizing the injury to specific viscera.

The specificity of US when scanning for hemoperitoneum in this study was quite low at 67%. Out of 9 patients (16%) who had no intra-abdominal fluid collection, 6 (11%) were correctly identified sonographically, while in 3 patients (5%), collections were reported to have been present at US, whereas none could be demonstrated at DPL or surgery.

The number of FN and positives in this study were similar to the findings in similar studies reviewed in the literature. While this study showed FNs of 3% and FP of 5% when scanning for intra-peritoneal fluid, Nural *et al.*,[11] in their study, which involved 454 patients, had 5 (1%) FN and 19 (4%) FP results. Yoshii *et al.*,[8] studying 1,239 patients had 19 (2%) FN and 44 (4%) FP results. Richards *et al.*,[12] studying 3,264 patients had 132 (4%) FN and 57 (2%) FP results. This study like the others reviewed shows that ultrasound scan for intra-peritoneal fluid has a high diagnostic accuracy.

In this study, 57 patients were studied and on scanning for free intra-abdominal fluid for the detection of intra-abdominal injury, there were 2 (3%) FNs and 3 (5%) FPs whereas, the FNs are few, the proportion of FPs seen in this study was a bit high and

Table 5: Multiple organ injuries in eight patients with blunt abdominal trauma

Initial	Sex	Age (years)	Spleen	Liver	Pancreas	Kidney	Diaphragm	Retroperitoneal hematoma	Stomach	Duodenum	Jejunum/ ileum	Large bowel
J.D	M	44		+				+				
I.N	M	18		+					+			+
A.I	M	19							+	+		
I.R	M	28	+					+				
H.A	M	27	+				+					
A.S	M	40						+			+	
M.D	M	35		+				+				
J.D	M	25						+			+	

consequently, a low specificity (67%). FP results have variously been attributed to physiological fluid observed in females, children and in association with pelvic fractures.[13-15] In this study, only 1 (2%) of the three FPs was female. She was a 27-year-old female with a sonographic diagnosis of hemoperitoeum and liver laceration in whom DPL was negative and who was successfully managed non-operatively. The other FPs were adult male patients, none of whom had associated pelvic fractures. Children were excluded in this study.

It must be emphasized that in the screening of blunt abdominal trauma patients with US, the most important problem is FN results and not the FP ones.[11] This is so because the consequence of failing to explore a patient falsely considered negative may be far reaching. The relevance of continuous clinical evaluation, therefore, remains indispensable in all circumstances.

In this study, 10 (18%) FN were observed when scanning for the visceral parenchymal injury. Out of these patients, 6 (11%) had gastrointestinal injury. However, free intra-peritoneal fluid was observed in these six patients and the correct diagnosis of intra-abdominal injury was still made in these patients. It is clear that in several studies including this one, ultrasound is not good at detecting gastrointestinal injury and may only pick these when there is associated free fluid present in the abdomen. This is similar to the findings of Yoshii *et al*.,[8] who reported 19 (2%) FN results of which 11 (1%) had gastrointestinal injuries. Equally, Nural *et al*.,[11] had 5 (1%) FN results, 3 (0.6%) of whom had gastrointestinal injuries.

It has also been shown that far better results are obtained by scanning for free intra-abdominal fluid than by scanning for the visceral parenchymal injury. However, US is clearly of value in the evaluation of patients with blunt abdominal trauma. The PPV of US when scanning to detect intra-abdominal fluid was 94% while the NPV was 75%. This reflects the degree to which a positive and a negative finding of free intra-abdominal fluid at US, accurately predicts the presence or absence of intra-abdominal injury respectively. The accuracy, which is a measure of the percentage of accurately diagnosed cases, both those with and those without intra-abdominal injury, by scanning for intra-abdominal fluid was found to be 91%.

On the other hand, when scanning for the visceral parenchymal injury, the PPV was low at 62% while the NPV was also low at 44%. This shows that the reliability of a negative ultrasound report for a specific visceral injury in confirming the absence of intra-abdominal injury was unacceptably low. The percentage of accurately diagnosed cases, both positive and negative by scanning for the visceral parenchymal injury was also low at 56%.

These findings show clearly that far better results are obtained by scanning to detect the presence of free intra-peritoneal fluid than by scanning to detect the specific visceral parenchymal injury. In view of its accessibility and its non-invasiveness, ultrasound scan has an advantage over DPL in screening for intra-abdominal injury in patients with blunt abdominal trauma, where there is no computed tomography scan.

The pattern of visceral injury in these patients studied showed that 38 patients (68%) had single visceral injuries while 8 patients (14%) had multiple visceral injuries. In patients with single visceral injuries, the spleen and liver were found to be the most commonly injured organs and this is often the finding in blunt abdominal trauma.[3,16-18] Gastrointestinal injury was quite common in this study as 11 patients (19%) in all, had injury involving the gastrointestinal tract.

In the future, the author would seek to study a cohort of patients with blunt abdominal trauma who would in addition to US, also have computed tomography scan. It would then be possible to delineate the grades of parenchymal injuries in the various abdominal organs that are detectable by either investigative modality.

Conclusion

In this study, the diagnostic value of US was found to be high in the evaluation of blunt abdominal trauma. Scanning for the presence of free intra-peritoneal fluid yielded better results than scanning for the visceral parenchymal injury.

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