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Is Multi-Detector Computed Tomography Mandatory after Ultrasound in the Assessment of Stable Patients with Blunt Abdominal Trauma?

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Abstract

Background: Assessment of blunt abdominal trauma patients is often difficult by clinical means alone. Laboratory tests and imaging studies are cornerstones for evaluation. The focused assessment with sonography for trauma (FAST) examination is important in hemoperitoneum detection. It can be performed in the emergency room, aiding in the initial triage of patients, to determine the need for urgent surgery. If the FAST revealed hemoperitoneum in a persistently unstable patient; laparotomy should be done, in any other circumstance, computed tomography is necessary. Currently, contrast-enhanced multidetector computed tomography (MDCT) is the gold standard imaging technique for the diagnosis of severe abdominal injuries; it aids in determining the amount of damage, and subsequent therapy can be planned. Because of radiation hazards and the high cost of MDCT scans, many studies tried to use the US as the sole imaging modality in blunt abdominal trauma [BAT], especially in vitally stable patients with negative FAST.

Aim of Study: To emphasise the circumstances in which the US could be sufficient in the evaluation of hemodynamically stable patients with acute abdominal trauma without the need for a MDCT scan, and assess the additive role of multi-detector CT over conventional ultrasound (US).

Patients and Methods: Sixty patients presented to the Emergency Room (ER) as victims of BAT in a hemodynamically stable condition. After the primary survey and clinical assessment, US was done for the detection of hemoperitoneum and organ injury. Contrast-enhanced MDCT scan was done for confirmation of US findings.

Results: For hemoperitoneum detection; the US detected 46 patients as positive, 38 of them were found true positive by MDCT (83%) while the other 8 were false positive. US excluded hemoperitoneum in 14 patients, all were found true negative by MDCT. That gave the US a positive predictive value [PPV] of 83%, a negative predictive value [NPV] of 100%, a sensitivity of 100% and a specificity of 64%. As for solid organ injury (SOI) detection's US detected 21 patients as positive, 17 were true positive by MDCT (81 %) and 4 were false positive. US excluded organ injury in 39 patients, 30 were true negative by MDCT (77%), while 9 patients were false negative. US had 81% PPV, 77% NPV, 65% sensitivity, and 88% specificity.

Conclusions: US is highly accurate for the detection of hemoperitoneum so a negative focused assessment with sonography in trauma (FAST) scan for hemoperitoneum can accurately exclude the need for MDCT. However, MDCT is a valuable adjunctive complementary imaging to US in the detection of visceral organ injuries.

Key Words: *US – MDCT – Blunt abdominal trauma – Stable – Hemoperitoneum – Organ injury.*

Introduction

BLUNT abdominal trauma (BAT) is a quiet common presentation at ER. It may cause injuries to solid organs like liver, spleen, kidneys or hollow visceral tears. According to the degree of injury, this may lead to significant bleeding and hemodynamic instability **[1]**.

Based on the assumption that all clinically significant abdominal injuries are associated with hemoperitoneum, the focused assessment with

Abbreviations:

EAST : Eastern Association for Surgery of Trauma.
US : Ultrasound.
MDCT : Multi-Detector Computed tomography.
BAT : Blunt abdominal trauma.
ER : Emergency room.
SBP : Systolic blood pressure.
BPM : Beets per minute.
PPV : Positive predictive value.
NPP : Negative predictive value.
SOI : Solid organ injury.
FAST : Focused assessment with sonography in trauma.
ATLS : Advanced trauma life support.
NOM : Non-operative management.
OM : Operative management.
RTA : Road traffic accident.

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sonography for trauma (FAST) examination is very important in the detection of hemoperitoneum. It is a rapid, reliable, and feasible investigation in patients with Blunt abdominal trauma (BAT), and it can be performed easily, safely, and quickly in the emergency room with an overall sensitivity, specificity and accuracy of 80.43, 75 and 80%. It aids in the initial triage of patients, to determine the need for urgent surgery [2].

If the FAST revealed hemoperitoneum and the patient is still unstable even after resuscitation; the patient must be sent to an operating room for laparotomy, in any other circumstance, computed tomography is necessary. Currently, contrast-enhanced multidetector computed tomography (MDCT) is the gold standard imaging technique for the diagnosis of severe abdominal injuries; it aids in determining the amount of damage, and subsequent therapy can be planned [3].

MDCT is the standard for the detection of solid organ injuries in hemadinamically stable patients, in addition, it can reveal associated injuries like retroperitoneal hematomas, vertebral, thoracic, pelvic fractures, arterial contrast extravasation as well as pseudoaneurysm with an accurate diagnosis of the severity of injuries and hence helping in the decision of surgical intervention or non-operative management [4].

In the current study, we compared the US and MDCT findings in BAT patients. We hypothesized that US can be sufficient and replaces MDCT in patients who are vitally stable. This would save hospital resources; contrast and MDCT usage and reduces radiation exposure.

The aim of this study was to emphasise the circumstances in which the US could be sufficient in the evaluation of hemodynamically stable patients with acute abdominal trauma without the need for MDCT scan, and assess the additive role of multidetector CT over conventional ultrasound (US).

Patients and Methods

Study design:

This is an observational cross sectional study.

Study population:

The study was done prospectively on 60 vitally stable victims of BAT presenting to the emergency departments of a Kasr Al-Ainy Hospitals, all patients underwent FAST US scan followed by contrast-enhanced MDCT scan of the abdomen and pelvis from the beginning of October 2018 to the end of March 2019. The study protocol was approved by the hospital research ethical committee. All patients were counseled and signed a consent form.

Inclusion criteria:

1- Patients' age group (14 years old).
2- Patient with blunt abdominal trauma being hemodynamically stable patients clinically indicated by systolic blood pressure (SBP) 90mmHg, pulse <100 beets per minute (bpm).
3- Unreliable physical examination.
4- Abdominal tenderness, rib fractures, abdominal wall contusion.

Exclusion criteria:

1- Pediatric age group (<14 years old).
2- Pregnant patients, since MDCT carries a high risk for the developing fetus.
3- Hemodynamically unstable patients indicated by systolic blood pressure <90mmHg, pulse >100 bpm or disturbed conscious level since they wouldn't do a MDCT according to up to date guidelines.
4- Patients with elevated creatinine level.

Methods:

Clinical, laboratory assessment and management:

Patients were managed according to advanced trauma life support (ATLS) guidelines in resuscitation room [5]. Primary survey was done to detect life threatening conditions first. IV access by wide bore cannulas 20 G or larger and blood sample were gained for lab assessment. Patients were then sent for radiologic assessment; FAST and radiographs of suspected fractures. Laboratory assessment including kidney functions before the approval of the contrast-enhanced MDCT examination.

US and contrast-enhanced MDCT were done for cases with normal kidney function, with no wide time interval, so no significant changes happen.

US examination:

Machine used:

The examination was done by the investigator using “TOSHIBA XARIO 200” or “SGHealthCare Q40” US machines. Both machines are of near the same resolution.

Probe used:

In all previous, the convex probe was mainly used which has a frequency of 3.5-5 MHz.

Technique:

Starting by FAST scan, checking the pericardium, peri-hepatic (including Morison's pouch and right sub-phrenic), peri-splenic (including splenorenal and left sub-phrenic) and pelvic regions for presence of free fluid. In all views the patient lies supine.

1- Pericardium: The probe was placed at the subxiphoid region and angulated cranially so that the beam projection is towards the heart.

2- Perihepatic: The probe was placed at right anterior axillary line longitudinally and scanning was done from 8th intercostal space to subcostal region and from anterior axillary to mid axillary line.

3- Perisplenic: The probe was placed longitudinally at left posterior axillary line at 7 th intercostal space and scanning was done anteriorly till anterior axillary line and caudally till the subcostal region.

4- Pelvic: The probe was placed at suprapubic region, angled cranially with variable pressure to displace intestinal gas and scanning was done transversely and then longitudinally.

- We checked for visceral organ injury at the same time while doing FAST. While scanning the perihepatic region, we checked the liver, the right kidney and the gall bladder. The gall bladder may resemble free fluid but can be easily differentiated by viewing its wall.
- While scanning the perisplenic region, we checked the spleen and the left kidney.
- While scanning the pelvis, we checked the urinary bladder walls for injury.
- Color Doppler was used to evaluate vascular pedicle of organs as well as parenchymal injuries. Hematomas and infarcted areas are avascular.
- We examined the chest in clinically suspected patients for hemothorax and pneumothorax as well. The probe was placed longitudinally at the 2nd intercostal space (right or left) mid clavicular line. We examined first by B-mode then M-mode US.
- The average time of the FAST was 2 minutes. For detailed US checking for organ injury was 5 minutes.

MDCT examination:

Patients with positive results in US scan [or negative in the presence of another indication for MDCT such as suspected lumbar spine injury, pelvic injury or suspected retroperitoneal injury] were assigned for MDCT of the abdomen and pelvis. Other parts sometimes were included according to the patient's examination findings and clinical findings (e.g. brain or chest).

Machine used:

Multi-detector CT [MDCT]; 16 slices “GE BrightSpeed CT” machine.

Contrast medium:

Patients were injected with 50ml of a non-ionic low osmolar medium “Ultravist 350”, the injection was done manually through an 18- or 20-G cannula. Oral contrast was added only in selected cases when a visceral injury was suspected according to the patient's condition and the referral data of the emergency clinician.

Technique:

- Range of scan: From the diaphragm (lower chest cuts) to the symphysis pubis with 10mm collimation and 10mm interval.
- Timing: The post contrast scans were taken 60 seconds after the beginning of injection, a delayed excretory phase [after 5 minutes] was taken when urologic injuries were suspected.
- MDCT examinations were done under the observation of theemergency radiology residents.

Interpretation:

MDCT was reviewed separately and blindly by two radiologists [5 and 20 years expertise].

Data handling:

Post processing with multi-planar reformatting was done on MDCT station immediately after scan. Sagittal and coronal images were obtained, besides soft tissue, bone and lung windows for better assessment of spine and vascular injuries. The MDCT scan reports and the post-processing images were revised by a senior consultant, with 15 years of experience.

Follow-up of patients and serial US examination:

- Patients who were admitted for conservative management were followed up daily by FAST until discharge from the hospital.
- Patients who had laparotomy were followed-up post-operatively.

Statistical analysis:

Microsoft excel 2013 for data entry and the statistical package for social science (SPSS version 24) was used for data analysis.

- Simple descriptive statistics (arithmetic mean and standard deviation) used for summary of quantitative data and frequencies used for qualitative data.
- Bivariate relationship was displayed in cross tabulations and comparison of proportions was performed using the chi-square and Fisher's exact tests where appropriate.
- Accuracy was represented using the terms sensitivity, specificity, positive predictive value and negative predictive value.
- p-values less than 0.05 was considered statistically significant.

Results

Demographic data:

Our study included 60 patients, 51 males (85%) and 9 females (15%). The age ranged from 14 to 88, with a mean age of 32 years old, the young age group 14-23 years old represented 39% of the population. Of the selected 60, 38 (63%) had hemoperitoneum, of which 26 (68%) had visceral organ injury (Table 1). None of them had multiple organ injuries as we were selecting the vitally stable patients. Rate of organ injury was as follows:

Almost all patients (58 out of 60 constituting 97%) succeeded on non-operative management (NOM), except two with grade IV splenic injury. Both started on conservative management but deteriorated later and splenectomy was done. No cases were managed by interventional radiological techniques though there were a few candidates.

Analysis of the obtained data:

The number of patients who had hemoperitoneum, amount of hemoperitoneum, organ injury and its grade for the US andMDCT examinations were demonstrated in (Tables 2,3) (Fig. 1).

US detected 46 patients as positive for hemoperitoneum, with 38 of them being true positive by MDCT (83%) while the other 8 were false positive. US excluded hemoperitoneum in 14 patients agreeing MDCT in all of them (100%) i.e. true negative. The US did not miss any patient with hemoperitoneum i.e. zero false negative (Table 4). US has a positive predictive value [PPV] of 83%, a negative predictive value [NPV] of 100%, a specificity of 64%, and a sensitivity of 100% with 86.7% accuracy for the detection of hemoperitoneum and p-value <0.001 (Fig. 2).

Organ injuries detected by US against MDCT as the standard of reference demonstrated. As we can see; US detected 21 patients with organ injury, 17 of them were true positive by MDCT (81%) and the other 4 were false positive. US excluded organ injury in 39 patients, 30 of which were true negative by MDCT (77%) while 9 patients were missed compared to MDCT i.e. false negative, with a 65% sensitivity, 88% specificity, 81% PPV and 77% NPV and 78% accuracy. p-value was <0.0001 (Table 5), (Fig. 2).

Ultrasound (US) had one false positive case of splenic injury, without hemoperotoneum, however MDCT revealed intact spleen and did not confirm the injury. Which confirmed the hypothesis that all patients without hemoperitoneum by MDCT had no visceral organ injuries. On the other hand, MDCT detected twenty six cases [68%] with visceral organ injury out of 38 patients of positive hemoperitoneum, while US missed 9 [35%] of those 26 patients i.e. did not detect the organ injury but only showed hemoperitoneum. The nine cases who had visceral organ injury missed by US were as follows; 1. Three with splenic injury grade III. 2. Two with splenic injury grade II. 3. One with splenic injury grade V. 4. One with liver injury grade III. 5. One with kidney injury grade II. 6. One with extraperitoneal UB injury grade II. We had 3 patients with grade IV splenic injury 2 of them had splenectomy. Two of them were graded III by US. The third which was the youngest 16 years old managed conservatively, was detected by US but downgraded III. We had 2 patients with grade IV hepatic injury both were managed conservatively. One was downgraded by US as III and the other matched MDCT grading. Here we can see US may miss or downgradea lesion that requires operative management (OM) rather than NOM (Table 5).

The amount of hemoperitoneum against the grade of organ injury (Table 6). The hemoperitoneum was subjectively estimated as minimal, mild or moderate. We didn't have severe cases as the study only included stable patients. The grade of organ injury if present according to the American Association for the Surgery of Trauma (AAST) system is tabulated. We hypothesized that organ injury grade and amount of hemoperitoneum would be proportionate. Yet, the relation yielded a p-value of 0.75 [>0.05], so it's an insignificant relation.

Table (1): Number and percentage of different organ injuries as identified by MDCT or intra-operative.

Organ involved	Number	%
Spleen	14	54
Liver	7	27
Kidneys	4	15
pancreas	0	0
Hollow viscus	1	4

Table (2): The number of patients with hemoperitoneum and its amount by US and MDCT examination.

Parameters	US	Count	%	MDCT	Count	%
Hemo-peritoneum	No	14	23.3	No	22	36.7
	Yes	46	76.7	Yes	38	63.3
Amount of hemoperi-toneum	No	14	23.3	No	22	36.7
	Minimal	16	26.7	Minimal	7	11.7
	Mild	23	38.3	Mild	27	45.0
	Moderate	7	11.7	Moderate	4	6.7

Table (3): The number and grades of organ injuries by US and MDCT examinations.

Parameters	US	Count	%	MDCT	Count	%
Organ injury	No	39	65.0	No	34	56.7
	Yes	21	35.0	Yes	26	43.3
Spleen	No	48	80.0	No	46	76.7
	I	1	1.7	I		
	II	5	8.3	II	3	5.0
	III	5	8.3	III	8	13.3
	IV	1	1.7	IV	3	5.0
Liver	No	52	86.7	No	53	88.3
	II	5	8.3	II		
	III	3	5.0	III	5	8.3
	IV			IV	2	3.3
Kidney	No	59	98.3	No	56	93.3
				I	1	1.7
	II	1	1.7	II	2	3.3
				IV	1	1.7
Hollow viscus	No	60	100.0	No	59	98.3
	I			I	1	1.7

Table (4): The analysis of the number and percentage of hemoperitoneum detection by US versus MDCT and their p-value.

Parameters	Hemoperitoneum by CT				p-value
	No		Yes		
	Count	%	Count	%	
Hemoperitoneum by US:					
No	14	63.6	0	0.0	<0.001
Yes	8	36.4	38	100.0	
Total	22	100.0	38	100.0	

Table (5): The analysis of the number and percentage of organ injury detection by US versus MDCT and their p-value.

	Organ injury by CT				p-value
	No		Yes		
	Count	%	Count	%	
Organ injury by US:					
No	30	88.2	9	34.6	<0.001
Yes	4	11.8	17	65.4	
Total	34	100.0	26	100.0	

Table (6): The analysis of the MDCT grade of visceral organ injury versus the MDCT amount of hemoperitoneum and their *p*-value.

	CT amount of hemoperitoneum						*p*-value
	Minimal		Mild		Moderate		
	Count	%	Count	%	Count	%	
CT grade of visceral organ injury:							
Negative	4	57.1	8	29.6	1	25.0	0.752
I	0	0.0	0	0.0	0	0.0	
II	1	14.3	4	14.8	1	25.0	
III	1	14.3	11	40.7	2	50.0	
IV	1	14.3	4	14.8	0	0.0	

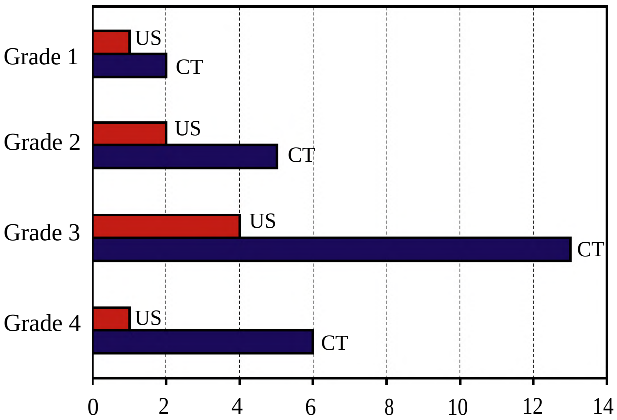

Fig. (1): Comparison between US and MDCT examination for different grades of organ injury.

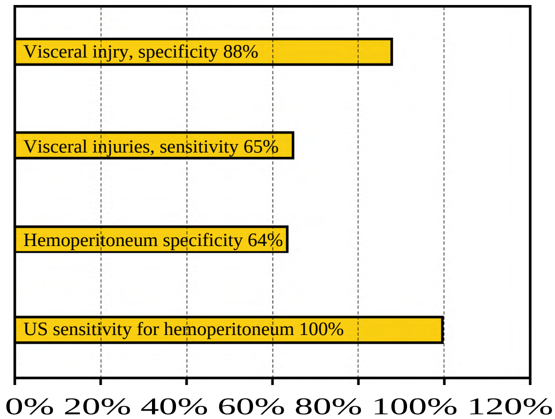

Fig. (2): Demonstrates the sensitivity and specificity values of US against MDCT examination in the detection of hemoperitoneum and visceral injury.

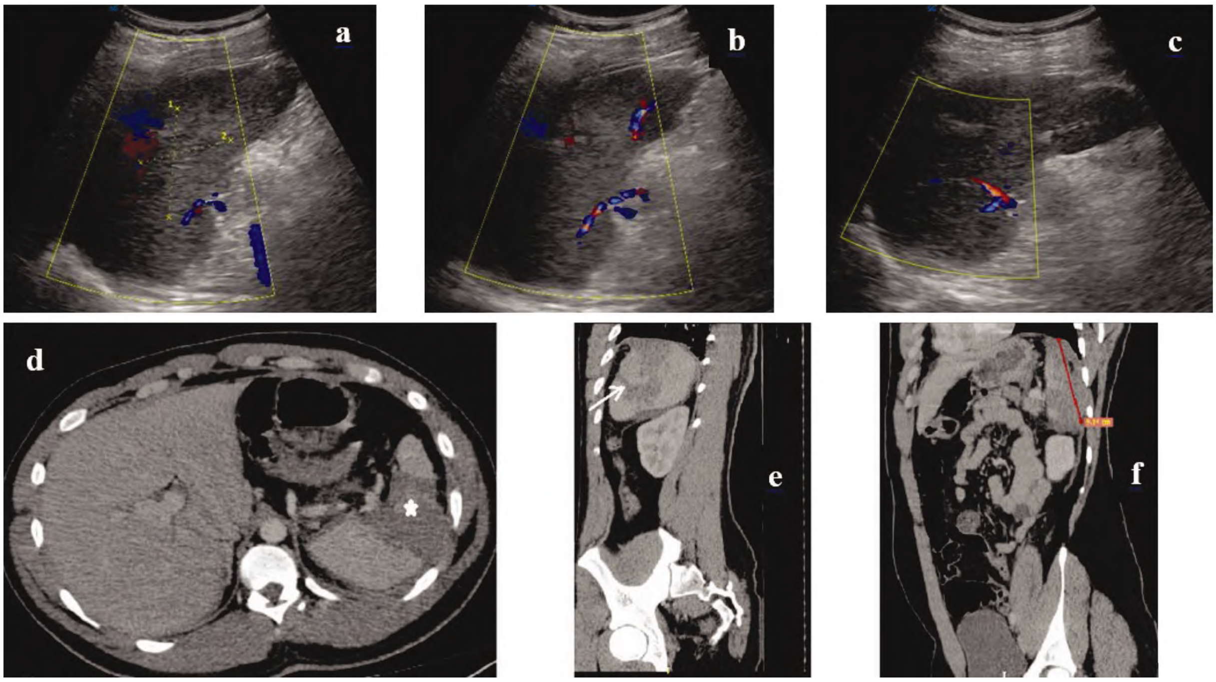

Fig. (3): A 21-year-old male, vehicle-pedestrian accident victim. FAST revealed; (A, B) Non-vascular hyperechoic region of hematoma of spleen. (C) Follow-up US on the next day showing heterogeneous spleen with no sizable lesion. Intact hilar vascularity is still noted. Doppler of splenic hilum to check its integrity showing intact splenic vessels. MDCT scan with IV contrast, (D) Shows the splenic hematoma [star] with surrounding preserved enhancement of rest of the spleen, (E) MPR oblique image showing the branching lacerations radiating from hematoma [arrow], (F) Sagittal reformatted image showing maximum dimension of the hematoma.

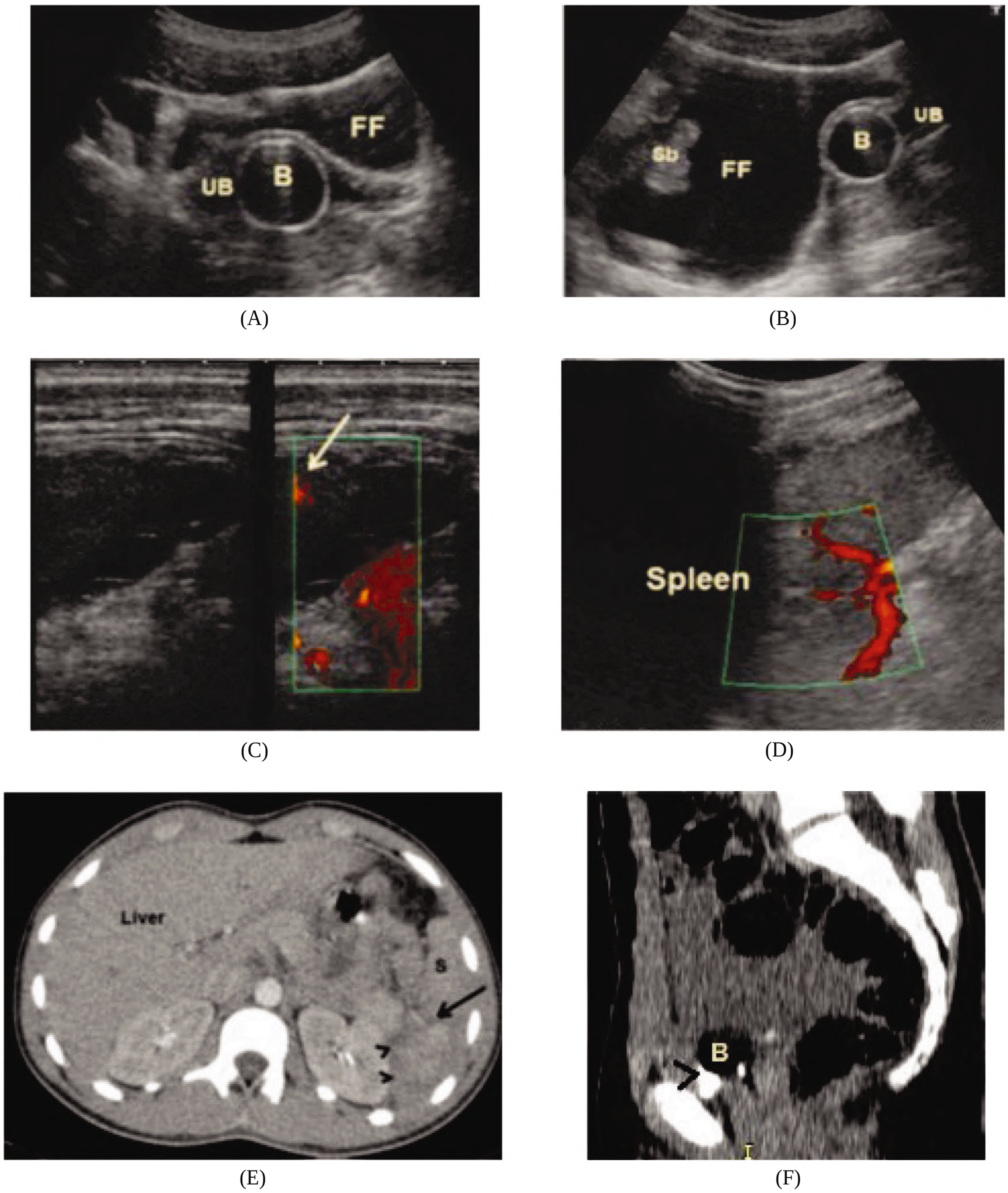

Fig. (4): 17-year-old male, vitally stable, presented to the ER vehicle-pedestrian accident victim. FAST revealed; (A, B) Pelvic transverse and longitudinal views showing collapsed urinary bladder [UB] on catheter balloon [B] and free fluid [FF], Sb: Small bowel loops. (C) US & Doppler of the spleen showing a hypoechoic region related to its lower pole which was considered perisplenic fluid rather than parenchymal contusion since Doppler showed intact vascularity. (D) Intact splenic hilar vessels. (E) Axial CT with IV contrast shows hemoperitoneum at the leinorenal recess [arrowheads] and a splenic nonenhancing linear hypodensity; a laceration [arrow]. (F) Reconstructed sagittal CT image of the pelvis showing hemoperitoneum filling out the pelvic recesses. B; catheter balloon, arrowhead; contrast in UB. (-ve SOI by US, and +ve SOI by MDCT)

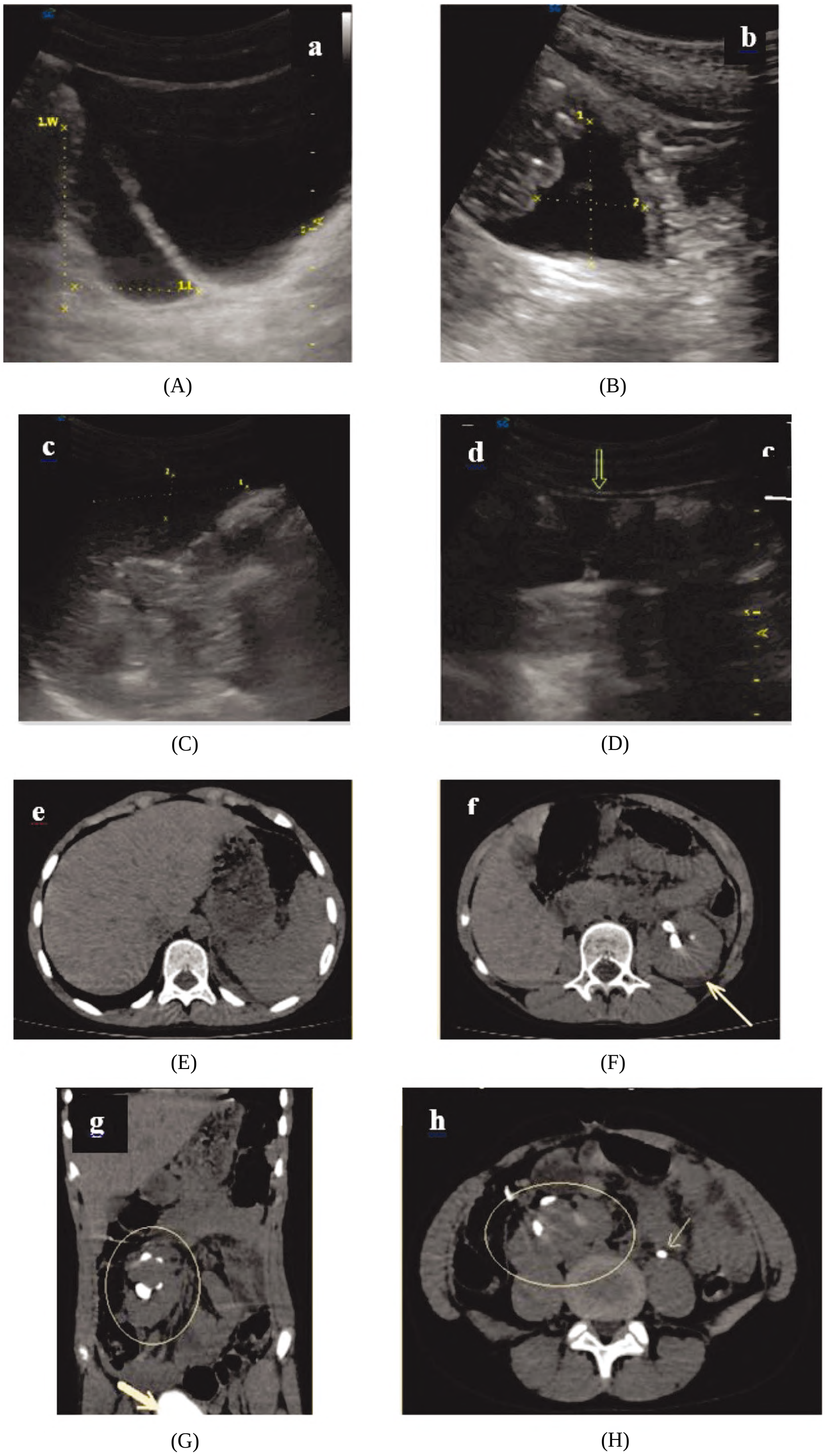

Fig. (5): A 17-year-old male, vehicle-pedestrian accident victim, vitally stable patient. FAST was done and revealed: measurement of the hemoperitoneum depth; (A) 3.1cm, (B) After a day of the left one is 4.7 cm. (C) Splenic hematoma. (D) Fluid in left paracolic gutter. MDCT with IV contrast delayed phase axial cuts showing (E) Normal spleen. (F) Left perirenal hematoma. MDCT coronal reconstructed image (G) and axial cuts (H) Showing right pelvic kidney [encircled]. Thick arrow; UB cystogram. Thin arrow; opacified left ureter.

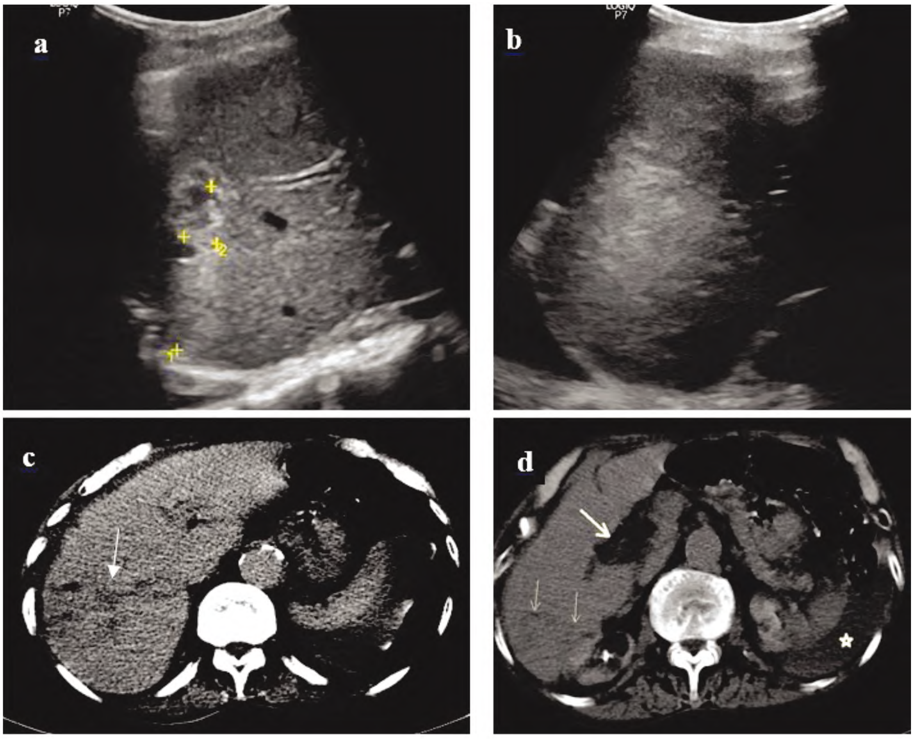

Fig. (6): A 58-year-old male, road traffic accident (RTA) victim, vitally stable patient. FAST revealed: US of liver shows (A) A linear hyper echogenicity, which revealed non-vascularity on Doppler examination, (B) Right hepatic lobe an ill-defined hyperechoic region measuring about 5.3 cm depth laceration. Coinciding with grade III. MDCT scan revealed (C) Right hepatic lobe branching laceration, (thin arrows) (D); another laceration, (Thick arrow); hematoma, corresponding to grade IV; left perisplenic hemoperitoneum (star).

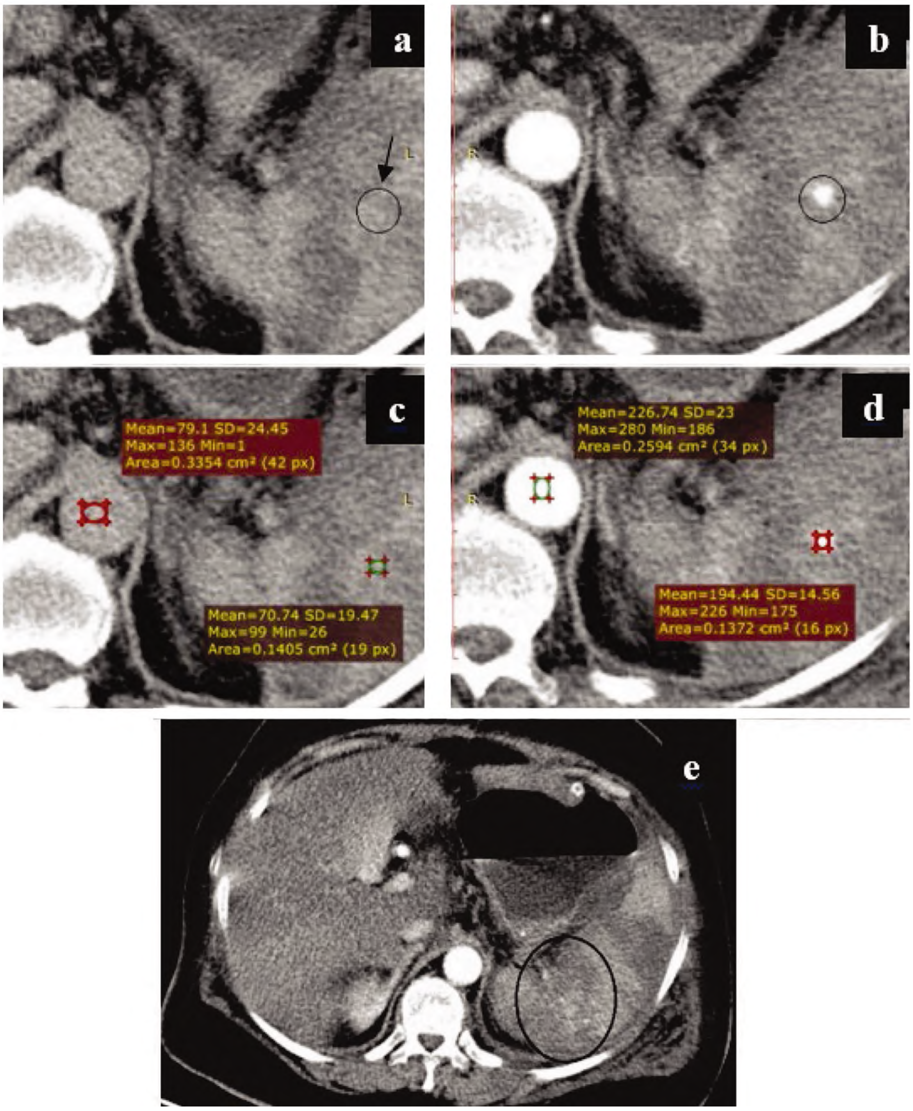

Fig. (7): A 64-year-old female, RTA victim, vitally stable patient, with a fractured left rib, US had a very limited role in this case and was misleading. MDCT axial cuts non-contrast phase showed left rib fracture with subcutaneous emphysema during chest tube insertion (A) Central splenic relatively hypodense area (thin arrows). CECT axial cuts on spleen (B) Shows a blob of contrast in arterial phase (D) Shows washout of contrast following the arterial pool, signifying an active contrast extravasation with pseudoaneurysm. (E) Multiple foci of contrast extravasation are contained within the shattered spleen (grade V).

Discussion

Trauma remains the most common cause of death for all individuals between the ages of 1 and 44 years. 10% of these fatalities are attributable to abdominal injury. The fatality rates for trauma are 20 times indeveloping countries that for developed countries. The management of patients with blunt abdominal injury has evolved greatly over the last few decadesfrom complete surgicalmanagementhistorically to present NOM in most of the cases [6]. In the current study, we compared the US andMDCT findings in BAT patients. We hypothesized that the US can be sufficient and replaces MDCT in patients who are vitally stable. This would save hospital resources; contrast and MDCT usage and reduces radiation exposure. The rate of organ injuries in this study coincides with the other reviewed studies.

The aim of this study was to emphasise the circumstances in which the US could be sufficient in the evaluation of hemodynamically stable patients with acute abdominal trauma without the need for MDCT scan, and assess the additive role of multidetector CT over conventional ultrasound (US).

Spleen and liver are the most commonly injured organs. In this study, the spleen was double the liver injuries. Many studies reported liver followed by spleen as the most injured organs. Others alternatively reported spleen followed by liver.

Also, the current study found that kidney injury is the commonest retroperitoneal and urinary system injured organ. Pancreatic injury is difficult to diagnose. MDCT shows fairly low diagnostic accuracy. The image quality afforded by 64-row MDCT may improve the detection of injury, though the morphology of the pancreas itself, with its many clefts, continues to present a diagnostic challenge [7]. In this study we didn't encounter any pancreatic injury. Hollow visceral injury is uncommon and difficult to diagnose. In consistence with Afshin et al., who found hollow visceral injury in 88 out of 1550 [6%] [8].

Only one case of hollow visceral; extraperitoneal UB injury [4%] was encountered in this study. US showed just hemoperitoneum in that case. MDCT cystography diagnosed the urinary bladder injuryandan associated pubic fracture. Mesenteric injuries are common and usually manifest only by hemoperitoneum in US and MDCT so usually pass undetected [9]. During this study, a case of mesenteric injury was encountered that only revealed hemoperitoneum on FAST; the patient was excluded from the study since he was vitally unstable. Mesenteric injury was diagnosed intraoperative. According to Yoshi, prevalence of organ injury without accompanying free fluid ranges from 5% to 37% [10]. In contrast, this study found no patient had visceral injury without hemoperitoneum.

Boulanger et al., reported that FAST scan takes an average time of 2.6±1.4 minutes [11]. In the current study the time for FAST was 2-5 minutes, taking more time in obese, elderly or patients with accompanying skeletal fractures. In a study by Michihiro et al., very similar to ours, they have limited the interval between US and MDCT to less than 12 hours [12]. We think that 12 hours would change the amount and appearance of hemoperitoneum in case of active peritoneal bleeding. We assured that US and MDCT were done with no wide time interval, so no significant changes happen. In the same study, they confined the time between trauma and admission to 48 hours. In our study, just few cases [<10%] exceeded 5 hours interval between trauma and FAST scan. Those few cases when the patient was referred from another Hospital or didn't go to a hospital until next day. Legome reported a sensitivity and specificity range from 85% to 95%, being higher in the hands of the more skilled operators [13]. Doody et al reported that the sensitivity of FAST for free intraperitoneal fluid is up to 98% and specificity is up to 100% [14]. In contrast, in the current study we assumed that FAST is more accurate when it excludes hemoperitoneum than when it proves it, the current study showed that US sensitivity is higher than its specificity with a sensitivity of 100% and specificity 64%.

This study agreed with a Cochrane review that found US has excellent specificity but low sensitivity in identifying visceral organ injuries. This means that a positive sonogram for visceral organ injury proves the presence of intraperitoneal injury, whereas a negative sonogram fails to confidently exclude traumatic organ lesions (Figs. 3,4) [1]. This study showed that US has 88% specificity, 65% sensitivity, 81% PPV and 77% NPV for detecting visceral organ injury. That means it's more liable to miss a SOI than to diagnose it.

During our study, we used color Doppler US to aid detect organ or vascular injuries, yet it was not statistically evaluated in our study. In one of our cases, we missed a splenic contusion by US but diagnosed it by MDCTie. A false negative case (Fig. 4). We decided to reexamine the patient again with US and Doppler for this specific region. Yet, it appeared of normal echo pattern and vascularity.

On the other hand, we had one case of false positive diagnosis of splenic hematoma by the US, which appeared to be perirenal collection by MDCT with intact spleen. (Fig. 5).

We agreed with Michihiro et al., study we've found injuries that commonly were missed by US such as hollow visceral injuries, superficial injuries surrounded by nearby hemoperitoneum, superficial injuries at organ-organ interface, small injuries, isoechoic lesions (according to time of injury), and when examination of an organ is not possible due to overlying rib fractures e.g. liver and spleen and retroperitoneal injuries **[12]**, (Fig. 6). We strongly agree with Stengel et al., that negative US scans are likely to reduce the need of MDCT scans. At best, US has no negative impact on mortality or morbidity **[1]**. Agreeing with the same study we've found solid organ injuries that were missed by US were almost always clinically insignificant. Severe injuries are detected easily even by little experienced sonographers. The attempt to detect solid organ injury by US is clinically important, feasible but requires training. In a study by Ma et al, conducted on 270 patients only two with stable vital signs required exploratory laparotomy. The rest of stable patients were successfully managed conservatively **[15]**. Coincidently, only two of our patients had a surgery. Both had grade IV splenic injury, started on conservative management but later on had to have splenectomy due to vital signs deterioration.

In our study we subjectively assessed the amount of hemoperitoneum and categorized it to minimal, mild, moderate and severe. We were guided by the number of peritoneal recesses involved and the amount of hemoperitoneum in each. We applied Huang et al., method for assessment of hemoperitoneum by US and the need for surgery to many of our cases and it matched our results i.e. indicated the need for conservative or operative management correctly **[16]**. To our experience, quantification of the amount of hemoperitoneum has the following fallacies; - Free fluid that takes free shapes can't be measured by straight lines even if we measured the three dimensions. - Changing the position of the patient changes the size of each pocket within a minute. - There's no established relation between pocket size and the absolute amount of free peritoneal fluid. - Quantitative methods would be liable to inter-observer differences caused by site and orientation of measurement. - Moving bowels and organs are not static structures to measure distances confidently. For example, just applying more compression during scan changes the measurement taken. However, when using these methods, significant changes can be evaluated more objectively on follow-up FAST. A semiquantitative method proposed by Federle et al to assess free peritoneal fluid by MDCT counts the number of compartments occupied by hemoperitoneum. Each compartment adds 1 to the score **[17]**. In this study, we assessed the amount of hemoperitoneum subjectively by assessing the number of involved recesses and the amount of fluid in each.

We graded hemoperitoneum to minimal, mild, moderate or severe. We tried the aforementioned Federle score and it matched our results. It is worth noting that Federle method that's applied on MDCT scan is quite similar to Huang method in assessment of free fluid based on US. Amusingly same score indication was concluded in both studies which are 10 years apart. Supporting Charbit recommendation at the end of his study that he strongly believes the semiquantitative assessment of hemoperitoneum has to be realized by FAST on hospital admission **[18]**.

In the current study we frequently encountered rib fractures were associated with hepatic when right ribs are affected or splenic when left ribs (Fig. 7). Meanwhile, lumbar vertebral fractures were associated with retroperitoneal hematoma or renal injury. The Park S. study on the same track reported intra-abdominal organ injury is more common in patients with lower rib fractures **[19]**. According to our experience we agree with an Indian study that a radiologist should always be in ER supervising MDCT scans; contrast injection and proper technique for each case. Physicians should feel free to consult their colleague radiologists **[3]**. Our study has the following limitations and weaknesses; - Trauma and ER studies often need a larger number of patients included in the study. - Adult vitally stable patients are often found free by the US, where the MDCT was not always done for comparison. Actually pediatric group (who are excluded) are commoner to have hemoperitoneum in that context.

Conclusion:

US is accurate for detecting hemoperitoneum in BAT but less accurate for detecting visceral organ injuries. The US can accurately exclude hemoperitoneum and thus no need for MDCT imaging. In cases where hemoperitoneum was detected, MDCT is recommended to search for visceral organ injury and take the most appropriate management strategy. Sometimes the US is insufficient due to the inability to examine a region with an overlying bone fracture. In that case, MDCT is mandatory for proper assessment. We used Doppler examination to check for solid organ injuries and major abdominal vessels,but it was not statistically evaluated. So that its implications need to be studied furtherly.

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هل يعد التصوير بالأشعة المقطعية متعددة الكواشف بعد فحص الموجات فوق الصوتية الزامى فى تقييم المرضى المستقرين فى حالات الصدمات البطنية الثلمة؟

تهدف الدراسة الحالية لمقارنة فحص الموجات فوق الصوتية على البطن والحوض والأشعة المقطعية فى تقييم حالات مرضى الصدمات البطنية الثلمة. تقارن الدراسة بين الفحصين من حيث إمكانية إظهار التجمع الدموى بداخل التجويف البريتونى ومن حيث إظهار جروح الأعضاء الداخلية كالكبد والطحال فى هذه الحالات. وقد أثبتت الدراسة أن الموجات فوق الصوتية تطابق الأشعة المقطعية بنسبة عالية من حيث تشخيص التجمع الدموى البريتونى، ولكن بنسبة منخفضة من حيث تشخيص جروح.