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Study of Role of Multi Slice Computed Tomography in Evaluation of Blunt Renal Trauma

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ABSTRACT
Background: Clinicians had difficulties in making correct diagnoses of renal damage caused by various traumas. After blunt trauma, computed tomography (CT) is the preferred method of visualizing the internal organs.
Objective: This study aimed to determine the relationship between multi detector computed tomography (MDCT) findings and clinical outcomes
Patients and Methods: A cross section study was performed in Emergency Department, Zagazig University on 24 patients presented with blunt thoraco-abdominal trauma and hematuria. Focused assessment with sonography in trauma (FAST) and Contrast-enhanced multiphasic renal CT study were done to all cases.
Results: There were statistically significant difference between CT & FAST specificity & PPV in diagnosing grade I renal injury. Moreover, the accuracy of CT in diagnosing grade I renal injury was statistically significant higher than that of FAST. There was statistically significant difference between CT & FAST specificity & PPV in diagnosing grade II renal injury. Moreover, the accuracy of CT in diagnosing grade II renal injury was statistically significantly higher than that of FAST. Sensitivity of CT was significantly higher than that of FAST in diagnosing grade III renal injury. The sensitivity, NPV & accuracy of CT in diagnosing grade V renal injury was significantly higher than that of FAST.
Conclusion: The anatomic and functional information provided by contrast-enhanced multi-slice computed tomography (MSCT) is crucial for precise grading according to the American Association for the Surgery of Trauma (AAST) classification system, making it the gold standard in evaluation and therapy of renal trauma.
Keywords: Computed tomography, Blunt renal trauma, FAST.

INTRODUCTION
The most common cause of renal damage is blunt abdominal trauma, affecting 1-5% of all trauma patients (80% to 90%). Despite its rarity, deep renal trauma can account for up to 20% **[1].** Bleeding, damage to the collecting system, and urine leakage are all possible outcomes of renal trauma to the parenchyma or renal vasculature. Injuries to the kidney are the norm in the genitourinary system (10% of all traumas) **[2].**

After a severe blow to the abdomen, the most reliable method of visualising the internal organs is computed tomography (CT). Delayed phase images evaluate the renal collecting system and ureteric continuity, while arterial and portal venous phase imaging detect active extravasation **[3].** Renal injuries, along with injuries to other abdominal or retroperitoneal organs, can be swiftly and correctly shown by contrast-enhanced CT, which is routinely available in emergency rooms **[4].** The most consistent manifestation of renal injury is gross hematuria; nevertheless, it may not occur in about 5% of patients, and the severity of the symptom does not correlate with the severity of the injury **[5].**

All stable patients with massive hematuria and those who present with microscopic hematuria and hypotension should undergo contrast-enhanced computed tomography (CT) for the definitive diagnosis of renal trauma**.** A CT scan should be performed if the mechanism of injury or the findings of a physical examination suggest renal injury **[6].** Surgery has become more cautious as a result of MDCT's accurate grading, with the exception of cases involving full lacerations, extensive extravasation, as well as abdominal injuries **[7]**.

We aimed at this study to determine the relationship between multi detector computed tomography (MDCT) findings and clinical outcomes.

SUBJECTS AND METHODS
Between May 2020 and February 2021, a cross-sectional study was conducted at The Emergency Room at Zagazig University. Twenty-four people participated in the study (14 males, 10 females) with ages ranging from 5-55 with a mean age of 21.63 ± 15.265.

Inclusion criteria: Any age group and sex with blunt thoraco-abdominal trauma and hematuria.

Exclusion criteria: Other (non-traumatic) causes of hematuria, penetrating trauma, pregnant females, haemodynamic or respiratory instability, poor renal function with high creatinine level (> 2 mg/dL), and allergy to contrast media.

The patients were subjected to complete history taking, as well as clinical examination and Radiological assessment:

I. **FAST (focused assessment with sonography in trauma):**
The GE Logiq P7A sector probe (3-5 MHz) machine can serve a variety of purposes. It was used for detecting the existence of free fluid in the abdomen or pelvis and analyzing its volume.

II. **Contrast-enhanced multiphasic renal CT study:**
Philips Ingenuity 128 CT Scanner machine using a powerful automatic injector was used with the patient

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in supine position without gantry tilt, scan from diaphragm to lesser trochanter of femur.

Administration of intravenous contrast medium.

MSCT protocol:

1. ***Initial non-enhanced study:*** was acquired for the entire abdomen to identify the location and size of the kidneys, as well as the presence of any foreign bodies, calcifications, or stones.
2. ***Arterial phase:*** Maximum opacification of renal arteries can be seen on scans collected between 15 and 20 seconds after contrast medium infusion began. In late arterial phase, the renal veins often get opacified as well. Arterial damage can be detected during this stage.
3. ***Porto-venous phase (corticomedullary phase):*** After the contrast injection had begun, scans were taken 30-40 seconds later. This was the optimal time for greatest opacifications of renal veins, and there was significant enhancement of the renal cortex while the medulla remains relatively less increased. In this stage, venous damage can be detected.
4. ***Nephrographic phase:*** The optimal time to detect modest parenchymal lesions is between 80 and 120 seconds following contrast administration, when the renal parenchyma has been uniformly enhanced.
5. ***Excretory phase*** were taken four to five minutes after the contrast dye infusion had begun. Calyces, renal pelvises, and ureters can be made opaque through the excretion of contrast media. During this time period, damage to the pelvicalyceal system or urine extravasation can be detected.

Post processing images: In most cases, a picture archiving and communication system was used to examine CT scan images.

Ethical approval

All participants gave signed informed consent forms, and the research was authorized by The Ethical Council of Zagazig University. The study followed the principles outlined in the Declaration of Helsinki.

Statistical analysis

SPSS for Windows version 20 was used for the statistical analysis (SPSS Inc., Chicago, IL, USA). The standard deviation was included with the mean when presenting statistical data. The chi-square test was used to find a statistically significant difference. The MDCT's screening validity was evaluated by measuring its sensitivity, specificity, positive predictive value, negative predictive value, and accuracy. A value ≤ 0.05 was considered significant.

RESULTS

Mean age of the studied participants was 21.6 ± 15.2 years ranging between 5-55 years. More than half of the studied participants were males, all patients presented to Emergency Department with gross hematuria. About one third of the studied participants presented by hypovolemic shock & severe abdominal pain (29.2%). Moreover, 12.5% of the studied participants presented by confusion & pallor. Only one patient presented by fracture (Table 1).

Table (1): Demographics and clinical characters of the studied participants

Variable	Studied group (N=24)	
Age: (years)		
• Mean± SD	21.63±15.265	
• Range	5-55	
	No	**%**
Sex:		
• Male	14	58.3
• Female	10	41.7
Hematuria	24	100
Hypovolemic shock	7	29.2
Abdominal pain		
• Severe	7	29.2
• Mild-moderate	4	16.7
Confusion	3	12.5
Pallor	3	12.5
Fracture	1	4.2

Table (2) showed that grades I & II were the most common among the studied participants (33.3%) followed by grades III & IV which represented 12.5%. Grade V was the least frequent (8.3%). While in CT, grade IV was the most common among the studied participants (33.3%) followed by grade V & grade III, which represented 20.8% each. Grade I was the least frequent (8.3%).

Table (2): Frequency distribution of FAST and CT examination grading of renal injuries among those who took part in the research

Variable	Studied group N= 24			
	FAST		CT	
	N	%	N	%
Grade I	8	33.3	2	8.3
Grade II	8	33.3	4	16.7
Grade III	3	12.5	5	20.8
Grade IV	3	12.5	8	33.3
Grade V	2	8.3	5	20.8

The accuracy of FAST vs. CT in diagnosing blunt renal trauma showed that grade I was 75% vs. 100%. There were statistically significant differences between CT & FAST specificity & PPV in diagnosing grade I renal injury. Moreover, the accuracy of CT in diagnosing grade I renal injury was statistically significantly higher than that of FAST.

Table (3): Validity of FAST and CT examination in diagnosis of renal injuries grade I compared to final diagnosis

Variable	Studied group N= 24			
	FAST	**CT**	**x2**	**P**
True positive	2	2	NA	NA
False Positive	6	0	Fisher	**0.01(S)**
True Negative	16	22	4.5	**0.03(S)**
False negative	0	0	NA	NA
Sensitivity	100%	100%	NA	NA
Specificity	72.7%	100%	2.75*	**0.002(S)**
PPV	25%	100%	5.3*	**0.0001(HS)**
NPV	100%	100%	NA	NA
Accuracy	75%	100%	2.6*	**0.004(S)**

NA: not applicable* Z test for proportion, PPV (positive predictive value), NPV (negative predictive value)

Table (4) showed that the CT was able to identify all cases without grade II blunt renal trauma (specificity 100%), while FAST specificity was 80%. The PVP was 100% for CT, while it was 50% for FAST in diagnosing grade II renal injury. The accuracy of FAST vs. CT in diagnosing blunt renal trauma grade II was 83.8% vs. 100%. There was statistical significant difference between CT & FAST specificity & PPV in diagnosing grade II renal injury. Moreover, the accuracy of CT in diagnosing grade II renal injury was statistically significantly higher than that of FAST.

Table (4): Validity of FAST and CT examination compared to final diagnosis in diagnosis of renal injury in grade II

Variable	Studied group N= 24			
	FAST	**CT**	**x2**	**P**
True positive	4	4	NA	NA
False Positive	4	0	Fisher	0.1
True Negative	16	20	1.77	0.18
False negative	0	0	NA	NA
Sensitivity	100%	100%	NA	NA
Specificity	80%	100%	2.3*	**0.01(S)**
PPV	50%	100%	4*	**<0.001(HS)**
NPV	100%	100%	NA	NA
Accuracy	83.8%	100%	2.05*	**0.01(S)**

Table (5) showed that CT was able to identify all patients with grade III blunt renal trauma with sensitivity 100% while FAST sensitivity was 60%. Sensitivity of CT was significantly higher than that of FAST in diagnosing grade III renal injury.

Table (5): Validity of FAST and CT examination compared to final diagnosis in diagnosis of renal injury in grade III

Variable	Studied group N= 24			
	FAST	**CT**	**X2**	**P**
True positive	3	5	0.6	0.4
False Positive	0	0	NA	NA
True Negative	19	19	NA	NA
False negative	2	0	Fisher	0.48
Sensitivity	60 %	100%	3.4	**0.0002(HS)**
Specificity	100 %	100%	NA	NA
PPV	100 %	100%	NA	NA
NPV	90.4 %	100%	1.5*	0.059
Accuracy	91.6 %	100%	1.4*	0.07

Table (6) demonstrated that CT had a sensitivity of 100% for detecting patients with grade IV blunt renal damage, while the sensitivity of FAST was only 37.5%. The NPV was 100% for CT, while 76.19% for FAST in diagnosing grade IV renal injury. The accuracy of FAST vs. CT in diagnosing blunt renal trauma grade IV was 79.17% vs. 100%. The sensitivity of CT and FAST for detecting grade IV renal damage differed statistically significantly. CT also outperformed FAST in terms of NPV and accuracy in identifying grade IV renal injury.

Table (6): Validity of FAST and CT examination compared to final diagnosis in diagnosis of renal injury in grade IV

Variable	Studied group N= 24			
	FAST	**CT**	**X2**	**P**
True positive	3	8	2.8	0.08
False Positive	0	0	NA	NA
True Negative	16	16	NA	NA
False negative	5	0	Fisher	**0.04(S)**
Sensitivity	37.5 %	100%	4.6*	**<0.0001(HS)**
Specificity	100 %	100%	NA	NA
PPV	100 %	100%	NA	NA
NPV	76.19 %	100%	2.5*	**0.005(S)**
Accuracy	79.17 %	100%	2.3*	**0.009(S)**

Table (7) showed that CT was able to identify all cases with grade V blunt renal trauma with sensitivity of 100%, while FAST sensitivity was 40%. NPV was 100% for CT while 86.4% for FAST in diagnosing grade V renal injury. The accuracy of FAST vs. CT in diagnosing blunt renal trauma grade V was 87.5% vs. 100%. The sensitivity, NPV & accuracy of CT in diagnosing grade V renal injury was significantly higher than that of FAST.

Table (7): Validity of FAST and CT examination compared to final diagnosis in diagnosis of renal injury in grade V

Variable	Studied group N= 24			
	FAST	**CT**	**X2**	**P**
True positive	2	5	1.5	0.2.
False Positive	0	0	NA	NA
True Negative	19	19	NA	NA
False negative	3	0	Fisher	0.2
Sensitivity	40 %	100%	4.5	**<0.0001(HS)**
Specificity	100 %	100%	NA	NA
PPV	100 %	100%	NA	NA
NPV	86.4 %	100%	1.87*	**0.03(S)**
Accuracy	87.5 %	100%	1.7*	**0.03(S)**

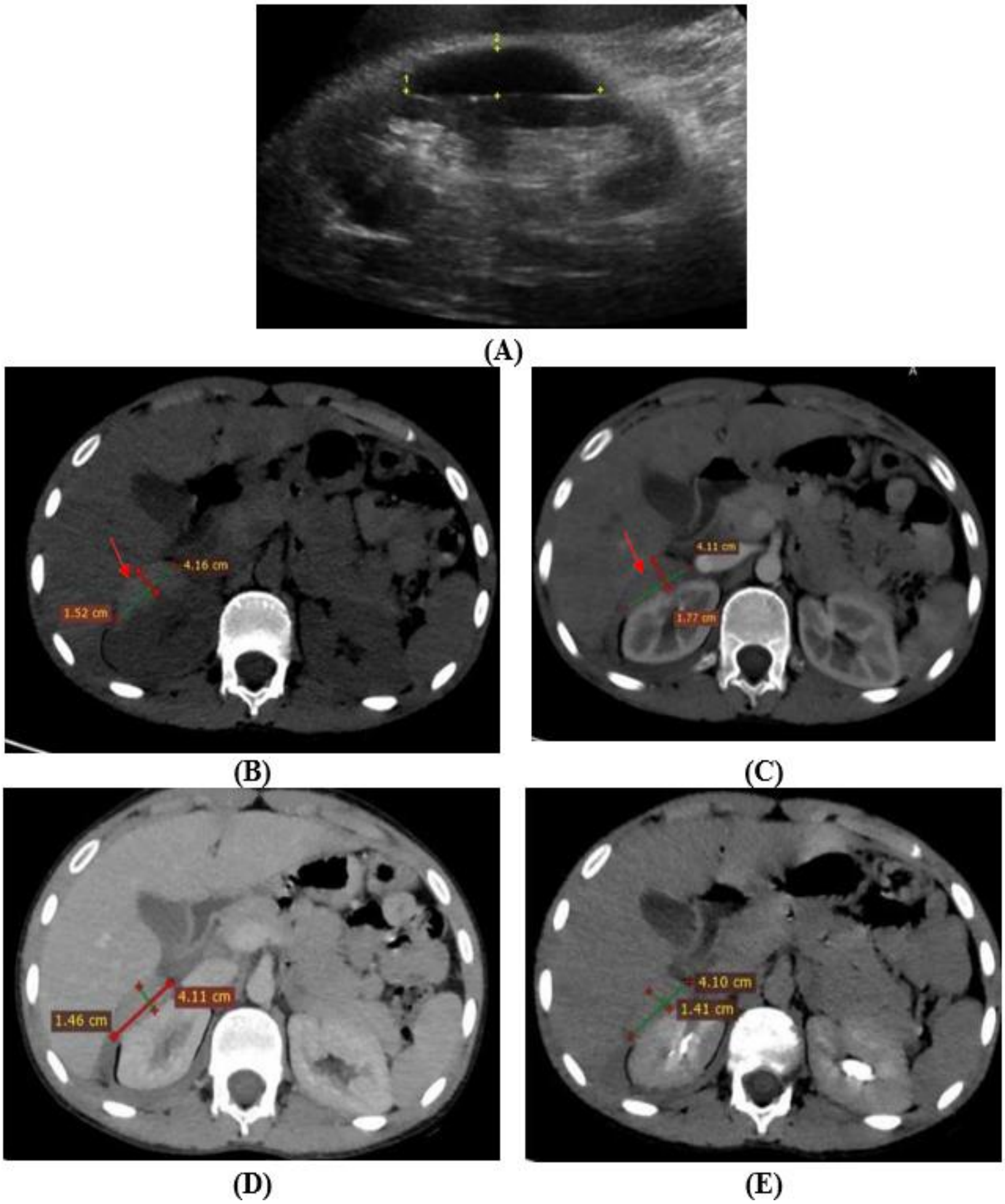

Figure (1): a 25 years old male patient was subjected to RTA, represented by hematuria. US revealed (A): mild amount of free fluid in pelvis angle with sub- capsular hematoma of right kidney. MSCT scan with contrast showed in axial cuts (non-contrast phase) at the level of the kidneys a well-defined hyperdense right subcapsular hematoma measuring 4.1x 4.5 cm **(B)**.

C&D: axial cuts (cortico-medullary and nephrogenic phases) at the level of the kidneys showed a well-defined right subcapsular iso-dense hematoma measuring 4.1x 1.7cm with no cortical or parenchymal lacerations. **E:** axial cuts (excretory phase) at the level of the kidneys showed no contrast extravasation with intact pelvi-calyceal system. According to AAST classification this is considered grade I renal trauma.

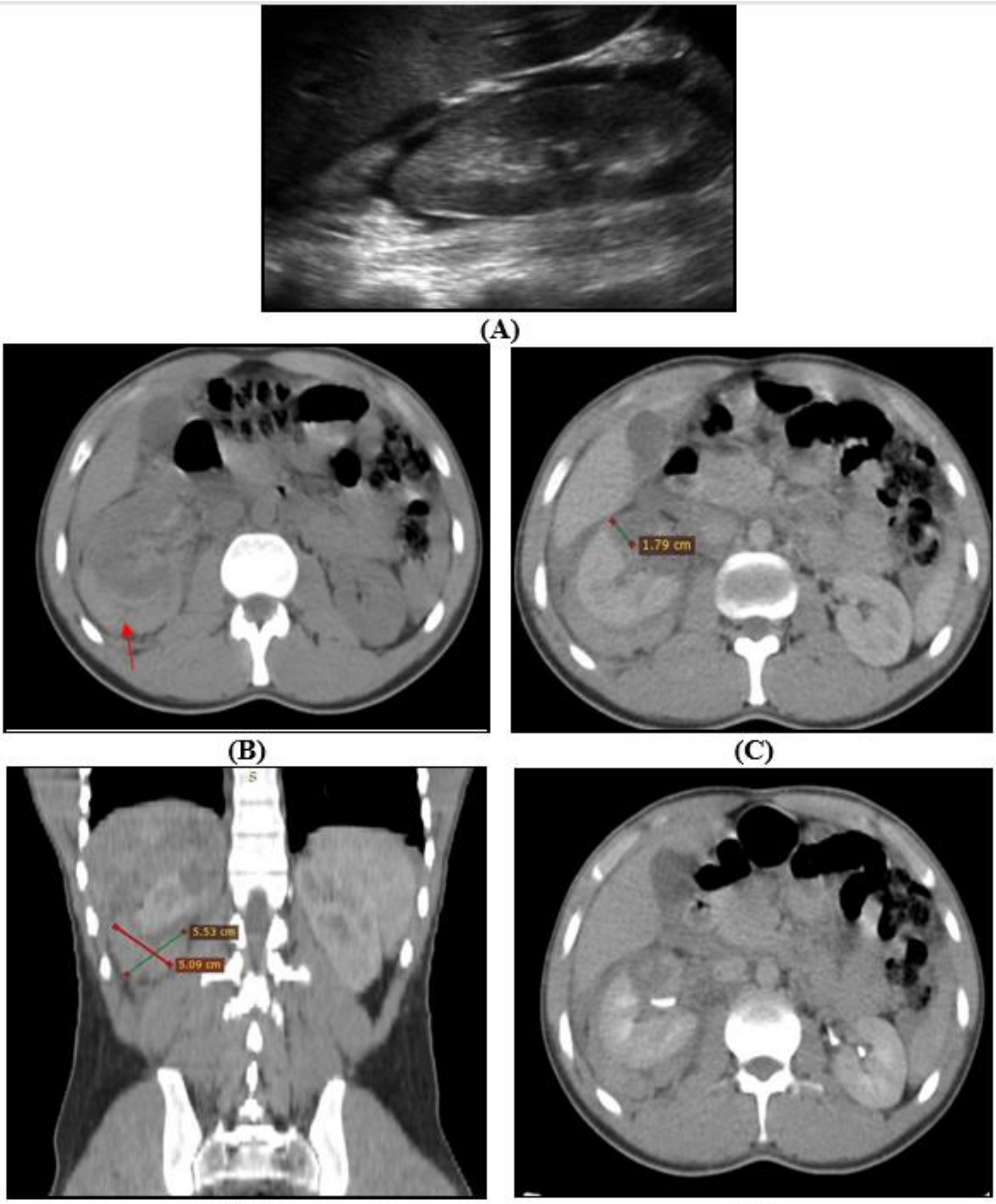

Figure (2): A 26 years old, male patient had been injured in RTA, represented by hematuria, abdominal pain and pallor. US revealed in **(A):** Moderate free fluid in hepato-renal angle and pelvis with peri-nephric hematoma that surrounded lower pole of the right kidney. MSCT scan with contrast showed in **B:** axial cut (non-contrast phase) at the level of the kidney, there was a hyperdense hematoma surrounding the lower pole of the kidney.

C & D: axial and coronal cuts at level of the kidney (nephrogenic phase) showed laceration in the upper pole of the right kidney that measured 1.8 cm with intact collecting system associated with hyperdense perinephric hematoma that measured 5x5.5 **E:** axial cut at the level of the kidney (delayed phase) showed intact collecting system with no urine extravasation. According to AAST classification this is considered grade III renal injury.

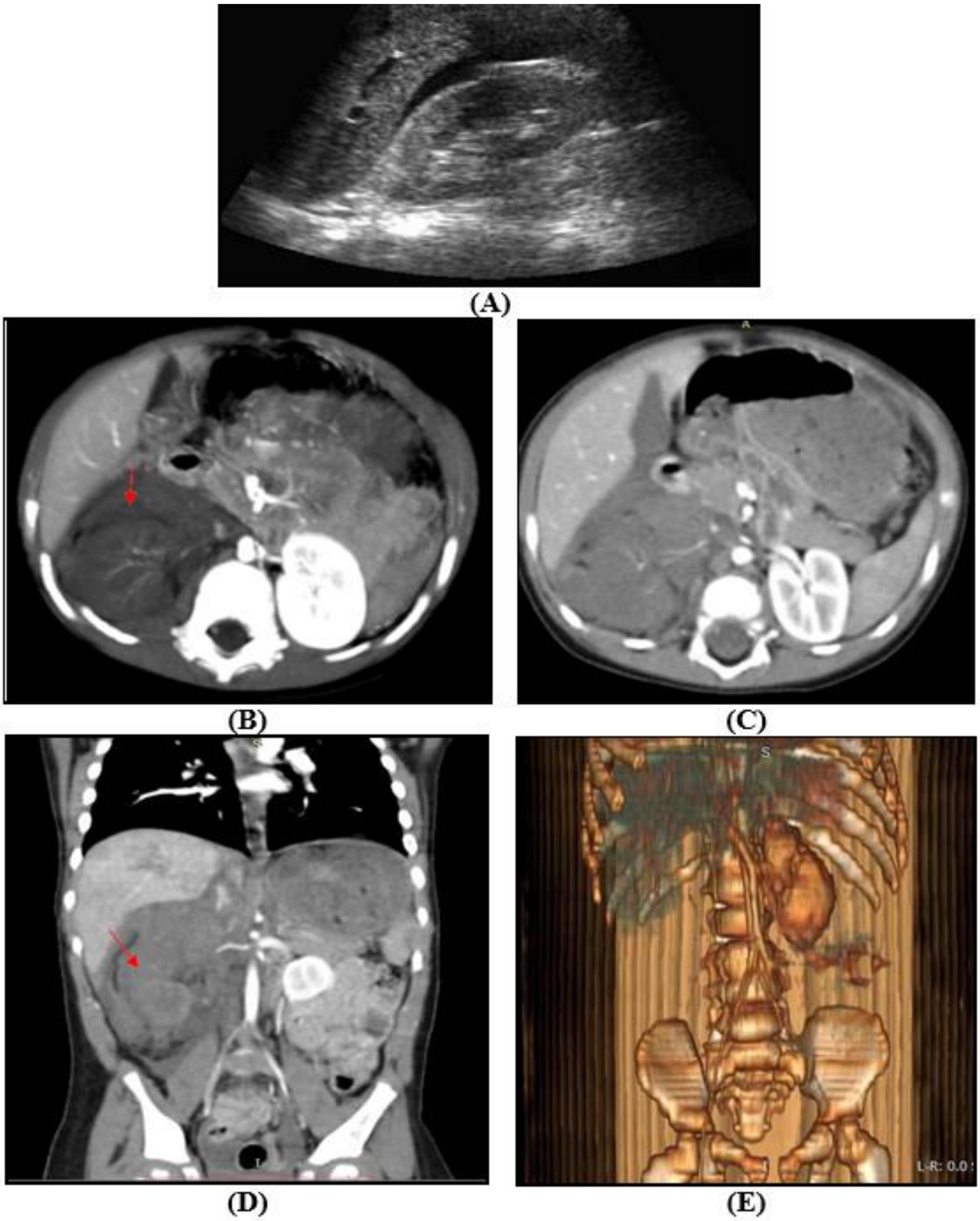

Figure (3): A 26 years old male patient had a blunt trauma at right flank, represented by hematuria and severe abdominal pain. US revealed in **(A):** mild amount of intra peritoneal fluid in right hepato- renal angle with hypoechoic lacerations in renal cortices. MSCT scan with contrast showed in **B &C:** axial cut at level of kidney (arterial & cortico-medullary phase, respectively) showed renal artery dissection leading to a normal looking right kidney. Neither active extravasation of contrast material nor parenchymal lacerations were seen. Large perinephric hematoma surrounded the right kidney. **D:** coronal reformation cut showed a hypovascularized right kidney. A large perinephric hematoma surrounded the kidney with attenuated RT renal artery. **E:** 3D volume rendering image showed non-visualized right kidney. According to AAST classification this is considered grade V renal injury.

DISCUSSION

Clinicians had difficulties in making correct diagnoses of renal damage caused by various traumas. There is a good chance that the clinical signs and symptoms of the intra-abdominal damage are being obscured by those of more evident or compelling injuries, as many of these individuals were the victims of several traumas. However, MDCT allows for a quick and precise assessment of the condition of abdominal organs, the retro-peritoneum, and the abdominal wall. In recent years, MDCT has inspired non-surgical approaches to treating blunt intra-abdominal trauma [(8)].

This study included 24 patients with history of renal trauma and all had positive US findings whether free intra-peritoneal fluid or renal injury and hemodynamically stable. They were 14 males (58.3%) and 10 females (41.7%), their ages ranged from 5 to 55 years. This study's age distribution matches that of similar studies conducted around the world, with the notable exception that males in this study were significantly more likely than females to have experienced trauma, accounting for the majority of the 20–80 percentage point gap. Our research showed that male patients were more likely to experience abdominal trauma (58.3% vs. 41.7%). This is consistent with **Awe *et al.*** [(9)] that there were 8.6 times as many male patients as female ones. Also, **Osman *et al.*** [(8)] stated that the incidence of blunt trauma in male is more compared to females.

In this study, cause of trauma attributed to road traffic accident was the most frequent type of trauma among the studied participants (50%), followed by falling from height & direct blunt trauma (29.2 & 16.6) respectively. While falling on hard object was the least frequent (4.2%). In agreement with **Alonso *et al.*** [(4)] who reported most genitourinary organ closure injuries are the result of blunt abdominal trauma, with auto accidents being the leading cause of this type of injury. And also, **Osman *et al.*** [(8)] which stated that The leading cause of blunt abdominal injuries is motor vehicle accidents (63.4%), followed by falls from height (4.9%). also **Peng *et al.*** [(10)] reported Accidents involving motor vehicles accounted for 34.1%, falls from great heights for 24.6%, and blunt force trauma accounted for 17.5%.

In our study, all patients presented to Emergency Department with gross hematuria. About one third of the studied participants presented by hypovolemic shock & severe abdominal pain (29.2%) and 12.5% of the studied participants presented by confusion & pallor. Only one patient presented by fracture (4.2%). This match with **Osman *et al.*** [(8)], who stated that All patients had gross hematuria, which is consistent with the other investigations despite the varying percentages that can be attributed to severe renal and other organ damage. Also, **Alonso and colleagues** [(4)] reported that in the absence of massive hematuria, there is no major damage to the urinary tract.

All patients underwent a CT scan with contrast enhancement, and the results were categorized using the American Association for the Surgery of Trauma (AAST) grading system.

In our study, we found that intraperitoneal free fluid was the most common US finding among the studied participants (62.5%) followed by perinephric hematoma (54.2%). Moreover, lacerations were found in 41.6% of the studied participants where half of them were deep. Renal contusion & distorted shape of the kidney were found in only 4.2% of the studied participants. According to ASST of renal grading, we found that grade I & II were the most common among the studied participants (33.3%) followed by grade III & IV, which represented 12.5%. Grade V was the least frequent (8.3%). While, the most common finding among the studied participants was deep lacerations (45.8%) followed by perinephric hematoma (41.7%) while 12.5 % of the studied participants suffered deep lacerations reaching collecting tubules & superficial lacerations. Non- enhanced kidney, attenuated renal artery and incomplete pelvicalyceal system avulsion were found in 20.8%, 8.3 % and 8.3% respectively of the studied participants. Only 4.2% of patients showed shattered kidney and segmental renal infarction, this is in agreement with **Shabaan *et al.*** [(7)] who stated that deep laceration (>1cm) not reaching the collecting system is the most common finding accounting for 36.5%. Also, our result is in consistence with **Alonso and colleagues** [(4)] who noted that blunt renal damage typically results in a peri-nephric hematoma.

In light of these standards Two patients (8.3%) were found to have sustained grade I injuries (small blood clots in the ureter), this is in contrast to **Alonso and colleagues** [(4)] **and Smith *et al.*** [(11)] who mentioned that seventy-five to eighty-five percent of renal injuries are classified as grade I. This is because patients with grade I renal injuries are considered to have minor injuries because they lack perinephric collection and, in the absence of other associated intra-abdominal organ injury, may lack also intra-peritoneal collection, resulting in a negative FAST examination. They are hemodynamically stable, therefore, a CT scan will not be performed unless there is evidence of severe hematuria. After CT examination, we determined that the presence of mild to moderate intraperitoneal free fluid on FAST evaluation was owing to multiple liver lacerations in the only two patients with grade I injury in our study. While, our result agrees with **Shabaan *et al.*** [(7)] who stated that five patients (14%), all with blunt and penetrating abdominal trauma and suspected renal injury, were found to have grade I injury, defined as a minor contusion without laceration or perinephric hematoma. Four patients, or 16.7%, were classified as having a grade II injury; one had a laceration (1 cm) and subcapsular hematoma, another had a laceration (1 cm) only, and the other two had subcapsular hematoma. This agrees with **Shabaan, *et al.*** [(7)] who stated that three patients (7.3%) were found to have sustained grade II injury; one had a laceration (1 cm), another had a burst cortical cyst, and the third had both cut (1 cm) and hemorrhagic cortical cysts.

There were 5 individuals with grade III injury (20.8%), all of whom had a deep laceration (>1 cm) that did not extend into the collecting system that is consonant with the findings of **Shabaan *et al.*** [7] who reported a diagnosis of grade III injury in 12 patients (29.3%), all of whom had profound laceration (>1 cm) that did not reach the collecting system as evidenced by the absence of contrast extravasation in the delayed phase.

The most common injury in our study was a grade IV injury, which was found in 8 patients (33.3 percent). This is likely because grade IV injury is a major renal injury, typically associated with a large retroperitoneal hematoma on FAST, and clinically the patient typically presents with gross hematuria or hypovolemic shock, calling for a CT scan.

Three patients in the current study suffered pelvicalyceal-level lacerations, two patients experienced incomplete pelvi-ureteric junction avulsion, two patients experienced attenuated renal artery with contained hematoma, and one patient suffered segmental lower polar infarction as a result of their injuries. This agrees with the findings of **Shabaan *et al.*** [7] who reported 22 patients with grade IV injuries (53.7%). In the delayed phase, contrast extravasation confirmed 10 cases (24.4%) of deep lacerations extending to the pelvicalyceal system. In the delayed phase, contrast extravasation caused a shattered kidney in a 2.4% patients who also sustained pelvicalyceal system damage. There were no related renal lacerations in the two patients (4.9% of the total) whose pelvic tears were proven by contrast extravasation from the renal pelvis during the delayed phase. Incomplete pelvi-ureteric junction avulsion was found in 1 patient (2.4%), Segmental lower polar infarction and many minor subsegmental infarcts were found in 2.4% patients who also did not sustain a renal laceration or a perinephric hemorrhage.

Grade V injury was diagnosed in 5 patients (20.8%), three patients had complete renal pedicle avulsion one of them was associated with shattered kidney and the other two patients had thrombosis of main renal artery. This is in accordance with the findings of **Shabaan *et al.*** [7] who reported that three patients (7.4%) suffered grade V injuries, one patient (2.4%), renal vein avulsion with a shattered kidney, and one patient (2.4%) thrombosis of the major renal artery with devascularization of the kidney sparing its lower pole, which is supplied by accessory renal artery.

Sensitivity of FAST was decreased with increased renal injury grade as it was 100% sensitive and 72.7% specific in grade I, 100% sensitive and 80% specific in grade II, 60% sensitive and 100% specific in grade III, 37.5% sensitive and 100% specific in grade IV, and 40% sensitive and 100% specific in grade V. There was high significant difference between FAST and CT especially in high grades that should be considered in all renal trauma patients, this is in consistence with **Reza *et al.*** [12] who stated that CT has a higher sensitivity and specificity than US, which only achieves 48% and 96%, respectively, and a lower 0.8 positive predictive value, 0.57 negative predictive value, and 79% accuracy, as well as **Osman *et al.*** [8] who stated that in this investigation, the sensitivity and specificity for using CT renal damage findings to guide patient therapy were both 100%.

In this study, the MDCT's sensitivity in identifying abdominal and pelvic damage to soft tissues was 100 percent. MDCT scanning with intravenous contrast had a sensitivity of 90–100%, according to a study by **Van *et al.*** [13]**.**

CONCLUSION

The anatomic and functional information provided by contrast-enhanced multi-slice computed tomography (MSCT) is crucial for precise grading according to the AAST classification system, making it the gold standard in evaluation and managing of renal trauma. Using CT results and the AAST grading system, MSCT played a crucial role in determining whether conservative or surgical therapy of renal trauma is warranted.

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