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# Incidence and Degree of Traumatic Kidney Injury in Polytrauma Patients Detected by Ultrasound versus Computed Tomography of the Abdomen

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## ABSTRACT

**Background:** Trauma has been considered a frequent cause of death or permanent disability in young subjects; hence, a timely diagnostic approach is crucial. In polytrauma cases, contrast-enhanced ultrasound (CEUS) has been demonstrated to be of great sensitivity compared to ultrasound (US) in the detection of solid organ traumas.

**Objective:** To evaluate the incidence and degree of traumatic kidney injury (TKI) in polytraumatic patients detected by ultrasound versus CT scan of the abdomen and effect of renal injuries on short term outcome.

**Patients and Methods:** This was a prospective study included 65 polytrauma patients with traumatic kidney injury. They were subjected to history taking including mechanism of injury and time of the injury and injury severity score (ISS), clinical examination, laboratory and radiological investigations (Fast abdominal Ultrasound and CT abdomen with contrast).

**Results:** No statistically significant relation was found between grades of renal trauma by CT and need of ICU admission, needing blood transfusion, sepsis and ICU stay duration. US validity in detecting renal trauma as compared to CT findings was highest among cases with hyperechoic or hypoechoic collection followed by perinephric collection hematoma, pelvic free fluid and subcapsular hematoma or collection.

**Conclusion:** Both ultrasound and CT are effective tools for detecting traumatic kidney injuries, with CT exhibiting a higher sensitivity and specificity. The degree of traumatic kidney injury varied significantly among the study population, highlighting the heterogeneity of polytrauma patients and the need for individualized treatment approaches.

**Keywords:** Kidney Injury, Computed Tomography, Ultrasound, Polytrauma.

## INTRODUCTION

Polytrauma, is a patient's state with multi-organ injuries that include several organs or tissues, is the main cause of morbimortality in young subjects. Trauma-associated injuries have been considered as a major public concern owing to their accompanying morbimortality, and socioeconomic consequences **[(1)]**. A lot of advances have been made in the care of the polytrauma patient, leading to improved survival. Additionally, the definition of polytrauma has been improved. ISS or related scoring systems which include the New ISS (NISS), were improved by adding patient distinctive factors or physiologic responses **[(2)]**.

The peritoneum, abdominal viscera, and the tough musculoskeletal structures of the posterior abdominal wall provide excellent protection and cushioning for the kidneys, which are positioned high up in the retroperitoneum. About 9% of all abdominal injuries are related to renal injuries, despite the kidney being the most frequently injured organ in the genitourinary system **[(3)]**.

In order to reduce the risk of death or limb amputation, immediate diagnostic investigations have to be conducted along with resuscitation measures. The experience gained during periods of war has made limb salvage a rule rather than an exception. To obtain promising outcomes, an integrated system composed of different subspecialties has to work together, which includes interventional radiology, vascular surgery, and well-trained teamwork **[(4)]**.

Ultrasound (US) represents a promising, simple, approach able to rapidly confirm or refute fatal diagnoses. In addition, Focused Abdominal Sonography for Trauma (FAST) has become a main component in the assessment of polytrauma cases; it is mainly reliant on the consecutive evaluation of pericardial, perihepatic, pelvic, and peri-splenic views. The examination was extended to assess numerous organs in the next years and is still a point-of-care examination. It offers a detailed overview of the case within a short time by assessing the airways, the chest, the heart, the abdomen with splanchnic perfusion, and the brain with transcranial Doppler and cerebral US. The actual name was as a result changed to "extended Focused Assessment Sonography for Trauma" **[(5)]**.

Computed tomography (CT) has been considered the best and first radiological approach in terms of cases with polytrauma with higher accuracy. On the other hand, when the diagnosis is established and the patient is stable, a number of options become available regarding which diagnostic imaging tool to use to monitor the lesions or identify adverse events. These options depend on the anatomical structures involved, the severity of each injury, and the accessibility and level of expertise of each imaging modality **[(3)]**. In recent years, contrast-enhanced CT (CECT) has been considered the best approach in the context of renal injury assessment. Nowadays, it is easily available at the majority of trauma centers, offers images that are simple to evaluate, and could reveal all the findings that correlate with surgical observation. In addition, contrast administration offers data as regards renal



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vessels and renal function that is helpful in the evaluation of devascularization and pelvicalyceal system injuries [(2)].

To the best of our knowledge, proper management of a polytrauma patient is quite difficult, and the managing physician is occasionally faced with the difficult decision to make as regards of which injury to start with. Although rare, aortic/cerebral injury management could be challenging where there is a necessity to anticoagulated the patient but cerebral injury prevents the anticoagulation. From the historical point of view, such injuries were often accompanied by fair outcomes. On the other hand, emerging technologies, which include endovascular aortic stenting, and the fact that anticoagulation isn't contraindicated in head trauma, means several cases could survive with a good life quality [(6)].

Aim of work was to evaluate the incidence and degree of TKI in polytraumatic patients detected by US versus CT scan of the abdomen and effect of renal injuries on short term outcome.

## PATIENTS AND METHODS

This prospective study was conducted on polytrauma cases with TKI. Cases were collected from Mansoura Emergency Hospital from January 2022 to January 2024. The study included 65 patients (42 females and 24 males, age ranged from 18 to 63 years.

All polytrauma cases whose age was more than 18 of both sexes were comprised in the current study. Cases with history of chronic kidney disease (CKD) and hemodialysis, cases with renal malignancy, patients with missing data on presentation and cases with data unreliable with signs of life were excluded from the current study.

All patients were subjected to full history taking including mechanism of injury and time of the injury and ISS, clinical examination, which included Glasgow Coma Score (GCS) and vital signs, laboratory (CBC, random blood glucose, LFTS, KFTs, ABG and coagulation profile) and radiological investigations (Fast abdominal ultrasound by Sony Logiq device and CT abdomen with contrast by SOMATOM go. Top CT device, German).

**Ethical approval:**

**The study design was approved by Ethics Committee, Faculty of Medicine, Mansoura University. Approval of the mangers of the health care facilities in which the study was conducted was obtained. Informed verbal consent was obtained from all the studied participants. Confidentiality and privacy were respected. The Helsinki Declaration was followed throughout the study's conduct.**

**Statistical analysis:**

The collected data were statistically analysed using SPSS program software version 20.0 Descriptive statistics were done for numerical parametric data as mean±SD and minimum and maximum of the range and for numerical non-parametric data as median and 1st and 3rd interquartile range (IQR), on the other hand, they were done for categorical data as number and percentage. Qualitative data were assessed by using Monte Carlo test for independent groups. In terms of all the previously tests, P was considered significant when its values were less than 0.05.

## RESULTS

The maximum age distribution of cases was 18 - 30 years representing 52.3% of the cases and most of the participants were males (Table 1).

**Table (1):** Demographic data of the studied cases:

| | n=65 | % |
|---|---|---|
| **Age/years** | | |
| Mean±SD (min-max) | 31.26±14.06 (18-63) | |
| **Age groups (years)** | | |
| **18-30** | 34 | 52.3 |
| **31-50** | 25 | 38.5 |
| **>50** | 6 | 9.2 |
| **Sex** | | |
| **Male** | 41 | 63.1 |
| **Female** | 24 | 36.9 |

Regarding mode of trauma, 81.5% of our patients had blunt trauma. Out of the visceral organs involved, liver was the predominant organ to be involved (Table 2).

**Table (2):** Mode of trauma among studied cases:

| | | n | % |
|---|---|---|---|
| **Mode of trauma** | Penetrating | 12 | 18.5 |
| | Blunt | 53 | 81.5 |
| **Liver injury** | -ve | 55 | 84.6 |
| | +ve | 10 | 15.4 |
| **Spleen injury** | -ve | 64 | 98.5 |
| | +ve | 1 | 1.5 |
| **Pancreas injury** | 0 | 0 | 0 |
| **Intestine injury** | 0 | 0 | 0 |

Table (3) demonstrates that subcapsular hematoma or collection was the most common US finding in the studied cases.

**Table (3):** Ultrasound findings of the studied cases:

| US findings | n | % |
|---|---|---|
| **Distorted kidney shape** | 1 | 1.5 |
| **Hyperechoic or hypoechoic collection** | 12 | 18.5 |
| **Subcapsular hematoma or collection** | 34 | 52.3 |
| **Perinephric collection hematoma** | 21 | 32.3 |
| **Pelvic free fluid** | 19 | 29.2 |

Table (4) shows that 35.4% of the studied cases were grade 4.

**Table (4):** CT findings of the studied cases:

| CT findings (renal trauma grade) | n=65 | % |
|---|---|---|
| **Grade 1** | 8 | 12.3 |
| **Grade 2** | 7 | 10.8 |
| **Grade 3** | 15 | 23.1 |
| **Grade 4** | 23 | 35.4 |
| **Grade 5** | 12 | 18.5 |

Table (5) demonstrates no statistically significant difference between different grades of renal trauma detected by CT and presence of liver, spleen, pancreas and intestine injury.

**Table (5):** Relation between site of injury and CT findings:

| | CT findings | | | | | Test of significance |
|---|---|---|---|---|---|---|
| | **Grade 1 n=8(%)** | **Grade 2 n=7(%)** | **Grade 3 n=15(%)** | **Grade 4 n=23(%)** | **Grade 5 n=12(%)** | |
| **Liver injury** | 0 | 3(42.9) | 2(13.3) | 3(13.0) | 2(16.7) | MC=5.68 P=0.225 |
| **Spleen injury** | 0 | 0 | 0 | 1(4.3) | 0 | MC=1.86 P=0.762 |
| **Pancreas injury** | 0 | 0 | 0 | 0 | 0 | |
| **Intestine injury** | 0 | 0 | 0 | 0 | 0 | |

MC: Monte Carlo test.

Table (6) displays that there was no statistically significant relationship between grades of renal trauma by CT and need of ICU admission, needing blood transfusion, sepsis, and ICU stay duration.

**Table (6):** Relation between complications and CT findings:

| | CT findings | | | | | Test of significance |
|---|---|---|---|---|---|---|
| | Grade 1 n=8 (%) | Grade 2 n=7(%) | Grade 3 n=15(%) | Grade 4 n=23(%) | Grade 5 n=12(%) | |
| **Need of ICU admission** | 0 | 0 | 3(20.0) | 4(17.4) | 2(16.7) | MC=3.21 P=0.523 |
| **Blood transfusion** | 0 | 0 | 5(33.3) | 10(43.5) | 4(33.3) | MC=8.67 P=0.07 |
| **Sepsis** | 0 | 0 | 1(6.7) | 4(17.4) | 2(16.7) | MC=3.55 P=0.469 |
| **ICU stay duration (days) median (min-max)** | not applicable | not applicable | 3(3-4) | 4(4-5) | 5(4-5) | KW=4.17 P=0.125 |

MC: Monte Carlo test, KW: Kruskal Wallis test.

Table (7) Demonstrates statistically significant relation between grades of renal trauma by CT and platelet count with the highest value among grade 5. Also, statistically significant relation was detected between grades of renal trauma by CT with ALT and AST.

**Table (7):** Relationship between CT findings, mode of trauma, laboratory findings and ultrasound findings.

| | CT findings | | | | | test of significance |
|---|---|---|---|---|---|---|
| | Grade 1<br>n=8 | Grade 2<br>n=7 | Grade 3<br>n=15 | Grade 4<br>n=23 | Grade 5<br>n=12 | |
| **Mode of trauma**<br>**Penetrating**<br>**Blunt** | 3(37.5)<br>5(62.5) | 0<br>7(100) | 5(33.3)<br>10(66.7) | 1(4.3)<br>22(95.7) | 3(25)<br>9(75) | MC=9.09<br>P=0.059 |
| **Laboratory findings** | | | | | | |
| **Hb(gm/dl)** | 11.06±0.86 | 11.0±0.58 | 9.93±2.20 | 9.43±2.31 | 10.17±2.43 | F=1.25<br>P=0.299 |
| **WBCS** | 9.25±0.71 | 9.0±1.15 | 10.13±1.55 | 9.91±2.67 | 10.73±2.31 | F=1.03<br>P=0.398 |
| **Platelet** | 171.38±35.86 | 191.86±7.74 | 177.53±30.37 | 170.43±21.23 | 216.17±53.42 | F=2.77<br>P=0.01* |
| **ALT(mg/dl)** | 21(19-25) | 30(20-300) | 30(19-234) | 32(19-340) | 22.5(18-256) | KW=10.9<br>p=0.02* |
| **AST(mg/dl)** | 22(20-26) | 27(21-250) | 36(21-240) | 30(15-267) | 36(20-261) | KW=12.0<br>P=0.017* |
| **Bilirubin(mg/dl)** | 0.6(0.6-0.9) | 0.8(0.5-2.6) | 0.6(0.3-2.5) | 0.5(0.3-2.6) | 0.6(0.3-2.5) | KW=8.67<br>P=0.07 |
| **Urea** | 21(17-24) | 22(16-23) | 20(15-23) | 20(13-24) | 20(13-23) | KW=5.09<br>P=0.277 |
| **Creatinine(mg/dl)** | 0.8(0.6-0.9) | 0.8(0.5-0.9) | 0.90(0.40-1.3) | 0.70(0.4-1.3) | 0.65<br>(0.5-1.0) | KW=5.97<br>P=0.201 |
| **US findings** | | | | | | |
| **Distorted kidney shape** | 0 | 0 | 1(6.7) | 0 | 0 | MC=3.39<br>P=0.496 |
| **Hyperechoic or hypoechoic collection** | 0 | 0 | 4(26.7) | 5(21.7) | 3(25.0) | MC=4.57<br>P=0.334 |
| **Subcapsular hematoma or collection** | 6(75) | 4(57.1) | 5(33.3) | 13(56.5) | 6(50.0) | MC=4.07<br>P=0.396 |
| **Perinephric collection hematoma** | 2(25) | 3(42.9) | 5(33.3) | 6(26.1) | 5(41.7) | MC=1.44<br>P=0.836 |
| **Pelvic free fluid** | 3(37.5) | 4(57.1) | 4(26.7) | 5(21.7) | 3(25.0) | MC=3.68<br>P=0.452 |

Median and range: non-parametric test.
F: One way ANOVA test, KW: Kruskal Wallis test MC: Monte Carlo test, *: Significant

Table (8) demonstrates that US validity in detecting renal trauma as compared to CT findings was highest among cases with hyperechoic or hypoechoic collection followed by perinephric collection hematoma.

**Table (8):** Validity of US findings in detection of grade 5 kidney injury compared to CT findings:

| US findings | Sensitivity % | Specificity % | PPV% | NPV% | Accuracy% |
|---|---|---|---|---|---|
| **Hyperechoic or hypoechoic collection** | 25 | 83 | 25 | 83 | 72.3 |
| **Subcapsular hematoma or collection** | 50 | 52.8 | 19.4 | 82.4 | 52.3 |
| **Perinephric collection hematoma** | 41.7 | 69.8 | 23.8 | 84.1 | 64.6 |
| **Pelvic free fluid** | 25 | 69.8 | 15.8 | 80.4 | 61.5 |

PPV: positive predictive value, NPV: Negative predictive value.

## CASE PRESENTATION

**CASE 1**

Female patient 49-year-old, with no past medical history, presented to the ER with severe direct abdominal trauma. On physical examination patient was vitally stable, with tenderness over left loin region. US showed mild pelvic free fluid. Axial CECT venous phase showed large perinephric collections 9.5 x 7.8 cm with extravasation of contrast at the level of renal pelvis into perinephric collection (black arrow) (Renal injury grade 4).

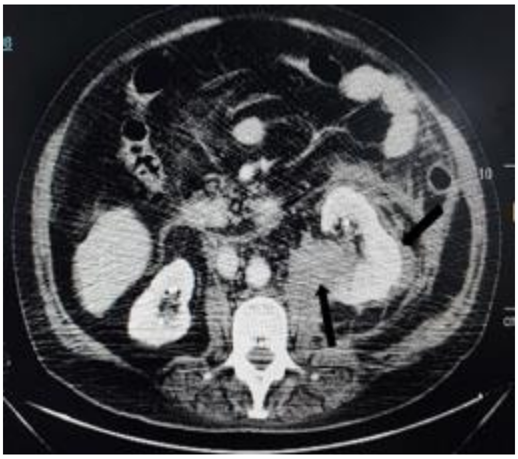

**Figure (1)**: Axial CECT venous phase shows large perinephric collections 9.5 x 7.8 cm with extravasation of contrast at the level of renal pelvis into perinephric collection (black arrow).

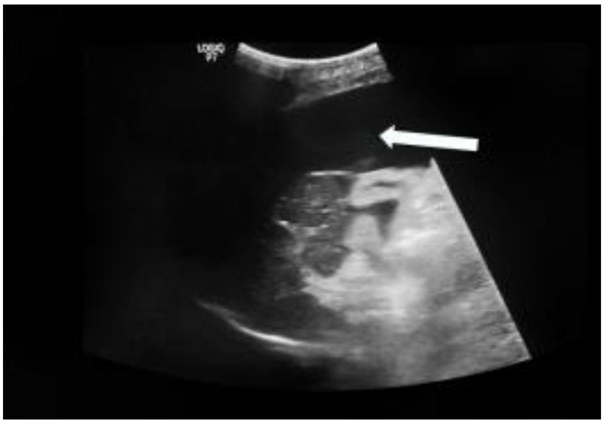

**Figure (2):** US shows mild pelvic free fluid (white arrow).

**CASE 2**

Male patient 35-year-old, with past medical history of HTN, presented to the ER with RTA and blunt trauma to the abdomen. On physical examination, patient was hypotensive, pale with cold extremities, tachycardia, tachypnea, BP 80/50, HR: 140, RR: 27, T 37. Hemoglobin value was seven g/dl. US showed loss of contour of the left kidney and pelvic free fluid. Axial CECT venous phase showed distorted shape of the left kidney with complete separation of the upper and lower part of the kidney and large perinephric hematoma grade (left renal injury grade 5).

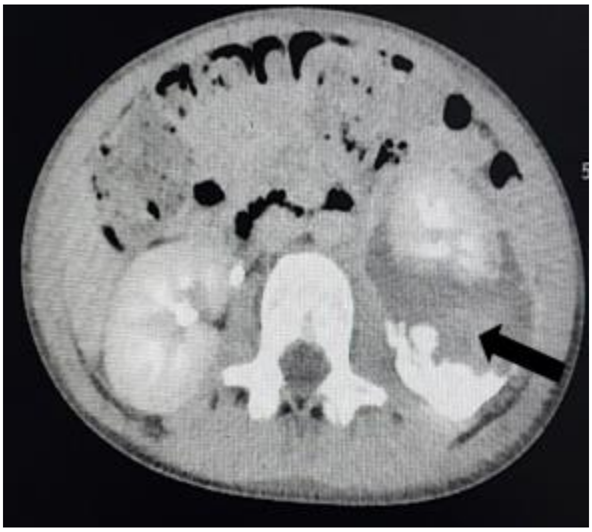

**Figure (3):** Axial CECT venous phase shows distorted shape of the lt kidney with complete separation of the upper and lower part of the kidney (black arrow) and large perinephric hematoma grade

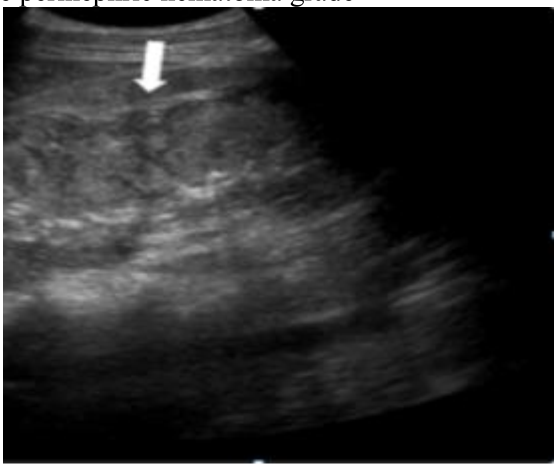

**Figure (4):** US shows loss of contour of the lt kidney (white arrow) and pelvic free fluid.

## DISCUSSION

Following polytrauma, serial abdominal examinations are often not possible as patients may have an altered level of consciousness. Additional difficulties arise when the patient has an injury to their spinal cord or nearby structures such as the lumbar spine or lower rib cage. All such factors have led to a more substantial utilization of diagnostic radiology for trauma cases with suspected abdominal traumas [7]. Imaging studies, such as FAST, allow a general abdominal preview and helps to rule out potentially fatal injuries but it is limited by its ability to access the retroperitoneum. Moreover, the FAST doesn’t permit for renal trauma classification and could miss some injuries. CT has improved considerably and permits the capability of detailed identification of vascular, parenchymal, and collecting systems. Actually, it has been demonstrated that; CT is a gold radiological approach in the context of renal injury diagnosis, especially when the patient is hemodynamically stable [8].

This study was a prospective study which included 65 polytrauma patients with traumatic kidney injury in the Emergency Department, Mansoura University Hospitals. The current study revealed that, the maximum age distribution of patients was 18 - 30 years representing 52.3% of the cases. Likewise, **Bhatia *et al.*** [9] have demonstrated that the peak age incidence of most of the cases ranged between 21 and 30 years. In addition, **Ochieng**[10] **and Kumar *et al.*** [11] were in accordance with this result. This could be explained by the fact that this age is often associated with daily activity, making them more susceptible to injuries.

Our study reported that, most of the subjects were males at 63.1% and 36.9% were females with a male: female ratio of 1.7: l. This was in accordance to different studies in which **Kumar *et al.*** [12] had 81% of male patients with blunt trauma injury and 19% of females cases. In contrast, **Chudasama and Darji** [13] recorded a higher percentage of male patients in their study. 79.5% were males in comparison with females (20.5%). This difference may be attributed to the geographic areas, as women are more houses bounded in some countries and relatively less comprised in risky activities might be the possible clarification.

Regarding mode of trauma, 81.5% of our patients had blunt trauma, while 18.5% had penetrating trauma. This comes in agreement with the previous study done by **Kumar *et al.*** [12], who demonstrated that most of the cases (66%) had blunt trauma, with the commonest mode of the accidents being motor car accidents. Also, **Lateef *et al.*** [14] recorded that all the cases had blunt trauma, with motor car accidents being the most frequent reason of trauma (58.9%) followed by falling (32.1%). This may be clarified by drivers' carelessness and recklessness, improper vehicle maintenance, frequent driving while intoxicated, and disrespect of traffic rules.

Out of the visceral organs involved, liver was the predominant organ to be involved accounting for 15.4% followed by spleen 1.5. However, none of the patients had either pancreatic or intestinal injuries. So, pancreas among the visceral organs is the least organ to be involved. This was in agreement with **Richardson *et al.*** [15], who encountered pancreatic injury in only 1% of the cases.

Our study also however, does not correlate with the findings of **Kumar *et al*.** [11] who accounted 26% of splenic injuries among visceral organs in their study. Splenic and hepatic injuries are most frequently recorded after blunt abdominal traumas, as they are superficial and more fragile organs. The other cause accompanied by fragility is that more inflammatory and infective situations are accompanied by the splenic and hepatic tissues. For instance, spleen in malarial endemic regions is more liable for trauma, even with trivial force[12]. Regarding our findings using US, 2% of the studied cases have distorted kidney shape, 18.5% hyperechoic or hypoechoic collection, 52.3% subcapsular hematoma or collection, 32.3% perinephric collection hematoma and 29.2% pelvic free fluid. Similarly, **McGahan *et al.*** [16] conducted their study on cases with renal injuries; they detected eleven subcapsular hematomas on CEUS compared to four on non-CEUS. Therefore, they reported that CEUS is superior to non-CEUS in the context of solid organ injury determination.

Our study results stated that US validity in detecting renal trauma as compared to CT findings was highest among cases with hyperechoic or hypoechoic collection followed by perinephric collection hematoma, pelvic free fluid and subcapsular hematoma or collection with the following accuracy (72.3 %, 64.6%, 61.5% and 52.3% respectively). **Chudasama and Darji** [13] found that the accuracy of USG for site of intraparenchymal hematoma and perinephric collection was 100% while it was 83.33% for site of renal lacerations. On the other hand, CT showed 100% accuracy in site of renal lacerations, intraparenchymal hematoma and perinephric collection. Similarly, **Boutros *et al.*** [17] study reported a sensitivity of 93%, and specificity of 99%. Moreover, **Patel *et al.*** [18] study reported a sensitivity of 98%, and specificity of 100% in detecting renal injuries. On the other hand, **Lateef *et al.*** [14] reported that 49 out of 56 included cases of kidney trauma were detected with USG and 7 cases were missed out, six of which were detected by CT scan. Lower sensitivity of FAST in this study could be owing to intestinal gas, subcutaneous emphysema, and obesity that represent frequent drawbacks to full US. The amount of free fluid essential to permit determination with FAST also represents a limitation of FAST.

The mortality rate among our patients was 13.8%. This is comparable to the outcomes recorded by **Mayet *et al.*** [19] where four patients died owing to their intra-abdominal injuries and 16 died owing to injuries to other body regions with a total percentage of 22.9% (20/284). This low mortality rate might be owing to the new applied modalities in the management of poly-trauma patients.

Although US and CT have substituted the majority of the older diagnostic approaches for the determination of renal injuries with a high specificity and sensitivity, apart from several benefits, both of such approaches have their disadvantages. Different researches propose false negative results are rare with US (1%). US cannot determine certain conditions such as diaphragmatic rupture. CT on the other hand, requires experienced personnel and isn’t an adequate diagnostic approach in hemodynamically unstable cases. In addition, radiation hazardous and contrast related issues can delay or limit CT assessment in certain cases.

## CONCLUSION

Our results demonstrated that both ultrasound and CT are effective tools for detecting traumatic kidney injuries, with CT exhibiting a higher sensitivity and specificity. This underscores the importance of early and accurate diagnosis to guide appropriate interventions and improve patient outcomes. Moreover, the degree of traumatic kidney injury varied significantly among the study population, highlighting the heterogeneity of polytrauma patients and the need for individualized treatment approaches. Additionally, the study reinforced the necessity for multidisciplinary collaboration among radiologists, trauma surgeons, and urologists to ensure optimal patient care.

## RECOMMENDATIONS

We recommend incorporating ultrasound into standard trauma protocols as an initial screening tool for detecting kidney injuries in polytrauma patients.

**Conflicts of interest:** None.
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