Original Article

Blunt renal trauma in pediatric population

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Abstract

Aims: This study aims to evaluate the magnitude and impact of renal trauma among pediatric population and to assess the effectiveness of conservative versus operative management.

Subjects and Methods: All pediatric patients (age <18 years) with blunt renal trauma, who presented to King Khalid National Guard Hospital in Jeddah between January 2000 and December 2012, were retrospectively reviewed. Medical records were reviewed for demographics, mechanism of injury, length of hospital stay, grade of renal trauma, hematuria, renovascular injuries, associated nonrenal injuries, conservative versus operative management, renal outcomes, and complications.

Results: Fifteen children with a blunt renal injury were identified, of which 14 met data inclusion criteria. The renal injury population had a mean age of 12.7 years (standard deviation 4.6) and was 85.7% male. The renal injuries were distributed as follows: Grade 1, $n = 3$ (21.4%); Grade 2, $n = 3$ (21.4%); Grade 3, $n = 3$ (21.4%); Grade 4, $n = 3$ (21.4%); and Grade 5, $n = 2$ (14.2%). Macroscopic hematuria was present in 64.3% of children. The median hospital length of stay was 13 days. Eleven children (78.5%) had traumatic injuries in multiple organs. Overall, 10 children (71.4%) were managed conservatively. Four children (28.5%) with high-grade trauma required operative intervention. Renovascular injuries were found in 4 cases (80%) of high-grade renal injuries.

Conclusions: Conservative management of kidney injuries was highly successful in children with low-grade renal trauma. Furthermore, operative intervention in high-grade renal injuries proved to be successful and had good renal outcomes. Renal preservation was achieved in 92.8% of cases.

Keywords: Blunt trauma, children, management, renal trauma

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INTRODUCTION

Major trauma is believed to be the 6th leading cause of mortality worldwide.[1] Trauma to the genitourinary tract accounts for 10% of all traumas.[2] Furthermore, the kidney is the most common site representing more than half of all urinary injuries.[3] Renal trauma is divided into blunt and penetrating with blunt trauma accounting for 90% of renal injuries.[4] Today, trauma results in more childhood deaths than all other causes combined.[5] Following trauma to the nervous system, renal trauma is the second most common in pediatric injuries.[6]

Over the years, management of pediatric trauma has shifted to conservative care rather than explorative surgery. This is primarily due to clinical, laboratory, and radiographic

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strategies enabling accurate injury assessment.[7] Ultrasound is an excellent method for rapidly detecting renal injuries which makes it the first choice of imaging in trauma cases.[8] All hemodynamically stable low-grade renal trauma (Grade I–III) injuries are managed conservatively.[9] Surgical intervention is warranted in hemodynamically unstable high-grade (Grade IV and V) traumas. Furthermore, there is little data to support long-term outcomes of one approach over the other.

In this retrospective study, we attempted to look at different aspects of pediatric renal trauma to compare our results to the literature and to provide descriptive statistics about 14 cases of pediatric renal trauma.

SUBJECTS AND METHODS

The trauma registry at King Khalid National Guard Hospital in Jeddah was retrospectively reviewed to identify all children (age <18 years) who presented with blunt renal trauma. The period reviewed was from January 2000 to December 2012. Following the approval of the research committee at our institution (Institutional Review Board), fifteen children were identified; one case was excluded due to the lack of imaging in medical records. The remaining 14 children are who comprise this report.

Data reviewed in the medical records included demographics, mechanism of injury, time between injury and hospital admission, length of hospital stay, admission Glasgow Coma Scale score, grade of renal trauma according to The American Association for the Surgery of Trauma (AAST) grading scale,[10] hematuria, renovascular injuries, associated nonrenal injuries, need for blood transfusion, conservative versus operative management, renal outcomes, and complications.

Renal computed tomography (CT) grading was performed in all patients included in this report. We defined Grades 1–3 as low grade, and Grades 4–5 were defined as high-grade renal trauma injuries. CT imaging is the gold standard for correctly diagnosing and grading renal injuries.[11] In this report, we reviewed ultrasonography (US) as another method of detecting renal trauma. The aim was to evaluate the effectiveness of US as a rapid screening method for pediatric renal trauma. Radiology reports from patients who underwent renal US were compared with those of CT.

All cases were initially evaluated by the trauma team according to advanced trauma life support standards. Each patient underwent selective management based on clinical presentation, hemodynamic stability, type or mechanism of trauma, and associated nonrenal injuries. All cases were subjected to early abdominal CT. All hemodynamically stable cases underwent conservative renal management. Cases that demonstrated severe nonrenal injuries or hemodynamic instability with signs of shock (presenting with hypotension) warranted immediate explorative renal surgery.[12] However, when identifying instability, shock does not appear to be a clinically useful indicator, neither is hypotension moreover, diagnostic evaluation should not be reserved only for those in shock only.[13]

RESULTS

During the 12-year period, reviewed 14 children were identified with blunt renal trauma from the trauma registry. The renal injury population ranged from 5 to 18 years of age (mean 12.7 years standard deviation [SD, 4.6]). The population consisted of 12 males (85.7%) and 2 females (14.2%). The most common mechanism of injury was motorized vehicular accidents which accounted for 42.9% of injuries; this was followed by falls (28.6%), automobile-pedestrian accidents (21.4%), and sport (7.1%) [Table 1]. Most cases were directly transferred to this hospital (64.3%). The remainders of the cases were transferred from other hospitals after undergoing medical intervention (21.4%) and before undergoing medical intervention (14.3%). Table 1 shows patient characteristics in high- versus low-grade renal injuries.

The grades of renal injuries were distributed as follows: Grade 1, $n = 3$ (21.4%); Grade 2, $n = 3$ (21.4%); Grade 3, $n = 3$ (21.4%); Grade 4, $n = 3$ (21.4%); and Grade 5, $n = 2$ (14.2%). The mean Glasgow Coma Scale score on

Table 1: Patient characteristics in high- versus low-grade renal injuries

Characteristics	Low-grade injuries (I-III)	High-grade injuries (IV-V)
Sex (*n*)		
Male	7	5
Female	2	0
Age (years)		
Mean	8.6	14.9
Range	5-14	8-18
Hospital stay (days)		
Mean	48.8	18.6
Range	11-210	12-23
Mechanism of injury (%)		
MVA	66.6	0
Pedestrian	11.1	40
Fall	11.1	60
Sports	11.1	0
Hematuria (%)		
Gross	55	80
Persistent	22	20
Renal management (%)		
Conservative	100	20
Operative	0	80

MVA: Motorized vehicular accidents

admission for the study group was 12.6 (SD 4.3) with 6 patients (42.8%) suffering from loss of consciousness. Most children had traumatic injuries in multiple organs accounting for 11 (78.5%) cases. In 3 cases (21.4%), the kidney was the only organ injured. Associated head, lung, and skeletal injuries were present in 48.8%, 50%, and 78.5% of children, respectively [Table 2].

Hematuria results were available in 13 patients (92.85%), in whom 64.3% demonstrated macroscopic hematuria and 28.6% had no hematuria. The median time for hematuria resolution was 4 days (interquartile range [IQR] 0–21). There were 3 cases where hematuria persisted and did not resolve. A perirenal hematoma was found in 12 cases (85.7%); it differed in severity according to the grade of renal injury. The median time for hematoma resolution was 10.5 days (IQR 7–50). Renovascular injuries were found in 4 (80%) of high-grade renal injuries; three of which (75%) were partially devascularized and the other one (25%) was completely devascularized. Three of them were arterial, and one was venous. Other early renal trauma complications are shown in Figure 1.

The median hospital length of stay was 13 days. Three children (21.4%) required a blood transfusion consisting of a Grade 3, 4, and 5 renal injury. Over half of the children underwent surgical procedures to treat nonrenal injuries during the hospital stay. Overall 10 children (72.4%) were managed conservatively of which 9 (64.4%) were cystoscopy and double J stent insertions, and the other one was a repair of a transected kidney and J-Vac drain insertion. No nephrectomy was performed, and children overall had good renal function outcome, according to serum creatinine levels before discharge. Late complications were hard to determine as there was no follow-up blood tests or renal imaging. However, a 1-year follow-up blood pressure (BP) was recorded in 9 children with a mean systolic BP of 118.3 (SD 8.9) and a mean diastolic BP of 69.7 (SD 7.3). We defined hypertension as BP higher than 140/90 mmHg. Only two children had mildly high BP; one with 132/80 mmHg and the other with 129/64 mmHg. None had hypertension.

Table 2: Associated nonrenal injuries

Associated injuries	Grade I (*n*=3)	Grade II (*n*=3)	Grade III (*n*=3)	Grade IV (*n*=2)	Grade V (*n*=3)	Total, *n* (%)
Head	2	2	2	0	0	6 (42.8)
Lung	2	2	2	1	0	7 (50)
Skeletal fracture	3	3	2	1	2	11 (78.5)
Liver	2	0	1	1	1	5 (35.7)
Spleen	1	1	1	1	0	4 (28.5)
Isolated renal injury	0	0	1	2	0	3 (21.4)

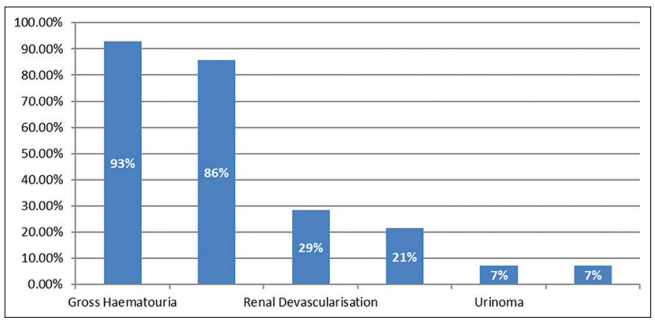

Figure 1: Early complications postrenal trauma in pediatric population in our case series

DISCUSSION

Blunt trauma to the genitourinary tract is popular to occur in children. The kidneys are the most frequent site of damage and represent 10%–20% of blunt abdominal trauma cases. Children are more susceptible to blunt renal trauma than adults. However, management of pediatric renal trauma remains a source of controversy.[3] Management of renal trauma in the pediatric population is based on examination, hemodynamic stability, grade of renal injuries, associated nonrenal injuries, and the presence or absence of hematuria.[11]

Classification of trauma is as follows: Grade I: contusion, microscopic, or gross hematuria with normal urological studies or subcapsular hematoma with no parenchymal laceration; Grade II: not expanding perirenal hematoma with laceration <1.0 cm parenchymal depth of renal cortex with no urinary extravasation; Grade III: laceration >1.0 cm parenchymal depth of renal cortex with no collecting system tear or urinary extravasation; Grade IV: parenchymal laceration extending through renal cortex, medulla, and collecting system vascular main renal artery or vein injury with contained hemorrhage; Grade V: completely shattered kidney vascular avulsion of renal hilum which devascularizes kidney.[14]

A study of 3,247,955 injuries from the National Trauma Data Bank is more representative of the distribution of renal injuries seen at all trauma center levels, though with some overrepresentation of level 1 trauma centers. The distribution of renal injuries in this was as follows: Grade 1 (28%), Grade 2 (30%), Grade 3 (20%), Grade 4 (15%), and Grade 5 (7%).[5]

One of the most critical steps in treating the patient is the proper diagnosis because this often sets the basis of either operative or conservative management to be done. Detecting significant renal injuries with blunt trauma

without hematuria must be carefully examined. A review of 180 children records with the same case proved that abdominal CT was correlated with urinalysis and clinical results. Significance between children and blunt trauma is improbable in the absence of substantial hematuria.[15]

Main renal artery embolization is primarily utilized in lieu of open nephrectomy in some series for blunt main renal artery avulsions and blunt AAST Grade 5 renal injuries. Sixty percent of cases proceeded to angioembolization. Twenty percent of these had adjunctive procedures necessary which included repeat angioembolization, nephrectomy, and perinephric drain placement.[5]

In Grade IV cases of blunt renal injuries, nonoperative management has higher success rate considering that at least partial renal preservation is possible in 95% of patients. Yielding the nonoperative management a safer choice in this case.[16] Transfusion requirements, operative rates, and outcome are consistent with other pediatric solid organ injuries, but clearance of gross hematuria correlated with severity of injury and was prolonged in Grade IV and V compared with Grade I–III injuries resulting to more children (93%) available for follow-up who were normotensive with normal renal function.[9] Most children with Grade IV renal injury can be treated conservatively. Patients with complete renal fracture or significant urinary extravasation on initial radiographic imaging may be less likely to undergo spontaneous resolution. While patients with a persistent urinary leak can be successfully treated with internal drainage. Grade V injuries are associated with an increased risk of requiring open operative intervention and low renal preservation rates.[17] A nonoperative management strategy was advantageous and successful in pediatric blunt renal injuries (94.7% successful nonoperative rate and 98.9% renal salvage rate). Adjunctive urologic procedures (e.g., ureteral stenting) were beneficial in selected cases.[8]

The four main objectives of radiographic imaging of renal trauma are to accurately stage the injury, recognize preexisting pathologies of the injured kidney, document the function of the opposite kidney, and identify associated injuries to other organs. In the past, intravenous urogram (IVU) and renal arteriography were used for staging renal trauma. CT is the cornerstone of the radiographic staging of hemodynamically stable renal trauma. Not all patients with renal injuries require a radiographic evaluation. The decision to image should be on the basis of history, mechanism of injury, physical findings, laboratory studies, and clinical status. Initial imaging must be altered to the stability of the patient and modified when immediate surgery is required due to the risk of bleeding and shock. Most children with microscopic hematuria do not require imaging. Because hypotension is a late manifestation of hypovolemia in pediatric age group, BP is not considered a reliable criterion for imaging. No prospective studies have determined the sensitivity and specificity of hematuria in the diagnosis of childhood renal injury. On the other hand, it appears that very few clinically significant renal injuries would be missed if, in children with blunt trauma, only those with >50 red blood cells/high-power field underwent imaging. The effect of missed injuries on the outcome is currently unknown although the chance of serious morbidity or mortality is likely to be very low.[5]

According to the demographics of the normal distribution of the renal injury grades, low grades account for the majority of trauma. In a study that looked at 336 cases of blunt pediatric renal trauma, 91.6% had Grade 1 renal injuries.[12] Our data lacked this normal distribution as there was almost equal incidence in all grade of renal injury. This might be because this is a national guard hospital and only accepts affiliated patients. This hospital also acts as a major tertiary referral center for specialized cases.

In our population, all cases that demonstrated low-grade renal injuries were hemodynamically stable and were managed conservatively. Nonoperative management has now become the standard of care for such cases.[18] Indications for conservative versus operative management in high-grade renal pediatric injuries remain a source of debate. There is a consensus that hemodynamic instability, penetrating injuries, and severe nonrenal injuries are indications for immediate explorative surgery. At the same time, management of hemodynamically stable high-grade renal injuries is still controversial as there is not enough data to support long-term outcomes of one approach over the other.[12,19]

High-grade renal injuries were sustained in five cases (35.7%) and only one case was managed conservatively, the remainder underwent renal surgery. The case that was managed conservatively was a Grade 5 renal injury with complete devascularization to the left kidney. The patient was transferred to this hospital from another medical center that was ill-equipped to handle this case. The patient transfer was after more than 24 h of the trauma to which point renal ischemia had taken effect and renal repair was not possible.

This is the only case that had a complete loss of function in a kidney; yet, the other four cases were managed operatively. One renal repair surgery was performed in a patient with a left-transected kidney with J-Vac drain insertion to drain

left pry-renal hematoma and urinary extravasation. The other renal procedure was a cystoscopy with double J stent insertion and retrograde pyelogram. This was done in three patients. The first was for severe renovascular injuries which consisted of multiple avulsions to the right kidney, severe retroperitoneal hematoma, and urinary extravasations. The second was for blood clots that blocked the pelvicalyceal system and resulted in hydronephrosis. The third was for pelvicalyceal system injury resulting in severe urinary extravasation. All three patients were followed up after 3 months for cystoscopy and double J stent removal.

All the cases reviewed in this report underwent renal CT for grading of renal injuries. It is the gold standard for diagnosing renal injury as it allows for the accurate evaluation of the renal vasculature, parenchyma, and collecting system.[8] We looked at US radiology reports to evaluate whether or not they can be used as rapid detection approach for renal trauma. Nine patients (64.2%) underwent US imaging initially as part of trauma evaluation. Renal injuries were detected in eight patients (88%). These results are supported by the literature, as a recent study illustrated that 91% (77out of 84) of renal injuries were correctly diagnosed by US imaging, and the undetected seven cases were Grade 1 injury.[20] These results demonstrate that US imaging is an excellent method for rapidly detecting renal injuries specifically high-grade renal injuries which makes the US imaging the first choice of imaging in trauma cases.[19]

Renal function was encouraging as the renal function was preserved in 13 (92.8%) of injuries which were consistent with other studies that demonstrated a 99% renal salvage rate.[19] All cases had a good renal function on discharge; this was determined through serum creatinine levels. After all, long-term renal function was difficult to assess as follow-up blood test, and imaging was needed too but not usually conducted. Provided that renal workup was done if patients displayed any signs or symptoms of renal disease, the medical records showed that there were none displayed by any patient.

Identifying long-term renal trauma complications needed a lengthy follow-up period. One of the known rare drawbacks for renal trauma is hypertension. We were able to record 1-year follow-up BP in nine children (64.2%) in our sample population. This was because BP measurement is a routine part of hospital checkup and only two demonstrated mildly high BP. Therefore, we cannot report the presence of hypertension as we defined it in our sample. Other long-term complications in our sample were 3 children presented with persistent hematuria caused by low-grade and high-grade injuries. Other complications were evident on patients who underwent follow-up imaging included: two children who developed renal scars, one had hydronephrosis, and one had renal cyst formation. After all, the literature lacks long-term follow-up data to determine long-term complication correlated with pediatric renal injuries; also, research needs to be done on long-term renal outcomes and complications between conservative versus operative management.

Since this is a retrospective study which carries its own limitation with the design, this opens the opportunity for future prospective studies. Data were acquired from patient's medical records that were managed by a wide range of hospital staff over an extended period. Moreover, this study was conducted in a referral center and not a major trauma center; so, the numbers of cases were limited and cases were usually more severe than the general demographic. In addition, renal follow-up radiology and blood tests are not regularly done; thus, follow-up renal function cannot be determined. Finally, long-term complications need additional follow-up research.

CONCLUSIONS

In conclusion, this study was able to replicate results of other studies with a bigger sample population. We were able to demonstrate that CT is the gold standard for the accurate diagnosis and staging of renal trauma. Yet, For the initial evaluation of a trauma US is the best imaging modality. At the same time, conservative management of kidney injuries was highly successful in children with low-grade renal trauma despite multiple traumatic injuries. Furthermore, operative intervention in high-grade renal injuries proved to be successful with the preservation of all the kidneys that were operated on. Regardless of the management style, the standard of care is renal preservation, which in our experience has been achieved in 92.8% of cases.

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Conflicts of interest
There are no conflicts of interest.

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