Characteristics and Management of Blunt Renal Injury in Children

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Abstract

Background: Renal trauma in the pediatric population is predominately due to blunt mechanism of injury. Our purpose was to determine the associated injuries, features, incidence, management, and outcomes of kidney injuries resulting from blunt trauma in the pediatric population in a single level I trauma center. Methods: This was a retrospective chart and trauma registry review of all pediatric blunt renal injuries at a regional level I trauma center that provides care to injured adults and children. The inclusion dates were January 2001–June 2014. Results: Of 5790 pediatric blunt trauma admissions, 68 children sustained renal trauma (incidence: 1.2%). Only two had nephrectomies (2.9%). Five renal angiograms were performed, only one required angioembolization. Macroscopic hematuria rate was significantly higher in the high-grade injury group (47% vs. 16%; P = 0.031). Over half of the patients had other intra-abdominal injuries. The liver and spleen were the most frequently injured abdominal organs. Conclusion: Blunt renal trauma is uncommon in children and is typically of low American Association for the Surgery of Trauma injury grade. It is commonly associated with other intra-abdominal injuries, especially the liver and the spleen. The nephrectomy rate in pediatric trauma is lower compared to adult trauma. Most pediatric blunt renal injury can be managed conservatively by adult trauma surgeons.

Keywords: Hematuria, nephrectomy, renal trauma

Introduction

Renal trauma in the pediatric population is predominately due to the blunt mechanism of injury, and children are more likely to sustain renal injury than adults following blunt abdominal trauma.[1-3] In children, the kidneys are low in the abdomen, less well protected by the lower ribs, more mobile, have less protective perirenal fat, and are proportionately larger in the abdomen.[2-3] The kidney is the most commonly injured genitourinary organ in blunt trauma followed by the bladder in both adult and pediatric populations.[4-6] As in adults, pediatric blunt renal trauma has trended to nonoperative management.[7-8] The literature lacks definitive data on the management and outcomes of pediatric blunt renal trauma patients. The controversy still exists about the role of conservative management in high-grade injuries.[9-11] The current guidelines for management of pediatric renal trauma are based on these limited data. There is need for additional studies to support the establishment of evidence-based recommendations. Our purpose was to determine the associated injuries, features, incidence, management, and outcomes of kidney injuries resulting from blunt trauma in the pediatric population in a single level I trauma center.

Methods

A retrospective chart and trauma registry review of pediatric (<18-year-old) blunt renal trauma admissions from January 1, 2001, to June 30, 2014, was performed. Approval for the study was granted by the Texas Tech University Health Sciences Center Institutional Review Board. University Medical Center of El Paso, the American College of Surgeons verified trauma center that provides care to injured adults and children of all ages is the only level I trauma center within a 270-mile radius and serves 1.2 million individuals. All patients were managed by adult trauma surgeons.

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The demographics, mean Injury Severity Score (ISS), mean length of stay (LOS), the American Association for the Surgery of Trauma (AAST) injury grade, management, associated injuries, and the kidney injury side were evaluated. The AAST renal injury grade was determined by chart review, as well as review of computed tomography (CT) reports and operative notes.[12] Renal injury grades were divided into low- (I–III) and high-grade (IV–V), respectively for comparative purposes.

Gross hematuria was determined by documentation of the visible appearance of the urine. Microscopic hematuria was defined as four or more red blood cells per high-power field (RBCs/HPF) as reported by our clinical laboratory.

Continuous data were compared between these two groups using unpaired t-test/Wilcoxon rank sum test. Categorical variables were compared using Fisher’s exact test. P ≤ 0.05 was considered as a significant result. Statistical analysis was conducted using SAS 9.3 (SAS Institute Inc.).

**RESULTS**

Of 5790 pediatric blunt trauma admissions over 13.5 years, 68 children sustained blunt renal injury (incidence: 1.2%). Their mean age was 12.4 years (range: 9 months–17 years), and 66% were male. The mean hospital LOS was 9 ± 9.5 days and the mean Intensive Care Unit (ICU) LOS was 6.9 ± 7.8 days. The mean ISS was 21 ± 14. Mortality rate was 5.8%. No deaths were caused by renal injury. The most common mechanism of injury was motor vehicle collision (46%) followed by all-terrain vehicle collision (12%), fall (12%), struck/sports (12%), pedestrian versus motor vehicle (10%), and motorcycle collision (7%).

Fifty-one patients (75%) had low-grade injury, and seventeen patients (25%) had high-grade injury [Table 1]. The laparotomy rates were higher in high-grade injury (53% vs. 17%; P = 0.0091). No nephorrhaphy was performed. Only two patients (2.9%) required a nephrectomy. Both patients had a high-grade injury (I–IV and I–V). Neither of the two nephrectomies was performed emergently.

The first patient was an 11-year-old male who was in a dirt bike collision. Initial CT scan showed an isolated Grade IV kidney laceration extending through the cortex, medulla, and calyces with a retroperitoneal hematoma. Due to a severely tender abdomen, an emergent laparotomy was performed with a finding of a stable perirenal hematoma. The decision was made not to perform a nephrectomy. On the 3rd hospital day, the patient had a distended abdomen, and repeat CT scan showed active contrast extravasation from the renal collecting system with free fluid. The cystoscopy, retrograde pyelogram, and double J-stent placement were performed by an urologist without success. The patient was taken for laparotomy to perform the nephorrhaphy. However, the kidney appeared to be devascularized and unsalvageable, so nephrectomy was performed.

The other patient was a 7-year-old female who was kicked by a horse. The patient was hemodynamically stable. However, she had an exquisitely tender abdomen, and CT scan showed the shattered left kidney. The patient had an emergent laparotomy. An isolated nonexpanding perinephric hematoma was found but not explored at that time. On the 6th hospital day, she had abdominal distension with a declining hemoglobin necessitating transfusion. The repeat CT scan revealed an enlarged left perinephric hematoma with active contrast extravasation from the renal pelvicalyceal system. It was uncertain if the extravasation was urinary or hemorrhagic. She was taken for a relaparotomy and received a nephrectomy due to a shattered, necrotic kidney.

Five patients had renal arterial angiography and only one required embolization [Table 1]. Renal angiography was performed concomitantly in two patients (13- and 15-year-old) when angiography for other organ injury was performed. A 9-year-old patient with a Grade IV renal laceration with active contrast extravasation on CT scan underwent angiography and angioembolization on the day of admission. A 14-year-old patient with a Grade I renal laceration had an adrenal hematoma with active contrast extravasation, and angiography was performed. Embolization was not performed since no renal arterial bleeding was found. Renal angiography for the 10-year-old patient with a Grade V kidney injury showed complete occlusion of the renal artery due to traumatic dissection. No intervention was necessary. The patient was discharged home without complications.

| Table 1: Treatment characteristics according to the American Association for the Surgery of Trauma injury grade |
|---------------------------------------------------------------|
| **Treatment** | **AAST injury grade** | **I (n=20), n (%)** | **II (n=13), n (%)** | **III (n=18), n (%)** | **IV (n=13), n (%)** | **V (n=4), n (%)** |
| Laparotomy | | 5 (25) | 3 (23) | 1 (6) | 7 (54) | 2 (50) |
| Nephrectomy | | 0 | 0 | 0 | 1 (7.7) | 1 (25) |
| Renal artery angiogram | | 1 (5) | 0 | 1 (5.6) | 2 (15) | 1 (25) |
| Renal angioembolization | | 0 | 0 | 0 | 1 (7.7) | 0 |
| Gross hematuria | | 3 (18) | 2 (18) | 2 (13) | 5 (45) | 2 (67) |
| Microscopic hematuria | | 12 (71) | 9 (82) | 13 (81) | 10 (83) | 2 (67) |
| Associated abdominal injury | | 13 (65) | 6 (46) | 9 (50) | 8 (62) | 1 (25) |
| Mortality | | 2 (10) | 1 (8) | 1 (6) | 0 | 0 |

ASST: American Association for the Surgery of Trauma
Fifty-nine patients (87%) had a urinalysis. Most had microscopic hematuria in both low- and high-grade AAST injury groups (77% vs. 80%; P = 1.00). On the contrary, gross hematuria was significantly more frequent in the high-grade injury group (16% vs. 47%; P = 0.031) [Table 2].

Four patients had bilateral kidney injuries. Comparing the kidney injury side, frequency of the right and the left are similar in the low-grade injury group (right: 51% vs. left: 43% vs. bilateral: 5.9%). However, in the high-grade injury group, the majority occurred on the left side (right: 12% vs. left: 82% vs. bilateral: 5.9%). When the distribution was compared between these two injury-grade groups, a significant difference was found (P = 0.0086) [Table 2].

The mean ISS, the mean length of hospital stay, and the mean length of ICU stay were all higher in the pediatric blunt renal trauma group. This is in contrast to the overall pediatric blunt trauma patients and also pediatric patients with blunt intra-abdominal injuries without renal injury [Table 3].

Fifty-four percent of the patients had associated intra-abdominal injuries [Figure 1]. The most frequently injured intra-abdominal organ was the liver (32%) followed by spleen (28%), adrenal gland (10%), intestine (6%), and pancreas (6%) [Figure 2]. No bladder, urethral, or ureteral injury was found in the 68 pediatric blunt renal trauma patients.

**DISCUSSION**

The majority of children with blunt renal trauma can be managed conservatively even with high-grade injuries.[13-18] Our study confirmed the previous findings of low pediatric nephrectomy rates (0%-3.2%). [7,17,19,20]

The 2.9% nephrectomy rate in our study was also lower than the nephrectomy rate of 5.9%-6.9% reported in the adult population.[21-23]

Our findings suggest that one should not make a decision of nephrectomy solely on CT finding of high-grade kidney injuries in pediatric population. Hemodynamic status, not injury grade, should determine need for operative intervention. Hemodynamic instability or life-threatening renal bleeding should be treated with immediate surgical intervention without delay.

We had two delayed nephrectomies (>72 h) but no emergent nephrectomies. Henderson et al. reported two emergent nephrectomies (1.6%) and two delayed nephrectomies (1.6%) in their study. They recommended a delayed (>72 h) operative approach for major urinary leak that requires operative intervention if the patient is hemodynamically stable. The rationale was that this allows time for bleeding to stop and makes it easier to intervene with reduced intraoperative and postoperative morbidity.[7,18,24] There have been successful reports of percutaneous drainage of urinoma and cystoscopic ureteral stent placement as well. Russell et al. recommends percutaneous drainage first and cystoscopic ureteral stent placement for persistent urinary leak.[25,26]

We perform CT scan in hemodynamically stable children when we suspect intra-abdominal organ injury for blunt trauma. If hemodynamically stable, we believe close observation with nonoperative management for even high-grade injury in the critical care unit is safe. If arterial extravasation is suspected on CT scan, angiography should be considered to assess for possible angioembolization depending on the hemodynamic status of the patient. Graziano et al. reported a renal arterial angioembolization rate of 1.4% and that an angioembolization is rarely performed for pediatric blunt renal trauma.[19] This was similar to our embolization rate of 1.5%.

Our study indicated that most pediatric blunt renal trauma patients had microscopic hematuria and that high-grade injuries had an increased rate of gross hematuria. Therefore, we should have high suspicion of significant kidney injury when a patient presents with gross hematuria. Morey et al. stated that significant pediatric kidney injury was unlikely in the absence of gross or significant microscopic hematuria (>50 RBCs/HPF) and that imaging studies might not be required.[27] However, Nguyen and Das showed that patients with only microscopic hematuria or normal urinalysis can also have high-grade kidney injury.[3] Our study was consistent with this latter finding. Even with Grade V injury, one patient had a normal urinalysis likely due to complete occlusion of the renal artery from traumatic dissection. Among patients with Grade IV injury, 17% had...
normal urinalysis. These suggest that hematuria by itself should not be criteria for an imaging study for pediatric blunt renal trauma. Renal imaging should be performed if renal trauma is suspected regardless of urinalysis result.

We compared hospital LOS between low- and high-grade injury groups, and no significant difference was found (7.3 ± 6.7 vs. 12.9 ± 13.9 days; P = 0.169). This is consistent with the previous studies that showed the length of hospital stay did

### Table 2: Comparison of variables according to categorized American Association for the Surgery of Trauma injury grade

| Variables                      | Entire cohort | Low-grade (I-III) | High-grade (IV-V) | P  |
|--------------------------------|--------------|------------------|-------------------|----|
| Age (year), mean ± SD          | 12.4 ± 4.7   | 12.8 ± 4.7       | 11.2 ± 4.7        | 0.217 |
| LOS (day), mean ± SD           | 8.88 ± 9.5   | 7.28 ± 6.7       | 12.9 ± 13.9       | 0.169* |
| ICU LOS (day), mean ± SD       | 6.88 ± 7.8   | 6.4 ± 7.6        | 7.8 ± 8.4         | 0.631* |
| ISS, mean ± SD                 | 21.2 ± 13.8  | 19.7 ± 14.10     | 25.6 ± 12.2       | 0.077* |
| Ventilation days (day), mean ± SD| 6.8 ± 7.1   | 5.8 ± 7.9        | 8.8 ± 5.2         | 0.087* |
| Gender, n (%)                  |              |                  |                   |     |
| Male                           | 45 (66.18)   | 37 (72.55)       | 8 (47.06)         | 0.077 |
| Female                         | 23 (33.82)   | 14 (27.45)       | 9 (52.94)         |     |
| Race, n (%)                    |              |                  |                   |     |
| Hispanic                       | 54 (79.41)   | 41 (80.39)       | 13 (76.47)        | 0.714 |
| White                          | 12 (17.65)   | 8 (15.69)        | 4 (23.53)         |     |
| Black                          | 1 (1.47)     | 1 (1.96)         | 0                 |     |
| Other                          | 1 (1.47)     | 1 (1.96)         | 0                 |     |
| Abdominal CT, n (%)            |              |                  |                   |     |
| Yes                            | 66 (97.06)   | 49 (96.08)       | 17 (100)          | 1.000 |
| No                             | 2 (2.94)     | 2 (3.92)         | 0                 |     |
| Gross hematuria, n (%)         |              |                  |                   |     |
| Positive                       | 14 (23.73)   | 7 (15.91)        | 7 (46.67)         | 0.031 |
| Negative                       | 45 (76.27)   | 37 (84.09)       | 8 (53.33)         |     |
| N/A                            | 9            | 7                | 2                 |     |
| Microscopic hematuria, n (%)   |              |                  |                   |     |
| Positive                       | 46 (77.97)   | 34 (77.27)       | 12 (80.00)        | 1.000 |
| Negative                       | 13 (22.03)   | 10 (22.73)       | 3 (20.00)         |     |
| N/A                            | 9            | 7                | 2                 |     |
| Left/right kidney injury, n (%)|              |                  |                   |     |
| Right                          | 28 (41.18)   | 26 (50.98)       | 2 (11.76)         | 0.009 |
| Left                           | 36 (52.94)   | 22 (43.14)       | 14 (82.35)        |     |
| Bilateral                      | 4 (5.88)     | 3 (5.88)         | 1 (5.88)          |     |
| Laparotomy, n (%)              |              |                  |                   |     |
| Yes                            | 18 (26.47)   | 9 (17.65)        | 9 (52.94)         | 0.009 |
| No                             | 50 (73.53)   | 42 (82.35)       | 8 (47.06)         |     |
| Nephrectomy, n (%)             |              |                  |                   |     |
| Yes                            | 2 (2.94)     | 0                | 2 (11.76)         | 0.060 |
| No                             | 66 (97.06)   | 51 (100)         | 15 (88.24)        |     |
| Mechanism of injury, n (%)     |              |                  |                   |     |
| MVC                            | 31 (45.59)   | 27 (52.94)       | 4 (23.53)         | 0.161 |
| MCC                            | 5 (7.35)     | 4 (7.84)         | 1 (5.88)          |     |
| Pediatric versus vehicle       | 7 (10.29)    | 5 (9.8)          | 2 (11.76)         |     |
| Struck/sport                   | 8 (11.76)    | 6 (11.76)        | 2 (11.76)         |     |
| Fall                           | 8 (11.76)    | 4 (7.84)         | 4 (23.53)         |     |
| ATV                            | 8 (11.76)    | 4 (7.84)         | 4 (23.53)         |     |
| Other                          | 1 (1.47)     | 1 (1.96)         | 0                 |     |
| Mortality, n (%)               |              |                  |                   |     |
| Alive                          | 64 (94.12)   | 47 (92.16)       | 17 (100)          | 0.565 |
| Dead                           | 4 (5.88)     | 4 (7.84)         | 0                 |     |
| Renal angiography, n (%)       |              |                  |                   |     |
| Yes                            | 5 (7.35)     | 2 (3.92)         | 3 (17.65)         | 0.095 |
| No                             | 63 (92.65)   | 49 (96.08)       | 14 (82.35)        |     |

*P*-value was calculated using Wilcoxon rank sum test. CT: Computed tomography, N/A: Not available, MVC: Motor vehicle crash, MCC: Motorcycle crash, ATV: All-terrain vehicle, LOS: Length of stay, ISS: Injury severity score, ICU: Intensive Care Unit, SD: Standard deviation
not increase with worsening severity of renal injury and instead, was determined by the severity of the nonrenal associated injuries.[18,24] Similarly, the ICU stay in our study did not differ significantly between low- and high-grade injury groups (6.4 ± 7.6 vs. 7.8 ± 8.4; \( P = 0.631 \)). This suggests that renal trauma itself has a good prognosis and other associated injuries are the factors that prolong the hospital stay.

There is a paucity of data in regard to laterality of renal injury, but prior studies have not compared low- and high-grade injury groups.[19] It was interesting to find that most of our high-grade injuries occurred on the left side. We do not have a definite explanation but it might be due to the protective effect of the liver. Typically, the right kidney is positioned just below the diaphragm, posterior to the liver, and slightly more to the midline than the left kidney. The right kidney is also slightly smaller than the left.[28]

In this study, the most frequently injured intra-abdominal organ was the liver followed by the spleen. Most studies report a similar result as the liver and the spleen are the most frequently associated injuries.[7,18,19,29] Associated liver injury was reported to be 14%–28%, and associated spleen injury was 16%–33%. We had a higher incidence of associated liver injury (32%) compared to other studies in spite of a higher incidence of high-grade renal injury on the left side.

Others have reported that associated pulmonary injury frequently occurred with blunt renal trauma (7%–45%).[7,18,19,29] Our study also showed a similar finding (40%). This can be explained by the fact that the kidney’s position is relatively high in the abdominal cavity. The thorax also needs to be evaluated thoroughly when a patient has blunt renal trauma.

Our study did not include patients with microscopic or gross hematuria with the normal finding of renal imaging study as Grade I injury. This might lead to a selection bias for higher grade injuries in this study. Other limitations of our study included the small number of patients, retrospective design, and lack of long-term follow-up.

**Conclusion**

Blunt renal trauma is rare in children, but just as in adults, the kidney is the most frequently injured genitourinary organ. The majority of injuries are of low AAST injury grade but commonly associated with other intra-abdominal injuries, especially the liver and the spleen. Although microscopic hematuria occurs in most pediatric blunt renal trauma, gross hematuria is more likely seen in the high-grade injuries.

The nephrectomy rate in pediatric blunt trauma is lower compared to adult. Most pediatric blunt renal injury can be managed conservatively by adult trauma surgeons.

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**Conflicts of interest**

There are no conflicts of interest.

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**Table 3: Injury Severity Score, hospital length of stay, and Intensive Care Unit length of stay in pediatric blunt trauma patients**

|                      | With blunt trauma | With intra-abdominal injury without kidney injury | With blunt kidney injury |
|----------------------|-------------------|-----------------------------------------------|-------------------------|
| \( n \)              | 5790              | 869                                           | 68                      |
| Mean ISS             | 8.8               | 13.9                                          | 21                      |
| Mean hospital LOS (days) | 3.0               | 4.7                                           | 9.0                     |
| Mean ICU LOS (days)  | 2.6               | 3.6                                           | 6.9                     |

LOS: Length of stay, ISS: Injury Severity Score, ICU: Intensive Care Unit
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