Trauma Surgery & Acute Care Open

Pediatric renal trauma: 17 years of experience at a major Scandinavian trauma center

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Received 5 July 2023
Accepted 13 October 2023

To cite: Ringen AH, Fatland A, Skaga NO, *et al*. *Trauma Surg Acute Care Open* 2023;**8**:e001207.

ABSTRACT

Background Children are at increased risk of renal injuries from blunt trauma due to their anatomic constitution. The kidney is injured in 5–20% of pediatric patients with blunt abdominal trauma. During the last decades, the management of pediatric renal injuries has evolved toward non-operative management (NOM) unless the patient is hemodynamically compromised. The aim of the present study was to assess contemporary treatment strategies and evaluate outcomes in pediatric patients with renal injuries admitted to a major Scandinavian trauma center.

Methods A retrospective cohort study of all trauma patients under 18 years admitted to our institution from January 1, 2003 to December 31, 2019 with main focus on patients with renal injury. Outcomes for two time periods were compared, 2003–2009 (Period 1; P1) and 2010–2019 (Period 2; P2), and the study cohort was also stratified into age groups, survivors and non-survivors and severity of renal injury.

Results In total, there were 4230 pediatric patients included in Oslo University Hospital Trauma Registry during this 17-year period and of these 115 (2.7%) had a renal injury. Nephrectomy was performed in four (3.5%) of the patients, angiographic embolization five (4.3%) and ureteral stent placement was performed in six patients (5.2%) due to urinary extravasation. Seven patients died, implying a crude mortality of 6.1%, with one exception secondary to traffic-related incidents. None of the deaths were attributed to renal injury and mortality fell to 1.2% in P2.

Discussion This study on contemporary pediatric renal trauma care is one of the largest from a single institution outside the USA. Our results clearly show that NOM, including minimally invasive procedures in selected cases, is achievable in more than 90% of cases with low mortality and morbidity.

Level of evidence Level IV.

BACKGROUND

Children are at increased risk of renal injuries from blunt trauma due to their anatomic constitution; a larger relative size of the kidney, less perirenal fat, and a more pliable rib cage.[1–4] The kidney is injured in 5–20% of pediatric patients with blunt abdominal trauma.[5–9] During the last decades, the management of pediatric renal injuries has evolved toward non-operative management (NOM) unless the patient is hemodynamically compromised.[10] Although the goals of treatment are obvious, that is, preservation of maximal functional renal parenchyma balanced with the limitation of complication or unnecessary intervention, there is a lack of clarity on how this is best achieved.[3 11] Compared with the overwhelming number of studies showing the success of NOM in children with liver and splenic injuries, there is a scarcity of major studies that analyze outcomes of pediatric renal injuries, in particular outside the USA.[3 11–14]

WHAT IS ALREADY KNOWN ON THIS TOPIC

⇒ Compared with the overwhelming number of studies showing the success of non-operative management (NOM) in children with liver and splenic injuries, there is a scarcity of major studies that analyze outcomes of pediatric renal injuries, in particular outside the USA.

WHAT THIS STUDY ADDS

⇒ Our results clearly show that NOM, including minimally invasive procedures in selected cases, is achievable in more than 90% of cases with low mortality and morbidity.

HOW THIS STUDY MIGHT AFFECT RESEARCH, PRACTICE OR POLICY

⇒ The study demonstrates that NOM can be safely performed in more than 90% of even high-grade pediatric renal injuries.

The aim of the present study was to assess contemporary treatment strategies and evaluate outcomes in pediatric patients with renal injuries admitted to a major Scandinavian trauma center during a 17-year period.

METHODS

Oslo University Hospital Ulleval (OUH-U) is the only high-volume trauma center in Norway with a catchment area of 3 million people covering approximately 60% of Norway's population. All trauma patients under the age of 18 years admitted to OUH-U during the period of January 1, 2003 to December 31, 2019 and included in the Oslo University Hospital Trauma Registry (OUH-TR) were identified.

The main focus of this retrospective cohort study was on patients with renal injury. We extracted data from OUH-TR and patient records. OUH-TR includes all trauma patients admitted through trauma team activation and patients with penetrating injury proximal to elbow or knee, or Injury Severity Score (ISS) >9 admitted to OUH-U directly or via a local hospital within 24 hours after injury. From the OUH-TR we extracted age, gender, mechanism of injury (MOI), date of injury, Glasgow Coma Scale score, ISS, trauma team activation rate, hospital length of stay (LOS), LOS in intensive care unit (ICU) and 30-day mortality. The anatomic injury was classified according to the Abbreviated Injury Scale 1990 revision-Update 98.[15] Renal injuries were graded according to the American Association for the Surgery of Trauma (AAST) Organ Injury Scale (OIS). From the patient records we extracted concomitant injuries, presence of hematuria, minimally invasive procedures performed (percutaneous drainage, ureteral stent placement, and angioembolization), emergency department (ED) surgery (immediate thoracotomy/laparotomy in the ED), NOM or operative management (OM), MOI, and follow-up. Survival status 30 days after injury was obtained from OUH-TR and the Norwegian Population Registry. The definition of NOM varies throughout the literature, and this article includes minimally invasive procedures such as stent placement and angioembolization, whereas OM refers to laparotomy and more extensive renal exploration or resection as defined by LeeVan *et al*.[11]

The study is presented according to Strengthening the Reporting of Observational Studies in Epidemiology guidelines, checklist completed and uploaded as part of the submission.[16] We described the patient characteristics and compared renal injured patients to patients without renal injury in the same period. We analyzed the renal injured population for differences between the periods 2003–2009 (Period 1; P1) and 2010–2019 (Period 2; P2). The cut-off point between time periods was chosen to visualize the effects of institutional changes in trauma organization including improved Damage Control Resuscitation (DCR) strategies with an updated massive hemorrhage protocol and the implementation of the regional trauma system further detailed with defined triage and transfer criteria. In addition to these changes there has been an increased focus on human resources with improved educational programs and enhanced clinical governance.[17–19] The renal injured cohort was also stratified into three age groups, 1–4 years (A1), 5–14 years (A2), and 15–17 years (A3), and subjected to subgroup analyses. Furthermore, the renal injured cohort was stratified into groups based on survivors and non-survivors as well as the severity of renal injury (low grade (AAST OIS grade ≤3) and high grade (AAST OIS grades 4 and 5)) and analyzed for differences.

Continuous data are presented as medians with quartiles (Qs). Comparisons between groups were performed using the Mann-Whitney U test. Categorical data are reported as proportions and tested for significance using Pearson's χ^2 test with Fisher's exact test when appropriate. For all analyses, a p value <0.05 (derived from a two-tailed test) was considered to indicate statistical significance. All statistical analyses were performed using IBM SPSS V.28.

RESULTS

In total, there were 4230 pediatric patients included in OUH-TR during this 17-year period and of these 115 (2.7%) had a renal injury. Patients with renal injury were older compared with those without renal injury (median age 14 years vs. 9 years, p<0.001), more severely injured (median ISS 17 vs. 5, p<0.001), more often underwent transfusion (11.3% vs. 2.3%, p<0.001) and ED surgery (2.6% vs. 0.2%, p<0.001) (table 1). Moreover, patients with renal injury had higher mortality compared with patients without renal injuries (6.1% vs. 1.2%, p<0.001) and longer ICU LOS (median 2 days vs. 1 day, p<0.001) and hospital LOS (median 5 days vs. 2 days, p<0.001).

The MOI was blunt in 98.3% of the 115 children with renal injuries. The injuries were secondary to traffic-related incidents in 33.9% (two-wheeled motor vehicle incidents, pedestrians, bicyclists, and car occupants), falls in 36.5%, and winter sports activities in 22.6%. In four patients (3.5%), renal anomalies predisposing to injury were present. Concomitant intra-abdominal organ injury occurred in 16.5% and concomitant extra-abdominal injuries in 52.2% of patients. Post-traumatic hypertension was identified in 4.3% (2 of 47) of the patients who had follow-ups at OUH (table 2).

Nephrectomy was performed in four (3.5%) of the patients: in two patients a devascularized kidney was removed while laparotomy was performed on non-renal indication on the day of injury. One patient underwent nephrectomy 2 days after injury

Table 1 Patient characteristics

	Total material n=4230	No renal injury n=4115	Renal injury n=115	P value
Age, years	9 (4; 14)	9 (4; 14)	14 (9; 16)	<0.001
Male gender, n (%)	2674 (63.2)	2596 (63.1)	78 (67.8)	0.299
GCS score	15 (15; 15)	15 (15; 15)	15 (15; 15)	0.743
ISS	5 (1; 15)	5 (1; 11)	17 (16; 33)	<0.001
TRISS 09 Ps	0.99 (0.99; 0.99)	0.99 (0.99; 0.99)	0.99 (0.96; 0.99)	<0.001
Blunt injury, n (%)	4071 (96.2)	3958 (96.2)	113 (98.3)	0.248
Traffic incidents, n (%)	1363 (32.2)	1324 (32.2)	39 (33.9)	0.694
Transfused, n (%)	107 (2.5)	94 (2.3)	13 (11.3)	<0.001
ED surgery, n (%)	13 (0.3)	10 (0.2)	3 (2.6)	0.005
Intubated, n (%)	646 (15.3)	620 (15.1)	26 (22.6)	0.027
TTA, n (%)	3944 (93.2)	3839 (93.3)	105 (91.3)	0.350
Mortality, n (%)	57 (1.3)	50 (1.2)	7 (6.1)	<0.001
LOS ICU, days	1 (0; 2)	1 (0; 2)	2 (1; 3)	<0.001
LOS hospital, days	2 (1; 6)	2 (1; 5)	5 (3; 7)	<0.001
Primary admission, n (%)	2622 (62.0)	2581 (62.7)	41 (35.7)	<0.001

Primary admission refers to primary admission at Oslo University Hospital (OUH). Values are median and interquartiles when not stated otherwise. Number of patients with missing values in total material and no renal injury: patients transfused 7, GCS score 2, LOS ICU 1 day.
ED, emergency department; GCS, Glasgow Coma Scale; ICU, intensive care unit; ISS, Injury Severity Score; LOS, length of stay; TRISS 09 Ps, Trauma and Injury Severity Score 2009 revision Probability of survival; TTA, trauma team activation.

Table 2 Patient characteristics stratified by treatment strategy

	NOM n=102	OM n=6	P value
Age, years	14 (9; 16)	11 (3; 13)	0.093
Male gender, n (%)	72 (70.6)	2 (33.3)	0.077
OIS	3 (3; 4)	4 (2; 5)	0.669
ISS	17 (16; 33)	21 (4; 29)	0.547
TRISS 09 Ps	0.99 (0.96; 0.99)	0.99 (0.98; 0.99)	0.273
TTA, n (%)	92 (90.2)	6 (100)	1.000
Transfused, n (%)	7 (6.9)	1 (16.7)	0.377
Traffic incidents, n (%)	32 (31.4)	1 (16.7)	0.665
Fall, n (%)	38 (37.3)	3 (50.0)	0.673
Isolated injury, n (%)	33 (32.4)	3 (50.0)	0.398
Concomitant IAI, n (%)	18 (17.6)	1 (16.7)	1.000
Concomitant EAI, n (%)	51 (50.0)	2 (33.3)	0.679
Follow-up at OUH, n (%)	43 (42.2)	4 (66.7)	0.224
Post-traumatic HT, n (%)	2 (2.0)	0 (0.0)	1.000
LOS ICU, days	2 (1; 3)	3 (0; 18)	0.610
LOS hospital, days	5 (3; 7)	14 (2; 28)	0.252

Values are median and interquartile when not stated otherwise.
EAI, extra-abdominal injury; HT, hypertension; IAI, intra-abdominal injury; ICU, intensive care unit; ISS, Injury Severity Score; LOS, length of stay; NOM, non-operative management; OIS, Organ Injury Scale; OM, operative management; OUH, Oslo University Hospital; TRISS 09 Ps, Trauma and Injury Severity Score 2009 revision Probability of survival; TTA, trauma team activation.

due to insufficient effect of angioembolization and ongoing need for transfusion. One patient underwent nephrectomy 2 months after injury because of a Wilms tumor. Laparotomy without renal exploration was performed in six (5.2%) patients and two (1.7%) patients underwent laparotomy including a kidney-preserving procedure. Cystoscopy with ureteral stent placement due to urinary extravasation was performed in six patients (5.2%) on days 0–16 after injury. The stents were removed without complications 2–6 weeks after insertion. Angiographic embolization was performed in five patients (4.3%): in four patients on the day of injury because of active bleeding, and in one patient on day 9 after injury due to a bleeding pseudoaneurysm (table 3).

A total of seven patients died resulting in a crude mortality of 6.1%, with one exception secondary to traffic-related incidents. The cause of death was traumatic brain injury in three patients, the other four patients exsanguinated from severe blunt torso trauma with abdominal and/or pelvic bleeding in P1. The kidney was never the primary source of bleeding nor the cause of death. No deaths occurred among patients with an isolated renal injury.

Table 3 Patient characteristics stratified by time periods

	P1 (2003–2009) n=30	P2 (2010–2019) n=85	P value
OIS renal injury grade	3 (2; 4)	4 (3; 4)	0.022
ISS	25 (15; 42)	17 (16; 28)	0.302
ED surgery, n (%)	3 (10.0)	0 (0.0)	0.016
Intubated, n (%)	12 (40.0)	14 (16.4)	0.012
Mortality, n (%)	6 (20.0)	1 (1.2)	0.001
NOM, n (%)	28 (93.3)	81 (95.3)	0.650
Cystoscopy with stent, n (%)	0 (0.0)	6 (7.1)	0.337
Angioembolization, n (%)	1 (3.3)	4 (4.7)	1.000
Nephrectomy, n (%)	1 (3.3)	3 (3.5)	1.000

Intubated refers to intubated prehospital or in the emergency department. Values are median and interquartiles when not stated otherwise.
ED, emergency department; ISS, Injury Severity Score; NOM, non-operative management; OIS, Organ Injury Scale; P1, Period 1; P2, Period 2.

The average annual number of children with renal trauma doubled from P1 to P2 (3.8 vs. 8.5). Median OIS renal injury grade increased from 3 in P1 to 4 in P2 (table 3).

Patient characteristics stratified by age groups are presented in table 4. Only eight patients were younger than 5 years. Differences between adjacent age groups were modest. ISS was highest in A3 with a median of 26 compared with 17 in A2 (p=0.048) and 18 in A1 (p=0.542). The injuries were most often secondary to falls in A1 and A2, and traffic related, especially two-wheeled motor vehicle crash, in A3. Concomitant extra-abdominal injuries occurred most often in A3.

There were 63 patients with low-grade (OIS ≤3) injuries and 52 patients with high-grade (OIS 4 and 5) injuries (table 5). Patients with high-grade renal injuries more often presented with isolated injuries and visible hematuria and more frequently underwent minimally invasive procedures as adjuncts to NOM.

DISCUSSION

There are few major single-center studies describing the characteristics of patients with traumatic kidney injury in a pediatric population.[11] The present study is a comprehensive analysis of 115 cases with renal injury in a cohort of 4230 pediatric trauma patients admitted to OUH-U. The study demonstrates that NOM can be safely performed in more than 90% of even high-grade pediatric renal injuries (table 2).

MOI was blunt in almost all cases, typically secondary to traffic-related incidents, falls or sports-related incidents. This is in accordance with most published studies.[2 3 20 21] The number of traffic-related injuries increased with age. This pattern is supported by the results presented by Nakao *et al* in a nationwide cohort study from Japan including 435 children with renal trauma.[20] Moreover, they found that patients aged 15 years and above were exposed to high-energy MOI, had a higher ISS, more concomitant injuries, and suffered less damage to the kidneys than younger teenagers and children in agreement with our observations (table 4). Nakao *et al* also suggested that young teenagers and children more often suffer isolated renal injury from a direct blow to the back or flank from relatively lower energy MOI, as observed in our study. Dangle *et al* reached a similar conclusion in their cohort study with 228 patients reviewing MOI and management of pediatric blunt trauma.[4]

In the oldest age group, concomitant extra-abdominal injuries were more frequent and are likely attributed to the aforementioned higher proportion of traffic-related MOI, especially two-wheeled motor vehicles (table 4). This is in accordance with the findings in a retrospective study of 386 childhood traffic incidents from Finland.[22] The authors found that the risk of traffic incidents and resulting injuries increased dramatically when the child reached the legal age of acquiring a driving license for moped underlining the need for specific prevention programs to improve child safety. Nakao *et al* underscored the importance of targeted sports injury prevention programs especially in teenagers to reduce renal injuries.[20] Such programs should be based on local needs, for example, in our region in addition to continuous focus on traffic injury prevention, an area of interest should be on the use of torso protectors to reduce the number of renal injuries secondary to winter sports incidents.

Management of pediatric renal trauma has shifted during the last three decades in favor of NOM.[1 11 23] Although randomized trials do not exist and would likely not be feasible in the trauma setting, NOM for low-grade (OIS 1–3) renal injuries is

Table 4 Patient characteristics stratified by age groups

	A1 (0–4 years) n=8	A2 (5–14 years) n=59	P value	A3 (15–17 years) n=48	P value
Male gender, n (%)	3 (37.5)	40 (67.8)	0.124	35 (72.9)	0.565
OIS renal injury grade	2 (2; 3)	4 (3; 4)	0.008	3 (2; 4)	0.035
ISS	18 (4; 47)	17 (16; 25)	0.845	26 (16; 36)	0.048
TRISS 09 Ps	0.99 (0.84; 0.99)	0.99 (0.99; 0.99)	0.815	0.97 (0.92; 0.99)	<0.001
Transfused, n (%)	3 (37.5)	6 (10.2)	0.068	4 (8.3)	1.000
ED surgery, n (%)	0 (0.0)	0 (0.0)	1.000	3 (6.3)	0.087
Intubated, n (%)	4 (50.0)	9 (15.3)	0.040	13 (27.1)	0.154
Mortality, n (%)	1 (12.5)	2 (3.4)	0.321	4 (8.3)	0.405
Isolated injury, n (%)	4 (50.0)	18 (30.5)	0.423	14 (29.2)	0.880
Concomitant IAI, n (%)	0 (0.0)	15 (25.4)	0.183	4 (8.3)	0.024
Concomitant EAI, n (%)	4 (50.0)	26 (44.1)	1.000	30 (62.5)	0.058
LOS ICU, days	3 (0; 10)	2 (1; 3)	0.469	2 (1; 5)	0.085
LOS hospital, days	5 (1; 14)	5 (4; 7)	0.733	5 (3; 9)	0.977

Intubated refers to intubated prehospital or in the emergency department. Isolated injury refers to isolated renal injury. Values are median and interquartiles when not stated otherwise. No patients under the age of 1 were identified.
A1, A2, A3, age groups 1–3; EAI, extra-abdominal injury; ED, emergency department; IAI, intra-abdominal injury; ICU, intensive care unit; ISS, Injury Severity Score; LOS, length of stay; OIS, Organ Injury Scale; TRISS 09 Ps, Trauma and Injury Severity Score 2009 revision Probability of survival.

well accepted and used with increasing frequency also in high-grade injuries (OIS 4–5).[23] However, failure to respond to resuscitation, which manifests in persistent hemodynamic instability, remains an absolute indication for OM.[24] In patients with high-grade renal injuries suitable for NOM a success rate of 80% and above is reported.[3 11 21 25] In our study, more than 90% of the patients even with high-grade injuries were selected for NOM, with only one failure. In that patient, angioembolization failed to achieve bleeding control, and a nephrectomy was performed.

There is an increased risk of nephrectomy in patients with a higher ISS, attributed to concomitant injuries that require a surgical intervention.[2 26] In two of our patients, a devascularized kidney was removed during laparotomy for primarily non-renal indication. A nephrectomy rate of 3.5% (4/115) is of the same magnitude as reported in the national data bank studies from the USA and Japan.[2 20] For the sake of clarity, we chose to report the nephrectomy performed 2 months after injury in a patient who was diagnosed with a Wilms tumor after blunt trauma with no indication for immediate surgery. Patients with pre-existing renal lesions like tumors or ureteropelvic junction obstruction are often diagnosed after low-impact injury.[3]

Pediatric renal trauma does not typically occur in isolation.[2 20 21 27] This is reflected in our trauma population, the group of patients with renal injury was more severely injured, more often underwent transfusion, had longer ICU and hospital LOS, and had higher mortality compared with patients without renal injury (table 1). None of the deaths were attributed to renal injury, the overall mortality was 6.1% and fell to 1.2% in P2 (table 3). Moreover, the average annual number of pediatric renal injuries more than doubled from P1 to P2 accompanied by an increase in renal injury severity which is likely an effect of the maturation of the trauma system with adherence to triage and transfer criteria implemented in 2010 as described in a previous publication from our institution.[17]

Isolated blunt renal trauma is rarer and often presumed to represent a minor injury leading potentially to less timely evaluation as suggested by Ghani *et al*.[1] They found that this group of patients had a higher risk of urine leaks and suspected that these injuries result from greater focal energy transfer (eg, sports-related injury) than multisystem scenarios in which the energy transfer is more diffuse (eg, motor vehicle crash). These speculations are supported by our observations that isolated renal injury was more common in high-grade compared with low-grade injury (table 5).

Urine leak is reported in 11–12% of children with renal trauma and is clearly associated with high-grade injuries.[1 5] To diagnose urine leaks in a timely fashion, routine on-arrival delayed CT in children with grade 3 injury and above has been recommended.[1] Such a strategy will reduce the need for repeat imaging and excess radiation.[5] Although many of these urine leaks heal spontaneously, kidney interventions and procedures are more common in this category of patients compared with those without leaks.[1] Minimal interventions (eg, cystoscopy with ureteral stent placement or

Table 5 Patient characteristics stratified by OIS renal injury grade

	Grade ≤3 n=63	Grades 4 and 5 n=52	P value
Age, years	14 (10; 16)	12 (9; 15)	0.110
Male gender, n (%)	45 (71.4)	33 (63.5)	0.363
ISS	26 (14; 34)	17 (16; 21)	0.167
TRISS 09 Ps	0.98 (0.95; 0.99)	0.99 (0.99; 0.99)	0.017
Transfused, n (%)	9 (14.3)	4 (7.7)	0.377
ED surgery, n (%)	2 (3.2)	1 (1.9)	1.000
Mortality, n (%)	6 (9.5)	1 (1.9)	0.126
Isolated injury, n (%)	10 (15.9)	26 (50.0)	<0.001
Concomitant IAI, n (%)	9 (14.3)	10 (19.2)	0.616
Concomitant EAI, n (%)	44 (69.8)	16 (30.8)	<0.001
Cystoscopy with stent, n (%)	1 (1.6)	5 (9.6)	0.090
Angioembolization, n (%)	0 (0.0)	5 (9.6)	0.017
Nephrectomy, n (%)	1 (1.6)	3 (5.8)	0.327
Gross hematuria, n (%)	13 (20.6)	40 (76.9)	<0.001
Primary admission at OUH, n (%)	25 (39.7)	16 (30.8)	0.321
LOS ICU, days	2 (2; 5)	2 (1; 2)	0.014
LOS hospital, days	5 (3; 7)	5 (4; 7)	0.570

Isolated injury refers to isolated renal injury. Values are median and interquartiles when not stated otherwise.
EAI, extra-abdominal injury; ED, emergency department; IAI, intra-abdominal injury; ICU, intensive care unit; ISS, Injury Severity Score; LOS, length of stay; OIS, Organ Injury Scale; OUH, Oslo University Hospital; TRISS 09 Ps, Trauma and Injury Severity Score 2009 revision Probability of survival.

percutaneous nephrostomy) are successful in most of such cases.[1 5] In our series, six patients underwent ureteral stent placement, as definitive treatment, due to symptomatic urine leaks (table 3).

Angiographic embolization is another minimally invasive procedure recommended as an adjunct to NOM in hemodynamically stable pediatric patients with renal trauma for ongoing or delayed bleeding.[11 23] In our series, six patients with high-grade injuries underwent angiographic embolization of which one failed and had a nephrectomy on day 2 after injury (table 3).

Visible hematuria at admission was seen in less than half of the children in our series (table 5), and even in patients with high-grade injuries gross hematuria was absent in nearly a quarter of the patients (table 5). Lack of hematuria in a significant number of children with renal injury is reported in a number of studies.[1 3 28] This underlines the importance of further assessment in all cases where there is clinical suspicion of significant renal injury. In our institution, CT is performed in the ED in children in all pediatric cases where significant abdominal injury is likely based on MOI, clinical findings (eg, compromised physiology, abdominal tenderness, contusion marks, gross hematuria) and/or a positive focused assessment with sonography in trauma examination.[3] Microscopic hematuria alone is not an indication for CT scan. If a significant renal injury is detected (grade ≥3), a second sequence is performed approximately 5 minutes later to assess for urinary leakage. Gross hematuria has been used to guide the length of bed rest and time of discharge.[25] However, there is minimal evidence to support routine ICU care or strict bed rest in children with renal injury.[11 25] Time to ambulate should be directed by pain from the retroperitoneal hematoma or concomitant injuries regardless of whether gross hematuria is present.[25] This is in accordance with our treatment strategy which resulted in a median hospital LOS of 5 days which is comparable to other large series.[1 2] Repeat CT imaging before discharge or at later follow-up should not be routinely performed in the absence of signs or symptoms of concern to avoid exposing these children to unnecessary radiation.[11 29 30]

Post-traumatic hypertension has been reported as a feared complication of renal trauma, with an estimated incidence of 4.2%.[23] Moreover, there has been concern that NOM may increase the risk of this adverse outcome, but based on their literature review, LeeVan *et al* did not find strong support for such a theory.[11] However, routine monitoring for hypertension on follow-up for at least 1 year is recommended.[3 5 23] Post-traumatic hypertension was identified in 4.3% (2 of 47) of the patients who had follow-ups in our institution (table 2).

Our study has several other limitations including those due to a relatively small sample size and its retrospective design, we collected information captured within the medical records and are subject to biases inherent to database review.

SUMMARY

This study on contemporary pediatric renal trauma care is one of the largest from a single institution outside the USA. Our results clearly show that NOM, including minimally invasive procedures in selected cases, is achievable in more than 90% of cases with low mortality and morbidity.

Contributors AHR, AF, PAN, and CG designed the study and conducted the literature search. AHR, AF, PAN, and CG analyzed the data. All authors interpreted the data and participated in writing, revising, and editing the article. AHR is acting as guarantor.

Funding The authors have not declared a specific grant for this research from any funding agency in the public, commercial or not-for-profit sectors.

Competing interests None declared.

Patient consent for publication Not applicable.

Ethics approval Approval for the study was obtained from the Institutional Data Protection Officer at OUH-U.

Provenance and peer review Not commissioned; externally peer reviewed.

Data availability statement Data are available upon reasonable request.

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