Abstract

**Introduction:** To report the management and outcome of paediatric patients sustaining high grade blunt renal trauma.

**Patients and methods:** Medical records were examined for all Grade III to Grade V blunt renal trauma cases admitted to a paediatric trauma centre during the era(s) 2005 to 2015. Data collected and analysed included - demographics, imaging modalities, management, length of hospital stay, complications and follow-up outcome(s).

**Results:** 18 children (12 males, 6 females) with mean age 11 years (4 - 15) were included. According to AAST Grading criteria, 39%(7/18) had Grade III, 50%(9/18) Grade IV and 11%(2/18) Grade V injuries. 44%(8/18) had concomitant injuries. 89%(16/18) cases were managed conservatively although 2/16 subsequently needed JJ stent insertion during inpatient stay for symptomatic urinoma(s). 11%(2/18) required interventional radiology service(s) involving selective embolisation for life threatening renal tract haemorrhage. Blood transfusion for renal injury exclusively was required in 11%(2/18) cases. 89%(16/18) patients had at least one follow up imaging study prior to hospital discharge – majority (13/16) had ultrasound and 3/16 required CT scans. Median length of hospital stay was 11 days (4 - 31). 17%(3/18) patients required hospital readmission within 30 days for complication(s) and all required intervention procedures - JJ stent for urinoma (n=1), embolisation of renal arterio-venous fistula (n=1) and embolisation for a post traumatic pseudoaneurysm (n= 1). Overall median patient follow-up in the study was 6 months (2 - 60 months). 78%(14/18) have had DMSA studies with 11/14 (79%) showing reduction(s) in renal function (range 3% to 44%).

**Conclusions:** This study supports a care pathway strategy advocating conservative management of high grade renal injuries in children. However, patients may experience a relative decline in renal function with higher grade injuries indicating the need for monitoring and follow up.

**Key words:** Paediatric, Blunt, Renal Trauma, Conservative management

**Introduction**

Blunt renal trauma is more likely to occur in children than adults. This is because the kidney in children is proportionately larger in size and has less surrounding perirenal fat. The ribcage of children is also less ossified and provides insufficient protection to the kidney which tends to project in an anatomical direction inferiorly [1]. Conservative management of high grade (grade III to V based on the American Association for the Surgery of Trauma (AAST) grading) blunt renal trauma in adults and children is becoming more common [2,3]. Ureteric stenting, arterial embolisation and percutaneous drainage procedures may however be additionally required in this patient cohort for drainage of urinoma(s), management of life threatening renal tract haemorrhage and definitive ablation of traumatic arterio-venous (AV) renal fistula including pseudoaneursym(s). Examining the literature, there is a distinct lack of comprehensive paediatric-specific guidelines for management and aftercare of patients sustaining high grade renal injury. Some centres have adopted the renal trauma guidelines for adults [4]. Systematic reviews have made effort to offer recommendations with limited expert consensus agreement [5,6]. Against this background the current study therefore reports management and outcome(s) of paediatric patients sustaining high grade blunt renal trauma at a leading UK trauma centre.

**Patients and methods**

Medical case records of all children admitted to Alder Hey Children’s Hospital Liverpool (a UK national paediatric trauma centre) between January 2005 to December 2015 with blunt renal trauma were examined. Extent of renal trauma was graded according to the AAST classification based on computed tomography (CT) findings reported by consultant paediatric radiologists. Initial trauma care was based on established Advanced Paediatric Life Support (APLS) and Advanced Trauma Life Support (ATLS) principles. Conservative management for haemodynamically stable children included analgesia, bed rest (until frank haematuria subsided), regular vital observations, interval haemoglobin/haematocrit monitoring and daily clinical examination.

A total of 18 consecutive children presenting with high grade renal trauma (grade(s) III to V) were identified. Data including mechanism of injury, imaging modalities, management, length of hospital stay, complications, follow-up outcome(s) were then detailed and recorded. Dimercaptosuccinic acid (DMSA) renal nuclear scan results were categorised into (i) ‘normal’ with ≥45% relative renal function, (ii) ‘mild renal loss’ with 40% - 44%, (iii) ‘moderate renal loss’ with 30% - 39% and (iv) ‘severe renal loss’ with <29%.

There were 12 males and 6 females with a mean age of 11 years old (range 4 to 15). All patients had a CT scan of abdomen and pelvis for diagnosis. 44% (8/18) had other associated concomitant injuries (Table 1). CT scan also detected an incidental pelvi-ureteric hydronephrosis in one patient and a polycystic kidney in another case. The commonest mechanism of injury was fall, followed by handlebar/bicycle injury (Table 2). Overall 39% (7/18), 50% (9/18) and 11% (2/18) of patients had grade III, IV and V injury respectively (Figure 1). All renal injuries were unilateral. 78% (14/18) had gross visible haematuria on clinical presentation.

**Results**

*Management*

16 out of 18 patients (89%) who were haemodynamically stable upon admission were managed conservatively. Among the 16 patients, two cases subsequently required retrograde ureteric stent insertion during the same admission for symptomatic urinoma leaks (pain and pyrexia).

The remaining two children (one grade IV and another grade V injury) required urgent interventional radiology procedures to achieve embolisation due to ongoing haematuria and significant loss of haemoglobin. Both of these patients were transferred from district general hospitals to our centre. Embolisation was carried out within 13 hours from the time of presentation of renal injury to the initial referring hospitals.

One patient required a laparotomy for a gastric perforation with the left renal injury managed conservatively. No single patient required direct operative intervention on the injured kidney to manage blunt renal trauma. Two patients (11%) received blood transfusions due to their renal injury. Eleven (61%) patients required urethral catheterisation during the course of admission. Seven (39%) patients were admitted to high dependency unit (HDU) for close observation.

Overall median length of hospital stay was 11 days (range 4 to 31 days). As expected, those with grade III injury had a shorter length of stay (median 6 days) compared to those with grade IV or V injuries (median 12 days). During hospital admission, 89% (16/18) had at least one inpatient follow up radiology study with the majority (13/16) having ultrasound scan(s).

*Re-admissions*

Three (17%) patients were re-admitted within 30-days of primary hospital discharge. All 3 patients required minimally invasive interventions. One case required retrograde insertion of a ureteric stent for a developing symptomatic urinoma. The other two patients required therapeutic embolisation; one case was re-admitted with gross haematuria 13 days after hospital discharge and was found to have a pseudoaneurysm of the renal artery. The other patient was re-admitted 18 days following discharge from hospital and had embolisation for an enlarging renal AV fistula.

*Follow-up outcomes*

The overall median length of surgical follow-up in the study was 6 months (range 2 to 60 months). Patients with significant renal function loss or those who had hypertension were referred to the nephrology service for further management. 78% (14/18) had DMSA nuclear scans as part of their follow-up surveillance imaging. The median time for scheduling nuclear scans from onset of injury was 6 months (range 1 to 11 months). 79% (11/14) of those who had DMSA scans demonstrated reduced relative renal function with a median relative function of 34% (range 3% to 44%). The majority (9/10) of patients with grade IV and V injury had reduced relative renal function (Table 3).

Blood pressure monitoring was available in 56% (10/18) children. One boy (age 11 years; grade IV injury) was noted to be hypertensive during hospital admission. He was reviewed by the nephrology team and commenced on amlodipine. Another boy (age 12 years; grade IV injury) was also noted to have hypertension during follow-up visits and was commenced on lisinopril. However, it was unclear in this latter patient whether hypertension was secondary to renal trauma or his underlying condition of polycystic kidney disease.

**Discussion**

Haematuria is common in paediatric patients sustaining renal trauma. It is however important to be aware that not all cases of renal trauma will however present with haematuria. Four (22%) of patients in our study did not present with visible haematuria including two children with grade IV injury. Other studies also showed similar findings with visible haematuria in 56% - 88% of paediatric blunt renal trauma cases [7-9]. It is therefore important to have a low index of suspicion of renal trauma even in those children who are otherwise haemodynamically stable, based on case history, clinical examination and mechanism of injury rather than presence of haematuria alone. By contrast adults with blunt renal trauma and non-visible haematuria who are clinically stable are most unlikely to have sustained any significant renal injury and therefore do not require imaging routinely [10].

There is now emerging evidence to support conservative management of children with high grade renal trauma who are clinically stable [6,11]. The European Association of Urology (EAU) also now advocates this care plan provided there is close clinical observation, serial imaging and frequent re-assessment of the child’s overall well-being [10]. Sixty one percent of cases (11/18) were treated successfully with conservative management without any intervention. The remaining 39% (7/18) of cases, including those who were re-admitted within 30-days of hospital discharge, benefited from minimally invasive strategies to manage renal tract co-morbidity which included therapeutic embolisation(s) and ureteric stent insertion(s). No patient with a grade III injury required any intervention at all. Likewise, in a similar study examining grade III, IV and V paediatric renal trauma, Mohamed et al. reported that no single patient with a grade III injury required intervention [9]. A recent systematic review involving critical analyses of 32 published articles concluded that the majority of eligible included studies showed an overall 80% success rate with conservative management of grade IV injuries in children [5]. Grade V injury however showed a wide variation of success rate(s) [5]. In one of the largest published studies comprising 18 children with grade V renal injury, Eassa et al. recorded that 50% of patients were successfully managed conservatively without requiring intervention with an overall renal salvage rate of 78% [11]. In the current study, no single paediatric patient required emergency surgery for their renal injury. Renal exploration is more common in cases with penetrating renal injury. Other indications for renal exploration are haemodynamic instability with shock, suspected renal pedicle avulsion and expanding/pulsatile haematoma. [10]

Most urinomas secondary to renal trauma that are asymptomatic are often managed conservatively as the majority will resolve spontaneously [6]. Issues to consider however are the ability of the health care professional to predict the patient who will likely develop a subsequent symptomatic urinoma that will require therapeutic intervention. Two patients in our series required ureteric stent insertion during the same primary hospital admission (at day 1 and day 10) and another case had a ureteric stent insertion following re-admission to our unit some 13 days after discharge. None of our patients had percutaneous drainage. Reese et al. investigated the timing and predictors for urinary drainage in children with conservatively managed grade IV renal injury [13]. Mean time to intervention here was 11 days and the main predictors for urinary drainage were (i) collecting system haematoma(s) and (ii) large urinoma size (mean largest dimension 4.29cm).

In the present series one patient developed a renal artery pseudoaneurysm and another case a renal AV fistula requiring embolisation following readmission to hospital. Both these children had sustained grade IV renal injury. Pseudoaneurysm and AV fistulae are often the cause of a significant secondary bleed [14]. However, these sequelae are more commonly associated with penetrating stab injuries to the kidney rather than blunt trauma [13]. In a recent literature review by Yamacake et al 38 reported cases of renal artery pseudoaneurysm following blunt renal trauma were identified of which only 4 were paediatric cases [15]. Eighty eight percent (23/26) of the cases were treated successfully by arterial embolisation [15]. Both children in our study were also treated successfully with embolisation and preserved good relative renal function(s) of 42% and 44% on DMSA nuclear scans.

DMSA scanning after renal trauma is very useful to determine renal morphology and assess any loss of relative renal function. The exact time to perform DMSA scans following renal trauma remains somewhat controversial. The majority (10/14) of our patients had a DMSA scan at least 12 weeks following their initial renal injury. Keller and Green performed DMSA scans in children with conservatively managed renal trauma at varied time periods of 3 months and 1 year [16]. They did not find any significant difference(s) in the functional outcome at 3 months versus 1 year and therefore DMSA scans at 3 months would appear to be adequate to predict long term relative renal function.

Overall, 71% (10/14) of the children in our study achieved adequate renal salvage rates (with mild - moderate loss of function). All four patients categorised in the severe renal loss group had interventions (n=2 - embolisation; n=2 - ureteric stent insertion). The degree of renal function loss correlated with the grade of injury, with the majority of grade IV and V injuries in our patients having some functional impairment. Keller et al. also showed somewhat similar findings where they reported 0%, 22% and 50% of children with severe renal function impairment on DMSA scans with grade II/III, IV and V injuries respectively [17].

Development of hypertension following renal trauma has always been a concern especially in the paediatric population and remains a controversial issue. In the present study 2 (11%) of patients were noted to have hypertension and were commenced on antihypertensive agents. The reported incidence of hypertension after sustaining renal trauma in the literature varies widely. LeeVan et al. in their recent systematic review found ten studies which reported no cases developing hypertension and nine studies which recorded transient or long-term hypertension in 5 % to 15% of patients on follow up [5]. In a further study with a large series of 62 children (grade III to V injury), 6.5% of children developed hypertension with half of them being transient only [18]. Although the risk of hypertension developing after renal trauma is perceived to be low, some studies have reported the development of renal scarring in children especially in those with high grade injury [19,20]. Renal scarring may be associated with the risk(s) of developing hypertension and it may therefore be wise for clinicians to consider providing follow-up surveillance in children on a long-term basis.

This study supports and reaffirms care strategies advocating the conservative management of high grade renal injury in children. Parents should be counselled that patients may require minimally invasive interventions during the course of their hospital stay or secondary readmission to manage comorbidity arising from higher grade IV and V renal injuries (i.e. stenting or embolisation). Therefore, high grade renal trauma should be managed in specialist trauma centre with interventional radiologist support. Similarly, this group of patient may experience a relative decline in renal function (with risk of hypertension) indicating the need for close monitoring and follow-up.

**References**

1. SL Brown, JS Elder, JP Spirnak. Are pediatric patients more susceptible to major renal injury from blunt trauma? A comparative study. J Urol1998; 160: 138-140.
2. RA Santucci, MB Fisher. The literature increasingly supports expectant (conservative) management of renal trauma – a systematic review. J Trauma 2005; 59(2): 499-503.
3. CG Henderson, S Sedberry-Ross, R Pickard et al. Management of high grade renal trauma: 20-year experience at a pediatric level I trauma centre. J Urol 2007; 178: 246-250.
4. Fitzgerald CL, Tran P, Burnell J, Broghammer JA, Santucci R. Instituting a conservative management protocol for pediatric blunt renal trauma: evaluation of a prospectively maintained patient registry. J Urol 2011; 185(3): 1058-64.
5. E LeeVan, O Zmora, F Cazzulino, RV Burke, J Zagory, JS Upperman. Management of pediatric blunt renal trauma: A systematic review. J Trauma Acute Care Surg 2016; 80(3); 519-528.
6. Umbreit EC, Routh JC, Husmann DA. Nonoperative management of nonvascular grade IV blunt renal trauma in children: meta-analysis and systematic review. Urology 2009; 744(3): 579-82.
7. Broghammer JA, Langenburg SE, Smith SJ, Santucci RA. Pediatric blunt renal trauma: its conservative management and patterns of associated injuries. Urology2006; 67(4): 823-7.
8. Russell RS, Gomelsky A, McMahon DR, Andrews D, Nasrallah PF. Management of grade IV renal injury in children*.* J Urol 2001; 166: 1049-1050.
9. Nance ML, Lutz N, Carr MC, Canning DA, Stafford PW. Blunt renal injuries in children can be managed nonoperatively: outcome in a consecutive series of patients. J Trauma 2004; 57(3): 474-8.
10. Tekgul S, Dogan HS, Hoebeke P et al. EAU guideline on paediatric urology: Paediatric trauma. https://uroweb.org/guideline/paediatric-urology/#3\_18
11. Eassa W, El-Ghar MA, Jednak R, El-sherbiny M. Nonoperative management of grade 5 renal injury in children: does it have a place? Eur Urol 2010; 57(1): 154-61.
12. Mohamed AZ, Morsi HA, Ziada AM et al. Management of major blunt pediatric renal trauma: single-center experience. J Pediatr Urol2010; 6(3): 301-5.
13. Reese JN, Fox JA, Cannon GM Jr, Ost MC. Timing and predictors for urinary drainage in children with expectantly managed grade IV renal trauma. J Urol 2014; 192(2): 512-7.
14. Heyns CF, Van Vollenhoven P. Selective surgical management of renal stab wounds. Br J Urol 1992; 69: 351-7.
15. Yamacake KG, Lucon M, Lucon AM, Mesquita JL, Srougi M. Renal artery pseudoaneurysm after blunt renal trauma: report on three cases and review of the literature*.* Sao Paulo Med J 2013; 131(5): 356-62.
16. Keller MS, Green MC. Comparison of short- and long-term functional outcome of nonoperatively managed renal injuries in children. J Pediatr Surg 2009; 44(1): 144-7.
17. Keller MS, Eric CC, Garza JJ et al. Functional outcome of nonoperatively managed renal injuries in children. J Trauma 2004; 57(1): 108-10.
18. Fuchs ME, Anderson RE, Myers JB, Wallis MC. The incidence of long-term hypertension in children after high-grade renal trauma. J Pediatr Surg 2015; 50(11): 1919-21.
19. Surana R, Khan A, Fitzgerald RJ. Scarring following renal trauma in children. Br J Urol 1995; 75(5): 663-5.
20. El-Sherbiny MT, Aboul-Ghar ME, Hafez AT, Hammad AA, Bazeed MA. Late renal functional and morphological evaluation after non-operative treatment of high-grade renal injuries in children. BJU Int 2004; 93(7): 1053-6.