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Title

Management of Pediatric Grade IV Renal Trauma.

Permalink

<https://escholarship.org/uc/item/37d3k08k>

Journal

Current urology reports, 18(3)

ISSN

1527-2737

Authors

Murphy, Gregory P
Gaither, Thomas W
Awad, Mohannad A
et al.

Publication Date

2017-03-01

DOI

10.1007/s11934-017-0665-z

Peer reviewed

Management of Pediatric Grade IV Renal Trauma

Gregory P. Murphy¹ · Thomas W. Gaither¹ · Mohannad A. Awad^{1,2} ·
E. Charles Osterberg³ · Nima Baradaran⁴ · Hillary L. Copp¹ · Benjamin N. Breyer^{1,5,6}

Published online: 23 February 2017
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Abstract

Purpose of Review Review the current literature regarding the management of grade IV renal injuries in children.

Recent Findings Children are at increased risk for renal trauma compared to adults due to differences in anatomy. Newer grading systems have been proposed and are reviewed. Observation of most grade IV renal injuries is safe. Operative intervention is necessary for the unstable patient to control life-threatening bleeding with either angioembolization or open exploration. Symptomatic urinomas may require percutaneous drainage and/or endoscopic stent placement. Ureteropelvic junction (UPJ) disruption, seen more often in children, requires immediate surgical repair.

Summary Grade IV renal injuries in children are increasingly managed in a conservative manner.

Keywords Pediatric · Renal trauma · Grade IV laceration

This article is part of the Topical Collection on *Pediatric Urology*

✉ Benjamin N. Breyer
Benjamin.Breyer@ucsf.edu

¹ Department of Urology, University of California-San Francisco, San Francisco, CA, USA

² Department of Surgery, King Abdulaziz University, Rabigh, Saudi Arabia

³ Department of Urology, Dell Medical School, University of Texas, Austin, TX, USA

⁴ Department of Urology, Medical University of South Carolina, Charleston, USA

⁵ Department of Biostatistics and Epidemiology, University of California - San Francisco (UCSF), San Francisco, CA, USA

⁶ Zuckerberg San Francisco General Hospital and Trauma Center, 1001 Potrero Suite 3A, San Francisco, CA 94110, USA

Introduction

Traumatic injuries are the number one cause of death in children [1]. Blunt abdominal trauma causes renal injuries in 10–20% of children making the kidney the most common organ injured in the urinary system [2•]. Renal trauma is divided into two types of mechanism: blunt and penetrating.

In many respects, management of pediatric renal trauma mirrors the adult population. However, the pediatric kidney is believed to be more susceptible to trauma because it sits lower in the abdomen and is less protected by an immature rib cage. Congenital renal abnormalities are three to five times more common in pediatric patients undergoing computed tomography (CT) scans for trauma compared to those in adults [3•]. Ureteropelvic junction (UPJ) obstruction, hydronephrosis, and horseshoe kidneys can present with increased severity of hematuria disproportionate to the degree of trauma. These congenital abnormalities are also thought to be associated with higher rates of UPJ disruption following blunt trauma [3•].

This review presents the most recent data regarding epidemiology, grading, management, complications, and follow-up of grade IV renal injuries in children.

Epidemiology

A review of the National Trauma Data Bank by Grimsby et al. from 2002 to 2007 revealed 2213 renal injuries in children [2•]. Renal trauma was more common in older children. Rates of injury vary across geography and population density, but this series as well as another large urban series demonstrate 90% of renal injuries are due to blunt trauma compared to 10% from penetrating injuries [2•, 4]. Penetrating trauma had a bimodal incidence in very young (age 0–1) and older children (age 15–18) at rates of 14 and 13%, respectively.

African American and Hispanic children were more likely to suffer penetrating renal injuries compared to Caucasian children. Grade IV injuries were diagnosed in 16% of patients with 87% of those injuries due to blunt trauma. Interestingly, 88% of patients in this database were treated at adult trauma centers with slightly higher rates of nephrectomy (6 vs 2% at pediatric hospitals) [2•]. Better trauma care of pediatric patients has been shown to occur at pediatric trauma centers so this discrepancy in nephrectomy rates is noteworthy [5].

Definition and Grading

The American Association for the Surgery of Trauma (AAST) grading system defines a grade IV renal injury as a parenchymal laceration extending through cortex, medulla, and collecting system, or injury to a main renal artery/vein with contained hemorrhage [6•]. Grade V injuries are defined as a completely shattered kidney or avulsion of the hilum which de-vascularizes the kidney [6•]. Multiple problems arise with these definitions. It is unclear how injuries to the renal pelvis should be classified. The term shattered is vague and does not specify how many grade IV injuries are required to upgrade an injury. Grouping main renal artery/vein injuries with collecting system injuries makes data and outcome interpretation difficult due to the heterogeneity of the population.

An updated grading system was proposed that attempts to simplify classification of high-grade injuries. The authors suggested grade IV injuries be classified as any injury to the collecting system or renal pelvis as well as all segmental vascular injuries. Grade V injuries were defined as damage to the main renal artery or vein. Statistically similar rates of renal salvage and nephrectomy were seen with the new grading system based on single-institution data [7].

Dugi et al. proposed a sub-stratification of grade IV injuries into 4a (low risk) and 4b (high risk). High-risk injuries were characterized by peri-renal hematoma greater than 3.5 cm, active contrast extravasation, and/or a medial lacerations. These features were associated with higher rates of operative intervention [8].

The AAST grading system and its variations were originally validated in the adult trauma population but are still used to describe pediatric injuries. Regardless of the grading system, grade IV injuries are a heterogeneous population and cannot all be managed identically, especially among pediatric patients who present with unique anatomic differences.

Management

Management of pediatric grade IV injuries includes a variety of options depending on the clinical scenario. Mechanism of injury, hemodynamic stability, concomitant injuries, and CT

findings are major factors that influence treatment decisions. In the stable patient, observation is recommended by both the American Urological Association (AUA) and the European Association of Urology (EAU) guidelines [9•, 10•]. Intervention is indicated for either active hemorrhage causing hemodynamic instability or symptomatic urinomas. For active bleeding, treatments include angioembolization, renorrhaphy, or nephrectomy. Symptomatic urinomas present with fever, flank pain, and ileus and are best managed with percutaneous drain placement and/or endoscopic ureteral stent placement (see Fig. 1 for algorithm). Thought to be more common in the pediatric population, UPJ avulsion requires immediate repair in the stable patient [3•].

Observation

Increasingly, renal trauma is managed in a conservative manner with more patients observed successfully [11]. Grade I–III injuries rarely require operative intervention while grade IV and V injuries have higher rates of intervention [3•, 9•, 12]. In hemodynamically stable patients, successful observation of blunt grade IV renal lacerations has become standard of care [9•, 11]. For collecting system injuries, immediate stent or drain placement is not necessary as many injuries will heal with observation alone [9•, 10•].

Buckley and McAninch reviewed 374 cases of pediatric renal trauma at San Francisco General Hospital in 2004 over the past 25 years. Of the 22 grade IV injuries, 11 (50%) were due to penetrating trauma and 9 (41%) were managed non-operatively. The authors recommend children be observed on bed rest with a Foley catheter in place to continually monitor hematuria. Hemodynamic monitoring and serial hematocrits in an intensive care unit for 48 h is also necessary [4].

Umbreit et al. performed a systematic review in 2009 of ten studies which had a total of 95 blunt grade IV injuries in children. They found that 72% were successfully managed with observation and did not require either an open or minimally invasive procedure [13].

LeeVan et al. performed a similar systematic review in 2015. The authors found 27 studies and report an observation rate ranging from 61.5 to 100%. Using 23 studies that reported data, 204 of 234 (87%) children with grade IV renal injuries were initially managed conservatively. One hundred eighty-four of those 204 (90%) were successful, never requiring subsequent intervention [14•].

Table 1 demonstrates rates of observation in selected larger series or systematic reviews. More recent studies report higher rates of observation indicating urologists are becoming increasingly comfortable managing pediatric grade IV injuries conservatively. Higher rates of observation are seen in series with exclusively blunt trauma. It should be noted that these rates are simply the initial decision to observe or intervene and

Fig. 1 Pediatric grade IV renal trauma algorithm

therefore include patients who have complications requiring delayed intervention (except for the series by Umbreit et al.).

Angioembolization

For active hemorrhage in the clinically unstable patient, angioembolization by interventional radiology versus open surgical exploration is recommended [10•]. Success rates for angioembolization are lower for patients with higher grades of penetrating trauma [15]. Super-selective embolization can be done to try to preserve as much renal parenchyma as possible [16]. Indications for angioembolization over surgical intervention are not as well defined. Rates vary significantly by series and are likely related to physician and hospital preferences [5, 14•].

Glass et al. surveyed 413 urologists and interventional radiologists regarding their practice of angioembolization at level I and II trauma centers. CT evidence for active hemorrhage and pseudoaneurysm were the two most common reasons for choosing angioembolization in 97 and 94% of clinicians, respectively. Concurrent visceral injury was the most common reason given for open exploration in 62% of respondents [17].

Breyer et al. recommend angioembolization for grade IV parenchymal injuries with persistent gross hematuria and/or rapidly decreasing hematocrit requiring two units of blood. However, operative repair was favored for injuries to the main renal artery/vein or renal pelvis avulsion [16].

The systematic review by LeeVan et al. pooled data on 14 studies which revealed 32 of 39 (82%) patients with grade IV injuries treated with angioembolization successfully avoided open surgery [14•].

Schuster et al. reviewed the pediatric angioembolization literature in blunt renal trauma patients as well. Indications for intervention typically included high-grade injury, active bleeding with contrast blush on CT, threatening or ongoing hemodynamic instability, and/or pseudoaneurysm. These authors suggest angioembolization is best suited in the space between non-operative management in the obvious stable child and the need for open surgery in the obvious unstable patient with grade IV to grade V injuries [18].

The advantage of angioembolization is that it provides an intervention while avoiding the morbidity of a laparotomy. The disadvantage is the frequent need for repeat embolization and subsequent damage caused to healthy nephrons that could potentially be spared with rennorhaphy. A solitary renal injury

Table 1 Rates of observation of grade IV renal lacerations by year

Year	Author	Type	Penetrating trauma	Initial rate of observation (%)
2001	Russell et al. [18]	Series	N	9/15 (60)
2004	Buckley and McAninch [4]	Series	Y—50%	9/22 (41)
2009	Mohamed et al. [26]	Series	N	10/14 (71)
2009	Umbreit et al. [13]	Systematic review	N	68/95 (72) ^a
2015	LeeVan et al. [14•]	Systematic review	N	204/234 (87)
2016	Lee et al. [20]	Series	N	22/26 (85)

^a Did not publish initial observation rate but successful observation rate

that meets clinical criteria for angioembolization at a high-volume center is an ideal situation.

Operative Exploration

Despite the high rates of observation and rise of minimally invasive interventions, open operative exploration is warranted in select scenarios. Hemodynamic instability is an absolute indication for intervention according to the AUA and EUA guidelines [9•, 10•]. Depending on the clinical situation, open abdominal exploration versus angioembolization by interventional radiology can be chosen [10•]. Open abdominal exploration should be favored in cases of penetrating trauma, severe hemodynamic derangements, injury to the main renal artery/vein, or concomitant visceral injury [15–17]. If the child is taken directly to the operating room prior to imaging, urology may be called if a hematoma is discovered in the retroperitoneum. Exploration of the retroperitoneum is required if the patient is hypotensive or if the hematoma is pulsatile or expanding [9•]. A one shot intravenous pyelogram (IVP) should be obtained prior to exploration to determine if the patient has two functional kidneys [3•]. Vascular control may be obtained prior to opening the Gerota's fascia. Medial to the inferior mesenteric vein, the abdominal aorta is identified. Dissecting cephalad, the left renal vein will be encountered as it crosses the aorta. From there, the renal hilum can be dissected out and controlled prior to medializing the colon and determining the extent of renal injury. Once identified, the renal laceration can potentially be repaired if damage is not too severe. Otherwise, a nephrectomy can be done if the renal unit is not salvageable or life-threatening bleeding is encountered [3•, 9•].

In the Buckley and McAninch series, 59% of grade IV injuries were explored with the majority of those from penetrating trauma. Renal salvage was high at 95% with the majority of children undergoing renorrhaphy as opposed to nephrectomy [4].

LeeVan et al. reported much lower rates of emergent exploration in pediatric blunt trauma, with 17 of 27 studies reporting exploration rates of less than 20% [14•].

As previously stated, much of the trauma literature on management originates from adult series that are then applied to children. One particular injury that is more commonly seen in children is a UPJ disruption thought to be due to higher rates of congenital abnormalities [3•]. CT scan findings can be misinterpreted as a collecting system injury but a true UPJ disruption requires operative exploration and repair. A high index of suspicion is required to make the diagnosis, and missed injuries can cause severe complications that will not heal without intervention. Umbreit et al. report two cases of missed UPJ disruption that failed minimally invasive intervention and eventually required nephrectomy. They recommend

immediate open repair if the injury is diagnosed within 5 days of the trauma [13]. Common CT findings include medial urinoma and lack of opacification of the distal ureter [3•, 10•, 13]. If there is any doubt, a retrograde pyelogram can be performed in the stable patient to make a definitive diagnosis [19–21].

Complications—Urinoma

Despite increasing success rates with observation, children with a collecting system injury may not heal appropriately and form a urinoma. Symptomatic urinomas can present with abdominal or flank pain, ileus, fever, and tachycardia. Repeat imaging should be obtained to determine the cause for these symptoms. Persistent and expanding urinomas should be treated with either percutaneous drainage, endoscopic ureteral stent placement, or both [10•]. In contrast to the adult population, pediatric ureteral stent removal often requires general anesthesia. Therefore, the decision to place a stent should be judicious. For symptomatic urinomas, percutaneous drain placement is the initial step followed by ureteral stent placement if drain outputs remain high [22].

Lee et al. reviewed their series of pediatric blunt grade IV renal trauma patients. Of the 22 children initially managed with observation, eight required intervention for symptomatic urinomas. Intervention was undertaken between days 4 and 18 so close follow-up is mandatory with these authors recommending a follow-up CT 4–5 days after the initial trauma. Injury characteristics associated with a need for intervention were hematoma greater than 2.2 cm, intravascular contrast extravasation, and antero-medial lacerations. These authors also reviewed multiple older series within the past 15 years and found intervention rates for complications after observation to be between 9 and 45% [23].

Another recent series of 147 children with blunt renal trauma reported 21 collecting system injuries with eight (38%) children failing conservative management and requiring stent placement. CT scan findings associated with failure of observation were filling defects in the renal pelvis and lack of opacification of the distal ureter, which was presumed to be blood clot in the collecting system [19].

Follow-up

Despite the high success rates for observation, complications are more common with higher grades of renal trauma. Follow-up imaging recommendations vary depending on which society guidelines are being followed. The AUA guidelines recommend a CT scan for grade IV injuries at 48 h while the European guidelines recommend against repeat imaging for grade IV injuries as long as the patient is clinically stable [9•,

10•, 24•]. These guidelines are based on many adult but also select pediatric studies when forming their recommendations so pediatric applications are appropriate. The use of ultrasound in an effort to decrease the radiation dose is controversial with some authors pointing out that sonograms are often inconclusive and CT imaging will ultimately be required [3•].

Though not a common finding, renovascular hypertension after renal trauma in children has been reported [22, 25]. Data is lacking, and the mechanism is unknown but all guidelines and many series recommend following patients with high-grade injuries for the development of hypertension [9•, 10•, 24•, 26]. Little is known about the risk of chronic renal insufficiency. To aid with family counseling, children with high-grade injuries can be offered a nuclear scan at least 1 week after injury to estimate long-term renal function [27].

Conclusion

Children are at increased risk of renal injury following blunt or penetrating trauma due to anatomic differences. Grade IV injuries represent a heterogeneous population. As a result, updated grading systems have been proposed. Management of grade IV injuries is increasingly conservative with observation being favored, especially in the setting of blunt trauma. The unstable trauma patient that does not respond to resuscitation warrants intervention with either angioembolization or operative exploration. Symptomatic urinomas should be treated with ureteral stent and/or percutaneous drain placement. UPJ disruption requires a high index of suspicion and immediate operative repair.

Compliance with Ethical Standards

Conflict of Interest Gregory P. Murphy, Thomas W. Gaither, Mohannad A. Awad, E. Charles Osterberg, Nima Baradaran, Hillary L. Copp, and Benjamin N. Breyer each declare no potential conflicts of interest.

Human and Animal Rights and Informed Consent This article does not contain any studies with human or animal subjects performed by any of the authors.

References

Papers of particular interest, published recently, have been highlighted as:

- Of importance

1. Heron M. Deaths: leading causes for 2010. *Natl Vital Stat Rep*. 2013;62:1.
- 2• Grimsby GM, Voelzke B, Hotaling J, Sorensen MD, Koyle M, Jacobs MA. Demographics of pediatric renal trauma. *J Urol*. 2014;192(5):1498–502. **Excellent study of the epidemiology of renal trauma in children.**
- 3• Hussman DA. Chapter 154: Pediatric genitourinary trauma. In: Campbell Walsh Urology: 11th Edition; Wein AJ, Kavoussi LR, Partin AW, Peters CA (EDS), Elsevier-Saunders, Philadelphia, PA. P. 3538. **Excellent chapter that summarizes pediatric trauma.**
4. Buckley JC, McAninch JW. Pediatric renal injuries: management guidelines from a 25-year experience. *J Urol*. 2004;172(2):687–90.
5. Petrosyan M, Guner YS, Emami CN et al: Disparities in the delivery of pediatric trauma care. *J Trauma*, suppl., 2009; 67: S114.
- 6• Moore EE, Shackford SR, Pachter HL, et al. Organ injury scaling: spleen, liver, and kidney. *J Trauma*. 1989;29:1664–6. **Original article describing renal trauma grading system.**
7. Buckley JC, McAninch JW. Revision of current American Association for the Surgery of Trauma Renal Injury grading system. *J Trauma*. 2011;70(1):35–7.
8. Dugi 3rd DD, Morey AF, Gupta A, Nuss GR, Sheu GL, Pruitt JH. American Association for the Surgery of Trauma grade 4 renal injury substratification into grades 4a (low risk) and 4b (high risk). *J Urol*. 2010;183(2):592–7.
- 9• Serafetinides E, Kitrey ND, Djakovic N, Kuehhas FE, Lumen N, Sharma DM, et al. Review of the current management of upper urinary tract injuries by the EAU Trauma Guidelines Panel. *Eur Urol*. 2015;67(5):930–6. **EAU guidelines for urotrauma.**
- 10• Morey AF, Brandes S, Dugi 3rd DD, Armstrong JH, Breyer BN, Broghammer JA, et al. Urotrauma: AUA guideline. *J Urol*. 2014;192(2):327–35. **AUA guidelines for urotrauma.**
11. Santucci RA, Fisher MB. The literature increasingly supports expectant (conservative) management of renal trauma—a systematic review. *J Trauma*. 2005;59:493.
12. Santucci RA, McAninch JM. Grade IV renal injuries: evaluation, treatment, and outcome. *World J Surg*. 2001;25(12):1565–72.
13. Umbreit EC, Routh JC, Husmann DA. Nonoperative management of nonvascular grade IV blunt renal trauma in children: meta-analysis and systematic review. *Urology*. 2009;74(3):579–82.
- 14• LeeVan E, Zmora O, Cazzulino F, Burke RV, Zagory J, Upperman JS. Management of pediatric blunt renal trauma: a systematic review. *J Trauma Acute Care Surg*. 2016;80(3):519–28. **Excellent systematic review of the pediatric blunt renal trauma series.**
15. Hotaling JM, Sorensen MD, Smith 3rd TG, Rivara FP, Wessells H, Voelzke BB. Analysis of diagnostic angiography and angioembolization in the acute management of renal trauma using a national data set. *J Urol*. 2011;185(4):1316–20.
16. Breyer BN, McAninch JW, Elliott SP, Master VA. Minimally invasive endovascular techniques to treat acute renal hemorrhage. *J Urol*. 2008;179(6):2248–52.
17. Glass AS, Appa AA, Kenfield SA, Bagga HS, Blaschko SD, McGeady JB, et al. Selective angioembolization for traumatic renal injuries: a survey on clinician practice. *World J Urol*. 2014;32(3): 821–7.
18. Schuster T, Leissner G. Selective angioembolization in blunt solid organ injury in children and adolescents: review of recent literature and own experiences. *Eur J Pediatr Surg*. 2013;23(6):454–63.
19. Au JK, Tan X, Sidani M, Stanasel I, Roth DR, Koh CJ, Seth A, Gargollo PC, Tu D, Gonzales ET, Smith TG 3rd, Janzen N. Imaging characteristics associated with failure of nonoperative management in high-grade pediatric blunt renal trauma. *J Pediatr Urol*. 2016 Oct;12(5):294.e1–294.e6.
20. 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.
21. He B, Lin T, Wei G, He D, Li X. Management of blunt renal trauma: an experience in 84 children. *Int Urol Nephrol*. 2011;43(4):937–42.
22. Russell RS, Gomelsky A, McMahon DR, Andrews D, Nasrallah PF. Management of grade IV renal injury in children. *J Urol*. 2001;166(3):1049–50.

23. Lee JN, Lim JK, Woo MJ, Kwon SY, Kim BS, Kim HT, et al. Predictive factors for conservative treatment failure in grade IV pediatric blunt renal trauma. *J Pediatr Urol*. 2016;12(2):93. e1-7.
24. • Bryk DJ, Zhao LC. Guideline of guidelines: a review of urological trauma guidelines. *BJU Int*. 2016;117(2):226–34. **Nicely compares and contrasts all urotrauma guidelines.**
25. Henderson CG, Sedberry-Ross S, Pickard R, Bulas DI, Duffy BJ, Tsung D, et al. Management of high grade renal trauma: 20-year experience at a pediatric level I trauma center. *J Urol*. 2007;178(1): 246–50.
26. Mohamed AZ, Morsi HA, Ziada AM, Habib EM, Aref AM, Kotb EA, et al. Management of major blunt pediatric renal trauma: single-center experience. *J Pediatr Urol*. 2010;6(3):301–5.
27. Moog R, Becmeur F, Dutson E, Chevalier-Kauffmann I, Sauvage P, Brunot B. Functional evaluation by quantitative dimercaptosuccinic acid scintigraphy after kidney trauma in children. *J Urol*. 2003;169(2):641–4.