Journal of Pediatric Urology (2016) 12, 294.e1–294.e6

# Imaging characteristics associated with failure of nonoperative management in high-grade pediatric blunt renal trauma

J.K. Au [a], X. Tan [b], M. Sidani [b], I. Stanasel [a], D.R. Roth [a], C.J. Koh [a], A. Seth [a], P.C. Gargollo [c], D. Tu [a], E.T. Gonzales [a], T.G. Smith III [b], N. Janzen [a]

[a]Baylor College of Medicine, Division of Pediatric Urology and Texas Children's Hospital, Clinical Care Center, 6701 Fannin Street, 6th Floor, Houston, TX 77030, USA

[b]Department of Urology, Baylor College of Medicine, 7200 Cambridge Street, 10th Floor, Suite A10.136, Houston, TX 77030, USA

[c]Department of Urology, 200 1st St SW, Rochester, MN 55902, USA

Correspondence to: J. K. Au, Clinical Care Center, 6701 Fannin Street, 6th Floor, Houston, TX 77030, USA.Tel.: +1 832 822 3160.

jau@bcm.edu (J.K. Au)

**Keywords**
Pediatric; Renal trauma; Imaging; Nonoperative management

Received 20 November 2015
Accepted 28 February 2016
Available online 22 April 2016

## Summary

### Introduction
Some children who sustain high-grade blunt renal injury may require operative intervention. In the present study, it was hypothesized that there are computed tomography (CT) characteristics that can identify which of these children are most likely to need operative intervention.

### Materials and methods
A retrospective review was performed of all pediatric blunt renal trauma patients at a single level-I trauma center from 1990 to 2015. Inclusion criteria were: children with American Association for the Surgery of Trauma (AAST) Grade-IV or V renal injuries, aged ≤18 years, and having available CT images with delayed cuts. The CTs were regraded according to the revised AAST grading system proposed by Buckley and McAninch in 2011. Radiographic characteristics of renal injury were correlated with the primary outcome of any operative intervention: ureteral stent, angiography, nephrectomy/renorrhaphy, and percutaneous nephrostomy/drain.

### Results
One patient had a Grade-V injury and 26 patients had Grade-IV injuries. Nine patients (33.3%) underwent operative interventions. Patients in the operative intervention cohort were more likely to manifest a collecting system filling defect ($P = 0.040$) (Fig. A) and lacked ureteral opacification ($P = 0.010$). The CT characteristics, including percentage of devascularized parenchyma, medial contrast extravasation, intravascular contrast extravasation, perirenal hematoma distance and laceration location, were not statistically significant. Of the 21 patients who had a collecting system injury, eight (38.1%) needed ureteral stents. Renorrhaphy was necessary for one patient. Although the first operative intervention occurred at a median of hospital day 1 (range 0.5–2.5), additional operative interventions occurred from day 4–16. Thus, it is prudent to closely follow-up these patients for the first month after injury. Two patients with complex renal injuries had an accessory renal artery resulting in well-perfused upper and lower pole fragments, and were managed nonoperatively without readmission (Fig. B).

### Conclusions
Collecting system defects and lack of ureteral opacification were significantly associated with failure of nonoperative management. A multicenter trial is needed to confirm these findings and whether nonsignificant CT findings are associated with operative intervention. In the month after renal injury, these patients should be mindful of any changes in symptoms, and maintain a low index of suspicion for an emergency room visit. For the physician, close follow-up and appropriate counseling of these high-risk patients is advised.

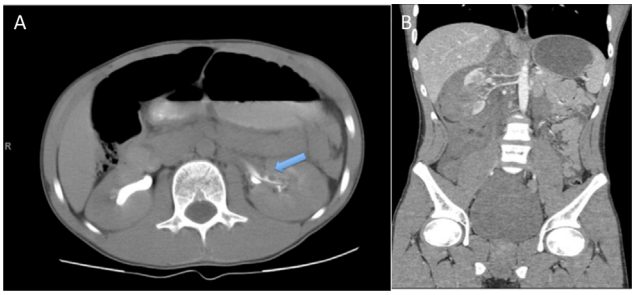


**Figure** A. Axial CT image demonstrating left renal pelvis extravasation and collecting system filling defect (blue arrow). B. Coronal CT image demonstrating dual arterial supply of right kidney with lower pole accessory artery (*) and well-perfused upper and lower pole fragments. (For interpretation of the references to color in this figure legend, the reader is referred to the web version of this article.)

http://dx.doi.org/10.1016/j.jpurol.2016.02.021

## Introduction

In children, more than 95% of renal trauma cases are secondary to blunt traumatic injury [1]. Gross hematuria is seen in approximately one third of significant renal injuries from pediatric blunt renal trauma [2]. Recent studies have shown that similar imaging criteria can be used in both adult and pediatric patients, but the mechanism and physical exam findings should also be taken into consideration [3]. A meta-analysis examining nonoperative management of American Association for the Surgery of Trauma (AAST) Grade-IV pediatric blunt renal trauma showed that in patients who were hemodynamically stable, over 70% required no intervention. Of those who presented with symptomatic urinoma or persistent urinary extravasation, 80% could be managed with ureteral stents and/or percutaneous drains [4].

Adult patients who have sustained high-grade renal trauma can be stratified into high-risk and low-risk categories based on computed tomography (CT) criteria to guide nonoperative management: intravascular contrast extravasation (ICE), medial renal laceration, perirenal hematoma distance (PHD) [2]. Another adult series demonstrated that fever $>38.5$ °C and ureteral clot obstruction were independent predictors of the need for ureteral stenting and that the only predictor of open surgery was the percentage of devascularized parenchyma [5].

In children, the concept of stratifying high-grade blunt renal trauma into high-risk and low-risk categories has been employed in small case series. Radiologic factors that have been associated with a higher risk of operative intervention include: medial contrast extravasation [1], collecting system clot, and large urinoma [6].

In the present study, it was hypothesized that in children who have sustained high-grade blunt renal trauma, there are identifiable CT characteristics that can identify which children are most likely to need operative interventions.

## Materials and methods

After appropriate Institutional Review Board approval, a retrospective analysis was performed of pediatric patients sustaining blunt renal trauma at a single level-I trauma center from 1990 to 2015. Inclusion criteria were: children with high-grade blunt renal trauma defined as AAST Grade-IV or V, aged $\leq$18 years, and with available CT images with delayed cuts for review. Patients who sustained penetrating injuries were excluded. The criteria for CT imaging included: mechanism of injury (high-speed deceleration injury, fall $>$10 feet, direct blow to the flank, etc.), gross hematuria, microhematuria $\geq$50 RBCs/HPF, and physical exam findings (i.e. abdominal/flank tenderness or bruising, rib fractures, etc.). All CT images were reviewed by three authors (JKA, TGS and NJ) and regraded according to the revised AAST renal trauma grading system proposed by Buckley and McAninch [7]. The revised system was chosen over the original 1989 AAST grading system as the authors felt it was a more clinically relevant grading system, where Grade-V injuries represent life-threatening renal pedicle injuries and not just a 'shattered kidney' in a clinically stable patient.

Details recorded during the CT image review included: AAST revised, presence of collecting system or vascular injury or both, medial renal laceration, medial contrast extravasation (MCE), intravascular contrast extravasation (ICE), and perirenal hematoma distance (PHD), as defined by Dugi et al. [2]. Additional CT findings included percentage of parenchymal devascularization ($<$25% vs. $>$25%), ureteral contrast opacification, collecting system filling defect, and presence of congenital renal anomalies. Perirenal hematoma distance was defined as the largest measurement from the renal capsule edge to hematoma edge from axial, coronal or sagittal CT cuts. Intravascular contrast extravasation was defined as a linear extension or pooling of extravascular fluid with a density equal to that of the adjacent intravascular contrast medium during the CT portal venous phase, suggesting an active bleed. The antero-posterior renal plane was based on an axis through the renal hilum. A line drawn perpendicular to this axis defined the medial and lateral renal halves to assess for MCE and laceration location (medial, lateral, both/complex). A second reviewer (JKA, TGS and NJ) corroborated all radiographic variables and measurements, and if there were any discrepancies, the third author reviewed the CT to break the tie. The authors were blinded to the clinical outcomes and radiology reports during the review of the images.

In addition, demographic data, mechanism of injury, hematuria status, total length of stay, total number of inpatient and outpatient CT scans and renal ultrasounds, and follow-up data were collected. Radiographic characteristics of renal injury, as previously stated, were correlated with the primary outcome of any operative intervention: ureteral stent, angiography, nephrectomy/renorrhaphy, and percutaneous nephrostomy/drain.

As per hospital protocol, all pediatric renal trauma patients were admitted to the Trauma Service (pediatric surgery). Urology consults were called in the ER and the urology service actively managed the patient's urologic issues throughout the hospital stay. Patients with high-grade renal injuries were initially put on bed rest in the Pediatric Intensive Care Unit. Serial hemoglobin and hematocrit labs were drawn until stability was demonstrated. Antibiotics were started at the discretion of the Trauma Service if the patient was febrile $>$38.5 °C after 48 h. Repeat CT or renal ultrasound (RUS) imaging was obtained at $>$48 h, at the discretion of the attending urology physician.

Indications for operative intervention with cystoscopy and ureteral stenting included: fever $>$48 h, persistent flank/abdominal pain, ileus, and persistent urinary extravasation. Angioembolization was performed for significant gross hematuria after transfusion of $>$2 units Packed Red Blood Cells, Intravascular Contrast Extravasation, or blush suggestive of pseudoaneurysm. After discharge, the patients were followed up with a renal ultrasound at 4—6 weeks. No functional renal imaging was obtained.

Data were presented as median and interquartile range (IQR) and frequency (%) for continuous and categorical variables, respectively. Bivariate comparisons were performed using the Mann—Whitney U test for continuous data and Fisher's exact test for categorical data, as appropriate. Any radiologic variables with a *P*-value $<$0.2 on univariate analysis were included in the multivariable logistic