Perinephric Hematoma Size is Independently Associated with the Need for Urological Intervention in Multisystem Blunt Renal Trauma

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Purpose: We examined radiographic predictors of intervention for blunt renal trauma independent of AAST-OIS (American Association for the Surgery of Trauma-Organ Injury Scale).

Materials and Methods: A total of 328 patients with blunt renal trauma from October 2004 to December 2014 were identified for analysis. Hospital records and diagnostic imaging were reviewed to identify the need for urological intervention, including angiographic embolization, nephrectomy, renorrhaphy, ureteral stenting or percutaneous drainage. Factors examined included patient age, gender, length of stay, ISS (Injury Severity Score), AAST-OIS, laceration location, length and number, perinephric hematoma characteristics, intravascular contrast extravasation and devitalized segment status. Descriptive statistics and binary logistic regression were performed as appropriate.

Results: Mean patient age was 37.0 years and mean ISS was 31.7. A total of 31 urological interventions were required in 27 patients (8.2%), including ureteral stenting in 38.7%, angiographic embolization in 32.3%, nephrectomy in 22.6%, renorrhaphy in 3.2% and percutaneous drainage in 3.2%. On univariate analysis AAST-OIS, hematoma diameter, hematoma area, intravascular contrast extravasation, laceration length, laceration number, degree of devitalization and devitalized fragment presence were associated with the need for intervention (each $p < 0.001$). On multivariate analysis only AAST-OIS grade (OR 69.4, 95% CI 6.4–748.3, $p < 0.001$) and hematoma diameter (OR 1.5, 95% CI 1.1–1.9, $p = 0.004$) or area (OR 1.03, 95% CI 1.01–1.06, $p = 0.012$) remained associated with urological intervention.

Conclusions: Although AAST-OIS is strongly associated with the need for urological intervention, perinephric hematoma size is also independently associated with this occurrence. Perinephric hematoma diameter should be considered during clinical decision making and incorporated into a revised injury grading system.

Key Words: kidney; wounds, nonpenetrating; hematoma; risk assessment; trauma severity indices

Abbreviations and Acronyms

AAST = American Association for the Surgery of Trauma

CT = computerized tomography

ICE = intravascular contrast extravasation

ISS = Injury Severity Score

OIS = Organ Injury Scale

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KIDNEYS are the most commonly injured genitourinary organ and blunt trauma is the leading mechanism of injury.[1–3] Renal trauma as classified by AAST-OIS was first described by Moore et al on a scale of I to V based on the depth of renal parenchymal damage and involvement of the collecting system or renal vessels.[4] This classification scheme, which was last updated

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in 2012, has been widely used to stratify renal injuries and has been validated as a predictor of intervention specifically for higher grade injuries.[5–7] Patients deemed at higher risk may be monitored more closely and perhaps undergo intervention sooner to prevent unnecessary complications and renal loss.

The AAST-OIS grading system has even been used as a guide for nontraumatic endoscopic, angiographic or open renal procedures. However, it does not include a number of factors that have been suggested as important factors to predict intervention.[8] These factors include perinephric hematoma size, laceration location, ICE and the presence or extent of devitalized renal fragments.[9–12] Dugi et al from Parkland Hospital were among the first to describe other diagnostic imaging parameters that may predict the need for intervention of renal trauma, namely ICE, perinephric hematoma diameter greater than 3.5 cm or a medial renal laceration site.[9,10] These criteria were examined by other groups but often assessed as univariate associations not independent of AAST-OIS grade.[11,12]

The objective of our study was to determine independent risk factors associated with urological intervention in a severely injured population of patients with blunt renal trauma. We hypothesized that perinephric hematoma characteristics would be independently associated with the need for urological intervention.

MATERIALS AND METHODS

This study is a health ethics board approved, retrospective review of the Alberta Trauma Registry from October 2004 through December 2014 inclusive. To qualify for the Alberta Trauma Registry a patient must be involved in a trauma with ISS 12 or greater and be admitted to a level 1 trauma center. The database was interrogated for ICD code 866 (kidney injury), which identified 487 major traumas managed at a level 1 trauma center at our institution. All charts were reviewed by at least 2 of the 3 study investigators to ensure data completeness and accuracy.

Inclusion Criteria

All patients 18 years old or older with blunt renal trauma were included in analysis regardless of AAST-OIS classification. Patients with penetrating trauma were excluded from study as they are more likely to undergo operative intervention based on the mechanism of injury rather than on clinical status or imaging findings. CT with intravenous contrast medium at hospital admission and prior to selective angioembolization or operative intervention were also requirements.

Radiological Review

All CT images were reviewed by a trainee who had been trained by a staff urologist in reading renal trauma imaging and by a staff reconstructive urological surgeon blinded to patient intervention status. The staff urologist ultimately determined the final reporting in the event of any discrepancy.

Recorded radiographic features included perinephric hematoma characteristics (maximal diameter, location and area), ICE, renal laceration site, length and number, and devitalized segment status. The length of the perinephric hematoma diameter variable was calculated in a manner similar to that of Nuss et al by measuring the longest distance from Gerota's fascia to the renal parenchyma.[9] Perinephric hematoma area was also calculated in a similar manner using the formula for the area of an ellipse. Each of these measurements was made using the CT image that provided the largest hematoma size.

Patient Characteristics

Hospital records were reviewed to determine patient age, gender, length of stay and ISS. Records were reviewed to identify the need for intervention related to the renal injury, including ureteral stenting, angiographic embolization, nephrectomy, renorrhaphy or percutaneous drainage. Ureteral stenting was performed for symptomatic urine leak or urinoma not responding to conservative treatment. Embolization and renal exploration were typically performed for hemodynamic instability.

Statistical Analysis

Descriptive statistics were used to characterize patient information. Univariate and multivariate binary regression analysis with categorical and continuous variables was done to assess the relationship between predictor variables and outcomes.

RESULTS

Demographics

Of the 487 trauma cases that presented during the study period 328 met study inclusion criteria (table 1). Mean patient age was 37 years, 79% of the patients were male and mean ISS was 32. Injuries were classified by AAST grade as grade I (hematuria with normal studies or subcapsular, nonexpanding hematoma) in 58 of the 328 patients (18%), grade II (nonexpanding perirenal hematoma or less than 1 cm parenchymal laceration without urinary extravasation) in 76 (23%), grade III (greater than 1 cm renal cortex laceration without collecting system injury) in 118 (36%), grade IV (parenchymal laceration extending into the collecting system or main renal artery, or vein injury with contained hemorrhage) in 65 (20%) and grade V (a completely shattered kidney or vascular avulsion of the renal hilum devascularizing the kidney) in 11 (3%) (table 1). The most common injury mechanisms were motor vehicle accidents in 52% of cases followed by pedestrians or cyclists injured by vehicles in 10% and a fall from a height in 10%.

Urological Interventions

Of the patients 8.2% underwent a total of 31 interventions (table 1). All renal trauma interventions were done for grade IV and V injuries. There was no

Table 1. *Demographics of patients in blunt renal trauma cohort, and outcomes and interventions*

No. pts	328	
Mean ± SD pt age (range)	37.0 ± 17.1	(17–86)
No. male (%)	260	(79.3)
No. female (%)	68	(20.7)
Mean ± SD Injury Severity Score (range)	31.7 ± 13.8	(12–75)
Mean ± SD Revised Trauma Score (range)	7.53 ± 0.83	(2.05–7.84)
No. AAST-OIS grade (%):		
I	58	(17.7)
II	76	(23.2)
III	118	(36.0)
IV	65	(19.8)
V	11	(3.4)
No. perinephric hematoma location (%):		
None	63	(19.2)
Medial	99	(30.2)
Lateral	165	(50.3)
Mean ± SD perinephric hematoma (range)		
Diameter (cm)	3.9 ± 2.9	(0–15.8)
Area (cm^2)	8.5 ± 14.3	(0–86.2)
No. intravascular contrast excretion (%)	5	(1.5)
Mean ± SD cm laceration length (range)	1.2 ± 1.1	(0–6)
No. laceration location (%):		
None	118	(36.0)
Medial	105	(32.0)
Lateral	104	(31.7)
Other	1	(0.3)
No. devitalized fragment (%)	79	(24.1)
Mean % devitalized involvement (range)	8.1	(0–100)
Mean days hospital stay (range)	18.9	(0–243)
No. transfusion (%)	92	(28.0)
No. death (%)	19	(5.8)
No. requiring intervention (%)	27	(8.2)
No. urological interventions (%):	31	
Ureteral stent	12	(3.7)
Angiographic embolization	10	(3.0)
Nephrectomy	7	(2.1)
Renorrhaphy	1	(0.3)
Percutaneous drainage	1	(0.3)

intervention for grades I to III during the study period. The most common intervention was ureteral stenting in 3.7% of cases, followed by selective angioembolization in 3.0%, nephrectomy in 2.1%, renorrhaphy in 0.3% and percutaneous drainage in 0.3%.

Urological Intervention Associations

On univariate analysis the need for urological intervention was associated with AAST-OIS grade, hematoma diameter, hematoma area, laceration number, laceration length, ICE, devitalized fragment presence and devitalized fragment percent (each $p < 0.001$, table 2). However, after multivariate analysis only AAST-OIS grade ($p < 0.001$, OR 69.4, 95% CI 6.4–748.3) and hematoma area ($p = 0.01$, OR 1.03, 95% CI 1.01–1.06) or hematoma diameter ($p = 0.004$, OR 1.5, 95% CI 1.1–1.9) remained independently associated with urological intervention (table 3). Descriptive statistics showed that a hematoma diameter 6 cm or less vs 6 or greater resulted in an intervention rate of 1.6% vs 31.1% ($p < 0.0001$) while a hematoma diameter greater than 4 cm was associated with a 16.2% rate of urological intervention with a 1.7% rate below this cutoff ($p < 0.0001$, table 4).

Table 2. *Univariate associations relating to need for urological intervention*

	p Value
Age	0.76
Gender	0.77
Max pulse rate	0.07
Systolic blood pressure	0.14
Injury Severity Score	0.40
Revised Trauma Score	0.31
Transfusion	0.13
AAST grade	<0.001*
Hematoma:	
Presence	0.11
Location	0.10
Diameter	<0.001*
Area	<0.001*
Laceration:	
Presence	0.26
No.	<0.001*
Location	0.053
Length	<0.001*
Intravascular contrast extravasation	<0.001*
Devitalized fragment:	
Presence	<0.001*
%	<0.001*

* Significant ($p < 0.05$).

DISCUSSION

Since its introduction, AAST-OIS has become an indispensable tool to manage renal trauma. This injury scale graded from I to V, which is based primarily on parenchymal laceration depth and the presence or absence of vascular or collecting system injury, has shown predictive validity to identify patients who require urological intervention.[13–17] We examined factors associated with urological intervention in a severely injured population of 328 patients who sustained blunt renal trauma. Using an initially conservative treatment approach 8.2% of patients required urological intervention and the renal salvage rate was 97.9%.

Table 3. *Multivariate analysis using hematoma diameter and area*

Hematoma	OR (95% CI)	p Value
Diameter + area:		
AAST grade	69.4 (6.4–748.3)	<0.001*
Hematoma diameter (cm)	1.5 (1.1–1.9)	0.004*
Laceration length (cm)	0.96 (0.53–1.74)	0.89
Laceration No.	1.6 (0.77–3.41)	0.21
Intravascular contrast extravasation	0.15 (0.01–3.60)	0.24
% Devitalized fragment	1.00 (0.98–1.03)	0.59
Area:		
AAST grade	33.2 (5.3–208.0)	<0.001*
Hematoma area (cm^2)	1.03 (1.01–1.06)	0.012*
Laceration length (cm)	1.20 (0.73–2.04)	0.45
Laceration No.	1.6 (0.75–3.37)	0.23
Intravascular contrast excretion	0.36 (0.02–6.92)	0.50
% Devitalized fragment	1.00 (0.99–1.03)	0.61

* Significant ($p < 0.05$).

Table 4. *Intervention rate descriptive statistics by hematoma diameter*

Hematoma Diameter (cm)	% Intervention (No./total No.)	p Value*
2 or Less vs greater than 2	2.4 (2/84) vs 10.2 (25/244)	0.02
4 or Less vs greater than 4	1.7 (3/180) vs 16.2 (24/148)	<0.0001
6 or Less vs greater than 6	1.6 (4/254) vs 31.1 (23/74)	<0.0001
8 or Less vs greater than 8	4.0 (12/297) vs 48.4 (15/31)	<0.0001
10 or Less vs greater than 10	7.3 (23/317) vs 36.4 (4/11)	0.008

* All values significant ($p < 0.05$).

This rate of intervention fits in the literature of blunt renal trauma but wide variation exists, which can influence the application of data across different centers.[18] Nonetheless, our finding emphasizes the benefits of conservative management, which has gained popularity among urologists, especially given the suggestion that aggressive surgical intervention may lead to a decreased renal salvage rate.[1,19] With the shift from open surgery to nonoperative treatment the easily obtainable clinical and radiographic features that are strongly associated with intervention must be more clearly defined.

Early Attempts to Substratify American Association for Surgery of Trauma-Organ Injury Scale

Our study confirms the finding that AAST-OIS remains strongly associated with intervention for renal trauma. However, this scale likely does not examine other important clinical and radiographic features associated with renal injury.[9–17,20–22] Buckley and McAninch first proposed a revision of the AAST-OIS injury scale.[7] This revised classification is based on the finding that main renal vascular injuries are associated with a higher exploration rate and a lower renal salvage rate. Malaeb et al questioned the usefulness of including segmental renal artery injuries in grade IV renal trauma.[23] Moreover, some grade V injuries can be managed nonoperatively in up to 46% of patients who are hemodynamically stable.[24] Additionally, it can be difficult to accurately differentiate segmental from main renal pedicle injuries in a timely manner without further invasive investigations. These specific changes to the AAST-OIS grading system may not practically stratify patients with renal trauma.

Any revision to the AAST classification should incorporate easily accessible information which stratifies patients who are best served by early intervention. Several potential factors exclusive of AAST-OIS have been found to be associated with intervention for renal trauma, including perinephric hematoma size, ICE, the presence or extent of devitalized renal segments and laceration location or number.[7,9–12,20–22]

Perinephric Hematoma Size

Some groups have suggested an increased rate of intervention based on perinephric hematoma size.[9–12,25] Perinephric hematoma size is likely a radiographic estimate of the magnitude of renal bleeding. Ichigi et al first reported that a larger hematoma area may be associated with renal embolization and/or open surgical exploration.[25] More recently the Parkland County group found higher intervention rates associated with increased perinephric hematoma diameter.[9,10] Our study reflects this finding since perinephric hematoma diameter and area were associated with intervention on univariate and multivariate analysis.

However, the exact cutoff point for intervention can often depend on the threshold of an individual surgeon. Several groups have observed increased intervention rates in patients with a perinephric hematoma diameter of greater than 3.5 cm with an intervention rate of 25.5% to 27% compared to about 3% to 4% in those with a hematoma diameter less than 3.5 cm.[10–12] Our data provide further rates of intervention by incremental hematoma diameter. Not surprisingly the intervention rate increased in accordance with hematoma diameter. In our population a hematoma diameter greater than 6 cm appeared to offer better distinction in patients undergoing intervention (31.1% vs 1.6%) compared to those with a smaller hematoma diameter such as 4 cm (16.2% vs 1.7%). It should be noted that these are isolated univariate descriptions but they provide meaningful clinical insights nonetheless.

Our data confirm that perinephric hematoma size (diameter or area) is crucial to decision making in renal trauma. Although both are useful as another assessment of hematoma size, hematoma diameter is most easily measured and it provides equivalent clinical information even in the context of other prognostic variables. It may be best used to substratify patients with grade IV renal injury.

Intravascular Contrast Extravasation

ICE is another factor reported to be associated with intervention for renal trauma.[9–12] ICE is direct radiographic evidence of ongoing bleeding and it correlates with active bleeding at other intra-abdominal sites.[26–29] Most series including this finding have reported it based on univariate associations without independently assessing these factors in the context of AAST-OIS.[11,12]

Our study shows that ICE is not associated with a higher rate of intervention on multivariate assessment when assessed concurrently with AAST-OIS. It is possible that ICE may not add further information than that already provided by AAST-OIS, given that AAST-OIS considers the degree of renal vascular injury. Additionally, the ICE rate reported by Dugi et al, which was 16.7% of grade III and IV renal traumas, is much higher than the 1.5% in our study.[10]

All cases of ICE in our series were associated with grade V injuries and the grade of injury rather than ICE was the driving factor for intervention. It is unclear why there is a discrepancy in reporting this. However, given that our population exclusively comprised blunt trauma, ICE may be a predictive phenomenon associated more frequently with penetrating trauma.

Devitalized Fragments

The presence or amount of devitalized renal tissue was also suggested as a prognostic factor. Long et al studied a group of 99 patients who presented with grade IV blunt renal trauma and found that a devitalized renal fragment greater than 25% was associated with the need for operative intervention.[22] Our study showed that the need for intervention failed to remain significant on multivariate analysis.

There has been a call for the devitalized fragment percent to be included in the revised AAST grading system. In light of our findings we believe that this requires additional investigation.

Laceration Location and Number

The location and number of lacerations were hypothesized to be factors associated with intervention for renal trauma.[9,10] It is thought that medial lacerations carry a greater risk of intervention due to the larger medial renal vasculature. Likewise multiple lacerations can incur larger volumes of hemorrhage and intervention related to bleeding or obstruction.

Our study suggests that laceration location and number are not independently associated with the need for urological intervention. These descriptors may simply be another surrogate for the degree of hemorrhage in blunt trauma. When taken in the context of AAST-OIS and perinephric hematoma size, they do not offer any further prognostic information.

Further stratifying grade IV injuries continues to be of interest to urologists as most variation in outcomes and decision making is in this grade of injury. Combining several factors may be helpful to substratify patients as reported by others, who found an intervention rate as high as 66.7% in patients with 2 of 3 risk factors.[10,12]

These data are interesting but are not conclusive, especially given existing discrepancies in the literature. Based on our data perinephric hematoma diameter should be incorporated into a revised grade IV injury scale while other factors such as ICE and laceration location may require additional investigation prior to incorporation into AAST-OIS. This substratification of injuries would help identify which patients are at highest risk for complications and, therefore, can be more closely monitored and undergo early intervention to avoid morbidity and renal loss.

Study Limitations

Our study is limited because of its retrospective nature. Also, a number of different urologists were practicing during the study period who likely had differing opinions and thresholds to initiate surgical interventions. Although many studies support nonoperative management of renal trauma, there is still controversy regarding standard indications of intervention. Nonetheless, our series represents real world management of renal trauma at a level 1 trauma center. Additionally, patients were followed in hospital only and we were unaware of any complications that might have required care beyond the acute hospital stay.

We also used any urological intervention as our clinical outcome, including embolization, nephrectomy, renorrhaphy, ureteral stenting and percutaneous drainage. Although not all of these interventions are directly related to bleeding, they represent clinically relevant outcomes that are an interrelated part of the patient overall health status, particularly since AAST-OIS specifies collecting system injury as an important factor when grading renal trauma. Ureteral stenting is a relevant urological intervention, especially when collecting system injury is present.

CONCLUSIONS

AAST-OIS grade remains strongly associated with the need for urological intervention in cases of blunt renal trauma. Perinephric hematoma size (diameter and area) is also independently associated with the need for intervention and it should be considered during clinical decision making. In particular, maximal perinephric hematoma diameter should be incorporated into a revised injury grading system. Our findings echo the proposals of others who have called for adding perinephric hematoma diameter or other hematoma size characteristics to a revised AAST-OIS grading system. A hematoma diameter greater than 6 cm may be most helpful when deciding on operative intervention.

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