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High-grade renal injuries are often isolated in sports-related trauma

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Abstract

Introduction—Most high-grade renal injuries (American Association for Surgery of Trauma (AAST) grades III–V) result from motor vehicle collisions associated with numerous concomitant injuries. Sports-related blunt renal injury tends to have a different mechanism, a solitary blow to the flank. We hypothesized that high-grade renal injury is often isolated in sports-related renal trauma.

Material and methods—We identified patients with AAST grades III–V blunt renal injuries from four level 1 trauma centres across the United States between 1/2005 and 1/2014. Patients were divided into "Sport" or "Non-sport" related groups. Outcomes included rates of hypotension (systolic blood pressure <90 mm Hg), tachycardia (>110 bpm), concomitant abdominal injury, and procedural/surgical intervention between sports and non-sports related injury.

Results—320 patients met study criteria. 18% (59) were sports-related injuries with the most common mechanisms being skiing, snowboarding and contact sports (25%, 25%, and 24%, respectively). Median age was 24 years for sports and 30 years for non-sports related renal injuries ($p = 0.049$). Males were more commonly involved in sports related injuries (85% vs. 72%, $p = 0.011$). Median injury severity score was lower for sports related injuries (10 vs. 27, $p < 0.001$). There was no difference in renal abbreviated injury scale scores. Sports related trauma was more

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likely to be isolated without other significant injury (69% vs. 39% ($p < 0.001$)). Haemodynamic instability was present in 40% and 51% of sports and non-sports renal injuries ($p = 0.30$). Sports injuries had lower transfusion (7% vs. 47%, $p < 0.001$) and lower mortality rates (0% vs. 6%, $p = 0.004$). There was no difference in renal-specific procedural interventions between the two groups (17% sports vs. 18% non-sports, $p = 0.95$).

Conclusions—High-grade sports-related blunt renal trauma is more likely to occur in isolation without other abdominal or thoracic injuries and clinicians must have a high suspicion of renal injury with significant blows to the flank during sports activities.

Keywords

Wounds; Non-penetrating; Abdominal injuries; Sports; Snow sports; Kidney

Introduction

Renal injuries are the most common traumatic genitourinary injury with approximately 245,000 cases worldwide each year [1]. Nearly 82–95% of renal injuries in the United States are caused by blunt trauma. Motor vehicle collisions (MVC) and falls account for most blunt renal injuries and often result in multiple traumatic injuries including other intra-abdominal or thoracic injury [2].

Blows to the flank sustained during sports related activities, such as skiing, contact sports, or biking can result in isolated renal injuries [3]. Most diagnostic and prognostic criteria for blunt renal injury reflect large urban trauma databases with MVC and falls as the predominant mechanisms of blunt renal injury. In these trauma series, injury severity score (ISS), American Association for the Surgery of Trauma (AAST) renal injury grade, and presence of haematuria or haemodynamic instability have been shown to be predictive of intervention and nephrectomy rates [1,4–6]. There are limited data regarding specific demographic factors, clinical signs, rates of procedural or surgical interventions, and mortality for less common mechanisms of blunt renal injury, such as sports related activities. Although most sports related renal injuries are low-grade (AAST grades I–II), isolated blows to the flank sustained during sports related activities can also produce high-grade renal injury (AAST grades III–V) [7,8,3,9].

We hypothesize that high-grade renal injury associated with sports related trauma is often isolated without the sequelae of polytrauma associated with non-sports related injury. We evaluated AAST grade III–V blunt renal injuries at four large trauma centres in the United States to determine differences in clinical characteristics and management for these two mechanistic groups of blunt renal trauma.

Materials and methods

We retrospectively reviewed all renal trauma records between January 2005 and January 2014 at four level 1 trauma centres across the United States including the University of Utah Hospital (Salt Lake City, UT), Intermountain Medical Centre (Murray, UT), Ben Taub General Hospital (Houston, TX), and San Francisco General Hospital (San Francisco, CA).

Each institution received Institutional Review Board approval prior to this study. The AAST grading system was used to define injury grade (Table 1) [10,11]. We limited our analysis to patients 17 years or older with grades III–V blunt renal injury. The mechanism of injury was identified as sports related or non-sports related. Sports related renal trauma was defined as snow-sport related injury (skiing, snowboarding, sledding), injury sustained during contact sports (contact with another person or object while playing football, soccer, rugby, etc.) and bicycle related injury (mountain or road biking). Sports related injuries excluded any accidents involving motorized vehicles including pedestrian versus motor vehicle, bicyclist versus motor vehicle, all terrain vehicles, motorcycles or dirt bikes, motorized scooters, snowmobiles, or motorized boats or other motorized watercraft.

We collected data on patient age, sex, injury mechanism, ISS, abbreviated injury scale (AIS), AAST renal injury grade, concomitant injuries, and systolic blood pressure and heart rate measurements before arrival or in the emergency department. Additionally, we gathered information on management and out-comes of blunt renal injury including rate of blood transfusion within 24 h of arrival, endoscopic or surgical intervention, nephrectomy, length of hospital stay, and mortality.

Our primary outcome measures were rates of hypotension and/or tachycardia and haemodynamic instability. Hypotension was defined as systolic blood pressure <90 mm Hg, and tachycardia was defined as heart rate >110 beats/min at any time before arrival or in the emergency department before resuscitation. We defined haemodynamic instability as the presence of either hypotension and/or tachycardia. Secondary outcome measures included differ- ences in ISS scores, rates of transfusion, rates of concomitant abdominal injury, and rates of any intervention between sports and non-sports related grades III–V blunt renal injury.

Demographic and clinical variables were summarized as count (%) or median (inter-quartile range, IQR) by injury mechanism (sports vs. non-sports related). Each variable was compared to injury mechanism controlling for institution using Firth's penalized-likelihood logistic regression [12,13]. Firth's logistic regression was used to overcome sparse institutional and clinical characteristics strata. Firth's penalized logistic regression produces consistent regression estimates when the maximum likelihood parameters do not exist due to sample separation. All analyses were conducted in R© v.3.0.3 (http://cran.us.r-project.org/) using two-sided tests with a 0.05 significance level.

Results

We identified 320 high-grade (AAST grades III–V) blunt renal injuries between January 2005 and January 2014, including 84 (26%) at the University of Utah, 85 (26%) at Intermountain Medical Centre, 105 (39%) at Ben Taub Hospital, and 46 (17%) at San Francisco General Hospital (SFGH). Two hundred and thirty seven patients (74%) were men. Mean age was 33.9 (SD: 16.0) years and mean ISS was 25.5 (SD: 14.7). The injury mechanism was sports-related in 59 (18%) injuries compared to 261 (82%) non-sports related injuries.

The demographics of high-grade renal injuries grouped by sports or non-sports related are shown in Table 2. Fifty (85%) and 187 (72%) patients were males in sports and non-sports related renal injuries, respectively ($p = 0.011$). AAST grade III injuries were the most common high-grade injuries with 32 (55%) sports related injuries and 146 (56%) of non-sports related injuries. The median age for sports related injuries was 24.0 years compared to 30.0 years for non-sports related renal injuries ($p = 0.049$). There was a significant difference in ISS (10 vs. 27, $p < 0.001$) and hospital length of stay (2.0 vs. 8.0 days, $p < 0.001$) for sport and non-sport injuries, respectively. No significant difference in AIS and AAST grade were observed between sports and non-sported related renal injury.

Mechanisms of sports related and non-sports related injuries are described in Table 3. The most common mechanisms of sports related injury was skiing, snowboarding, and contact sports, implicated in 15 (25%), 15 (25%), and 14 (24%) of sports related injuries, respectively. MVC was the most common mechanism of non-sports related renal injury (114 cases, 44%).

Sports related injury presented more frequently as an isolated kidney injury vs. non-sports related renal injury as shown in Table 4 (69% vs. 39%, respectively, $p < 0.001$). Sports related renal injury was less likely to be associated with concomitant pelvic fracture or thoracic injury compared to non-sports related renal trauma ($p < 0.001$ and $p = 0.004$, respectively).

There was no difference in signs of haemodynamic instability including hypotension and/or tachycardia between the two cohorts (Table 4). However, blood transfusion rates were less frequent for sports versus non-sports related renal injury (7% vs. 47%, $p < 0.001$). The rates of any renal specific procedural/surgical intervention were 17% for sports related renal injuries and 18% for non-sports ($p = 0.95$). Of the 320 total cases of renal trauma, 261 (82%) were managed conservatively, 14 (4%) had a ureteral stent placed, 10 (3%) underwent embolization, 10 (3%) underwent partial nephrectomy or open repair, and 2 (0.6%) had a renal artery stent placed. Among sports-related injuries ($n = 59$), 5 (8%) had ureteral stent, 2 (3%) had open repair or partial nephrectomy, and 1 (1%) had a renal artery stent. No embolizations were performed for sports related injuries. Nephrectomy was infrequent among all injuries. Rates of nephrectomy were 3% vs. 7% for sports vs. non-sports related renal injuries ($p = 0.24$). Mortality for sports related injuries was significantly lower than non-sports related injuries (0% vs. 6%, $p = 0.004$).

Discussion

In our multi-centred study of high-grade (AAST grades III–V) blunt renal injury, sports related injury made up 18% of all overall injuries. The most common high-grade sports related mechanisms were skiing, snowboarding, and contact sports. Patients with sports related renal injuries were more likely to be younger and male compared to non-sports related injuries. Additionally, sports related trauma was more likely to cause isolated renal injury and have lower ISS compared to non-sports related trauma. Sports related renal injuries also had shorter hospital length of stay, lower transfusion rates, and lower mortality rates. Despite differences in concomitant traumatic injuries between sports and non-sports related renal injuries, no significant difference was observed in renal AIS score or rates of hypotension, tachycardia, any intervention, or nephrectomy.

Several previous studies have reported significant renal injury with blunt sports related trauma. Most sports related renal injuries involve a direct blow to the flank rather than deceleration injury associated with the more common mechanisms such as motor vehicle accidents or falls [14]. Several cases of isolated grade IV renal injury have been reported in football and softball related trauma [7,15]. Biking is one of the more common sports activities associated with blunt renal trauma and several studies have shown that a significant proportion of renal injuries sustained from biking are high-grade [8,11,16]. We observed a high number of snow-related sports injuries due to the participation of two trauma centres in Utah, but the other common sports related injury mechanisms of injuries were also seen in our urban centres (SFGH and Ben Taub General Hospital).

Lloyd et al. reported a series of 106 recreational blunt renal injuries in Vail, Colorado [3]. This is one of the largest sports-related renal injury cohorts to date. The emphasis of the study was evaluation of the SFGH imaging criteria established by Miller and McAninch for these types of injuries [4]. These imaging criteria include gross haematuria or microscopic haematuria with hypotension and will identify 99.5% of patients with AAST grade 2 or higher injuries. However, these criteria reflect urban trauma mostly caused by deceleration related mechanisms such as MVCs and free-falls. These criteria were not as sensitive for recreational mechanisms of renal injury as reported by Lloyd et al. In fact, the authors found that gross haematuria or haemodynamic instability with microhaematuria was not present in 5 of 22 (23%) grade 3 and 2 of 12 (17%) grade 4 cases in this study. This suggests that prognostic indicators and imaging criteria derived from deceleration related mechanisms of blunt renal injury might not be appropriate for sports-related mechanisms of renal injury. Limitations of this study were that greater than 50% of cases were AAST Grade 1 and 2 renal injuries and sports related injuries were not compared with non-sports related injuries. This restricts the interpretation and generalizability of these results [3]. We were unable to evaluate the SFGH imaging criteria in our current study because information about gross or microscopic haematuria was not available in many of the cases.

We did not observe a difference in the rates of hypotension, tachycardia or haemodynamic instability between sports related and non-sport related renal trauma, despite the greater likelihood of isolated kidney injury, lower ISS scores, lower transfusion rates, lower mortality, and shorter hospital stays with sports related renal trauma. This may be a function of the excellent overall haemodynamic reserve and younger age of those sustaining sports related injuries conferring increased resistance to hypotension, tachycardia, or haemodynamic stability compared to non-sports related injuries [17].

An important conclusion from our study is that sports related activities could cause significant renal injuries in the absence of other concomitant abdominal, pelvic or thoracic injuries seen with non-sports related mechanisms of blunt injury. Despite the lack of significant difference in the presence of haemodynamic instability between the two mechanisms, it is important to emphasize that 23 (39%) cases of sports related high-grade renal trauma presented as an isolated renal injury without associated hypotension and 19

(32%) presented as an isolated injury without associated tachycardia. Additionally, 14 (24%) of cases presented as an isolated renal injury without associated hypotension or tachycardia. These findings emphasize that a high clinical suspicion of renal injury is needed when evaluating patients who have sustained a significant blow to the flank during sports related activity given the frequency of isolated renal injuries without concomitant haemodynamic instability. Since sports related mechanisms of renal injury are often less pronounced than non-sports related injury, a significant injury could easily be overlooked.

Identification and accurate grading of traumatic renal injuries is essential to safely managing patients conservatively, and many complications may be ameliorated in individual cases. Studies estimate a short-term complication rate of 9.3–12.6% in patients with AAST grades III–V blunt renal injuries managed conservatively [18–20]. There is limited data regarding the rates of long-term complications for blunt renal injury managed conservatively. However, identifying patients with high-grade renal injury may offer an opportunity for appropriate counselling regarding risks and signs of secondary bleeding, hypertension, and long-term renal dysfunction [20]. Several studies have shown that as early as 6 months after injury, a significant proportion of patients with grades III–V injuries have some degree of renal dysfunction [21,22].

Although sports related injuries and blows to the flank may produce high-grade renal injury (AAST grades III–V), these injuries are rare compared to those caused by non-sports related mechanisms such as MVC or falls. Sports related injuries only made up 18% of all high-grade renal injuries requiring hospital admission in our study. It is likely that many high-grade sports related renal injuries are not brought to medical attention, undergo imaging, or require hospital admission but this is largely unknown. Despite the possibility of high-grade sports related renal injuries shown in our study, the risk of these injuries compared to all traumatic injuries is very low. There were approximately 60,000– 80,000 trauma admissions at our four level 1 trauma centres during the 8 years of this study; however, only 59 were high-grade sports related renal injury. Additionally, the National Electronic Injury Surveillance System estimates that the national annual incidence of renal injury requiring hospital admission was <900 cases. Given the low overall risk of high-grade sports related renal injuries, patients with solitary kidneys should be allowed to participate in contact sports according to current recommendations [23].

There are several limitations to our study. This was a retrospective analysis and several clinical factors were not available including information on gross or microscopic haematuria. Additionally, sports related renal injuries made up a small percentage of all blunt renal injuries in this study compared to non-sports related injuries. We were therefore unable to further characterize clinical characteristics and interventions by various sub-groups including different mechanisms of sports related renal injury, AAST grade, and isolated renal injuries.

Conclusions

Blows to the flank sustained during sports related activities can produce high-grade (AAST III–V) renal injury. Sports related renal injuries are more likely to occur in isolation without other abdominal, pelvic or thoracic injuries. Patients are more likely to be younger and male compared to non-sports related renal injuries. Even though there was no difference in signs of haemodynamic instability (hypotension or tachycardia), renal AIS scores, any intervention rates, and nephrectomy rates between these two mechanistic groups of blunt renal injury, sports related renal injuries have lower ISS scores, lower transfusion rates, lower mortality, and shorter hospital stays, all indicative of an overall lower injury severity. Clinicians should have a high suspicion of renal injury with significant blows to the flank sustained during sports activities.

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Table 1

American Association for the surgery of trauma kidney injury scale.[a]

Grade[b]	Type of injury	Description of injury
I	Contusion	Microscopic or gross haematuria, urologic studies normal
	Haematoma	Subcapsular, nonexpanding without parenchymal laceration
II	Haematoma	Nonexpanding perirenal hematma confirmed to renal retroperitoneum
	Laceration	<1.0 cm parenchymal depth of renal cortex without urinary extravagation
III	Laceration	<1.0 cm parenchymal depth of renal cortex without collecting system rupture or urinary extravagation
IV	Laceration	Parenchymal laceration extending through renal cortex, medulla, and collecting system
	Vascular	Main renal artery or vein injury with contained haemorrhage
V	Laceration	Completely shattered kidney
	Vascular	Avulsion of renal hilum which devascularizes kidney

[a] http://www.aast.org/library/traumatools/injuryscoringscales.aspx#kidney.

[b] Advanced one grade for bilateral injuries up to grade III.

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Table 2

Demographics of sports vs. non-sports related renal injury.

	Sports related *n* = 59 (18%)	Non-sports related *n* = 261 (82%)	p^a
	Median (IQR)	Median (IQR)	
Age	24.0 (19.5, 33.5)	30.0 (22.0, 46.0)	**0.049**
ISS	10.0 (8.0, 18.0)	27.0 (17.0, 36.0)	**<0.001**
AIS kidney	3 (2.0, 3.5)	3 (2.0, 4.0)	0.87
LOS	2.0 (1.0, 3.8)	8.0 (3.0, 17.0)	**<0.001**
	Sports related *n* = 59 (18%)	Non-sports related *n* = 261 (82%)	p^a
	Median (IQR)	Median (IQR)	
	n (%)	*n* (%)	
No. of Males	50 (85%)	187 (72%)	**0.011**
Grade III	32 (54%)	146 (56%)	0.36
Grade IV	22 (37%)	84 (32%)	
Grade V	5 (8%)	31 (12%)	

Bold values indicates statistically significant p value (ie p-value <0.05).

[a]Firth's logistic regression predicting sports vs. non-sports related injury controlling for institution.

ISS, Injury severity score; AIS, abbreviated injury scale, AAST, American Association for the Surgery of Trauma; LOS, length of stay.

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Table 3

Mechanisms of sports related and non-sports related renal injury.

	n	%
Sports-related injury	59	18
Skiing	15	25
Snowboarding	15	25
Contact sport[a]	14	24
Bicycle related	8	14
Other	7	12
Non-sports related Injury	261	82
Motor vehicle collision	114	44
Motorcycle or motorized recreational vehicle collision	58	22
Motorized vehicle vs. pedestrian	48	18
Fall	30	11
Other	11	4

[a]Contact with another person or object during organized sporting activity.

Table 4

Clinical characteristics and interventions for sports vs. non-sports related renal injury.

	Sports-related *n* (%)	**Non-sports related *n* (%)**	***p*[a]**
Hypotension[b]	12 (21)	48 (18)	0.69
Tachycardia[c]	18 (32)	116 (44)	0.15
Haemodynamic instability[d]	23 (40)	132 (51)	0.30
Isolated renal injury	41 (69)	102 (39)	**<0.001**
Abdominal hollow-organ injury	1 (2)	21 (8)	0.17
Pelvic fracture	0 (0)	49 (19)	**<0.001**
Thoracic injury	17 (29)	129 (50)	**0.004**
Transfusion[e]	4 (7)	123 (47)	**<0.001**
Any renal intervention[f]	10 (17)	46 (18)	0.95
Nephrectomy	2 (3)	18 (7)	0.24
Death	0 (0)	16 (6)	**0.004**

[a] Firth's logistic regression predicting sports vs. non-sports related injury controlling for institution.

[b] Systolic blood pressure <90 mm Hg.

[c] Heart rate >110 beats per min.

[d] Haemodynamic instability (systolic blood press <90 mm Hg *or* heart rate >110 beats per min.

[e] Transfusion <24 h of arrival.

[f] Any intervention = any endoscopic, procedural, or surgical intervention.