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ORIGINAL ARTICLE

Independent predictors of mortality for patients with traumatic renal injury

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Abstract

Purpose To investigate the parameters of renal trauma, including emergent intervention type, that predict the mortality of patients with traumatic renal injury.

Methods A retrospective database analysis was performed on patients who sustained a traumatic renal parenchymal injury identified by the 2017 National Trauma Data Bank. Data were analyzed to identify differences in hospital length of stay, ER and hospital disposition, and mortality based on patient age, gender, race, Injury Severity Score, renal injury grade, and need for emergent intervention (angioembolization versus open surgery). Logistic regression was used to correlate intervention type and trauma parameters to mortality.

Results A total of 4,876 of 1,004,440 trauma patients (0.49%) had a traumatic renal injury. Of those, 220 (4.5%) underwent an emergent intervention—29 (0.59%) angioembolization and 191 (3.9%) open renal surgery. 83 patients with a blunt renal trauma (2.0%) underwent renal intervention, whereas 136 (21.0%) with a penetrating injury required a procedure. Forty-five of the 220 patients (20.5%) who had a renal intervention died, while 377 of 4,656 (8.1%) who did not have an intervention died. Multiple logistic regression identified black race, age > 45 years, penetrating trauma, and ISS > 15 to be independent predictors of mortality. Neither angioembolization nor open renal surgery was associated with a significantly higher likelihood of mortality in the multivariable model.

Conclusion While procedural interventions are associated with higher mortality for patients with traumatic renal injury, other factors, such as race, age, trauma type, and injury severity may be more predictive of death under care.

Keywords Kidney · Wounds and injuries · Trauma severity indices · Hospital mortality

Introduction

Traumatic renal parenchymal injury can cause significant morbidity and mortality in trauma patients despite its relatively low incidence among overall trauma cases [1]. The degree of morbidity and mortality has significant associations with trauma type, injury severity, and whether or not patients require operative management [2–4]. A recent meta-analysis of nearly 14,000 patients who suffered blunt or penetrating renal trauma found overall morbidity and mortality to be 33% and 14%, respectively [4]. The mortality rate for operative management (OM) was more than twice the rate of non-operative management (NOM).

Since trauma management is a potentially modifiable predictor of patient morbidity and mortality, OM versus NOM of traumatic renal injury has been the subject of much discussion over the last several decades. NOM has emerged as the standard of care, particularly with the advent of diagnostic angiography and angioembolization. The majority of patients who suffer blunt renal trauma are managed non-operatively, with emergent intervention in the form of surgery or embolization reserved for higher grade injuries [5]. A lower proportion of penetrating renal trauma is managed non-operatively, but expectant management is still performed with high success rates [6, 7].

While much of the literature on renal trauma focuses on factors that are predictive of a patient requiring surgery instead of NOM [6, 8–11], little is known about the parameters of a trauma or patient demographics that are predictive

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of patient outcomes, such as admission to an intensive care unit (ICU), ultimate hospital disposition, or death under care. Furthermore, the association between the type of emergent intervention, i.e., angioembolization versus surgery, and patient mortality is not well studied. We thus sought to characterize a recent cohort of traumatic renal injury patients and identify factors that were predictive of their mortality rates.

Materials and methods

Data from the 2017 National Trauma Databank, Version 1.0, were used for this study. All patients who sustained a traumatic renal parenchymal injury were identified using the International Classification of Diseases, 10th Revision (ICD-10). Codes beginning with S37.0, corresponding to injury of the kidney, identified patients with traumatic renal injury.

All renal injury patients had the following data abstracted: gender, race, age, injury severity score (ISS), Abbreviated Injury Scale (AIS) Code, trauma type, and intervention type. AIS Code was used to assign an American Association for the Surgery of Trauma renal injury grade (I–V) in accordance with previously published conversion standards [12]. Trauma type was categorized as blunt, penetrating, and other. An intervention occurred if a patient underwent angioembolization of the kidney or renal surgery. Renal surgery was determined by ICD-10 procedure codes that corresponded to open repair, resection, excision, or extraction of the kidney.[1] Patients' dispositions from the emergency room (ER) or hospital were also extracted from the databank. Dispositions included the hospital floor, ICU, operating room, home, outside facility, or dead.

To examine if certain parameters, such as demographics, trauma type, ISS, or renal injury grade had an association with receiving an emergent intervention, patients were divided into those who had an embolization or surgery and those who did not. Patients were then subdivided into groups based on gender, race, age, trauma type, ISS, and renal injury grade and compared with the incidence of an intervention. ISS was divided into ranges based on thresholds previously described to indicate the severity of trauma [13]. As age and ISS were stratified into ranges, Pearson's chi-squared test was used for all of these comparisons.

Patients were then divided into no intervention, embolization, and surgery groups to examine if intervention type or lack thereof was associated with a difference in ER or hospital disposition. They were then compared across different dispositions using Pearson's chi-squared test. Mean length of stay (LOS) was calculated for intervention and no intervention groups with corresponding 95% confidence intervals.

To determine if the likelihood of death under care was associated with the aforementioned parameters, simple logistic regression was used for each parameter to estimate odds ratios and 95% confidence intervals. Finally, to assess independent predictors of death under care, a multivariable analysis was performed with logistic regression of race, age group, injury type, ISS, renal injury grade, and intervention type. All analyses were completed using Stata Statistical Software: Release 16 (StataCorp, College Station, TX). Tests with a p value < 0.05 were considered statistically significant.

Results

Of the 1,004,440 trauma patients in the 2017 NTDB, 4876 (0.49%) patients sustained a renal injury. Four hundred twenty-two (8.7%) of these patients died under care. The majority of renal trauma patients were male (72.3%, 3525/4876), of white race (66.1%, 3225/4876), and ages 21–64 years old (64.4%, 3141/4876) (Table 1). The most common type of injury was blunt trauma (85.7%, 4178/4876). ISS's were left-skewed, with nearly one-third of renal trauma patients receiving an ISS greater than 25. Two hundred twenty (4.5%, 220/4876) renal trauma cases required intervention with embolization or open surgery, with three patients requiring both procedures. Twenty-nine (0.59%, 29/4876) patients underwent embolization and 191 (3.9%, 191/4876) patients underwent open renal surgery.

Outcomes of traumatic renal injury varied across patient characteristics and whether or not they required emergent intervention. The most common ER disposition for renal trauma patients was the ICU (36.0%, 1753/4876), followed by the hospital floor (30.4%, 1483/4876) and operating room (25.7%, 1254/4876) (Table 2). Half of the patients who required angioembolization for renal trauma went to the ICU from the ER. The length of stay for patients requiring any intervention was significantly higher (13.8 days; 95% CI 11.8–15.8), compared to those who did not (8.9 days; 95% CI 8.5–9.3). Finally, death under care, or the mortality rate after an individual arrives to the ER or hospital, was strongly associated with requiring an intervention. Death under care for those who underwent surgery or embolization was significantly higher than those who did not (20.5% vs. 8.1%, $p < 0.001$).

Simple logistic regression identified several predictors of death under care (Table 3). Under univariate analysis, the requirement for procedural intervention was associated

[1] 0TQ00ZZ, 0TQ10ZZ: Repair Right and Left Kidney, Open Approach; 0TQ30ZZ, 0TQ40ZZ: Repair Right and Left Kidney Pelvis, Open Approach; 0TT00ZZ, 0TT10ZZ: Resection of Right and Left Kidney, Open Approach; 0TB00ZX, 0TB10ZZ: Excision of Right and Left Kidney, Open Approach; 0TD00ZZ, 0TD10ZZ: Extraction of Right and Left Kidney, Open Approach.

Table 1 Characteristics of renal injury patients

	No intervention $n=4656$	Intervention $n=220$	Total $n=4876$	p value
Gender (%)				
Male	3349 (95)	176 (5)	3525	0.009
Female	1307 (97)	44 (3)	1351	
Race (%)				
White	3132 (97)	93 (3)	3225	< 0.001
Black	717 (89)	85 (11)	802	
Other	807 (95)	42 (5)	849	
Age group (%)				
< 16	470 (98)	10 (2)	480	< 0.001
16–20	564 (94)	39 (6)	603	
21–44	1976 (94)	126 (6)	2102	
45–64	1010 (97)	29 (3)	1039	
65+	636 (98)	16 (2)	652	
Trauma type (%)				
Blunt	4095 (98)	83 (2)	4178	< 0.001
Penetrating	525 (79)	136 (21)	661	
Other	36 (97)	1 (3)	37	
ISS (%)				
1–8	740 (99)	8 (1)	748	< 0.001
9–15	1163 (98)	19 (2)	1182	
16–24	1333 (97)	47 (3)	1380	
25+	1420 (91)	146 (9)	1566	
AAST renal injury grade (%)				
I	999 (95)	67 (6)	1048	0.838
II	1038 (95)	52 (5)	1090	
III	1391 (96)	60 (4)	1451	
IV	875 (95)	45 (5)	920	
V	353 (96)	14 (4)	367	
Trauma center level				
I	2447 (95)	130 (5)	2557	0.060
II	977 (96)	40 (4)	1017	
III	179 (99)	2 (1)	181	
Unknown	1053 (96)	48 (4)	1101	
Intervention type[a] (%)				
Surgery	0	191 (87)		
Angioembolization	0	29 (13)		

[a]Three renal trauma patients underwent both surgery and angioembolization. For purposes of analysis, these cases were categorized within the surgery group

Table 2 Patient outcomes by intervention

	No intervention $n=4656$	Embolization $n=29$	Surgery $n=191$	Total $n=4876$	p value
ER disposition (%)					
Floor	1477 (32)	3 (10)	3 (2)	1483 (30)	< 0.001
ICU	1721 (37)	15 (52)	17 (9)	1753 (36)	
OR	1075 (23)	9 (31)	170 (89)	1254 (26)	
Home	39 (1)	0	0	39 (1)	
Dead	112 (2)	0	0	112 (2)	
Other	232 (5)	2 (7)	1 (1)	235 (5)	
Hospital disposition (%)					
Home	2843 (61)	15 (52)	114 (60)	2972 (61)	< 0.001
Facility	1073 (23)	6 (21)	33 (17)	1112 (23)	
Dead	265 (6)	6 (21)	39 (20)	310 (6)	
Other	475 (10)	2 (7)	5 (3)	482 (10)	
Died under care (%)					
No	4279 (92)	23 (79)	152 (80)	4454 (91)	< 0.001
Yes	377 (8)	6 (21)	39 (20)	422 (9)	

with a significantly higher likelihood of death under care (OR 2.92; 95% CI 2.07–4.12; $p < 0.001$). Compared to blunt injuries, penetrating injuries also had a higher likelihood of death under care (OR 1.68; 95% CI 1.30–2.16; $p < 0.001$). An ISS above 15 was highly predictive of mortality, particularly with a score of 25 or higher (OR 53.5; 95% CI 19.9–144; $p < 0.001$). Age was also significantly associated with higher mortality, with odds ratios progressively increasing with groups over 20 years of age, using age < 16 years as the referent. There was no significant association between gender and death under care. AAST renal injury grade was also not significantly associated with death under care. Patients of black race were significantly more likely to die under care compared to those of other races (OR 1.59; 95% CI 1.23–2.04; $p < 0.001$).

Multiple logistic regression identified black race, age greater than 45 years old, penetrating trauma, and ISS > 15 to be independent predictors of death under care (Table 4 and Fig. 1). A high ISS was the most predictive of the likelihood that a patient would die after arriving to the hospital. Neither AAST renal injury grade nor a procedural intervention was associated with a significantly higher likelihood of death under care in the multivariable model.

Comments

Traumatic renal injury is a relatively rare event, with the vast majority of cases managed without emergent procedural intervention. Our data show that 0.49% (4876/1,004,440) of all trauma patients are diagnosed with injury to the kidney, slightly lower but still consistent with past studies estimating 1–5% of traumatic injuries resulting in renal injury [9, 11]. Over 90% (4656/4876) of our identified cases were managed without angioembolization or open surgery. In a study by Wright et al. [11] that examined the NTDB from 1994 to 2003, nearly 11% of patients with traumatic renal injury underwent some form of operative management. However, for the 2017 NTDB patients in our study, only 3.9%

Table 3 Simple logistic regression models for death under care

	OR (95% CI)	*p* value
Gender		
Male	Reference 1.0	
Female	0.90 (0.72–1.13)	0.367
Race		
White	Reference 1.0	
Black	1.59 (1.23–2.04)	< 0.001
Other	1.14 (0.87–1.50)	0.331
Age group		
< 16	Reference 1.0	
16–20	1.56 (0.92–2.65)	0.101
21–44	1.95 (1.24–3.07)	0.004
45–64	2.39 (1.49–3.83)	< 0.001
65+	2.54 (1.55–4.17)	< 0.001
Injury type		
Blunt	Reference 1.0	
Penetrating	1.68 (1.30–2.16)	< 0.001
Other	1.40 (0.49–3.96)	0.532
ISS		
1–8	Reference 1.0	
9–15	1.75 (0.55–5.51)	0.341
16–24	8.01 (2.90–22.17)	< 0.001
25+	53.5 (19.9–144)	< 0.001
AAST grade		
I	Reference 1.0	
II	0.95 (0.69–1.30)	0.730
III	1.18 (0.89–1.57)	0.261
IV	1.15 (0.84–1.58)	0.377
V	1.25 (0.83–1.88)	0.289
Intervention		
No intervention	Reference 1.0	
Intervention	2.92 (2.07–4.12)	< 0.001
Intervention type		
No intervention	Reference 1.0	
Embolization	2.96 (1.20–7.32)	0.019
Surgery	2.91 (2.02–4.20)	< 0.001

Table 4 Multiple logistic regression model for death under care

	OR (95% CI)	*p* value
Race		
White	Reference 1.0	
Black	1.43 (1.06–1.94)	0.021
Other	1.08 (0.81–1.45)	0.603
Age group		
< 16	Reference 1.0	
16–20	0.91 (0.52–1.60)	0.734
21–44	1.18 (0.73–1.91)	0.511
45–64	2.06 (1.25–3.39)	0.005
65+	3.61 (2.12–6.16)	< 0.001
Injury type		
Blunt	Reference 1.0	
Penetrating	1.51 (1.08–2.10)	0.015
Other	2.51 (0.71–8.90)	0.154
ISS		
1–8	Reference 1.0	
9–15	1.79 (0.57–5.66)	0.319
16–24	8.85 (3.19–24.6)	< 0.001
25+	63.60 (23.05–172.2)	< 0.001
AAST grade		
I	Reference 1.0	
II	0.88 (0.63–1.24)	0.463
III	1.26 (0.92–1.71)	0.150
IV	1.19 (0.85–1.68)	0.312
V	1.30 (0.83–2.04)	0.250
Intervention type		
No intervention	Reference 1.0	
Embolization	1.64 (0.62–4.34)	0.315
Surgery	1.19 (0.78–1.83)	0.418

(191/4876) of patients underwent open surgery. Furthermore, intervention rates across AAST renal injury grades were not significantly different. These findings reflect the literature supporting NOM for renal trauma, even for high-grade and penetrating trauma [4], and suggests that clinical practice is adjusting accordingly.

Despite the relative rarity of renal trauma, its overall mortality rate is still significant. We found that 8.7% (422/4876) of patients who sustained a traumatic renal injury died after presenting to the emergency department or being admitted to the hospital. Our multivariate analysis of the data show that several parameters were independent predictors of death under care: ISS, age, trauma type, and race. That emergency intervention alone is not an independent predictor of death under care, despite its association with a higher mortality rate, suggests its appropriate reservation for the sickest patients.

The independent predictors of death under care are consistent with previous studies of renal trauma and trauma in general. It is unsurprising that a patient's ISS was most predictive of mortality, as the score estimates overall injury severity and can incorporate multiple injuries to more than one area of the body [14]. Similarly, age as a predictor for death under care follows rationale that there is a lower tolerance for trauma in older patients. For patients in our study older than 45 years of age, the odds ratio of death under care rose above two times that of our reference population. This is consistent with a 2005 study by Kuhne et al., which found age above 56 years to be associated with a significant increase in mortality, independent of ISS [15]. With regards to trauma type, we found penetrating injury to be an independent predictor of death under care. It follows that the

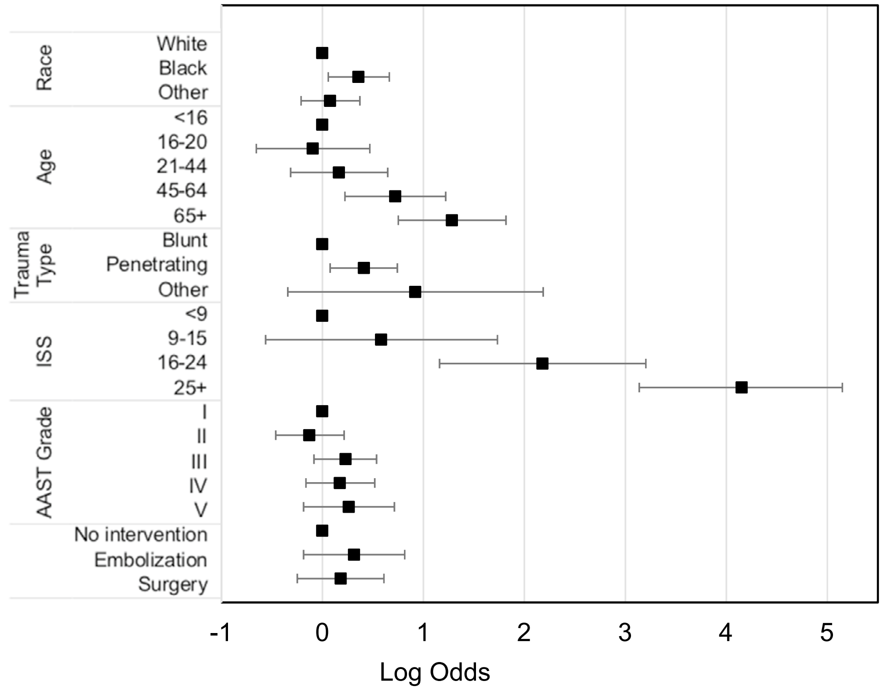

Fig. 1 Multiple logistic regression model of death under care. Reference values: race = white, age < 16, trauma type = blunt, ISS < 9, AAST = 1, and no intervention

trauma type associated with a higher rate of operative management [6, 7] would be predictive of higher death under care. Further confirming this notion, the meta-analysis of renal trauma performed by Mingoli et al. [4] showed that the overall mortality rate for penetrating trauma to be nearly twice that of blunt trauma. Finally, our multiple logistic regression found black race to be a significant predictor of death under care. A meta-analysis by Haider et al. demonstrated the significant disparities of trauma outcomes by race across multiple studies, with the majority of studies showing black race to be an independent predictor of higher mortality in trauma [16]. Among other variables, Haider et al. suggested various prehospital factors, such as access to emergency services, hospital transit time, and resource level of hospitals, as possible reasons for disparities that could be applicable to patients of black race in our study.

A limitation of our study is that patients who were identified as sustaining renal trauma did not necessarily suffer from isolated kidney injury. The performance of a renal intervention, such as open surgery, may have been initially driven by other abdominal injuries. The difficulty in extracting the primary driver of renal intervention is an intrinsic limitation of the NTDB. Similarly, as death under care was significantly associated with ISS and not with renal injury grade, mortality rates were likely driven by concomitant injuries outside of renal trauma. However, while controlling for severe concomitant injuries, our analysis demonstrated that increasing renal injury severity was not associated with an increased likelihood of mortality in the ED or hospital.

Conclusions

Determining the independent predictors of death under care in renal trauma does not imply the need for changes to current guidelines of initial management [17]. However, understanding the increased likelihood of adverse outcomes in a patient with certain risk factors, such as an older patient with a penetrating renal injury, can help one anticipate the level of care or urgent treatment that may be required during admission. Furthermore, the confirmation that race plays a role in the seemingly equalizing environment of trauma should spur further investigation of the racial disparities that exist in the continuum of trauma care.

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Compliance with ethical standards

Conflict of interest The authors declare that they have no conflict of interest.

Research involving human participants and/or animals This is a retrospective analysis of a national trauma data registry that contains de-identified information.

Informed consent No identifying details of individuals are included in this manuscript.

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