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Contemporary Trends in the Immediate Surgical Management of Renal Trauma Using A National Database

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Abstract

Background—The National Trauma Data Bank was utilized to analyze open surgical management of renal trauma during the first 24 hours of hospital admission, excluding those who were treated with conservative measures. A descriptive analysis of initial management trends following renal trauma was also performed as a secondary analysis.

Methods—Using the NTDB, patients with renal injuries were identified, and AIS codes were stratified to a corresponding AAST renal injury grade. Trends in initial management were assessed using the following initial treatment categories: observation, minimally invasive surgery, and open renal surgery. Analysis of initial open surgery was further examined according to etiology of injury (blunt vs. penetrating), type of open renal surgery, concomitant abdominal surgery, patient demographics, and time to surgery.

Results—9,002 renal injuries (0.3%) mapped to an AAST renal grade. Of these, 1,183 patients underwent open surgery for their renal injury in the first 24 hours. There were 773 penetrating and 410 blunt injuries within this cohort. The majority of surgical patients sustained a high-grade renal injury (AAST 4–5: 64%). The overall nephrectomy rate in the first 24 hours was 54% and 83% for the penetrating and blunt groups, respectively. While the overall nephrectomy rate for AAST 1–3 renal injuries in the first 24 hours was low (1.8%), the nephrectomy rate was higher in the setting of an exploratory laparotomy (30%). Of those undergoing renal surgery in the first 24 hours, 86% had concomitant surgery performed for other abdominal injuries. Mean time from ED presentation to surgery was less for penetrating trauma.

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Conclusions—Of patients requiring open surgery for renal trauma within 24 hours of admission, nephrectomy is the most common surgery. Continued effort to reduce nephrectomy rates following abdominal trauma are necessary.

Level of Evidence—III (exploratory cohort analysis, nonrandomized)

Keywords

kidney; trauma; surgery; early intervention

Introduction

The treatment of renal trauma follows one or a combination of the following pathways: observation only, minimally invasive intervention, or open operative intervention. Observation entails bed rest and monitoring of hemodynamic and laboratory parameters to assess for ongoing hemorrhage or urinary extravasation. If observation fails, patients commonly proceed to minimally invasive or open surgical intervention. Options for minimally invasive therapy are driven by the nature of injury. For example, angioembolization is a minimally invasive approach for persistent arterial bleeding from the injured kidney. Ureteral stent placement, perinephric drain placement, or percutaneous nephrostomy tube placement can be utilized for collecting system injuries (i.e., urinoma). Open operative interventions include nephrectomy, partial nephrectomy, or renorrhaphy.

Observation with hemodynamic monitoring is the preferred initial management of renal trauma if the patient is hemodynamically stable. In a recent review of 3,528 renal injuries, 90% of renal units were managed without open surgical intervention[5]. According to the 2004 trauma consensus guidelines for renal trauma, absolute indications for intervention include the following: persistent life-threatening hemorrhage; renal pedicle avulsion (grade 5 injury); or an expanding, pulsatile hematoma[6].

Given improved dissemination of renal trauma guidelines and advances in minimally invasive treatment such as angioembolization for the treatment of renal trauma, a recent updated analysis of the NTDB revealed that only 8% of patients required a nephrectomy[7, 8]. In the present paper, we present a descriptive analysis of patients who required surgical intervention for renal trauma during the first 24 hours of admission.

The NTDB is a robust source for population-based analysis of trauma that also provides information on time following index admission. Using this database, trends in initial management will be assessed using the following initial treatment categories: observation, minimally invasive surgery, and open renal surgery. Initial surgical management in the first 24 hours will be stratified by injury mechanism (blunt vs. penetrating). Analysis of open surgery will be further examined according to injury grade and type of renal surgery, concomitant abdominal surgery, patient demographics, and time to surgery.

Methods

Data Source

The NTDB is a multi-institutional trauma registry dataset managed by the American College of Surgeons that contains trauma admissions from participating Level 1–4 trauma centers throughout the United States and Puerto Rico[9]. The dataset includes extensive socio-demographic, clinical, insurance, charges, cost and disposition data from initial evaluation until discharge or death during the index hospitalization. All submitted reports are reviewed for completeness of data and information is resubmitted if data fields are missing. Once

fields are complete, the data fields are iteratively reviewed and validated. Fields are set to missing if there is ambiguity. We assessed records in the NTDB from 2002–2007. This study received a Certificate of Exemption from the University of Washington Human Subjects Institutional Review Board (UW HSD 39251).

Subjects and Method of Classification

The American College of Surgeons permits renal injuries to be coded by International Classification of Disease-9 (ICD-9) or Abbreviated Injury Scale (AIS) codes. ICD-9 codes do not allow sufficient determination of AAST renal injury grade; therefore, patients with only ICD-9 codes were excluded. We do not feel that exclusion of patients with ICD-9 codes will affect our data, as hospital utilization of either coding system was random. To confirm this hypothesis, a sensitivity analysis comparing those renal injuries that mapped to an AAST grade and those without an AAST grade (i.e., ICD-9 code) showed no significant difference between the two groups.

Renal AIS codes were mapped to AAST renal injury grades by methods previously described[10–12]. Kidney injuries were categorized by AAST grades (Grade 1 - AIS code 541612, Grade 2 – AIS code 541622, Grade 3 – AIS code 541624, Grade 4 – AIS code 541626, Grade 5 – AIS codes 541628). Buckley and McAninch recently proposed a revision of the 1989 renal AAST classification system[5]. Proposed changes to the 1989 grading system include stratifying grade 4 injuries into deep parenchymal injuries with collecting system involvement, isolated collecting system injuries (i.e., renal pelvis or UPJ), and segmental arterial and venous injuries. ICD-9 codes do not allow sub-stratification of these grade 4 injuries; therefore, the original 1989 AAST classification system was used[12]. After identification of renal injury grades, patients were further grouped by mechanism of injury (blunt vs. penetrating).

Patients were stratified into three groups according to the method of management during the first 24 hours after emergency department admission. These groups include the following: (1) open renal surgery (ICD 9 codes: nephrectomy 55.5–55.54, partial nephrectomy 55.4, suture of kidney laceration/renorrhaphy 55.81, nephrotomy 55.01, or other open kidney operation 55.89), (2) minimally invasive procedure (ICD9 codes: diagnostic renal angiography 88.45, selective renal angioembolization 38.86, ureteral stent 59.8, retrograde nephroureterogram 87.74, percutaneous nephrostomy tube 55.02, 55.03, 55.92 and 55.93, and ureteroscopy 56.31), and (3) observation (i.e., no intervention). Basic demographics of the three cohorts (observation, minimally invasive surgery, and open surgery) were examined for the following: age, gender, Injury Severity Score (ISS), concomitant open abdominal surgeries, length of index hospitalization, and length of ICU stay (Table 1). We defined observational management as a lack of minimally invasive or open surgical intervention during the first 24 hours after emergency department admission. Four patients who had initial operative intervention were excluded from further analysis, as no mechanism of injury was available for our review. The types of open surgical procedures were examined. The median time to surgery for blunt and penetrating cohorts was also assessed, as well as the hemodynamic stability of patients at the time of presentation.

Statistical Analysis

The table was generated stratifying demographic, trauma, hospital and clinical characteristics by type of surgical management. Chi-squared analyses were used for categorical variables and student's t-test for continuous variables. All analyses were performed in STATA11 (College Station, TX).

Results

Of 3,247,955 trauma injuries available for review in the NTDB from 2002–2007, 9,002 renal injuries (0.3%) were identified and mapped to an AAST renal grade.

The vast majority (80%) of initial renal trauma management was observation (Table 1). Relative to the initial observation cohort, patients in the initial minimally invasive and initial open surgery cohort had a higher median ISS, were more commonly hypotensive (SBP < 90 mmHg) at admission, and their median hospital LOS was more prolonged. Active intervention in the first 24 hours via open surgery or minimally invasive therapy also increased as renal AAST grade rose, while non-interventional observation decreased with increasing AAST grade. Mortality was highest in the surgical cohort; however, the majority (64%) of AAST 5 renal injuries were in this group.

Minimally invasive therapy was utilized during the first 24 hours at a rate of 6.7% (Table 1). AAST renal grade 2–4 injuries (80%) were the most common injuries managed in a minimally invasive manner. Roughly 80% of injured renal units were managed in an observational manner (i.e., no active intervention) during the first 24 hours following emergency department admission. As would be expected, the majority of the injured renal units in this cohort were AAST 1–3 injuries (88%). The overwhelming majority of these injuries in the minimally invasive and observation cohorts were secondary to a blunt etiology.

Overall, 1,183 patients with an identifiable mechanism of injury were treated with initial surgical management. More patients with penetrating renal injury underwent initial open surgical management (773 penetrating vs. 410 blunt).

Eighty-six percent of patients in the open surgery group had a concomitant abdominal surgery in the first 24 hours. After 24 hours, only 65% of patients had concomitant abdominal surgery during renal surgical interventions.

Nephrectomy was performed following all grades of renal injury (AAST 1–5) within the blunt and penetrating cohorts (Figures 1 and 2). Across all renal injury grades, a blunt etiology correlated with a higher nephrectomy rate when compared to penetrating trauma (83% vs. 54%, $p < 0.0001$). Nephrectomy was not a rare event among AAST 1–3 renal injuries. Among low- to intermediate-grade renal injuries (AAST 1–2 and 3), 23.5% and 65.7% of renal injuries resulted in nephrectomy for the penetrating and blunt cohorts, respectively. Renorrhaphy and partial nephrectomy were used sparingly across all injury grades. ‘Other surgery’ was performed commonly in the AAST 1–3 cohort, which likely represents retroperitoneal exploration and renal exploration without renal intervention. None of the patients with this surgical cohort had nephrectomy or partial nephrectomy/renorrhaphy simultaneously coded; therefore, we assumed that these patients did not have partial or radical nephrectomy.

The mean time to open surgical intervention was evaluated to examine for possible differences in initial therapy based upon grade and trauma etiology. Patients with penetrating renal injury underwent operative intervention sooner than those with blunt renal injury. The overall median time to surgery was < 30 minutes and < 120 minutes in the penetrating and blunt cohorts, respectively. Overall injury severity was examined to further understand this difference. The penetrating and blunt cohorts had ISS scores of 17 and 34, respectively ($p = 0.001$). Furthermore, the blunt and penetrating groups were analyzed for hemodynamic instability as defined by a systolic blood pressure <90 mmHg. 14.2% of patients with penetrating renal injuries were hemodynamically unstable at presentation, whereas 8.36 % of patients with blunt renal injuries were hemodynamically unstable.

Discussion

Herein we present our descriptive analysis of a unique cohort of renal trauma patients: those who had renal surgery during the first 24 hours after emergency department admission. The overall nephrectomy rate in the first 24 hours among this cohort was 64%. Nephrectomy rates were higher for blunt than penetrating trauma (83% and 54%, respectively). Although no direct correlation can be inferred from our descriptive analysis, this likely reflects the higher injury grades in seen in the blunt cohort. As would be expected, the cohort that required initial surgery during the first 24 hours of admission included a predominance of severe renal injuries (82.9% AAST 4–5 blunt, 53.8% AAST 4–5 penetrating).

Nephrectomy in the first 24 hours was also performed for a noticeable amount of patients with low to intermediate grade renal injuries (AAST 1–3). Among patients with AAST 1–3 renal injuries who underwent surgery in the first 24 hours of admission, approximately 30% (129/427) underwent a nephrectomy. Fortunately, the nephrectomy rate during the first 24 hours of admission only represents 1.8% (129/7100) of all renal AAST 1–3 renal injuries among the three management cohorts; however, it can be surmised that the risk of nephrectomy, whether necessary or unnecessary, was increased in the setting of an exploratory laparotomy. In this sample, a higher percent of patients had an abdominal procedure in addition to renal surgery relative to renal surgery alone (86% vs. 65%). This analysis infers that nephrectomy risk may have been increased in the setting of exploratory laparotomy. The indication for renal exploration in this present cohort is unknown. It is possible that the nephrectomy was increased due to need for “damage control,” as reflected by the high rate of other concomitant abdominal surgeries in this cohort of patients.

Single-center studies from centers of excellence have traditionally differed from national trends. For example, 13% of patients who underwent open intervention required a nephrectomy following blunt and penetrating trauma at one well-published, center of excellence with a urology service trained in the management of renal trauma [13]. This is much lower than our series of national data, in which 64% of patients who underwent open intervention had a nephrectomy in the first 24 hours of admission. A series from a different single center that examined nephrectomy rates following *only* penetrating renal trauma noted a higher nephrectomy rate of 56%, which is closer to the rates that we report [14]. The reason for these discrepancies is unknown based on the present data. No information exists in this dataset on the role of the urology service or interventional radiology. It is unknown if the lack of partial nephrectomy within this cohort is related to surgeon expertise. Details on technical aspects renal exploration are also lacking. For instance, it is unknown if early vascular control was utilized in this cohort. Early vascular role of the renal hilum has been shown to decrease nephrectomy rates in previously published series [11].

To our knowledge, this is the first paper to describe the time elapsed between presentation to the trauma bay and surgical exploration for renal trauma. It is not surprising that penetrating injuries were explored more quickly than blunt injuries, despite a lower ISS relative to the blunt cohort. Historical guidelines emphasize the role of exploration in penetrating injuries; however, recent articles have discussed a role for observation of penetrating injuries [15, 16]. The absence of major blood loss, major intra-abdominal injury, major renal parenchymal injury, and renal vascular injury are predictors for observation following penetrating renal injury [17]. Furthermore, our analysis of hemodynamic stability at presentation showed that the penetrating cohort was more likely to be hemodynamically unstable. This data offers an alternate explanation on why patients with penetrating injuries were explored more quickly.

The findings in this paper reveal a high nephrectomy rate in patients undergoing open surgery for renal trauma within the first 24 hours of admission. While select single

institution studies have set the renal preservation bar high, a concerted effort among trauma surgeons, general surgeons, interventional radiologists, and urologists is necessary to reduce the rate of open renal intervention. Nephron preservation begins with a trial of observation, if indicated. Conservative therapy for blunt, and more recently penetrating, renal trauma is an accepted management option, with many reports espousing the benefit of this strategy to preserve renal function[18, 19]. When open surgery of renal trauma is required, nephron-preserving approaches should be considered when feasible.

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Figure 1.

Distribution of **penetrating** injuries stratified by grade and the type of open surgical treatment. The overall nephrectomy rate for this cohort was 54%.

Figure 2.

Distribution of **blunt** injuries stratified by grade and the type of open surgical treatment. The overall nephrectomy rate for this cohort was 83%.

Table 1

Demographics of the three patient cohorts.

	Conservative Management Only* N=7210 (%)	Minimally Invasive N=605 (%)	Open Operative Interventions N=1187 (%)**	p-value
Mean age, years (SD)	31 (18)	33 (18)	30 (15)	0.48
Sex (n, %)				0.0001
Female	2049 (29)	195 (32)	235 (20)	
Male	5150 (72)	410 (68)	951 (80)	
Missing	11 (0.1)	0 (0)	1 (0.08)	
Hospital Course				
Median ISS	20	26	25	<0.0001
Mean LOS, days (SD)	10.3 (15)	15.5 (17)	16.4 (21)	<0.0001
Mean ICU LOS, days (SD)	4.56 (9)	8.44 (18)	7.48 (12)	<0.0001
% Nephrectomy	N/A	14 (2.3)	760 (64)	<0.0001
Admit SBP<90	517 (8)	83 (14)	245 (21)	<0.0001
Grade (n, %)				
I	2418 (34)	89 (15)	26 (2)	<0.0001
II	2410 (33)	155 (26)	148 (13)	
III	1475 (21)	124 (21)	255 (22)	
IV	760 (11)	200 (33)	427 (36)	
V	147 (2)	37 (6)	331 (28)	
Missing	0 (0)	0 (0)	0 (0)	
Trauma Mechanism				
Blunt	6442 (89)	527 (87)	410 (35)	<0.0001
Penetrating	750 (11)	77 (13)	773 (65)	
Other	18 (0.2)	1 (0.2)	4 (0.3)	
Mortality (n, %)	698 (10)	59 (10)	219 (19)	<0.0001

* Patients who did not have active intervention in the first 24 hours after admit to the Emergency Dept.

** Four patients were excluded from this number secondary to no known mechanism of injury.