Outcomes of renal salvage for penetrating renal trauma: a single institution experience

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Introduction: *Conservative management of penetrating renal trauma is emerging, with data originating from centers with variable level of trauma care. This study reviews the outcomes of renal salvage after penetrating trauma at a level I trauma center.*

Materials and methods: *An institutional review board approved trauma registry at Saint Louis University Hospital was retrospectively analyzed, for patients with penetrating renal trauma from 2009 to 2014. Patients were divided into nephrectomy group (NG) or non-nephrectomy group (non-NG), and compared. A multi-variable analysis was performed to determine predictors of nephrectomy, with cross validation to evaluate the performance of the multi-variable model. Data was analyzed using R version 3.3.2. A p value of < 0.05 was considered as significant.*

Results: *A total of 121 patients were identified with penetrating renal trauma. Gunshot injury was the leading cause of injury (87%). Eighteen (15%) patients required nephrectomy. The overall mean injury severity score (ISS). was 20. High grade (grade 4-5) renal injuries were noted in 41 patients (34%). Among these, 14 patients (34%) underwent a nephrectomy, while 27 patients (66%) were managed conservatively to salvage renal units. CT grade of renal injury was the only predictor of nephrectomy, on multi-variable analysis (OR 17.09 CI 2.75-105.99, p = 0.002). CT grade of injury and injury severity score were predictors of endoscopic intervention on a sub group analysis of non-NG.*

Conclusions: *CT grade of injury predicts nephrectomy after penetrating renal trauma. Conservative management is a feasible option in penetrating renal trauma even with a higher grade of injury.*

Key Words: penetrating trauma, renal, nephrectomy, outcomes

Introduction

Trauma is the sixth leading cause of death worldwide. Genitourinary (GU) trauma is common in patients with multiple injuries. Approximately 10% of abdominal trauma cases have urologic organ involvement, where 24% of solid organ trauma involves kidney injury.[1] Recent epidemiological data on renal trauma revealed an overall renal injury rate of 16% from penetrating mechanisms.[2] GU trauma guidelines recommend an initial conservative approach, especially for low grade and blunt renal trauma injuries.[3] On the other hand, the recommendations for non-operative management of penetrating renal trauma are slowly emerging. Contemporary studies report nephrectomy rates varying from 15% to 54% for penetrating renal trauma.[4,5]

Postoperative renal failure remains to be the most common complication in patients who undergo nephrectomy for renal trauma.[6] Such patients are at an eight fold increased risk of renal failure, post nephrectomy.[6] These findings advocate use of non-surgical management to salvage traumatic kidneys. Current reports on outcomes of conservative management of penetrating renal trauma are limited by the number of patients.[2] On the other hand larger series are based on patients from national trauma database, which include results from level I-IV trauma centers, with varying

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degree of trauma care. This study aims to determine the outcomes of renal salvage for penetrating renal injuries from a single institution level I trauma center.

Materials and methods

Saint Louis University Hospital is an American College of Surgeons designated level I adult trauma center. The division of trauma surgery prospectively maintains a trauma registry, which was retrospectively reviewed for all penetrating renal injuries, after an institutional review board approval (IRB: 23906).

Saint Louis University Hospital serves as a level I trauma center for 12 counties of eastern Missouri and Region 4 in the state of Illinois. The trauma service treats about 2200 trauma patients each year, with the support of a dedicated trauma and critical care team. Additionally a highly specialized interventional radiology department supports the trauma team in management of complex trauma patients. Patients are primarily managed by trauma team however subspecialty consult services are obtained for relevant organ injuries. Management decisions for renal injuries were made in consultation with on-call attending urologist, when permissible, based on the clinical condition of the patient.

Patients with penetrating renal trauma from the trauma registry, between January 2009 and November 2014, were identified. Renal injuries were graded according to the American Association for the Surgery of Trauma 2004 guidelines,[7] after relevant available cross sectional imaging. Patients were divided into nephrectomy (NG) or non-nephrectomy (non-NG) groups. Both groups were compared in terms of age, gender, mechanism of injury, injury severity score

TABLE 1. **Descriptive characteristic of patients with penetrating renal trauma**

Characteristic	**All (n = 121)**	**Nephrectomy (n = 18)**	**No nephrectomy (n = 103)**	**p value**
Mean age (years)				0.59
Mean	30	30	30	
Median	27	30	26	
Gender				0.81
Male	109 (90%)	17 (94%)	92 (89%)	
Female	12 (10%)	1 (6%)	11 (11%)	
Injury severity score				0.005
Mean	20	28	18	
Median	17	32	17	
Missing	4 (3%)	0 (0%)	4 (4%)	
CT grade kidney injury				< 0.0001
1-3	67 (55%)	2 (11%)	65 (63%)	
4-5	41 (34%)	14 (78%)	27 (26%)	
Missing	13 (11%)	2 (11%)	11 (11%)	
Mechanism of injury				0.16
Non firearm	16 (13%)	0 (0%)	16 (16%)	
Firearm	105 (87%)	18 (100%)	87 (84%)	
Serum Cr on adm.				0.008
Mean	1.2	1.6	1.1	
Median	1.1	1.3	1	
Missing	3 (3%)	2 (11%)	1 (1%)	
Serum Hgb				0.23
Mean	12.3	11.6	12.5	
Median	12.6	12.2	12.6	
Missing	2 (2%)	1 (6%)	1 (1%)	
Mortality				0.06
No	115 (95%)	15 (83%)	100 (97%)	
Yes	6 (5%)	3 (17%)	3 (3%)	

TABLE 2. **Multivariable analysis of predictors of nephrectomy**

Characteristic	OR (95% CI)	p value
Age (years)	1.05 (0.98, 1.14)	0.17
Gender		0.69
Male	Reference	
Female	0.59 (0.05, 7.78)	
Injury severity score	1.02 (0.96, 1.08)	0.59
CT grade kidney injury		0.002
1-3	Reference	
4-5	17.09 (2.75, 105.99)	
Mechanism of injury		0.99
Non firearm	Reference	
Firearm	3.02* 104 (NA, NA)	
Serum Cr on adm.	2.69 (0.28, 25.97)	0.39
Serum Hgb	0.76 (0.48, 1.19)	0.23

(ISS) and associated other visceral injuries. Chi square tests were used to compare categorical variables, while Wilcoxon rank-sum tests were used to compare continuous variables. Additionally, a complete case multivariable logistic regression analysis was performed to determine the predictors of nephrectomy. To further evaluate the predictors of nephrectomy, cross-validation of the multi-variable regression model was performed to estimate its AUC, sensitivity, and specificity. Data analysis was performed using R version 3.3.2. The p value was set to < 0.05 as significant.

Results

A total of 121 patients were identified with penetrating renal trauma. The patients were predominantly male (90%) and young, with a mean age of 30 years.

TABLE 3. **Management strategies for patients without nephrectomy**

Non-nephrectomy management strategy	n = 103	%
Observation	63	61.2
CT Grade 1-3	42	
CT Grade 4-5	15	
Missing	6	
Cystoscopy + retrograde pyelogram + ureteral stent	9	8.7
CT Grade 1-3	2	
CT Grade 4-5	7	
Missing	0	
Drain placed	19	18.4
CT Grade 1-3	14	
CT Grade 4-5	3	
Missing	2	
Kidney laceration sutured	12	11.7
CT Grade 1-3	7	
CT Grade 4-5	2	
Missing	3	

Gunshot injury was the leading mechanism of penetrating renal injury (87%). Eighteen (15%) patients required nephrectomy. The mean ISS was 20 for the entire cohort. Over all high grade (grade 4-5) renal injuries were seen in 41 patients (34%). Among these, 14 patients (34%) underwent a nephrectomy, while 27 patients (66%) were managed conservatively to salvage renal units, Table 1. Multivariable analysis revealed CT grade of renal injury as the only predictor of nephrectomy following penetrating renal trauma (OR 17.09 CI 2.75-105.99, p = 0.002); Table 2. Cross-validation of the multi-variable model yielded an AUC of 0.713, a sensitivity of 0.667, and a specificity

TABLE 4. **Predictors of endoscopic intervention (nephrectomy patients excluded)**

	Estimate (odds ratio)	95% CI LB	95% CI UB	p value
Age	1.02	0.95	1.09	0.52
Gender	0.45	0.04	5.46	0.53
CT groups	3.95	1.17	13.33	0.03
Injury severity score	1.05	1.00	1.12	0.04
Firearm	0.47	0.08	2.73	0.40
Serum.Cr. on adm.	2.03	0.24	17.29	0.52
Serum Hgb on adm.	0.97	0.67	1.41	0.89

of 0.718. Regarding non nephrectomy management, observation was performed in 63 patients (61%), followed by drain/nephrostomy placement in 19 patients (18%), Table 3. CT grade of injury and ISS were predictors of endoscopic intervention on a sub group analysis of non-NG, Table 4.

Discussion

Management of renal trauma has undergone considerable change, with successful utilization of conservative approach, even for advanced renal injuries in hemodynamically stable patients. This is well established for blunt trauma however the evidence for penetrating injuries is still emerging.[8] This study presents data from a level I trauma center, where high volume of trauma are managed with appropriate intensive monitoring and minimally invasive intervention. The study noted gunshot wounds to be the most common mechanism of penetrating trauma, with a nephrectomy rate of 15%, despite the fact that at least one third of the injuries were grade 4 or more. Among the high grade injuries, 64% of the patients were saved from undergoing a nephrectomy.

Two largest series reporting penetrating renal trauma, utilized the National Trauma Databank. Wright et al, reported a nephrectomy rate of 21% for 1573 penetrating trauma patients, while McClung et al reported a 26% rate for 1600 patients from a later era (2002-2007).[5,9] In both studies the nephrectomy group had 80% grade 4-5 renal injuries, which may explain their higher nephrectomy rates, compared to this study. Interestingly 71% of the nephrectomies were performed at level I trauma center. The largest single institution series of 582 patients with penetrating trauma reported a 20% nephrectomy rate, with 51% grade 4-5 renal injuries.[9] Our study reports a lower single institution nephrectomy rate however our number of patients is limited and does not span over a 13 year period. Higher nephrectomy rates are reported by other single institution series compared to our results, Table 5. The reasons for lower nephrectomy rates in our series are possibly attributed to a smaller patient cohort, and fewer high grade injuries, contrary to what is seen in larger data sets.

Dagenais et al reported an increasing trend in utilization of non-operative management for renal trauma across US, with an increase of 24.8% over an 11 year period.[10] The study was based on the pooled data, with a large representation of community hospitals. Based on the renal trauma volume, the study reported that intermediate trauma centers (15-20 renal trauma cases per year) were more likely to receive high grade renal injuries and penetrating trauma. Additionally patients at high level trauma centers (> 20 renal trauma cases per year) were significantly less likely to undergo surgical intervention compared to low or intermediate care centers (12.6% versus ~30%). These findings validate our lower nephrectomy rates, being a level I trauma center.

Complications of renal trauma remain to be the pivotal factor, which supports observational approach, to avoid nephron loss. Starnes et al reported 6.2% of kidney related complications for penetrating renal trauma.[6] Renal failure had a higher association with nephrectomy, compared to any other therapeutic intervention. Interestingly no difference in complication outcomes were noted between non-exploration versus exploration of kidneys after severe renal trauma, however complication rates were better for

TABLE 5. **Contemporary series with data on penetrating trauma**

Author name	Patients (renal units)	Non-operative management (%)	Operative (%)	Nephrectomy (%)	High grade renal injury (%)
Bjurlin et al[14]	94 (95)	37 (40)	57 (60)	21 (22)	33 (35)
McClung et al[5]	1600	750 (47)	773 (48)	416 (26)	416 (26)
Moolman et al[13]	70 (75)	49 (65)	25 (33)	18 (24)	NR
Kansas et al[15]	93	19 (20)	74 (80)	44 (47)	34 (37)
Starnes et al[6]	582	292 (50)	290 (50)	146 (25)	132 (22)
Buckley et al[16]	87	11 (10)	77 (89)	15 (17)	87 (100)
Wright et al[9]	1573	1003 (64)	570 (36)	333 (21)	486 (31)
Voelzke et al[4]	201 (206)	71 (34)	135 (66)	30 (15)	77 (37)
Current study	121	63 (52)	40 (25)	18 (15)	41 (34)

non-exploration group with minor or moderate renal trauma. These findings advocate the observational approach towards management of penetrating renal trauma.

Interventional radiology and minimally invasive techniques to manage urine leaks have evolved as successful alternatives for open exploration. Super selective angioembolization helps to control an isolated bleed, hence sparing adequate nephrons for normal renal functions in future.[11] Manker et al reported a 27% failure rate of angioembolization that lead to nephrectomy, during non-operative management of blunt renal trauma.[12] Moolman et al reported only four patients with delayed hematuria after penetrating renal trauma, which were successfully managed with angioembolization.[13] Failed cases required higher blood transfusions within the first 24 hours. Such advancements, available at specialist centers, have certainly improved the outcomes of non-operative management. Additionally, utilization of intensive care facilities also maintains minimal use of exploration. Altogether such advancement in management of trauma patients has given rise to lower nephrectomy rates, as evidenced by current study.

The results from our study will have to be carefully considered due to some limitations. Retrospective nature is an inherent limitation of this study. Additionally this study is also limited in the number of patients. The grade of renal injury is reported by radiologists, hence can be subject to a bias, as no inter-rater reliability was established. Unfortunately our study does not report long term renal functions and outcomes of this patient cohort, which remains to be the focus of future work. Interestingly urologists were not involved in all cases of decision making. Due to the retrospective nature of the study we cannot determine if the final outcomes differed between a urologist versus a non-urologist when making a management decision in acute trauma setting. This also remains to be a key emphasis of a future study. Lastly our outcomes are based on the experiences of a level I trauma center, hence applicability of our results for community hospitals will have to be considered with caution.

Conclusion

The role of conservative management of penetrating renal trauma is emerging. A high number of high grade injuries can be managed conservatively. CT grade of renal injury is a predictor of subsequent nephrectomy and endoscopic intervention. □

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