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Readmission After Treatment of Grade 3 and 4 Renal Injuries At A Level 1 Trauma Center: Statewide Assessment Using The Comprehensive Hospital Abstract Reporting System

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Abstract

Purpose—One criticism of the existing renal trauma research is the limited outpatient follow-up after index hospitalization. We assessed readmission rates following treatment for AAST grade 3 and 4 renal injury using the Comprehensive Hospital Abstract Reporting System (CHARS).

Materials and Methods—We evaluated all patients with AAST grade 3 and 4 renal injuries admitted to Harborview Medical Center (HMC) between 1998–2010, the only level 1 trauma center in Washington state. Grade 4 renal injuries were stratified by collecting system laceration (CSL) or segmental vascular injury (SVI). Data was abstracted from the CHARS database for readmissions to any Washington State hospital within six months of renal injury. Clinical variables, diagnoses, and procedures were queried based on ICD-9 codes.

Results—477 grade 3 and 159 grade 4 renal injuries were initially treated at HMC. On admission, 111 patients required intervention: 75/477 (16%) grade 3 and 36/159 (23%) grade 4 injuries. Within six months of index hospitalization, 86/477 (18%) grade 3 and 38/159 (24%) grade 4 patients were readmitted to any WA state hospital. 80% of grade 3 injuries and 66% of grade 4 injuries returned to HMC compared to secondary hospitals ($p=0.08$). At readmission, 19/86 grade 3 (22%) and 16/38 grade 4 (42%) injuries had a urologic diagnosis. Subsequent procedural intervention was required on readmission in 6/86 (7%) of grade 3 and 5/38 (13%) of grade 4 renal injuries (all CSL injuries).

Conclusions—A subset of patients treated for grade 3 and 4 renal trauma will be readmitted for further management. While urologic diagnoses and additional procedures may be low overall, readmission to outside hospitals may preclude accurate determination of renal trauma outcomes. Based on these data, patients with grade 4 CSL injuries appear to be at the highest risk for readmission and to require a subsequent urologic procedure.

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CONFLICTS OF INTEREST:

None.

MEETINGS PRESENTED:

None.

INTRODUCTION

Trends in renal trauma management have changed considerably since the AAST renal trauma grading system was developed(1) with many institutions now employing non-operative or conservative therapies, even in high-grade injuries.(2–5) As renal trauma grading continues to evolve, evidence based management of renal trauma focusing on outcomes is of paramount importance. Further, accurate long-term follow up after renal trauma management is essential to detect injury sequelae including urinoma, infection, and hypertension. Unfortunately, there is limited data regarding management efficacy following initial management after renal trauma with previous authors noting wide variance in follow-up visits (6–94%).(4, 6–16) A major reason for this is the regionalization of trauma care, which may limit a patient's ability to comply with follow-up given the distance of travel from the patient's home. We hypothesize that examining outcomes based on the index institution alone may be insufficient, as some patients might present to a local hospital following discharge rather than the index trauma center. These readmissions to different hospitals will result in missed outcomes and an inaccurate perception of effective renal trauma management..

We chose to examine this hypothesis at Harborview Medical Center (HMC), the only level I trauma center in Washington State, allowing the unique opportunity to capture all renal injuries of interest admitted to the sole level I trauma center. Using HMC as the index institution, we examined readmission rates in renal trauma patients using the Comprehensive Hospital Abstract Reporting System (CHARS), a database that tracks hospital admissions across Washington State. Specifically, we focused on any readmissions within six months of renal trauma management in AAST grade 3 and 4 renal injuries (with or without concomitant injuries), as these are most likely to require readmission. Clinical variables including diagnoses and procedures were queried based on ICD-9 codes using the CHARS database.

MATERIALS AND METHODS

Index admission

Institutional review board approval was obtained from the Washington State Department of Social and Health Services (D-020110-H) and University of Washington IRB (38206). HMC is the only level one trauma center in a five state region, with ~5,000 trauma admissions per year and ~2% experiencing renal trauma.(17) Patients with AAST grade 3 and 4 renal injuries between 1998–2010 were identified utilizing the HMC trauma registry. (17) Grade 5 injuries were excluded as they are more commonly associated with nephrectomy. Grade 4 renal injuries were grouped into collecting system laceration (CSL) or segmental vascular injury (SVI), (excluding main vessel injury with contained hemorrhage) following review of their available radiographic imaging. When imaging was not available (i.e., nephrectomy in absence of preoperative imaging), operative findings were used for grading purposes. Age, sex, trauma etiology (blunt vs. penetrating), initial management of renal injury, length of stay, and deaths were evaluated during the index hospitalization. Patients living outside of Washington State at time of admission were excluded from the analysis.

Readmission

Follow up data was abstracted from the Comprehensive Hospital Abstract Reporting System (CHARS, www.doh.wa.gov), an inpatient hospital coding discharge database spanning Washington State. Based upon the known HMC hospitalizations of grade 3 and 4 renal trauma patients, we queried the CHARS database for any readmissions of these patients within six months of initial injury. Queried variables included time to readmission following initial discharge from HMC, urologic diagnoses, urologic-related procedures, and death. Readmission diagnoses and procedures were queried based on appropriate genitourinary ICD-9 codes (Supplemental Table 1). Urologic readmission diagnoses included acute renal failure (584), acute pyelonephritis (590.1), other pyelonephritis (590.8), infections of the kidney (590), hydronephrosis (591), other ureteric obstruction (593.4), UTI site not specified (599.0), hematuria (599.7), unspecified disorder of kidney/ureter (593.9), kidney, other (593.89), hematoma without rupture of capsule (866.01), laceration (866.02), open/complete disruption of parenchyma (866.13). Queried readmission interventions included open (any open kidney surgery), endoscopic (ureteral stenting), interventional radiology procedures (percutaneous interventions). We could not accurately track if abdominal CT scans were performed on readmission due to urologic diagnoses and therefore this variable was excluded. Statistical analysis was performed using unpaired t-tests with unequal variances for continuous variables and Chi-square test for categorical variables as appropriate (STATA software, version 13, College Station, TX).

RESULTS

Index admission data

A total 636 patients with AAST grade 3 and 4 renal injuries were admitted to HMC during the 12-year study period. The majority of patients were male, presented with blunt trauma, and experienced grade 3 renal injuries (Table 1). Mean age was similar between grade 3 and 4 renal trauma patients (range 31–33). On index admission, grade 4 trauma patients required more admission procedures compared to grade 3 trauma ($p=0.047$). Open procedures were more common in grade 3 trauma. Interventional radiology (IR) procedures were performed only in grade 3 renal trauma patients, while endoscopic procedures (ureteral stenting) were performed only in grade 4 trauma patients. There were no differences in length of stay or death rates between grade 3 and grade 4 renal trauma.

Stratified grade 4 admission data revealed no differences in age, gender, or nature of injury (open vs. blunt) (p -values in grey, Table 1). Admission procedures were significantly more common in the CSL group ($p=0.004$), and they were primarily endoscopic in nature. Open procedures were similar between the two grade 4 cohorts with no IR procedures performed. Length of stay and death rates were also similar. A summary of selected admission procedures comparing grade 3 vs. stratified grade 4 is shown in Table 2.

We performed an exploratory analysis to evaluate whether year of admission affected management of renal trauma patients with a focus on major open, endoscopic, and IR interventions (Table 3). The cohort was grouped *a priori* by admission year into tertiles (1998–2001, 2002–2005, 2006–2010), as a fellowship-trained trauma/reconstruction

urologist began working at HMC in 2002. We noted a significant decrease in admission procedures over time (26%, 16%, 12%, respectively, $p=0.002$). Renorrhaphies were more common in the 1998–2001 grouping, while partial nephrectomies was more common in the 2002–2005 group (both NS). Admission IR procedures were more common in the earlier of the two groupings. Additionally, there was a trend over time with fewer trauma nephrectomies ($p<0.001$), while there was an increase in endoscopic procedures performed ($p=0.003$).

Readmission data

The overall readmission rate (with or without a urologic diagnosis as part of readmission) to any WA state hospital among patients with an AAST grade 3 and 4 injury was 20% (86/477 grade 3 (18%) and 38/159 grade 4 (24%)) (Table 4). Most patients returned to HMC; however, 20% (17/86) of patients with a grade 3 renal injury and 34% (13/38) of patients with a grade 4 renal injury were readmitted to an outside hospital. Of those readmitted, 28% (35/124) had a urologic diagnosis including 22% (19/86) of grade 3 injuries and 42% (16/38) of grade 4 injuries (Table 4). The majority of these patients returned to HMC (26/35, 74%).

Urologic diagnoses at readmission included acute renal failure (7), UTI site not specified (7), hematuria (5), pyelonephritis (5), kidney, other (3), and unspecified disorders of kidney/ureter (3). Average time to readmission did not vary significantly between grade 3 and 4 renal trauma patients; however, multiple readmissions were more common in grade 4 patients (34% [13/38] vs. 26% [22/86], $p=0.09$). Urologic diagnoses at time of readmission did not vary by readmission site ($p=0.93$). Urologic interventions on readmission were performed in 7% (6/86) of grade 3 injuries (3 ureteral stents, 3 percutaneous interventions) and 13% (5/38) of grade 4 injuries (2 ureteral stents, 3 percutaneous interventions) ($p=0.53$).

Stratified grade 4 renal trauma data revealed a similar percentage of grade 4 CSL (23/95, 24%) and SVI (15/64, 23%) patients were readmitted with the majority of patients returning to HMC (25/38, 66%) (p-values in grey, Table 4). There was no difference in multiple readmissions or time to readmission; however, a trend towards earlier presentation in grade 4 SVI patients was seen at outside hospitals ($p=0.08$). Urologic diagnoses on readmission were more common in the CSL cohort and in those patients readmitted to HMC. Diagnoses among the grade 4 CSL cohort included: infection of the kidney (4), hematuria (3), acute renal failure (3), other (3), acute pyelonephritis (2), hydronephrosis (1), other ureteric obstruction (1), and laceration (1). Two patients in the grade 4 SVI cohort were readmitted with a urologic diagnosis (2/15, 13%), one with acute renal failure, while the other was not quantified. Adjuvant procedures were required only in CSL cohort (5/23, 22%) and included 2 endoscopic (2/23, 9%) and 3 IR (3/23, 13%) procedures.

When stratified by year of admission, readmission rates were not significantly different in either grade 3 vs. grade 4 or grade 4 CSL vs. grade 4 SVI comparisons ($p=0.27$ and $p=0.21$, respectively, data not shown). In those admitted with a urologic diagnosis and who underwent a readmission procedure, no significant differences were seen (grade 3 vs. grade 4: $p=0.39$; grade 4 CSL vs. grade 4 SVI: $p=0.08$, data not shown).

Table 5 outlines the association of readmission relative to age, gender, type of injury, and assorted readmission procedures. We found ‘any admission procedure’ was significantly associated with readmission and specifically in those with grade 4 CSL injuries. We found no significant differences in readmissions based on the remainder of the categories. Given the overall small event rate, multivariate analysis was not performed. Complete data for those patients who underwent a procedure at time of index hospitalization are outlined in Supplemental Table 2. Twenty-five grade 3 patients who underwent a procedure at index hospitalization were readmitted (25/86, 29%). Five patients (5/25, 2%) had a urologic diagnosis as part of their readmission and 3 (3/25, 1%) required a subsequent procedure. Thirteen grade 4 CSL patients were readmitted after an index admission procedure (13/24, 57%) with 9/13 (69%) carrying a urologic diagnosis and 5/13 (22%) requiring a subsequent procedure. Two grade 4 SVI patients were readmitted after an index admission procedure (2/15, 13%) with no patients having or urologic diagnosis or requiring a subsequent procedure.

Few patients with >1 readmissions presented with subsequent urologic diagnoses. In the grade 3 cohort, two patients returned. One patient was diagnosed with hematuria and the other with pyelonephritis. Three grade 4 CSL patients had a urologic diagnosis at second readmission including one with hematuria. A second CSL patient presented with ureteral obstruction requiring stent placement during a second admission but ultimately required ureteropelvic junction repair on a third admission. The third CSL patient presented with ‘urinary complications not otherwise specified’ and ‘kidney, other’ and underwent a percutaneous intervention on the 1st readmission. The patient ultimately was admitted a second and third time where ureterolysis was performed at the final readmission.

DISCUSSION

Outpatient follow-up visits after renal trauma management is generally quite poor and with wide variance (6–94%).(4, 6–16) In this study, we sought to better understand how patients with a AAST renal grade 3 and 4 injury fare following discharge from a level I trauma center (HMC) by examining readmission rates using the statewide CHARS database. In doing so, we are the first to report statewide readmission rates for renal trauma. Among patients with an AAST grade 3 or 4 renal injury, ~20% of patients required readmission for both urologic and non-urologic reasons. Only 36% of readmitted patients carried a urologic diagnosis as part of their readmission including 22% of grade 3 injuries and 42% of grade 4 injuries. The majority of patients requiring readmission returned to HMC (76% overall, 74% in those with urologic diagnosis as a part of readmission). Subsequent procedural intervention was required on readmission in 7% of grade 3 and 13% of grade 4 renal injuries.

The majority of grade 3 and 4 renal injuries presented with blunt trauma as a mechanism of injury, which is consistent with existing literature (current cohort: 85–91% vs. 82–95%(18)). Overall, grade 4 renal trauma patients required more admission procedures, with grade 4 CSL patients more commonly readmitted than grade 4 SVI patients. However, it is the practice at our institution of performing a repeat CT urogram ~48 hours from time of initial diagnosis of renal trauma and employing a prophylactic ureteral stent in those with a

persistent/worsening urine leak. This policy potentially increased the number of adjuvant interventions among the cohort of patients with a collecting system injury. Interestingly, more open procedures were performed in grade 3 renal trauma patients, an unexpected finding. In our stratified analysis by years of admission however, we found a decrease in nephrectomy and renorrhaphy procedures over time, suggesting a trend towards conservative management, which is consistent with current renal trauma literature.(2–5) Again, this finding may also be related to the addition of a urologic trauma fellowship-trained urologist at our institution in 2002.

Readmissions, urologic diagnoses and interventions on readmission were more common in grade 4 vs. grade 3 injuries. The majority of these patients, including those with a urologic diagnosis, returned to HMC; however, 20% of grade 3 and 34% of grade 4 renal trauma patients presented to an outside hospital with five grade 3 and four grade 4 patients carrying documented urologic diagnoses, possibly indicating injury-related sequelae. When looking at grade 4 injuries specifically, there was no significant difference in CSL vs. SVI readmissions, however, CSL injured patients were much more likely to carry a urologic diagnosis (60%) and require additional procedures (22%). Further, in grade 4 patients who experienced a urologic procedure on index admission, CSL patients were more likely to be readmitted with a urologic diagnosis and require an adjuvant procedure. When we attempted to evaluate the association of readmission relative to the queried categories, only ‘any admission procedure’ was significantly associated with readmission and specifically in the grade 4 CSL grouping.

There are limitations to this study. First, all grade 4 injuries were reviewed by the authors to delineate CSL vs. SVI. We were not able to perform this in patients with grade 3 injuries, leaving the possibility of misclassification. Indeed, many patients with grade 3 injuries underwent an open procedure on admission, however, we feel this is due to operative exploration of concomitant injuries and possibly surgeries performed by the general surgery service prior to a trauma fellowship trained urologist arriving at HMC. Overall, we feel the risk of misclassification of a grade 4 injury to a grade 3 would be small and our operative data suggests changing practice patterns over time with fewer and fewer of these injuries explored operatively. Second, all analyses within CHARS are limited to correct coding by each practitioner and the possibility of misclassification of readmission diagnoses and/or interventions cannot be ruled out. In those readmitted to outside hospitals, we did not have complete granularity (just billing codes) and it is possible that interventions were missed or incorrectly classified. Third, while we queried all renal trauma within a 12-year period, low relative event rates and other unavailable clinical variables of interest (including comorbidity indices) precluded multivariate analysis. Fourth, index admission was at a single institution with fellowship-trained urologic trauma urologists with established renal trauma management patterns (e.g. grade 4 CSL injuries), and therefore treatments and results may not be generalizable to all areas. For instance, there were 6 patients with grade 4 SVI, an injury usually managed non-operatively, who underwent an open kidney surgery on admission (nephrectomy, partial nephrectomy or renorrhaphy). These interventions likely reflect earlier practice patterns and are managed non-operatively at our institution currently. (14) It is also worth noting, that historically we do not use interventional radiology for grade 4 CSL injuries (which can be necessary for perinephric fluid collections) as our patients

undergo repeat imaging at 48 hours with prophylactic stenting for residual urine leak, thus making IR unnecessary in most cases. In regards to IR procedures performed, we did not have complete data regarding the nature of the procedure ('percutaneous aspiration') and therefore make some assumptions as to the nature of each (e.g. CSL injury: percutaneous aspiration refers to drainage of urinoma). Finally, small sample size, lack of data on insurance type, home address zip code, and the retrospective review of available coding data, which may have its own inherent flaws, may have influenced these results.

Taken together, these data indicate that renal trauma outcome analysis may be limited by readmissions to secondary or referring hospitals. We noted that a subset of grade 3 and grade 4 renal trauma patients will be readmitted to an outside hospital, some with urologic diagnoses, suggesting possible un-captured renal trauma management sequelae. Patients with grade 4 CSL injuries appear to be at a higher risk for readmission with a urologic diagnosis and to require a subsequent urologic intervention. Moving forward, implementation of a national database to track hospital admissions and readmissions would be the logical next step to further examine this hypothesis. Unfortunately, our current healthcare system is not configured to allow this recommendation with innumerable electronic health records precluding crosstalk. An ideal system would allow patients to be tracked, receive reminders about clinical follow up, or even alert index institutions of hospital readmissions elsewhere with details regarding management. Telemedicine may offer a future avenue to allow hospitals to communicate when trauma patients are readmitted to different networks. Given the complexities of trauma care with multiple organ systems compromised and the requisite imaging tests and hospital services, communication across hospitals with a medium such as telemedicine can improve delivery of care and hopefully reduce associated medical costs. Further, increased granularity of accurate renal trauma outcomes with the ability to perform multivariate analysis of risk factors has applications in both serving to update existing trauma grading systems and, more importantly, improve patient care.

CONCLUSION

One in five patients sustaining a grade 3 or 4 renal injury will require a readmission with a third of these patients carrying a urologic diagnosis. While the majority of these patients will return to their index institution and additional readmission procedures may be low, failure to assess beyond the index institution is a limit to renal trauma outcome research. Based on these data, patients with grade 4 CSL injuries appear to be at the highest risk for readmission and to require a subsequent urologic procedure. Further data analysis from level 1 trauma centers with statewide capture of readmission rates across the United States may further corroborate these findings.

Supplementary Material

Refer to Web version on PubMed Central for supplementary material.

Acknowledgments

DISCLOSURES:

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Table 1

Grade 3 and 4 renal trauma index admission data

Category	Grade III (%)	Grade IV CSL (%)	Grade IV SVI (%)	P-value
Number (N=636)	477 (75)	95 (60)	64 (40)	-
Mean Age (SD)	31 (16)	34 (20)	31 (15)	0.38
				0.34
Sex				
Male	344 (72)	62 (65)	45 (70)	0.25
Female	133 (28)	33 (35)	19 (30)	0.51
Admission Data				
Blunt Injury	405 (85)	87 (92)	57 (90)	0.07
				0.60
Any Admission Procedure	75 (16)	29 (31)	7 (11)	0.047*
				0.004*
Open Procedure	61 (13)	7 (7)	7 (11)	0.18
				0.44
Endoscopic Procedure	0 (0)	25 (26)	0 (0)	-
IR Procedure	10 (2)	0 (0)	0 (0)	-
Median Length of Stay (Days, IQR)	7 (3–13)	6 (4–12)	8 (3–18)	0.93
				0.70
Death	55 (12)	8 (8)	5 (8)	0.24
				0.89

All values in parentheses = % unless otherwise stated.

* Denotes significance, $p < 0.05$.

P-values represent grade 3 vs. all grade 4 followed by those in grey representing only grade 4 CSL vs. SVI comparisons (t-tests and Chi-squared tests as appropriate). Test of medians utilized for length of stay analysis.

Table 2

Select interventions on index admission in grade 3 versus stratified grade 4 injuries

Procedure	Grade III (%)	Grade IV CSL (%)	Grade IV SVI (%)	P-Value
Admission Procedure (111)	75 (68)	29 (26)	7 (6)	0.001 *
IR procedure (10)	10 (100)	0 (0)	0 (0)	-
Ureteral Catheterization (25)	0 (0)	25 (100)	0 (0)	-
Renorrhaphy (21)	17 (80)	2 (10)	2 (10)	0.77
Partial Nephrectomy (10)	6 (60)	2 (20)	2 (20)	0.48
Nephrectomy (43)	38 (88)	3 (7)	2 (5)	0.11

All values in parentheses = % unless otherwise stated.

* Denotes significance, $p < 0.05$

Table 3

Rate of index admission procedures stratified by year of presentation

Category	Total (N=636)	1998–2001 (N=174)	2002–2005 (N=259)	2006–2010 (N=203)	P-value
Admission Procedure	111 (17)	45 (26)	41 (16)	25 (12)	0.002 *
Admission Nephrectomy	43 (7)	25 (14)	14 (5)	4 (2)	<0.001 *
Partial Nephrectomy	10 (2)	2 (1)	6 (2)	2 (<1)	0.45
Renorrhaphy	21 (3)	10 (6)	6 (2)	5 (2)	0.11
Endoscopic Procedure	25 (4)	0 (0)	11 (4)	14 (7)	0.003 *
IR Procedure	10 (2)	4 (2)	6 (2)	0 (0)	0.09

All values in parentheses = % unless otherwise stated.

* Denotes significance, $p < 0.05$

Table 4

Readmission Data for patients with AAST Grade 3 or 4 Renal Trauma

	Grade III N=477	Grade IV CSL N=95	Grade IV SVI N=64	P-value
Total Readmissions	86 (18)	23 (24)	15 (23)	0.11
				0.91
Readmission Hospital				
Harborview Medical Center	69 (80)	15 (65)	10 (67)	0.08
Other	17 (20)	8 (35)	5 (33)	0.93
Median Time to Readmission				
Harborview Medical Center (Days, IQR)	13 (5–47)	14 (6–82)	61 (18–131)	0.24
				0.07
Other (Days, IQR)	45 (10–63)	47 (8–79)	11 (10–21)	0.71
				0.14
Multiple Readmissions	22 (26)	6 (6)	7 (11)	0.09
				0.30
Urologic Diagnosis at 1st Readmission				
Harborview Medical Center	14 (16)	10 (43)	2 (13)	0.93
Other	5 (6)	4 (17)	0 (0)	0.38
Total	19/86 (22)	14/23 (61)	2/15 (13)	
Urologic Interventions on 1st Readmission				
	N=86	N=23	N=15	
None	78 (91)	18 (78)	15 (100)	0.53
Endoscopic	3 (4)	2 (9)	0 (0)	0.15
Interventional radiology	3 (3)	3 (13)	0 (0)	
Total	6/86 (7)	5/23 (22)	0/0 (0)	

All values in parentheses = % unless otherwise stated. No open interventions were performed on readmission in this cohort.

* Denotes significance, $p < 0.05$.

P-values represent grade 3 vs. all grade 4 followed by those in grey representing only grade 4 CSL vs. SVI comparisons (t-tests and Chi-squared tests as appropriate). Test of medians utilized for time to readmission analysis.

Table 5

Stratified Readmission Data for patients with AAST Grade 3 or 4 Renal Trauma

	Grade III N=477		Grade IV CSL N=95		Grade IV SVI N=64		P-value
	Yes	No	Yes	No	Yes	No	
Totals	86	391	23	72	15	49	0.27
Mean Age (SD)	32 (15)	31 (16)	31 (20)	34 (20)	33 (15)	30 (16)	0.94 [^]
Male (N=451)	65 (19)	279 (81)	16 (26)	46 (74)	10(22)	35 (78)	0.69
Female (N=185)	21 (16)	112 (84)	7 (21)	26 (79)	5 (26)	14 (74)	
Type of Injury							
Blunt Injury	61 (15)	344 (85)	20 (25)	67 (75)	12 (21)	45 (79)	0.26
Open Injury	25 (35)	47 (65)	3 (38)	5 (62)	3 (43)	4 (57)	
Admission procedures							
Any Admission Procedure	25 (33)	61 (67)	13 (45)	10(55)	2 (29)	5 (81)	0.01 [*]
Renorrhaphy	2 (12)	15 (88)	1 (50)	1 (50)	0 (0)	2 (100)	0.69
Partial Nephrectomy	3 (50)	3 (50)	2 (100)	0 (0)	1 (50)	1 (50)	0.55
Nephrectomy	13 (46)	25 (54)	1 (33)	2 (67)	1 (50)	1 (50)	0.29

All values in parentheses = % unless otherwise stated. Interventional radiology and endoscopic procedures were excluded from this analysis as they were only performed in 1 of 3 groups.

[^] Indicates t-test is comparing grade 3 vs. combined grade 4.^{*} Denotes significance, p<0.05.

T-tests and Chi-squared were performed for continuous and categorical variables as appropriate.