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Analysis of Diagnostic Angiography and Angioembolization in the Acute Management of Renal Trauma Using a National Data Set

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Abstract

Purpose—To our knowledge data on diagnostic angiography and angioembolization after renal trauma have been limited to single institution series with small numbers. We used the National Trauma Data Bank® to investigate national patterns of diagnostic angiography and angioembolization after blunt and penetrating renal trauma.

Materials and Methods—All renal injuries treated between 2002 and 2007 were identified in the National Trauma Data Bank by Abbreviated Injury Scale codes and converted to American Association for the Surgery of Trauma renal injury grades. Diagnostic angiography and angioembolization were identified by ICD-9 codes and examined. Initial angioembolization was considered a failure if subsequent therapy was needed. Repeat diagnostic angiography was not considered a failure.

Results—A total of 9,002 renal injuries were available for analysis. A total of 165 patients (2%) underwent diagnostic angiography after renal injury, including 77 (47%) who underwent concomitant angioembolization. Of the patients 78% sustained grade III–V renal injuries. Of the 77 patients with initial angioembolization 68 required successive therapy. Repeat angioembolization was the most common management choice (29% of patients). Secondary angioembolization was durable during the index hospitalization with success in 35 of 36 cases. Successive therapy was required after initial angioembolization for all grade IV and V renal injuries in 48 patients. The overall renal salvage rate was 92%, including 88% for grade IV and V injuries.

Conclusions—Successive therapy is common after initial management of renal injury by angioembolization. Close observation is highly recommended after initial angioembolization for grade IV–V renal injuries. National agreement on the use of diagnostic angiography and angioembolization is needed since these procedures may be overused after grade I–III renal injuries.

Keywords

kidney; wounds, penetrating; wounds, nonpenetrating; angiography; embolization, therapeutic

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In the last 2 decades nonoperative management for blunt renal injury has been adopted, resulting in a low nephrectomy rate.[1,2] Patients with renal trauma are at 64% risk for nephrectomy when renal injuries are explored regardless of operative intent, further strengthening the argument for nonoperative intervention unless absolutely necessary.[3] The renal salvage rate may be higher at centers of excellence.[4] Groups at many centers are beginning to use less invasive options to treat renal injury to increase renal salvage.[5]

Interventional radiologists can now access segmental renal arterial branches, ie superselective AE, allowing salvage of uninjured renal parenchyma. Renal angiography and embolization after high grade renal trauma have been limited to single institution case series with contradictory results and treatment recommendations.[6,7] To our knowledge there have been no studies evaluating outcomes, annual trends or complications in a large national cohort of patients with renal injury who underwent renal AE. Examination of national trends may provide important information on the incidence of DA and/or AE as initial treatment and aid in developing treatment algorithms after renal trauma. We evaluated national patterns of DA and AE use, stratified by renal injury grade.

MATERIALS AND METHODS

NTDB, a repository of trauma related data that are voluntarily submitted by participating American trauma centers, includes more than 3 million records for analysis of the index hospitalization. Level I–IV trauma centers are included in NTDB. The most severe injuries are cared for at level I trauma centers. Overall level I and II trauma center participation in NTDB is excellent at 94% and 77%, respectively, with 17% participation by level III and IV trauma centers.[8]

We used the methodology described by Kuan et al to convert AIS to AAST codes.[3] Patients with AIS codes that mapped to AAST codes, including grade 1—AIS code 541612, grade 2—AIS code 541622, grade 3—AIS code 541624, grade 4—AIS code 541626 and grade 5—AIS codes 541628, were included in analysis while those with AIS codes that did not map to a specific AAST code were excluded.[3,9,10] We determined which patients with renal injuries underwent DA (abdominal angiography, ICD-9 88.51) or AE (renal AE, ICD-9 38.86) as the initial procedure. Preliminary sensitivity analysis of excluded patients using bivariate statistics revealed no significant differences from our included cohort.

We performed our analysis using the intent to treat principle (patients who underwent DA with or without AE) since those who underwent DA or AE were subject to the same arterial access risks (see table). However, in this study any perceived benefit of DA over AE is artificial and introduced by how we defined these terms for analysis. Demographic and injury specific factors were compared in patients who underwent DA alone vs those who underwent AE. The need for subsequent urological renal procedures was examined, as identified by ICD–9 procedure codes (nephrectomy, 55.5–55.54; partial nephrectomy, 55.4; suture of kidney laceration/renorrhaphy, 55.81; autotransplant, 55.61; nephrotomy, 55.01 or other open kidney operation, 55.89; ureteral stent, 59.8; retrograde nephroureterogram, 87.74; percutaneous nephrostomy tube, 55.02, 55.03, 55.92 and 55.93; and ureteroscopy, 56.31).[11] The need for successive urological procedures after initial AE was assessed but repeat DA was not considered a failure of initial AE.

Multivariate regression analysis was done to examine predictors of failed initial AE with a priori adjustment for sex, age, race (white, black, Hispanic or other), renal AAST score (I to V), ISS, maximum nonrenal abdominal AIS score, region (Midwest, Northeast, South or West), trauma hospital level status (level I vs all others) and injury mechanism (blunt vs penetrating).

Adjusted analysis was done using Poisson regression analysis with robust SE reporting, assuming a nonnormal distribution of the failure outcome. Poisson regression was performed since our failure outcome was relatively common (42%) and logistic regression would have overestimated RR.[12] All p values were 2 sided with significance considered at $p < 0.05$. Statistical analysis was done with Stata,® version 11.0. This study received a certificate of exemption from the University of Washington human subjects division.

RESULTS

In NTDB 18,003 injuries were available for analysis from 2002 to 2007, of which 9,002 renal injuries mapped to an AAST renal trauma grade. Of this cohort 88 and 77 patients underwent DA and AE, respectively (overall 1.8%). DA or AE was primarily performed in patients with blunt renal injury (88%). There were no significant differences between the DA and AE cohorts in regard to age, sex or race. However, mean ISS was higher, mean intensive care unit length of stay was briefer and the nephrectomy rate was higher in the AE cohort. All patients who underwent nephrectomy were in the AE cohort. Institution region and university status did not vary between the groups but more DA and AE procedures were performed at level I trauma centers. Median costs did not differ between the DA and AE cohorts. By definition patients in the AE group had arterial extravasation and, thus, had more serious renal injuries, including intermediate to high grade renal injuries in 78% with AAST IV–V in 62% and AAST III in 16%. Median ISS increased as AAST renal injury grade severity worsened with mortality proportionately higher in the AE than in the DA cohort (7.8% vs 5.7%).

Initial AE was not definitive management for most renal injuries. There was no specific AAST renal injury grade for which initial AE was conclusively successful in all patients. In 68 of the 77 patients (88%) in the AE cohort at least 1 adjunctive procedure was required for a total of 87. The most common secondary procedure was repeat DA (see figure). Repeat AE was the most common therapeutic procedure done after failed initial AE (29% of cases). Repeat AE was successful in 35 of 36 patients (97%). Patients who underwent open surgery after failed initial AE had a higher AAST renal grade than those who did not require open surgery. Furthermore, 88% of the patients who underwent open renal surgery after initially failed AE underwent nephrectomy.

Overall AE was successful for treating AAST IV and V renal injuries without the need for nephrectomy in 78% and 83% of cases, respectively. In all 48 patients with AAST IV and V renal injuries initial AE failed (0% success). There was no identifiable pattern of subsequent management after failed initial AE in renal AAST IV or V cases. Nephrectomy was ultimately required in 10 of 48 patients with AAST IV or V renal injury.

We analyzed independent predictors of repeat procedures after initial DA or AE (see table). DA and AE were included in the model since patients who underwent only DA were presumably transported to the angiography suite for potentially successive AE. Sex, race, maximum nonrenal abdominal AIS score and ISS were not associated with AE or DA failure. Age was associated with a 4% per year risk of AE or DA failure (RR 1.04, 95% CI 1.01–1.06). Higher AAST grade was associated with an increased likelihood of repeat procedures after initial AE. AAST grade IV renal injuries carried an increased risk of additional procedures, although this did not attain statistical significance (RR 2.6, 95% CI 0.95–7.15). AAST grade V renal injuries were significantly associated with a repeat procedure after initial DA/AE (RR 4.08, 95% CI 1.25–13.38). There was a decreased risk of DA or AE requiring repeat procedures in the South and West. Level I trauma center status was associated with a 55% decrease in the risk of initial AE or DA failure (RR 0.45, 95% CI

0.24–0.83). Penetrating trauma was more likely to be associated with initial AE or DA failure (RR 3.04, 95% CI 1.60–5.79).

DISCUSSION

The initial AE success rate was low. Of the patients 88.3% required some type of secondary intervention. Higher AAST renal grade was associated with an increased risk of AE failure and the need for repeat intervention. The failure rate was 100% in the 36 and 12 patients with AAST IV and V renal injuries, respectively, for the first attempt at AE alone. However, initial and repeat AE for these high grade injuries prevented nephrectomy in 78% to 83% of these patients. Secondary open surgery after failed AE was done in 22% of patients with nephrectomy the most common surgical procedure.

A number of reports detail DA and AE in the setting of renal trauma.[5–7,13,14] These reports consist of single institution case series of fewer than 40 patients with conflicting outcomes.[5,7,13,15–17] Some groups recommended that DA and AE be used for injuries up to and including AAST renal grade IV while others advocated DA/AE after AAST grade V injuries.[5,16] A retrospective series of 5 patients showed a 100% success rate with no need for repeat AE after AAST grade V renal injuries.[7] Conversely AE was not successful for any AAST grade V renal injuries at a different institution.[6] Our analysis of patients in NTDB revealed 100% failure of initial AE in the setting of AAST IV–V renal injuries. Despite this there was ultimate success in half of these patients after additional treatment.

Overall 30% of the patients in our study who underwent DA and AE had grade I and II injuries. These low grade renal injuries accounted for 37% of the DA group and 22% of the AE group. Given the benign nature of AAST I and II renal injuries, it is not surprising that DA was more common than AE since AAST renal I and II injuries are a contusion and injury to the parenchyma less than 1 cm, respectively. All except 1 patient in this low grade cohort had concomitant injuries that could have prompted DA. Accordingly renal DA and AE may have been done in the setting of concomitant visceral or pelvic injuries, or in patients without prior radiographic imaging to stage the renal injury. When staged appropriately, our preference has been to not perform initial AE for AAST renal injuries less than grade III since conservative therapy is almost universally successful.[8] Despite an absent standardized protocol to determine when to intervene in the setting of active renal bleeding, we often transfuse 2 to 3 U packed red blood cells before considering angiography or surgical intervention.

Our analysis revealed a strong association of improved outcomes at level I trauma centers with a 55% decreased risk of DA or AE failure (RR 0.45, 95% CI 0.24–0.83), although more severely injured patients are treated at level I centers. This is in keeping with a recent study of outcomes at trauma centers, which revealed a 15% decrease in mortality in polytrauma patients treated at such centers.[18] Our study of NTDB revealed better outcomes and less questionable use of DA and AE for low grade injuries. This argues for tiered delivery of trauma care and the development of standardized algorithms for DA and AE after renal trauma.

Multivariate Poisson regression indicated regional differences in outcome in patients who underwent DA or AE (see table). More facilities in the Midwest (32.8%) and South (32.8%) are represented in NTDB than in the Northeast (14.6%) or West (19.7%), making direct comparison of care in each region difficult. Despite this difference DA and AE were most commonly done in the South (62.6% of DA/AE cases) and Midwest (28.2%). We can only infer that increased DA/AE use in the South translated to increased success with 49% better

success than the Midwest (the reference region). However, these findings should be carefully considered since DA and AE were not performed uniformly across each region.

As expected, the risk of initial AE or DA failure increased with AAST grade. Previous analysis of NTDB showed that the AAST renal injury scale is the strongest predictor of nephrectomy.[10] The risk of DA/AE failure for more severe renal injuries is not as convincing as the results of Wright et al in their study of nephrectomy.[10] This difference may be secondary to advances in DA and AE, such as wide-spread adoption of coaxial catheters capable of superselective AE.

Blunt trauma was predominant in our analysis (87.9% of cases). Despite this our model indicates that DA or AE was 3-fold more likely to fail for penetrating trauma (RR 3.04, 95% CI 1.60–5.79). The limited number of patients with penetrating trauma in our series precluded our ability to make definitive conclusions. However, with reports that conservative management of penetrating trauma is possible in select cases, renal DA/AE in the setting of failed conservative therapy for penetrating trauma must be critically considered based on our observations.[19,20]

A major limitation of NTDB is that it is not a population based data set, contributing to the uncontrolled confounding that went into the cohort for our analysis. NTDB only includes data on the index hospitalization, which prevents analysis of the eventual outcome. There is no information on AE extent (main vs segmental renal artery branches) in NTDB, which prevented us from assessing the use of main renal artery embolization vs superselective AE. It is possible that some patients who underwent DA were undergoing repeat abdominal angiography primarily for concomitant injuries. The coding algorithms that allowed us to map AIS codes to AAST injury grades excluded a significant number of renal injuries, which may have introduced selection bias.

The relationship of renal injury grade, the transfusion rate and AE is an interesting topic. Assessing the need for AE after observation and blood transfusion to avoid major or minimally invasive therapy would provide useful information for future algorithms. Unfortunately we could not analyze this relation since blood transfusion use in NTDB is not a required entry variable. Hopefully future NTDB updates will address this issue. Finally, our model was intentionally built to be conservative by excluding repeat DA as a failure. As a result, we omitted potential patients who may have undergone repeat DA for other reasons, resulting in incidental repeat renal DA. Thus, it is possible that our estimates are biased toward the null hypothesis of no difference.

CONCLUSIONS

AE for AAST grade IV–V injuries should be done with caution since national analysis of data revealed a low initial success rate. Multi-institutional analysis in prospective fashion is a logical future direction for renal DA/AE, given the increasing adoption of this as renal trauma intervention. In the absence of such data we provide our analysis of DA/AE using the largest available American trauma database. Close observation is recommended for AAST IV–V renal injuries after initial AE because AE required additional procedures in all patients. The overall rate of renal salvage of high grade lesions was high since successive procedures, most commonly AE, proved to be more successful. National agreement on DA and AE use are needed because there may be overuse of these procedures after AAST I–III renal injuries.

Abbreviations and Acronyms

AAST	American Association for the Surgery of Trauma
AE	angioembolization
AIS	Abbreviated Injury Scale
DA	diagnostic angiography
ISS	injury severity score
NTDB	National Trauma Data Bank

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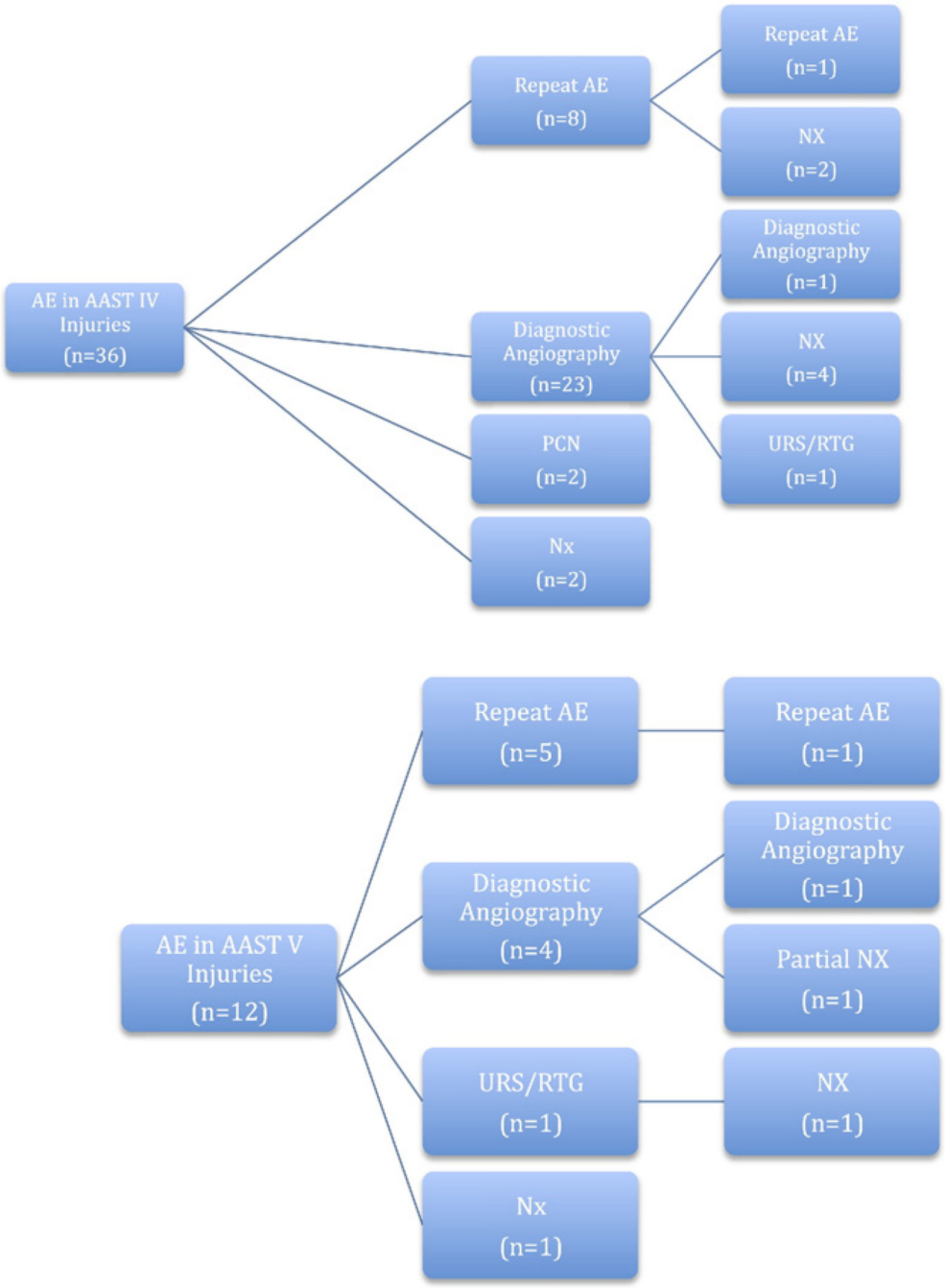

1. .
Repeat procedures in patients with grade IV or V injury who underwent AE. *NX*, nephrectomy. *PCN*, percutaneous nephrostomy. *URS/RTG*, ureteroscopy/retrograde nephroureterogram.

Poisson regression analysis of predictors of failed DA or AE, as defined by need for repeat AE or open renal surgery

	RR*	p Value	95% CI
Sex (referent male)	0.55	0.069	0.29– 1.05
Age	1.04	0.001	1.01– 1.06
Race (referent white):			
Black	2.32	0.022	1.13– 4.75
Hispanic	1.92	0.206	0.70– 5.30
Other	1.00	0.997	0.30– 3.37
AAST score (referent I):			
II	1.70	0.444	0.44– 6.67
III	1.81	0.427	0.42– 7.79
IV	2.16	0.223	0.62– 7.50
V	4.05	0.031	1.14–14.42
Max nonrenal abdominal AIS score	0.89	0.477	0.66– 1.22
ISS	1.03	0.026	1.00– 1.06
Region (referent Midwest):			
Northeast	0.75	0.642	0.22– 2.52
South	0.51	0.006	0.32– 0.82
West	0.25	0.116	0.04– 1.41
Level I center (referent all other centers)	0.45	0.01	0.24– 0.83
Penetrating mechanism (referent blunt)	3.04	0.001	1.60– 5.79

*Poisson regression with robust SE estimates.