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Clinical and Radiographic Factors Associated With Failed Renal Angioembolization: Results From the Multi-institutional Genitourinary Trauma Study (Mi-GUTS)

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OBJECTIVE To find clinical or radiographic factors that are associated with angioembolization failure after high-grade renal trauma.

MATERIAL AND METHODS Patients were selected from the Multi-institutional Genito-Urinary Trauma Study. Included were patients who initially received renal angioembolization after high-grade renal trauma (AAST grades III-V). This cohort was dichotomized into successful or failed angioembolization. Angioembolization was considered a failure if angioembolization was followed by repeat angiography and/or an exploratory laparotomy.

RESULTS A total of 67 patients underwent management initially with angioembolization, with failure in 18 (27%) patients. Those with failed angioembolization had a larger proportion ofgrade IV (72% vs 53%) and grade V (22% vs 12%) renal injuries. A total of 53 patients underwent renal angioembolization and had initial radiographic data for review, with failure in 13 cases. The failed renal angioembolization group had larger perirenal hematoma sizes on the initial trauma scan.

CONCLUSION Angioembolization after high-grade renal trauma failed in 27% of patients. Failed angioembolization was associated with higher injury grade and a larger perirenal hematoma. Likely these characteristics are associated with high-grade renal trauma that may be less amenable to successful treatment after a single renal angioembolization. UROLOGY 148: 287−291, 2021. © 2020 Elsevier Inc.

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Most hemodynamically stable patients with traumatic kidney injuries can be managed nonoperatively.[1] These strategies reduce unnecessary surgical interventions and any adverse sequelae that may follow.[1] Angioembolization, a nonoperative management strategy, has proven to be effective for many types of traumatic solid organ injuries including renal injuries.[2-5] The utilization of angioembolization for trauma related renal injuries has increased over time; with a 27-fold increase in the annual number of trauma-related angioembolization procedures from 1997 to 2003.[6]

Despite widespread use and success, renal trauma initially managed with angioembolization can fail, requiring additional interventions in as many as 33% of patients.[7-12] Failure in one series was associated with a higher blood transfusion requirement.[7] In another series, a larger proportion of patients required additional interventions among those with grade V renal injuries relative to grade IV renal injuries.[13] It is important to understand which factors may portend to angioembolization failure. A more thorough understanding of features associated with angioembolization failure could allow better patient selection for conservative management with angioembolization versus operative management.

This multi-institutional study sought to investigate clinical and radiographic characteristics associated with renal angioembolization failure. We hypothesized that clinical or radiographic factors associated with ongoing or large blood loss would be associated with angioembolization failure.

MATERIALS AND METHODS

Study Setting and Design

The Multi-institutional Genito-Urinary Trauma Study (MiGUTS)[9,14,15] is a prospective observational study from 21 level-1 trauma centers across the United States and was supported by both the American Association for Surgery of Trauma (AAST) Multi-institutional Trials Committee and the Trauma and Urologic Reconstruction Network of Surgeons. For the current study, data were included from phase-1 (2014-2017) and phase-2 (2013-2018) of the MiGUTS project (a full list of the participating centers and collaborators can be found at http://www.turnsresearch.org/page/genito-urinary-trauma-study-miguts-renal).

Study Patients

Patients were included in the current analysis if all the following criteria were met: (1) sustained high-grade renal trauma (AAST grades III-V) that resulted in admission at one of the participating centers in phases 1 or 2 of the MIGUTS project, (2) a diagnostic angiography study was conducted during that admission, and (3) angioembolization for renal bleeding was indicated during that diagnostic study. Patients were excluded if they were: (1) younger than 18 years old, (2) underwent urgent open surgery at an outside hospital without clinical and imaging available, or (3) were dead before arrival at the receiving hospital.[9]

Primary Outcome

The primary outcome was angioembolization failure. The initial angioembolization was defined as a failure if angioembolization was followed by (1) repeat angiography and/or (2) an exploratory laparotomy.

Data Collection

Data collection was done on the AAST TraumaSource centralized database platform and Research Electronic Data Capture electronic databases as previously described.[9,14] Data collected included: demographics (age, gender, and body mass index), injury characteristics, Injury Severity Score, AAST Organ Injury Scale for renal injuries, admission systolic blood pressure, systolic blood pressure nadir in first 4 hours after admission, admission heart rate, length of hospital stay, length of intensive care unit stay, and mortality during admission. The initial computed tomography (CT) scan was used to extract radiographic data. For each CT scan, 2 radiologists blinded to the outcomes independently reviewed the available CT scans to extract radiologic data. If disagreements existed, input from a third reviewer was used to reach consensus. Radiographic variables collected pertinent to the renal injury included vascular contrast extravasation, largest hematoma rim diameter, and renal laceration size. Their definitions have been previously described.[14]

Statistical Analysis

Comparisons between continuous and nominal variables were conducted using Student's *t* test with unequal variance and Fisher's Exact Test, respectively. A subgroup analysis was conducted among patients who had a diagnostic computed topography (CT) scan of the abdomen and pelvis at presentation. All statistical analyses were performed on Stata version 15.1 (StataCorp, College Station, TX).

RESULTS

Study Patients

A total of 67 patients from 17 of the 21 participating centers underwent angioembolization treatment for renal bleeding as the initial treatment. Angioembolization failure occurred in 27% (18/67) of patients with high-grade (grade III-V) renal trauma. Among only AAST grade IV and V injuries, the failure rate was 35% (17/49). Table 1 summarizes the demographic and injury characterization data for the successful and failed angioembolization groups. The angioembolization failure group had a larger proportion of grade IV and V AAST renal injuries ($P < .05$). Table 2 summarizes the clinical course data for the successful and failed angioembolization groups. There were no statistically significant differences in patient vitals at the time of presentation, length of hospital or intensive care unit stay, and mortality.

Radiographic Data

A total of 53 patients underwent renal angioembolization and had initial radiographic data for review (Table 3). The failed renal angioembolization group had larger perirenal hematoma sizes (5.8 cm vs 3.8 cm) at the time of the initial CT scan ($P < .05$). While not statistically significant, there was a higher proportion of patients with vascular contrast extravasation present in the failed angioembolization group (92% vs 63%; $P = .08$).

Table 1. Demographics and injuries characterization

		Successful AE (*n* = 49)	Failed AE (*n* = 18)	*P*-value
Age in years, *median* (IQR)		46 (27-63)	31 (21-53)	0.08
Gender (%)	Female	12 (24%)	2 (11%)	0.32
	Male	37 (76%)	16 (89%)	
BMI, median (IQR)		28 (24-32)	24 (23-28)	0.05
ISS, *median (IQR)*		22 (17-34)	30 (17-38)	0.36
Injury Mechanism	Blunt	44 (90%)	15 (83%)	0.67
	Penetrating	5 (10%)	3 (17%)	
Renal AAST Grade	Grade 3	17 (35%)	1 (6%)	0.04
	Grade 4	26 (53%)	13 (72%)	
	Grade 5	6 (12%)	4 (22%)	

AE, Angioembolization; BMI, Body Mass Index; ISS, Injury Severity Score.

Table 2. Clinical course data

	Successful AE (*n* = 49)	Failed AE (*n* = 18)	*P*-value
SBP ER in mmHg, *median* (IQR)	114 (91-132)	118 (87-139)	0.61
SBP Nadir ER in mmHg, *median* (IQR)	90 (70-111)	96 (87-110)	0.42
HR ER beats/min, *median* (IQR)	89 (77-115)	98 (73-109)	0.65
Length of Hospital Stay in days, *median* (IQR)	8 (5-19)	12 (9-18)	0.08
Length of ICU Stay in days, *median* (IQR)	3 (1-9)	4 (1-7)	0.83
Mortality			
No	44 (90%)	18 (100%)	0.31
Yes	5 (10%)	0 (0%)	

AE, Angioembolization; ER, Emergency Room; SBP, Systolic Blood Pressure.

DISCUSSION

In this multi-institutional study, 27% of patients with high-grade renal trauma failed initial management with angioembolization and required repeat interventions. Those who failed management with angioembolization had higher renal AAST injury grades and larger perirenal hematomas on the initial trauma scan. Collectively, our results suggest that predictors of failed renal angioembolization for traumatic injuries include high-grade renal injuries and clinically significant blood loss. Despite the wide utility and uptake of angioembolization, it is important that operative management remain a component of the trauma surgeon's armamentarium.

The reported angioembolization failure rates in the literature vary widely, ranging from 0% to 33%.[7,8,11,12,16-18] This heterogeneity is explained, in part, by methodology by which institutions and/or clinicians decide who should be offered immediate operative management versus angioembolization. A lower threshold to operate will result in less severe injuries being managed nonoperatively (eg, angioembolization); in turn, angioembolization of these less severe injuries would be more likely to result in success.[19] While success rates for angioembolization are high for less severe injuries, this comes at the expense of possible overtreatment.[20] Technical excellence related to case volume may also explain differences in the success of treatment. A previous multi-institutional analysis evaluated nonoperative failure of splenic injuries at level-1 trauma centers and found that nonoperative failure was less likely at centers with high-volume splenic angioembolization.[21,22]

In the present study, we found that renal angioembolization failure was associated with a larger perirenal hematoma. This suggests that treatment failure is more likely in injuries that result in large blood loss. Other studies have identified proxies of severe or ongoing blood loss as being predictive of angioembolization failure. A single-institutional study in patients with blunt renal trauma found that angioembolization failure was associated with a larger blood transfusion requirement in the first 24 hours.[7] Interestingly, the presence of vascular contrast extravasation and a larger perirenal hematoma size have both been previously shown to predict the need for angioembolization among renal trauma patients managed nonoperatively.[23,24] Thus, such radiographic findings likely indicate

Table 3. Renal radiographic data

	Successful Renal AE (*n* = 40)	Failed Renal AE (*n* = 13)	*P*-value
Vascular contrast extravasation present	25 (63%)	13 (92%)	0.08
Laceration Size, *cm* mean (95% CI)	2.9 (2.4-3.4)	3.2 (2.1-4.2)	0.61
Hematoma rim diameter, *cm* mean (95% CI)	3.8 (3.2-4.3)	5.8 (4.0-7.6)	0.03

AE, Angioembolization.

the need for intervention—whether angioembolization or operative; However, in this study angioembolization failure was associated with perirenal hematoma diameters of 4-7.6cm, suggesting a single angioembolization may not be sufficient for treatment success in patients with larger perirenal hematomas. Additionally, though not statistically significant, 92% of those with failed angioembolization had vascular contrast extravasation compared to 63% in those with a successful angioembolization. Taken together, we hypothesize that there exists a point where injuries after trauma are so severe that occlusion cannot be achieved after a single angioembolization treatment. It may not be feasible nor safe to deliver large amounts of embolic material in these cases as clinicians balance concerns for inducing ischemia and must consider complications associated with angioembolization.

This study is not without limitations. Previous publications using this database have outlined the limitations of the MiGUTS database.[9,14,15] Firstly, there exists heterogeneity in the practice management after high-grade renal trauma across the 21 trauma centers, in part, because of a lack of clear evidence-based genitourinary trauma guidelines. Secondly, the database did not collect follow-up data, so we were unable to comment on renal function after angioembolization or on any other long-term sequelae. Thirdly, this database did not collect intraprocedural data during the angiographic study including what vessels were injured and/or embolized, what embolization techniques were used, and which and how much embolization material was used. Lastly, the small sample size in this study limits our statistical power and may be masking other findings. With a larger cohort, we would expect to find that failed angioembolization would be associated with other proxies of significant blood loss, such as the presence of renal vascular contrast extravasation. These limitations notwithstanding, we demonstrate that despite the wide use and acceptability of angioembolization as first line for trauma, it is not without failure.

Future investigations of angioembolization should consider intraprocedural factors associated with angioembolization failure. Specifically, the impact intraprocedural factors have on decision-making for the proceduralist and the impact those factors have on angioembolization outcomes. In particular, no guidelines exist on what clinical encounters are appropriately managed with angioembolization, which embolization material should be used, and what amount of embolizing material makes treatment success likely.[25] Consequently, there is wide heterogeneity in the use of angioembolization.

CONCLUSION

Angioembolization in patients with high-grade renal trauma failed in 27% of patients. Failure was associated with having higher-grade renal injuries and larger perirenal hematomas. These characteristics are likely reflective of the severity of trauma and thus would be less amenable to a single angioembolization for effective treatment. Future investigations should investigate how intraprocedural factors impact angioembolization success and failure.

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