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Selective angioembolization for traumatic renal injuries: a survey on clinician practice

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Abstract

Purpose—A variety of clinical and imaging findings are used by clinicians to determine utility of renal angioembolization (AE) in managing renal trauma. Our purpose was to investigate specific criteria that clinicians who manage high-grade renal trauma (HGRT) utilize in decision-making for primary or delayed AE.

Methods—A total of 413 urologists and interventional radiologists (IRs) who practice at level 1 or 2 trauma centers within the United States were provided an original survey via email on experience and opinions regarding the utility of AE for HGRT. We described overall practice patterns and assessed differences by clinician type, using the Fisher's exact test.

Results—A total of 79 (20 %) clinicians completed the survey. All clinicians had AE capability for HGRT management. A higher proportion of IRs reported using AE for grade I–II (33 vs. 3 %, $p = 0.002$), grade III (65 vs. 26 %, $p = 0.001$), and penetrating injuries (83 vs. 58 %, $p = 0.02$). A greater proportion of urologists reported using AE for grade V injuries (81 vs. 56 %, $p = 0.03$). Clinicians most commonly cited computed tomography evidence of active arterial bleeding (97 %), or arteriovenous fistula/pseudoaneurysm (94 %) as indications for primary AE, and 62 % identified concurrent visceral injury as factor that would necessitate surgical intervention.

Conclusion—In a survey of clinicians, we report that IRs and urologists utilize AE differently when managing HGRT, as a higher proportion of IRs use AE to manage lower grade as well as penetrating injuries. Validation studies are needed to establish algorithms to identify patients with HGRT who would benefit from selective renal AE.

Keywords

High-grade renal trauma; Imaging; Renal angioembolization; Clinician survey

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Background

Renal injury occurs in up to 10 % of cases of external abdominal trauma [1]. Most injuries are due to blunt trauma and consist of lower-grade, non-life-threatening injuries. A substantial body of evidence supports the effectiveness of non-operative strategies for the majority of such injuries [2, 3]. High-grade renal trauma (HGRT), defined as grade III–V injury based on the 1989 American Association for the Surgery of Trauma Organ Injury Scale (AAST OIS), includes any injury with a parenchymal laceration >1 cm or vascular/ collecting system injury [4]. While surgical exploration is required more often with such injuries, careful selection and appropriate staging allow many of these patients to be safely managed conservatively with bed rest and serial hematocrits (HCTs) [3, 5].

Selective renal angioembolization (AE) was introduced in the 1970s for the management of acute renal parenchymal and vascular trauma [6]. While this method is generally more successful for lower-grade injuries [7, 8], recent reports support its use as a minimally invasive method to manage adult HGRT [9–11] and pediatric renal injuries [12–14]. Conversely, some studies have reported high failure rates with AE in grade IV–V injuries [9], with up to 100 % of these patients requiring one or more secondary interventions [15]. A variety of clinical criteria have been proposed as key factors that predict need for renal embolization, including AAST OIS grade, mechanism of injury, patient clinical stability, and concomitant visceral injuries, as it have multiple computed tomography (CT) findings, such as active arterial bleeding, perirenal hematoma rim size, and disruption of Gerota's fascia [9, 10, 15–18]. Our objective was to investigate specific clinical and imaging findings that clinicians who care for HGRT patients utilize when deciding if and when to use renal AE. We hypothesize that in practice, clinicians use AE to treat renal injuries for a variety of clinical and imaging indications, some of which maybe questionable such as low-grade injuries.

Materials and methods

Subjects

Level 1 and 2 trauma centers within the United States were identified through the American College of Surgeons-verified trauma centers listing (http://www.facs.org/trauma/verified.html). This list was subsequently narrowed to include only trauma centers with an academic affiliation. Most of these centers were identified via affiliation with a medical school, but a small number of hospitals that described themselves as a teaching hospital with mention of trainees were also included. In order to locate provider email addresses, institution-specific Web pages (not provided on listing) were queried online and reviewed by authors (AAA, ASG) to identify faculty listed under interventional radiology (IR) and urology departments. We included both general urologists as well as those designated by trauma/reconstructive subspecialty training. Urologists in a non-trauma-related field, i.e., oncology, female urology/ urodynamics, pediatrics, endourology, and andrology/infertility, were excluded. Also excluded were interventional radiologists (IRs) with a practice limited to neuro-IR. Provider email addresses were first searched for on their institutional Web sites and, if found, were treated as verified contact information. Alternatively, email addresses were retrieved from a PubMed publication and then verified by a search of the institutional

Web site or by confirmation with the department's office by phone. This approach yielded a total of 413 clinicians (272 IRs and 141 urologists) with a verifiable email address. There were 10 clinicians for which an accurate email was not attainable.

Survey

REDCap™ (Research Electronic Data Capture) is a webbased software tool that allows researchers to create secure online surveys and then capture, manage, and analyze survey response data in an easy-to-use format [19]. An original 19-question survey was designed within our institution's REDCap version (REDCap Software Version 4.13.10 © 2013 Vanderbilt University) to query specific individual clinician opinions regarding the appropriate use of AE for HGRT (see Appendix I in ESM; https://redcap.ucsfopenresearch.org/surveys/?s=jCHJgW) [2, 4].

Questions ascertained clinician demographics (age, specialty, practice type, practice location, trauma center level designation, and availability of AE in their practice). Table 1 summarizes a recent publication describing contemporary use of the AAST's renal injury classification system [2] and was used in our original survey.

Clinicians were asked to provide the specific number of adult and pediatric HGRT cases managed within the past year and the number of these cases in which primary AE was utilized as well as the type of secondary interventions required (if any) in these cases. This survey included questions regarding utility of AE based on renal injury grade and mechanism as well as specific CT findings that indicated primary AE (disruption of Gerota's fascia, active arterial bleeding, arteriovenous fistula or pseudoaneurysm, hematoma size [perirenal hematoma rim distance] >4 cm, other specific hematoma size, or specific hematoma: kidney area ratio). Additionally, the role of clinical factors prompting use of AE (i.e., hemodynamic status, persistent gross hematuria, transfusion requirement) was assessed. As an incentive, subjects were also asked to provide his or her email addresses at the end of survey completion, to be entered into a random drawing to win a Kindle Fire® (Amazon.com, Inc.).

This survey was emailed to all clinicians with verified email addresses, and survey responses were collected and de-identified for analysis. The Local Committee on Human Resources reviewed our study, and it was deemed exempt from formal institutional review board review.

Statistical analysis

Differences in AE practice patterns by clinician type (IR vs. Urology) were analyzed using the Fisher's exact test. In a sensitivity analysis, responses were analyzed by HGRT exposure (number of HGRTs managed in past year) in quintiles, comparing upper quintile versus lower 4 quintiles within each specialty. All reported p values are 2-sided, with $p < 0.05$ considered statistically significant. All statistical methods were performed using SAS Software version 9.2 (SAS Institute Inc. Cary, NC).

Results

Clinician demographics

After excluding those who contacted the investigators requesting that he/she not be included in the study ($N = 10$), a total of 79/403 (20 %) clinicians completed the online survey. Of the responding clinicians, 72 (91 %) reported practicing at a level 1 trauma center and 79 (100 %) reported AE was available for management of HGRT in his/her hospital. A total of 62 (78 %) clinicians reported they managed ≥1 adult HGRT within the last year, and 59 (75 %) reported they primarily used AE to manage HGRT. Additionally, 24 (30 %) of clinicians reported management of ≥1 pediatric HGRT within the last year, and 7 (9 %) used AE as their primary management. Of those who reported experience with using AE as primary treatment for adult and/or pediatric HGRT ($N = 60$), use of secondary interventions included repeat AE reported by 8 (13 %), nephrectomy by 3 (5 %), and nephrorrhaphy by 1 (2 %) clinician(s). Additional demographics of survey respondents are provided in Table 2.

Injury grade and mechanism

Overall, clinicians reported using AE to manage renal injury grades I–II (22 %), III (49 %), IV (86 %), and V (66 %) injuries. Responses stratified by specialty (IR vs. Urology) are described in Table 3. Compared with urologists, a greater proportion of IRs reported using AE for grade I–II (33 vs. 3 %, $p = 0.002$) and grade III (65 vs. 26 %, $p = 0.001$) injuries. The majority of responding clinicians used AE for grade IV injuries (85 % of IRs and 87 % of urologists), but a significantly higher proportion of urologists supported use of AE for grade V injury (81 vs. 56 %, $p = 0.03$). Regarding injury mechanism, a greater proportion of IRs supported use of AE for penetrating injuries (83 vs. 58 %, $p = 0.02$), while a large proportion in both groups supported use for blunt injuries (77 and 71 %). In the sensitivity analysis that stratified each clinician type by the number of HGRT cases managed (comparing upper vs. lower four quintiles), no statistically significant differences within clinical specialty (all $p > 0.05$) were observed regarding trauma management based on grade or injury mechanism (data not shown).

Imaging variables

Overall, the most commonly reported CT findings indicating AE as appropriate first-line strategy for HGRT management included active arterial bleeding (97 %) and arteriovenous fistula or pseudoaneurysm (94 %) (Table 3). Disruption of Gerota's fascia as an indication was only reported by IRs, all of who were in the upper quintile of HGRT exposure (30 % of upper quintile vs. 0 % lower 4 quintiles, $p = 0.007$, data not shown). Other findings reported by IRs (2 %) included "transfusion requirement," while urologists (16 %) responses included "severity of CT findings in relation to clinical status," "declines in HCT," and "presence of medially located hematoma." No clinician identified/specified other hematoma size or hematoma/kidney area ratio as a reason to perform AE.

The survey included questions regarding specific CT findings that indicated surgical intervention as a first-line strategy. Concurrent visceral injury was the most common response indicated by both IRs (60 %) and urologists (65 %). A higher proportion of urologists than IRs felt evidence of active arterial bleeding necessitated primary surgical

intervention (32 vs. 13 %, $p = 0.02$). Other indications for AE were provided by 10 % of IRs and 26 % of urologists, and included “renal pedicle or main vascular injury,” “ureteral injury,” “grade V injury,” “bowel perforation or other non-renal injury requiring surgery,” or “persistent hemodynamic instability despite supportive measures.” No clinician identified/ specified other hematoma size or hematoma/ kidney ratio as an indication for immediate surgical intervention.

Clinical variables

In response to the question, *A patient with HGRT is initially placed on conservative management consisting of bed rest and serial* (*HCTs*). *What clinical criteria would cause you to perform delayed AE?*, the most common responses, overall, included declining hemodynamic status (82 %) and repeat CT indicating active bleeding (82 %). Of the 41 (52 %) clinicians who reported persistent gross hematuria as an indication for AE, a greater percentage of IRs than urologists identified this as a relevant factor for delayed AE (65 vs. 32 %, $p = 0.006$). Similarly, a higher proportion of IRs than urologists identified declining HCT requiring transfusion >2 packed red blood cells (PRBC) as an indication for AE (63 vs. 35 %, $p = 0.02$). A single urologist mentioned other indication being “transfusion requirement ≥4 units PRBCs.”

Additionally, clinicians were asked to rate the utility of primary AE for 4 clinical scenarios (stable and unstable grades IV and V injuries) on a scale of 1 (not at all useful) to 10 (very useful). Results by specialty are provided in Fig. 1. We observed statistically significant differences in utility responses by clinician specialty for grade IV injuries, including both stable ($p = 0.008$) and unstable ($p = 0.006$) injuries. A greater proportion of urologists rated AE for *stable*, grade IV injury as having no utility (rated 1–2) (32 vs. 4 %). Additionally, a greater proportion of IRs rated AE for *unstable*, grade IV as a very useful (rated 9–10) primary management strategy (26 vs. 8 %).

Discussion

We describe findings from a national survey of IRs and urologists who practice at high-level trauma centers with the United States. A total of 79 (20 %) clinicians completed our original survey, which primarily consisted of relatively young (71 % <50-year old) academicians practicing in an urban setting. Further, a fairly high proportion of our study’s subjects have exposure to HGRT and availability of AE, with 60 (76 %) reportedly using AE as primary treatment for 1 or more adult and/or pediatric HGRT within the past year.

Significant differences were observed when responses were stratified by clinician type. One-third of IRs supported use of AE for renal injury grades I–II. This is a surprisingly high rate, as most low-grade injuries can be adequately managed with conservative therapy [3]. It is further theorized that observation allows for maximum nephron preservation, as embolization potentially results in infarction of non-traumatized tissue [20]. Hotaling and colleagues reported a similar finding in a review of 9,000 renal injuries within the National Trauma Data Base. The authors found that 30 % of patients who underwent diagnostic angiography or AE had grade I–II injuries, but it was unknown if these patients had concomitant visceral injury or were without prior radiographic staging [15]. Additionally,

we found that 83 % of IRs supported use of AE for penetrating injuries as compared to 58 % of urologists ($p = 0.02$). While non-operative therapy has been successful for selected penetrating injuries [21], higher failure rates of AE for penetrating (versus blunt) injuries are reported in the literature [15], questioning the utility of AE as a first-line strategy for these cases. A greater proportion of IRs also identified certain clinical criteria that suggest delayed AE is appropriate, including persistent gross hematuria and decreasing HCT with a transfusion requirement >2 PRBCs. Our findings suggest that IRs have a lower threshold of recommending primary AE, especially for lower-grade and penetrating injuries. This finding may be of potential concern. International authorities on the management of urologic trauma have cautioned that the risks of AE are similar to other invasive therapies (ischemia time, associated injuries limiting success of intervention) [22, 23]. Additionally, AE could pose unnecessary risk of postembolization syndrome, found to occur in up to 10 % of patients [24]. Differing use of AE may be related to individual clinical experience, procedure knowledge, availability of newer technologies, or financial incentive.

In the majority of renal trauma injuries, renal-sparing therapies are often safe and effective strategies that avoid complications of major pelvic surgery, while maximally preserving renal function. With advances in embolization techniques, which now allow super-selective abilities, there is an increasing body of literature supporting the use of AE in the management of HGRT [9–11]. Selective AE has been purportedly indicated in as high as 40 % of HGRT and advocated as a method to reduce failure of observation in the setting of HGRT [17]. While a variety of clinical and CT criteria, as well as algorithms, have been proposed, there are currently no validated criteria for optimal selection of renal trauma AE candidates. The University of California San Francisco criteria [9] for selective renal AE include persistent bleeding from a renal segmental artery with or without parenchymal laceration; unstable condition with grade III–IV injury, arteriovenous fistula, or pseudoaneurysm; persistent gross hematuria and/or rapidly decreasing HCT requiring transfusion of 2 or more PRBCs. Investigators found that AE was highly effective in patients with grade IV injuries who failed trial of conservative therapy and was associated with low complication rates [9]. Charbit et al. [17] described using AE in HGRT for patients who required transfusion of ≥2 units PRBCs (without other known cause of bleeding) with presence of intravascular contrast extravasation (ICE) or large perirenal hematoma on CT. These investigators reviewed AAST OIS grade, complexity of laceration, hematoma size, continuity of Gerota's fascia, and presence of ICE and suggested angiography be performed with presence of ICE, but in the absence of ICE, only be considered when hematoma size is 25 mm or larger. Nuss et al. [16] reviewed CT images of 52 patients who underwent AE for grade III–IV renal trauma, noting that perirenal hematoma size >40 mm and ICE provided for two readily identifiable CT features associated with the need for embolization. Other measurements, including hematoma area ≥128 cm^2, hematoma/kidney ratio ≥2.75, hematoma/kidney diameter ≥76.5 cm^2, were associated with need for embolization. Other reports confirm ICE, hematoma size, discontinuity of Gerota's fascia, and arteriovenous fistula as CT factors that independently predict need for AE [18, 25, 26].

Several strengths of this study exist, including national sampling of two specialties that are involved in management of HGRT. Based on the demographics of our subjects, we believe

our data largely capture opinions of clinicians with greatest experience and knowledge of HGRT and selective renal AE in the United States. Significant limitations of this study include the small percentage of clinicians who responded (20 %) as well as potential for selection bias of those who volunteered to complete this online survey. This low response rate may reflect methodological limitations of Internet surveys. Prior methodological investigation of various survey approaches reported much lower postal (7.5–10.5 %) and Internet (2.2–4.7 %) completion rates within a large communitybased survey of 128,000 Australian residences [27]. In addition, it is plausible that given the low number of renal AEs performed for trauma nationwide that some physicians had minimal case volume and in turn chose not to participate in the study. Not all study participants (only 76 %) reported managing any number of HGRTs within the last year, and thus, our findings include opinions of physicians with less trauma exposure who may be less knowledgeable in the contemporary management of renal injuries. An important, but unanswerable, question would be the sequence and authority in decision-making within each clinician's institution. Within teaching based institutions, where there is stronger presence of a multi-disciplinary decision model, continual collaboration would presumably promote agreement among specialties.

In conclusion, renal AE is a treatment strategy that can be successfully used in selected cases of HGRT. In an online survey of clinicians who manage HGRT, we revealed several important differences in how urologists and IRs consider and use AE for the management of HGRT. Urologists and IRs place equally high support for the use of AE for blunt injuries and for grade IV injuries as well as utility of clinical and CT criteria when performing delayed AE. A higher proportion of IRs supported use of AE for lower-grade and penetrating injuries. Validation studies are needed to establish treatment algorithms that use clinical and CT criteria to identify patients with HGRT who would benefit from selective renal AE.

Supplementary Material

Refer to Web version on PubMed Central for supplementary material.

Abbreviations

IR	Interventional radiology
IRs	Terventional radiologists
AE	Angioembolization
HGRT	High-grade renal trauma
AAST OIS	American Association for the Surgery of Trauma Organ Injury Scale
CT	Computed tomography
HCT	Hematocrit
PRBCs	Packed red blood cells

ICE Intravascular contrast extension

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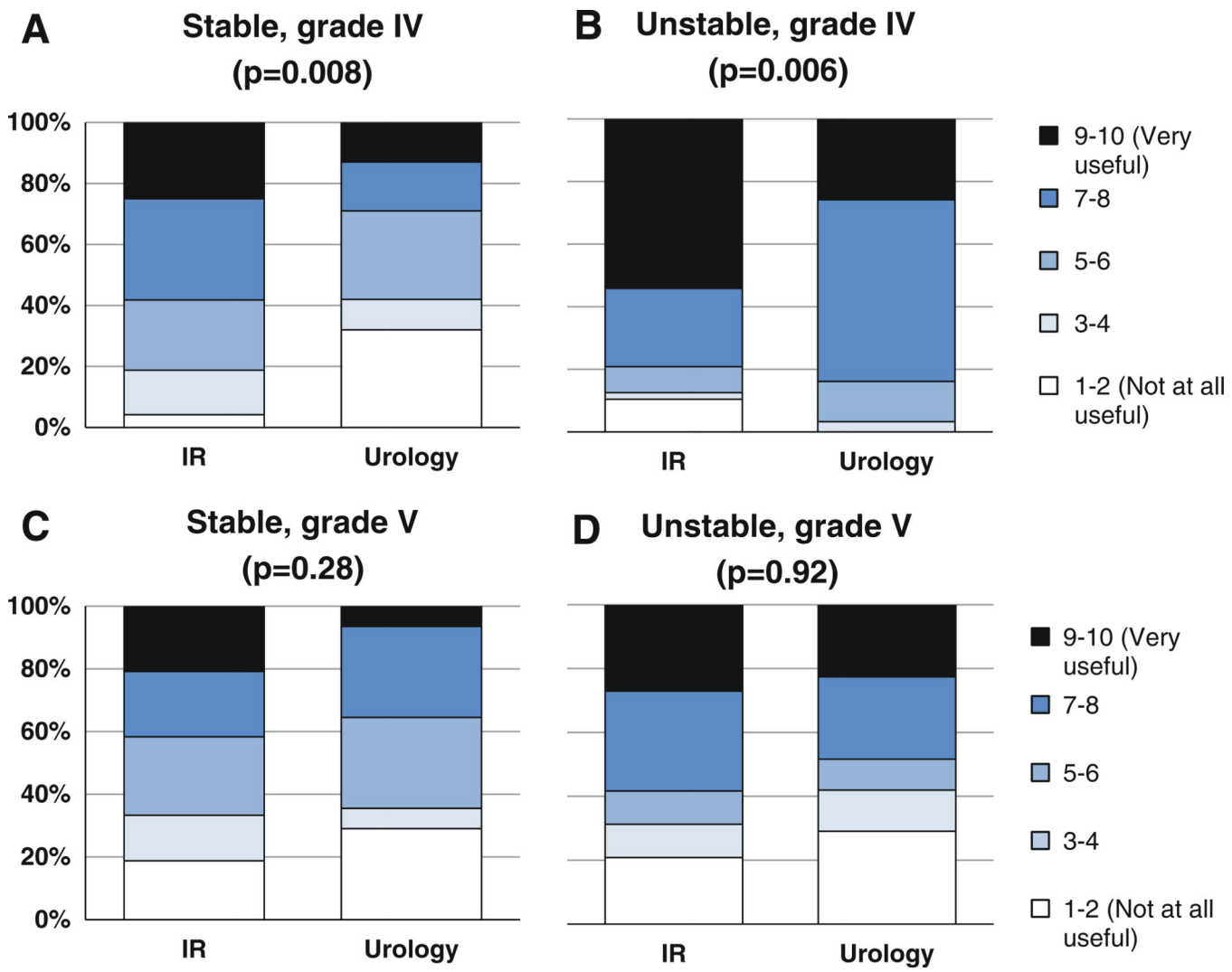

Fig. 1.

On a scale of 1–10, how useful is renal angioembolization for the following renal injures? Clinician responses to the following renal injury scenarios: stable, grade IV (**a**), unstable, grade IV (**b**), stable, grade V (**c**), unstable, grade V (**d**). *P* values represent Fisher's exact test

Table 1

Modified American Association for the Surgery of Trauma renal injury classification (Buckley and McAninch [2])

Grade	Injury definition
1	
Parenchyma	Subcapsular hematoma and/or contusion
Collecting system	No injury
2	
Parenchyma	Laceration <1 cm cortex depth, small hematoma contained within Gerota's fascia
Collecting system	No injury
3	
Parenchyma	Laceration >1 cm cortex depth and into medulla, hematoma contained within Gerota's fascia
Collecting system	No injury
4	
Parenchyma	Parenchymal laceration into collecting system or vascular injury to segmental vein or artery
Collecting system	≥1 laceration into collecting system with urinary extravasation or renal pelvis laceration with or without complete ureteral pelvic disruption
5	
Vascular	Laceration or avulsion of main renal artery or vein or thrombosis of main renal artery or vein

Table 2

Demographics of survey respondents

Specialty, *N* (%)	
IR	48 (62)
Urology	31 (38)
Age in years, *N* (%)	
30–39	24 (30)
40–49	32 (41)
50–59	18 (23)
60–69	4 (5)
70+	1 (1)
Practice type, *N* (%)	
Academic	76 (96)
Private, small group	1 (1)
Private, solo	1 (1)
Other	1 (1)
Practice location, *N* (%)	
Rural	5 (6)
Suburban	10 (13)
Urban	64 (81)
Median (range) cases grade ≥III renal trauma*	
Adult	3 (0–20)
Pediatric	<1 (0–5)
Median (range) cases renal AE performed for grade ≥III renal trauma*	
Adult	2 (0–100)
Pediatric	<1 (0–2)

*Managed in last year

AE angioembolization

Table 3

Percent of total, urologist, and IRs responses

Survey question	% (*N* = 79 total)	% (*N* = 48 IRs)	% (*N* = 31 urologists)	*p**
In your practice, is AE used for any of the following scenarios?				
Grade I–II renal injury	22	33	3	0.002
Grade III renal injury	49	65	26	0.001
Grade IV renal injury	86	85	87	1.0
Grade V renal injury	66	56	81	0.03
Penetrating injury	73	83	58	0.02
Blunt injury	75	77	71	0.60
None	1	0	3	1.0
What CT findings would indicate AE as first-line strategy for HGRT?				
Disruption of Gerota's fascia	4	6	0	0.28
Active arterial bleeding	97	100	94	0.15
AVF or pseudoaneurysm	94	96	90	0.38
Hematoma size >4 cm	13	13	13	1.0
Other CT criteria	8	2	16	0.03
None	1	0	3	0.39
What CT findings indicate surgery as first-line strategy for HGRT?				
Concurrent visceral injury	62	60	65	0.81
Disruption of Gerota's	6	6	6	1.0
Active arterial bleeding	19	13	32	0.02
AVF or pseudoaneurysm	8	6	10	0.67
Hematoma size > 4 cm	0	0	0	–
Other CT criteria	16	10	26	0.12
None	23	25	19	0.60
What clinical criteria would cause you to perform delayed angioembolization?**				
Decline in hemodynamic status	82	85	77	0.38
Persistent gross hematuria	52	65	32	0.006
HCT, TReq >2 PRBCs	52	63	35	0.02
HCT, TReq >3 PRBCs	52	54	48	0.65
Repeat CT indicating active bleeding	82	85	77	0.38
Other clinical finding	1	0	3	0.39
None	0	0	0	–

AE angioembolization, *CT* computed tomography, *HGRT* high-grade renal trauma, *AVF* arteriovenous fistula, *HCT* hematocrit, *TReq* transfusion requirement, *PRBCs* packed red blood cells

* *p* value from Fisher's exact test,

** Patient is initially placed on conservative management with bed rest and serial HCTs