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Authors
Hakam, Nizar
Keihani, Sorena
Shaw, Nathan M
et al.

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ORIGINAL ARTICLE

Grade V renal trauma management: results from the multi-institutional genito-urinary trauma study

Nizar Hakam[1] · Sorena Keihani[2] · Nathan M. Shaw[25,26] · Behzad Abbasi[1] · Charles P. Jones[1] · Douglas Rogers[3] · Sherry S. Wang[3] · Joel A. Gross[4] · Ryan P. Joyce[4] · Judith C. Hagedorn[5] · J. Patrick Selph[6] · Rachel L. Sensenig[7] · Rachel A. Moses[8] · Christopher M. Dodgion[9] · Shubham Gupta[10] · Kaushik Mukherjee[11] · Sarah Majercik[12] · Brian P. Smith[13] · Joshua A. Broghammer[14] · Ian Schwartz[15] · Nima Baradaran[16] · Scott A. Zakaluzny[17] · Bradley A. Erickson[18] · Brandi D. Miller[19] · Reza Askari[20] · Matthew M. Carrick[21] · Frank N. Burks[22] · Scott Norwood[23] · Jeremy B. Myers[2] · Benjamin N. Breyer[1,24] · for the Multi-institutional Genito-Urinary Trauma Study Group (MiGUTS)

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Abstract

Purpose To investigate management trends for AmericanAssociation for the Surgery of Trauma (AAST) grade V renal trauma with focus on non-operative management.

Methods We used prospectively collected data as part of the Multi-institutional Genito-Urinary Trauma Study (MiGUTS). We included patients with grade V renal trauma according to the AAST Injury Scoring Scale 2018 update. All cases submitted by participating centers with radiology images available were independently reviewed to confirm renal trauma grade. Management was classified as expectant, conservative (minimally invasive, endoscopic or percutaneous procedures), or operative (renal-related surgery).

Results Eighty patients were included, 25 of whom had complete imaging and had independent confirmation of AAST grade V renal trauma. Median age was 35 years (Interquartile range (IQR) 25–50) and 23 (92%) had blunt trauma. Ten patients (40%) were managed operatively with nephrectomy. Conservative management was used in nine patients (36%) of which six received angioembolization and three had a stent or drainage tube placed. Expectant management was followed in six (24%) patients. Transfusion requirements were progressively higher with groups requiring more aggressive treatment, and injury characteristics differed significantly across management groups in terms of hematoma size and laceration size. Vascular contrast extravasation was more likely in operatively managed patients though a statistically significant association was not found.

Conclusion Successful use of nonoperative management for grade V injuries is used for a substantial subset of patients. Lower transfusion requirement and less severe injury radiologic phenotype appear to be important characteristics delineating this group.

Keywords Kidney trauma · Nonoperative management · Nephrectomy · Urologic trauma

Abbreviations

AAST	American Association for the Surgery of Trauma
CT	Computed Tomography
ED	Emergency Department
ISS	Injury Severity Score
IQR	Interquartile range

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Extended author information available on the last page of the article

Introduction

Management trends for renal trauma have progressively shifted toward less invasive approaches with data suggesting improved renal preservation and patient outcomes [1–5]. For patients with American Association for the Surgery of Trauma (AAST) grade V injuries, guideline statements provide non-uniform recommendations. The World Society of Emergency Surgery (WSES) and the AAST kidney and urogenital trauma management guidelines recommend intervention (by either angioembolization or surgery) for all patients with grade V injuries [6]. On the other hand, American Urological Association (AUA) and European Association of

Urology (EAU) guidelines emphasize the patient's clinical status and downplay the renal injury grade as the decision-making factor [7, 8].

Evidence for nonoperative management of grade V injuries has been lacking and mainly consists of small cohort studies [9–11]. In the most extensive study to date using data from the National Trauma Databank (NTDB), it was found that nearly one-third of the patients with grade V trauma were managed successfully without intervention [12]. However, this study was limited by lack of radiologic data leading to concern for renal trauma grade misclassification within the NTDB.

In this study, we aim to investigate management trends for AAST grade V renal trauma from a prospective multi-institutional database, with focus on nonoperative management.

Methods

Data source

We used data collected as part of the Multi-institutional Genito-Urinary Trauma Study (MiGUTS). The study protocol and methods of data collection have been previously described, and full data on study sites and collaborators are available at (http://www.turnsresearch.org/aast-mitc-studies-bladder-trauma-research/genito-urinary-trauma-study-miguts) [13]. In brief, clinical and radiological data on patients with high-grade renal trauma were prospectively collected from 21 level 1 trauma centers for Phases 1 & 2 of the study. Institutional review board approval was obtained at all participating sites.

Study population

We included patients with grade V renal trauma according to the AAST Injury Scoring Scale 2018 update [14]. All cases submitted by participating centers with computed tomography (CT) images available were independently reviewed by blinded radiologists to confirm renal trauma grade. The methodology for review has been previously described [15]. Of 61 assigned grade V cases reviewed, most were reclassified and only 15 (24.6%) were validated by the 2018 AAST classification. There were also ten cases submitted as grade IV injuries but were upstaged to grade V after applying the 2018 AAST grading criteria. Patients who did not undergo renal diagnostic imaging (too clinically unstable) were analyzed as a separate group. Grade V injury in these patients was decided based on intraoperative or autopsy findings. This group was treated separately as staging by inspection could be very challenging, especially in a life-threatening situation; thus, it is likely that some of these cases were staged incorrectly.

Study variables

Clinical variables analyzed included: age, sex, mechanism of injury (blunt vs penetrating), body mass index (BMI), Injury Severity Score (ISS), lowest systolic blood pressure (SBP) in emergency department (ED), shock during first 4 h (defined as SBP < 90 mm Hg), heart rate in ED, lowest hemoglobin level in ED, number of red blood cell transfusions received in first 24 h, and the presence of other organ injuries defined as presence of any of the following injuries: solid organ, gastrointestinal, spinal cord, major vascular, and pelvic fracture.

Radiologic variables included vascular contrast extravasation (VCE), hematoma size (largest distance from edge of kidney to hematoma rim in the axial plane), para-renal hematoma (defined as hematoma extending beyond aorta on the left or inferior vena cava on the right or inferior to the aortic bifurcation), laceration size (continuous, and based on a 2.5 cm cut-off [16]), kidney devascularization percent (> 50–95% and > 95%), the presence of main vascular injury, and completely shattered kidney (defined as three or more segments of kidney separated by fluid or blood).

Renal trauma management was classified as either *expectant* (observation of the patient with no renal-related interventions), *conservative* (performing renal angioembolization or renal vascular stent placement, endoscopic (e.g., ureteral stenting), or percutaneous procedures (e.g., nephrostomy tube or perirenal drain placement)), or *open operative* (performing renal-related interventions during laparotomy, including nephrectomy, partial nephrectomy, renorrhaphy, and renal packing for bleeding control) [13].

Statistical analysis

Baseline patient parameters were summarized using descriptive statistics. Continuous variables were reported as median (interquartile range (IQR)), and categorical variables were reported as frequency (%). We first considered the group with imaging and a confirmed grade V injury. We reported management patterns and compared clinical and radiological characteristics based on management approach. We used the Kruskal–Wallis test for continuous variables and a chi-square or Fisher exact test for categorical variables. We also reported management patterns and mortality for those who did not undergo renal diagnostic imaging, and we univariately compared their characteristics to those who were diagnosed with CT using Mann–Whitney U test for continuous variables and a chi-square or Fisher exact test for categorical variables Statistical analysis was performed using Stata® 17, and a p value > 0.05 was considered statistically significant. The Strengthening the Reporting of Observational Studies in Epidemiology (STROBE) statement guidelines for reporting observational studies were followed [17].

Results

Eighty patients with a grade V injury were identified; 25 were radiologically confirmed and comprised the main analysis set. The other 55 were in the non-imaging group (straight to operating room or expired before imaging).

Median age was 35 years (IQR 25–50), and 19 /25 (76%) were males. The majority (23 /25 or 92%) had a blunt trauma mechanism. Ten patients (10/25; 40%) were managed operatively, and they all underwent nephrectomy. Three of these ten patients had renal angioembolization performed before nephrectomy. Conservative management was used in nine patients (9/25 or 36%) of which six received angioembolization and three had an endoscopic or percutaneous procedure to place a ureteral stent or drainage tube. Expectant management was followed in six (6/25 or 24%) who had no renal-related interventions. All patients survived to hospital discharge. Table 1 summarizes and compares the clinical and radiological characteristics based on management approach, and individual patient data are listed in Table 2.

There were several statistically significant differences across management groups. Red blood cell transfusion requirement was progressively higher with more aggressive treatment; the expectant group received a median of 0 (IQR 0–0) transfusions, whereas the conservative group received a median of 1 (IQR 0–2) transfusion and the operative group received a median of 7 (IQR 2–18) transfusions ($p = 0.006$). Other hemodynamic parameters such as lowest SBP, proportion of patients with shock, and heart rate tended to be less favorable with more aggressive approaches, though not statistically significant. We also found significant differences in injury characteristics in terms of hematoma size and laceration size (Table 1). The presence of vascular contrast extravasation was more likely with more aggressive therapy, though the relation was not statistically significant (Table 1). Sample injury images for patients managed expectantly, conservatively and operatively are presentedin Online Appendix 1, respectively. Additional sample images are presented in Online Appendix 1.

In the second group of 55 patients identified as having grade 5 injuries but without imaging, the diagnosis was made intraoperatively in 50 or on autopsy in 5. Compared

Table 1 Comparison of clinical and radiological characteristics based on management approach

	Expectant ($n = 6$)	Conservative ($n = 9$)	Operative ($n = 10$)	p value
Age[a]	42.5 (25–63)	32 (24–34)	44 (26–49)	0.7
Male sex	5 (83.3%)	6 (66.7%)	8 (80%)	0.72
BMI	28.3 (23.5–33)	25.9 (23.1–28.9)	24.6 (24.1–26.3)	0.64
ISS	31 (25–38)	29 (29–35)	35 (30–41)	0.73
lowest SBP ED	117.5 (110–122)	111 (106–123)	88.5 (70–116)	0.16
Shock /first 4 h	2 (33.3%)	4 (44.4%)	7 (70%)	0.35
HR in ED	84.5 (80–94)	96 (80–108)	104 (70–120)	0.72
Lowest Hgb in ED	13.2 (11.5–13.7)	10.2 (9.8–11.6)	11.9 (8.9–13.2)	0.07
No. RBC transfusion /first 24 h	0 (0–0)	1 (0–2)	7 (2–18)	**0.006**
Associated injuries	5 (83.3)	6 (66.7)	8 (80)	0.72
Vascular contrast extravasation	2 (33.3%)	5 (55.6%)	9 (90%)	0.055
Hematoma size (cm)	2.18 (0.8–4.45)	4.8 (2.75–6.7)	6.65 (4.6–7.05)	**0.047**
Hematoma size ≥ 3.5 cm	2 (33.3%)	6 (66.7%)	9 (90%)	0.06
Para-renal hematoma	4 (66.7%)	9 (100%)	9 (90%)	0.22
Laceration size (cm)	0.75 (0–3.45)	4.45 (3.9–4.6)	3.9 (3.45–5.4)	0.051
Laceration size ≥ 2.5 cm	2 (33.3%)	8 (88.9%)	9 (90%)	**0.028**
Devascularization > 50%	5 (83.3%)	2 (22.2%)	6 (60%)	0.058
> 50–95%	1 (16.7%)	1 (11.1%)	3 (30%)	0.82
> 95%	4 (66.7%)	1 (11.1%)	3 (30%)	0.09
Main vascular injury	3 (50%)	1 (11.1%)	3 (30%)	0.33
Completely shattered kidney	1 (16.7%)	5 (55.6%)	6 (60%)	0.27

BMI body mass index, *ISS* injury severity score, *SBP* systolic blood pressure, *ED* emergency department, *Hgb* hemoglobin, *RBC* red blood cell

[a]All continuous variables expressed as median (IQR)

Table 2 Individual patient clinical and radiological characteristics

Age	SBP	Hgb	HR	Transfusion	No. PRBC	ISS	Shock	VCE	Para-renal hematoma	Hematoma size(cm)	Laceration size(cm)	Devascularization > 50%	MVI	CSK	Management	LOS	Associated injury
25	122	10.8	119			29			Yes	2.59	0	> 95%	Yes		Expectant	12	Spleen (IV)
63	119	13.6	85	Yes	2	25	Yes	Yes	Yes	7.05	3.45				Expectant	9	
20	110	15.3	94			38		Yes	Yes	1.75	1.5	> 95%			Expectant	7	Liver (II)
76	54	11.5	58			45	Yes			0.8	0	> 95%	Yes		Expectant	40	Liver (V)
35	116	13.69	80			33			Yes	4.44	4.25	> 50–95%		Yes	Expectant	6	Liver (I)
50	138	12.63	84			17				0	0	> 95%	Yes		Expectant	5	Liver (III) + Pancreas (I)
21	123	10.8	98			34			Yes	4.8	4.9			Yes	Stent/tube	37	Liver (I) + Pancreas (II)
21	127	12.8	70			26			Yes	2.75	4.25			Yes	Stent/tube	4	
83	95	10.19	84	Yes	1	17	Yes	Yes	Yes	5.34	4.55				Stent/tube	6	
24	106	12.5	117			57	Yes		Yes	2.5	4.45			Yes	AE	31	Spleen (II)
34	123	9.19	80	Yes	2	29		Yes	Yes	6.94	4.8			Yes	AE	12	Major vascular
32	111	10	96	Yes	1	35		Yes	Yes	11.64	3.9		Yes		AE	9	Liver (II)
33	108	9.8	108	Yes	1	29	Yes		Yes	6.69	4.6	> 50–95%			AE	10	Major vascular
27	74	8.4	140	Yes	16	50	Yes	Yes	Yes	2.4	0	> 95%			AE	42	Liver (III) + Pelvic fracture
76	138	11.6	73	Yes	2	29		Yes	Yes	4.75	2.8				AE	28	
46	68	12.8	120	Yes	6	30	Yes	Yes	Yes	11.94	6.05	> 95%	Yes		AE then Nx	5	
18	130	13.19	53	Yes	1	17		Yes	Yes	3.29	3.55			Yes	AE then Nx	18	Major vascular
53	87	8.9	98	Yes	3	17	Yes	Yes	Yes	4.45	6.05	> 50–95%		Yes	AE then Nx	14	Liver (I) + Spleen (I)
47	116	8.8	118	Yes	14	45	Yes	Yes	Yes	6.59	0	> 95%	Yes	Yes	Nx	19	
58	96	11.1	63			35		Yes	Yes	6.69	3.45	> 50–95%		Yes	Nx	11	Spleen (IV)
49	70	13.19	70	Yes	19	35	Yes	Yes	Yes	7.44	5.4	> 50–95%		Yes	Nx	17	Spleen (V)
26	73	12.73	140	Yes	18	38	Yes	Yes	Yes	7.05	2.95				Nx	11	Spleen (II) + Pancreas (I)
25	123	13.19	83	Yes	2	30	Yes			4.94	4.05				Nx	6	Liver (V)
41	54	9.89	133	Yes	8	50	Yes	Yes	Yes	7	4.45	> 95%		Yes	Nx	6	Spleen (I) + Pancreas (III) + Pelvic fracture
42	90	8.4	110	Yes	35	41		Yes	Yes	4.6	3.75		Yes		Nx	39	Spleen (IV)

SBP systolic blood pressure, *Hgb* hemoglobin, *HR* heart rate, *PRBC* packed red blood cells, *ISS* injury severity score, *VCE* vascular contrast extravasation, *MVI* main renal vascular injury, *CSK* completely shattered kidney, *LOS* length of stay, *AE* angioembolization, *Nx* nephrectomy

For associated injuries, the number between parentheses indicates the AAST grade of the injured organ

Table 3 Comparison of characteristics of patients diagnosed with and without CT scans

Diagnosed with CT?	No ($n=55$)	Yes ($n=25$)	p value
Age (IQR)[a]	29 (22–37)	35 (25–50)	0.055
Male sex (%)	47 (85.5)	19 (76)	0.35
BMI (IQR)	26.5 (22.5–30.2)	25.9 (23.8–29.2)	0.78
Penetrating (%)	42 (76.4)	2 (8)	< 0.001
ISS	29 (26–38)	33 (29–38)	0.57
SBP	117 (88–134)	110 (87–123)	0.29
Shock /first 4 h	27 (49.1)	13 (52)	1
Heart rate in ED	103 (84–125)	94 (80–117)	0.12
Lowest Hemoglobin in ED	11.58 (9.7–13.1)	11.5 (9.9–12.8)	0.94
No. transfusion /first 24 h	10 (4–17)	1 (0–6)	0.0001
Associated injuries	55 (100)	19 (76)	0.001

BMI body mass index, *ISS* injury severity score, *SBP* lowest systolic blood pressure in emergency department, *ED* = emergency department

[a]All continuous variables expressed as median (interquartile range)

to patients diagnosed with CT (Table 3), these patients had substantially higher proportion of penetrating trauma mechanism (76.4% vs 8%, $p < 0.001$) and higher number of red cell transfusions within the first 24 h (median 10 (IQR 4–17) vs 1 (IQR 0–6), $p = 0.0001$). Nephrectomy was done in 48 out of 55 patients (87%), and the other 7 underwent renal packing for bleeding control ($n = 5$), renal angioembolization ($n = 1$), and renorrhaphy and packing ($n = 1$). Fourteen patients who underwent nephrectomy died (14 /48 or 29.2%) versus none in the imaging group. There were also seven patients who died that have received no renal-related intervention, of which six died in the first 24 h.

Discussion

In a cohort of 25 patients with AAST grade V renal trauma, we observed that 15 (60%) were managed nonoperatively. Despite the very small sample size of all groups, we noted several statistically significant differences in clinical characteristics based on management approach. Less red blood cell transfusion requirements and smaller hematoma size characterized patients receiving nonoperative management. These patients also demonstrated more favorable hemodynamic parameters in terms of SBP, shock, heart rate, and hemoglobin level, but these were not statistically significant. Only one of those managed expectantly or conservatively received more than 2 red cell transfusion units, whereas most operatively managed patients received 6 or more units. Additionally, an expectant approach was followed in four out of six patients with a laceration size < 2.5 cm but in only 2 out of 19 with a laceration size ≥ 2.5 cm. Prior studies have similarly reported associations between surrogates of hemodynamic stability or renal bleeding magnitude and increased likelihood of intervention especially nephrectomy [12, 18, 19]. These findings are in line with the AUA guidelines which indicate immediate intervention in such cases. [7] Vascular contrast extravasation has been previously shown to predict the need for bleeding intervention in the MiGUTS data and other studies[16, 20, 21]; however, it was not statistically significant associated with management in this study probably due to limited sample size. It should be also mentioned that clinical judgment plays an important role in defining management approach, which might be affected by factors we might not capture but drive surgeons' discretion.

These data add to the quality of evidence on nonoperative management of grade V renal trauma by being the first to examine radiologic parameters in relation to management approach in grade V injuries. In a prior study examining the national trauma databank, it was found that 35–40% of grade V patients were managed without intervention; however, a limitation of this database is that the validity of the renal trauma grade could not be confirmed by a review of radiographic images. Despite this limitation, the reported rate for conservative management is comparable to that seen in our study [12].

In the group of patients with grade V injury that did not have imaging, most of the diagnoses were made intraoperatively. Such cases mostly resulted from penetrating trauma as opposed to those determined by trauma CT scans, which were overwhelmingly the result of blunt trauma. Penetrating trauma mechanism has been shown to be strongly associated with nephrectomy in the setting of high-grade renal trauma [13, 19]. Nevertheless, we expect that the renal trauma has been incorrectly staged in a portion of these. All cases taken to the operating room without being imaged ended up undergoing nephrectomy. This might be related to lack of comfort or experience with renal reconstruction or might be a result of a "damage control" approach [22] where the kidney was removed in a patient in extremis to control active bleeding.

This study is limited by small sample size. High-grade renal trauma remains relatively uncommon and even longitudinal multicenter data from high volume centers can result in small numbers. Long-term clinical outcomes were not assessed as followup of patients was not available beyond the period of treatment for their trauma. We are also unable to determine the role of clinical decisions and the indications for interventions during the course trauma management. For example, it is unknown if any of the operatively managed patients were initially managed conservatively and taken to the operating room based on changing clinical characteristics at a later point. Retrospective observation of management of grade V injuries offers limited insight into the appropriateness of care in this setting. Thus, there is need for a prospective clinical trial evaluating nonoperative management for patients with grade V trauma who are stable enough to avoid emergency surgery and undergo diagnostic imaging. Only two of the grade V patients identified by renal imaging had a penetrating trauma mechanism, limiting the generalizability of these results to grade V kidney injury resulting from blunt trauma.

Conclusion

In a group of patients with AAST grade V renal trauma identified by renal imaging over half of the cases were managed expectantly or conservatively. Lower transfusion requirement and less severe radiologic injury findings appear to be important characteristics delineating the group of patients that can be managed nonoperatively.

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Author contributions NH and SK contributed to project development, data collection and management, data analysis, manuscript writing. CPJ was involved in data analysis and manuscript editing. SSW, JAG, RPJ, JPS, JCH, RAM, CMD, SG, KM, BPS, SM, JAB, IS, NB, SAZ, BAE, BDM, RA, MMC, FNB, SN, RLS, BA and DR contributed to manuscript editing. JBM, NMS and BNB were involved in project development, data analysis, and manuscript editing.

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Declarations

Conflict of interest None.

Research involving human participants and/or animals Institutional review board approval was obtained at all participating center.

Informed consent Informed consent was not applicable to the study.

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Authors and Affiliations

Nizar Hakam[1] · Sorena Keihani[2] · Nathan M. Shaw[25,26] · Behzad Abbasi[1] · Charles P. Jones[1] · Douglas Rogers[3] · Sherry S. Wang[3] · Joel A. Gross[4] · Ryan P. Joyce[4] · Judith C. Hagedorn[5] · J. Patrick Selph[6] · Rachel L. Sensenig[7] · Rachel A. Moses[8] · Christopher M. Dodgion[9] · Shubham Gupta[10] · Kaushik Mukherjee[11] · Sarah Majercik[12] · Brian P. Smith[13] · Joshua A. Broghammer[14] · Ian Schwartz[15] · Nima Baradaran[16] · Scott A. Zakaluzny[17] · Bradley A. Erickson[18] · Brandi D. Miller[19] · Reza Askari[20] · Matthew M. Carrick[21] · Frank N. Burks[22] · Scott Norwood[23] · Jeremy B. Myers[2] · Benjamin N. Breyer[1,24] · for the Multi-institutional Genito-Urinary Trauma Study Group (MiGUTS)

✉ Benjamin N. Breyer
Benjamin.Breyer@ucsf.edu

1 Department of Urology, University of California San Francisco, San Francisco, CA, USA

2 Division of Urology, Department of Surgery, University of Utah, Salt Lake City, UT, USA

3 Department of Radiology, University of Utah, Salt Lake City, UT, USA

4 Department of Radiology, Harborview Medical Center, University of Washington, Seattle, WA, USA

5 Department of Urology, Harborview Medical Center, University of Washington, Seattle, WA, USA

6 Department of Urology, University of Alabama at Birmingham, Birmingham, AL, USA

7 Division of Trauma, Department of Surgery, Cooper University Hospital, Camden, NJ, USA

8 Department of Surgery, Section of Urology, Dartmouth Hitchcock Medical Center, Lebanon, NH, USA

9 Department of Surgery, Medical College of Wisconsin, Milwaukee, WI, USA

10 Department of Urology, University of Kentucky, Lexington, KY, USA

11 Division of Acute Care Surgery, Loma Linda University Medical Center, Loma Linda, CA, USA

12 Division of Trauma and Surgical Critical Care, Intermountain Medical Center, Murray, UT, USA

13 Division of Trauma and Surgical Critical Care, Hospital of the University of Pennsylvania, Philadelphia, PA, USA

14 University of Kansas Medical Center, Kansas City, KS, USA

15 Department of Urology, Hennepin County Medical Center, University of Minnesota, Minneapolis, MN, USA

16 Department of Urology, Wexner Medical Center, The Ohio State University, Columbus, OH, USA

17 Division of Trauma, Acute Care Surgery, and Surgical Critical Care, Department of Surgery, University of California Davis Medical Center, Sacramento, CA, USA

18 Department of Urology, University of Iowa, Iowa City, IA, USA

19 Department of Urology, Detroit Medical Center, Detroit, MI, USA

20 Division of Trauma, Department of Surgery, Brigham and Women's Hospital, Boston, MA, USA

21 Medical City Plano, Plano, TX, USA

22 Department of Urology, Oakland University William Beaumont School of Medicine, Royal Oak, MI, USA

23 Department of Surgery, UT Health Tyler, Tyler, TX, USA

24 Department of Epidemiology and Biostatistics, University of California San Francisco, San Francisco, CA, USA

25 Department of Urology, Medstar Georgetown University Hospital, Washington, DC, USA

26 Department of Plastic and Reconstructive Surgery, Medstar Georgetown University Hospital, Washington, DC, USA