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Current Management of Extraperitoneal Bladder Injuries: Results from the Multi-Institutional Genito-Urinary Trauma Study (MiGUTS)

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Abbreviations and Acronyms

CD = catheter drainage

CT = computerized tomography

EBI = extraperitoneal bladder injury

ISS = injury severity score

NTDB = National Trauma Data Bank

OR = operative repair

ORIF = open reduction and internal fixation

Purpose: We studied the current management trends for extraperitoneal bladder injuries and evaluated the use of operative repair versus catheter drainage, and the associated complications with each approach.

Materials and Methods: We prospectively collected data on bladder trauma from 20 level 1 trauma centers across the United States from 2013 to 2018. We excluded patients with intraperitoneal bladder injury and those who died within 24 hours of hospital arrival. We separated patients with extraperitoneal bladder injuries into 2 groups (catheter drainage vs operative repair) based on their initial management within the first 4 days and compared the rates of bladder injury related complications among them. Regression analyses were used to identify potential predictors of complications.

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Results: From 323 bladder injuries we included 157 patients with extraperitoneal bladder injuries. Concomitant injuries occurred in 139 (88%) patients with pelvic fracture seen in 79%. Sixty-seven patients (43%) initially underwent operative repair for their extraperitoneal bladder injuries. The 3 most common reasons for operative repair were severity of injury or bladder neck injury (40%), injury found during laparotomy (39%) and concern for pelvic hardware contamination (28%). Significant complications were identified in 23% and 19% of the catheter drainage and operative repair groups, respectively ($p=0.55$). The only statistically significant predictor for complications was bladder neck or urethral injury (RR 2.69, 95% 1.21–5.97, $p=0.01$).

Conclusions: In this large multi-institutional cohort, 43% of patients underwent surgical repair for initial management of extraperitoneal bladder injuries. We found no significant difference in complications between the initial management strategies of catheter drainage and operative repair. The most significant predictor for complications was concomitant urethral or bladder neck injury.

Key Words: epidemiology, urinary bladder, wounds and injuries, trauma centers, multicenter study

Bladder trauma is the second most common genitourinary injury and occurs in about 4% of patients with traumatic pelvic fractures.[1–3] The majority of bladder injuries are extraperitoneal and are accompanied by other abdominal organ injuries.[4,5] Intraperitoneal bladder injuries are usually surgically repaired, however, the role of surgical repair for extraperitoneal bladder injuries is not well-defined.

Current guidelines from the American Urological Association recommend catheter drainage for the initial management of uncomplicated, blunt EBI.[6] The relative indications for operative repair of EBI include concomitant injuries to the bladder neck, rectum or vagina; bony spicules within the bladder and persistent gross hematuria with clots.[6,7] However, data are conflicting regarding the utility of OR for EBI and the associated complications of either CD or OR. For instance, the University of Texas at Houston reported their 7-year data in which 23% of their 39 EBI cases underwent OR.[8] Additionally, in a more recent series of 80 patients with EBI from the Vanderbilt University, 30% underwent OR as a secondary procedure during nonurological interventions.[9]

Research on EBI is mostly limited to retrospective, single-institutional studies, or studies using administrative data such as the National Trauma Data Bank. We sought to understand the current management trends and outcomes of CD versus OR for EBI in a large contemporary multi-institutional cohort.

METHODS

This study is part of the Multi-institutional Genito-Urinary Trauma Study (MiGUTS), which is a partnership between the American Association for the Surgery of Trauma (AAST) Multi-institutional Trials Committee, and the Trauma and Urologic Reconstruction Network of Surgeons (TURNS). For the current study, bladder trauma data were included from 20 level 1 trauma centers participating in phase 1 (2014 to 2017) or phase 2 (2013 to 2018) of the MiGUTS project (a full list of participating centers and collaborators can be found at http://www.turnsresearch.org/page/genito-urinary-trauma-study-miguts-bladder).

We excluded patients with an intraperitoneal bladder injury component and those who died within 24 hours of admission. Several clinical variables were considered, including age, sex, trauma mechanism (blunt vs penetrating), presence of concomitant injuries (solid organ, gastrointestinal, spinal cord, major vascular, and pelvic fracture), ISS an anatomical scoring system ranging from 0 to 75 reflecting overall injury severity in polytrauma patients and calculated based upon abbreviated injury scores from 6 body regions),[10] exploratory laparotomy for nonurological reasons, pelvic orthopedic interventions (open reduction and internal fixation, closed reduction and internal fixation, and external fixation of pelvis), hospital length of stay, and complications. Significant complications were defined as the presence of urological or orthopedic conditions such as pelvic infection/urinoma, persistent urinary extravasation, urinary tract fistula, nonunion fractures, hardware infection or removal, and pelvic osteomyelitis. Operative variables included type of physician performing the bladder repair (urologist vs trauma/acute care surgeon) and the main reasons for repair, which included the ability to choose 1 or more of the options of discovered during laparotomy and repaired at the time of exploration; repaired at the time of pelvic fixation due to concern over urinary leakage and contamination of pelvic hardware; hematuria and blood clots hindering urine drainage; severity of extraperitoneal injury (large injury, bladder neck injury, other); and concomitant rectal, bowel, or vaginal injury. When available, followup imaging data were collected to assess healing of bladder injury. Persistent urinary extravasation was defined as any indication of urine leak from the bladder injury in the followup images regardless of timing of the study. Time to catheter removal was recorded if documented. Patients were grouped as either CD or OR based upon their initial management within the first 4 days after hospital admission. We compared clinical variables, and urological and orthopedic complications between these 2 groups.

Data are presented as mean (SD) or median (25th–75th IQR) when appropriate. Independent samples t-test (or Wilcoxon rank-sum test when appropriate) and chi-squared test (or Fisher's exact test when appropriate) were used to compare continuous and categorical variables between the management groups, respectively. Mixed effect univariable Poisson regression models, with clustering by facility and robust estimator for error, were developed to assess the associations between different predictors and complications after EBI. Results from regression models are reported as risk ratios with 95% CIs. The multivariable model included bladder management as well as variables with $p < 0.1$ from the univariable analyses. As the number of outcomes were small, we relaxed the rule of 10 events per predictor to include 5 to 6 variables in the multivariable model.[11] All statistical analyses were conducted using STATA® 15 and $p < 0.05$ was considered statistically significant.

RESULTS

We identified 323 bladder injuries of which 164 (51%) involved only EBI. After excluding those who died within 24 hours of hospital arrival, 157 patients with EBI were included. The mean age was 40.6 (SD 17.5) years, 106 (68%) were male, and 121 (77%) had a blunt mechanism of injury. Mean ISS was 26.1 (SD 12.5) and concomitant injuries occurred in 139 (88%) with pelvic fracture seen in 124 (79%). Pelvic fracture related orthopedic procedures were performed in 85 (54%) patients and included ORIF (57, 47%), closed reduction and internal fixation (35, 29%), and external fixation (29, 24%) (some patients underwent more than 1 procedure). There were 3 additional mortalities in our cohort of patients with EBI after the initial exclusion step with none related to the genitourinary injuries. Patients who underwent surgical repair were younger, more were male, had a higher rate of penetrating and bladder neck injury, had lower ISS and had lower rates of pelvic fracture compared to the nonoperative group. Patient and injury characteristics are summarized in table 1.

Sixty-seven (43%) patients underwent surgical repair of their EBI. Median time to repair was 5.4 hours (IQR 1.7–22.7). Urologists repaired the bladder in 48 (72%) cases, and the remainder were repaired by trauma/acute care surgeons. Time to catheter removal was not significantly different between the CD and OR groups (18 vs 16 days, $p = 0.16$, data available for 98 [62%] patients). Fifty-one patients (76%) had information available on followup imaging as fluoroscopic cystogram was performed in 33 (65%), compared to CT cystogram in 18 (35%). The 3 leading reasons for EBI repair were severity of the injury or bladder neck injury (40%), injury found during laparotomy (39%) and concerns about pelvic hardware contamination (28%). The top 3 reasons were similar with different orders among urological vs nonurological surgeons who performed the repairs (the top reason being severity of injury for urologists and injuries found during laparotomy for nonurologists). Table 2 describes the surgically repaired cohort.

We found no significant difference in the total bladder related urological or orthopedic complications between the CD and OR groups (23% vs 19%, $p = 0.55$). Table 3 compares the urological and orthopedic complications between the groups. The significant univariable predictors for complications included age and associated bladder neck/urethral injury. Other factors including nonoperative management, ISS, pelvic fracture and pelvic orthopedic procedures were not significant predictors of bladder related complications (table 4). In the multivariable analysis only presence of bladder

Table 1. *Demographics and management of extraperitoneal traumatic bladder injury*

	Total (157)	Catheter Drainage (90)	Operative Repair (67)	p Value
Mean age (SD)	40.6 (17.5)	44.7 (18.6)	35.0 (14.2)	<0.001
No. male sex (%)	106 (68)	54 (60)	52 (78)	0.02
No. injury type (%):				0.001
Blunt	121 (77)	83 (92)	38 (57)	
Penetrating	36 (23)	7 (8)	29 (43)	
Mean ISS (SD)	26.1 (12.5)	28.4 (13.1)	23.0 (11.2)	0.01
No. concomitant injuries (%):	139 (88)	82 (91)	57 (85)	0.24
Pelvic fracture	124 (79)	79 (89)	45 (67)	0.001
Bladder neck injury	19 (12)	5 (6)	14 (21)	0.004
Urethral injury	15 (10)	7 (8)	8 (12)	0.38
Colon injury	16 (10)	6 (7)	10 (15)	0.09
Rectal injury	18 (11)	4 (4)	14 (21)	0.001
No. nonurological operation (%):				
Exploratory laparotomy	65 (41)	15 (17)	50 (75)	<0.001
Pelvic orthopedic procedure	85 (54)	52 (58)	33 (49)	0.29
Median days length of stay (IQR)	12 (6–21)	12 (6–20)	12 (6–21)	0.81
Median days intensive care unit length of stay (IQR)	6 (3–13)	5 (3–13)	6 (2–15)	0.97
Median days to catheter removal (IQR)	17 (13–24)	18 (14–27)	16 (12–22)	0.16
No. urological complications (%)	27 (17)	16 (18)	11 (16)	0.82
No. orthopedic complications (%)	10 (6)	5 (6)	5 (7)	0.74

Table 2. *Characteristics of the surgical repair cohort*

Median hrs to initial repair (IQR)	5.4 (1.7–22.7)	
No. reason for initial repair (%):		
Severity of injury/bladder neck injury	27	(40)
Injury found during laparotomy	26	(39)
Concern for pelvic hardware contamination	19	(28)
Concomitant gastrointestinal or vaginal injury	11	(16)
Hematuria or blood clots obstructing urine drainage	8	(12)
No. type of physician performing initial repair (%):		
Urologist	48	(72)
Acute care surgeon/general surgeon	16	(24)
Not recorded	3	(4)
No. followup imaging modality (%):		
Fluoroscopic cystogram	33	(65)
CT cystogram	18	(35)
No. persistent urinary extravasation (%)	9	(13)
No. management of persistent extravasation (%):		
Additional bladder repair(s)	2	(22)
Continued Foley drainage	3	(33)
Suprapubic tube/percutaneous nephrostomy	4	(45)
No. pts with urological complications (%):	11	(16)
Clavien-Dindo I	2	
Clavien-Dindo IIIa	4	
Clavien-Dindo IIIb	5	
No. pts with orthopedic complications (%):	5	(7)
Clavien-Dindo IIIb	5	

neck/urethral injury was a significant predictor for complications after EBI (RR 2.69, 95% 1.21–5.9, p=0.01). Overall, 19 patients had bladder neck injury. Of the 5 EBI with bladder neck injury in the CD group 3 were eventually repaired due to persistent leak or more complex injuries (including 1 with bone fragments in the bladder). Of the 14 patients with bladder neck injury in the OR group 3 had persistent leak that was healed with temporary urinary diversion and/or continued catheter drainage, 3 had more complex courses with fistulas, urinary incontinence and multiple or failed repairs, and the other 8 had no complications.

Persistent urinary extravasation was identified in 25 (20%) of 122 patients with EBI who had followup imaging, with 16 (23%) in the CD cohort and 9 (18%) in the OR group. Of the 9 patients from the operative cohort with persistent leak 2 required additional repairs, 3 were treated with continued catheter drainage and 4 needed additional drainage tubes placed (suprapubic or nephrostomy tubes). Of the 16 patients who had persistent leak in the CD group 10 were managed with continued catheter drainage and median time to resolution of leak was 28 days after injury. Six patients had delayed repair after initial management of CD. Of these patients 2 had bone fragments identified at followup imaging and 1 patient had cutaneous fistula formation to the labia. The other 3 did not have further details regarding the circumstances surrounding the repair. The figure depicts a flow chart for management of persistent urinary extravasation in our cohort.

DISCUSSION

In this contemporary multi-institutional cohort of bladder trauma, 51% of injuries were extraperitoneal, of which 43% underwent surgical repair as initial management. We found that bladder neck/urethral injury was associated with a higher bladder related complication rate after EBI. The complication rate was not different with respect to the initial management strategy of CD or OR, although this may reflect selection bias with the complexity of injuries being more severe in the OR group.

Studies from the NTDB demonstrated a 50% rate of bladder repair in adults with EBI with an association between bladder repair and better survival.[4,12] In the NTDB the mortality rate for EBI was 10.8% compared to our rate of 6.1%. However, all 10 mortalities in our cohort occurred due to the severity of concomitant injuries with 7 within the first 24 hours. Possible explanations for the associations observed in the NTDB are inclusion of intraperitoneal injuries and that severely injured patients may not have undergone bladder repair due to the higher priority injuries or poor prognosis, and then died at a higher rate without bladder repair.

Neither CD nor OR was free from complications. However, we found no difference in the overall urological or orthopedic complication rates between the 2 groups. Despite a large number of patients with EBI included in our series, our study might be underpowered to address this question given the small number of complications in each group. However, our

Table 3. *Bladder injury related significant urological and orthopedic complications in patients with extraperitoneal bladder injury separated by management*

	Catheter Drainage (90)	Operative Repair (67)	p Value
Total No. pts with complications (%)	21 (23)	13 (19)	0.55
No. urological complications (%):			
Pelvic infection/urinoma	1 (1)	4 (6)	0.16
Persistent urinary extravasation	16 (18)	9 (13)	0.46
Urinary tract to skin fistula	1 (1)	3 (4)	0.31
No. orthopedic complications (%):			
Nonunion	1 (1)	1 (1)	0.99
Hardware infection/removal	4 (4)	5 (7)	0.50
Pelvic osteomyelitis	0 (0)	2 (3)	0.18

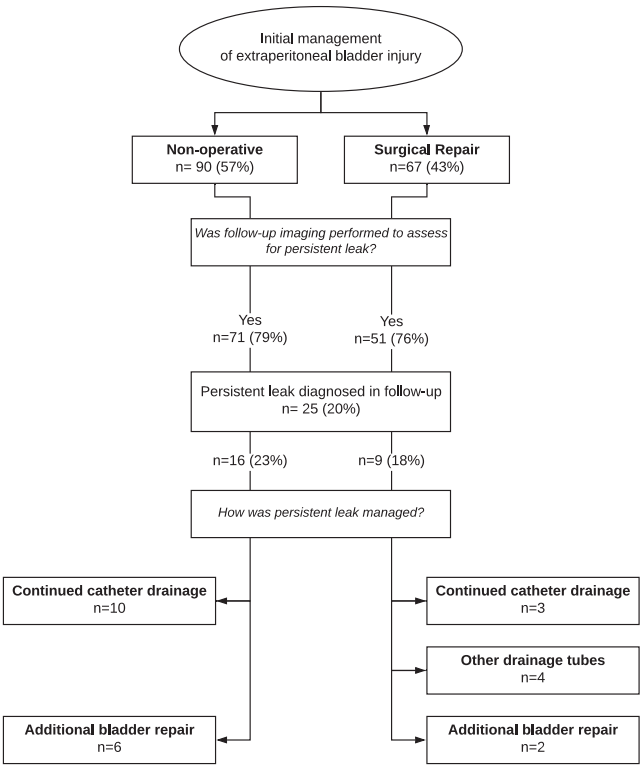
Table 4. *Regression analyses of factors predicting complications after extraperitoneal bladder injury*

	Univariable		Multivariable	
	RR (95% CI)	p Value	RR (95% CI)	p Value
Age (per yr)	1.02 (1.00–1.04)	0.05	1.02 (0.99–1.04)	0.16
Male sex	1.01 (0.50–2.01)	0.99	—	—
ISS (per unit)	1.02 (1.00–1.05)	0.07	1.01 (0.98–1.04)	0.41
Penetrating trauma	0.32 (0.10–1.05)	0.06	0.68 (0.15–2.94)	0.61
Pelvic fracture	2.67 (0.81–8.72)	0.11	—	—
Bladder neck/urethral injury	3.02 (1.49–6.11)	0.002	2.69 (1.21–5.97)	0.01
Colon/rectal injury	1.25 (0.54–2.87)	0.60	—	—
Pelvic orthopedic procedure	2.03 (0.97–4.25)	0.06	1.31 (0.55–3.12)	0.53
Nonoperative management	1.20 (0.60–2.40)	0.60	1.20 (0.53–2.72)	0.66

23% complication rate in the CD group is consistent with a previous report on 29 EBI cases treated with CD alone that showed a 26% complication.[13] A more contemporary series suggested a reduced rate of major complications in patients with EBI who underwent bladder repair at the time of ORIF or exploratory laparotomy compared to those who underwent these procedures without repair (4% vs 30% complication rate, respectively).[9] However, similar to our study, the conclusions could have easily been affected by just 1 or 2 cases due to the low numbers of complications and rarity of EBI.

Complex EBIs include concomitant injuries to the bladder neck, rectum or vagina, bony spicules within the bladder or persistent gross hematuria with clots.[6,7] The diagnosis of complex EBI is nuanced and depends on multiple factors, including imaging modality (CT vs plain x-ray), and the quality and timing of the imaging study. In our study 6 patients who were first treated with CD ultimately underwent OR due to persistent urinary extravasation. Two patients had bone spicules in the bladder and likely would have benefited from early repair if this had been diagnosed on original imaging. We found a significant association between bladder related complications and the presence of bladder neck/urethral injuries. These concomitant lower tract injuries may lead to increased urinary extravasation, prolonged exposure of the pelvis to urine, or could increase the complexity of both the urological or orthopedic surgeries. Both the AAST and the AUA guidelines recommend bladder repair for patients with concomitant bladder neck injury.[6,14] However, in our cohort 5 of the 19 patients with bladder neck injury identified were initially treated with CD. Although we did not have details on the reasons for this approach, 3 of these 5 patients eventually underwent a bladder repair for persistent urinary extravasation. Additionally, about half of patients with bladder neck injury who initially underwent OR had delayed healing or a complicated recovery course. These observations stress the importance of diagnosing bladder neck injury so initial management with CD is truly reserved for uncomplicated injuries. CT cystogram with initial noncontrast view and retrograde filling of the bladder with more than 300 cc is the gold standard to assess for bladder injury, and provides the most anatomic detail.[15]

Previous orthopedic and urological literature, including the AUA trauma guidelines, has stressed patients with EBI undergo bladder repair if orthopedic hardware is implanted, especially if ORIF is performed due to the potential hardware contamination with urine.[6,16,17] Of note, in our series 42% of patients who underwent ORIF did not undergo bladder repair (either immediate or delayed). Rates of orthopedic complications were not different in



Management of extraperitoneal bladder injury with persistent urinary extravasation on followup imaging.

ORIF cases who underwent CD vs OR. Although some of these ORIF procedures might have only involved screw placement and some might have been performed after partial healing of bladder injuries, this finding raises the question of whether immediate bladder repair is needed for all patients undergoing pelvic ORIF. However, concern for pelvic hardware contamination was still the third most common reason reported for initial repair of EBI in our cohort. This approach might find root in the literature recommending EBI repair at the time of ORIF, although the evidence behind these recommendations is weak.[13,16–18]

This study has similar limitations to any nonrandomized cohort study, and there is a possibility of selection bias for treatment groups. We suspect more complex injuries undergo repair at a higher rate and thus a comparable rate of complications between patients managed with CD and OR may not be valid. Currently, a robust method of classifying complex EBI is lacking, and until a strategy is developed to better stratify severity of EBI this limitation will remain a confounder of studies on this injury pattern. Furthermore, the initial management and followup protocols were not standardized across all centers. Thus, surgical technique, catheter type and duration, and the use of postoperative imaging might vary across the centers. These differences could be based on local trauma protocols, the type of surgeon managing the injury (trauma/acute care surgeon vs urologist) and individual surgeon experience and preferences. Despite these limitations, our study does reflect contemporary real-world management of EBI from 20 level 1 trauma centers across the United States and is the largest contemporary study on management of EBI. The multi-institutional nature of the data and not relying upon historic data spanning periods where genitourinary trauma management has changed substantially are other strengths of this study.

CONCLUSION

In this large multi-institutional cohort, we found that 43% of patients underwent operative repair for initial management of EBI. We did not find any significant difference in pelvic orthopedic or urological complications between the initial management strategies of catheter drainage and operative repair, but given the possible selection bias in management decisions these results should be interpreted with caution. The most significant predictor for complications was concomitant urethral or bladder neck injury. We recommend adhering to the current guidelines about operative repair of EBI in the presence of bladder neck injuries. More data are needed on the timing and type of followup imaging, and also the necessity of bladder repair in patients with orthopedic hardware.

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EDITORIAL COMMENTS

Optimal management of extraperitoneal bladder injuries in the setting of blunt and penetrating trauma has been a source of confusion for medical practitioners. This is largely produced by a dearth of quality literature regarding outcomes of conservative (catheter drainage) management, as compared to early operative repair. The current landscape of the urological trauma literature is largely composed of single center, retrospective reporting (reference 9 in article).[1]

The current study, a multi-institutional, prospective registry across 20 nationally recognized level 1 trauma centers, represents a significant concerted effort from leading urological trauma surgeons to shed some light on management and outcomes of EBIs. The authors hypothesized that catheter drainage for EBI would exhibit a higher complication rate compared to early operative repair when controlled for severity of injury. While overall complication rates were similar between the 2 groups, the study was limited by significant selection bias given the lack of randomization. Nevertheless, the authors provide an important addition to an underrepresented body of evidence.

This study further highlights the benefit of working across institutions to amass meaningful data for the advancement of urological surgery. The authors are to be commended for their efforts and encouraged to continue their collaboration to advance the field of genitourinary trauma.

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All areas of urology have their associated dogmata but perhaps nowhere else is it as prevalent as it is with genitourinary trauma. Obtaining hypothesis driven data in this field has unique challenges related to patient acuity, informed consent, high rates of concomitant injuries and the relative infrequency with which some urological injuries occur. This is especially true for extraperitoneal bladder injury, where there is a lack of robust evidence and as a consequence indications for surgical intervention are poorly defined. In general, the relative indications for operative repair include presence of bony spicules within the bladder, bladder entrapment, suboptimal urinary drainage, penetrating trauma and concurrent injury to the bladder neck, rectum or vagina (reference 6 in article).[1]

This is a multi-institutional study examining outcomes of extraperitoneal bladder injury treated with operative repair or catheter drainage. This study is well articulated and an important contribution to the trauma literature. Of 157 patients 57% were managed with catheter drainage while the remaining 43% underwent operative repair. The overall complication rate was 22%, which did not differ by treatment approach despite the operative group having higher rates of penetrating trauma (43%), rectal injury (21%) and bladder neck injury (21%). On multivariate analysis only bladder neck/urethral injury was associated with complications while rectal injury, nonoperative treatment, penetrating trauma and concurrent pelvic hardware were not. Although it was impossible to avoid some selection bias, this study confirms that patients with extraperitoneal bladder injury and concurrent bladder neck or urethral injury require aggressive management and careful attention regardless of treatment approach.

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