Traumatic blunt urethral injuries in females

A retrospective study of the National Trauma Data Bank

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ABSTRACT

INTRODUCTION: Female blunt urethral injury (FBUI) is much less common than in males. Due to this rarity, studies of FBUI are largely confined to smaller case series. This study analyzes circumstances associated with FBUI and its contribution to mortality in greater detail.

METHODS: Using the National Trauma Data Bank, we analyzed predictors of FBUI, and tested FBUI as a predictor of mortality. Univariate analysis used Chi-squared for categorical data and T-test for continuous data. Multivariate analysis used multiple logistic regression.

RESULTS: A total of 245 (0.021%) of 1 185 904 female blunt trauma patients sustained FBUI vs. 2242 (0.145%) for males ($p<0.001$). Eighty-seven FBUIs (0.097%) occurred under age 16 vs. 153 (0.016%) in older patients ($p<0.001$). FBUI was more common with motorcycle (n=14, 0.203%), bicycle (n=11, 0.110%), and automobile vs. pedestrian accidents (n=47, 0.146%) than falls (n=72, 0.011%) or automobile accidents (n=61, 0.029%) ($p<0.001$). FBUI occurred in 114 (0.011%) patients with Injury Severity Score (ISS) <15 vs. 131 (0.091%) with ISS >15 ($p<0.001$). Slightly more than half (56.7%) of FBUI occurred with pelvic fractures. Age (odds ratio [OR] 0.95, $p<0.001$), injury severity (OR 1.05, $p<0.001$), auto vs. pedestrian (OR 4.1, $p<0.001$), motorcycle crashes (OR 6.9, $p<0.001$), and bicycle crashes (OR 3.9, $p<0.001$) independently predicted FBUI. A total of 9.4% of FBUI patients died vs. 2.5% without FBUI ($p<0.001$). The association of FBUI with death was not significant on multivariate analysis.

CONCLUSIONS: FBUI is more prevalent in young patients with high-force direct trauma. FBUI is not an independent predictor of mortality, suggesting that it is a marker of severe injury rather than a direct cause of death.

INTRODUCTION

Urethral injuries constitute up to 4% of all genitourinary trauma.[1] A large majority of blunt urethral injury is sustained by males, in part due to a longer and more fixed urethra. Female blunt urethral injury (FBUI), in contrast, is a rare occurrence, with 5–10 times lower incidence than in males.[1-3] Due to the rarity of the injury, most previous studies regarding its predictive factors and associated outcomes are limited to case series and small data sets.

Although previous studies have estimated that only 4% of pelvic fractures in women involve urethral injury (UI), various studies report that it is uncommon for a UI to occur in the absence of a pelvic fracture.[4,5] Due to the high force necessary to disrupt the pelvis, the association of FBUI with outcome is confounded by concomitant injuries.[3] Although the urethra is not a vital organ, FBUI may be a sentinel injury that marks the presence of other life-threatening conditions. Our hypothesis is that UI is a marker of mortality in women with blunt trauma. Our study will try to elucidate some of the risk factors, mechanisms, and outcomes of this injury.

METHODS

Study design and population

This is a retrospective cohort study that analyzes predictors of FBUI and the association of FBUI with mortality. Data for this analysis was derived from the American College of Surgeons National Trauma Data Bank (NTDB), which compiles patient

KEY MESSAGES

- Female blunt urethral injury is rare but is more common among young patients suffering unprotected, high-force, direct trauma.
- Although associated with severe traumas, female blunt urethral injury is not an independent predictor of mortality.
- The presence of blunt urethral injury in females may be useful as a marker for severe injury but is unlikely to be a direct cause of death.

information from over 900 trauma centers across the U.S.[6] The years 2017 through 2019 were chosen. Female patients with BUI were included in the analysis.

Data collection and statistical analysis

Chi-squared was used to test for significance for categorical variables. T-test was used to test for significance for continuous variables. Multivariate analysis was performed with multiple logistic regression. To avoid multicollinearity in the multivariate analysis, a modified injury severity score (ISS) was recalculated without the contribution of urethral injury. The independent variables for prediction of FBUI are age, ISS, and Elixhauser index. The independent variables for prediction of mortality are FBUI, age, ISS, and Elixhauser index.

All statistical analysis was conducted with SPSS Statistics, version 27.0 (IBM Corp., Armonk, N.Y., U.S.).

RESULTS

Patient demographics

Our study encompassed 3 137 799 trauma patients, of which 3220 (0.10%) patients suffered a UI. Out of all UI, only 287 (8.9%) occurred in females, indicating that UI occurs in males 10.2 times more often (Table 1). A majority of these female UI (n=245) were blunt injuries, which we further investigate in this study.

The age distribution of FBUI heavily favors the younger population. Females less than 16 years of age presenting with trauma have a 0.097% chance of FBUI, whereas this probability significantly decreases in the older population to 0.033% in patients between 16 and 60 years, and to 0.0041% in patients older than 60 years (p<0.001) (Table 1).

The ISS is a scale employed for trauma to categorize the severity of systemic injuries, with higher scores up to 75 reflecting more severe traumas. The ISS for FBUI tends to be high, suggesting that it often occurs alongside severe injury. Out of female traumas with ISS <15, 0.011% suffer FBUI, compared to female traumas with ISS <15, where 0.091% suffer FBUI (p<0.001) (Table 1).

Mechanism of injury

The most common blunt mechanisms of injury for FBUI involve motorcycle accidents, bicycle accidents, automobile vs. pedestrian accidents, motor vehicle crashes (MVC), and falls. Proportionally for all injuries of each

Table 1. Demographical characteristics for FBUI patients

Mean age, years (SD)	27.06 (21.77)
Age >16	0.097%
FBUI	87
Total	89 191
Age 16–60	0.0331%
FBUI	129
Total	389 766
Age>60	0.0041%
FBUI	24
Total	579 639
Mean Injury Severity Score (ISS) (SD)	20.55, median 17.0 (16.31)
Not severe (ISS <15)	0.011%
FBUI	114
Total	1 041 253
Severe (ISS >15)	0.091%
FBUI	131
Total	144 406
Mean Revised Trauma Score (RTS) (SD)	7.21, median 7.84 (1.38)
Mean Elixhauser Index (SD)	11.31, median 0 (18.72)
Associated injuries	
Pelvic fracture	139/245 (56.7%)
Gyn injury	132/245 (53.9%)
Bladder injury	69/245 (28.2%)
Other genitourinary (GU) injury	24/245 (9.8%)
Rectal injury	Rectal injury

FBUI: female blunt urethral injury; SD: standard deviation.

Table 2. Incidence of FBUI by mechanism	
Mechanism	Proportion with FBUI
Falls	0.011%
FBUI	72
Total	654 545
MVC	0.029%
FBUI	61
Total	210 345
Bicycle crash	0.110%
FBUI	11
Total	10 000
Auto vs. pedestrian	0.146%
FBUI	47
Total	32 192
Motorcycle crash	0.203%
FBUI	14
Total	6897

p<0.001 for differences between categories. FBUI: female blunt urethral injury.

mechanism, FBUI was more likely with motorcycle (0.203%), bicycle, (0.110 %), and pedestrian (0.146%) injuries compared to MVC (0.029%) and falls (0.011%) (Table 2).

Multivariate analysis of predictors of UI

Multivariate analysis identifies three mechanisms of injury, relative to the reference mechanism of MVC, that are strong predictors of FBUI, particularly motorcycle (odds ratio [OR] 6.92, p<0.001), automobile vs. pedestrian (OR 4.11, p<0.001), and bicycle (OR 3.88, p<0.001) incidents (Table 3). Age is a protective factor against FBUI (OR 0.96, p<0.001). A modified ISS, which is the ISS calculated without the contribution of FBUI, is a predictive factor (OR 1.047, p<0.001).

Multivariate analysis of predictors of death

On univariate analysis, patients presenting with FBUI had a 9.4% chance of suffering death during their index admission compared to 2.5% of all females in our study population (Table 4); however, in our multivariate analysis to detect factors contributing to mortality, isolated FBUI was not a significant predictor of death (OR 0.574, p=0.071) (Table 4). Increasing age (OR 1.03, p<0.001) and modified ISS (OR 1.14, p<0.001) were significantly predictive of death. Relative to MVC, injuries associated with pedestrian accidents (OR 1.91, p<0.001) were predictive of death, whereas bicycle accidents (OR 0.81, p=0.031) were protective.

DISCUSSION

Blunt urethral trauma is rare in women.[2-4,7] In our study, the incidence of UI among women with blunt trauma was 0.021%, or only about 1 in 4831. Although it is rare, studying FBUI may help us achieve a better understanding of epidemiology, anatomy, injury mechanics, and associated injuries.

The pattern of FBUI highlights contrasts between male and female urogenital anatomy. In an analysis of the NTDB, Bjurlin et al found that in the setting of pelvic fractures 1.5% of males, but only 0.15% of females suffered a UI. Bladder injury was equal (3.41% vs. 3.37% in women).[3] It does not appear that the pelvis is more protective in general in women, but that the protective effect is specific to the urethra.

The male urethra tends to rupture at the bulbomembranous junction, with 2/3 resulting in complete disruption.[8] In contrast, Delaney et al attributed the sparing of the female urethra from injury to its short length, protected position, and less rigid fixation to the pelvic bone.[2] It also benefits from greater elasticity and flexibility.[9] When the female urethra is damaged in blunt trauma, it is usually a partial tear of the anterior wall due to direct trauma.[10]

This anatomic pattern of injury is consistent with the mechanisms we found for FBUI. FBUI is more common when there is less protection from direct force. Eidelman et al reported that the majority occur in motor vehicle accidents.[11] In our study as well, transportation accidents accounted for most injuries, but patients involved in bicycle, motorcycle, and auto vs. pedestrian accidents had far greater risk of FBUI than occupants of a vehicle. With respect to FBUI, outside of the vehicle is the most dangerous location in an accident. This is consistent with previous reports.[3,12] This pattern suggests a mechanism of direct trauma, rather than deceleration of a mobile structure with inertia resulting in a tear from a fixed point.

Recognizing BUI is especially important due to the age distribution of this injury. Our data show that FBUI is largely a disease of the young, with the pediatric age group most severely affected, consistent with previous reports.[2,9] This results in a group who will have to live longer with the sequelae of injury. We can offer some speculation as to what makes younger female patients

Table 3. Significant multivariate predictors of FBUI

Predictor	Adjusted OR	p
Age	0.96	<0.001
Modified ISS	1.05	<0.001
Mechanism		
Motorcycle crash	6.92	<0.001
Auto vs. pedestrian	4.11	<0.001
Bicycle crash	3.88	<0.001

For mechanism, adjusted odds ratio (OR) is odds vs. reference value of motor vehicle accident. Area under the curve (AUC) 0.871. FBUI: female blunt urethral injury; ISS: Injury Severity Score.

Table 4. Significant multivariate predictors of death

Predictor	Adjusted OR	p
FBUI	0.57	0.71
Age	1.03	<0.001
Modified ISS	1.14	<0.001
Mechanism		
Auto vs. pedestrian	1.91	<0.001
Bicycle crash	0.81	0.031

For mechanism, adjusted odds ratio (OR) is odds vs. reference value of motor vehicle accident. Area under the curve (AUC) 0.852.

more vulnerable. There are probably subtle differences in mechanism not captured with current categories. ICD10 external causes of morbidity codes, while detailed, might not be precise enough to describe the exact application of force. For instance, tears of the anterior wall of the female urethra are consistent with straddle injuries, but there is no way to identify straddle injuries with the current classification. Another suggested explanation for the preponderance of BUI in the young is that the urinary tract is in a more superior position in the abdomen, with less protection.[9]

The association with pelvic fracture is frequently mentioned. Bjurlin et al analyzed female UI exclusively in the context of pelvic fracture.[3] In his review of urological guidelines, Bryk et al stated that FBUI "occur almost exclusively as a result of pelvic fractures."[5] In contrast to Bryk's assertion, our data show that 43.3% of BUI occurred without a pelvic fracture, making the sensitivity of pelvic fracture as a predictor of female BUI 56.7%. Although BUI is more than 13 times more likely when a pelvic fracture is present, an intact pelvis does not always protect the urethra, thus the absence of pelvic fracture is not sufficiently sensitive to rule out BUI.

Although BUI is not directly lethal, it may be a sentinel of other injuries. In addition to pelvic fracture, the presence of certain other associated injuries should raise vigilance for BUI. Delaney et al identified risk factors for BUI in female children with pelvic fracture.[2] They found four variables independently associated with BUI in this group: vaginal laceration, disruption of the pelvic circle, multiple pelvic fractures, or a sacral spine injury.[2] Eidelman reported gynecological, bladder, and other genitourinary trauma in association with FBUI.[11] Rectal injuries were also seen but rare at 3.3%.[11] Battaloglu et al found associated intra-abdominal visceral (27%), genital (20%), and rectal (5%) injuries.[13]

We found a similar pattern, with over half of the patients experiencing a gynecological injury. Bladder and other genitourinary injuries were also higher than in the overall trauma population. Our rate of rectal injury was also low at 3.3%, but this is still well above baseline and merits careful evaluation. Understanding the expected pattern of associated injuries helps to raise the index of suspicion and direct a focused exam.

FBUI is a marker of overall severity of trauma, including mortality.[14] Battaloglu et al reported a mortality of 12% with FBUI, well above baseline.[13] Patel et al showed that mortality doubled in the presence of urethral injury 12 vs. 6% ($p<0.01$).[9] In addition, female mortality with BUI was twice that of male mortality (15 vs. 7%).[9] Our data also show that BUI is strongly associated with mortality, at 9.4 vs. 2.5% (relative risk [RR] 3.76, $p<0.001$). Although univariate analysis shows a strong association with death, FBUI is not a significant predictor of mortality on multivariate analysis when controlling for age, injury severity, and mechanism. This is consistent with FBUI as a marker of injury severity, rather than a direct cause of death. Although it is not an independent predictor, a marker of mortality can be a valuable clinical tool. As part of a predictive model, a marker may be useful for forming a prognosis, determining acuity of care, and allocating resources.

Strengths and limitations

We used a large dataset for greater statistical power. We provide more detail on mechanism, with an attempt to correlate the mechanism with the injury pattern. Our study reports more detail on age and injury association. We highlight the finding that a large portion of FBUIs occur without a pelvic fracture, indicating that the lack of a pelvic fracture is not sufficiently sensitive to rule out a FBUI.

Our study is limited to the information provided by the NTDB. This restricts our analysis to the index admission, without information on long-term outcome. As with any registry study, ours is subject to under-reporting and sampling bias.

CONCLUSIONS

FBUI is rare but still frequent enough that it will be seen from time to time in tertiary centers. As an uncommon injury, it requires a high index of suspicion to recognize promptly. Recognition can be aided by the presence of typical associated injuries, such as bladder, gynecological, and rectal injuries. FBUI is associated with pelvic fracture; however, the injury can occur in its absence; thus, the lack of a fractured pelvis does not rule out BUI. Younger patients are much more vulnerable, especially the pediatric age group.

Motorcycle, bicycle, and auto vs. pedestrian accidents are more likely to cause UI than falls and auto accidents, suggesting that the mechanism is direct trauma rather than inertia or deceleration around a fixed point. FBUI is a predictor of injury severity and mortality due to the protected position of the urethra and the high force necessary to disrupt it. As a marker of injury severity, it is useful for prognosis, raising suspicion of other injury, directing further workup, and assigning resources and acuity of care.

COMPETING INTERESTS: The authors do not report any competing personal or financial interests related to this work.

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