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ORIGINAL ARTICLE

Injury severity score associated with concurrent bladder injury in patients with blunt urethral injury

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Abstract

Background Delayed diagnosis of concurrent bladder damage in a patient with blunt urethral trauma can lead to a high rate of morbidity. In patients with a high index of suspicion, genitourinary workup is recommended. In complicated patients with multi-trauma, this workup has a risk of being delayed. A proven prognostic indicator to evaluate the likelihood of bladder injury in this population has not been established. The aim of this study was to determine if there was a clinical association between the Injury Severity Score (ISS) and bladder injury involvement among these patients.

Methods Retrospective analysis was performed on a cohort of 98 patients who presented with blunt urethral trauma to R. Adams Cowley Shock Trauma Center between 2002 and 2014. Univariate analysis was performed to determine if there was an association between concurrent bladder injuries and ISS among other factors. A receiver operating characteristic curve plot was performed to analyze the association between ISS and bladder involvement.

Results Of the 98 patients with blunt urethral trauma, 28 had concurrent bladder injury. ISS was shown to have a significant correlation with concurrent bladder injury (OR = 2.2 per 10 unit change in ISS, $p = 0.0001$). ROC curve analysis showed an area under the curve for the prediction of bladder injury. Patients with ISS ≥ 34 had a 54% chance of bladder injury, while patients with ISS < 34 had a 13% chance.

Conclusion ISS ≥ 34, a score in the range of severe multi-trauma, may be a clinical indicator of bladder injury in patients presenting with blunt urethral trauma.

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Keywords Urethral trauma · Bladder trauma · Injury Severity Score

Abbreviations

ISS	Injury Severity Score
GU	Genitourinary
CT	Computed tomography
TRISS	Trauma Injury Severity Score

Introduction

Urogenital trauma is commonly seen in major trauma centers, and may be present in up to 10% of all the abdominal trauma cases [1]. Urethral and bladder traumas occur less frequently than other genitourinary organ traumas, and concurrent urethral and bladder injuries are rare events [2, 3]. Despite the rarity of this injury type, the mechanism behind such injuries has been well described within the literature [4]. Among the civilian population, the majority of blunt traumatic events to the urethra and bladder neck stem from motor vehicle accidents and often involve pelvic fracture [5].

Patients presenting with blunt urethral trauma and concurrent bladder injury represent a small but important subset of the trauma population. The lack of reliable predictive factors to indicate a concurrent bladder injury leads to potential for missed injuries [3]. To properly assess the bladder health at the time of trauma workup, additional imaging is needed. A CT- cystogram is a highly reliable method to assess bladder injuries; in a trauma setting and within the operating room (OR), a retrograde cystogram is both sufficient and accurate [6, 7]. Current AUA guidelines indicate that patients in

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stable condition that present with gross hematuria and pelvic fracture should receive this imaging [8]. However, patients without a pelvic fracture may also have bladder injury, and in all patients in a trauma environment, a variety of factors can limit the ability of physicians to perform a cystogram on every patient with a urethral injury [9, 10]. Surgeons mainly rely on the presence of common signs of bladder trauma, such as gross hematuria and pelvic fracture, to determine treatment, but these are not always reliable [11]. The lack of predictability in addition to the relative rarity of injury has left the decision to pursue further workup to the discretion of the surgeon, leading to the possibility of missed or delayed diagnoses. Misdiagnosed bladder injury in patients with traumatic injury has been shown to lead to a high rate of morbidity [11].

Reliable predictive factors may be found within the patient's own history and physical findings during trauma evaluation. Upon entering a trauma center, a high level of data are gathered from the patients, and metrics for injury severity are calculated. If some of these metrics could show correlation with the injury of interest, surgeons may be given a higher level of confidence before treating those patients. Of note, the Injury Severity Score (ISS) is a commonly used, scientifically validated prognostic indicator, with a higher score indicating a more serious injury [12, 13]. The ISS correlates with mortality, morbidity, and length of hospitalization. It is currently one of the trauma scores used at R. Adams Cowley Shock Trauma center. The aim of this study was to assess whether a patient's ISS is associated with bladder perforation in patients who present with blunt urethral trauma.

Methods

Study population

An institutional review board-approved retrospective study was performed on patients who had come to Shock Trauma UMMC with urethral trauma, between 2002 and 2014. Inclusion criterion for the analysis was blunt urethral trauma. Exclusion criterion was penetrating urethral trauma. A cohort of 98 patients was collected. There were no restrictions on age or gender in the population studied.

Data analysis

The cohort was divided into two groups before the analysis was conducted; one group consisted of patients with concurrent bladder perforation and the other group was comprised of patients with isolated urethral injury. Statistical significance levels were two-sided, and statistical significance was assigned the threshold of $p < 0.05$. T tests were performed to analyze ISS, Trauma Injury Severity Score (TRISS), and age. For the binary data, pelvic fracture and complete urethral distraction, an odds ratio was calculated. From the calculated odds ratio, a 95% confidence interval was then computed. Once the confidence interval was obtained, it was utilized to calculate a p value [14]. A receiver operating characteristic (ROC) curve was generated to assess the utility of ISS in predicting bladder injury and an area under the curve was calculated. The point of least distance on the ROC curve from a sensitivity and specificity of 100% was used to calculate the optimal cutoff for ISS to predict bladder injury. A decision curve analysis was also generated to compare treating all men with urethral injury as they had bladder involvement or treating none of those with urethral injury as if they had bladder involvement.

To calculate the Injury Severity Score, the body is divided into six anatomical regions. The injuries within these regions are individually assigned an abbreviated injury scale score from 0 to 6, with a score of 0 being least severe and 6 representing a non-survivable injury. If there are multiple injuries within the same region, the injury with the highest score is used. The abbreviated injury scale scores from three body regions with the highest level of injury are then squared and summed to attain an ISS. Major trauma is indicated by an ISS > 15 and a score > 75 represents a non-survivable injury [12]. The scores are often gathered by experienced nursing staff.

Results

Between 2002 and 2014, 98 patients with blunt urethral trauma were admitted to the R. Adams Cowley Shock Trauma Center at the University of Maryland Medical Center. Table 1 displays the mechanisms of injury of the patients within this cohort. Out of the 98 cases, 68 (69%) of the injuries were caused by a motor vehicle accident. Motor vehicles were then subcategorized based on the status of injured party as either within the vehicle or a pedestrian. Fifty of those injuries occurred to individuals within a motor vehicle, with 18 occurring to pedestrians. Falls were the next most common cause of injury accounting for 11 cases.

Patient demographics and diagnoses are shown in Table 2. In our cohort, 92 patients were male and 6 were female. The median age of the patients was 41 years. Complete urethral distraction was present in 41 patients; 14 of those with complete urethral distraction also had bladder involvement. The urethral damage was treated with primary realignment in 64 patients while the remaining 34 underwent delayed repair.

Within the cohort, 28 (29%) patients had concurrent bladder perforation. Of those with bladder injury, 11 had injuries that were in communication with intraperitoneal

Table 1 Mechanism of injury

Mechanism of injury	Number of patients
Motor vehicle accident	50
Motor vehicle accident—pedestrian injured	18
Fall	11
Mining, agricultural, or industrial machine accident	6
Falling object striking patient	3
Caught between two objects	3
Non-motor vehicle collision	3
Watercraft accident	2
Strenuous movement	1
Unspecified means of injury	1
Total	98

space. Diagnoses of bladder injuries were as follows: 10 were diagnosed with cystogram, 13 were diagnosed with CT scan, and 5 were diagnosed intra-operatively. Of note, in the two patients with delayed diagnoses, both CT scans of the pelvis had initially missed the diagnosis. In addition, both of these cases had their bladder diagnosis delayed by 3 days. Of those with concurrent bladder injury, gross hematuria or blood at the meatus was present in 20 patients, absent in 6 patients, and not documented in 2 patients. Among those without bladder injury, gross hematuria was present in 53 cases, absent in 9 patients, and not documented in 8 patients. Gross hematuria and pelvic fracture was found in 16 patients with extravasation and 43 patients without extravasation.

When evaluated in a univariate analysis, ISS was predictive of bladder injury (OR = 2.2 per 10 unit increase in ISS, $p = 0.0001$). The total cohort's average ISS was found to be 27.7. The mean ISS amongst those with bladder injury was found to be 35.4 and those without bladder injury was found to be 25.0. Upon further analysis, an ISS of 34 was shown to be a significant reference point in predictability of concurrent bladder injury. As seen in Table 3 and displayed graphically in Fig. 1, when the ISS was ≥ 34, there was a 54% chance that the patient had a concurrent bladder injury. In patients with an ISS < 34 only 13% of patients had a concurrent bladder injury. Graphical analysis done using a receiver operating characteristic curve displayed an area under the curve of 0.76. This curve is shown in Fig. 2. Regarding the decision curve analysis, the plot shows for a threshold probability of between 0.2 and 0.6, ISS > 34 is superior to the blanket strategies of treating all men with blunt injury as if they have bladder perforation, and treating none of the men with blunt injury as if they have perforation. Since in our study the prevalence was 28.5% of such injury, the ISS is highly relevant. This can be seen in Fig. 3.

We also examined a variety of other factors as possible predictors of concurrent bladder injury. As shown in Table 2, complete urethral distraction, pelvic fracture, age, or TRISS [15] did not show any significant correlation in the population with concurrent bladder injury, $p > 0.05$. TRISS, an injury stratification system based on physiologic and anatomic scoring, was near significant at $p = 0.08$. Of note, in our cohort,

Table 3 Analysis using an ISS reference point of 34

	ISS ≥ 34	ISS < 34
No. of patients	37	61
No. of concurrent bladder injuries (%)	20 (54)	8 (13)

The table displays numerically, the correlation between an ISS ≥ 34 and concurrent bladder injuries

Table 2 Patient demographics and injury information

	Total cohort	Bladder injury present	Bladder injury absent	*p* value
Patients with blunt urethral trauma	98	28	70	–
Male (%)	92 (93.9)	25 (89)	67 (96)	0.3
Female (%)	6 (6.1)	3 (11)	3 (4)	–
Primary realignment (%)	64 (65)	–	–	–
Delayed repair (%)	34 (36)	–	–	–
Gross hematuria	73	20	53	–
Pelvic fracture (%)	85 (87)	24 (86)	61 (87)	0.9
Gross hematuria and pelvic fracture	59	16	43	–
Complete urethral distraction (%)	41 (42)	14 (50)	27 (39)	0.3
Average ISS (SD)	27.7 (12.5)	35.4 (11.9)	25.0 (11.4)	0.0001*
Average ISS male (SD)	30.0 (12.0)	34.0 (11.3)	24.3 (11.2)	0.0006
Average ISS female (SD)	36.7 (17.2)	47.0 (11.8)	30.0 (17.2)	0.2
Median age (IQR)	41 (25.8–50)	42 (27.25–55.25)	40 (24–48.25)	0.3
Total cohort average TRISS (SD)	0.85 (0.23)	0.78 (0.23)	0.88 (0.22)	0.08

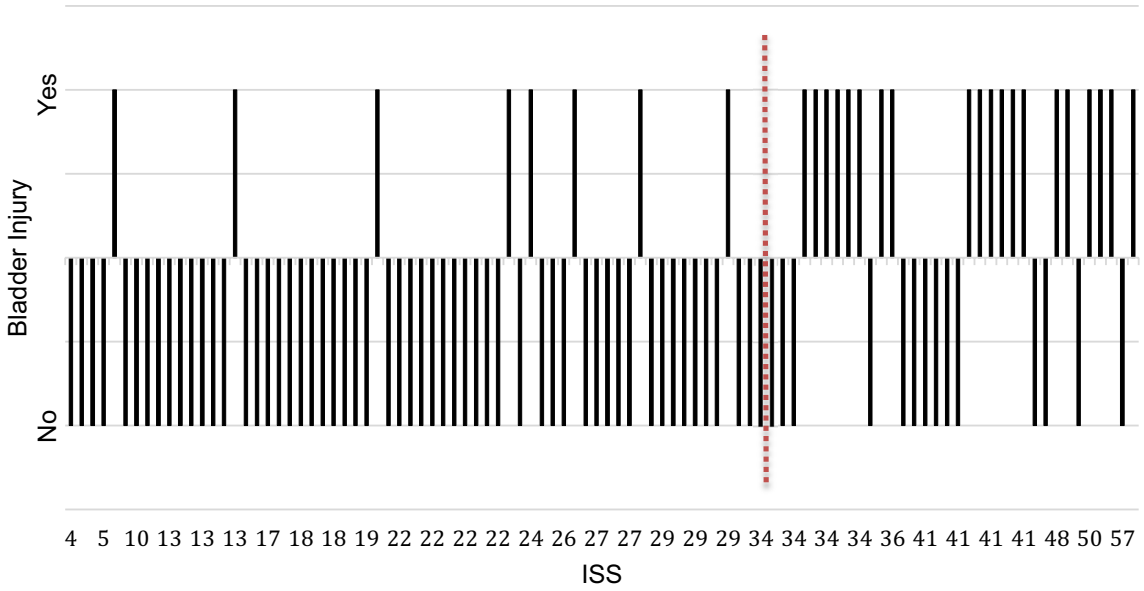

Fig. 1 ISS and bladder injury. The array of injury scores seen in the database and who had bladder injury. The bar goes up if bladder injury was present and down is absent. The red dashed line represents the reference point of ISS = 34

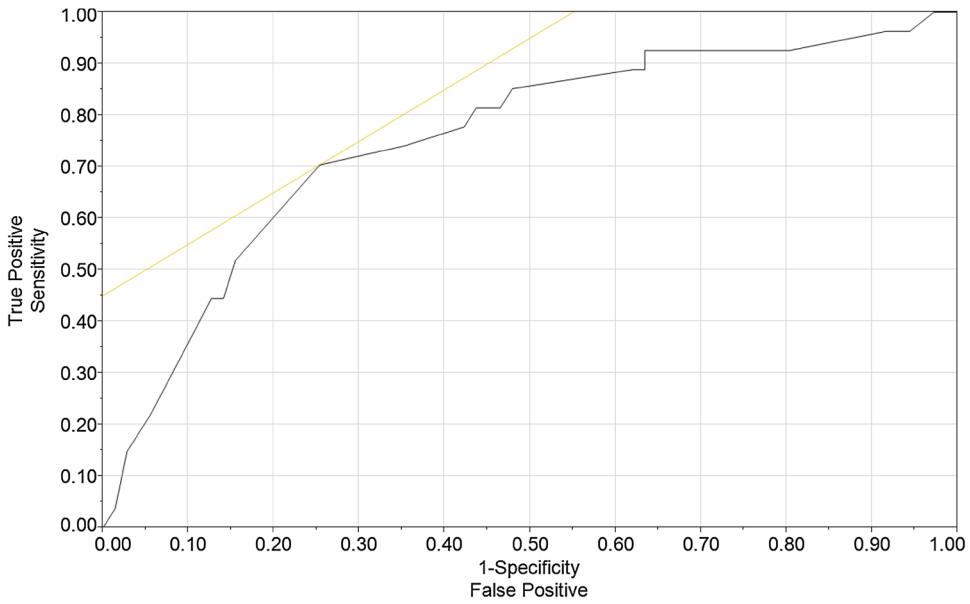

Fig. 2 Receiver operating characteristic chart. Receiver operating characteristic (ROC) curve for ISS and bladder injury. The ROC curve for use of ISS score to predict bladder injury. The area under the curve is 0.76. The yellow line demonstrates the point at which sensitivity and specificity are maximized with an ISS cutoff of 34

bladder injury was equally prevalent in patients with and without pelvic fractures (28.2% versus 30.8%, $p = 0.9$). Within the total cohort, pelvic fractures occurred in 85 patients (86%). The age of the patient does not appear to have any correlation to bladder perforations in this cohort.

Discussion

The 98 patients of shock trauma analyzed in this study represent one of the largest cohorts of urethral trauma

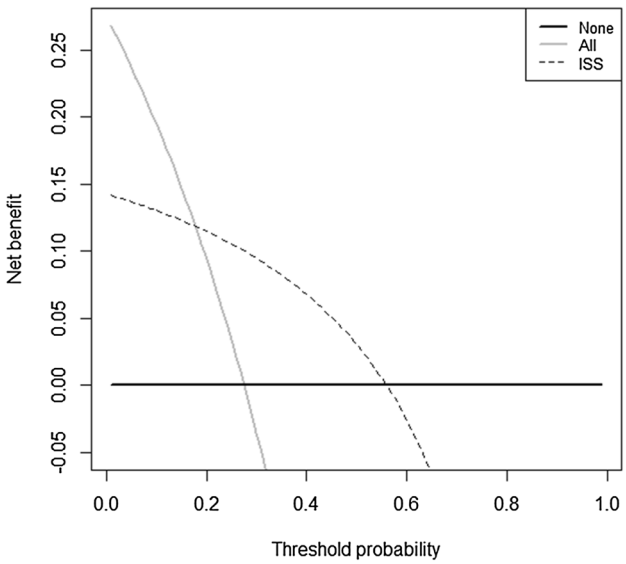

Fig. 3 Decision curve analysis of ISS score for bladder injury suspicion

ever collected from an individual institution. The findings in this study were consistent with previous studies in the literature, as the majority of patients within our database were injured in car accidents [11]. Our study further illustrated the high rate of pelvic fracture among this population. Numerically, 87% of those with urethral injuries were shown to have pelvic fractures as well; this percentage is similar to those reported in multiple previous studies [11]. However, in this study, we did not find pelvic fracture as predictive of bladder injury since the patients without bladder injury also had a high rate of pelvic fracture in this cohort.

As noted, a reliable predictor to indicate concurrent bladder injury when a patient presents with blunt urethral trauma could assist in ensuring rapid and accurate identification of patients at highest risk and improve the accuracy of diagnoses. Currently, gross hematuria is commonly cited as a reason to believe that the bladder has sustained injury; however, this is not seen in every patient [11]. The potential error of relying on gross hematuria was demonstrated in our population with bladder injury as gross hematuria was only seen in 77% of the documented patients. Interestingly, gross hematuria was also present in a large percentage of the patients without bladder extravasation—85% of the documented cases. Therefore, using gross hematuria alone as a predictive factor for additional screening may not be as informative as previously believed, within a trauma setting.

In the presence of multi-system trauma, focused workup for possible injuries is necessary. In the setting of other more acute issues, genitourinary diagnoses such as bladder perforation can be overlooked or delayed [16]. Broad surveys do have the potential to miss diagnoses. In our cohort, the two cases of delayed bladder injury diagnosis, both received pelvic CT scans but it did not lead to prompt recognition of the injury. Diagnosis in both these cases was 3 days following the pelvic CT. They were found to have extraperitoneal bladder extravasation. The ISS in these cases were 13 and 41. As they were both extraperitoneal, they were managed conservatively. These cases highlight the importance of maintaining a high index of suspicion of bladder perforation even in the absence of CT imaging when clinical signs remain present.

This retrospective study showed that ISS is a reliable predictor of bladder injuries in our patient population. It was the only variable that showed a significant correlation between concurrent injuries and bladder injury in the setting of diagnosed urethral injury. It is not difficult to assume that a population with a more severe injury score would have a higher likelihood of bladder involvement. However, in our cohort, not only did a higher ISS predict a higher likelihood of injury, but a distinct and significant reference value was also established. This value has potential clinical relevance in improving the efficiency of additional imaging, as an ISS $\geq$ 34 represented over a 50% chance of concurrent bladder injury and an ISS < 34 represented a population with only a 13% risk of bladder injury. Of note, the area under the curve of the receiver operating characteristics was 0.76, while this portends to a fair result, it cannot be overlooked that in 24% of the patients the correlation between ISS and bladder injuries was incorrect. As such, the use of a specific ISS number as a benchmark is unlikely to dictate care over clinical judgment, and clinicians should maintain a high index of suspicion in these patients. What this study may underscore is that for patients who arrive with urethral injuries, prompt genitourinary workup should be administered, particularly in patients with severe multi-traumatic injuries.

Once the diagnoses of bladder rupture has been made, it is important to determine the nature of injury as intraperitoneal or extraperitoneal as these factors determine care. It has been generally accepted that intraperitoneal injuries should be treated surgically, while extraperitoneal may be properly handled with proper catheterization in select patients [17]. Untreated intraperitoneal bladder extravasations have been associated with a much higher morbidity than extraperitoneal and surgical repair has been correlated with improved survival [18]. In this study, the incidence of intraperitoneal bladder extravasation was low and therefore was felt unlikely to determine robust predictive factors of this subset of the population. Further research must be done to find a direct indicator of intraperitoneal injury.

This study has some limitations. As a retrospective, single-institution study, the results may not be generalizable. Female urethral injuries are exceedingly rare in relation to male urethral injuries, as evident in the discrepancy in the

patient sample size [2]. With additional data, differences in predictive outcome between the sexes may be elucidated. The cohort in this study was reserved to patients who had noted blunt urethral trauma. Ideally this research can be expanded to study all patients who arrive with trauma to the pelvis and lower abdomen to assess the likelihood of bladder injury. Also, due to the nature of trauma patients, some elements on their charts were left undocumented, such as gross hematuria. This led to the inability to perform advanced statistical calculations regarding this metric; however, trends in the data regarding gross hematuria were noted. Finally, the trauma population is less likely to attempt to seek out adequate follow-up care particularly from specialty branches such as urology. As such, the database used had high-quality data on the nature of injury but sparse detail on long-term urologic outcome. To validate the results from this study, further research from multiple institutions is needed to replicate the significant correlation between ISS and bladder perforation. A large cohort from multiple institutions can better assess the validity and significance between ISS and intraperitoneal extravasation in subjects after abdominal and pelvic trauma.

In conclusion, the Injury Severity Score has a statistically significant correlation with the presence of concurrent bladder perforation in patients presenting with blunt urethral trauma. A more comprehensive assessment of overall measure of anatomic injury may be a predictor for clinically significant bladder injury.

Author contribution EE: data management, data analysis, manuscript writing. IS: project development, data collection, data analysis. GC: project development, data collection, data analysis. ES: data collection. RB: data collection. SC: data collection. DM: data collection. DMS: project development. MMS: project development, data analysis, manuscript editing.

Compliance with ethical standards

Conflict of interest The authors declare that they have no conflict of interest.

Ethical approval All procedures performed in studies involving human participants were in accordance with the ethical standards of the institutional and/or national research committee and with the 1964 Helsinki Declaration and its later amendments or comparable ethical standards. This article does not contain any studies with animals performed by any of the authors.

Informed consent For this type of study formal consent is not required.

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