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Authors

Lui, Jason L
Hakam, Nizar
Shaw, Nathan M
et al.

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JU Insight

Alcohol Intoxication Is Associated With Bladder Injury and Bladder Surgical Repair in Patients Sustaining Motor Vehicle Collisions

Jason L. Lui, Nizar Hakam, Nathan M. Shaw, et al.

Correspondence: Benjamin N. Breyer (email: Bdaenjamin.Breyer@ucsf.edu).

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Study Need and Importance: Alcohol intoxication is a known risk factor for motor vehicle collisions (MVCs). With the combination of diuresis and risk of pelvic trauma, the risk of bladder dome injury is thought to be elevated in this population. We hypothesize ethanol intoxication increases the risk of bladder injury and surgical repair, especially at higher blood alcohol content levels.

What We Found: We identified 594,484 patients with MVCs in the National Trauma Data Bank®, 97,831 (16.5%) of whom had a positive alcohol screen. Patients intoxicated with alcohol were more likely to have a bladder injury (1% vs 0.4%, $P < .001$) and receive bladder surgical repair (0.7% vs 0.15%, $P < .001$) compared to nonintoxicated patients. This risk increased with rising blood alcohol concentration (see Figure). Remarkably, alcohol intoxication above the legal limit (blood alcohol content $\geq$0.08) was more predictive of bladder surgical repair than pelvic fracture. Additionally, seat belt use in combination with alcohol intoxication further increased the risk of bladder repair.

Limitations: As alcohol screening was not done in a systematic manner in the study population, there were 239,739 patients with no data for alcohol screening. The choice was made to incorporate these patients (who had all other variables intact) in the unexposed groups rather than exclude them from analysis. Any bias would diminish the study effect and trend toward the null hypothesis (alcohol is not related to bladder injury or repair), therefore this risk was felt to be minimal.

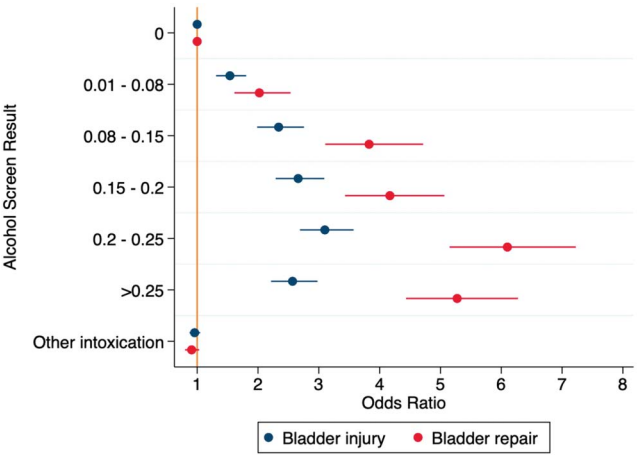

Figure. Odds ratio comparison across blood alcohol concentration categories for outcomes of bladder injury and bladder repair.

Interpretation for Patient Care: Alcohol increases the risk of operative bladder injuries for patients injured in MVCs. Intoxication, particularly above the legal limit, is more predictive of bladder injury requiring surgical repair than pelvic fracture. Trauma providers should have a high index of suspicion for intraperitoneal bladder injuries in alcohol intoxicated patients, particularly those with seat belt restraints.

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Alcohol Intoxication Is Associated With Bladder Injury and Bladder Surgical Repair in Patients Sustaining Motor Vehicle Collisions

Jason L. Lui[1], Nizar Hakam[1], Nathan M. Shaw[1], Joseph Cuschieri[2], Behzad Abbasi,[1] and Benjamin N. Breyer[1,3]*

[1]Department of Urology, University of California San Francisco, San Francisco, California
[2]Department of Surgery, University of California San Francisco, San Francisco, California
[3]Department of Biostatistics and Epidemiology, University of California San Francisco, San Francisco, California

Purpose: Alcohol intoxication is a known risk factor for motor vehicle collisions. We hypothesize ethanol intoxication increases the risk of bladder injury and surgical repair, especially at higher blood alcohol content levels.

Materials and Methods: We identified all patients involved in motor vehicle collisions from the National Trauma Data Bank from 2017-2019. Patients were categorized into an intoxication and intoxication negative group. Variables collected included age, sex, blood alcohol content level, driver status, seat belt restraint use, nonalcoholic intoxication, pelvic fracture, and Injury Severity Scale. Primary outcome measures of bladder injury and bladder surgical repair were assessed and interaction with pelvic fracture and restraint use were measured.

Results: We identified 594,484 patients and 97,831 (16.5%) had a positive alcohol screen. Patients in the intoxication group were more likely to be intoxicated with other substances (32.8% vs 14.6%, $P < .001$), have a bladder injury (1% vs 0.4%, $P < .001$) and receive bladder surgical repair (0.7% vs 0.15%, $P < .001$). Injury Severity Scale and pelvic fracture were statistically significant predictors of bladder injury. In adjusted analysis, higher blood alcohol content was associated with both outcomes. Above the legal limit, alcohol intoxication was more predictive of bladder surgical repair than pelvic fracture. The association of alcohol intoxication with both outcomes did not differ by pelvic fracture, but strengthened with seat belt use at higher intoxication levels.

Conclusions: Alcohol intoxication is independently associated with increased risk of bladder injury and subsequent bladder surgical repair following motor vehicle collisions. Trauma providers should have a high index of suspicion for bladder injuries in alcohol intoxicated patients, particularly those using seat belt restraints.

Key Words: alcoholic intoxication, wounds and injuries

Bladder injuries occur in up to 10% of abdominal trauma and usually take place in the setting of a direct, high-energy impact to a distended bladder.[1]

While uncommon, traumatic bladder injury causes significant patient morbidity and is associated with a mortality rate of 10% to 22%, which has not improved in the last 3 decades.[1-3] Most cases of bladder rupture are caused by blunt force abdominal trauma following motor vehicle collisions (MVCs).[4] Understanding the factors that predispose bladder injury are important, as early detection and timely management prevent complications and improve outcomes.[3]

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* Correspondence: Department of Urology, University of California San Francisco, Zuckerberg San Francisco General Hospital and Trauma Center, 1001 Potrero, Suite 3A, San Francisco, California 94110 (telephone: 415-206-8805; FAX: 415-206-4499; email: Benjamin.Breyer@ucsf.edu).

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Alcohol (ethanol) consumption is a known risk factor for MVCs as it impairs cognitive and attention abilities.[5] Drinking alcohol also produces a diuretic effect.[6] Alcohol consumption increases urine output and causes rapid bladder filling, bladder distention, and thinning of the bladder wall.[7,8] As the bladder distends, the dome exits the protective retropubic space and is susceptible to trauma.[4,9] Despite the biological plausibility, the relationship between alcohol intoxication and bladder injury following MVCs is only explored by a few case reports and small series.[10-12] Given the World Society of Emergency Surgery and American Association for the Surgery of Trauma and AUA (American Urological Association) guidelines recommend intraperitoneal bladder ruptures be managed with surgical repair, bladder injuries may dramatically change a patient's clinical course.[13,14] Bladder injuries are rarely isolated, with 94%-97% of cases associated with other injuries including pelvic long bone fracture, head/spinal, or visceral injuries.[4] Establishing and understanding the role of alcohol intoxication in bladder injury will aid trauma providers in risk stratification and clinical decision making.

We sought to examine the relationship between alcohol intoxication and outcomes of bladder injury and bladder surgical repair in patients following MVCs using a large trauma registry. We hypothesize that intoxication increases the risk of bladder injury (particularly intraperitoneal) and the need for surgical repair. Further we hypothesize that a threshold effect exists: higher blood alcohol content (BAC) levels increase the likelihood of bladder injury and bladder surgical repair up to a certain intoxication level. Finally, we hypothesize that intoxication with other substances will have no effect on bladder injury or need for surgical repair.

METHODS

Data Source

The National Trauma Data Bank® is the largest North American trauma registry containing comprehensive injury and patient data. We performed a retrospective cohort study using National Trauma Data Bank data from 2017-2019 and followed STROBE guidelines for observational studies.[15] An Institutional Review Board exemption was granted given that data were deidentified.

Study Population and Outcomes

We included all patients involved in MVCs. We extracted patient and clinical variables, including age, sex, BAC level, driver status (driver, passenger, unknown), other (non-alcohol) intoxication, pelvic fracture, and Injury Severity Scale (ISS). Patients were categorized into 2 groups, an intoxicated group comprising patients whose BAC test result was any level above zero and an intoxication negative group comprising of patients whose BAC test result was zero. Patients who did not undergo an alcohol screen were included in the unexposed group, as well as those with an unfilled field for alcohol screen. Patients who had polysubstance use (positive screen for alcohol and other substance) were included in the alcohol intoxication group. Our primary outcomes were bladder injury and bladder surgical repair. These were defined by the presence of an International Classification of Diseases-10 injury code for bladder injury (S37.2; S37.20; S37.20XA; S37.20XS; S37.22; S37.22XA; S37.22XD; S37.22XS; S37.23; S37.23XA; S37.23XD; S37.23XS; S37.29; S37.29XA; S37.29XD; S37.29XS) or a code for bladder surgical repair (0TQB0ZZ; 0TQB3ZZ; 0TQB4ZZ; 0TQB7ZZ; 0TQB8ZZ; 0TQC0ZZ; 0TQC3ZZ; 0TQC4ZZ; 0TQC7ZZ; 0TQC8ZZ).

Statistical Analysis

Patient characteristics were reported and compared across the intoxication groups using a chi-square or Fisher's exact test for categorical and the Mann-Whitney U test for continuous variables. To assess the association between alcohol intoxication and the primary outcomes (bladder injury and bladder surgical repair), we constructed multivariable logistic regression models with a priori adjustment for the following covariates: age, sex (male vs female), pelvic fracture (present vs absent), ISS, nonalcoholic intoxication. Using restricted cubic splines, it was determined that the linearity assumption of blood alcohol level in the logistic model was not appropriate, and BAC was analyzed as multilevel categorical variable (BAC 0.01-0.08 [legal level threshold]); >0.08-0.15; >0.15-0.20; >0.20-0.25; >0.25). These categories fit the spline-fit model as well as closely approximated multiples of the legal limit which has possible clinical correlation.[16] Goodness-of-fit of the models was assessed using a Hosmer-Lemeshow test.[17] Subgroup analysis was performed for differences in the association by patient status (drivers only or passengers only) using an interaction term, which did not reveal significant interaction.

Due to our finding of an association between alcohol intoxication and risk of bladder injury and bladder surgical repair, we subsequently tested for differences in the effect by presence of pelvic fracture, with the hypothesis that this variable may be driving higher rates of bladder injury and subsequent bladder surgical repair in intoxicated patients. Additionally, we examined interaction of alcohol intoxication on bladder repair among the subgroup of patients with bladder injury. Difference in effect was tested using an interaction term in the adjusted regression model. We also tested for interaction with seat belt restraint use in patients without pelvic fractures. All statistical analysis was performed using Stata® 17 and all P values were 2-sided with significance level set at $< .05$.

RESULTS

We identified 594,484 patients who were involved in an MVC during the study period (2017-2019). A total of 97,831 (16.5%) had a positive alcohol screen test result. In the intoxication positive group, the majority of patients were male (70.3%), identified as the driver (71.8%), and had a median age of 33 (Table 1). When compared to the intoxication negative group, patients in the intoxication positive group were more likely to be intoxicated with other substances (32.8%

Table 1. *Cohort Characteristics*

Characteristics	All Patients (N = 594,484)	Intoxicated (n = 97,831)	Nonintoxicated (n = 496,653)	*P* Value*
Age, (IQR)	37 (24-58)	33 (25-47)	39 (23-60)	< .001
Sex, No. (%)				< .001
Male	341,822 (57.5)	68,798 (70.3)	273,024 (55)	
Female	252,662 (42.5)	29,033 (29.7)	196,629 (45)	
BAC, No. (%)				
0 g/dL		0	496,653 (100)	
0.01-0.08 g/dL		25,747 (26.3)	0	
0.08-0.15 g/dL		16,005 (16.4)	0	
0.15-0.20 g/dL		17,392 (17.7)	0	
0.20-0.25 g/dL		17,911 (18.3)	0	
>0.25 g/dL		20,776 (21.2)	0	
Driver status, No. (%)				< .001
Driver	398,370 (67)	70,248 (71.8)	328,122 (66)	
Not driver	169,289 (28.5)	22,273 (22.8)	147,016 (29.6)	
Unclear	26,825 (4.5)	5,310 (5.4)	21,515 (4.3)	
Seat belt use, No. (%)	354,514 (59.6)	46,159 (47.2)	308,355 (62.1)	< .001
Positive drug screen for other drugs, No. (%)	104,679 (17.6)	32,071 (32.8)	72,608 (14.6)	< .001
ISS, (IQR)	9 (4-14)	9 (5-17)	9 (4-14)	< .001
Pelvic fracture, No. (%)	3,776 (0.6)	604 (0.62)	3,172 (0.64)	.444
Bladder injury, No. (%)	2,975 (0.5)	972 (1)	2,003 (0.4)	< .001
Bladder surgical repair, No. (%)	1,414 (0.24)	656 (0.7)	758 (0.15)	< .001

* *P* value corresponds with Mann-Whitney test for continuous variables and chi-squared test for categorical variables comparing intoxicated and nonintoxicated groups.

vs 14.6%, $P < .001$). Both groups had similar rates of pelvic fracture (0.62% vs 0.64%, $P = .444$).

Univariate analysis (chi-square test) demonstrated significant associations between alcohol intoxication and bladder injury, bladder surgical repair, and ISS. Compared to the intoxication negative group, patients in the intoxication positive group were more likely to have a bladder injury (1% vs 0.4%, $P < .001$) and need bladder surgical repair (0.7% vs 0.15%, $P < .001$).

On adjusted multivariate analysis using logistic regression, alcohol intoxication, pelvic fracture, and ISS were associated with increased risk of bladder injury and bladder surgical repair (Table 2). There were statistically significant differences across all BAC groups for both outcomes, with higher odds ratios in the higher BAC groups (Fig. 1 and Table 2). The highest risk of bladder injury was found in the BAC group of 0.2-0.25 (OR 3.10, 95% CI 2.69-3.57). Similarly, the highest risk of bladder surgical repair was found in the BAC group of 0.2-0.25 (OR 6.10, 95% CI 5.15-7.23). Notably, all BAC groups >0.08 were more strongly associated with bladder surgical repair than pelvic fracture (OR 2.90, 95% CI 2.11-3.99; Table 2). In addition to the increased odds from alcohol consumption, pelvic fracture increased the odds of a bladder injury (OR 4.10, 95% CI 3.39-4.96). Similarly, for bladder surgical repair, the odds ratio on multivariate analysis were significant for ISS (OR 1.06, 95% CI 1.06-1.07), for pelvic fracture (OR 2.90, 95% CI 2.11-3.99), and notably for alcohol intoxication across all BAC categories (Fig. 1). Age and male sex were associated with decreased risk of both bladder injury and bladder surgical repair. Intoxication with other drugs was not associated with either of the outcomes. In subgroup analysis by driver type, there was no associated relationship between driver status and bladder injury or bladder surgical repair.

Table 2. *Multivariate Logistic Regression of Bladder Injury and Bladder Surgical Repair*

	Bladder Injury			Bladder Surgical Repair		
Outcome	Odds Ratio	95% CI	*P* Value	Odds Ratio*	95% CI*	*P* Value*
BAC level, g/dL						
0.01-0.08	1.54	1.31-1.81	< .001	2.02 (1.64)	1.61-2.54 (1.19-2.25)	< .001 (.002)
0.08-0.15	2.34	1.99-2.76	< .001	3.83 (2.73)	3.11-4.71 (1.96-3.82)	< .001 (< .001)
0.15-0.20	2.66	2.29-3.09	< .001	4.17 (2.44)	3.43-5.06 (1.81-3.30)	< .001 (< .001)
0.20-0.25	3.10	2.69-3.57	< .001	6.10 (5.08)	5.15-7.23 (3.68-7.03)	< .001 (< .001)
>0.25	2.57	2.22-2.98	< .001	5.28 (5.95)	4.44-6.27 (4.18-8.48)	< .001 (< .001)
Age	1.00	0.99-0.99	< .001	0.99 (0.99)	0.99-0.99 (0.99-0.99)	< .001 (< .001)
Male sex	0.79	0.74-0.85	< .001	0.85 (1.16)	0.76-0.95 (0.99-1.35)	.004 (.06)
Pelvic fracture	4.10	3.39-4.96	< .001	2.90 (0.69)	2.11-3.99 (0.46-1.02)	< .001 (.06)
Positive drug screen for other drugs	0.96	0.88-1.05	.356	0.91 (0.37)	0.80-1.03 (0.76-1.11)	.143 (.37)
ISS	1.07	1.07-1.07	< .001	1.06 (1.0)	1.06-1.07 (0.99-1.00)	< .001 (.16)

Adjusted for age, sex, pelvic fracture, ISS, and nonalcoholic intoxication. BAC reference level was set at 0.
* Odds ratio, confidence interval, and *P* value for bladder surgical repair using bladder injury as a covariate is shown in parentheses.

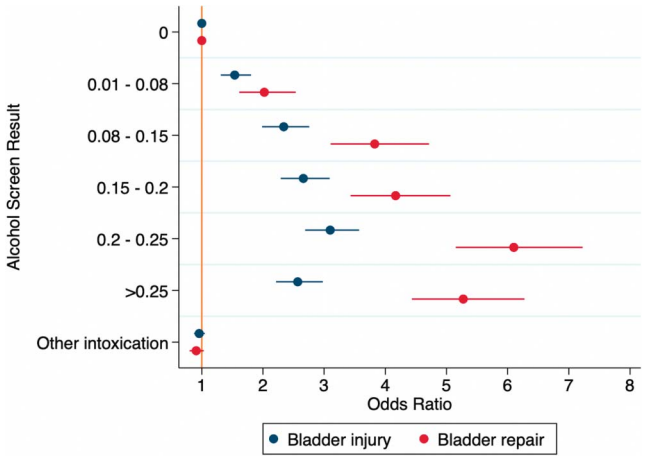

Figure 1. Odds ratio comparison across blood alcohol content categories for outcomes of bladder injury and bladder repair.

Pelvic fracture did not moderate the association between alcohol intoxication and either bladder outcome. However, on multivariate analysis seat belt restraint use was a significant moderator of the effect in patients without pelvic fracture for BAC levels above 0.08 g/dL (bladder injury model) and above 0.15 g/dL (bladder surgical repair model; Table 3). When interaction was present, the risk of bladder injury or surgical repair was higher in patients with seat belt restraints compared to those without seatbelt restraints. Model predicted risks of outcomes stratified by seat belt restraint use are depicted in Figure 2 (bladder injury) and Figure 3 (bladder surgical repair).

DISCUSSION

Alcohol consumption causes MVC-related injuries in a dose-dependent manner.[18] We found alcohol intoxication at any level is associated with increased risk of bladder injury and bladder surgical repair (Fig. 1). While an empty bladder is rarely injured, a full bladder is most susceptible to trauma and injury.[3,4] Ethanol's suppression on the release of antidiuretic hormone increases urine volume and subsequently, bladder fullness. The acute diuretic response to alcohol is directly related to BAC.[19] Our observations confirmed this relationship in a dose-dependent manner, with higher BAC levels increasing the likelihood of bladder injury and need for bladder surgery. In patients involved in a MVC who have a positive blood alcohol screening, trauma providers should suspect and assess for signs of bladder injury. Timely identification and intervention of bladder injury is crucial, as delayed diagnosis is associated with longer hospital stays, an increased risk of complications, and higher costs of care.[14,20]

Pelvic fracture is a significant risk factor for bladder injury with 90% of bladder injuries associated with pelvic fracture.[21] Given the high risk of concomitant injury, first responders, trauma providers, and physicians are taught to have a high index of suspicion for bladder injury in patients with a pelvic fracture.[14,21] Interestingly, we found that a BAC above the legal limit of 0.08 g/dL was more predictive of bladder injury requiring surgical repair than occurrence of pelvic fracture. Pelvic fracture did not moderate the association between alcohol intoxication and bladder injury or bladder surgical repair in patients following MVCs. Furthermore, we found that intoxication had higher odds of requiring operative repair than bladder injury. We suspect that the types of injuries associated with intoxication are likely blunt injuries at the bladder dome which are almost universally operatively explored. Intoxication therefore increases bladder injury overall, but to a lesser extent than it elevates the risk of specific dome injuries (and therefore operative repair) relative to other factors in the analysis. Furthermore, the odds of requiring surgical repair with increasing BAC is preserved even when using bladder injury as a

Table 3. *Moderating Effect of Seat Belt Use on Association Between Alcohol Intoxication and Bladder Injury, and Bladder Surgical Repair in Patients Without Pelvic Fractures*

	No Seatbelt		Seatbelt		
Bladder Injury	Odds Ratio	95% CI	Odds Ratio	95% CI	*P* Value
BAC level in patients with bladder injury, g/dL					
0	Reference		1.22	1.11-1.35	
0.01-<0.08	1.42	1.11-1.82	1.75	1.32-2.32	.354
0.08-<0.15	2.02	1.58-2.57	2.48	1.87-3.27	.022
0.15-<0.2	2.19	1.76-2.73	2.69	2.07-3.49	.001
0.2-<0.25	2.31	1.86-2.87	2.84	2.19-3.68	< .001
≥0.25	2.08	1.67-2.58	2.55	1.97-3.30	< .001
BAC level in patients with bladder surgical repair, g/dL					
0	Reference		1.47	1.25-1.71	
0.01-<0.08	1.67	1.14-2.44	2.46	1.58-3.83	.206
0.08-<0.15	3.47	2.53-4.76	5.11	3.46-7.54	.211
0.15-<0.2	3.43	2.54-4.64	5.05	3.46-7.36	.014
0.2-<0.25	4.58	3.49-6.01	6.74	4.73-9.6	< .001
≥0.25	4.77	3.68-6.17	7.01	4.90-9.90	.042

Adjusted regression model predicted odds ratios are shown with 95% confidence intervals.

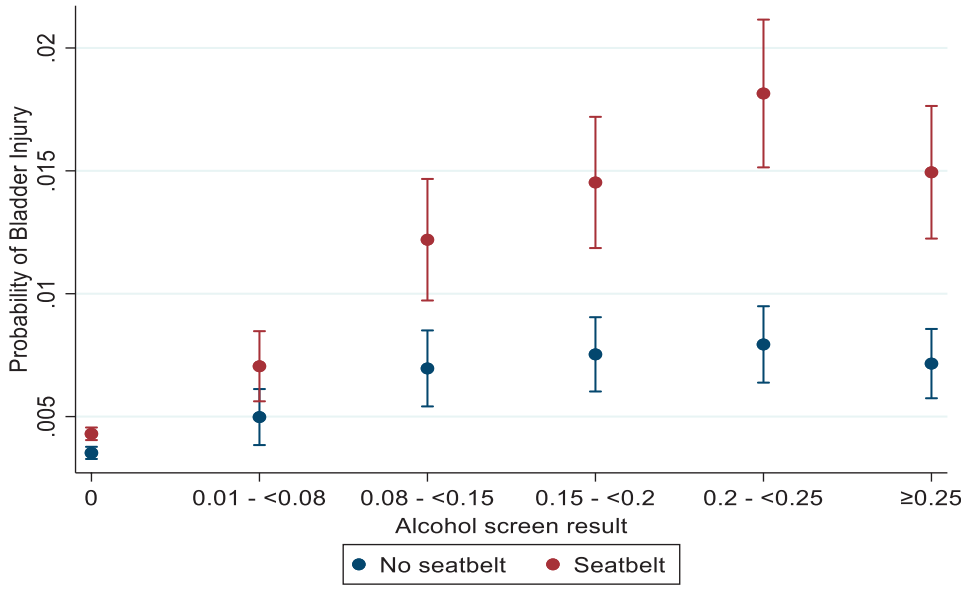

Figure 2. Moderating effect of seat belt use on association between alcohol intoxication and bladder injury in patients without pelvic fractures. Adjusted regression model predicted probabilities are shown with 95% confidence intervals.

covariant. In the same analysis, the presence of pelvic fracture loses significance and has an odds ratio of less than 1. This suggests a pattern of bladder injury that ultimately requires repair is different from the bladder injury associated with pelvic fracture. We suspect this correlates clinically to the rupture of the bladder dome in a distended bladder; an injury that can occur at potentially lower force than required to fracture a pelvis.

Blunt bladder injury is most commonly caused by the abrupt deceleration forces with or without involvement of the seat belt or steering wheel in the setting of a motor vehicle accident.[4,22] Due to the restraining force of the seat belt, intra-abdominal injuries are the most common form of seat belt injury.[23,24] To assess the role of steering wheel, a subgroup analysis examined the position of injured person (driver vs passenger). We found no significant differences between occupant seating position and bladder outcomes. Furthermore, subgroup analysis examined intoxicated patients with and without concomitant pelvic fracture. Among seat belt restrained patients without pelvic fracture there was a higher risk of bladder injury and bladder surgical repair at higher intoxication levels. Among seat belt restrained patients with pelvic fracture we did not detect significant interaction between seatbelt and BAC

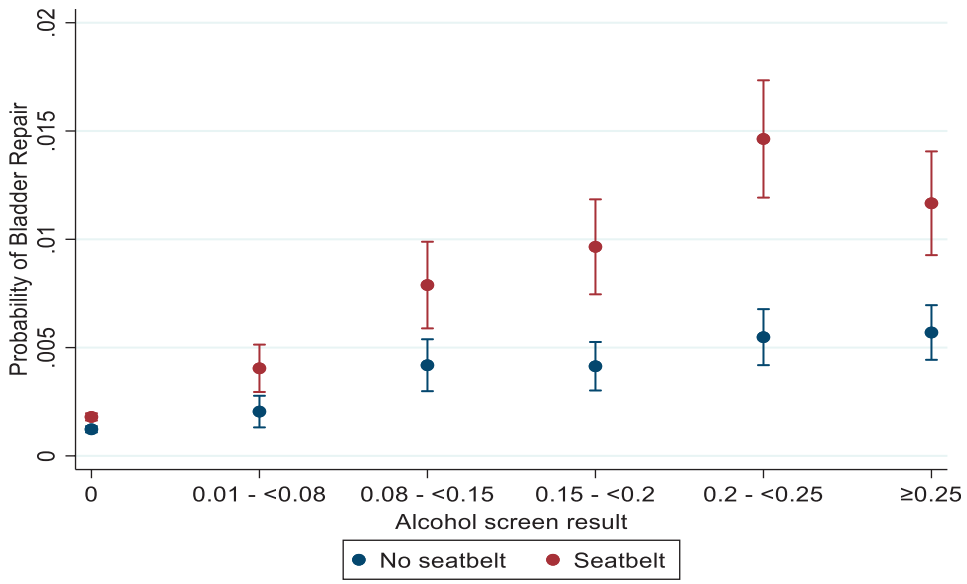

Figure 3. Moderating effect of seat belt use on association between alcohol intoxication and bladder surgical repair in patients without pelvic fractures. Adjusted regression model predicted probabilities are shown with 95% confidence intervals.

on either outcome (bladder injury or repair). This suggests, at a certain threshold, alcohol intoxication may have a pronounced effect on bladder filling and increase its vulnerability to injury. Based on the abrupt deceleration force during a vehicle collision and the fixed seat belt across the pelvis, there is likely direct pressure over the low pelvis and bladder. It is possible that a 3-point fixation belt (similar to an infant car seat) or seat belts without a pelvic strap may distribute these forces differently and account for less bladder injury. Ultimately, the combination of a full bladder and significant pelvic trauma will always represent a risk of bladder rupture. Even in the absence of pelvic fracture, providers should have a high index of suspicion for bladder injury requiring surgical repair in intoxicated patients with seat belt restraint use.

An interesting finding in this study was the decreasing odds ratio of bladder injury and repair at higher levels of intoxication beyond 0.25 BAC. There is always the possibility it is a function of a small exposed denominator. While the rate of injury goes down after 0.25 BAC level, the exposed n is a disproportionately small part of the data. Thus this group could be relatively underpowered. Alternatively, one clinical theory that could explain the finding is that excessively intoxicated individuals have succumbed the diuretic effects of ethanol without fluid replacement and are relatively dehydrated. These patients may therefore be at lower risk of bladder injury and repair.

Intoxication with other drugs was not found to be associated with bladder injury and bladder surgical repair. Almost a third of patients in the intoxication positive group were co-intoxicated with other drugs, suggesting this is an important factor to consider. This finding furthers supports the impact ethanol has on the development of bladder injury and need for bladder surgical repair. We recognize this variable has its limitations, as the causal agent and severity of co-intoxication are unknown.

The study limitations merit consideration. The National Trauma Data Bank is not a population-based data set and may not be representative of all trauma hospitals across the North America. A limitation which is shared by many large data set analyses is statistical significance does not per se suggest clinically relevant information. For example, age was a significant predictor with an OR of 1 in our analysis. The statistical significance here likely had minimal clinical correlation. While we controlled for a number of covariates in all models and included a large sample size in our analysis, some cofounders may not be accounted for and some selection bias may be present. While BAC accounts for the total amount of alcohol consumed, its levels can be affected by tolerance and differential pharmacokinetics across individuals, which we cannot account for. As alcohol screening was not done in a systematic manner in the study population, there were 239,739 patients with no data for alcohol screening. The choice was made to incorporate these patients (who had all other variables intact) in the unexposed groups rather than exclude them from analysis. This introduces the risk of bias as there could be alcohol exposed patients who were categorized as unexposed. As this would diminish the study effect and trend toward the null hypothesis (alcohol is not related to bladder injury or repair), this risk was felt to be minimal. Additionally, there is also the possibility that patients who were exposed but not overtly intoxicated had a differential risk of being screened for alcohol relative to the more intoxicated (higher BAC). The effect of this is unknown on the model evaluating the role of BAC level in bladder injury and repair.

Our interpretation of the data is that the increased chances of operative intervention on the bladder was driven by intraperitoneal injuries. The most common mechanism of bladder rupture requiring surgical repair is a full bladder during impact in a motor vehicle accident.[25] Current World Society of Emergency Surgery and American Association for the Surgery of Trauma and AUA guidelines state intraperitoneal bladder ruptures should be repaired surgically, while uncomplicated extraperitoneal bladder ruptures treated nonoperatively with catheter drainage.[13,14] Given the limitations of the database, we cannot confirm that the outcome of bladder surgical repair only captures intraperitoneal injuries, as a small number of extraperitoneal injuries are managed surgically.[14] A sensitivity analysis capturing patients with nonpelvic fracture bladder injuries was performed accordingly and was unrevealing.

CONCLUSIONS

In patients involved in MVCs, alcohol intoxication increases the risk of both bladder injury and subsequent surgical repair. Increased intoxication, particularly above the legal limit, is more predictive of bladder injury requiring surgical repair than pelvic fracture. Indeed, among patients with bladder injury, pelvic fracture may predict nonoperative management. Trauma providers should have a high index of suspicion for bladder injuries in alcohol intoxicated patients, particularly those with seat belt restraints.

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