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Injured patients with very high blood alcohol concentrations

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Abstract

Objective—Most data regarding high blood alcohol concentrations (BAC) 400 mg/dL have been from alcohol poisoning deaths. Few studies have described this group and reported their alcohol consumption patterns or outcomes compared to other trauma patients. We hypothesized trauma patients with very high BACs arrived to the trauma center with less severe injuries than their sober counterparts.

Method—Historical cohort of 46,222 patients admitted to a major trauma center between January 1, 2002 and October 31, 2011. BAC was categorized into ordinal groups by 100 mg/dL intervals. Alcohol questionnaire data on frequency and quantity was captured in the BAC 400 mg/dL group. The primary analysis was for BAC 400 mg/dL.

Results—BAC was recorded in 44,502 (96.3%) patients. Those with a BAC 400 mg/dL accounted for 1.1% (147) of BAC positive cases. These patients had the lowest proportion of severe trauma and in-hospital death in comparison with the other alcohol groups ($p < 0.001$). In adjusted analysis, the risk for severe injury increased with the BAC groups between 1–199 mg/dL and was not different or decreased for groups above 200 mg/dL in reference to the BAC negative group (test for trend $p = 0.001$). BAC 400 group encountered more injuries caused by blunt trauma in comparison with the other alcohol groups ($p < 0.001$), and the group comprised mainly of falls.

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Admission Glasgow Coma Scale was a poor predictor for traumatic brain injury in the high BAC group. Readmission occurred in 22.4% (33) of patients the BAC 400 group. The majority of these patients reported drinking alcohol four or more days per week (81, 67.5%) and five or more drinks per day (79, 65.8%), evident of risky alcohol use.

Conclusions—Most traumas admitted with BAC 400 mg/dL survived and their injuries were less severe than their less intoxicated and sober counterparts. They also had evidence for risky alcohol use and nearly one-quarter returned to the trauma center with another injury over the study period. Recognition of this highest BAC group presents an opportunity to provide focused care for their risky alcohol use.

Keywords

injury; injury prevention; blood alcohol level; ethanol; trauma recidivism; alcohol consumption; alcohol use disorder; blunt trauma; forensic toxicology; alcohol poisoning

INTRODUCTION

Between 2010 and 2012, acute alcohol poisoning deaths in the United States accounted for 8.8 deaths per 1 million populations, an average of six deaths daily¹. Although these deaths were the most severe form of alcohol intoxication, they only accounted for 1.9% of alcohol-related mortality and 3.3% of mortality from acute effects of alcohol². Forensic Medicine textbooks and studies of acute alcohol poisoning suggested blood alcohol concentrations (BAC) in excess of 400 mg per 100 ml should result in fatality^{3–6} but no cohort studies, including trauma patients have examined outcomes in patients with BAC 400 mg/dL.

BAC is a common biomarker used at trauma centers to assess acute alcohol exposure in patients⁷. Elevated BACs have been found in 30–50% of trauma patients^{8–10}, and risky alcohol users accounted for 25–67% of patients admitted with a positive BAC^{11–13}. Cohort observational studies in alcohol-related trauma have not examined survivorship in trauma patients admitted with BAC 400 mg/dL, levels fatal for most people. Only a handful of case reports mentioned survivors with BAC above these levels, and large epidemiologic studies using trauma registries sometimes excluded very high BACs because they were assumed erroneous¹⁴. Several studies describe non-lethal BACs above 300 mg/dL including a case-series of 81 drivers apprehended by law enforcement with BAC above 400 mg/dL¹⁵. However, none of the studies examined drinking behaviors or outcomes.

We aimed to characterize the cohort of trauma patients with BAC 400mg/dL across ten years from a high volume statewide referral trauma center with routine BAC testing and detailed alcohol questionnaire data. We hypothesized trauma patients with very high BACs will be less injured than their sober counterparts.

METHODS

Environment

We conducted a historical cohort study of patients admitted directly from the injury scene to trauma center between January 1, 2002 and October 31, 2011. The trauma center is a

freestanding, urban, adult trauma center, admitting over 5,000 primary trauma patients annually from a catchment of over six million people in urban, suburban, and rural communities. The trauma center has been the central referral resource for critically injured adults in the state for more than three decades and has maintained a trauma registry since the mid-1980s. All trauma admissions arrived via ambulance or medevac directly to the trauma center, separate from the Emergency Department. BAC is routinely measured on all patients on admission. Re-admissions for follow up care of the same injury and transfers from outside hospitals were excluded. The institutional review board of the trauma center approved this study.

Injury and Alcohol Data

BAC was categorized into ordinal groups by 100 mg/dL intervals. We defined severe injury as an injury severity score (ISS) ≥ 16 ¹⁶ and serious traumatic brain injury (TBI) as injury with an abbreviated injury score (AIS) for brain ≥ 3 . The Glasgow Coma Score (GCS) is a physiologic trauma score used as part of the assessment for brain injury, separate from the anatomical AIS score for traumatic brain injury. GCS is scored between 3 and 15 and composed of best eye response, best verbal response, and best motor response. GCS ≤ 8 represents serious brain injury¹⁷. Chart reviews were performed on all patients with BAC ≥ 400 mg/dL (M.A.). Patients' responses to questions from an alcohol questionnaire were recorded in the medical record as part of an Alcohol Screening, Brief Intervention and Referral to Treatment (SBIRT) program performed during the trauma nurse's intake interview. The alcohol questions used in the trauma center's program regarding alcohol frequency and quantity in screening for risky or hazardous alcohol use was previously validated to have 83% sensitivity and 84% specificity^{18, 19}. The alcohol questions were administered during hospital stay once the patient was assessed by the providing nurse as capable of answering the questions adequately. We performed chart reviews with laboratory data to verify that all BACs ≥ 400 mg/dL were accurately recorded in the trauma registry. To further verify BAC values, we calculated serum osmolalities for each patient and compared it to the recorded level of BAC; all osmolalities were consistent with the recorded BAC²⁰ (Supplemental Table 1). For each BAC case ≥ 400 mg/dL, recidivism at the trauma center was identified by review of the electronic medical record for subsequent admissions due to a separate injury between the patient's first admission date and June 1, 2014.

Missing Alcohol Data in Trauma Deaths

A large proportion of missing BAC (640/2,062) occurred in patients who had no laboratory data collected because they were pronounced dead soon after arrival, and the body was transferred to the medical examiner before testing could be conducted. To improve the BAC data for all in-hospital deaths, we reduced the proportion of missing alcohol laboratory data by retrieving toxicology reports from the postmortem investigations conducted by the state's Office of the Medical Examiner (OCME) on our cases dying soon after arrival to the trauma center. Valid BAC results were obtained from OCME toxicology reports on 74% (474/640) of deaths in which BAC values were missing. OCME samples for alcohol testing were often tested from multiple sources and we selected specimens to include in the analysis in the following order: hospital blood (3/474), heart (272/474), peripheral blood (81/474), pericardial blood (1/474), cavity blood (116/474), and liver (1/474). After postmortem

alcohol levels were retrieved from the medical examiner, the proportion of alcohol testing on in-hospital trauma deaths improved to 92.0% (1,896) from 69.0% (1,422).

Analytic Approach

The primary analysis was for patients with BAC ≥ 400 mg/dL. Baseline characteristics were presented as medians with interquartile ranges. Comparison of the ordinal alcohol groups was performed using a chi-square test or Fisher's exact test for proportions or the Kruskal-Wallis one-way analysis of variance for continuous variables. Both unadjusted and adjusted analyses were performed with logistic regression model for the outcomes injury severity, blunt injury, and in-hospital death. The final analysis cohort used in logistic regression comprised of complete BAC, demographic, and injury information (Figure 1). The ordinal groups of alcohol were compared with reference to the BAC=0 mg/dL group. Covariates included in the model for adjustment included age, sex, and race. To test for significant trend between the ordinal BAC groups, quadratic contrasts in the coefficients corresponding to the variables representing the BAC groups were used in logistic regression. Likelihood ratio test was used for comparison of nested models, and covariates that did not cause a significant change in the overall model were removed ($p > 0.05$). The Spearman's rank correlation coefficient was used to test the correlation between Brain AIS and admission GCS. The traditional threshold of $p = 0.05$ was used to determine statistical significance. Analysis was performed using SAS Version 9.4 (SAS Institute, Cary, NC).

RESULTS

Blood alcohol was recorded in 44,502 (96.3%) of patients. Between January 2002 and October 2011, 12,535 (28.2%) trauma admissions had a positive BAC. The greatest proportion of patients with positive BAC was in the 100–199 mg/dL group with 4,260 (34.0%). Patients with BAC ≥ 400 mg/dL accounted for 1.1% (147) of the BAC-positive cases (Table 1), and had the highest median age of any BAC group (44 years old, interquartile range (IQR) 36–49). Similar to the other BAC groups, most patients in the BAC ≥ 400 mg/dL were male (79.6% 117/147). In the BAC ≥ 400 mg/dL group, no significant differences in injury mechanism, ISS, or admission GCS occurred between males and females (data not shown). Across the ten year study period, 21 patients had BAC ≥ 500 mg/dL and the highest recorded BAC was 613 mg/dl (30 year old male who fell down steps).

Patients with BAC ≥ 400 mg/dL encountered more injury from blunt trauma in comparison with the other alcohol groups ($p < 0.001$) (Table 1). Amongst the type of blunt injuries, falls comprised the greatest proportion in the BAC ≥ 400 mg/dL group at 53% (71) (Table 1). Fall down steps was the most common fall injury for this group. The patients with a BAC ≥ 400 mg/dL also had the lowest proportion of severe injuries and in-hospital death in comparison with the other alcohol groups ($p < 0.001$). Only 3.4% of patients died in-hospital and 84.4% were discharged home (Table 1). A greater proportion of patients in the BAC ≥ 400 mg/dL group had a severely depressed sensorium (admission GCS ≤ 8) in comparison with the other alcohol groups. However, admission GCS correlated very poorly with brain AIS in this group with a Spearman's correlation coefficient of -0.09 ($p = 0.25$). Of those patients with a GCS ≤ 8 , 48% (12/25) had no brain injury documented (brain AIS equal to 0). In adjusted

analysis for age, sex, and race, there was an initial increased risk for severe injury in the BAC groups 1–99 mg/dL and 100–199 mg/dL followed by no risk and decreasing risk for the subsequent BAC groups in reference to the negative BAC group ($p=0.001$) (Figure 2A). For injury from blunt trauma, the BAC groups 1–99 mg/dL and 100–199 mg/dL had a decreased risk followed by an increased risk for each subsequent BAC group in reference to the BAC negative group ($p<0.001$) (Figures 2B). No significant trend in risk for in-hospital death occurred by BAC group ($p=0.10$). Chart review with follow-up between 2.9 and 12.6 years identified 22.4% (33) of patients with BAC ≥ 400 mg/dL had an admission for another injury at the trauma center.

In patients with BAC ≥ 400 mg/dL, admission urine drug screen was performed in 95.2% (140/147). A positive urine drug screen was identified in 25.7% (36). Benzodiazepines was detected in 17.9% (25), cannabinoid metabolites in 5.0% (7), barbiturates in 4.3% (6), cocaine in 2.9% (4), opioid in 2.9% (4), and propoxyphene in 1.4% (2).

Alcohol intake questionnaire was completed in 81.6% (120) of patients with BAC ≥ 400 mg/dL. The groups with and without alcohol questionnaire data were similar (Supplement Table 2a and 2b). When asked the question, “Do you drink alcohol”, only 2.5% (3) of patients with BAC ≥ 400 mg/dL responded “NO”. The majority of patients with BAC ≥ 400 mg/dL reported drinking alcohol four or more days per week (81, 67.5%) and five or more drinks per day (79, 65.8%) (Figure 3 and Figure 4). When asked the question, “Have you had any past drug or alcohol abuse”, 39.2% (47) of patients with BAC ≥ 400 mg/dL responded yes.

DISCUSSION

Patients with BAC ≥ 400 are older and more likely to sustain injury caused by blunt trauma, specifically falls. The majority of these patients survived their injuries and had evidence for risky alcohol use. In the patients with BAC ≥ 400 , admission GCS was not a reliable metric of traumatic brain injury. This represents the largest cohort of trauma patients with BAC ≥ 400 mg/dL to date in the literature.

The large majority of patients at our trauma center with BAC ≥ 400 mg/dL arrived with minor and survivable injuries. Their admission to the trauma center may be partly attributable to their injuries appearing more severe due to their inebriation. Nearly half of these patients had a severely depressed sensorium (GCS ≤ 8) but no documented brain injury, suggesting their depressed sensorium was associated with their alcohol intoxication. GCS was previously shown to poorly correlate with TBI in alcohol-exposed patients, and overestimated the severity of injury owing to impairment caused by alcohol^{21–24}. We also found that GCS correlated poorly with brain AIS. Although patients in the BAC ≥ 400 mg/dL group represented the greatest proportion with a severely depressed sensorium, confounding from very high BAC in their injury assessment may have accounted for worse GCS scores. In fact, these patients had the lowest risk for severe injuries. Prior studies showed alcohol-exposed trauma patients were more likely to have inflated assessments of their injuries than their sober counterparts^{25, 26}. We also showed the higher the BAC at trauma presentation, the more likely the injury was from a fall, likely a consequence of their alcohol exposure.

Although it may appear that the very high alcohol BAC patients are at lower risk for severe injury when compared to their less intoxicated and sober counterparts, it is important to consider a misclassification bias in their initial injury assessment resulting in more intoxicated patients with minor, survivable injuries arriving at specialized trauma centers such as ours.

Patients with very high BACs were previously shown to have high rates of risky alcohol use^{11, 27}. The large majority of patients with BAC ≥ 400 mg/dL at the trauma center were risky alcohol users. Nearly half self-reported any prior drug or alcohol abuse. These patients also had a high rate of co-substance use with over a quarter having positive urine drug screens. Trauma patients with risky alcohol use were previously shown to be at high risk for recidivism²⁸. Nearly one quarter of our patients with BAC ≥ 400 mg/dL returned to the same trauma center with another injury. Prior studies reported successful interventions to reduce recidivism in patients with risky alcohol use^{29, 30}. Injured patients with BAC ≥ 400 mg/dL may benefit from focused care around their risky alcohol use and co-substance use.

Most published reports of BAC ≥ 400 mg/dL were in forensic medicine and comprised of postmortem cases of alcohol poisoning deaths and suggested a high likelihood for death in BAC ≥ 400 mg/dL^{4, 31–33}. In one report with 213 cases of acute alcohol deaths, 62% of fatalities had BAC above 400 mg/dL and the remainder had levels between 300 and 400 mg/dL³⁴. While alcohol levels in excess of 300 mg/dL indicated severe alcohol intoxication with concomitant respiratory depression³⁵, our study suggests that higher BACs in trauma were tolerated, with many of these patient navigating steps or operating motor vehicles immediately prior to injury. Risky alcohol users were previously shown to tolerate BACs above 200 mg/dL with minimal psychomotor vigilance impediment²⁷. In the case of the highest recorded BAC in ten years at the trauma center, the patient was 30-year old, presented with a BAC of 613 mg/dL, and arrived breathing spontaneously and unassisted with stable physiologic parameters after a fall. Patients admitted to the trauma center with BACs ≥ 400 mg/dL were engaged in risky activities further supporting the need for focused care in this group.

Our trauma center has been an area-wide trauma center for the city and a regional trauma referral center for the state with direct admissions from the injury scene. The patient cohort was representative of the aggregate of trauma patients treated at other trauma centers in the United States³⁶. Patients were typically referred to the trauma center for serious injuries whereas less serious injuries were more likely to have been treated at local emergency centers. Therefore, our case-rate for recidivism likely underestimates the risk because only admissions to our single center were captured. A strength of our study was nearly complete BAC attainment in all admissions and greater than 80% alcohol drinking histories available in patients with BAC ≥ 400 mg/dL. Future studies comparing rates of recidivism, collecting more detailed alcohol drinking histories, and performing diagnostics for alcohol use disorders between BAC groups are need to better risk-stratify by BAC.

CONCLUSION

Patients with BAC 400 presented to our adult trauma center with less severe injuries. The majority of these patients had evidence for risky or hazardous alcohol use by self-report questionnaire and nearly a quarter had recidivism to the same center. Patients with BAC 400 mg/dL should not be discounted in future studies and GCS is unreliable and should not be used in this group of trauma patients. Trauma patients with very high BAC may benefit most from interventions aimed at their risky or hazardous alcohol use that may, in turn, reduce recidivism.

Supplementary Material

Refer to Web version on PubMed Central for supplementary material.

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Figure 1.
CONSORT

Figure 2A. Odds Ratios with 95% Confidence Intervals for All Severe Injuries (ISS ≥ 16) by Alcohol Group

Points represent adjusted odds ratio for severe injury (ISS ≥ 16) for each ordinal alcohol group. Error bars represent 95% confidence intervals. Adjusted for age, sex, and race. Reference group is BAC = 0 mg/dL (OR = 1.0). P-value for quadratic trend test.

Figure 2B. Odds Ratios with 95% Confidence Intervals for Blunt Mechanism by Alcohol Group
 Points represent adjusted odds ratio for blunt mechanism for each ordinal alcohol group. Error bars represent 95% confidence intervals. Adjusted for age, sex, and race. Reference group is BAC = 0 mg/dL (OR = 1.0). P-value for quadratic trend test.

Figure 3.
Frequency of Alcohol Consumption (days per week) in Patients with BAC $\geq$ 400 mg/dL
(n=120)

Figure 4.
Quantity of Alcohol Consumption (drinks per day) in Patients with BAC $\geq$ 400 mg/dL
(n=120))

Table 1

Patient Demographics and Injury Characteristics by BAC Group (mg/dL)

Variables	Total (n=44492)	0 (n=31957)	1–99 (n=3518)	100–199 (n=4260)	Ordered BAC			P-value
					200–299 (n=3658)	300–399 (n=952)	400(n=147)	
Age in year (IQR)	35 (23–49)	36 (23–52)	31 (22–45)	30 (23–43)	34 (25–46)	41 (29–50)	44 (36–49)	<0.001
Male Sex (%)	31120 (70.0)	21082 (66.0)	2725 (77.5)	3397 (79.7)	2993 (81.8)	806 (84.7)	117 (79.6)	<0.001
White Race (%)	26108 (58.7)	19242 (60.2)	1652 (47.0)	2428 (57.0)	2171 (59.4)	533 (56.0)	82 (55.8)	<0.001
Injury Mechanism								
Blunt (%)	37658 (84.6)	27566 (86.3)	2553 (72.6)	3388 (79.5)	3155 (86.3)	862 (90.6)	134 (91.1)	
Penetrating (%)	6099 (13.7)	3803 (11.9)	916 (26.0)	829 (19.5)	466 (12.7)	78 (8.2)	7 (4.8)	<0.001
Other (%)	735 (1.7)	588 (1.8)	49 (1.4)	43 (1.0)	37 (1.0)	12 (1.2)	6 (4.1)	
Injury Type (Blunt)								
MVC (%)	23701 (62.9)	17410 (63.2)	1698 (66.5)	2293 (67.7)	1918 (60.8)	348 (40.4)	34 (25.4)	
Falls (%)	7972 (21.2)	6138 (22.3)	395 (15.5)	452 (13.3)	611 (19.4)	305 (35.4)	71 (53.0)	<0.001
Assaults (%)	2917 (7.7)	1372 (5.0)	326 (12.8)	514 (15.2)	521 (16.5)	164 (19.0)	20 (14.9)	
Other (%)	3068 (8.1)	2646 (9.6)	134 (5.2)	129 (3.8)	105 (3.3)	45 (5.2)	9 (6.7)	
Severe Injury (%) (n=43237)	10790 (24.3)	7456 (24.1)	962 (28.0)	1185 (28.2)	925 (25.7)	233 (24.8)	29 (19.9)	<0.001
Admission GCS 8 (%)	3127 (7.0)	1854 (5.8)	334 (9.5)	410 (9.6)	393 (10.7)	111 (11.7)	25 (17.0)	<0.001
Serious Brain Injury (%)	5781 (13.0)	3892 (12.2)	483 (13.7)	625 (14.7)	592 (16.2)	167 (17.5)	22 (15.0)	<0.001
Length of Stay (Days)	0.6 (0.2–3.2)	0.5 (0.2–3.2)	0.7 (0.2–3.8)	0.7 (0.3–3.6)	0.6 (0.3–2.9)	0.6 (0.4–2.5)	0.7 (0.5–2)	<0.001
Disposition (%)								
Home	35313 (79.4)	25077 (78.5)	2764 (78.6)	3479 (81.7)	3071 (84.0)	798 (83.8)	124 (84.4)	
Acute Care	7039 (15.8)	5301 (16.6)	535 (15.2)	597 (14.0)	473 (12.9)	115 (12.1)	18 (12.2)	
Chronic Care [‡]	110 (0.2)	104 (0.3)	4 (0.1)	2 (0.1)	0 (0.0)	0 (0.0)	0 (0.0)	<0.001
Other	144 (0.3)	111 (0.3)	9 (0.3)	10 (0.2)	14 (0.4)	0 (0.0)	0 (0.0)	
In-hospital death	1886 (4.2)	1365 (4.3)	206 (5.9)	172 (4.0)	100 (2.7)	38 (4.0)	5 (3.4)	

GCS = Glasgow Coma Score; ISS = Injury Severity Score; BP = blood pressure; MVC = motor vehicle collision

[‡]Chronic Care: Skilled Nursing Facility/Long Term Acute Care

Continuous values are presented as medians with interquartile ranges, and categorical values are presented as numbers with percentages.

Severe injury defined as injury severity score 16. Serious brain injury is brain abbreviated injury score 3.