Toxicology Screening Results: Injury Associations Among Hospitalized Trauma Patients

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Background: **Substance abuse is associated with injuries, but these associations have not been well characterized by type of substance and injury type.**

Methods: **A cross-sectional study of patients selected for toxicology screening compared those with positive and those with negative test results for drugs and alcohol.**

Results: **Patients with positive alcohol toxicology results were more likely to have violence-related and penetrating injuries than patients with negative results. However, after adjustment for positive cocaine toxicology results, the association between alcohol and penetrating injury was no longer significant. Positive test results for any drug were not associated with any specific injury type, but cocaine was independently associated with violence-related injury. The associations of alcohol and cocaine with violence-related injury appear to be additive. In contrast, opiates were independently associated with nonviolent injuries and burns.**

Conclusions: **Alcohol and cocaine use is independently associated with violence-related injuries, whereas opiate use is independently associated with nonviolent injuries and burns.**

Key Words: **Substance-related disorders, Wounds and injuries, Trauma, Alcohol, Cocaine, Narcotics.**

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The etiology of traumatic injury is complex, but alcohol abuse is a common, highly salient risk factor.[1] Excessive alcohol use or acute intoxication is associated with motor vehicle accidents,[2,3] bicycling injuries,[2,4] falls,[5–7] violent injuries[1,3,5,6] (especially assaults[8–10] and stab wounds[1,11]), traumatic brain injuries,[5] poorer outcomes after spinal cord injury,[12] burns,[7,13] hypothermia,[13] unintentional drowning,[14] injuries to internal organs,[15] and fatal injury.[3,16–18] Although traumatic injuries often are presumed to be episodic events, Sims et al.[19] have suggested that trauma can be viewed as a chronic disease. Among victims of violent trauma (e.g., stab wounds, gunshot wounds, blunt injury assaults), these authors observed a 44% recurrence rate and a 20% 5-year mortality rate. Findings have shown alcohol intoxication at the time of injury to be associated with greater risk of recurrent injury.

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Dischinger et al.[20] followed a cohort of 27,399 hospitalized trauma patients with positive test results for alcohol or other drugs at the time of their index admission for injuries. For these toxicology-positive patients, the eventual death rate was nearly double (1.9% vs. 1%; $p < 0.001$) that for toxicology-negative patients during the follow-up period. Rivara et al.[21] examined the records for 2,578 trauma patients and found that those intoxicated with alcohol at the time of initial injury were 2.5 times more likely than nonintoxicated patients to sustain a second injury within the following 18 months, and that those with evidence of chronic alcohol abuse at the time of injury were 3.5 times more likely to sustain such injury. Given these results, Hargarten[22] has suggested that no further evidence is needed to support the causal relation between alcohol use and traumatic injury. However, these studies did not specifically determine whether injury and death occurred among those who used only alcohol, drugs in general, a specific drug, or combinations of drugs and alcohol.

The relation between trauma and drug abuse is much less clear than the relation between traumatic injury and alcohol abuse. At least a dozen major studies have examined the prevalence of drug use among trauma victims,[23–33] and these are summarized in Table 1. In general, associations between drug use and motor vehicle accidents or trauma severity have not been found. However, benzodiazepine use among the elderly has been associated with hip fractures and motor vehicle crashes.[34,35] The association of drug use with injuries attributable to violence has been noted, but not consistently. Any study investigating the association of drug use with traumatic injury will be confounded by coexisting alcohol problems. Soderstrom et al.[28] found that 24.1% of 1,118 trauma victims were alcohol dependent at the time of injury,

Table 1 Summary of Published Studies of Trauma and Drug and Alcohol Toxicology, 1986–2001

Patient Population	City Sample Date Publication Date	No. of Subjects	No. Screened: Sample BAC Drugs	No. +	% +	Urine Drug-Positive as a % of Those Screened						Associations: BAC-Positive				Associations: Drug-Positive
						CAN	COC	OPI	BNZ	AMP	PCP	Youth	Male	Black	LOS	
Major trauma without burns	San Diego 12/1984–12/1985 1986[23]	NR	381 381 381	263 213 84	69 56 32	NR	5	4	NR	14	3	0	NR	NR	NR	Not evaluated
Major trauma with altered mental status	Chicago 1/1988–6/1988 1989[24]	1741	654 623 623	NR NR NR	86 41 NR	37	34	16	7	2	10	+	NR	+	NR	Not related to injury severity ($p > 0.05$)
Major trauma	Philadelphia NR 1989[25]	372	169 169 169	139 61 126	82 36 75	37	54	11	10	5	NR	NR	NR	NR	NR	Cocaine related to violent injury ($p = 0.003$)
Major trauma	Seattle 2/1986–8/1986 1989[26]	1314	525 316[a] 452	NR NR 182	60 38 40	26	10	12[a]	4[a]	NR	NR	+	+	NR	NR	Cocaine not related to assault ($p > 0.05$)
Medical examiner's cases	Seattle 2/1986–8/1986 1989[26]	235	160 159 160	NR NR NR	48 39 19	11	8	2[a]	4[a]	NR	NR	+	+	NR	NA	Cocaine associated with death by assault ($p < 0.001$)
Major trauma	Cleveland 1/1989–12/1989 1995[27]	165	108 104 90	85 65 43	79 63 48	7	42	7[a]	8[a]	NR	3	NR	NR	NR	NR	Not evaluated
Major trauma with intact cognition	Baltimore 9/1994–11/1996 1997[28]	1909	NR 1,827 1,220	NR 541 557	NR 30 46	11[b]	14[b]	16[b]	NR[b]	0.1[b]	1[b]	+	+	0	NR	Not evaluated
Motor vehicle injuries	Ann Arbor 4/1992–8/1994 1997[29]	NR	894 894 894	257 188 124	30 21 14	14[c]	1[c]	1[c]	NR	NR	NR	+	+	0	0	Not associated with crash severity ($p > 0.01$)
Fractures and dislocations	Houston 1/1992–12/1994 1997[30]	1776	1,195 1,126 873	NR 467 191	54 41 22	10	1	2[d]	8	6[e]	0.5	+	+	0	+	Longer hospital LOS ($p < 0.05$)
Life-threatening injuries	New Orleans NR 1999[31]	557	450 450 450	319 NR NR	70 NR NR	NR	NR	NR	NR	NR	NR	+	+	0	0	Intentional trauma ($p < 0.005$)
Emergency trauma	Leeds, UK 7/1997–12/1997 2000[32]	116	93 89 79	NR NR 28	NR 27[f] 35	13	3	19	6	6	NR	NR	NR	NR	NR	Assault ($p < 0.005$)
Motor vehicle injuries	Baltimore 5/1994–11/1996 2001[33]	1338	778 748 500	NR 224 214	NR 30 43	10	19	24	NR	0	2	NR	NR	NR	NA	License and other violations ($p = 0.017$)

BAC, blood alcohol concentration; CAN, cannabinoids (marijuana); COC, cocaine; OPI, opiates (e.g., morphine, codeine) does not include opioids (e.g., meperidine, methadone); BNZ, benzodiazepines; AMP, amphetamines; PCP, phencyclidine; LOS, length of hospital stay; NR, not reported; NA, not applicable

[a] Iatrogenic administration excluded.

[b] Percentages based on a subset of 718 subjects.

[c] Results of serum toxicology only.

[d] Includes opioids.

[e] Screening test only; may include subjects with over-the-counter sympathomimetic amines.

[f] For values > 80 mg/dL.

and that 17.7% were dependent on other drugs at the time of the injury. Overall, the rate of current alcohol and drug dependence was 8.3%.

Several of the studies in Table 1 had methodology problems: lack of definition of the patient population, sampling bias, incomplete toxicology testing, limitations of screening tests alone, inability to distinguish licit from illicit drug use, and analysis based on a general category of "drug abuse" rather than the specific drug used. For example, it may be expected that violent injuries would be associated with stimulant abuse (e.g., amphetamines, cocaine). On the other hand, falls and motor vehicle accidents could be associated with the abuse of tranquillizers or sedatives. These relations have not been explored in detail among major trauma patients.

The purpose of this study was to determine the alcohol- and drug-specific associations of toxicology screening results with injury characteristics and outcomes.

METHODS

This study was conducted in the only designated level 1 trauma center serving a region of about 2 million people, including a city, its suburbs, and the surrounding rural area, in the Midwest. The entire service area has a radius of about 100 miles. Nearly all cases of major trauma from the entire area and many cases of minor trauma from the city are treated at this facility. The study subjects included all the patients admitted to the hospital for more than 48 hours with a primary diagnosis of traumatic injury in the year 2001. The local institutional review board reviewed the study protocol and determined that the study was "exempt."

Data Collection

Data were abstracted from an in-house database that follows the protocols of the Trauma Registry of the American College of Surgeons (TRACS), from a review of electronic records of laboratory data, and from an audit of the paper medical record, if required. The TRACS data extracted for the study included demographic data (age, gender, race), injury data (injury site, mechanism of injury, type of injury, Glasgow Coma Score [GCS][36] before hospital admission and/or at the referring hospital, when available, and at hospital admission), the results of a computerized tomogram (CT) scan of the head, clinical diagnosis of a substance use disorder (SUD) or withdrawal as noted by the clinicians of the trauma team, and outcomes (length of stay [LOS] in the intensive care unit [ICU] and in the hospital, discharge disposition). The hospital electronic laboratory database was used as the source of the patient blood alcohol concentration (BAC) at hospital admission and the results of the urine toxicology screen.

Urine and serum volatiles were identified by gas chromatography/mass spectrometry, as determined with a Shimadzu GC-8A unit (Shimadzu Corp., Kyoto, Japan). Blood ethanol level was considered to be positive at 10 mg/dL. Urine drug screens were performed with the Hitachi 911 analyzer (Hitachi, Ltd., Tokyo, Japan) using the Microgenics CEDIA DAU EMIT screen (Microgenics Corp., Fremont, CA). Drugs detected in the urine were considered to be positive at the following minimal levels: amphetamines (>1,000 ng/mL), barbiturates (>200 ng/mL), benzodiazepines (>300 ng/mL), cannabinoids (marijuana: >50 ng/mL), cocaine metabolites (>150 ng/mL), opiates (>300 ng/mL), phencyclidine (>25 ng/mL), and propoxyphene (>300 ng/mL). Spot screens were performed for urine phenothiazines using FPN (cutoff, 1 mg/mL) and for urine and serum salicylates using FeCl (cutoff, 5 mg/dL).

Data Analysis

Odds ratios (ORs) were used to measure the association between each characteristic (e.g., age, gender, type of injury) and toxicology testing, toxicology results, and substance use diagnosis. They also were used to measure the association of a positive toxicology result for a drug class or alcohol with injury characteristics (e.g., type, mechanism) and discharge disposition (e.g., home, jail). Both unadjusted ORs and ORs adjusted for the presence of alcohol or other drugs were calculated. For example, ORs were calculated for the risk of violence-related injuries by comparing patients who were alcohol positive with those who were alcohol negative before and after adjustment for cocaine as a confounding variable. Confidence intervals (CIs) and p values were calculated using the Wald method.[37] Logistic regression was used to adjust the primary association of interest for each confounding variable considered. The unequal variance t test was used to test for significant differences between the groups in terms of mean age, mean GCS, mean hospital LOS, and mean ICU LOS.

Statistical analyses were performed using the Statistical Package for the Social Sciences (SPSS) Version 11.0 (SPSS, Inc., Chicago, IL., 2001), the Statistical Analysis System (SAS) Version 8.01 (SAS Institute Inc., Cary, NC, 2000), and StatXact Version 5 (Cytel Software Corp., Cambridge, MA, 2000).

Power Analysis

Determination of sample size for this study focused on achieving sufficient statistical power to detect important associations between positive screens for alcohol or drugs and injury characteristics or outcomes. Previous clinical experience with trauma patients such as those in the current study suggested that about 25% would have positive screen results for alcohol. Assuming that an OR of 2 or greater is clinically important, and that the injury characteristic or outcome of interest has a prevalence of 5% or greater in the group that has negative screen results for alcohol, a sample of 351 patients with positive screen results for alcohol and 1,054 with negative screen results would be sufficient to achieve 80% power for detecting an OR of this magnitude.

Previous clinical experience also suggested that about 10% of the patients in the current study would have positive screen results for cocaine (the least frequently occurring drug

class of those considered in this study). Assuming that an odds ratio of 3 or greater is clinically important and that the injury characteristic or outcome of interest has a prevalence of 5% or greater in the group that has negative screen results for cocaine, a sample of 94 patients with positive screen results for cocaine and 855 with negative screen results would be sufficient to achieve 80% power for detecting an odds ratio of this magnitude. This sample size also would yield sufficient power for any drug class in which more than 10% of the patients have a positive screen.

RESULTS

From January 1, 2001, to December 31, 2001, 1,544 patients, ranging in age from 14 to 97 years, were admitted to the study hospital through the trauma service. Table 2 summarizes the demographic information of the entire study population. Data were not complete for all the subjects, and this is noted where appropriate. Among the patients in the study population, 887 had results available for both serum toxicology for alcohol and urine toxicology for drugs. This group served as the study sample. The subject selection process is summarized in Figure 1. Among all of the patients admitted to the hospital, 34.3% were noted to have a substance use disorder, as recorded in the Trauma Registry list of discharge diagnoses.

Subjects Tested for Alcohol and Drugs

Table 3 summarizes the results for the significant comparisons between the study sample and the subjects not included in the study sample who did not have complete toxicology testing or were not tested at all. Those tested were younger, on the average, and more likely to be injured on the roadway, to have a blunt or vehicular injury, and to be transferred to a rehabilitation facility. They were less likely to be 65 years old or older, to be injured at home, to have sustained a burn, or to be released home. Differences by gender and race were not significant.

Compared with those that had positive test results for all substances (alcohol and/or drugs), the patients with positive test results (n = 504) at presentation to the hospital were younger on the average (36.01 ± 14.63 years vs. 46 ± 21.68 years; $p < 0.001$) and more likely to be black (OR, 2.813; 95% CI, 1.600–4.947; $p < 0.001$) or Hispanic (OR, ∞; 95% CI, 1.107–∞; $p = 0.038$), to be male (OR, 1.692; 95% CI, 1.235–2.317; $p = 0.001$), to be 18 to 25 years old (OR, 1.811; 95% CI, 1.236–2.654; $p = 0.002$) or 26 to 34 years old (OR, 1.845; 95% CI, 1.195–2.847; $p = 0.006$), to be injured at a site other than home or a roadway (OR, 1.558; 95% CI, 1.064–2.280; $p = 0.023$), to have sustained a burn injury (OR, 4.480; 95% CI, 1.048–19.159; $p = 0.043$), and to be sent home (OR, 1.931; 95% CI, 1.418–2.630; $p < 0.001$). Those with positive test results also were less likely to be white (OR, 0.323; 95% CI, 0.197–0.529; $p < 0.001$), to be 65 years old or older (OR, 0.193; 95% CI, 0.122–0.306; $p < 0.001$), to be injured at home (OR, 0.471; 95% CI, 0.256–0.865; $p = 0.015$), and to die (OR, 0.508; 95% CI, 0.310–0.833; $p = 0.007$) or to be transferred to another hospital (OR, 0.372; 95% CI, 0.179–0.772; $p = 0.008$) or a nursing home (OR, 0.455; 95% CI, 0.221–0.937; $p = 0.033$).

Subjects With Positive Results for Psychoactive Drugs

Comparisons were made between patients with positive test results for psychoactive drugs in the urine at presentation to the hospital and patients with negative test results. Those with positive test results for any drug were younger on the average (35.69 ± 14.86 years vs. 43.61 ± 19.95 years; $p < 0.001$), more likely to be 18 to 25 years old (OR, 1.581; 95% CI, 1.134–2.204; $p = 0.007$) or 26 to 34 years old (OR, 1.546; 95% CI, 1.067–2.240; $p = 0.021$), and less likely to be 65 years old or older (OR, 0.372; 95% CI, 0.179–0.772; $p = 0.008$). As indicated in Table 4, the patients with positive test results for any drug also were more likely to have sustained a burn and to be discharged home, and less likely to die or be transferred to another hospital than those with negative test results. However, when patients were compared by specific drug classes, other associations became significant (Table 4). The presence of cocaine was associated with violent injuries and penetrating injuries (i.e., those attributable to stab or gunshot wounds). These patients were less likely to be transferred to another hospital and more likely to go to jail after hospital discharge than those who with negative test results for cocaine. By comparison, the presence of opiates was associated with nonviolent injury and burns. Adjustment for the presence of alcohol did not affect the significance of these relations in any meaningful way. Hence, only the unadjusted results are presented in Table 4. Associations of positive toxicology test results for either cannabis or benzodiazepines with injury type, injury mechanisms, and outcomes were not statistically significant (data not shown).

Subjects With Positive Results for Alcohol

On the average, as compared with those who showed negative results for BAC, those with a positive results for BAC at admission were younger (35.24 ± 12.23 years vs. 40.64 ± 19.40 years; $p < 0.001$), had a shorter stay in the ICU (6.11 ± 9.29 days vs. 7.97 ± 11.40 days; $p = 0.043$) and in the hospital (10.51 ± 12.40 days vs. 13.06 ± 15.66 days; $p = 0.008$), and had a lower GCS at presentation to the hospital (11.90 ± 4.54 vs. 12.79 ± 3.96; $p = 0.004$). Those with positive test results also were less likely to be white (OR, 0.411; 95% CI, 0.290–0.583; $p < 0.001$) and younger than 18 years (OR, 0.078; 95% CI, 0.019–0.325; $p < 0.001$) or 65 years old or older (OR, 0.165; 95% CI, 0.079–0.347; $p < 0.001$). They were more likely to be black (OR, 1.939; 95% CI, 1.303–2.884; $p = 0.001$) or Hispanic (OR, 7.772; 95% CI, 1.640 – 36.829; $p = 0.010$), to be male (OR, 2.790; 95% CI, 2.049–3.800; $p < 0.001$), and to be 26 to 34 years old (OR, 1.881; 95% CI, 1.324–2.673; $p < 0.001$).

Table 2 Characteristics of All Admitted Trauma Patients (n = 1544)

Characteristic	Mean	n	%
Mean age (n = 1,531) (years)	40.18 ± 18.30	—	—
Female gender	—	458	29.8
Race			
White	—	1267	82.1
Black	—	197	12.8
Hispanic	—	17	1.1
Asian	—	6	0.4
Other	—	57	3.7
Injury site (n = 1,440)			
Roadway	—	951	66.0
Home	—	113	7.8
Other	—	376	26.1
Injury mechanism (n = 1,425)			
Blunt	—	1165	81.8
Penetrating	—	175	12.3
Burn	—	83	5.8
Other	—	2	0.1
Injury type (n = 1,536)			
Nonviolent[a]	—	1181	76.8
Vehicular[b]	—	918	59.8
Violent[c]	—	229	14.9
Other[d]	—	126	8.2
Mean ED GCS (n = 1,501)	12.89 ± 3.98	—	—
Serum screen performed (n = 1,522)	—	1140	74.9
Positive result for BAC	—	402	26.4
Urine screen performed (n = 1,522)	—	893	58.7
Positive result	—	545	35.8
Opiates	—	293	19.3
Cannabis	—	232	15.2
Benzodiazepines	—	179	11.8
Cocaine	—	110	7.2
Other drugs[e]	—	63	4.1
CT scan performed	—	909	58.9
Positive result	—	275	17.8
Substance abuse diagnosis	—	504	32.6
Alcohol abuse	—	255	16.5
Alcohol dependence	—	37	2.4
Alcohol withdrawal	—	37	2.4
Drug abuse	—	117	7.6
Drug dependence	—	47	3.0
Drug withdrawal	—	11	0.7
Mean ICU length of stay (n = 881)	6.76 ± 10.49	—	—
Mean hospital length of stay (n = 1,536)	10.71 ± 15.96	—	—
Hospital disposition (n = 1,532)			
Home	—	1091	71.2
Rehabilitation	—	191	12.5
Death	—	133	8.7
Hospital transfer	—	53	3.5
Nursing home	—	52	3.4
Jail	—	12	0.8

ED GCS, Emergency Department Glasgow Coma Score; BAC, blood alcohol concentration; CT, computerized tomogram; ICU, intensive care unit.

[a] Nonviolent injuries include vehicular injuries, falls, and burns.

[b] Vehicular injuries include motor vehicle collisions, motorcycle collisions, pedestrians struck, and all-terrain vehicle collisions.

[c] Violent injuries include assaults, stab wounds, and gunshot wounds.

[d] Other injuries include electrical and chemical burns, frostbite, and machine and other injuries.

[e] Other drugs include barbiturates, propoxyphene, and amphetamines. Although tested, there was no incidence of phencyclidine.

Table 5 summarizes the results for the comparisons between the patients with positive BAC results at presentation to the hospital and those with negative BAC results in terms of injury characteristics and outcomes before and after adjustment for the results of urine toxicology. Those with positive BAC results (not adjusted for drugs) were less likely to

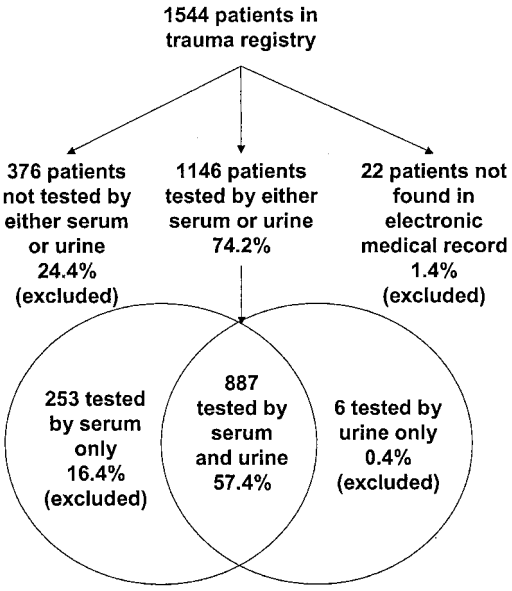

Fig. 1. *Subject selection process.*

have sustained a nonviolent or vehicular injury, or to be transferred to another hospital or rehabilitation facility for physical problems, and they were more likely to have sustained an injury as the result of violence, including a penetrating injury, or to be released home. However, when these relations were adjusted for the presence of cocaine, the associations of positive BAC results with penetrating injury and transfer to another hospital were no longer significant (Table 5). The analyses for the associations of injury with the BAC value did not differ in any meaningful way from results obtained when the test results for BAC were dichotomized as "alcohol positive" or "alcohol negative" (data not shown).

Associations of Combinations of Alcohol and Various Drugs With Injury Occurrence

Table 6 summarizes the associations of various drug and alcohol combinations with type of injury. Cocaine-positive toxicology was associated with violent injuries, whereas positive opiate toxicology was associated with nonviolent injuries and inversely associated with violent injuries. However, positive test results for any drug were not found to be significantly associated with any injury type, indicating that the significant associations of cocaine and opiates "canceled each other out" in the aggregate patient sample.

It was noted also that the association between alcohol and violent injuries as well as the association between cocaine and violent injuries appeared to be additive. When the toxicology test results were positive for both substances, the odds of an associated violent injury was greater than when toxicology test results were positive for either substance alone. Among the patients with positive test results for both opiates and alcohol, there was no significant association with any type of injury.

DISCUSSION

The finding that toxicology test results for alcohol and cocaine are more prevalent among those with intentional injuries has been noted by others.[25] The association of positive opiate toxicology results and unintentional injuries appears to be a new finding, but the study design does not permit an inference of causality.

The tables illustrate three important points to be remembered by those studying the associations between the results of toxicology testing and traumatic injury. First, Table 4 demonstrates the importance of drug-specific interpretation of positive toxicology results. The type of injury a drug-using

Table 3 Significant Comparisons of Patient Characteristics by Toxicology Status

Characteristic	Incomplete Tests* n (%)	Complete Tests n (%)	OR	95% CI	*p* Value
Age (n = 1,518) (years)					
Mean	42.05 ± 19.40	38.51 ± 17.67	N/A	1.63–5.45	<0.001[a]
65 and older	104 (16)	89 (10)	0.57	0.42–0.78	<0.001[a]
Injury site (n = 1,420)					
Roadway	336 (58)	600 (72)	1.85	1.48–2.31	<0.001[a]
Home	67 (12)	45 (5)	0.44	0.29–0.65	<0.001[a]
Other	179 (31)	193 (23)	0.67	0.53–0.86	0.001[a]
Injury mechanism (n = 1,406)					
Blunt	445 (77)	703 (85)	1.79	1.36–2.35	<0.001[a]
Burn	58 (10)	25 (3)	0.28	0.18–0.46	<0.001[a]
Injury type (n = 1,428)					
Vehicular only[b]	326 (63)	588 (73)	1.56	1.23–1.98	<0.001[a]
Mean ED GCS (n = 1,479)	13.51 ± 3.56	12.48 ± 4.19	N/A	−0.63–1.43	<0.001[a]
Outcomes (n = 1,510)					
Home	467 (74)	606 (69)	0.78	0.62–0.98	0.032[b]
Rehabilitation	53 (8)	135 (15)	1.98	1.41–2.77	<0.001[a]

OR, odds ratio; CI, confidence interval; N/A, not applicable; ED GCS, emergency department Glasgow Coma Score.
[a] "Incomplete tests," referring to all who did not receive both serum and urine toxicology screening.
[b] Vehicular injuries, including motor vehicle collisions, motorcycle collisions, pedestrians struck, and all-terrain vehicle collisions.

Table 4 Drug-Specific Comparison of Associated Injuries and Outcomes Between Trauma Patients With Positive Drug Toxicology and Those With Negative Toxicology

Characteristic	Positive for Any Drug			Positive for Cocaine			Positive for Opiates		
	OR	95% CI	*p* Value	OR	95% CI	*p* Value	OR	95% CI	*p* Value
Injury type									
Nonviolent[a]	1.19	0.82–1.74	0.359	0.33	0.21–0.52	<0.001[b]	1.80	1.16–2.80	0.009
Vehicular only[c]	0.93	0.68–1.26	0.626	0.48	0.32–0.73	0.001	0.86	0.62–1.18	0.350
Violent[d]	0.84	0.57–1.22	0.359	3.07	1.93–4.87	<0.001[b]	0.56	0.36–0.86	0.009[b]
Injury mechanism									
Blunt	0.96	0.65–1.43	0.842	0.45	0.27–0.74	0.002[b]	0.94	0.63–1.42	0.777
Penetrating	0.73	0.47–1.12	0.145	2.45	1.44–4.16	0.001[b]	0.48	0.29–0.82	0.007[b]
Burn	4.82	1.43–16.25	0.011[b]	1.35	0.45–4.01	0.592	11.60	3.94–34.14	<0.001[b]
Outcome									
Home	1.53	1.14–2.04	0.004[b]	1.17	0.75–1.82	0.486	1.66	1.21–2.29	0.002[b]
Rehabilitation	1.03	0.71–1.50	0.873	0.85	0.48–1.52	0.593	0.88	0.59–1.31	0.539
Death	0.51	0.32–0.84	0.007[b]	0.00	0.00–0.72	0.034[b]	0.74	0.33–1.69	0.478
Hospital transfer	0.48	0.23–1.00	0.050[b]	1.29	0.66–2.53	0.461	0.27	0.13–0.55	<0.001[b]
Nursing home	0.52	0.25–1.06	0.073	0.47	0.11–2.01	0.310	1.14	0.54–2.41	0.732
Jail[e]	2.58	0.29–23.21	0.397	10.75	1.78–65.09	0.010[b]	—	—	—

OR, odds ratio; CI, confidence interval.
[a] Nonviolent injuries including vehicular injuries, falls, and burns.
[b] Significant inverse associations are indicated.
[c] Vehicular injuries including motor vehicle collisions, motorcycle collisions, pedestrians struck, and all-terrain vehicle collisions.
[d] Violent injuries including assaults, gunshot wounds, and stab wounds.
[e] No opiate-positive subject went to jail.

trauma patient sustains varies with the type of drug abused. In this study no positive drug toxicology results were associated with either violent or nonviolent injury. Drug-specific comparisons showed, however, that cocaine use was associated positively with violent injuries and negatively with nonviolent injury. In contrast, opiate use was associated negatively with violent injury and positively with nonviolent injury. The danger of analyzing the data for an association with positive toxicology results alone is that these effects will cancel each other out.

Second, Table 5 shows that the effects of alcohol intoxication must be interpreted in the light of other abused drugs. For example, violent injuries were found to be associated with alcohol intoxication, even when control was used for the results of a drug screen. However, penetrating injuries (i.e., stab wounds, gunshot wounds) were associated with alcohol

Table 5 Associations of Injury Characteristics and Outcomes With Positive Blood Alcohol Concentration (BAC) Results Before and After Adjustment for Positive Drug Toxicology Results

Characteristic	Positive BAC Not Adjusted for + Drug Test			Positive BAC Adjusted for + Drug Test			Positive BAC Adjusted for + Cocaine Test			Positive BAC Adjusted for + Opiate Test		
	OR	95% CI	*p* Value	OR	95% CI	*p* Value	OR	95% CI	*p* Value	OR	95% CI	*p* Value
Injury type												
Non-violent[a]	0.36	0.24–0.53	0.001[b]	0.35	0.24–0.51	<0.001[b]	0.41	0.28–0.61	<0.001[b]	0.37	0.25–0.54	<0.001[b]
Vehicular only[c]	0.63	0.46–0.86	0.004[b]	0.64	0.47–0.87	0.004[b]	0.70	0.51–0.96	0.025[b]	0.63	0.46–0.86	0.003[b]
Violent[d]	2.78	1.90–4.06	<0.001	2.87	1.96–4.21	<0.001	2.43	1.64–3.58	<0.001	2.73	1.86–3.99	<0.001
Injury mechanism												
Blunt	0.74	0.49–1.09	0.127	0.74	0.50–1.10	0.131	0.84	0.56–1.26	0.390	0.73	0.49–1.09	0.121
Penetrating	1.73	1.12–2.67	0.013	1.81	1.17–2.79	0.008	1.52	0.97–2.38	0.069	1.67	1.08–2.58	0.022[a]
Burn	0.45	0.17–1.21	0.115	0.40	0.15–1.08	0.070[b]	0.41	0.15–1.13	0.085	0.52	0.19–1.43	0.206
Outcome												
Home	1.86	1.35–2.56	<0.001	1.80	1.31–2.48	<0.001	1.87	1.35–2.59	<0.001	1.94	1.40–2.67	<0.001
Hospital transfer	0.37	0.14–0.98	0.045[b]	0.40	0.15–1.05	0.062	0.44	0.17–1.16	0.085	0.36	0.14–0.96	0.041[b]
Death	1.01	0.61–1.68	0.963	1.09	0.65–1.81	0.753	0.97	0.58–1.63	0.911	0.45	0.57–1.59	0.853
Nursing home	0.54	0.23–1.28	0.162	0.58	0.25–1.36	0.211	0.58	0.25–1.39	0.223	0.55	0.23–1.29	0.167
Jail	1.27	0.21–7.37	0.795	1.17	0.19–7.11	0.861	0.67	0.10–4.42	0.678	1.16	0.19–7.01	0.870

OR, odds ratio; CI, confidence interval; + drug test, urine toxicology positive for psychoactive drugs (see text list of drugs and cutoff values).
[a] Nonviolent injuries including vehicular injuries, falls, and burns.
[b] Significant inverse associations are indicated.
[c] Vehicular injuries including motor vehicle collisions, motorcycle collisions, pedestrians struck, and all-terrain vehicle collisions.
[d] Violent injuries including assaults, gunshot wounds, and stab wounds.

Table 6 Associations of Positive Toxicology for Drugs, Alcohol, and Various Combinations With Types of Injury

Toxicology	Nonviolent Injury			Vehicular Injury			Violent Injury		
	OR	95% CI	*p* Value	OR	95% CI	*p* Value	OR	95% CI	*p* Value
Positive drug results[a]									
Any drug positive	1.19	0.82–1.74	0.359	0.93	0.68–1.26	0.626	0.84	0.57–1.22	0.359
Cannabis	0.90	0.59–1.35	0.597	1.20	0.85–1.69	0.314	1.12	0.74–1.69	0.597
Cocaine	0.33	0.21–0.52	<0.001[b]	0.48	0.32–0.73	0.001[b]	3.07	1.93–4.87	<0.001
Opiates	1.80	1.16–2.80	0.009	0.86	0.62–1.18	0.350	0.56	0.36–0.86	0.009[b]
Multiple drugs	0.69	0.47–1.00	0.051	0.87	0.64–1.18	0.364	1.45	1.00–2.11	0.051
Positive alcohol results	0.36	0.25–0.53	<0.001[b]	0.63	0.46–0.86	0.004[b]	2.78	1.90–4.06	<0.001
Drug–alcohol combinations									
Any drug + alcohol	0.50	0.34–0.75	0.001[b]	0.71	0.50–0.99	0.045[b]	1.99	1.33–2.96	0.001
Cannabis + alcohol	0.54	0.33–0.88	0.014[b]	0.74	0.48–1.13	0.163	1.84	1.13–3.00	0.014
Cocaine + alcohol	0.30	0.17–0.52	<0.001[b]	0.43	0.26–0.72	0.001[b]	3.34	1.93–5.78	<0.001
Opiates + alcohol	0.85	0.47–1.55	0.602	0.94	0.57–1.53	0.790	1.77	0.65–2.12	0.602
Multiple drugs + alcohol	0.50	0.34–0.75	0.001[b]	0.71	0.50–0.99	0.045[b]	1.99	1.33–2.96	0.001

[a] Relationships are unadjusted for alcohol. See Table 4 for adjusted relation.
[b] Significant inverse associations are indicated.

intoxication only when the unadjusted odds ratio for cocaine was used. When this association was adjusted for the positive results of a cocaine screen, it was no longer significant.

Third, Table 6 illustrates the importance of considering the effects of various drug and alcohol combinations on injury. For example, the associations of positive alcohol and cocaine toxicology results with violence-related injuries appear to be additive.

Although Soderstrom et al.[38] noted that the reliance on toxicology testing alone is inadequate for identifying all trauma patients with substance use disorders, they also observed that toxicology testing is a first step in detecting those at risk.[28] It is difficult to determine from the toxicology screen alone whether the patient has a substance use disorder or, if the results are positive, whether drug use has been illicit. If the results for a screen are positive for cocaine or marijuana, then it is reasonable to conclude that the patient has used illicit drugs. However, if the results for a screen are positive for a controlled substance available by prescription, then the conclusion is not as clear. The positive results could be attributable to the administration of medications en route to the hospital or in the emergency room. They could be the result of appropriate therapeutic use or inappropriate use of medications by the patient before the injury. They could be the result of drug abuse by a patient who visits multiple physicians to obtain drugs ("doctor shopping"). Finally, they could be attributable to prescription drugs purchased from an illicit source. Additional clinical information from the patient, the patient's family, the patient's primary physician, pharmacy records, or state prescription databases may be required to determine the correct category: appropriate drug use, drug misuse, drug abuse, or drug dependency.[39]

Limitations

This was a correlational study, so causality cannot be inferred from the results because there was no control group. The associations reported are between the results of toxicology testing and injuries that are severe enough for admission to a trauma center.

Not all patients received toxicology testing in this study. It appears that patients were not tested randomly (Table 3) by the physicians in the emergency department, and this might have produced a sampling bias. For example, older patients, particularly those 65 years old or older, and patients injured at home were less likely to be tested than younger patients or those injured on a roadway. Although it was the policy of the Trauma Service to obtain toxicology screening tests for all trauma patients, the physicians in the emergency department advised the authors of this study that they did not usually obtain toxicology tests when they thought the likelihood was low that a given patient had an alcohol or drug abuse problem (e.g., a nursing home patient who fell or a patient who was injured on the job). Therefore, the results of this study may not apply to patients at low risk for an alcohol- or drug-related injury. Several patients eligible for the study did not receive urine toxicology testing (for drugs) because urine (unlike blood) was not always obtained initially in the emergency department, or because there was an insufficient quantity for toxicology testing.

It is difficult to determine from a retrospective study whether a patient was under the influence of drugs at the time of traumatic injury. Whereas serum toxicology was performed for the study patients to test for alcohol, urine toxicology was used to test for drugs of abuse. Thus, whereas those who had positive BAC results in this study were likely to have been under substance influence at the time of their injury, this is not true for a positive result for drugs because urine toxicology results can be positive from 3 days (e.g., for cocaine or opiates) to 4 weeks (e.g., for marijuana) after the last episode of drug use.

The type of urine toxicology testing performed can compromise the sensitivity of the test. For example, at the study

institution, the opiate test is standardized to morphine. Oxycodone has 3.1% cross-reactivity with this test, whereas methadone does not cross-react at all because it is a synthetic opioid, not an opiate. Therefore, these tests may underdetect two of the most popular abused opioids (oxycodone and methadone) in the geographic area of the study.

The diagnosis of a substance use disorder, which was made for 34.3% of all the trauma patients, was a clinical diagnosis. A rigorous clinical study would use a structured interview to verify the diagnosis of a substance use disorder. The trauma nurses entered the substance use disorder diagnoses into the trauma database, where diagnoses are coded according to the International Classification of Diseases, 9th Revision, Clinical Modification (ICD-9-CM) criteria using information available from the medical record, and not from information obtained directly from the patients. In addition, a maximum of 14 diagnoses can be entered into the Trauma Registry database. If the patient has a large number of diagnoses associated with acute injuries and chronic medical problems, then a diagnosis of a substance use disorder may not be entered into the database because of insufficient space.

Recommendations

This study examined the associations of alcohol and drug use with traumatic injury. Additional studies are needed to define the cause and effect relation between drug use and injuries. The results of these studies may help guide the planning of appropriate patient interventions to prevent further injuries. For example, if findings show that cocaine abuse contributes to the cause of violent injury and is predictive of future injuries, then cocaine users could be specifically targeted for interventions designed to increase the likelihood that they will engage in a drug rehabilitation program to decrease in the rate of future injuries to themselves and/or innocent victims.

The authors believe that future studies based on the following considerations would be of the most benefit:

1. A prospective cohort design should be used.
2. Sample bias should be avoided. Toxicology screening tests should be obtained for all patients, or at least a random sample of all patients. Selective testing by emergency department staff could produce a sampling bias.
3. Blood obtained at the scene should be used if possible, because this would be ideal for determining whether a given patient was under the influence of a particular drug at the time of the injury.
4. A positive urine drug screen should be confirmed with a diagnostic test. False-positive screening tests for opiates (e.g., from quinolones) or amphetamines (e.g., from pseudoephedrine) are not uncommon. Gas chromatography/mass spectrometry, liquid chromatography, or thin-layer chromatography should be used to confirm a positive screening test when appropriate.
5. Drug screens may need to be modified on the basis of local drug prevalence. For example, the typical screening toxicology test checks for phencyclidine, opiates, cocaine, marijuana, and amphetamines, but does not check for benzodiazepines or methadone. In the geographic area of the study, phencyclidine and heroin abuse is unusual, whereas abuse of benzodiazepines, prescription opiates, and methadone is common.
6. A diagnosis of a substance use disorder should be made by a structured patient interview.
7. Efforts should be made to monitor data quality. Some discrepancies were observed between trauma registry toxicology data extracted from the paper medical record and laboratory toxicology data available from the electronic medical record, suggesting errors in trauma registry data entry. A common error (noted for about 100 patients) was entry of a "not done" code into the "toxicology" field of the registry when the laboratory data actually were available. The laboratory toxicology data rather than the registry toxicology data were used in this study to avoid this error and because either only one drug or a "polydrug" was coded into this field of the registry.
8. Data analyses should be drug specific and adjusted for confounding variables such as alcohol intoxication. Categorizing patients as either "drug screen positive" or "drug screen negative" may obscure important findings.

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