Alcohol Abuse/Dependence in Motor Vehicle Crash Victims Presenting to the Emergency Department

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ABSTRACT

Objective: 1) To determine the prevalence of current alcohol abuse/alcohol dependence (AA/AD) among the full injury range of ED motor vehicle crash (MVC) patients; and 2) compare AA/AD and non-AA/AD patient characteristics.
Methods: This was a prospective cohort study using a stratified random sample of MVC patients aged ≥18 years presenting to a university hospital and university-affiliated community hospital ED from May 1, 1992, to August 30, 1994. A diagnosis of current AA/AD was based on the alcohol section of the Diagnostic Interview Survey (DIS). Other measurements included the presence of blood alcohol (BAC+), Injury Severity Score (ISS-85), occupant status (driver/passenger), age, gender, seat belt use, culpability for crash, and ED disposition (admitted vs released). A weighted prevalence was determined; subgroups were compared using t-tests, χ^2, 2-factor analysis, and logistic regression modeling; $\alpha = 0.05$.
Results: 1,161 patients were studied. The weighted prevalence of current AA/AD was 22.5%; 53% of these patients were released from the ED. Almost 45% of the patients with current AA/AD were BAC−. When controlling for BAC and AA/AD, greater injury severity and culpability were associated with a BAC+, but not with current AA/AD.
Conclusion: Almost 23% of ED MVC patients have current AA/AD; BAC testing does not accurately identify these patients. Intervention strategies must be directed to both admitted and released patients.
Key words: alcohol; ethanol; substance abuse; alcohol abuse; motor vehicle; injury; motor vehicle collision; injury prevention.

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Reducing death and disability caused by alcohol-related injuries is a national health status goal.[1] In general, the costs of alcohol-related problems have been estimated to be more than $136 billion.[2] Of particular concern are alcohol-related motor vehicle crash (MVC) injuries. Currently, MVC injuries are the single largest component of injury mortality and injury costs in the United States. Alcohol is associated with a substantial proportion of those injuries and alcohol is involved in >40% of MVC fatalities and an estimated 1,000,000 MVC injuries.[3]

Studies in the United States and elsewhere have shown significant relationships between the frequency and quantity of drinking and injury.[4–12] Problem drinkers may experience nonfatal injuries 1.6 times as frequently as do their nondrinking counterparts and incur health care costs 3 times as high.[13] In a prospective study of trauma patients, Rivara et al. found that alcohol abuse in trauma is associated with an increased risk of admission for subsequent trauma.[14] Studies from trauma centers have noted rates of chronic alcohol abuse among admitted patients to be as high as 70% and that a substantial portion of patients with chronic abuse do not have positive blood alcohol tests.[14–17]

For the emergency physician (EP), obtaining alcohol levels and drinking histories for MVC patients is important, not only for the acute care of these patients but also for the detection of current AA/AD.[18–30] Interventions for these individuals could result in a reduction in AA/AD, and subsequently less MVC injury.[31–35] The magnitude of AA/AD among the complete range of patients presenting to an ED following an MVC and the characteristics of MVC patients with current alcohol abuse are unknown.

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Such information is critical to develop appropriate screening methodologies and subsequent intervention strategies for AA/AD among MVC victims.

The study we report is unique in that it analyzes the full range of patients presenting to the ED following an MVC and does not focus on admitted patients only; provides information about both injury severity and AA/AD; and provides an in-depth comparison of MVC victims with and without current AA/AD. The purpose of our study was 2-fold: first, to determine the frequency and prevalence of current AA/AD among the full range of MVC patients presenting to the ED, and second, to determine patient characteristics associated with AA/AD that may be used to identify patients with AA/AD who present to the ED following an MVC.

METHODS

Study Design: This was a prospective observational investigation of MVC victims presenting to 2 EDs to determine the prevalence of AA/AD in this population and to compare patient subgroups with and without AA/AD. This study was approved by the institutional review boards of both the university hospital and the community hospital. Informed consent was obtained prior to blood alcohol concentration (BAC) analysis and interviewing.

Patient Population and Setting: Subjects were patients, ≥18 years old, who were occupants of automobiles or small trucks involved in an MVC and who presented directly from the crash scene to the ED within 6 hours of the crash. Pregnant patients, institutionalized patients, and transfer patients were excluded. Subjects were recruited from among patients presenting to 2 university affiliated EDs: a large university hospital verified as a Level-1 trauma center by the American College of Surgeons (site 1), and a large community teaching hospital affiliated with the university hospital (site 2). Both of these hospitals are located in Ann Arbor, MI. Ann Arbor is a city of approximately 125,000 citizens, situated within a metropolitan statistical area (MSA) county of 330,000, and surrounded by similar populated counties.

Data collection occurred over a 29-month period at site 1 (April 1992–August 1994) and over a 15-month period at site 2 (April 1993–June 1994).

Study Protocol: At the university hospital site, the subjects were sampled using full sampling during evening hours (3:30–11:30 PM, the time of highest MVC concentration) and time sampling during day and midnight shifts. Time sampling allowed the creation of representative samples for certain analyses by weighting observations differentially according to our sampling frame. Time samples consisted of 2-week blocks in which day and night shifts were covered on 3 consecutive days; days the first week in the block, nights the second week in the block. The start day of these blocks was shifted sequentially throughout the study period, so that all days of the week were eventually sampled during each month of the year. Due to resource limitations, a purposive sampling procedure was used at the community hospital site. At this site, only full sampling of evening shifts was used. This time interval was selected because preliminary data indicated that most MVC victims presented during the evening shift.

Data sources included hospital records, ambulance reports, and crash reports. Diagnostic interviews were conducted by specially trained research assistants and were completed in the ED, in an inpatient unit, or subsequently by phone after making follow-up arrangements in the ED. Crash reports were abstracted by specially trained research assistants. Information from medical records was abstracted by certified emergency nurses who had attended the Association for the Advancement of Automotive Medicine injury scoring course and had experience in injury scoring.

Measurements: Current AA/AD was determined using the alcohol section of the Diagnostic Interview Schedule (DIS).[36] The DIS contains 30 stem questions and is administered in a standardized format. The DIS identifies both past and current AA/AD as defined by criteria in the *Diagnostic and Statistical Manual of Mental Disorders, Third Edition, Revised.*[37] The DIS also identifies the number of lifetime symptoms related to alcohol use. It is a *standardized diagnostic instrument*, not a screening tool.

The BAC was determined by serum analysis (enzyme immunoassay, Ektachem 700 XR Analyzer, Johnson and Johnson, Rochester, NY), whole blood analysis (gas chromatography, Hewlett Packard 5890 Gas Chromatograph, Hewlett Packard, Wilmington, DE), or breath analyzer (Alco-Sensor III, Model #1020312, Intoximeters, St. Louis, MO) conducted in the ED. Blood or breath samples were obtained within 6 hours of the injury. Injury severity was defined by the Injury Severity Score (ISS) using the Abbreviated Injury Scale (AIS), 1985 version, and Tri-Code injury scoring software (Tri-Analytics R, Bel Air, MD).[38-40] Mean corpuscular volume (MCV) and gamma-glutamyl transferase (GGT) were also determined. These measures have been used by some investigators to identify chronic alcohol abuse, with elevated levels of GGT and MCV values >95 femtoliters (fL) being suggested as indicators of chronic alcohol abuse.[14-16,41-47] The MCV was performed using the Coulter STKR Blood Analyzer (Coulter Electronics, Hialeah, FL); institutional norms for ages ≥18 years are in the range of 80–100 fL. For GGT, an enzyme immunoassay was conducted using the Ektachem 700XR Analyzer (Johnson and Johnson); institutional norms are in the range of 1–35 IU/L.

Vehicle occupant position, restraint use, and, for drivers, culpability for the crash were determined from the

TABLE 1 Prevalence of Current Alcohol Abuse/Dependence (AA/AD) by Age and Gender

Gender/Age	Crude Study Sample Prevalence	Weighted Study Sample Prevalence	General Population Prevalence*
Men			
18–29 yr	34.5	41.5	17.0
30–44 yr	34.0	30.6	14.1
45–64 yr	20.5	24.6	7.9
≥65 yr	3.1	9.8	3.1
Women			
18–29 yr	15.8	15.6	4.1
30–44 yr	5.7	6.3	2.1
45–64 yr	4.1	5.2	1.0
≥65 yr	0.0	0.0	0.7

*Kessler RC, McGonagle KA, Zhao S, et al. Lifetime and 12-month prevalence of DSM-III-R psychiatric disorders in the United States. Arch Gen Psychiatry. 1994; 51:8–19.

crash report. All crash reports were completed using the Michigan Uniform Crash Report (UD-10). Culpability for the crash was determined to be present if the crash report noted that the driver had committed a hazardous action. Age, gender, and disposition from the ED were also determined by ED record review.

Data Analysis: Prevalence of current AA/AD was determined using weighted estimates from the probability sample at the university hospital study site. Prevalence also was calculated for gender- and age-specific groups based on age groupings from previous epidemiologic studies.[48] The diagnosis was considered present if the subject met DIS criteria for AA/AD (mild, moderate, or severe) and had experienced symptoms within the preceding year. To determine the demographic and clinical patient characteristics that best discriminated diagnostic groups, multiple logistic regression models were run. First, analyses were conducted to model potential selection bias in the sample. Eligible subjects who fell within the sample frame, but who were not recruited for alcohol testing or did not receive the diagnostic interview portion of the study, were compared with the remaining fully studied sample. Clinical records and crash reports provided sufficient data for hospital site, age, position in the car, seat belt use, culpability, and injury severity. Significant univariate differences occurred in gender, ISS, and hospital site. When these 3 predictors were used simultaneously, ISS and site were sufficient to model inclusion in the sample, and gender did not significantly augment the model ($\chi^2 = 30.8$, $p < 0.0001$).

To guard against selection bias in our primary comparisons, ISS and hospital site were included as covariates in statistical models. Comparisons among diagnostic groups were rerun after including ISS and hospital site as covariates (for ISS as a dependent measure, only hospital site was used as a covariate). The 2-group comparisons (Table 2) were virtually unchanged. The 2-factor comparisons (Table 3) had slightly disparate results. All significant effects remained significant in the new models. How-

TABLE 2 Characteristics of Patients with and without Current Alcohol Abuse or Dependence (AA/AD)

	Current AA/AD (*n* = 222)	No Current AA/AD (*n* = 939)	p-value
Age			
Mean	29.2 yr	36.5 yr	0.0001
SD	10.1	16.3	
Gender			
Male	162 (73%)	371 (40%)	<0.0001
Female	60 (27%)	568 (61%)	
BAC+*	122 (55%)	60 (6%)	<0.0001
BAC (≥22 mmol/L)	92 (41%)	30 (3%)	<0.0001
Alcohol symptoms			
Mean	4.89	1.05	<0.0001
SD	1.92	1.79	
ISS†-85			
Mean	5.87	3.57	0.0001
SD	7.54	6.33	
Restraint use	117 (52.7%)	722 (76.9%)	<0.0001
Occupant status			
Driver	174 (78.4%)	734 (78.2%)	NS‡
Passenger	48 (21.6%)	205 (21.8%)	
Culpable (drivers only)	130 (76.4%)	384 (53.0%)	<0.0001
Disposition			
Released	116 (53%)	684 (74%)	<0.0001
Admitted	103 (47%)	241 (26%)	
	(*n* = 219)	(*n* = 925)	
Study site			
Site 1	152 (68.5%)	580 (61.8%)	NS
Site 2	70 (31.5%)	358 (38.2%)	
MCV§ (fL)			
Mean	88.7	87.2	NS
SD	6.5	6.4	
MCV >95 fL	17 (7.7%)	25 (2.7%)	<0.0001
GGT¶ (IU/L)			
Mean	63.8	35.2	NS
SD	180.99	32.6	
GGT >85 IU/L	22 (9.9%)	25 (2.7%)	<0.0001

*BAC = blood alcohol concentration.
†ISS = Injury Severity Score.
‡NS = not significant.
§MCV = mean corpuscular volume.
¶GGT = gamma-glutamyl transferase.

TABLE 3 Two-factor Analysis Comparing Patient Characteristics Using Blood Alcohol Concentration (BAC) and Alcohol Abuse/Alcohol Dependency (AA/AD) as the Two Factors

	AA/AD+		AA/AD−		Factor p-values		
	Group 1—BAC+ (*n* = 122)	Group 2—BAC− (*n* = 100)	Group 3—BAC+ (*n* = 60)	Group 4—BAC− (*n* = 876)	BAC	AA/AD	Interaction
Age—mean (SD)	31.2 (9.6) yr	26.7 (10.1) yr	33.2 (15.4) yr	36.7 (16.3) yr	NS*	0.0001	NS
Gender—male	100 (82%)	62 (62%)	42 (70%)	327 (37%)	0.0001	0.0001	NS
Restraint use	44 (36%)	73 (73%)	28 (47%)	691 (79%)	0.0001	NS	NS
Driver	98 (80%)	76 (76%)	47 (78%)	684 (78%)	NS	NS	NS
Culpable (drivers only)	92 (94%)	38 (50%)	44 (94%)	340 (50%)	0.0001	NS	NS
Admitted	83 (69%)	20 (20%)	37 (62%)	204 (24%)	0.0001	NS	NS
MCV† >95 fL	15 (12%)	2 (2%)	3 (5%)	22 (3%)	NS	NS	NS
GGT‡ >85 IU/L	18 (15%)	4 (4%)	4 (7%)	20 (2%)	NS	NS	NS
Mean ISS§-85 (SD)	7.9 (8.4)	3.4 (5.4)	6.4 (10.0)	3.4 (5.9)	0.001	NS	NS
Mean alcohol symptoms (SD)	5.13 (1.91)	4.59 (1.90)	2.00 (1.8)	0.98 (1.8)	0.0001	0.0001	NS

*NS = not significant.
†MCV = mean corpuscular volume.
‡GGT = gamma-glutamyl transferase.
§ISS = Injury Severity Score.

ever, one effect emerged when these sources of variance were controlled, i.e., main effects of BAC status on age ($p < 0.004$). The emergence of these effects appears to be due to site differences in age, with the site 1 subjects being slightly younger than the site 2 patients (34.3 vs 36.5 years). Within each site, the BAC+ subjects were consistently younger than the BAC− subjects (site 1: 31.4 vs 35.1 years; site 2: 33.2 vs 37.2 years). The group differences were sharpened by using the hospital site as a covariate.

Diagnostic groups were compared several ways. Univariate comparisons were made between the 2 diagnostic groups (using χ^2 for dichotomous or t-tests for continuous measures) or among 4 groups [using analysis of variance (ANOVA)], subdividing the diagnostic groups by BAC results (positive vs negative diagnosis × positive vs negative BAC). The interaction of diagnostic group and BAC was included in the ANOVA. Overall, a corrected p-value ≤ 0.05 was considered significant; using Bonferroni's correction to adjust for multiple comparisons, individual tests were considered significant at the 0.002 level. A second set of analyses was run with ISS and study site included as covariates, to ensure that group differences were not due to potential selection bias.

Finally, logistic regression was used to create a model for predicting which ED patients are likely to meet criteria for AA/AD. Variables that would be available quickly in the ED setting [sex, age, reported use of seat belts or other restraints, BAC level, MCV, GGT, and high BAC {≥22 mmol/L (≥100 mg/dL)}] were included as predictors in a stepwise selection process. The best predictors were entered into another logistic regression to determine their sensitivities and specificities for current AA/AD.

RESULTS

A total of 1,833 subjects who met study criteria fell within the sampling frame. There were 318 patients excluded because alcohol testing was not conducted (185 refused the test and 133 were not identified in a timely fashion by our research staff). Another 354 patients were excluded because a personal interview was not conducted. Of these patients, 161 refused to consent to an interview, while for 118 subjects, research staff were unable to complete the interviews, and for 75, a limited interview was conducted with a family informant because the identified subject either was incapacitated or had died. The remaining 1,161 patients are included in the main analysis.

On average, samples for BAC determination were drawn 58 minutes after the crash (range: 1–325 minutes). Of the analyzed subjects, 222 (19.1%) had current AA/AD. Weighted prevalence for current AA/AD was 22.5% (university site). Almost 55% of the patients with current AA/AD were released from the ED. Almost 48% of those with current AA/AD did not have a positive BAC at the time of ED evaluation.

Table 1 shows the age- and sex-adjusted prevalence for our study population compared with those in the general population. Table 2 compares those patients with current AA/AD and those without these diagnoses. Significant differences exist for all characteristics except occupant status. Table 3 shows the characteristics of the patients with and without current AA/AD, stratified by results of BAC testing. Groups 1 and 2 contain current AA/AD patients; group 1 patients were positive for alcohol and group 2 patients were negative for alcohol. Groups 3 and 4 contain patients who were negative for current AA/AD. Group 3 patients were positive for alcohol and group 4 patients were negative. In general, the main effects of BAC status were highly significant (except for age and driver). Diagnosis did not affect crash or injury characteristics after accounting for BAC status. Effects were generally additive, given the absence of strong interactions between BAC and diagnosis for AA/AD.

The strong effects of BAC status are consistent with the remarkable similarities between groups 1 and 3 and groups 2 and 4 for restraint use, culpability, ED disposition, and injury severity. Among the patients testing positive for BAC, those with current AA/AD more frequently had BACs ≥22 mmol/L (≥100 mg/dL) than did those without a current diagnosis. Also, the mean number of lifetime alcohol symptoms varied by both the presence of alcohol and current AA/AD, as would be expected.

Prediction of which ED patients are likely to meet criteria for AA/AD was modestly accurate. A stepwise logistic regression using sex, age, reported use of seat belts or other restraints, BAC level, MCV, GGT, and high BAC resulted in a final model including only sex, age, and BAC level. A regression model using these 3 predictors was highly significant ($\chi^2 = 267.8$, $p < 0.0001$). The test characteristics of this predictor set showed an accuracy of 76.8% correct classification, sensitivity 71.3%, and specificity of 78.3%. The false-negative rate was 9.1% and the false-positive rate was 52.6%.

DISCUSSION

Almost 20% of the MVC patients had current AA/AD. The weighted prevalence for MVC patients was 24%. Previous epidemiologic studies have estimated the prevalence of current AA/AD in the general U.S. population to be 7%.[48] Our findings suggest that this prevalence, overall, is almost 3.5 times higher among MVC patients presenting to the ED. For specific age and gender categories, prevalence varies from 2 to >5 times higher than the general population. The majority of patients with AA/AD were released from the ED. Blood alcohol testing was negative in almost half of the patients with current AA/AD. Furthermore, using the best predictors of current AA/AD in a logistic regression model to identify these patients yielded a sensitivity of only 71% and a specificity of 78%. Sixty of 936 (6.4%) patients without current AA/AD had positive BACs and 30 (3.2%) had BACs ≥22 mmol/L (≥100 mg/dL). These 30 patients, while not fulfilling DSM-III-R criteria for AA/AD, represent a group of patients who should have some form of intervention regarding their drinking behavior. Our study also found that when considering both BAC status and presence or absence of current AA/AD diagnosis, ISS, disposition status, and culpability varied by BAC status, but not by diagnosis status.

Although many studies have been conducted measuring BAC in ED injury patients or performing screening examinations for alcohol abuse in ED injury patients, we found only 2 prior studies that used a standardized diagnostic instrument to determine AA/AD in injured patients.[17,49] Using the standardized clinical interview and DSM-3-R criteria, Soderstrom et al. found that 68% of BAC+ patients and 46% of BAC− patients met criteria for alcohol dependence.[17] Cherpitel used the Composite International Diagnostic Interview (CIDI) and ICD-10 criteria to analyze both injury and noninjury patients presenting to the ED.[49] Among injury patients, 9% had positive alcohol tests; however, 16% of all subjects had a diagnosis of harmful drinking and 19% of all subjects were alcohol-dependent. Similar to these 2 studies, we found that a significant proportion of our study population were currently abusing or were dependent on alcohol and that many of these individuals tested negative for alcohol. Our study is unique in that it: 1) provides extensive information regarding the severity and mechanism of injury that is lacking in Cherpitel's study; 2) considers the whole range of injury that is lacking in Soderstrom et al.'s study; and 3) focuses on MVC injuries, which neither of these studies has done.

Another important finding in this study, based on our 2-factor analysis, is that ISS and disposition status varied significantly by BAC status but not by current diagnosis for AA/AD. This suggests that acute alcohol use rather than a diagnosis of current AA/AD is a greater risk factor for injury resulting from an MVC. Our findings are different from those of Jurkovich et al., who concluded that chronic alcohol use, not acute BAC level, was more strongly associated with injury severity.[15] Perhaps these differences reflect that Jurkovich et al. analyzed only admitted trauma patients and determined chronic alcoholism using biochemical markers, while our study looked at the full spectrum of injury and used a standardized diagnostic instrument to make an AA/AD diagnosis. In our 2-factor analysis, we also noted that culpability was significantly associated with BAC but not a diagnosis for AA/AD. This finding suggests that alcohol-related crashes among individuals with current AA/AD result mainly from the acute effects of alcohol as opposed to some underlying tendency for risky behavior. Furthermore, our findings support injury control strategies that focus on drinking and driving among individuals with current AA/AD rather than strategies that address risk-taking behavior in general.

The implications from our study are many. The fact that >50% of the subjects with current AA/AD were released from the ED confirms that EPs have a major role to play in the identification and treatment of MVC victims who have current AA/AD.[7,25,28-30,33,35,49-54] Second, efforts to detect and treat AA/AD among MVC patients cannot be focused only on admitted patients. Third, alcohol testing alone, or in conjunction with the use of other patient characteristics, will not accurately identify MVC victims with current AA/AD. Fourth, acute alcohol use, rather than a diagnosis of current alcohol AA/AD, is related to greater injury severity and crash culpability. Fifth, and of particular interest, among MVC patients presenting to the ED, a full spectrum of alcohol misuse is present.

LIMITATIONS AND FUTURE QUESTIONS

Our study has several potential limitations. Our participating hospitals were situated in a relatively suburban setting. Hence, our findings may not be generalizable to hospitals in larger urban or rural areas. Selection bias may have affected our results. This analysis involved only those who had alcohol testing and agreed to a DIS interview, which could result in an underestimation of the frequency and prevalence of current AA/AD in the sample. Selection bias modeling was used to test for and correct potential problems with generalizability. In fact, when potential biasing variables were included in group comparisons, the results were quite similar. Hence, we believe that the impact of selection bias is minor relative to the interpretation or implications of results in this study. Another concern is that our study did not attempt to identify patients who are excessive drinkers, yet who do not meet DSM-III-R criteria for AA/AD. Therefore, our study probably underestimates the percentage of MVC patients who would benefit from an intervention regarding alcohol use.

The challenges facing EPs in treating AA/AD among MVC victims are formidable, yet offer exciting research opportunities. Issues that should be addressed include: 1) how do we best screen for AA/AD among MVC patients presenting to the ED?; 2) what are the most effective interventions for AA/AD among these patients?; 3) what are the costs of these interventions and who will pay for them?; 4) what is the cost–effectiveness of these interventions compared with AA/AD interventions in other clinical settings?; 5) will EPs support and/or participate in such interventions?; and 6) will the training of EPs need to be altered to ensure that future EPs have the appropriate approach and skills to support and/or participate in AA/AD interventions?

CONCLUSION

Patients presenting to the ED following an MVC have a relatively high frequency of current AA/AD. The majority of these patients are released from the ED and almost half have negative BACs. Strategies and methods that can be used to identify and treat MVC victims effectively with current AA/AD need to be developed, evaluated, and implemented.

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