Alcohol-Related Hospital Encounters Trigger Thrombotic and Hemorrhagic Vascular Events

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Background and Purpose: We investigated the associations between alcohol-related emergency department visits and hospitalizations and vascular events including acute ischemic stroke, intracerebral hemorrhage (ICH), and subarachnoid hemorrhage. *Methods:* The New York State Inpatient and Emergency Department Databases were examined (2006-2013). Validated International Classification of Diseases 9th edition definitions identified index vascular hospitalizations and alcohol abuse encounters. We used case cross-over analysis with conditional logistic regression to estimate odds ratios (OR) for the association between alcohol-related encounters during 6 case periods (7, 14, 30, 60, 90, and 120 days before index event) compared to control periods (1 year before). Multivariate logistic regression was used to examine the association between an alcohol-related encounter within 6 months before index admission and 30-day readmission after discharge. *Results:* An alcohol encounter before index admission was associated with acute ischemic stroke (OR = 1.765 within 60 days, 1.418 within 90 days, and 1.287 within 120 days) and subarachnoid hemorrhage (OR = 2.375 within 90 days), but not ICH. Alcohol-related encounters within 6 months before index vascular events increased the likelihood of 30-day readmission after index admission. *Conclusion:* We found that a recent alcohol-related counter was associated with occurrence of vascular events, but not ICH, as well as worse outcomes after index admission.

Key Words: Alcohol—stroke—myocardial infarction—venous thromboembolism

Introduction

Risk factors for stroke and cardiovascular disease have been characterized, yet there is relatively less known about why discrete vascular events occur at a particular time[1] However, these events do not happen stochastically, as suggested by the relationship between circadian rhythm and onset of acute myocardial infarction (MI) and ischemic stroke.[2,3] In fact, short-term risk factors, or "triggers," may increase the risk of sudden vascular events over a relatively short period of time and may even directly precipitate their onset.[1,2,4]

Several triggers for acute cardiovascular events have been postulated, including physical exertion, infection, emotional distress, and alcohol use.[5] While alcohol use has been implicated as a possible trigger, there is discordant evidence regarding alcohol use as a long-term risk factor for cardiovascular events. Light-to-moderate alcohol consumption is associated with a reduced risk of cardiovascular disease and stroke, but heavy drinking confers an increased risk.[6,7] There is a similar pattern of evidence regarding the association between alcohol consumption and outcomes after cardiovascular events. Modest beneficial associations exist between low alcohol consumption and outcomes after stroke and MI, but heavy alcohol consumption showed either no association or a negative association with functional outcome and mortality after ischemic and hemorrhagic stroke.[8–10]

Several studies have suggested that there is a potential triggering effect of heavy alcohol consumption on acute, discrete vascular events.[11–15] However, previous studies have used small sample sizes and focused on, at most, a 1-week short-term risk period. Furthermore, no previous case-crossover study has concurrently examined how

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heavy alcohol consumption impacts both risk for and outcomes after cardiovascular events.

In this study, we used a large statewide administrative database to analyze the association between alcohol use and (1) the occurrence of, and (2) outcomes after, vascular events, including MI, venous thromboembolism (VTE), acute ischemic stroke (AIS), intracerebral hemorrhage (ICH), and subarachnoid hemorrhage (SAH). Inpatient hospitalizations and emergency department (ED) visits as a result of alcohol intoxication between 1 week and 120 days prior to index admission for respective vascular events were used as proxies for heavy alcohol use. Based on previous research, we hypothesized that (1) there is an association between recent alcohol-related encounters and risk of vascular events, and that (2) an alcohol-related encounter within 6 months of a vascular event results in worse outcomes after the event.

Methods

The New York State Inpatient Databases and State Emergency Department Databases from 2006 to 2013 were examined (Fig 1). Under an Agency for Healthcare Research and Quality initiative, these datasets are made available by the Healthcare Cost and Utilization Project (HCUP), and contain data on 97% of hospitalizations and ED visits for New York State at community hospitals, for all payers and the uninsured. Both of the aforementioned databases allow analysis of admissions and ED visits with the use of a verified, anonymized linkage identifier for each individual. An anonymized variable signifying the number of days between encounters (ED visits and hospitalizations) for each individual is also provided. The Mount Sinai IRB reviewed and approved this analytic plan, and all analyses comply with the HCUP data use agreement, including the stipulation not to report cell counts or frequencies less than 10 to maintain anonymity of individuals. Mandip S. Dhamoon had full access to all the data in the study and takes responsibility for its integrity and the data analysis.

International Classification of Disease, Ninth Revision, Clinical Modification (ICD-9) codes were used to identify index admissions, vascular risk factors, and alcohol-related encounters (supplementary Table 1). Index admissions were defined as those in which MI, VTE, AIS, SAH, or ICH were coded as the primary non-procedural diagnosis for admission so as to avoid inclusion of patients with only a history of these events.[16] ICD-9 codes previously validated in the literature were used to identify patients with MI (sensitivity and specificity ≥86%), VTE (positive predictive value = 64.6%), AIS (specificity 90%; sensitivity 81%), SAH (specificity 98%; sensitivity 92%-98%), and ICH (specificity 96%; sensitivity 85%).[17–22] Vascular risk factors included diabetes, hypertension, hypercholesterolemia, smoking history, and atrial fibrillation or flutter. ICD-9 codes for the aforementioned vascular risk factors have been evaluated in other studies and have been deemed specific (>0.95) but not sensitive (.25-.75).[23,24]

Alcohol-related encounters were defined as a hospitalization or ED visit with an alcohol drinking, abuse, or dependency code in the primary diagnosis position. The utility of ICD-9 codes to identify current diagnoses of alcohol drinking, abuse, and dependence has been previously studied and shown to be highly specific (96.9%) but not as sensitive (68.2%), with a positive predictive value of 87.4%.[25] Characteristics of the index hospitalizations were defined by HCUP and included insurance payer (Medicare, Medicaid, private insurance, self-pay, no charge, other) and discharge status (routine, transfer to short-term hospital, transfer to other facility, home health care, against medical advice, and unknown).

Statistical Analysis

We calculated demographics and comorbidities during index admission for each index event (MI, VTE, AIS, ICH, and SAH). We calculated means and standard deviations for continuous variables and frequencies and percentages for categorical variables.

To assess whether exposure to an alcohol-related encounter was associated with the occurrence of MI, VTE, AIS, ICH, and SAH, we performed a case-crossover analysis for each index event in separate models. The case

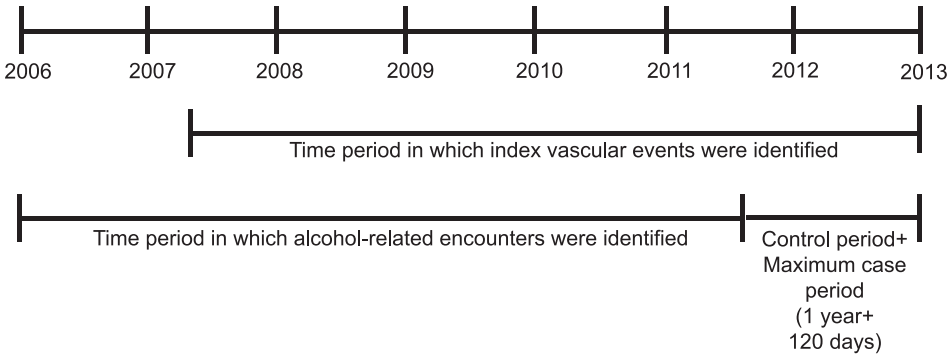

Figure 1. *Timeline of the identification of index vascular events and alcohol-related events.*

period refers to the period leading up to the index vascular event during which an alcohol-related event may have occurred. The control period refers to the period of time exactly 1 year before the case period plus the duration of the case period. The case-crossover analysis only includes data on cases, and each individual serves as his or her own control, obviating the need to adjust for confounders. This case-crossover analysis tested whether alcohol-related events within progressively longer case periods (7, 14, 30, 60, 90, and 120 days before index admission), compared to control periods exactly 1 year before the case period, was associated with the occurrence of the index event (Fig 2). We used conditional logistical regression models to estimate odds ratios and 95% confidence intervals for associations.

Next, we tested whether recent alcohol-related encounters were associated with worse outcomes following the index event. We ran unadjusted and adjusted logistic regression models testing associations between exposure to an alcohol-related encounter within 6 months before index admission and 30-day all-cause readmission after discharge from the index event. We ran separate models for each index event, and models were adjusted for age, sex, atrial fibrillation or flutter, diabetes, hypertension, hypercholesterolemia, and smoking. Analyses were performed in SAS version 9.4.

Results

203848 MI, 134173 VTE, 152356 AIS, 27257 ICH, and 11853 SAH index admissions were identified. The demographics, medical co-morbidities and hospitalization characteristics of these index admissions are described in Table 1. The mean ages at index admission were 68.48, 62.33, 71.74, 89.62, and 58.98 years for MI, VTE, AIS, ICH, and SAH, respectively. The percentage of those with alcoholism at index admission was highest for ICH (2.3%) and lowest for VTE (.89%). The prevalence of diabetes was highest for MI (33.87%) and lowest for SAH (13.39%). Hypertension was equally prevalent among all 5 conditions. High cholesterol was more common at index admission for MI (50.8%) and ICH (44.03%) compared to VTE (24.05%), ICH (28.21%), and SAH (18.28%). Routine discharges were more common after index admission for VTE (62.62%) than for MI (47.55%), AIS (32.66%), SAH (28.72%), and ICH (16.56%).

Results of the case-crossover conditional logistic regression models are displayed in Table 2. An alcohol-related encounter within 30, 60, 90, and 120 days before index admission was significantly associated with a higher risk for MI (with a declining magnitude of the OR with longer time windows: 1.463, 1.483, 1.400, and 1.298, respectively). There were significant associations between an alcohol-related encounter within 7, 14, 30, 60, 90, and 120 days of index admission and increased risk of VTE (with a declining magnitude of the OR with longer time windows: 2.364, 2.611, 2.738, 2.102, 1.977, and 1.79, respectively). An alcohol-related encounter within 30, 60, and 120 days before index admission was significantly associated with a higher risk for AIS (with OR of 1.765, 1.418, and 1.287, respectively, also declining with longer time windows). An alcohol-related encounter within 90 days of index admission was significantly associated with increased risk of SAH (OR 2.375). Alcohol-related encounters were not associated with ICH.

Univariate and multivariate logistic regression models testing the associations between alcohol-related encounters and 30-day readmission after index events are shown in Table 3. In both univariate and multivariate models, an alcohol-related encounter within 6 months before index admissions for MI, VTE, AIS, ICH, and SAH was significantly associated with a higher likelihood of all-cause 30-day readmission (Table 3). Compared to MI, AIS, and ICH, there was a higher magnitude of effect of

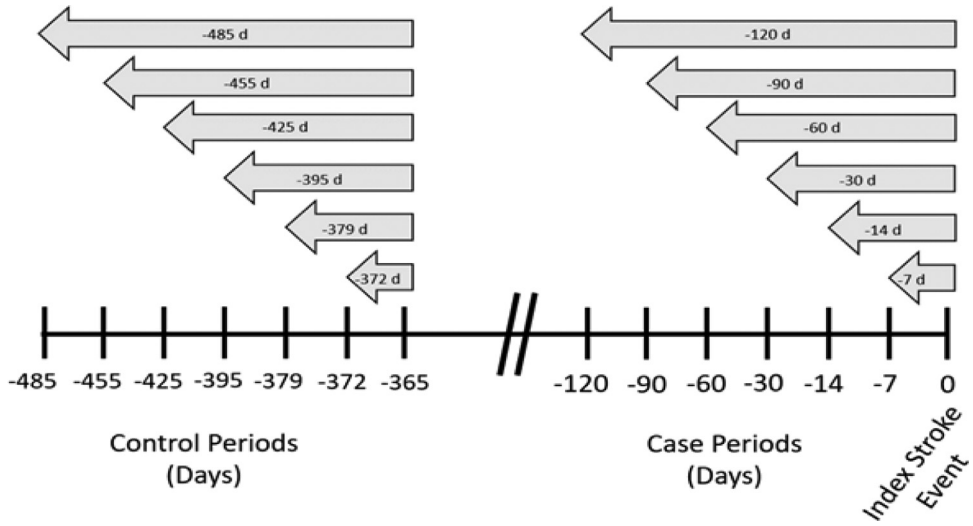

Figure 2. *Conceptual depiction of a case-crossover design.*

Table 1. *Characteristics during hospitalization for index event*

	Index event				
Variable	MI	VTE	AIS	ICH	SAH
*Frequency (%)**					
Total number of index admissions	203848	134173	152356	27257	11853
Demographics					
Age, years, mean (SD)	68.48 (14.90)	62.33 (18.20)	71.74 (14.79)	69.62 (15.72)	58.98 (16.52)
Female	83647 (41.03)	74639 (55.63)	81026 (53.18)	13569 (49.78)	7274 (61.37)
Race:					
White	139090 (68.72)	87110 (65.24)	93950 (61.98)	16176 (59.71)	6671 (56.65)
Black	21197 (10.47)	24388 (18.27)	28042 (18.50)	4758 (17.56)	1848 (15.69)
Hispanic	17252 (8.52)	11598 (8.69)	13427 (8.86)	2504 (9.24)	1322 (11.23)
Asian or Pacific Islander	5534 (2.73)	2016 (1.51)	4803 (3.17)	1273 (4.70)	533 (4.53)
Native American	1016 (.50)	462 (.35)	699 (.46)	144 (.53)	62 (.53)
Other	18322 (9.05)	7948 (5.95)	10672 (7.04)	2238 (8.26)	1339 (11.37)
Medical comorbidities					
Alcoholism	2319 (1.14)	1196 (.89)	2272 (1.49)	627 (2.3)	203 (1.71)
Smoking	62137 (30.48)	22419 (16.71)	29354 (19.27)	3484 (12.78)	2441 (20.59)
Depression	13090 (6.42)	11464 (8.54)	12453 (8.17)	1775 (6.51)	677 (5.71)
Diabetes	69043 (33.87)	24391 (18.18)	50593 (33.21)	6839 (25.09)	1587 (13.39)
Hypertension	109034 (53.49)	55304 (41.22)	100697 (66.09)	17726 (65.03)	5829 (49.18)
High cholesterol	103551 (50.8)	32265 (24.05)	67076 (44.03)	7688 (28.21)	2167 (18.28)
Atrial fibrillation	35407 (17.37)	10919 (8.14)	36887 (24.21)	5121 (18.79)	869 (7.33)
Hospitalization characteristics					
Length of stay, mean (SD)	5.35 (7.40)	4.85 (6.05)	6.59 (8.94)	8.92 (13.97)	11.03 (14.59)
Discharge disposition:					
Routine	96933 (47.55)	85346 (63.62)	49755 (32.66)	4514 (16.56)	3404 (28.72)
Short-term hospital	35213 (17.27)	2353 (1.75)	8012 (5.26)	3172 (11.64)	2364 (19.95)
Other facility	26669 (13.08)	17808 (13.27)	62352 (40.93)	10546 (38.69)	2974 (25.09)
Home health care	29298 (14.37)	24011 (17.90)	20781 (13.64)	2054 (7.54)	898 (7.58)
Against medical advice	2621 (1.29)	1771 (1.32)	2289 (1.50)	168 (.62)	64 (.54)
Died	13096 (6.42)	2863 (2.13)	9157 (6.01)	6799 (24.95)	2147 (18.12)
Insurance, primary payer:					
Medicare	116257 (57.03)	63514 (47.35)	99439 (65.27)	16407 (60.19)	3935 (33.2)
Medicaid	20904 (10.26)	16260 (12.12)	15835 (10.39)	3410 (12.51)	2135 (18.01)
Private insurance	53789 (26.39)	45569 (33.97)	29242 (19.19)	5596 (20.53)	4511 (38.06)
Self-pay	9122 (4.48)	5657 (4.22)	5528 (3.63)	1336 (4.90)	942 (7.95)
No charge	235 (.12)	118 (.09)	105 (.07)	11 (.04)	11 (.09)
Other	3535 (1.73)	3031 (2.26)	2202 (1.45)	497 (1.82)	319 (2.69)

Abbreviations: AIS, acute ischemic stroke; ICH, intracerebral hemorrhage; MI, myocardial infarction; SAH, subarachnoid hemorrhage; SD, standard deviation; VTE, venous thromboembolism.

*Unless otherwise noted.

an alcohol-related encounter within 6 months of index admission on 30-day readmission after VTE and SAH (multivariate OR 4.144 versus multivariate OR 3.963, respectively).

Discussion

This study demonstrated that a recent alcohol-related ED visit or hospitalization was significantly associated with both thrombotic and hemorrhagic events—including MI, VTE, AIS, ICH, and SAH—as well as increased 30-day readmission rates after these events. VTE had the strongest overall association with an alcohol-related event 7, 14, 30, 60, and 120 days prior to index admission, with a greater than twofold risk of VTE within 60 days of an alcohol-related encounter. The risk of SAH was highest following an alcohol-related encounter 90 days prior to index admission. ICH was not associated with a prior alcohol-related encounter during any time period. The risk was highest for AIS and VTE within 30 days of an alcohol-related encounter, and highest within 14 days for MI. Furthermore, the risk declined with longer time periods preceding the index events, supporting the view that alcohol-related encounters may trigger these events. In an adjusted model, the odds of readmission after index admission for those with at least 1 alcohol-related encounter within the 6 months prior were highest for VTE and lowest for ICH, showing not only a possible effect of an

Table 2. *Case-crossover analysis: conditional logistic regression results for association between alcohol-related encounters and index events*

Exposure to alcohol-related encounter in case vs control periods	OR	95% CI	*P* value	# Exposed in case period	# Exposed in control period
Index event: myocardial infarction					
7 vs 365-372d before index admission	.920	.522-1.621	.7729	25	27
14 vs 365-379d before index admission	1.531	0.981-2.391	.0608	54	37
30 vs 365-395d before index admission	1.463	1.035-2.068	.0312	90	65
60 vs 365-425d before index admission	1.483	1.134-1.941	.0041	157	114
90 vs 365-455d before index admission	1.400	1.096-1.788	.007	199	155
120 vs 365-485d before index admission	1.298	1.039-1.621	.0215	238	197
Index event: venous thromboembolism					
7 vs 365-372d before index admission	2.364	1.436-3.891	.0007	53	23
14 vs 365-379d before index admission	2.611	1.778-3.834	<.0001	97	39
30 vs 365-395d before index admission	2.738	2.042-3.671	<.0001	179	73
60 vs 365-425d before index admission	2.102	1.671-2.643	<.0001	263	144
90 vs 365-455d before index admission	1.977	1.605-2.436	<.0001	322	192
120 vs 365-485d before index admission	1.790	1.476-2.172	<.0001	369	242
Index event: ischemic stroke					
7 vs 365-372d before index admission	1.077	0.506-2.291	.8474	15	14
14 vs 365-379d before index admission	1.091	0.612-1.946	.7682	27	25
30 vs 365-395d before index admission	1.765	1.159-2.688	.0081	69	43
60 vs 365-425d before index admission	1.418	1.037-1.938	.0286	111	83
90 vs 365-455d before index admission	1.280	0.976-1.678	.0749	142	116
120 vs 365-485d before index admission	1.287	1.001-1.655	.0492	173	142
Index event: intracerebral hemorrhage					
7 vs 365-372d before index admission	2.333	.603- 9.023	.2195	<10	<10
14 vs 365-379d before index admission	2.00	.751- 5.329	.1657	13	<10
30 vs 365-395d before index admission	1.583	.769- 3.262	.2127	20	13
60 vs 365-425d before index admission	1.400	.789- 2.485	.2504	32	24
90 vs 365-455d before index admission	1.286	.785- 2.107	.3186	42	34
120 vs 365-485d before index admission	1.314	.847- 2.04	.2231	53	42
Index event: subarachnoid hemorrhage					
7 vs 365-372d before index admission	5.00	.584- 42.79	.1418	<10	<10
14 vs 365-379d before index admission	5.00	.584- 42.79	.1418	<10	<10
30 vs 365-395d before index admission	1.600	.523- 4.891	.4097	10	<10
60 vs 365-425d before index admission	1.778	.786- 4.023	.1673	19	12
90 vs 365-455d before index admission	2.375	1.04- 5.455	.0401	26	15
120 vs 365-485d before index admission	1.462	.722- 2.959	.2917	27	21

alcohol-related encounter on the occurrence of thrombotic and hemorrhagic events, but also poorer outcomes after these events overall.

Previous work has also suggested an association between recent heavy alcohol use and MI and AIS. In a prior case-crossover analysis among 3869 participants, risk of MI was higher in the hour following alcohol consumption.[13] However, alcohol intake was self-reported, introducing recall bias into the study. Also, this study used a significantly smaller sample size and older data (years of 1989-1996) than the current study. Finally, this study examined the time period of one hour prior to MI, while our study examined several time periods to evaluate for a decrement of risk with longer time windows. Another case-crossover analysis by the same group analyzed interviews with 390 AIS patients about alcohol consumption in the hour prior to their stroke onset.[12] There was a higher risk of stroke in the hour after consuming alcohol. ICH and SAH patients were not included in this study. Similarly, a hospital-based observational cross-sectional study demonstrated that alcohol use 1 week prior to index admission triggered stroke onset.[14] A meta-analysis examining alcohol and immediate risk of cardiovascular events, including MI, ischemic stroke, and hemorrhagic stroke, concluded that there was a higher risk for the aforementioned cardiovascular events immediately following alcohol consumption, but beyond 24 hours prior to the event, only heavy alcohol intake continued to increase risk.[11] The current study also supports an association between increased risk of MI and stroke and recent heavy alcohol use, although the risk periods in this study were at least 1 week prior to index admission for the cardiovascular event. These results suggest that the time window in which an alcohol-related encounter may trigger

Table 3. *Unadjusted and adjusted logistic regression models testing associations between alcohol-related encounters and 30-day readmission after index events*

	Outcome: all-cause 30-day readmission					
	Univariate model			Fully adjusted model*		
Main predictor: alcohol-related encounter in 6 months prior to the following index admissions	OR	95% CI	*P* value	OR	95% CI	*P* value
Myocardial infarction	2.421	1.852-3.166	<.0001	2.506	1.915-3.281	<.0001
Venous thromboembolism	4.833	3.922-5.956	<.0001	4.144	3.357-5.115	<.0001
Ischemic stroke	2.606	1.811-3.75	<.0001	2.542	1.765-3.662	<.0001
Intracerebral hemorrhage	2.499	1.277-4.887	.0075	2.348	1.196-4.609	.0131
Subarachnoid hemorrhage	4.044	1.875-8.723	.0004	3.963	1.827-8.596	.0005

*Adjusted for: age, sex, atrial fibrillation/flutter, diabetes, hypertension, hypercholesterolemia, smoking.

thrombotic and hemorrhagic events may be longer than previously thought.

Few studies have explored alcohol as a trigger for SAH or ICH. A prospective cohort study of 15965 Finnish men and women who were followed up for a 10-year period showed that a binge-drinking habit was associated with a higher risk of hemorrhagic stroke (HR = 1.5).[26] While our study did not find any association between alcohol-related encounters and ICH within any of the exposure periods, we found that an alcohol-related encounter within 6 months of ICH index admission increased the likelihood of 30-day readmission to the hospital. Similarly suggestive of worse outcomes after ICH and alcohol use, a 2012 prospective cohort study of 540 patients with ICH showed that heavy alcohol intake was predictive of 2 year mortality among ICH patients under 60.[27] While our group found that risk of SAH was increased within 90 days of an alcohol-related encounter, another case-crossover analysis showed that there was no association between SAH and heavy alcohol intake 26 hours prior to index admission, but only 8 patients had consumed alcohol during the defined risk period.[28] The current study explores this relationship across longer time periods of exposure and with a much larger sample size.

Research on alcohol as a trigger for VTE is conflicting. A recent retrospective analysis, using a large national database with a sample size of over 2 million patients, showed that trauma patients with a positive blood alcohol content had a lower rate of VTE compared to those with a negative blood alcohol content.[29] In contrast, our results suggest a strong positive association between VTE risk and recent alcohol-related encounters at least 1 week prior to index admission. Our findings are more consistent with a prospective study of almost 27,000 subjects showing that heavy alcohol intake was associated with increased risk of VTE compared to abstainers, although this group did not examine the risk of alcohol intake across different time period preceding VTE, not the outcomes after VTE.[30]

Many potential physiological mechanisms could explain why alcohol may trigger cardiovascular events. The exact mechanisms triggering hemorrhagic events are expected to differ from those that trigger ischemic infarction, but both may stem from liver dysfunction. Chronic liver disease resulting from long-term heavy alcohol consumption causes a balanced reduction in procoagulant and anticoagulant factors, predisposing to both hemorrhage and thrombosis depending on the prevailing concomitant risk factors.[31] That being said, in our study, alcohol-related encounters had a stronger relationship with thrombotic events than with hemorrhagic events, so perhaps alcohol tips this scale more so in the direction of thrombosis. Virchow's triad—stasis, hypercoagulability, and endothelial dysfunction—is known to lead to thrombosis.[32] Alcohol is thought to impair endothelial function by interfering with production and release of nitric oxide from endothelial cells and inducing the proapoptotic caspase pathway.[33,34] Heavy alcohol intake is associated with increased levels of fibrinogen, von Willebrand factor, and factor VII, as well as platelet hyperaggregability.[35,36] Furthermore, alcohol increases inflammation via direct metabolic effects as well as activation of Kupffer cells, which in turn activates coagulation.[37,38] On the other hand, alcohol consumption could also precipitate hemorrhagic events due to the relationship between heavy alcohol intake and arterial hypertension, as well as chronic liver disease, which causes thrombocytopenia, low levels of coagulation factors, and elevated levels of tissue plasminogen activator.[31,39,40]

There are several explanations for the increased readmission rates after index admission for MI, VTE, AIS, ICH, and SAH following alcohol-related encounters. First, increasing alcohol consumption has been shown to increase mortality from many diseases, including hypertensive heart disease, and hemorrhagic and ischemic stroke.[41] Second, conditions that are often comorbid with alcohol abuse, such as liver disease, could result in worse outcomes. Third, although only a small percentage of the patient population carried a formal diagnosis of alcoholism, alcohol use disorders have been shown to negatively affect self-care

adherence for chronic diseases, which in turn leads to increased morbidity and mortality.[42,43]

To our knowledge, no prior study has collectively examined the risk of and outcomes after MI, VTE, AIS, ICH and SAH with regard to prior alcohol-related encounters. The strengths of this study include a large sample size, long follow-up period, and longer time periods of exposure compared to other studies. Reliance on previously validated ICD-9 codes to identify all ED and inpatient encounters in a large database eliminated recall bias, but precluded garnering more information about the amount or type of alcohol consumed outside the hospital resulting in an alcohol-related encounter, or whether alcohol was consumed between the alcohol-related encounter and the index admission for a vascular event. Also, the severity of the alcohol-related encounters and MI, VTE, AIS, SAH, and ICH could not be assessed in this study. Furthermore, people who drink alcohol but were not admitted to the hospital as a result were unable to be captured in this study.

In summary, we demonstrated an association between increased risk of MI, VTE, AIS, and SAH and a recent alcohol-related hospitalization or ED visit. The magnitude of this risk increased as exposure periods decreased, suggesting that alcohol may trigger these events. Furthermore, our data suggest worse outcomes after MI, VTE, AIS, SAH, and ICH among those with recent alcohol-related encounters. Recognizing that patients with a history of alcohol use are at higher risk for vascular events has implications for clinical practice.[1] Further study is required to better understand mechanisms of increased risk for ischemic and hemorrhagic events following heavy alcohol consumption, which may inform targeted interventions.

Funding

None.

Conflict of Interest

None.

Supplementary materials

Supplementary material associated with this article can be found in the online version at doi:10.1016/j.jstrokecerebrovasdis.2019.104395.

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