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IMAGING OF FREQUENT EMERGENCY DEPARTMENT USERS WITH ALCOHOL USE DISORDERS

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Abstract

Background—Patients with altered level of consciousness secondary to alcohol use disorders (AUDs) often undergo imaging in the emergency department (ED), although the frequency and yield of this practice over time are unknown.

Study Objectives—We describe the use of imaging, the associated ionizing radiation exposure, cumulative costs, and identified acute and chronic injuries and abnormalities among frequent users of the ED with AUDs.

Methods—This is a retrospective case series of individuals identified through an administrative database having 10 or more annual ED visits in 2 consecutive years who were prospectively followed for a third year. International Classification of Diseases, 9th Revision, Clinical Modification and Current Procedural Terminology codes were used to select individuals with alcohol-related diagnoses, track imaging procedures, and calculate cost. Diagnoses, imaging results, and radiation exposure per computed tomography (CT) study were abstracted from the medical record.

Results—Fifty-one individuals met inclusion criteria and had a total of 1648 imaging studies over the 3-year period. Subjects had a median of 5 (interquartile range [IQR] 2–10) CT scans, 20 (IQR 10–33) radiographs, 28.3 mSv (IQR 8.97–61.71) ionizing radiation, 0.2% (IQR 0.07–0.4) attributable risk of cancer, and $2979 (IQR 1560–5440) in charges using a national rate. The incidence of acute fracture or intracranial head injury was 55%, and 39% of the cohort had a history of moderate or severe traumatic brain injury.

Conclusion—The remarkable use of imaging and occurrence of injury among these highly vulnerable and frequently encountered individuals compels further study to refine clinical practices through the development of evidence-based, effective interventions.

Keywords

imaging; alcohol use disorders; frequent users; trauma; overcrowding

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INTRODUCTION

The presence of alcohol intoxication in patients presenting to the emergency department (ED) can limit the quality of the medical history and physical examination, thereby hindering their ability to guide the need for imaging and other diagnostic studies (1–3). As a result, physicians in the ED may be more liberal with the use of computed tomography (CT) imaging in patients with diminished levels of awareness, behavioral disturbances, or with evidence of injury – particularly when a description of the mechanism is unobtainable secondary to an alcohol-induced altered level of consciousness (4).

The rising use of CT imaging for medical evaluation has generated concern about the consequences of exposure to ionizing radiation, suggesting the need to study prevalence among groups at risk for repeated exposure (5). One such group includes frequent users of the ED with alcohol use disorders (AUDs), who, although managed on a daily basis in busy EDs across the globe, are not well represented in the literature (6). ED staff can eventually become inured to these frequent presentations and subsequently reassured by seeing the same individuals reliably metabolize their alcohol, wake up, and walk out. Familiarity may engender comfort in treating these patients, but in a population at such a high risk of morbidity and mortality, evidence-based practice is needed (7,8).

As part of a multifaceted initiative to develop and test effective interventions targeting frequent utilizers of the ED with severe AUDs, we have begun to characterize the most extreme subset found at our institution (9,10). In this current retrospective case series, we perform a descriptive analysis to quantify the use of CT imaging, the associated ionizing radiation exposure, lifetime attributable risk (LAR) of cancer, and cost. We also report the abnormalities identified in the imaging of the head and the prevalence of traumatic brain injury (TBI), cerebrovascular accident (CVA), and seizure disorders among the cohort.

MATERIALS AND METHODS

Bellevue Hospital is an urban public academic hospital and Level I trauma center that has a volume of approximately 120,000 annual ED visits. The study was approved via expedited review, with a waiver of consent by the Institutional Review Board at the New York University School of Medicine and the New York City Health and Hospitals Corporation.

This retrospective cohort was identified using the Bellevue Hospital administrative database of billing records. Patients with frequent use of the ED and who had been assigned an alcohol-related International Classification of Diseases, Ninth Revision (ICD-9-CM) diagnostic code at any visit were selected (ICD-9-CM codes, Appendix 1). Inclusion criteria required patients to have a minimum of 10 ED visits annually for 2 consecutive years beginning April 2008. These individuals were then followed prospectively for a third year. No exclusion criteria were adopted.

The imaging procedures performed for the 3-year period (April 2008–March 2011) in the ED and inpatient setting were identified by Current Procedural Terminology (CPT) codes. CT, magnetic resonance (MR), and plain radiograph imaging were included in the analysis; nuclear medicine studies, fluoroscopy, mammography, and angiography were not included.

The billing database records were verified by cross-referencing the CT procedures listed in the database with the Picture Archiving and Communication System and generated reports (for CT and MR only).

Two study members (AS, BH) trained in chart abstraction by the study principal investigator independently reviewed the electronic medical record during this 3-year period to identify sociodemographic characteristics and diagnoses of interest: AUD, moderate to severe TBI (included only if a clearly documented event or injury was reported to have occurred prior to or during the study period), CVA, seizure disorder, or other significant central nervous system pathology. The completed electronic abstraction sheets were compared for discrepancies by the study principal investigator (RPM), who also conducted a full chart review.

Radiation exposure was calculated using the actual radiation received by each patient per procedure for CT images. The GT Lightspeed VCT 64-slice machine (GE Corp., Milwaukee, WI) used for all CTs records the actual radiation delivered in the form of dose-length product (DLP). Published estimates were used to calculate the exposure received via plain radiograph and were imputed for CT scans in which the actual dose was not recorded (11).

Conversion of the DLP into an estimated effective dose, E, was based on the formula $E = k \times DLP$ (12). The coefficient value k is dependent on the anatomical region imaged, and areas protocoled together to yield a reduced radiation exposure were accounted for (13). Organ-specific dosing was not calculated.

The LAR of cancer incidence per 100,000 people was derived using conversion factors adjusted for the mean age and male predominance of the cohort. This outcome was calculated using the risk for “all cancers” listed in Table 12D-1 in the BEIR VII report (14). Subsequent data processing, including aggregate dosing levels and LAR by patient and by study, were grouped using Microsoft Excel (Microsoft Corporation, Redmond, WA).

The imaging charges were calculated using the 2009 Centers for Medicare & Medicaid fee schedule based on CPT codes. We assigned both the national and regionally (New York) adjusted values for procedures.

RESULTS

Fifty-one patients met the inclusion criteria. The mean age was 49 years (SD 10.4), with one subject over the age of 65 years. The cohort was composed predominantly of publically insured males with a history of homelessness or precarious housing during the study period (Table 1). At least 14 of the 51 individuals have since died, including 8 during the 3-year period of analysis. None had CT imaging at Bellevue Hospital on their terminal visit. The cause of death was accidental in 8 and the remaining natural deaths were largely attributed to alcoholism.

A total of 1648 imaging studies were obtained over the 3-year period, of which 72% were plain radiographs. Forty-six of the 51 patients (90%) had CT scans; the median number of

CT procedures per patient was five (interquartile range [IQR] 2–10) (Table 2). A total of four MRIs were conducted. All patients had plain radiographs; the median number of radiographs per patient was 20 (IQR 10–33). The anatomical distribution of studies was predominantly of the head and neck region for CT imaging (84%) and of the chest and extremities for radiographs (66% and 30%, respectively) (Table 2).

The 3-year incidence of acute intracranial hemorrhage (ICH), CVA, or fractures of the face or skull among our cohort during the 3-year period was 55% overall, and 90% and 73% among those with a history of TBI and a seizure disorder, respectively (Table 3). One quarter of all the patients in the cohort had a new ICH over the same time period. Of the total number of head CT scans performed, 3% were positive for acute ICH, and 6.6% were positive for acute fracture with or without ICH.

The median cumulative radiation dose per patient during the 3-year period was 28.3 mSv (IQR 8.97–61.71). The LAR of cancer for the patient with the greatest exposure to ionizing radiation, totaling 144.85 mSv, is 0.89% (898.09 per 100,000) (Table 3). CT scans comprised 22% of the total procedures, but accounted for 92.9% of the radiation exposure. The actual DLP was missing for 34 studies (9%). When adjusted for adjacent anatomical areas scanned together in a single protocol, the number of CT scans reported in the billing database and actual imaging procedures performed were accurately matched.

The imaging-associated charges for the 51 patients in the cohort during the 3-year period totaled $192,999 using the Centers for Medicare & Medicaid Services national fee schedule, and $241,710 including the regional fee adjustment (Table 2). The overall direct hospital billable services for this cohort during the study period, calculated using the New York State Department of Health Institutional Cost Report fee schedule was estimated to be in excess of $75,000 per subject per year (10).

DISCUSSION

The descriptive statistics derived from this case series confirm that individuals with extremely frequent uses of the ED with alcohol use disorders undergo a significant number of CT and plain radiograph imaging procedures. It is estimated that this cohort was transported to other EDs for approximately 50% of their Emergency Medical Services (EMS) encounters (10). If clinical practices at these hospitals are similar, our data would likely underestimate the number of studies performed and associated radiation exposure and cost by half. Observational studies of similar populations presenting to other institutions have demonstrated considerably higher rates of CT use, which further supports our assertion that our study underestimates the actual volume of imaging per patient (15,16).

Although the retrospective design of our study does not allow us to make direct conclusions about the decisions involved in ordering imaging studies, the yield of acute radiologic findings is considerably higher than the aforementioned observational studies and comparable to large-scale trials that have prospectively applied the Canadian CT Head Rule and the New Orleans Criteria in cases of minor head trauma (3,17). This may suggest that our clinicians may have adopted a practice of observing these patients in lieu of early imaging. The anatomic predominance of CTs involving the head was expected given the concern for acute intracranial pathology among individuals who present intoxicated with an altered level of consciousness and heightened risk for trauma.

The median exposure in this group of patients, 9.43 mSv/year, is approximately 100 times the median value of 0.1 mSv found in a population-based study of roughly one million nonelderly adults in the United States (18). Using the classification system introduced in that study, the stratification of annual radiation exposure for our cohort was 25.5% low (≤3 mSv), 47.0% moderate (>3 to 20 mSv), and 27.5% had high to very high exposure (>20 mSv). This distribution contrasts significantly with that of the larger population study, which was 78.6%, 19.4%, and 2.1%, respectively. Furthermore, 37% of the radiation exposure in that study came from nuclear (e.g., cardiac stress testing) and other forms of imaging procedures not included in our analysis.

The expense and resource utilization related to imaging must be weighed against less tangible costs and resources that may be required by efforts to minimize its use. More rigorous patient observation in lieu of early CT imaging may increase length of stay, require additional personnel, and increase the risk and consequences of delayed diagnoses. Information sharing among institutions in similar EMS catchment areas could improve knowledge of the health profiles of these individuals who are so often unable to provide histories and could potentially improve coordination of care. A robust analysis of costs and outcomes comparing differing practice algorithms is necessary to determine the cost efficiency and cost effectiveness of approaches.

Limitations

The limitations of this study include the size of the cohort and the retrospective collection of data that was restricted to a single site. The retrospective design did not allow us to determine the appropriateness of the imaging procedures; indications and outcomes were not assessed. Additionally, the incidence of acute injury among subgroups with TBI and a seizure disorder is confounded by the fact that this diagnosis could have been established by events occurring during the study period.

Calculating effective dose using the DLP of each imaging study is acknowledged to produce only an estimate of actual radiation exposure, although the approximation of doses found in this case series with values previously published supports the use of this method in future studies. Similarly, the mechanism of deriving the LAR of developing cancer from ionizing radiation remains inexact. Available data used for these calculations have been extrapolated largely from single acute exposures, including nuclear catastrophes (14). A recent cohort study of pediatric patients followed longitudinally demonstrated a correlation between cumulative imaging-associated radiation dosage and the subsequent development of malignancy (5). However, in light of the high morbidity and mortality of this current study’s population secondary to acute structural injury to brain, spine, chest, or abdomen, the radiation-attributable risk seems far less consequential.

A prospective, multicenter study with independent assessment of appropriateness and tracking of outcomes could potentially provide further information to guide clinical practice of this population that is typically excluded from research protocols and clinical algorithms. It would support a comprehensive estimate of procedural prevalence, address the redundancy of imaging studies, and help identify site-specific practice differences. These data could potentially demonstrate the degree to which timely interhospital communication might reduce duplication of studies and the associated radiation exposure, cost, and other resource utilization. Furthermore, after adjusting for confounders, a secondary data analysis could show how sociodemographic characteristics, comorbid conditions, timing of procedures, and other variables, including study site differences, affect utilization and outcomes.

CONCLUSION

This case series confirms that this cohort of 51 patients with AUDs and persistent, frequent presentations to an urban municipal ED received a significant number of imaging procedures and had a high incidence and prevalence of acute fractures or intracranial injuries. Our data underestimate the radiation exposure and procedure-associated costs given the frequency with which this cohort visits multiple EDs. These findings help define this complex, high-risk, and high-cost population for whom little evidence-based practice exists, and reinforce the need for development of evidence-based, effective interventions.

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APPENDIX 1: ICD-9 CODES RELATED TO ALCOHOL USE

ICD-9 Code	ICD-9 Description
291.	Alcoholic Psychoses
291.0	Alcohol Withdrawal Delirium
291.1	Alcohol Amnestic Syndrome
291.2	Other Alcoholic Dementia
291.3	Alcohol Withdrawal Hallucinosis
291.4	Idiosyncratic Alcohol Intoxication
291.5	Alcoholic Jealousy
291.81	Alcohol Withdrawal Psychosis
291.89	Other Specified Alcohol Psychosis, not Elsewhere Classified
291.9	Unspecified Alcoholic Psychosis
292.	Drug Psychoses
303.	Alcohol Dependence Syndrome
303.0	Acute Alcoholic Intoxication
303.00	Acute Alcoholic Intoxication in Alcoholism, Unspecified Use
303.01	Acute Alcoholic Intoxication in Alcoholism, Continuous Use
303.02	Acute Alcoholic Intoxication in Alcoholism, Episodic Use
303.03	Acute Alcoholic Intoxication in Alcoholism, in Remission
303.9	Other and Unspecified Alcohol Dependence
303.90	Other and Unspecified Alcohol Dependence, Unspecified Use

ICD-9 Code	ICD-9 Description
303.91	Other and Unspecified Alcohol Dependence, Continuous Use
303.92	Other and Unspecified Alcohol Dependence, Episodic Use
303.93	Other and Unspecified Alcohol Dependence, in Remission
305.	Nondependent Abuse of Drugs
305.0	Alcohol Abuse
305.00	Alcohol Abuse, Unspecified Drinking Behavior
305.01	Alcohol Abuse, Continuous Drinking Behavior
305.02	Alcohol Abuse, Episodic Drinking Behavior
305.03	Alcohol Abuse, in Remission

ICD-9 = International Classification of Diseases, Ninth Revision.

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ARTICLE SUMMARY

1. Why is this topic important?

Patients with frequent emergency department (ED) use related to alcohol are at high risk and often undergo medical imaging, yet the extent of their risk and the results of these tests are not well described.

2. What does this study attempt to show?

We studied the use of imaging, the associated cost and radiation exposure, and injuries discovered among the most frequent ED users with alcohol use disorders.

3. What are the key findings?

Our findings indicate that these patients do undergo a significant number of imaging tests, and have high incidence of acute injury.

4. How is patient care impacted?

This information may help guide the practice of emergency physicians who encounter these patients on a regular basis.

Table 1

Patient Demographics, Comorbidities, and Mortality

Characteristic	Subjects, n = 51
Age, mean (SD)	49.1 (10.4)
Gender, male (%)	45 (88.2)
Alcohol use disorder, severe (%)	51 (100)
History of homelessness (%)	48 (94.1)
Insurance (%)	49 (96.1)
Medicaid or Medicare (%)	49 (96.1)
No insurance (%)	2 (3.9)
History of seizure disorder (%)	33 (64.7)
History of traumatic brain injury (%)	20 (39.2)
History of cerebrovascular accident (%)	3 (5.8)
Parkinsonism or cerebral palsy (%)	3 (5.8)
Number of ED visits, median over 3 years (IQR)	53 (42–84)
Number of inpatient days, median over 3 years (IQR)	50 (23–94)
Mortality through April 2012 (%)	14/51 (27.4)

SD = standard deviation; ED = emergency department; IQR = interquartile range.

Table 2

Distribution of Patient Studies by Ionizing Radiation Calculations and Anatomic Region Over 3 Years

Study Characteristics	CT n (%)	X-ray Study n (%)	Coefficient k	Effective Dose per Study (mSv, Calculated) (IQR)
Total studies	432 (26.2)	1216 (73.8)		
Total radiation	1771.5 (92.9)	136.2 (7.1)		
Anatomic region (number of studies)				
Head ± face	300 (69.4)	0	0.0021	2.44 (0.38)
C-spine	64 (14.8)	0	0.0059	4.07 (3.9)
Chest	30 (6.9)	804 (66.1)	0.014	7.55 (8.0)
Abdomen/pelvis	38 (8.8)	18 (1.5)	0.015	14.55 (7.9)
Extremity	0	361 (29.7)	n/a	
Other	0	33 (2.7)	n/a	

CT = computed tomography; IQR = interquartile range.

Table 3

Imaging, Ionizing Radiation Exposure, Cost, and Head CT Abnormalities Among All Subjects, Those Diagnosed with Moderate to Severe TBI, and Those with a History of Seizure Disorders

Characteristic	All Subjects n = 51	History of TBI n = 20	History of Seizure Disorder n = 33
CT, median (IQR)	5 (2–10)	12 (4.25–17.5)	6 (2.5–13.5)
X-ray, median (IQR)	20 (10–34)	20.5 (15.5–37.25)	22 (12.5–37.5)
Radiation, mSv (IQR)	38.2 (10.9–77.0)	62.7 (38.8–77.5)	44.0 (17.1–74.6)
Lifetime attributable risk, per 100K (IQR)	201 (68–448)	389 (240–481)	272.7 (105.8–462.7)
Cost – National, in dollars (IQR)	2979 (1560–5440)	5464 (3029–7938)	4064 (1786–7353)
Cost – New York State, in dollars (IQR)	3746 (1951–6803)	6838 (3799–9944)	5077 (2238–9212)
Deceased (%)	11 (21.6)	9 (45.0)	10 (30.3)
New intracranial injury (%)	13 (25.5)	10 (50.0)	12 (36.4)
New intracranial injury or fracture (%)	28 (54.9)	18 (90.0)	24 (72.7)
Focal encephalomalacia (%)	23 (45.1)	15 (75.0)	18 (54.5)
Microvascular disease (%)	28 (54.9)	11 (66.7)	22 (66.7)
Atrophy out of proportion for age (%)	33 (64.7)	15 (75.0)	23 (69.7)

CT = computed tomography; TBI = traumatic brain injury; IQR = interquartile range.