

LORAZEPAM FOR THE PREVENTION OF RECURRENT SEIZURES
RELATED TO ALCOHOLGAIL D'ONOFRIO, M.D., NIELS K. RATHLEV, M.D., ANDREW S. ULRICH, M.D., SUSAN S. FISH, PHARM.D., M.P.H.,
AND ERIC S. FREEDLAND, M.D.**ABSTRACT**

Background and Methods Alcohol abuse is one of the most common causes of seizures in adults. In a randomized, double-blind study, we compared lorazepam with placebo for the prevention of recurrent seizures related to alcohol. Over a 21-month period, we studied consecutive patients with chronic alcohol abuse who were at least 21 years of age and who presented to the emergency departments of two hospitals in Boston after a witnessed, generalized seizure. The patients were randomly assigned to receive either 2 mg of lorazepam in 2 ml of normal saline or 4 ml of normal saline intravenously and then observed for six hours. The primary end point was the occurrence of a second seizure during the observation period.

Results Of the 229 patients who were initially evaluated, 186 met the entry criteria. In the lorazepam group, 3 of 100 patients (3 percent) had a second seizure, as compared with 21 of 86 patients (24 percent) in the placebo group (odds ratio for seizure with the use of placebo, 10.4; 95 percent confidence interval, 3.6 to 30.2; $P < 0.001$). Forty-two percent of the placebo group were admitted to the hospital, as compared with 29 percent of the lorazepam group (odds ratio for admission, 2.1; 95 percent confidence interval, 1.1 to 4.0; $P = 0.02$). Seven patients in the placebo group and one in the lorazepam group were transported to an emergency department in Boston with a second seizure within 48 hours after hospital discharge.

Conclusions Treatment with intravenous lorazepam is associated with a significant reduction in the risk of recurrent seizures related to alcohol. (N Engl J Med 1999;340:915-9.)

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ALCOHOL abuse is one of the most common causes of adult-onset seizures.¹ Although primary prevention of seizures during alcohol withdrawal has been reported,²⁻⁶ only a few studies have addressed the treatment and prevention of recurrent seizures related to alcohol in patients in the emergency department.⁷⁻⁹ Multiple explanations have been postulated for the association between alcohol and seizure activity. The relation of seizures to withdrawal from alcohol was described by Huss in 1852.¹⁰ Victor and Brausch¹¹ reported that seizures occurred in approximately 10 percent of adults during alcohol withdrawal. Generalized tonic-clonic seizures occurred in 95 percent of patients, with 60 percent of patients having multiple seizures. The interval from the first to the last seizure was 6 hours or less in 85 percent; and

the first seizure occurred 7 to 48 hours after the last drink in 90 percent. Ninety percent of patients had normal electroencephalograms.

Other factors independent of abstinence may also increase the risk of seizures among patients who are dependent on alcohol. Alcohol itself may induce seizures¹² or exacerbate preexisting epilepsy.^{13,14} In addition, people who chronically abuse alcohol have an increased frequency of structural abnormalities in the brain that may contribute to seizures, including cerebral vascular lesions and lesions due to head injury.¹⁵⁻¹⁷

Prevention of recurrent seizures related to alcohol use is important,¹⁸ and the ability of specific drugs to prevent seizures has been assessed. Phenytoin does not prevent recurrent alcohol-related seizures.⁷⁻⁹ Benzodiazepines are effective in the management of the acute alcohol syndrome, including the primary prevention of seizures in patients with alcohol dependence.¹⁹⁻²⁴ Because lorazepam is distributed in tissue less rapidly and less extensively than is diazepam, its ability to control seizures is prolonged.^{25,26} Lorazepam has minimal depressant effects on respiration and circulation.²⁷⁻³⁰ It uses the same γ -aminobutyric acid receptors in the brain as alcohol and has sedative and anxiolytic effects.³¹ Lorazepam has a shorter half-life than diazepam and has no active metabolites.^{32,33} Its half-life is not substantially prolonged in patients with liver or renal dysfunction, and parenteral administration is associated with a predictable pattern of absorption.³⁴⁻³⁶ Therefore, we assessed the ability of lorazepam to prevent recurrent alcohol-related seizures in patients with alcohol abuse who presented with a seizure.

METHODS**Study Design**

We conducted a 21-month, prospective, randomized, double-blind trial in the emergency departments of Boston City Hospital and Carney Hospital, two teaching hospitals in Boston. Consecutive patients with chronic alcohol abuse who were at least 21 years of age, who presented after a witnessed generalized seizure, and who had had one or more drinks within the previous 72 hours were eligible for enrollment. A research nurse reviewed emergency department logs weekly to determine whether all patients who were eligible were enrolled. Patients were excluded from enrollment if there was another possible cause of the seizures given any of the following abnormal serum laboratory values: less than

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60 mg of glucose per deciliter (3.3 mmol per liter), less than 120 mmol of sodium per liter or more than 160 mmol per liter, less than 6.0 mg of calcium per deciliter (1.5 mmol per liter), less than 1.0 mg of magnesium per deciliter (0.41 mmol per liter), more than 100 mg of urea nitrogen per deciliter (35.7 mmol per liter), or more than 10.0 mg of creatinine per deciliter (884 μ mol per liter). Patients were also excluded from enrollment if they were taking drugs (as determined on the basis of their history or the results of toxicologic screening) that cause or protect against recurrent seizures, including cocaine and phenobarbital, but not phenytoin; if they refused to provide consent; or if they had already been enrolled in the study. Patients were excluded after enrollment if they required treatment for symptoms of moderate-to-severe withdrawal other than seizures, according to the guidelines for the assessment of the severity of alcohol-withdrawal symptoms used by both hospitals. These symptoms consisted of either changes in two of the following three vital signs: an increase in the pulse rate to more than 100 beats per minute, an increase in diastolic blood pressure to more than 100 mm Hg, and an increase in oral temperature to more than 37.7°C, or the presence of hallucinosis (auditory, visual, or tactile) or delirium (disorientation, abnormal sensorium, or agitation). These symptoms could appear in combination with any other, less severe symptoms of withdrawal, such as tremors, anxiety, hyperreflexia, nausea, vomiting, and diaphoresis.

Computed tomographic (CT) examinations of the head and electroencephalography were performed only when clinically indicated and were not a mandatory part of the protocol. An abnormal electroencephalogram was defined as one showing activity consistent with the presence of an epileptogenic focus. Abnormal CT results were those that showed any post-traumatic structural abnormalities, such as old contusions, skull fractures, evidence of craniotomy for blood evacuation, or mass lesions, that were potential seizure foci. For the purposes of the study, CT findings of brain atrophy or small lacunar infarcts were not considered abnormal (positive).

An alcohol-related seizure was diagnosed on the basis of the patient's history of alcohol use, the absence of recent trauma, and the medical record. Patients with new-onset seizures were admitted to the hospital and evaluated by the medical services, neurologic services, or both. All consultants were unaware of the patients' treatment assignments.

Blood was obtained in the emergency department for the measurement of serum sodium, potassium, chloride, carbon dioxide, urea nitrogen, creatinine, calcium, magnesium, glucose, and ethanol levels. If toxic effects were suggested on the basis of the history or clinical signs, serum and urine were sent for toxicologic screening.

The study was approved by the institutional review boards of both hospitals, and patients provided written informed consent for participation. Consent was initially waived for any patients who were unable to give informed consent at presentation because of intoxication or postictal phenomena. Once treatment had been administered and the patient became alert, consent was required for the continued collection of data. The rationale for the waiver of consent was that lorazepam is an accepted treatment for seizures and that at the time, the standard treatment for recurrent seizures related to alcohol at both institutions was supportive care with referral to a detoxification unit.

Study Protocol

Patients were randomly assigned to receive 2 mg of lorazepam (Ativan, Wyeth-Ayerst, Philadelphia) or 2 ml of normal saline as a placebo according to a table of random numbers for each site. Before administration, 2 ml of normal saline was added to each sample to produce equal volumes and similar viscosity and to minimize irritation at the injection site. All patients underwent continuous electrocardiographic and oxygen-saturation monitoring, with blood pressure measured every 15 minutes. The patients and all care providers were unaware of the treatment assignments.

TABLE 1. REASONS FOR EXCLUSION FROM THE STUDY.

REASON FOR EXCLUSION	PLACEBO GROUP (N=16)	LORAZEPAM GROUP (N=27)	TOTAL (N=43)
Previously enrolled	14	21	35
Use of drugs that prevent or cause seizures			
Cocaine	1	2	3
Phenobarbital	0	2	2
Hypomagnesemia	0	1	1
Refusal to provide consent	1	0	1
Focal seizure	0	1	1

All patients initially had their serum glucose levels measured in a sample obtained by a finger stick and received intravenous hydration with normal saline or 5 percent dextrose with normal saline, as well as 100 mg of thiamine intravenously, one ampule of multivitamins, and 2 g of magnesium in the first liter of intravenous fluid.

End Points

The observation period ended with the development of a second generalized seizure, witnessed by the emergency department physician or nurse, or six hours after the administration of lorazepam or placebo.

Follow-up

The Boston Emergency Medical Services data base was used to determine whether the patients presented to any Boston hospital with a diagnosis of seizures within 48 hours after discharge.

Statistical Analysis

The objective of the analysis was to compare the rates of recurrent seizures related to alcohol in patients who received lorazepam and patients who received placebo. Patients who were enrolled but who were later found to meet the initial exclusion criteria were not included in the analysis. If patients with repeated episodes of generalized seizures were inadvertently enrolled more than once, only the first episode was included. Patients who underwent randomization and who subsequently met exclusion criteria were included in an intention-to-treat analysis.

Base-line characteristics were compared in the two groups with use of the chi-square test or Fisher's exact test for categorical variables and the t-test for two independent samples for continuous variables. Unadjusted rates of recurrent seizures were compared with use of the chi-square test. After adjustment for clinically important base-line characteristics, the rates of recurrent seizures were compared by multiple logistic-regression analysis. All tests of significance were two-tailed.³⁷ A P value of 0.05 or less was considered to indicate statistical significance.

RESULTS

We enrolled all 229 eligible patients who presented at either institution between March 9, 1993, and December 15, 1994. Forty-three patients met the initial exclusion criteria, including one who refused to provide consent (Table 1). Thus, a total of 186 patients (152 from Boston City Hospital and 34 from Carney Hospital) met the criteria for study entry and were included in the intention-to-treat analysis. Sixteen patients met the exclusion criteria after en-

rollment but were included in the intention-to-treat analysis: 11 required benzodiazepine therapy, 3 had incomplete data, 1 received droperidol, and in 1 the cause of the seizure was unclear. Consent was obtained from 78 patients at study entry and from 108 patients before the completion of the study.

Base-Line Characteristics

Eighty-six patients (46 percent) were assigned to receive placebo, and 100 patients (54 percent) were assigned to receive lorazepam. The base-line characteristics of the two groups were similar (Table 2). Most of the patients were middle-aged men. Like the patients in an earlier study,¹¹ most of these patients had a long history of alcohol abuse and drank heavily. Eighty-five percent had consumed at least 1 pint (473 ml) of distilled alcohol per day for more than 10 years. Most patients had their first seizure 7 to 48 hours after their last drink. The time from the first seizure to the administration of lorazepam or placebo was also similar in both groups.

Serum electrolyte, urea nitrogen, creatinine, glucose, magnesium, and calcium levels were similar in the two groups. The majority of the patients had an ethanol level of zero at entry; among those with detectable ethanol levels, the levels were similar in the two groups. Among patients with detectable levels of phenytoin, the levels were similar in the two groups and were in the low therapeutic range.

Diagnostic Studies

A total of 109 patients had documented electroencephalograms, and 153 had CT examinations of the head (Table 2). The percentages of patients with abnormal electroencephalograms and CT examinations were similar in the two groups.

Recurrent Seizures

Twenty-four patients (13 percent) had a second seizure: 21 in the placebo group (24 percent) and 3 (3 percent) in the lorazepam group (odds ratio for seizure with the use of placebo, 10.4; 95 percent confidence interval, 3.6 to 30.2; $P < 0.001$). The results were similar when the data for the 16 patients who met the exclusion criteria after enrollment were omitted from the analysis. Twenty-one of 77 patients in the placebo group (27 percent) had a second seizure, as compared with 3 of 93 patients in the lorazepam group (3 percent; odds ratio for seizure, 11.25; 95 percent confidence interval, 3.9 to 32.5; $P < 0.001$). There were no complications related to the administration of lorazepam.

A review of the records of the three patients in the lorazepam group who had a second seizure did not identify any specific characteristics that were predictive of a second seizure. These patients were not taking antiepileptic drugs and had normal electroencephalograms. One patient had findings on CT

TABLE 2. BASE-LINE CHARACTERISTICS OF THE STUDY GROUPS.*

CHARACTERISTIC	LORAZEPAM GROUP (N=100)	PLACEBO GROUP (N=86)
Male sex — no. (%)	97 (97)	81 (94)
Age — yr	45 ± 10	44 ± 9
Years of alcohol abuse — % of patients		
0–5 yr	6	6
6–10 yr	10	9
>10 yr	84	85
Daily consumption of distilled alcoholic beverages — % of patients		
<1 pint (473 ml)	21	25
1 pint–1 fifth (473–757 ml)	36	34
>1 fifth (757 ml)	43	41
Hours from last drink to first seizure — % of patients		
0–6 hr	16	17
7–24 hr	49	46
25–48 hr	24	33
>48 hr	11	4
Time from first seizure to administration of study drug — min	146 ± 188	141 ± 147
Serum levels†		
Ethanol — mg/dl‡	195 ± 135	206 ± 154
Phenytoin — µg/ml§	10 ± 5	10 ± 5
Sodium — mmol/liter	139 ± 4	136 ± 20
Carbon dioxide — mmol/liter	22 ± 5	23 ± 5
Urea nitrogen — mg/dl	11 ± 5	11 ± 4
Creatinine — mg/dl	1.0 ± 0.4	0.9 ± 0.3
Glucose — mg/dl	121 ± 33	122 ± 48
Calcium — mg/dl	9.2 ± 0.58	9.3 ± 0.56
Magnesium — mg/dl	1.8 ± 0.45	1.8 ± 0.39
Diagnostic studies — % positive (no. positive/total no. examined)		
Electroencephalography	11 (6/54)	7 (4/55)
Computed tomography	19 (15/80)	21 (15/73)

*Plus-minus values are means ± SD. There were no significant differences between the groups.

†To convert the values for ethanol to millimoles per liter, multiply by 0.2171; to convert the values for phenytoin to micromoles per liter, multiply by 3.96; to convert the values for urea nitrogen to millimoles per liter, multiply by 0.357; to convert the values for creatinine to micromoles per liter, multiply by 88.4; to convert the values for glucose to millimoles per liter, multiply by 0.0556; to convert the values for calcium to millimoles per liter, multiply by 0.250; and to convert the values for magnesium to millimoles per liter, multiply by 0.41.

‡Ethanol levels are given for the 24 patients in the lorazepam group and the 27 patients in the placebo group who had levels of more than 0.

§Phenytoin levels are given for the 15 patients in the lorazepam group and the 17 patients in the placebo group who had levels of more than 0.

examination consistent with the presence of an old subdural hematoma. In another patient, delirium tremens developed within minutes after entry into the study; he was admitted to the intensive care unit, and the CT scan and electroencephalogram were normal. It is unclear whether this patient actually had a recurrent generalized tonic-clonic seizure or whether the initial “seizure activity” was actually early delirium tremens.

Three additional patients who remained in the emergency department for other reasons had a second seizure after the end of the six-hour study period.

All three of these patients were in the placebo group and were subsequently hospitalized.

Predictors of Recurrent Seizures

We used logistic-regression analysis to determine whether any of the following characteristics were independent predictors of recurrent seizures: age, sex, treatment group, hospital, serum ethanol level, the number of years of alcohol use, and the time since the last drink. Variables for electroencephalographic and CT results were not included because of the large numbers of patients (77 in the case of electroencephalography and 33 in the case of CT scanning) who did not undergo these examinations. Age ($P=0.10$), sex ($P=0.49$), hospital ($P=0.15$), the number of years of alcohol use ($P=0.24$), the time since the last drink ($P=0.75$), and ethanol level ($P=0.09$) were not significantly associated with the likelihood of recurrent seizures. The only statistically significant independent predictor was treatment group ($P<0.001$).

Disposition of Patients

Thirty-six patients in the placebo group (42 percent) were admitted to the hospital, as compared with 29 patients (29 percent) in the lorazepam group (odds ratio for admission, 2.1; 95 percent confidence interval, 1.1 to 4.0; $P=0.02$). Of the patients who were discharged directly from the emergency department, 14 patients in the placebo group (28 percent) and 9 patients in the lorazepam group (13 percent) agreed to be referred to a detoxification unit directly from the emergency department.

Follow-up

Eighty-five percent of the enrolled patients had been transported to the emergency departments by ambulances owned by Boston Emergency Medical Services. Therefore, we used that data base to determine which study patients were transported to emergency departments in Boston within 48 hours after discharge from the study hospitals' emergency departments. Of the 50 patients in the placebo group who were discharged from the emergency department after the study, 7 (14 percent) were transported to an emergency department in Boston within 48 hours with a second seizure. The respective number in the lorazepam group was 1; this patient was readmitted for a second seizure 2.5 hours after discharge.

DISCUSSION

We found that intravenous lorazepam significantly reduced the risk of recurrent seizures related to alcohol. We attempted to enroll patients soon after they arrived at the emergency department to avoid the occurrence of a second seizure before enrollment.

One strength of this study is that we included all patients with alcohol-related seizures. Persons with alcohol dependence and seizures may have various

underlying structural causes of seizures in addition to alcohol withdrawal. Some may benefit from long-term therapy with anticonvulsant medications, such as phenytoin, and should be encouraged to take their medication.^{38,39} Patients who are noncompliant may be at risk for seizures.⁴⁰ When an alcohol-dependent patient with documented poor compliance with medication makes repeated visits to the emergency department, the primary physician and neurologist should be consulted about improving compliance.

Our findings suggest that all patients with acute and chronic alcohol abuse who present with seizures may benefit from the use of lorazepam. For patients who do not require admission to the hospital, treatment in a detoxification unit may be beneficial. It is likely, however, that many such patients will be sent home or to shelters, where their use of alcohol may resume. Our findings suggest that lorazepam is safe and effective for such patients.

One limitation of our study is that the observation period lasted only six hours. In a study by Victor and Brausch,¹¹ in 15 percent of patients who had recurrent alcohol-related seizures, the last seizure occurred more than six hours after the first. It is possible that the administration of lorazepam simply delayed the occurrence of additional seizures. However, our follow-up data from the Boston Emergency Medical Services data base suggest that this explanation is unlikely. It is important to note that there may have been patients who had recurrent seizures who were not transported to the emergency department by the emergency medical services and therefore were not included in the data base.

In this as well as a previous study,⁹ we found that the rate of recurrent seizures was 24 percent in the placebo group. In institutions in which hospital admission is required after a second observed seizure related to alcohol, treatment with lorazepam may avert many such hospitalizations. In our study, the rate of hospital admission was lower in the lorazepam group than in the placebo group.

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We are indebted to the nursing staff at Boston Medical Center and Carney Hospital for their support and clinical assistance; to Dr. Robert Dart for his efforts in accessing the Boston Emergency Medical Services data base; to Drs. Herbert Kayne, Lisa Sullivan, and Suzette Levenson for their review of the data and statistical support; to Cathy Coffin for technical review; and to Dr. Jeffrey Samet for reviewing the manuscript and offering advice.

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CORRECTION

Lorazepam for the Prevention of Recurrent Seizures Related to Alcohol

To the Editor: D'Onofrio et al. (March 25 issue)¹ found that treatment with intravenous lorazepam is associated with a significant reduction in the risk of recurrent seizures related to alcohol. They studied patients with a history of chronic alcohol abuse who presented to the emergency departments of two hospitals in Boston after a witnessed, generalized seizure.

My first shock (of many) was that the patients were randomly assigned to receive either lorazepam or a saline placebo, even though it was recognized that without treatment a much higher rate of seizures was expected. I was anticipating a dose-response study or a comparison with another antiepileptic medication.

In explaining the need for their study, the authors stated: "Prevention of recurrent seizures related to alcohol use is important." So why was it acceptable to withhold treatment from some patients? Furthermore, two of the studies cited by the authors^{2,3} document the efficacy of lorazepam for this indication. Indeed, D'Onofrio et al. stated in the Methods section that lorazepam is an accepted treatment. Why was it necessary to perform this study at all?

My next shock came when I read that "consent was initially waived for any patients who were unable to give informed consent at presentation because of intoxication or postictal phenomena." If patients are unable to give true informed consent for entry into an important study, it should be obtained from a relative or guardian; otherwise, such patients should not be enrolled under any circumstances, even for a short period. It is important to prevent the mistreatment of patients who cannot protect themselves.

It is hard for me to believe that any patient who had a seizure would consent to participate in a study in which effective treatment might be withheld if the patient understood that this might happen and also understood that he or she was likely to have more seizures. The patients could not have been aware of the dubious value of this study. Therefore, it seems unlikely that true informed consent was obtained from any of the participants.

If lorazepam or another effective antiepileptic medication had been administered to the patients in the control group instead of saline, approximately 18 patients would not have suffered from recurrent seizures within six hours, 11 would not have needed to be hospitalized, and 6 would not have needed to return to the emergency department.¹ This was the cost in human suffering that was needed to demonstrate that lorazepam is superior to saline for the prevention of recurrent alcohol-related seizures. It was a high price to pay for a trivial result.

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To the Editor: Several questions came to mind after I read the article by D'Onofrio et al.: Were the patients who were released from the emergency department after a seizure due to alcohol withdrawal given any medication (e.g., a benzodiazepine or a barbiturate) to reduce the symptoms and possibly prevent progression to delirium tremens on discharge? What criteria determined the admission of 42 percent of the placebo group and 29 percent of the lorazepam group to the hospital? Since delirium tremens may develop more than 48 hours after a withdrawal seizure, why was the 48-hour period chosen as the means of determining whether the patients returned to the emergency department with a recurrent seizure?

Since most clinicians would consider a withdrawal seizure a complication of withdrawal and a risk factor for progression to the more serious withdrawal syndrome of delirium tremens (which still carries a considerable mortality rate), how did the authors determine that these patients could or should be released with or without medication rather than be admitted for observation and controlled detoxification?

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The authors reply:

To the Editor: We refer Dr. Sosis to our article, which clearly states that at the time of the study, the standard of care at both institutions for patients who presented with a recurrent seizure related to alcohol was similar to that at most urban emergency departments in the United States and included supportive care only.¹ Therefore, at no time did we withhold an accepted treatment.

For years, we as well as other researchers have sought to improve the care of patients with recurrent seizures related to alcohol. In the 1980s and early 1990s, we exclusively used the anticonvulsant phenytoin without success.² At the time of this study, it was not recognized that treatment with lorazepam would reduce the rate of recurrent seizures related to alcohol, since no previous randomized, controlled trial had addressed the issue. The study cited by Dr. Sosis included

patients who were admitted to an inpatient rehabilitation center and observed for five days for primary prevention of any signs of alcohol withdrawal.³

We believe that Dr. Sosis is confusing two very separate issues: the care of the patient presenting to an emergency department with a recurrent seizure related to alcohol and the primary prevention of withdrawal symptoms, which include seizures, in a controlled inpatient setting. In the first situation, the patient is more likely to refuse a referral to a detoxification program and resume alcohol consumption on discharge. The risks and benefits of the administration of lorazepam in this setting had not been identified. The second scenario involves the monitoring of patients in an inpatient setting for signs of withdrawal. The evidence in this situation suggests therapy with benzodiazepines.⁴

In response to Dr. Matz: Patients who had signs and symptoms of moderate to severe alcohol withdrawal during the study period were treated with benzodiazepines, as we described.¹ Patients were not given oral medications on discharge from the emergency department unless they were admitted to the hospital or a detoxification unit. The criteria for admission to the hospital included the presence of recurrent seizure, the progression of withdrawal symptoms to moderate or severe intensity, and the presence of coexisting illness requiring admission.

A 48-hour interval for follow-up was chosen because seizures related to alcohol withdrawal typically occur within this period after the cessation of drinking. Delirium tremens is often a later complication of withdrawal. Extended follow-up could have been confounded by repeated cycles of drinking and abstinence.

We agree that seizures are a serious complication of alcohol withdrawal. Therefore, we offered treatment for substance abuse to every patient. Unfortunately, most of the patients refused these services.⁵

Finally, in the abstract and in the Results section of our article we incorrectly reported the odds ratio for hospital admission in the placebo group as compared with the lorazepam group as 2.1 (95 percent confidence interval, 1.1 to 4.0; $P=0.02$). The correct odds ratio is 1.71 (95 percent confidence interval, 0.92 to 3.2; $P=0.09$). We regret the error.

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