



Acute Hemodialysis for Treatment of Severe Ethanol Intoxication

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A male college student presented to the emergency department with altered mental status and a serum ethanol level higher than the hospital laboratory assay. His course was complicated by mechanical ventilation, vasopressors, and cardiotoxicity. Thirteen hours into admission and despite aggressive supportive measures, the patient remained obtunded off sedation with serum ethanol level elevated at 428 mg/dL. A decision was made to initiate hemodialysis to expedite ethanol clearance and prevent further end-organ damage. Two hours into hemodialysis, mental status improved and serum ethanol level had decreased to 264 mg/dL. A total of 4 hours of hemodialysis were completed and serum ethanol level continued to downtrend. Dialysis increased the rate of ethanol elimination by a factor of 4 and prevented further cardiotoxicity or electrolyte level abnormalities. This case supports the use of hemodialysis for adult patients who meet the criteria of severe ethanol toxicity requiring critical care resources and having evidence of organ toxicity to 1 or more organ.

Complete author and article information provided before references.

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INTRODUCTION

Each year in the United States, there are about 2,200 deaths due to alcohol poisoning, and ethanol intoxication alone is responsible for more than 600,000 emergency department (ED) visits.¹⁻³ The treatment for acute ethanol intoxication remains largely supportive, with observation, serial examinations, and fluid resuscitation.

Although most patients presenting to the ED do not require escalation of care, a retrospective observational study of ED patients from 2011 to 2016 found that critical care resources were required for 1% of patients presenting to the ED with altered mental status from alcohol intoxication.⁴ Klein et al⁴ noted that risk factors for transfer to the intensive care unit included abnormal vital signs, hypoglycemia, and chemical sedation.

In this cohort of severe ethanol intoxication, the recommendation regarding course of treatment is less clear and guidelines continue to recommend aggressive supportive care. However, serum ethanol levels > 300 mg/dL have been shown to have increased risk for respiratory depression and cardiac arrest, and levels > 500 mg/dL can lead to death.⁵ This patient group would benefit from enhanced serum ethanol elimination, and hemodialysis should be considered in the treatment plan.

We report a case of a male college student who presented with altered mental status and a serum ethanol level higher than the assay who required 4 hours of hemodialysis for rapid ethanol elimination and made a full recovery.

CASE REPORT

A male college student with no significant medical history presented to the ED with altered mental status and serum

ethanol level > 550 mg/dL. The patient was obtunded with a Glasgow coma scale of 3, was unresponsive to voice, and had an oral airway in place. Initial vital signs showed blood pressure of 124/63 mm Hg, pulse rate of 75 beats/min, temperature of 97 °F, respiratory rate of 14 breaths/min, and oxygen saturation of 79%. Following desaturations to the mid-70s and an arterial blood gas with pH of 7.14 and Pco₂ of 72 mm Hg, the patient was intubated and transferred to the medical intensive care unit. Laboratory results on admission are shown in Table 1 and were significant for a negative urine toxicology workup, no anion or osmolal gap, and negative for ethylene glycol, acetaminophen, and methanol.

The patient's serum ethanol level remained higher than the assay for greater than 9 hours with aggressive supportive measures, including intravenous fluid and thiamine, and he remained unresponsive off sedation. Then the patient experienced an episode of bradycardia to the mid-40s with a new pressor requirement. Telemetry and electrocardiography showed first-degree block with prolonging of the PR interval, concerning for Mobitz type 1, and with A-V dissociation without third-degree block. Rhythm reverted to normal sinus following administration of atropine, 0.5 mg, along with epinephrine. The patient's laboratory results were also significant for hypocalcemia and he was given 6 g of calcium gluconate.⁶

Following consultation with the renal service and in the setting of severe alcohol toxicity with direct cardiotoxicity, the decision was made to treat urgently with hemodialysis for rapid elimination of ethanol and its toxic metabolites. Serum ethanol measured before the start of dialysis and 13 hours into admission was 428 mg/dL (93 mmol/L). The patient was started on hemodialysis with the high-flux dialyzer F160 NR

Table 1. Laboratory Data

	On Admission	At HD Initiation	After HD/On Discharge
Complete blood cell count			
White blood cells, K/ μ L	13		10.6
Red blood cells, M/ μ L	5.23		4.19
Hemoglobin, g/dL	16.3		12.9
Hematocrit, %	48.7		38.1
Mean corpuscular volume, fL	9.3		91
Differential			
Poly, %	51		70
Lymphocytes, %	40		18
Eosinophils, %	1		0
Basophils, %	0		0
Coagulation			
Prothrombin time, s	13.4		15.4
International normalized ratio	1.11		1.28
Partial thromboplastin time, s	35		30
Chemistry			
Sodium, mmol/L	137	141	134
Potassium, mmol/L	3.3	3.8	4
Chloride, mmol/L	106	110	104
Carbon dioxide, mmol/L	19	19	26
Anion gap	12	12	4
SUN, mg/dL	14	11	11
Creatinine, mg/dL	0.81	0.84	0.8
Glucose, mg/dL	120	93	103
Calcium, mmol/L	9	7.8	8.5
Ionized calcium, mg/dL	4.6	4.3	4.6
Protein, g/dL	7.8		6.3
Albumin, g/dL	4.7		3.7
Total bilirubin, mg/dL	0.6		1.1
Aspartate aminotransferase, U/L	27		31
Alanine aminotransferase, U/L	17		20
Alkaline phosphatase, U/L	110		86
Trop, ng/mL	<0.006		
Serum osmolality, mOsm/kg	447		
Calculated osmolality, mOsm/kg	412-441		
Osmolar gap, mOsm/kg	5.7		
Serum toxicology			
Ethanol, mg/dL	>550	428	None detected
Ethylene glycol	Negative		

(Continued)

Table 1 (Cont'd). Laboratory Data

	On Admission	At HD Initiation	After HD/On Discharge
Methanol	Negative		
Salicylate	<3.0		
Tricyclic	Negative		
Tylenol	Negative		
Urine			
Toxicology	Negative		
Blood gas (venous)			
pH	7.2	7.37	7.41
Paco ₂ , mm Hg	62	33	41
Bicarbonate, mEq/L	24.2	19.1	26

Note: Laboratory data from admission, including before, during, and after dialysis. Serum osmolality was obtained on second laboratory draw on admission using sodium, 141 mmol/L; SUN, 12 mg/dL; glucose, 115 mg/dL; and serum ethanol, 550 mg/dL. Calculated osmolality was obtained using the following formula: Serum osmolality, US units = $(2 \times \text{Na} + (\text{SUN}/2.8) + (\text{glucose}/18) + (\text{ethanol}/3.7))$. Abbreviations: HD, hemodialysis; Poly, polymorphs; SUN, serum urea nitrogen; Trop, troponin.

(Fresenius Polysulfone membrane), blood flow rate of 300 mL/h, dialysate flow rate of 500 mL/h, 4 mEq/L potassium, 3 mEq/L calcium, and 30 mEq/L bicarbonate. While receiving dialysis, the patient's ethanol level decreased by 56 mg/dL per hour. Two hours into dialysis, the patient awoke, was responding appropriately to commands, and was extubated. The patient was dialyzed for a total of 4 hours to reduce the ethanol level to a less toxic value of 204 mg/dL (44.3 mmol/L) as estimated using the following formula⁷ and assuming ethanol has a similar clearance as urea: $[V \ln(44.3/A)]/0.06 k$ (12), where V is total-body water = 53 L, A is initial toxin level = 93 mmol/L, K is 80% of the manufacturer-specified dialyzer urea clearance = (160 mL/min)].

The patient's mentation continued to improve on dialysis and his serum ethanol level continued to down-trend when dialysis was stopped. The following day, the patient made a full recovery with return of normal mental status and discharge from the hospital with appropriate primary care follow-up.

DISCUSSION

For patients who present with severe ethanol intoxication with measured serum levels higher than the assay and toxicity to 1 or more organ system, hemodialysis should be considered. Ethanol is easily removed by dialysis. It is a small water-soluble molecule that is not protein bound, has a small volume of distribution, and easily transverse across biological barriers.^{8,9} Hemodialysis can significantly increase the rate of ethanol elimination and prevent further organ toxicity in a critically ill patient.

Ethanol elimination is a zero-order process and in the setting of acute intoxication, the rate of elimination is constant over time.¹⁰ The mean rate of elimination for nondrinkers is 12 mg/dL per hour, for social drinkers is

Table 2. EtOH HD Data Interpretation

Time, h	Serum EtOH, mg/dL
Pre-HD (calculated)	
0	634
4	572
8	510
12	449
On HD (measured)	
13.38	428
14.92	341
16.11	264
Post HD (measured)	
17.10	223
23.85	119

Note: Time 0 is time at admission (~14 hours before the onset of HD). HD gives $y = -56.279x + 1179.5$, $R^2 = 0.9955$, for HD elimination rate of -56 mg/dL per hour. Post HD gives $y = -15.407x + 270.76$, for metabolism elimination rate of -15.407 mg/dL per hour. Extrapolation using that metabolic elimination rate gives presenting serum EtOH level of 634.198 requiring 41.16 hours for natural elimination without HD.

Abbreviations: EtOH, ethanol; HD, hemodialysis.

15 mg/dL per hour, and for long-term drinkers is 30 mg/dL per hour. This suggests that the rate of elimination increases with drinking experience.¹⁰

In our case, the patient's metabolism elimination rate off dialysis was calculated to be 15.407 mg/dL per hour. Using this elimination rate, a prediction of the patient's initial serum ethanol level on presentation can be calculated using the first serum ethanol level measurable on assay of 428 mg/dL detected 13.38 hours into admission. This puts the patient's initial serum ethanol level at 634 mg/dL. Based on these values, clearance of ethanol, without dialysis, would take about 41 hours. While receiving dialysis, the patient's elimination rate increased by a factor of 4 from 15 to 56 mg/dL per hour (Table 2).

Dialysis was initiated 14 hours into the admission and ran for 4 hours; this reduced the total time for clearance from 41 hours to 28 hours (Fig 1; Table 2).

Prior case reports (shown in Table 3) support the efficacy of hemodialysis in the treatment of severe alcohol toxicity, with serum ethanol levels > 450 mg/dL.^{8,9,11,12} Almost all these reports describe patients presenting with or developing a comatose state despite early aggressive supportive care, requiring escalation of care and mechanical ventilation. All patients received hemodialysis for at least 3 hours, with blood flow rates of ~ 200 mL/min described in at least 2 cases.^{8,9} Hemodialysis proved to be excellent in achieving rapid ethanol clearance, resulting in improved mental status and clinical course of all patients involved.

In our case, similarly the patient had features of severe ethanol toxicity with end-organ damage. Increased ethanol clearance was beneficial because the patient was having cardiotoxicity secondary to the high ethanol level in his system and its subsequent effects on his electrolyte levels and vagal tone. In terms of electrolyte abnormalities, the course was complicated by hypocalcemia. Initially, ionized calcium level was 4.6 mg/dL, but 7 hours into admission, this level decreased to 3.8 mg/dL. This level of hypocalcemia is dangerous and can predispose to ventricular arrhythmias.¹³ A likely cause of the hypocalcemia is the transient hypoparathyroidism, which can result following acute ethanol intoxication.⁶ Studies have shown that 3 hours after acute ethanol intoxication, parathyroid hormone level reaches a nadir and that 8 to 12 hours after ingestion, ionized calcium levels reach their minimum.⁶ This time course matches our patient's presentation and explains why the patient's calcium level continued to decrease after presentation. In combination with the patient's electrolyte level abnormalities, the

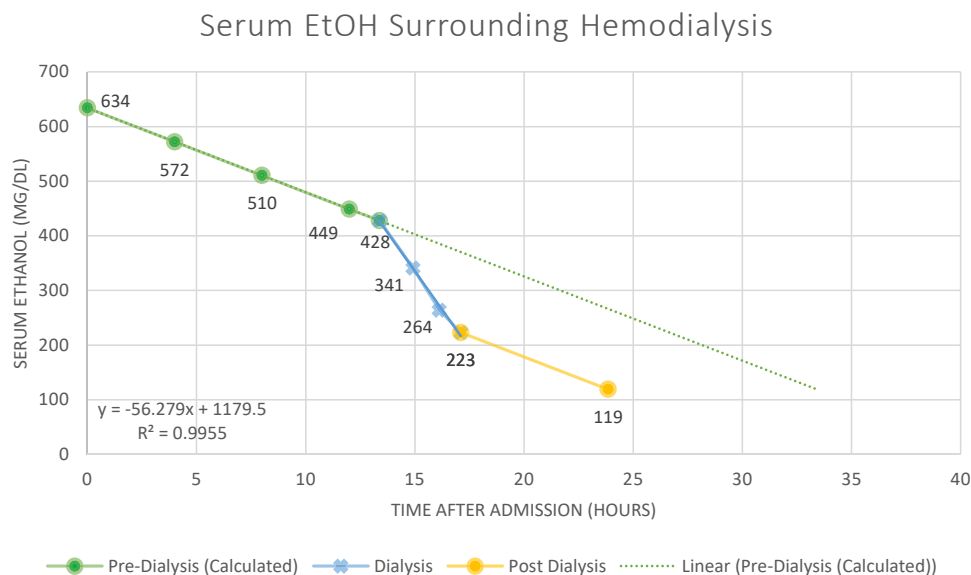


Figure 1. Serum ethanol (EtOH) levels measured during admission in relation to the start of dialysis.

Table 3. Case Reports of Severe Ethanol Toxicity Treated With Hemodialysis

Report	Total Hours of HD	Serum EtOH, mg/dL, Pre-HD	Serum EtOH, mg/dL, Post-HD
Wildenauer et al ⁹	4	615	214
Atassi et al ⁶	4	523	100
Elliott and Hunter ¹¹	3	465	255
Morgan et al ¹²	3.5	767 at time of HD 407 l	84

Abbreviations: EtOH, ethanol; HD, hemodialysis.

depressive effects of ethanol caused high vagal tone and contributed to the patient's bradyarrhythmia. Given the cardiotoxicity present and the risk for ventricular arrhythmias, rapid elimination of ethanol and normalization of calcium level with a high calcium bath was warranted in this case.¹⁴

Although this patient did not experience withdrawal symptoms following rapid ethanol elimination on hemodialysis, this may be a concern for patients with alcohol use disorder. There are no case studies in the literature detailing hemodialysis inducing alcohol withdrawal syndrome, but this is most likely due to the limited use of hemodialysis in acute ethanol intoxication. Induction of alcohol withdrawal in long-term alcohol users should be considered and appropriately managed if hemodialysis is used for rapid ethanol clearance.

In the guidelines for pediatric severe ethanol intoxication, hemodialysis is recommended for patients who present with blood ethanol levels > 450 mg/dL or those who have underlying liver disease.^{12,15} In adult medicine, this recommendation has not made it into treatment guidelines. This case demonstrates the role and benefit of hemodialysis for a critically ill patient who is experiencing organ toxicity and exposes a need for an updated recommendation in this specific set of patients.

ARTICLE INFORMATION

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