

# SIMULATION

## Ethylene Glycol Ingestion

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### ABSTRACT:

**Audience:** This scenario was developed to educate emergency medicine residents on the diagnosis and management of ethylene glycol ingestion. This case is also appropriate for senior medical students and advanced practice providers. The principles of crisis resource management, teamwork, and communication are incorporated into the case.

**Introduction:** Ethylene glycol is a component of antifreeze and engine coolant, and its ingestion is much less common than ethanol intoxication. Poison control centers have reported between 4000 and 6000 cases of ethylene glycol exposures per year.<sup>1</sup> Nonspecific symptoms such as depressed mental status with ingestion of either substance may lead providers to misdiagnose ethylene glycol for ethanol intoxication unless a high level of suspicion is maintained, and the morbidity of ethylene glycol ingestion is significant, with more than 6,000 exposures and 22 deaths in the US in 1998.<sup>1</sup> It has been reported that 18.1% of ethylene glycol exposures died when treated with ethanol, while 4.1% died when treated with fomepizole.<sup>2</sup> While ethylene glycol is not directly toxic to the body, it has toxic metabolites, including the nephrotoxic oxalic acid. However, with proper medical intervention, many of its toxic effects can be prevented.

Affected individuals may suffer from end-organ dysfunction, particularly renal failure, and subsequent death without proper intervention. Laboratory hallmarks that support the diagnosis of ethylene glycol ingestion include an increased osmolar gap, calcium oxalate crystals on urinalysis (UA), and renal dysfunction.<sup>2</sup> A patient's urine may also fluoresce under black light due to the addition of fluorescein to ethylene glycol (although this finding is not sensitive or specific).

Typical interventions for ethylene glycol toxicity include fomepizole administration and evaluation for hemodialysis, particularly if a patient has acidemia or end-organ dysfunction. Other toxic alcohols include methanol (which may be found in cologne and windshield washer fluid) and isopropyl alcohol (or rubbing alcohol). Methanol typically presents similarly to ethylene glycol with nonspecific intoxication symptoms, but with the additional symptoms of vision changes or blindness. Isopropyl alcohol presents with gastric irritation and ketosis without acidosis. Treatment of methanol ingestion is similar to ethylene glycol, while treatment of isopropyl alcohol ingestion is generally supportive.<sup>2</sup>

# SIMULATION

This simulation scenario allows learners to reinforce their ethylene glycol ingestion management skills in a psychologically-safe learning environment, and then to receive formative feedback on their performance.

**Objectives:** By the conclusion of the simulation session, learners will be able to: 1) obtain a thorough toxicologic history, including intent, timing, volume/amount, and assessment for co-ingestions, 2) distinguish the variable clinical signs and symptoms associated with toxic alcohol ingestions, 3) identify metabolic derangements associated with toxic alcohol ingestions, 4) discuss the management of toxic alcohol ingestion, 5) appropriately disposition the patient for admission to intensive care unit (ICU).

**Method:** This simulation was written for a high-fidelity simulator, followed by a debriefing session and lecture on the diagnosis and management of ethylene glycol ingestion. However, it could be run with a low- or moderate-fidelity simulator or as an oral boards case. Debriefing methods may be left to the discretion of participants, but the authors have utilized advocacy-inquiry techniques.

**Topics:** Medical simulation, ethylene glycol ingestion, toxic alcohol ingestion, toxicology.



# USER GUIDE

## List of Resources:

Abstract	26
User Guide	28
Instructor Materials	30
Operator Materials	41
Debriefing and Evaluation Pearls	45
Simulation Assessment	49

## Learner Audience:

Medical Students, Interns, Junior Residents, Senior Residents

## Time Required for Implementation:

Instructor Preparation: 30 minutes

Time for case: 20 minutes

Time for debriefing: 40 minutes

## Recommended Number of Learners per Instructor:

4

## Topics:

Medical simulation, ethylene glycol ingestion, toxic alcohol ingestion, toxicology.

## Objectives:

By the end of this simulation session, the learner will be able to:

1. Obtain a thorough toxicologic history, including intent, timing, volume/amount, and assessment for co-ingestions.
2. Distinguish the variable clinical signs and symptoms associated with toxic alcohol ingestions.
3. Identify metabolic derangements associated with toxic alcohol ingestions.
4. Discuss the management of toxic alcohol ingestion.
5. Appropriately disposition the patient for admission to intensive care unit (ICU).

## Linked objectives and methods:

Ethylene glycol is not commonly encountered, but emergency medicine providers must be familiar with its pathophysiology, presentation, potential complications, and treatment. Providers are expected to obtain a thorough toxicologic history to assess a patient's current and projected clinical course, as well as any cofounding co-ingestants (objective 1). Identifying nonspecific presenting signs and symptoms, as well as more specific presentations, may help obtain the proper diagnosis in an encephalopathic or otherwise uncooperative patient, and these signs and symptoms are reviewed in the debriefing (objective 2). Learners should identify an anion gap metabolic acidosis, osmolar gap, acute kidney injury, and hypocalcemia that are

associated with toxicity, but clinically may present at different times and with varying severity, depending on amount ingested and timing of ingestion, which will be reviewed during debriefing (objective 3). Not only should learners administer fomepizole and discuss hemodialysis with nephrology, but also should continue aggressive intravenous (IV) fluid administration to mitigate the risk of worsening renal injury. Adjunctive therapies such as pyridoxine and thiamine should also be considered, and all treatments should be reviewed during debriefing (objective 4). Ultimately, the patient requires disposition to the intensive care unit due to tenuous status and requirement for close monitoring (objective 5), and management must be discussed during the case with nephrology, poison control, and the intensivist.

## Recommended pre-reading for instructor:

We recommend that instructors review literature regarding toxic alcohol ingestion, including its diagnosis and management.

Suggested readings include:

- Scalley RD, Ferguson DR, Smart ML, Archie TE. Treatment of ethylene glycol poisoning. *Am Fam Physician*. 2002;66(5):807-812.
- Beatty L, Green R, Magee K, Zed P. A systematic review of ethanol and fomepizole use in toxic alcohol ingestions. *Emerg Med Int*. 2013; Article ID 638057. doi: 10.1155/2013/638057
- Wiener SW. Toxic alcohols. In: Hoffman RS, Howland M, Lewin NA, Nelson LS, Goldfrank LR. eds. *Goldfrank's Toxicologic Emergencies*. 10<sup>th</sup> ed. New York, NY: McGraw-Hill; 2015:804-816.
- Kraut JA, Mullins ME. Toxic alcohols. *N Engl J Med*. 2018;378(3):270-280. doi: 10.1056/NEJMra1615295
- Beauchamp GA, Valento M. Toxic alcohol ingestion: prompt recognition and management in the emergency department. *Emerg Med Pract*. 2016;18(9):1-20.
- McMartin K, Jacobsen D, Hovda KE. Antidotes for poisoning by alcohols that form toxic metabolites. *Br J Clin Pharmacol*. 2016;81(3):505-515. doi: 10.1111/bcp.12824
- Miller H, Barceloux DG, Krenzelok EP, Olson K, Watson W. American Academy of Clinical Toxicology Practice Guidelines on the treatment of ethylene glycol poisoning. *J Toxicol Clin Toxicol*. 1999;37(5):537-560.

## Results and tips for successful implementation:

This simulation was written to be performed as a high-fidelity simulation scenario, but also may be used with low- or moderate-fidelity or as a mock oral board case.



# USER GUIDE

The case was written for emergency medicine residents and may be presented in a freestanding, community-based, or academic emergency department setting. We have conducted a piloted ethylene glycol simulation case for approximately 20 emergency medicine residents during the 2013-2014 academic year. Although the simulated urine sample was created to fluoresce under a black light, teams did not often ask to assess for urine fluorescence while running the scenario. However, the fluorescence was displayed as a teaching point during debriefing. When mentioned, the instructor should point out that while this finding is interesting, it is neither sensitive nor specific. Participant feedback was overall positive during the post-session debriefing, with comments specifically focused on appreciation of osmolal gap calculation review and discussing the different presentations and treatments of toxic alcohols.

## References/suggestions for further reading:

1. Kraut JA, Mullins ME. Toxic alcohols. *N Engl J Med*. 2018;378(3):270-280. doi: 10.1056/NEJMra1615295
2. Beauchamp GA, Valento M. Toxic alcohol ingestion: prompt recognition and management in the emergency department. *Emerg Med Pract*. 2016;18(9):1-20.
3. McMartin K, Jacobsen D, Hovda KE. Antidotes for poisoning by alcohols that form toxic metabolites. *Br J Clin Pharmacol*. 2016;81(3):505–515. doi: 10.1111/bcp.12824
4. Miller H, Barceloux DG, Krenzelok EP, Olson K, Watson W. American Academy of Clinical Toxicology Practice Guidelines on the treatment of ethylene glycol poisoning. *J Toxicol Clin Toxicol*. 1999;37(5):537–560.
5. Scalley RD, Ferguson DR, Smart ML, Archie TE. Treatment of ethylene glycol poisoning. *Am Fam Physician*. 2002;66(5):807-812.
6. Beatty L, Green R, Magee K, Zed P. A systematic review of ethanol and fomepizole use in toxic alcohol ingestions. *Emerg Med Int*. 2013; 2013:638057.
7. Wiener SW. Toxic alcohols. In: Hoffman RS, Howland M, Lewin NA, Nelson LS, Goldfrank LR. eds. *Goldfrank's Toxicologic Emergencies*. 10<sup>th</sup> ed. New York, NY: McGraw-Hill; 2015:804-816.



# INSTRUCTOR MATERIALS

**Case Title:** Ethylene Glycol Ingestion

**Case Description & Diagnosis (short synopsis):** Patient is a 47-year-old male with history of depression and alcohol abuse who presents from home after being found unconscious in his garage. Per paramedics, the patient has been under a great deal of stress as reported by his wife. He was in the garage doing car maintenance when his wife went to check on him and found him on the ground, minimally verbally responsive, confused, and covered in vomit. Participants should obtain an electrocardiogram (ECG), head computed tomography (CT), chest X-ray, and bloodwork. Diagnostics will reveal an osmolar gap, an anion gap metabolic acidosis, an elevated lactate, and an undetectable ethanol level. A urinalysis should be obtained, which will contain calcium oxalate crystals and fluoresce under Wood's lamp. The case should be discussed with poison control, and then the patient should be admitted to the ICU. Nephrology should also be consulted to discuss the potential for emergent hemodialysis.

**Equipment or Props Needed:**

High fidelity simulation mannequin

T-shirt with emesis (teams may elect to use water to signify emesis, but may use more creative moulage techniques as desired)

Angiocaths for peripheral intravenous access = 18g, 20g, 22g

Cardiac monitor

Pulse oximetry

Intravenous (IV) pole

Normal saline (1Lx2)

Foley catheter

Urinalysis sample: combine water with fluorescein and food coloring to achieve a yellow-brown color

Wood's lamp

Simulated medications with labeling: Fomepizole, pyridoxine, thiamine

**Confederates needed:**

Primary nurse and wife. Faculty running the simulation may call in as nephrology, poison control, and the intensivist.

**Stimulus Inventory:**

#1 CT head

#2 Chest X-ray



# INSTRUCTOR MATERIALS

- #3 ECG
- #4 Complete blood count (CBC)
- #5 Basic metabolic panel (BMP)
- #6 Liver function tests (LFTs)
- #7 Coagulation panel
- #8 Lactic acid
- #9 Troponin
- #10 Ethanol
- #11 Salicylate level
- #12 Acetaminophen level
- #13 Serum osmolality
- #14 Arterial blood gas (ABG)
- #15 Urinalysis
- #16 Urine Toxicology Screen
- #17 Carboxyhemoglobin

**Background and brief information:** Emergency medical services (EMS) was called by wife from the patient's home. Paramedics bring patient to emergency department (ED).

**Initial presentation:** Patient is a 47-year-old male with history of alcohol abuse who presents from home via EMS with altered mental status and vomiting. The patient is lying supine, mildly tachypneic, and able to converse but intoxicated.

**How the scenario unfolds:** Patient is a 47-year-old male who presents from home by EMS after being found altered by his wife in the garage, covered in vomit. Participants should obtain an ECG which shows prolonged QTc, bloodwork which reveals an elevated osmolar gap and metabolic acidosis and hypocalcemia, an undetectable ethanol level, and a urinalysis with calcium oxalate crystals that fluoresces under Wood's lamp (Wood's lamp and urine sample should be concealed within simulation bay until specifically requested), and a head CT which does not show an acute process. The team should administer IV fluids, initiate fomepizole therapy, discuss the case with poison control, notify nephrology to discuss emergent dialysis, and admit to the ICU. The patient will become more hypotensive and tachycardic until both intravenous fluid (IVF) bolus and fomepizole are administered. If the patient does not receive fomepizole by the 12-minute mark, he will go into a pulseless electrical activity (PEA) arrest requiring two rounds of CPR to attain ROSC.



# INSTRUCTOR MATERIALS

## Critical actions:

1. Order IV access and order IV fluid bolus.
2. Obtain point of care glucose level.
3. Identify increased osmolality gap.
4. Order insertion of foley catheter.
5. Identify and treat hypocalcemia.
6. Order appropriate toxicology blood work including acetaminophen and salicylate levels.
7. Administer fomepizole.
8. Discuss the case with the poison control center.
9. Discuss the case with nephrology.
10. Admit to the intensive care unit.



# INSTRUCTOR MATERIALS

**Case title:** Ethylene Glycol Ingestion

**Chief Complaint:** Altered mental status and vomiting.

**Vitals:** Heart Rate (HR) 126      Blood Pressure (BP) 154/72      Respiratory Rate (RR) 24  
Temperature (T) 98.0°F      Oxygen Saturation (O<sub>2</sub>Sat) 98% on room air  
Weight (Wt) 90 kg

**General Appearance:** Lying supine in bed, shirt covered in vomit.

## Primary Survey:

- **Airway:** Intact.
- **Breathing:** Clear to auscultation, mildly tachypneic.
- **Circulation:** Regular rate and rhythm. 2+ symmetric pulses

## History:

- **History of present illness:** Patient is a 47-year-old male who presents today from home, brought in by EMS after being found stuporous by his wife in the garage. He is arousable to loud voice and sternal rub, and he has been vomiting. The wife stated he was in a normal state of health earlier today, and she went to check on him after he had been in the garage for several hours. She found him confused and called 911.

Patient appears intoxicated, but can answer simple questions.

- **Past medical history:** Depression, alcohol abuse, hypertension, hyperlipidemia.
- **Past surgical history:** Remote cholecystectomy, appendectomy.
- **Patient's medications:** Simvastatin and lisinopril.
- **Allergies:** None.
- **Social history:** History of alcohol abuse; no other known drug use. Drinks six beers per day on average. No tobacco use.
- **Family history:** Noncontributory.

## Secondary Survey/Physical Examination:

- **General appearance:** Lying supine in bed. He appears intoxicated and is drowsy but arousable to loud voice and to touch. He appears disheveled and is covered in vomit.
- **HEENT:**



## INSTRUCTOR MATERIALS

- **Head:** within normal limits
- **Eyes:** within normal limits
- **Ears:** within normal limits
- **Nose:** within normal limits
- **Throat:** within normal limits
- **Neck:** within normal limits
- **Heart:** Tachycardic, otherwise, within normal limits
- **Lungs:** Clear lung sounds. mildly tachypneic at rest
- **Abdominal/GI:** within normal limits
- **Genitourinary:** within normal limits
- **Rectal:** within normal limits
- **Extremities:** within normal limits
- **Back:** within normal limits
- **Neuro:** Ataxic with difficulty with heel-to-shin maneuvers, finger-to-nose testing, and sitting up in bed. Slurred speech. No focal motor or sensory deficits. If tested, he is uncoordinated in all extremities. No clonus. Cranial nerves intact. Glasgow coma scale (GSC) 13 (eyes 3, verbal 4, motor 6)
- **Skin:** within normal limits
- **Lymph:** within normal limits
- **Psych:** Patient endorses suicidal ideation.



## INSTRUCTOR MATERIALS

### Results:

#### *Non-contrast head CT*

Ciscel, A. Normal CT scan of the head; this slice shows the cerebellum, a small portion of each temporal lobe, the orbits, and the sinuses. In: Wikimedia Commons.

[https://commons.wikimedia.org/wiki/File:Head\\_CT\\_scan.jpg](https://commons.wikimedia.org/wiki/File:Head_CT_scan.jpg). Published 12 August 2005. CC BY-SA 2.0.



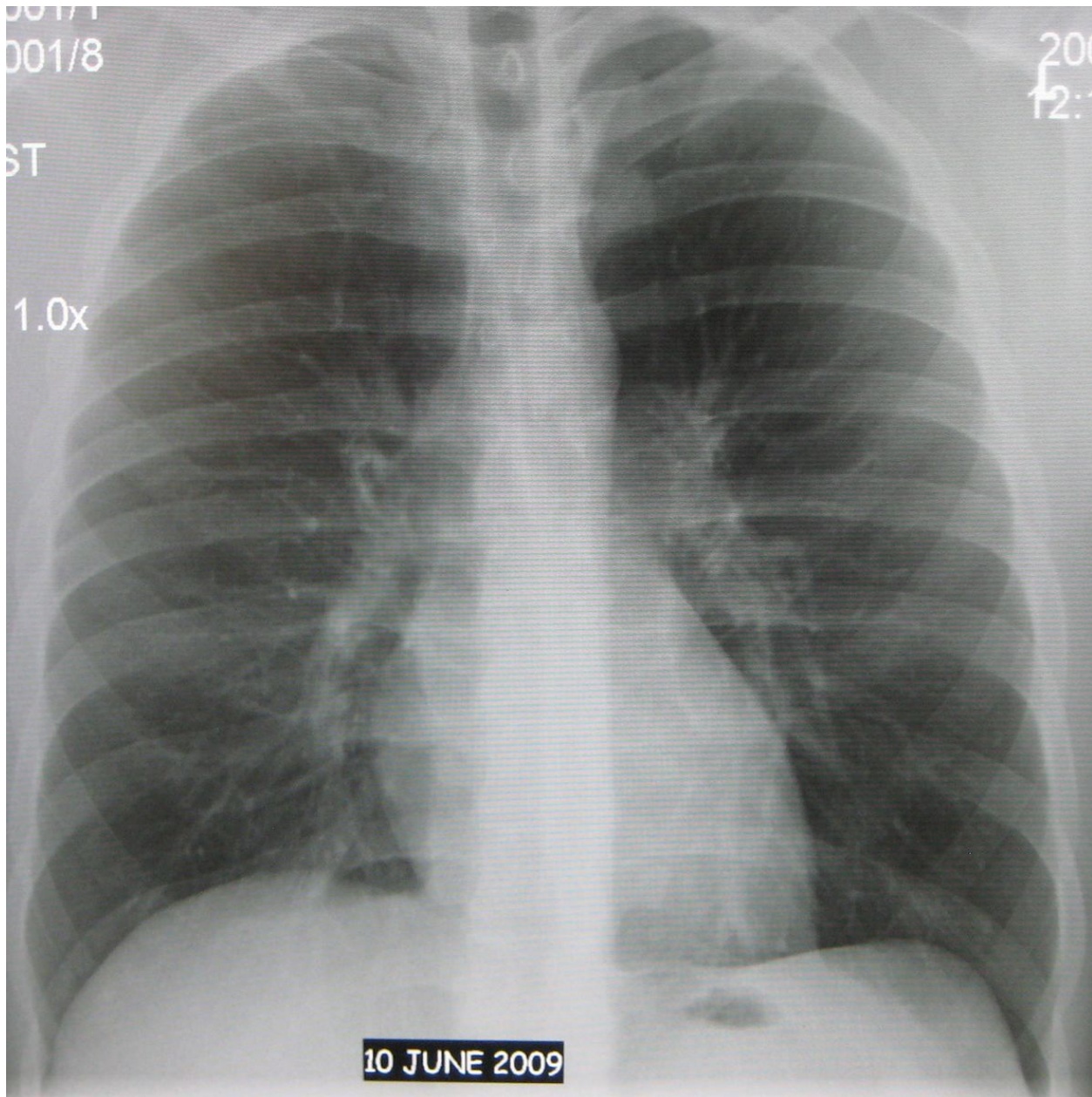


# INSTRUCTOR MATERIALS

## *Chest Radiograph*

Heilman, J. Normal AP chest x-ray. In: Wikimedia Commons.

[https://commons.wikimedia.org/wiki/File:Normal\\_AP.JPG](https://commons.wikimedia.org/wiki/File:Normal_AP.JPG). Published May 11, 2009. CC BY 3.0.



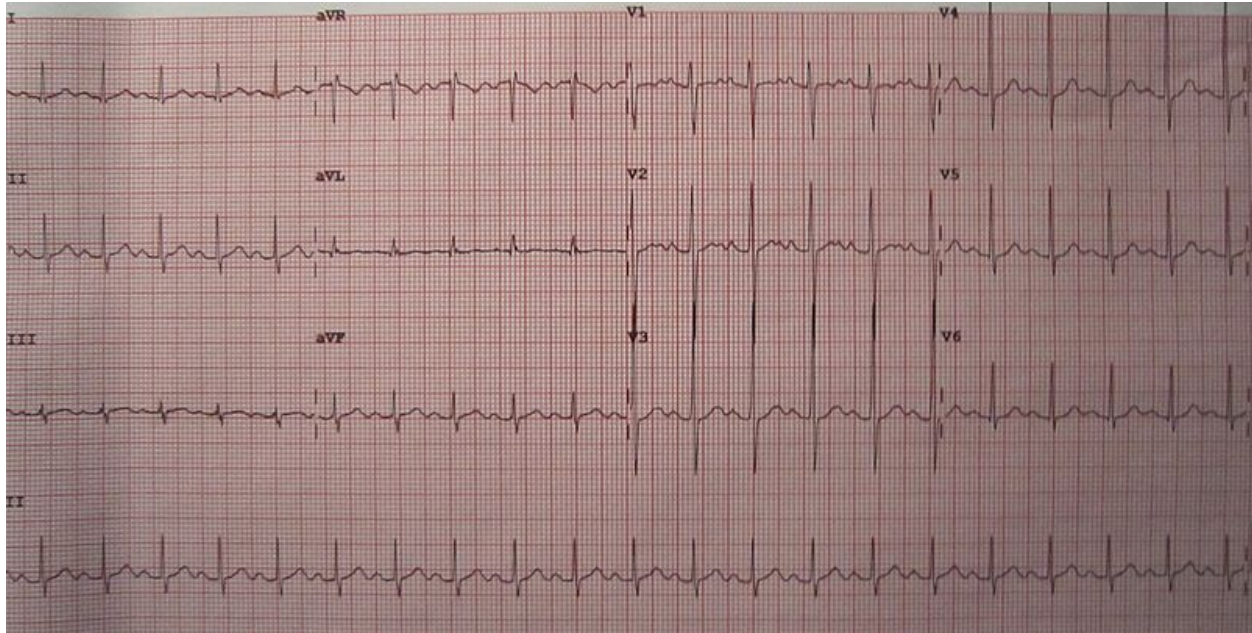


# INSTRUCTOR MATERIALS

## *Electrocardiogram*

Heilman, J. Sinus tachycardia as seen on ECG. In: Wikimedia Commons.

<https://commons.wikimedia.org/wiki/File:Sinustachy.JPG>. Published June 15, 2012. CC BY-SA 3.0.





# INSTRUCTOR MATERIALS

## *Complete blood count (CBC)*

White blood count (WBC)	13.0 x1000/mm <sup>3</sup> (H)
Hemoglobin (Hgb)	12.5 g/dL
Hematocrit (HCT)	36.0%
Platelet (Plt)	270 x1000/mm <sup>3</sup>
Segs:	70%
Bands:	7%

## *Basic metabolic panel (BMP)*

Sodium	133 mEq/L
Chloride	100 mEq/L
Potassium	4.2 mEq/L
Bicarbonate (HCO <sub>3</sub> )	15 mEq/L
Blood Urea Nitrogen (BUN)	60 mg/dL
Creatine (Cr)	2.2 mg/dL
Glucose	85 mg/dL
Calcium	6.4 mg/dL

## *Liver Function Tests (LFTs)*

Aspartate Aminotransferase (AST)	30 Units/L
Alanine Aminotransferase (ALT)	40 Units/L
Total Bilirubin (T bili)	0.8 mg/dL
Direct Bilirubin (D bili)	0.2 mg/dL
Albumin	3.8 g/dL
Alkaline Phosphate (alk phos)	46 Units/L
Total Protein:	7.0 g/dL

## *Coagulation Studies*

Prothombin Time (PT)	11 seconds
International Normalized Ratio (INR)	0.8
Partial Thromboplastin Time (PTT)	35 seconds

*Lactic Acid* 3.2 mmol/L

*Troponin* <0.015 mcg/L



## INSTRUCTOR MATERIALS

<i>Ethanol</i>	<0.001 mg/dL
<i>Salicylate level</i>	None detected
<i>Acetaminophen level</i>	None detected
<i>Serum osmolality</i>	316
<i>Arterial blood gas (ABG)</i>	
pH	7.25
pCO <sub>2</sub>	32 mmHg
pO <sub>2</sub>	94 mmHg
HCO <sub>3</sub>	16 mEq/L
O <sub>2</sub> saturation	96% on room air
<i>Urinalysis (UA)</i>	
Leukocyte esterase	negative
Nitrites	negative
Blood	none
Ketones	none
Glucose	none
Color	dark yellow
White blood cells (WBC)	0-5 WBCs/high powered field (HPF)
Red blood cells (RBC)	0-5 RBCs/HPF
Squamous epithelial cells	0-5 cells/HPF
Specific gravity	1.015
Other	calcium oxalate crystals, muddy brown casts present



# INSTRUCTOR MATERIALS

## *Urine Toxicology Screen*

Amphetamines	Negative
Barbiturates	Negative
Benzodiazepines	Negative
Cocaine	Negative
Methadone	Negative
Opiates	Negative
Oxycodone	Negative
PCP	Negative
THC	Negative

*Carboxyhemoglobin* 1%



# OPERATOR MATERIALS

## SIMULATION EVENTS TABLE:

Minute (state)	Participant action/ trigger	Patient status (simulator response) & operator prompts	Monitor display (vital signs)
0:00 (Baseline)	Participants should begin by placing the patient on a monitor, obtaining a history and physical exam.	Patient moved into bed in the emergency department.	T 98°F HR 126 BP 154/72 RR 24 O <sub>2</sub> sat 98% RA
4:00	Participant should perform a thorough physical exam, obtain ECG, obtain a point-of-care glucose level, order labs and CT head.	If the team administers IV fluids, tachycardia will improve  If the team does not administer IV fluids, patient will become more hypotensive and tachycardic.	With IV fluids: T 98°F HR 110 BP 120/60 RR 24 O <sub>2</sub> sat 98% RA  Without IV fluids: T 98°F HR 140 BP 100/70 RR 30 O <sub>2</sub> sat 98% RA
6:00	Blood work, CT, urine, ECG are available.  Participants should recognize likely ethylene glycol intoxication based on history and labs.	If participants ask to check urine fluorescence under a Wood's lamp, it will be made available by the nurse. If participants discuss lumbar puncture with wife, she adamantly refuses, saying that he hates needles, and "aren't there other tests you can run to figure out what's wrong with him?"  If participants do not recognize ethylene glycol intoxication, then wife may state that she found an empty bottle of antifreeze in the garage. Once directly questioned, patient will admit to intentional ingestion as a suicide attempt.	



# OPERATOR MATERIALS

Minute (state)	Participant action/ trigger	Patient status (simulator response) & operator prompts	Monitor display (vital signs)
8:00	Participants may call Poison Control.	<p>If they do not but team suspects toxic ingestion, nursing can prompt learners to call – “Is there anyone else we can call if you’re worried that he took something?”</p> <p>If poison control is called for undifferentiated encephalopathy or unspecific toxic alcohol ingestion, the phone line will be busy</p> <p>Poison control will only be available once team voices specific concern for ethylene glycol ingestion. How helpful poison control will be is left to the discretion of the facilitator. Poison control may provide all treatment suggestions (medications, dialysis indications, and doses), just dosages, or may just confirm the accuracy of medications and doses provided by the team. Poison control may offer adjunctive therapies (pyridoxine and thiamine) to the team.</p>	
10:00	Participants should order fomepizole to prevent further metabolism of ethylene glycol.	<p>(A) If team administers fomepizole, vitals will stabilize. Continue to 15:00.</p>	<p>With fomepizole: and with IV fluids: T 98°F HR 104 BP 130/70 RR 22 O<sub>2</sub>sat 98% RA</p> <p>With fomepizole but if IVF have not been given: T 98°F HR 120 BP 90/60 RR 24 O<sub>2</sub>sat 98% RA</p>



# OPERATOR MATERIALS

Minute (state)	Participant action/ trigger	Patient status (simulator response) & operator prompts	Monitor display (vital signs)
		<p>(B) If fomepizole is not administered, patient will progressively become hypotensive and more tachycardic.</p> <p>If fomepizole is still not given after two more minutes, the patient will go into pulseless electrical activity (PEA) cardiac arrest (see 12:00).</p>	<p>Without fomepizole (regardless if IVF given):</p> <p>T 98°F HR 150 BP 80/50 RR 24 O<sub>2</sub>sat 98% RA</p>
12:00 Patient arrests	Participants run ACLS with appropriate CPR, epinephrine administration and oxygenation with bag-valve-mask.	<p>Patient will be unresponsive.</p> <p>PEA arrest on the monitor.</p> <p>Return of spontaneous circulation (ROSC) will be achieved with 2 rounds of appropriate ACLS.</p>	<p>HR 0 BP 0 RR bag-valve-mask (BVM) O<sub>2</sub>sat 94%</p> <p>Post-ROSC HR: 110 BP: 90/50 RR: BVM (bag-valve-mask) rate O<sub>2</sub>sat 97% BVM</p>
15:00 Case Completion	Participants call nephrology for hemodialysis consideration and ICU for admission. Participants sign out to the ICU.	<p>If nephrology is called without the specific request to evaluate for hemodialysis, they will state they are busy and to call them back when you know what you want from them.</p> <p>If nephrology is contacted to evaluate for hemodialysis, they will say they will be right down to evaluate the patient.</p> <p>If the ICU is called but providers do not specifically state that the patient has ethylene glycol toxicity, the intensivist will tell them to call back when they figure out what's wrong with him, then hang up.</p> <p>If ICU is contacted for ethylene glycol toxicity admission but nephrology was not yet called, the intensivist will tell them that they are busy and to</p>	<p>If patient did not arrest</p> <p>T 98°F HR 80 BP 120/80 RR 12 O<sub>2</sub>sat 98% RA</p> <p>Post-ROSC HR: 110 BP: 90/50 RR: BVM rate O<sub>2</sub>sat 97% BVM</p>



# OPERATOR MATERIALS

Minute (state)	Participant action/ trigger	Patient status (simulator response) & operator prompts	Monitor display (vital signs)
		<p>call someone else to help them manage the patient in the meantime.</p> <p>If ICU is called and the patient has been treated appropriately with IV fluids and fomepizole, nephrology has been contacted, and the team reports concern for ethylene glycol toxicity, the ICU will accept the patient.</p> <p>If the patient arrested, ICU will ask why the patient arrested. They may provide further treatment guidance as felt appropriate per instructor. Then they will accept the patient.</p> <p>Case ends.</p>	

**Diagnosis:**

Ethylene Glycol Ingestion

**Disposition:**

Admit to ICU



# DEBRIEFING AND EVALUATION PEARLS

## Ethylene Glycol Ingestion

### Ingestions and Altered Mental Status

Do not forget to assess for co-ingestants and non-toxicologic causes of altered mental status, including but not limited to hypoglycemia, infections, seizures, stroke, and head trauma.

### Ingestions and Suicide

All patients with a suspected overdose should be screened for suicidal intent.

### Toxic Alcohols

The differential for an elevated anion gap after liquid ingestion should always include toxic alcohol ingestion, especially if the patient appears intoxicated but there is no clear history of ethanol ingestion or the patient does not smell of ethanol. Once discovered, clinicians should also order a lactate and calculate an osmolal gap.<sup>2</sup>

Methanol is found in windshield-washer fluid, while ethylene glycol is present in antifreeze, engine coolant, and brake fluid. Isopropanol may be found in hand sanitizer and rubbing alcohol. Diethylene glycol may be found in automotive brake fluid, as a manufacturing solvent, or as a diluent in pediatric medications. Propylene glycol can be found in several consumer products, but toxicity may be seen in hospitalized patients, as high-dose infusions of medications which contain propylene glycol as a diluent (including phenobarbital, lorazepam, phenytoin, diazepam, esmolol, and nitroglycerin). Isopropanol is available as a 70% rubbing alcohol solution.<sup>1</sup>

Toxic alcohols cause inebriating effects, but only isopropanol is directly toxic. Ethylene glycol and methanol are first metabolized by alcohol dehydrogenase and then subsequently by aldehyde dehydrogenase to their toxic metabolites. Methanol is metabolized to formic acid, while ethylene glycol is metabolized to glycolic acid, glyoxylic acid, and the nephrotoxic oxalic acid. Propylene glycol metabolizes to lactate, and isopropanol metabolizes into acetone.<sup>2, 3</sup>

Co-ingestion of ethanol delays production of the toxic alcohol metabolites because ethanol is a competitive substrate for alcohol dehydrogenase.<sup>1</sup>

Methanol toxicity is most commonly associated with vision impairment, including the classically described “snowstorm vision,” as well as abdominal pain, nausea, and vomiting.<sup>2</sup>



## DEBRIEFING AND EVALUATION PEARLS

Oxalic acid from ethylene glycol forms oxalate crystals which deposit in the kidney, as well as the lungs and heart. Not all ethylene glycol containing liquids contain the fluorescein additive that cause urinary oxalate crystals to fluoresce under a Wood's lamp, and false-positive tests are common. Deposition of oxalate crystals in the cerebral vasculature may result in neurotoxicity. The oxalate crystals precipitate with calcium, which may induce symptomatic hypocalcemia.<sup>2</sup>

Isopropanol toxicity induces ketosis without acidosis.<sup>2</sup>

Toxic alcohols increase both serum osmolality and the osmolal gap. Calculated serum osmolality may be calculated by  $(2 \times \text{Na}^+ \text{ [in millimoles per liter]}) + (\text{blood urea nitrogen [in milligrams per deciliter]} \div 2.8) + (\text{glucose [in milligrams per deciliter]} \div 18)$ .<sup>4</sup>

Measured serum osmolality – calculated serum osmolality = osmolal gap.  
The normal osmolal gap is less than 10 mOsm/kg of water.<sup>4</sup>

Initially, the osmolal gap is elevated from accumulation of the initial parent alcohol, but the gap decreases as the alcohols are metabolized. Co-ingestion of ethanol will prolong the anion gap because it impedes the metabolism of the toxic parent alcohols.<sup>1</sup>

Conversely, the anion gap rises due to the increase in toxic metabolites. Therefore, early ingestions present with an elevated osmolal gap and a normal anion gap, while later ingestions may present with a normal osmolal gap and an elevated anion gap.<sup>1</sup>

Some ethylene glycol metabolites, such as glycolate, are closely structurally similar to lactate, causing a factitious elevated lactic acid level and subsequently induce an even higher anion gap.<sup>2</sup>

Lactic acidosis, ketoacidosis, and chronic kidney disease may also cause elevated osmolal and anion gaps.<sup>2</sup>

Toxic alcohols are rapidly absorbed from the GI tract. Gastric decontamination is not effective for toxic alcohol ingestions.<sup>2</sup>

Fomepizole inhibits alcohol dehydrogenase and has minimal side effects. If this is not readily available, ethanol may be given orally or intravenously to inhibit alcohol dehydrogenase.



# DEBRIEFING AND EVALUATION PEARLS

Dosing includes a 15 mg/kg IV loading dose, then 10 mg/kg IV every twelve hours for forty-eight hours. If a patient requires hemodialysis, dosing is increased to every four hours.<sup>3,5</sup>

Do not delay fomepizole treatment for volatile panel confirmation or if the osmolal gap is not significantly elevated because the patient may have had bloodwork drawn relatively later in the clinical course<sup>2</sup>. Generic forms of fomepizole are now available.<sup>3</sup>

Fomepizole should not be given to patients with isolated isopropyl toxicity, however, because it will delay its metabolization and cause a prolonged intoxication.<sup>5</sup>

Hemodialysis should be initiated for severe metabolic acidosis, methanol concentrations above 50mg/dl, ethylene glycol concentrations above 50mg/dl, isopropanol concentrations above 500 mg/dL, hemodynamic instability, visual disturbances after methanol ingestion, or acute kidney injury.<sup>1</sup>

Treatment of propylene glycol is largely conservative with discontinuation of the offending agent, but hemodialysis may be indicated if otherwise unexplained lactic acidosis develops.<sup>1</sup>

Folate may be used as an adjunctive therapy for methanol toxicity. Folate assists in the metabolism of the toxic formic acid metabolite to water and carbon monoxide.<sup>5</sup>

Adjunctive therapies for ethylene glycol ingestions includes pyridoxine and thiamine. Pyridoxine 100mg IV encourages the metabolism of ethylene glycol to other substrates instead of downstream toxic metabolites, and thiamine 100 mg IV converts glyoxylic acid to alpha-hydroxy-beta-ketoadipic acid versus oxalic acid.<sup>5</sup>

## Other debriefing points

Closed-loop communication among the team: was it used? Why or why not?

Were there any implications of using it as opposed to not using it during case execution?

## Pearls Section References

1. Kraut JA, Mullins ME. Toxic alcohols. *N Engl J Med*. 2018;378(3):270-280. doi: 10.1056/NEJMra1615295
2. Wiener SW. Toxic alcohols. In: Hoffman RS, Howland M, Lewin NA, Nelson LS, Goldfrank LR, eds. *Goldfrank's Toxicologic Emergencies*. 10th ed. New York, NY: McGraw-Hill; 2015:804-816.



## DEBRIEFING AND EVALUATION PEARLS

3. McMartin K, Jacobsen D, Hovda KE. Antidotes for poisoning by alcohols that form toxic metabolites. *Br J Clin Pharmacol*. 2016;81(3):505–515. doi: 10.1111/bcp.12824
4. Scalley RD, Ferguson DR, Smart ML, Archie TE. Treatment of ethylene glycol poisoning. *Am Fam Physician*. 2002;66(5):807-812.
5. Cohen JP, Quan D. Alcohols. In: Tintinalli, JE, Stapczynski J, Ma O, Cline DM, Yealy D, Meckler GD, eds. *Tintinalli's Emergency Medicine: A Comprehensive Study Guide*. 8<sup>th</sup> ed. New York, NY: McGraw-Hill; 2016:1243-1251.



# SIMULATION ASSESSMENT

## *Ethylene Glycol Ingestion*

Learner: \_\_\_\_\_

### **Assessment Timeline**

This timeline is to help observers assess their learners. It allows observer to make notes on when learners performed various tasks, which can help guide debriefing discussion.

#### **Critical Actions:**

1. Order IV access and order IV fluid bolus.
2. Obtain point of care glucose level.
3. Identify increased osmolality gap.
4. Order insertion of foley catheter.
5. Identify and treat hypocalcemia.
6. Order appropriate toxicology blood work, including acetaminophen and salicylate levels.
7. Administer fomepizole.
8. Discuss the case with the poison control center.
9. Discuss the case with nephrology.
10. Admit to the intensive care unit.

0:00



# SIMULATION ASSESSMENT

## *Ethylene Glycol Ingestion*

Learner: \_\_\_\_\_

### **Critical Actions:**

- Order IV access and order IV fluid bolus.
- Obtain point of care glucose level.
- Identify increased osmolality gap.
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- Order appropriate toxicology blood work, including acetaminophen and salicylate levels.
- Administer fomepizole.
- Discuss the case with the poison control center.
- Discuss the case with nephrology.
- Admit to the intensive care unit.

### **Summative and formative comments:**



# SIMULATION ASSESSMENT

## Ethylene Glycol Ingestion

Learner: \_\_\_\_\_

### Milestones assessment:

	Milestone	Did not achieve level 1	Level 1	Level 2	Level 3
1	<b>Emergency Stabilization (PC1)</b>	<input type="checkbox"/> Did not achieve Level 1	<input type="checkbox"/> Recognizes abnormal vital signs	<input type="checkbox"/> Recognizes an unstable patient, requiring intervention  Performs primary assessment  Discerns data to formulate a diagnostic impression/plan	<input type="checkbox"/> Manages and prioritizes critical actions in a critically ill patient  Reassesses after implementing a stabilizing intervention
2	<b>Performance of focused history and physical (PC2)</b>	<input type="checkbox"/> Did not achieve Level 1	<input type="checkbox"/> Performs a reliable, comprehensive history and physical exam	<input type="checkbox"/> Performs and communicates a focused history and physical exam based on chief complaint and urgent issues	<input type="checkbox"/> Prioritizes essential components of history and physical exam given dynamic circumstances
3	<b>Diagnostic studies (PC3)</b>	<input type="checkbox"/> Did not achieve Level 1	<input type="checkbox"/> Determines the necessity of diagnostic studies	<input type="checkbox"/> Orders appropriate diagnostic studies.  Performs appropriate bedside diagnostic studies/procedures	<input type="checkbox"/> Prioritizes essential testing  Interprets results of diagnostic studies  Reviews risks, benefits, contraindications, and alternatives to a diagnostic study or procedure
4	<b>Diagnosis (PC4)</b>	<input type="checkbox"/> Did not achieve Level 1	<input type="checkbox"/> Considers a list of potential diagnoses	<input type="checkbox"/> Considers an appropriate list of potential diagnosis  May or may not make correct diagnosis	<input type="checkbox"/> Makes the appropriate diagnosis  Considers other potential diagnoses, avoiding premature closure



# SIMULATION ASSESSMENT

## Ethylene Glycol Ingestion

Learner: \_\_\_\_\_

	Milestone	Did not achieve level 1	Level 1	Level 2	Level 3
5	<b>Pharmacotherapy (PC5)</b>	<input type="checkbox"/> Did not achieve Level 1	<input type="checkbox"/> Asks patient for drug allergies	<input type="checkbox"/> Selects an medication for therapeutic intervention, consider potential adverse effects	<input type="checkbox"/> Selects the most appropriate medication and understands mechanism of action, effect, and potential side effects  Considers and recognizes drug-drug interactions
6	<b>Observation and reassessment (PC6)</b>	<input type="checkbox"/> Did not achieve Level 1	<input type="checkbox"/> Reevaluates patient at least one time during case	<input type="checkbox"/> Reevaluates patient after most therapeutic interventions	<input type="checkbox"/> Consistently evaluates the effectiveness of therapies at appropriate intervals
7	<b>Disposition (PC7)</b>	<input type="checkbox"/> Did not achieve Level 1	<input type="checkbox"/> Appropriately selects whether to admit or discharge the patient	<input type="checkbox"/> Appropriately selects whether to admit or discharge  Involves the expertise of some of the appropriate specialists	<input type="checkbox"/> Educates the patient appropriately about their disposition  Assigns patient to an appropriate level of care (ICU/Tele/Floor)  Involves expertise of all appropriate specialists
9	<b>General Approach to Procedures (PC9)</b>	<input type="checkbox"/> Did not achieve Level 1	<input type="checkbox"/> Identifies pertinent anatomy and physiology for a procedure  Uses appropriate Universal Precautions	<input type="checkbox"/> Obtains informed consent  Knows indications, contraindications, anatomic landmarks, equipment, anesthetic and procedural technique, and potential complications for common ED procedures	<input type="checkbox"/> Determines a back-up strategy if initial attempts are unsuccessful  Correctly interprets results of diagnostic procedure



# SIMULATION ASSESSMENT

## Ethylene Glycol Ingestion

Learner: \_\_\_\_\_

	Milestone	Did not achieve level 1	Level 1	Level 2	Level 3
20	<b>Professional Values (PROF1)</b>	<input type="checkbox"/> Did not achieve Level 1	<input type="checkbox"/> Demonstrates caring, honest behavior	<input type="checkbox"/> Exhibits compassion, respect, sensitivity and responsiveness	<input type="checkbox"/> Develops alternative care plans when patients' personal beliefs and decisions preclude standard care
22	<b>Patient centered communication (ICS1)</b>	<input type="checkbox"/> Did not achieve level 1	<input type="checkbox"/> Establishes rapport and demonstrates empathy to patient (and family) Listens effectively	<input type="checkbox"/> Elicits patient's reason for seeking health care	<input type="checkbox"/> Manages patient expectations in a manner that minimizes potential for stress, conflict, and misunderstanding.  Effectively communicates with vulnerable populations, (at risk patients and families)
23	<b>Team management (ICS2)</b>	<input type="checkbox"/> Did not achieve level 1	<input type="checkbox"/> Recognizes other members of the patient care team during case (nurse, techs)	<input type="checkbox"/> Communicates pertinent information to other healthcare colleagues	<input type="checkbox"/> Communicates a clear, succinct, and appropriate handoff with specialists and other colleagues  Communicates effectively with ancillary staff