Target Audience: Emergency Medicine Residents, Medical Students

Primary Learning Objectives:

1. Recognize signs and symptoms of ethylene glycol and toxic alcohol (TA) ingestions
2. Recognize and interpret blood gas, anion gap, and osmolal gap in setting of TA ingestion
3. Demonstrate knowledge of initial management of patient with TA ingestion
4. Discuss potential complications of ethylene glycol ingestion
5. Order appropriate laboratory and radiology studies in ethylene glycol toxicity/ingestion

Secondary Learning Objectives: detailed technical/behavioral goals, didactic points

1. Describe the diagnostic and therapeutic priorities in the management of the patient with altered mental status
2. Propose a differential diagnosis for toxin-associated altered mental status
3. Recognize the influence bias has on the formulation of a differential diagnosis, especially in situations where information is limited or conflicted
4. Recognize indications for hemodialysis after a toxic alcohol ingestion

Critical actions checklist:

1. Obtain appropriate diagnostics
2. Recognize the osmolal gap
3. Start intravenous fluid resuscitation
4. Initiate serum alkalinization
5. Initiate alcohol dehydrogenase blockade
6. Get Nephrology Consultation for hemodialysis
7. Consult Poison Center/Toxicology

Environment:

1. Room Set Up – ED psychiatric holding area
    a. Manikin Set Up – Mid or high fidelity simulator, tachypneic
    b. Props – Standard ED equipment
2. Distractors – ED noise, nurse leading that “this is a drunk we know well”

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CASE SUMMARY

SYNOPSIS OF HISTORY/ Scenario Background

The setting is a “psychiatric area” of an urban emergency department.

Patient is a 52-year-old female with a history of alcoholism and depression brought to the emergency department by EMS for altered mental status and alcohol intoxication. She is well known to the department. She was found staggering down the middle of street and “smelled of alcohol” per medic report. She was directed to the psychiatric holding area to sleep it off.

PMHx: depression, hypertension, alcoholism
PSHx: none known
Medications: sertraline, Lisinopril (known history of poor compliance)
Allergies: NKDA
SocHx: 1 ppd cigarettes, daily alcohol (previously reported as 1/5 of vodka daily), no illicits

[Patient has ingested antifreeze; she is drowsy, mildly hypotensive, tachycardic, and tachypneic. She is placed in the psychiatric holding area for presumed alcohol intoxication. The nurse should resist bringing the patient to the acute care area of the emergency department for appropriate medical evaluation.]

SYNOPSIS OF PHYSICAL

Patient is initially drowsy and will push the examiner away.
Notable signs include tachycardia and tachypnea. She is mildly hypotensive.
Airway is protected.
Neurologic exam notable for altered mental status as noted above.
Pupils are mildly dilated, briskly reactive.
Skin is dry. Mucous membranes are dry.

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CRITICAL ACTIONS

1. Obtain appropriate diagnostics

Order appropriate diagnostics. **At a minimum**, this must include (1) an ethanol level (Breathalyzer or serum ethanol level is sufficient); (2) BMP (3) pH (venous or arterial blood gas is sufficient), (4) serum osmolality, (5) urinalysis with microscopy, (6) toxic alcohol levels (ethylene glycol, methanol, isopropyl alcohol, propylene glycol), although these will be made unavailable (6) serum calcium or ionized calcium (patient may be hypocalcemic because oxalate binding of calcium).
Cueing Guideline: The nurse can ask if the doctor would like to do order any diagnostic tests. The nurse can state that, if the participant asks for toxic alcohol levels, those tests will be sent, but results will not be immediately available.

2. Recognize the osmolal gap

The examinee should be able to calculate the serum osmolality using the formula OsmGap = (Osmolality) – (2[Na] + [BUN]/2.8 + [Glucose]/18 + [Ethanol]/4.6) – assuming units are given the U.S. system – and recognize the gap.
Cueing Guideline: The nurse should ask if any other tests could be done in the setting of a negative ethanol level to help explain the altered mental status.

3. Start intravenous fluid resuscitation

Bilateral large bore IV access should be established as the patient is hypotensive and tachycardic. 1-2 L of crystalloid should be given. The patient should receive a total of 4-6 liters of crystalloid during the case.
Cueing Guideline: The nurse may say, “We have a line in place. Would you like any fluids?” Alternatively, the nurse can mention the tachycardia. If not done, the patient will become more tachycardic (140s) and BP may drop to 75/43.

4. Initiate serum alkalinization

Recognize severe metabolic acidosis. Give 2-4 amps of sodium bicarbonate and start a bicarbonate infusion (150 mEq of $NaHCO_3$ or 3 amps of $NaHCO_3$ in 1 L of D5W; bonus points for addition of 20-40 mEq KCl to the infusion) at 200 cc/hr.
Cueing Guideline: Nursing can note worsening hypotension if pH correction is not addressed. Reemphasis of blood gas or BMP results can be made.

5. **Initiate alcohol dehydrogenase blockade**

   15 mg/kg of fomepizole should be ordered. Administration of ethanol is also sufficient – 4-5 shots of hard liquor down a nasogastric tube. IV ethanol is not available. (Target serum ethanol level should be 100-150 mg/dL if fomepizole is not available).
   Cueing Guideline: If not done, patient will become increasingly tachypneic and altered. If blood gas repeated, metabolic acidosis will be more profound. Acidosis will be refractory to sodium bicarbonate. Ultimately, patient will seize and die.

6. **Get Nephrology Consultation for hemodialysis**

   Due to high osmolal gap and severe metabolic acidosis, the patient requires hemodialysis for removal of ethylene glycol and metabolites and correction of pH.
   Cueing Guideline: patient will continue to decompensate with hypotension, progressive obtundation, and seizure refractory to bicarbonate or other measures.

7. **Consult Poison Center/Toxicologist**

   The local Poison Center or Toxicology service should be consulted for further management recommendations (addition of pyridoxine and thiamine, dosing of fomepizole, criteria for initiation of hemodialysis, etc.)
   Cueing Guideline: The nurse can ask the doctor if the Poison Center/Toxicologist have been called yet.

Critical Actions Checklist[1]

Resident Name	
Case Description	

Skills measured **Core competencies: PC** Patient care, **MK** Medical knowledge, **IC** Interpersonal and communication skills **P** Professionalism, **PB** Practice-based learning and improvement **SB** Systems-based practice	Very Unacceptable		Unacceptable		Acceptable		Very Acceptable	
Data Acquisition (D) PC MK I	1	2	3	4	5	6	7	8
Problem Solving (S) PC MK PB	1	2	3	4	5	6	7	8
Patient Management (M) PC MK IC P PB SB	1	2	3	4	5	6	7	8
Resource Utilization (R) PC PB SB	1	2	3	4	5	6	7	8
Health Care Provided (H) PC SB	1	2	3	4	5	6	7	8
Interpersonal Relations (I) IC P	1	2	3	4	5	6	7	8
Comprehension of Pathophysiology (P) MK PB	1	2	3	4	5	6	7	8
Clinical Competence (C) PC MK IC P PB SB	1	2	3	4	5	6	7	8

Critical Actions

Yes	No		Comments:
		Obtain appropriate diagnostics	
		Recognize the osmolal gap	
		Start intravenous fluid resuscitation	
		Initiate serum alkalinization	
		Initiate alcohol dehydrogenase blockade	
		Get Nephrology Consultation for hemodialysis	
		Consult Poison Center/Toxicology	

Yes	No	
		Dangerous actions

[1] Modified ABEM Oral Certification Examination checklist and scoresheet

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HISTORY

You are called to see a new patient (52-year-old female) in the psychiatric holding area of the Emergency Department. She was brought in by police for public intoxication. She is well known to the Department.

Onset of Symptoms: Unknown

Background Info: 52-year-old female is drowsy and arouses to tactile stimulus. She cannot, or refuses to, provide history. She was found in this state 1-hour prior to arrival. She is known for multiple previous visits for alcohol intoxication.

Additional History

From Police: If asked, patient was found staggering down a city street. They are familiar with this patient from prior episodes of alcohol intoxication.

Chief Complaint: Altered mental status, intoxication

Past Medical Hx: Depression, hypertension

Past Surgical Hx: None known

Habits:
Smoking: 1 ppd
ETOH: daily, vodka
Drugs: none

Family Med Hx: Hypertension, diabetes

Social Hx:
Marital Status: Single
Children: None
Employment: Unemployed

ROS: Patient is unable to answer.

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CASE CONTINUATION

You are called for initial evaluation of this intoxicated patient who has been placed in the psychiatric holding area of the Emergency Department.

Vital Signs: BP: 85/57 mmHg P: 127/minute R: 37/minute T: 35.9C (96.6F)
POx: 94% (FiO_2=0.21)

Primary Survey

- Airway – Patent. Groans and slurs speech when stimulated.
- Breathing – Marked tachypnea, no increased work of breathing, 94% SpO_2
- Circulation – Tachycardia (120's), SBP 80's, radial pulses diminished
- Disability – Patient is drowsy. Speech is barely intelligible.
- Exposure – No trauma, rash, drug patches.

Required Actions Over Time 0-2 Minutes

- Move patient to critical care or acute care area of the Emergency Department
- Establish safety net (IV, oxygen, cardiac monitor, two large bore IVs, draw blood for labs, blood gas)
- A/B – Provide supplemental oxygen.
- C – Cardiac monitor; 2-4L IV crystalloid bolus for presumed volume depletion
- D – Finger stick glucose = 90 mg/dL; labs are sent

Branch Point

- **IF NO INTERVENTIONS ARE PERFORMED,** then the patient becomes more hypotensive (78/45 mmHg) and tachycardic (138/minute).
- **SEDATION, PARALYSIS AND ENDOTRACHEAL INTUBATION IN THE PATIENT WITH SEVERE METABOLIC ACIDOSIS CAN BE EXTREMELY DANGEROUS. AT FACULTY DISCRETION, IF THIS PROCEDURE IS PERFORMED SLOWLY OR DELAYED FOLLOWING THE ADMINISTRATION OF PARALYTICS,** then the patient will suddenly develop worsening acidosis and sudden cardiac arrest will develop.
- **IF AT ANY TIME DURING THE CASE, ENDOTRACHEAL INTUBATION IS PERFORMED AND VENTILATOR SETTINGS ARE NOT ADJUSTED TO MAINTAIN THE RESPIRATORY RATE AND PARAMETERS AT LEVELS APPROPRIATE IN THE CONTEXT OF SEVERE METABOLIC ACIDOSIS (e.g., INCREASED RATE, ADEQUATE I:E RATIO),** the patient will suddenly develop worsening acidosis and sudden cardiac arrest will develop.

CASE CONTINUATION

General Appearance: Middle-aged, disheveled woman, appears to be sleeping.

Vital Signs: BP: 85/57 mmHg P: 127/minute R: 37/minute T: 35.9C (96.6F)
POx: 94% (FiO_2=0.21)

Head: Normocephalic and atraumatic

Eyes: PERRL, pupils 4-5 mm OU

Ears: TM's normal.

Mouth: Dry mucous membranes

Neck: Trachea midline, supple

Skin: Warm, dry, no rash

Chest: Notable tachypnea and hyperpnea. No trauma. Good chest rise

Lungs: Clear, equal bilaterally, tachypneic and hyperpneic (if the patient has been intubated, mechanical breath sounds)

Heart: Tachycardic, S1 S2, no murmurs

Back: Normal

Abdomen: Soft, non-tender, no signs of trauma, no rebound/guarding

Extremities: No signs of trauma, no edema, radial pulses weak, central pulses strong

Genital: Digital vaginal exam negative for retained foreign body

Rectal: Normal tone, guaiac negative

Neurological: Groans to pain, pushes examiner away. Moves all 4 extremities though follows commands poorly. No hyperreflexia or clonus

Mental Status: Drowsy

Required Actions over Time 2-4 Minutes

- Further resuscitation with IV NS 1-2 L
- Obtain and interpret lab results including blood gas, BMP, and osmolality
- Administer 2-4 50-mL ampules of 8.4% $NaHCO_3$ IV bolus
- May order non-contrast head CT but cannot obtain until patient is more stable
- May place a Foley catheter (drain 900 mL of urine)

Branch Points

- **IF NO INTERVENTIONS ARE PERFORMED,** then the patient continues to worsen, becoming even more hypotensive and tachycardic.

Required Actions over Time 4-6 Minutes

- SBP remains in 90s mmHg
- Serum/urine toxicology diagnostic tests are all undetectable.
- Microscopy on UA will have calcium oxalate crystals
- If urine is fluoresced with Wood's lamp, it will fluoresce
- Participant must now recognize presence of toxic alcohol
- Fomepizole (15 mg/kg) or ethanol via NG tube (4-5 shots of liquor would suffice) administration should be initiated by this time

Branch Points

- **IF ALCOHOL DEHYDROGENASE BLOCKADE IS NOT INITIATED BY THIS TIME,** then the patient 's acidosis will continue to worsen, mental status will deteriorate, and Kussmaul respirations will worsen.

Required Actions over the Remainder of the Case
Branch Points

- Arrange for MICU admission
- Contact PC/Toxicology for further recommendations
- Contact Nephrology for hemodialysis

- **IF NEPHROLOGY IS NOT CONSULTED,** then the patient will develop hypotension and acidosis refractory to fluid resuscitation and sodium bicarbonate administration

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STIMULUS INVENTORY

#1	Complete blood count
#2	Basic metabolic panel
#3	Urinalysis
#4	Liver function tests
#5	Venous blood gas
#6	Point-of-care glucose
#7	Toxicology
#8	Initial CXR
#9	Repeat CXR
#10	ECG
#11	Lactate

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LAB DATA & IMAGING RESULTS

Stimulus #1	
Complete Blood Count (CBC)	
WBC	20,400/mm^3
Hemoglobin	15.2 g/dL
Hematocrit	46%
Platelets	79,000/mm^3
Differential	
PMNLs	45%
Lymphocytes	55%
Monocytes	2%
Eosinophils	1%

Stimulus #2	**Basic Metabolic Profile (BMP)**	
	INITIAL	**REPEAT (no bicarb given)**
Sodium	142 mEq/L	142 mEq/L
Potassium	3.4 mEq/L	3.9 mEq/L
Chloride	108 mEq/L	100 mEq/L
Bicarbonate	9 mEq/L	4 mEq/L
Glucose	92 mg/dL	90 mg/dL
BUN	28 mg/dL	12 mg/dL
Creatinine	1.7 mg/dL	1 mg/dL
Calcium	7 mg/dL	

Stimulus #3	
Urinalysis	
Color	Yellow
Specific gravity	1.030
Glucose	Negative
Protein	Negative
Ketones	1+
Leuk. Esterase	Negative
Nitrites	Negative
WBC	0/hpf
RBC	0/hpf
Microscopic	Calcium oxalate crystals

Stimulus #4	
Liver Function Tests	
AST	57 U/L
ALT	48 U/L
Alk Phos	110 U/L
Total Bilirubin	1.1 mg/dL
Direct Bilirubin	0.2 mg/dL
Albumin	2.9 mg/dL
Protein	7 g/dL

Stimulus #5	
Initial Venous Blood Gas	
pH	7.20
pCO_2	24 mm Hg
pO_2	52 mm Hg
HCO_3 base deficit	9 mEq/L -17

Stimulus #6	
Troponin	
Value	< 0.01 ng/mL

Stimulus #7	
Toxicology	
Salicylate	Undetectable
Acetaminophen	Undetectable
Ethanol	Undetectable
Urine drug screen	
Amphetamines	Negative
Benzodiazepines	Negative
Cocaine	Negative
Opiates	Negative
TCAs	Negative
THC	Negative

Stimulus #8	
CXR	Normal

Stimulus #9	
CT head	Normal

Stimulus #10	
AXR	Normal

Stimulus #10	
ECG	NSR

Stimulus #11	
Venous Blood Gas (no bicarb given or HD)	
pH	7.02
pCO_2	16 mm Hg
pO_2	60 mm Hg
HCO_3 base deficit	4 mEq/L -24

Stimulus #1

Complete Blood Count (CBC)

WBC	20,400/mm^3
Hemoglobin	15.2 g/dL
Hematocrit	46%
Platelets	79,000/mm^3
Differential	
PMNLs	45%
Lymphocytes	55%
Monocytes	2%
Eosinophils	1%

Stimulus #2A

Initial Basic Metabolic Profile (BMP)

Sodium	142 mEq/L
Potassium	3.4 mEq/L
Chloride	108 mEq/L
Bicarbonate	9 mEq/L
Glucose	92 mg/dL
BUN	28 mg/dL
Creatinine	1.7 mg/dL
Calcium	7 mg/dL

Stimulus #2B

Repeat Basic Metabolic Profile (BMP)

Sodium	142 mEq/L
Potassium	3.9 mEq/L
Chloride	100 mEq/L
Bicarbonate	4 mEq/L
Glucose	90 mg/dL
BUN	12 mg/dL
Creatinine	1 mg/dL

Stimulus #3

Urinalysis

Color	Yellow
Specific gravity	1.030
Glucose	Negative
Protein	Negative
Ketones	1+
Leuk. Esterase	Negative
Nitrites	Negative
WBC	0/hpf
RBC	0/hpf
Microscopic	Calcium oxalate crystals

Stimulus #4

Liver Function Tests

AST	57 U/L
ALT	48 U/L
Alk Phos	110 U/L
Total Bilirubin	1.1 mg/dL
Direct Bilirubin	0.2 mg/dL
Albumin	2.9 mg/dL
Protein	7 g/dL

Stimulus #5

Initial Venous Blood Gas

pH	7.20
pCO_2	24 mm Hg
pO_2	52 mm Hg
HCO_3 base deficit	9 mEq/L -17

Stimulus #6

Troponin

Value	< 0.01 ng/mL

Stimulus #7

Toxicology

Salicylate	Undetectable
Acetaminophen	Undetectable
Ethanol	Undetectable

Urine drug screen

Amphetamines	Negative
Benzodiazepines	Negative
Cocaine	Negative
Opiates	Negative
TCAs	Negative
THC	Negative

Stimulus #8	
CXR	Normal

Stimulus #9	
CT head	Normal

Stimulus #10	
AXR	Normal

Stimulus #11	
Venous Blood Gas	
pH	7.02
pCO_2	16 mm Hg
pO_2	60 mm Hg
HCO_3 base deficit	4 mEq/L -24

Debriefing Materials – <u>Ethylene Glycol Toxicity</u>

Sources of Exposure:

- Engine coolants (antifreeze), plastics industry (polymer precursor)
- Sweet in taste ("glycol")
- Bittering agents may be added to deter exploratory or pet consumption
- Fluorescent dye may be added (to aid vehicle technician in detecting radiator leaks)
- Note: gas line antifreeze typically contains methanol, rather than ethylene glycol

Pathophysiology:

- The metabolites of ethylene glycol are thought to be the primary toxic entities
- Ethylene glycol is metabolized by alcohol and acetaldehyde dehydrogenases in stepwise fashion to glycoaldehyde and glycolic acid, respectively. Glycolic acid is similarly oxidized to oxalic acid in a two-step fashion
    - Each of these oxidation steps is coupled with the reduction of NAD^+ to NADH
- The generation of these unmeasured organic acids (glycolic and oxalic acids) results in metabolic acidosis and elevation of the anion gap
    - Unchecked metabolic acidosis results in inappropriate vasodilation, myocardial suppression, and, ultimately, combined vasoplegic and cardiogenic shock
- Primary specific end-organ toxicity of EG consumption is nephrotoxicity
    - Oxalate combines with calcium forming calcium oxalate monohydrate crystals, which precipitate in the proximal tubules and are often clearly evident on biopsy/post. Additionally, detection on microscopic UA may be of diagnostic assistance (see below).
    - Biopsy/post also may show damage to glomerular basement membranes – the etiology of this is uncertain
- Myocardial injury may occur from direct deposition of calcium oxalate, alternatively, oxalate may "sequester" free calcium resulting in hypocalcemia, QT prolongation, and cardiac dysrhythmia
- Cerebral edema, elevated ICP, and papilledema are reported, as well as delayed central nervous system effects – commonly isolated or multiple cranial nerve palsies – presumably due to direct injury from calcium oxalate
    - Intracranial hemorrhage involving globus pallidus also described

Severity of Ingestion:

- GI absorption is rapid and complete
- Serum EG levels (or, by surrogate, osmolal gap) and degree of metabolic acidosis are more indicative of toxicity than the reported amount ingested
- All possible ingestions should be evaluated in a healthcare setting
- Treatable EG levels are possible after ingestion of only a "mouthful" of antifreeze
- It is debatable about whether to empirically block alcohol dehydrogenase based on history alone in the absence of immediately available laboratory confirmation
- Patients may present as if inebriated (as in this case)

Organ System Effects:

- Renal:
  - Primary organ(s) of injury
  - Kidney injury may be seen early after ingestion, but creatinine can be expected to rise 2-3 days after injury
    - Early signs of kidney injury, may, in fact, be due to hypoperfusion
  - Degree of injury may vary from proteinuria/hematuria with mild BUN elevation to prolonged anuria and azotemia
  - In cases where hemodialysis is continued for renal failure, renal function is expected to recover over the course of weeks to months
- Pulmonary:
  - Direct pulmonary pathology would be unusual
  - Aspiration pneumonitis should be expected
- Cardiovascular:
  - Prolongation of the PR and QT intervals due to systemic hypocalcemia with subsequent cardiac dysrhythmia
  - Cardiogenic shock due to metabolic acidosis +/- direct oxalate myocardial injury
- Neurologic:
  - As with most alcohols, EG is inebriating leading to symptoms anywhere from euphoria, to ataxia and dysarthria, to somnolence, to coma
  - Delayed cerebral edema is reported, such patients would have coma or persistent alteration in mental status
  - Cranial nerve palsies may occur – these are typically delayed in nature, with one report of an abducens palsy at 9 days post ingestion
  - Basal ganglia injury and acquired Parkinson-like symptoms may occur
  - Globus pallidus hemorrhage may occur
- Other:
  - Multisystem organ toxicity and failure secondary to hypotension and shock
    - Shock is multifactorial and initially emphasis should be placed on volume resuscitation as patients may be multiple liters down due to nausea and vomiting, as well as diuresis due to osmotic effects

Diagnostic Testing:

- Ethylene glycol level
  - In most non-tertiary care centers serum ethylene glycol levels are not readily available
  - Ethanol, methanol, propylene glycol, and isopropyl alcohol levels should also be obtained simultaneously unless the actual ingested product is strongly verified (e.g. “antifreeze” may actually be gas line antifreeze which contains methanol)
- Osmolality
  - Available at most centers, however, the method of obtaining this lab may be critical
  - The optimal method is freezing point depression; the alternative method – boiling point elevation – risks falsely reporting below the actual osmolality due to volatility of some dissolved xenobiotics, including ethanol and methanol
- Chemistry Panel
  - Should be obtained SIMULTANEOUSLY with the osmolality

    - Repeat as needed to follow anion gap and electrolytes, particularly potassium if sodium bicarbonate being administered
- Ethanol Level
    - Should be obtained SIMULTANEOUSLY with the osmolality
- Calculation of osmolal gap:
    - Gap = (Measured [Osms]) – (2x[Na^+] + [BUN]/2.8 + [Glu]/18 + [EtOH]/4.6)
        - Assumes that [BUN], [Glu], and [EtOH] reported in mg/dL
        - Doubling of [Na^+] accounts for sodium and all associated anions (Cl^-, $HCO3^-$, albumin, etc.)
        - The whole point of the conversions of BUN, glucose, and ethanol are to convert from mg/dL to mmol/L = mOsm/L
    - "Normal" osmolal gap generally considered 0-10 mOsm/L
- Salicylate and acetaminophen levels in cases of intentional ingestions
- ECG
    - Watch for PR and QT prolongation (hypocalcemia)
- Blood gas + lactic acid
    - Venous blood gas will suffice unless hypoxia present
    - Repeat as needed to ensure pH correction
- Calcium/ionized calcium levels
- Urinalysis
    - Presence of calcium oxalate crystals on microscopy may suggest EG ingestion
    - Consider use of Wood's Lamp to look for urine fluorescence
        - Absence of fluorescence does not rule out EG ingestion as not all antifreeze products contain fluorescent dye
        - Dip gauze in urine and fluoresce, do not fluoresce in Foley bag as the plastic itself may appear to fluoresce
- Computed tomography if altered mental status not otherwise explained
- Relationship between osmolal gap and anion gap
    - Early after ingestion, osmolal gap will be elevated, while anion gap will be nil
    - Over time (hours), osmolal gap will fall as anion gap rises – as EG is metabolized to acid metabolites, their presence in serum becomes accounted for by sodium in the osmolal gap calculation (while bicarb and chloride fall)
    - Late ingestions of ethylene glycol may have not have a significant osmolal gap at all

Treatment:

- Decontamination
    - NG aspiration can be considered if presentation is immediate after ingestion
    - Due to rapid absorption, no role for AC, NGL, WBI
- Volume resuscitation with crystalloid
    - If hypotensive, 4-6 L over 1-2 hours
- Correction of pH
    - 100-200 mEq sodium bicarbonate boluses to restore pH to at least 7.2-7.3
    - Start sodium bicarbonate infusion at 200-250 cc/hr (5% dextrose in water + 150 mEq sodium bicarbonate, consider addition of 40 mEq KCl)
    - pH refractory to correction is an absolute indication for hemodialysis
- Alcohol dehydrogenase blockade
    - Indications:

        - Documented EG ingestion and EG level >20 mg/dL or osmolal gap >10 mOsm/L

          OR
        - Suspected ingestion and 3 of the following:
            - pH < 7.3
            - Serum bicarbonate <20 mmol/L
            - Osmolal gap >10 mOsm/L
            - Oxalate crystalluria
    - Fomepizole (4-methylpyrazole): 15 mg/kg (maintenance is 10 mg/kg q12hrs x4 doses, then 15 mg/kg q12hrs)
        - Ideally, ensure an ethanol level is available prior to initiation of 4-MP (see below)
    - If no 4-MP available, ethanol can be administered
        - PO may be best due to ease of availability and dosing
            - IV ethanol increasingly rare and approximately now cost-equivalent to 4-MP
        - 4-5 shots of hard liquor via NG tube for the average adult.
        - IV ethanol is not recommended due to difficulty of dosing, need for central access
        - Goal serum ethanol is 100 mg/dL which should effectively block metabolism of ethylene glycol
- Hemodialysis
    - Indications:
        - Metabolic acidosis (pH <7.2-7.3) that is refractory to standard measures
        - Hemodynamic instability refractory to standard measures
        - Acute kidney injury or renal failure
    - If initiated, HD should be continued until acidosis corrected and osmolal gap closed OR [EG] < 20 mg/dL
    - IHD is preferred over CRRT
    - Patients without acidosis and normal kidney function can be managed with 4-MP alone
- Vitamin repletion
    - Thiamine and pyridoxine may promote metabolism of toxic metabolites to nontoxic entities, and administration is considered benign
        - Thiamine 100 mg IV q8hrs, pyridoxine 50 mg IV q6hrs
- Normalize magnesium
- Supplement calcium only for symptomatic hypocalcemia or seizures
- Vasopressors: titrate to improving markers of perfusion: mean arterial pressure, capillary refill, lactate, urine output
    - Norepinephrine 1st line: start at 0.1 mcg/kg/min
    - Epinephrine 2nd line: start at 0.1 mcg/kg/min
    - Vasopressin 3rd line: 0.4 units/min

Consultations:

- Regional poison center or a local medical toxicologist for additional information and patient care recommendations
- Nephrology if meeting or potentially meeting hemodialysis criteria

Disposition:

- All potential ingestions should be evaluated in an emergency care setting
- Admit patients with major signs and symptoms or requiring HD to an ICU
- **Note: concurrent ingestion of ethanol may delay the development of toxicity**
- Consult psychiatric service personnel for stabilized patients with intentional overdose.

Take-Home Points:

- Obtain SIMULTANEOUS chemistry panel, ethanol level, and osmolality
- EG level or osmolality and metabolic acidosis are better predictors of toxicity than the reported amount ingested
- Aggressive crystalloid resuscitation is a must – patients may be SEVERELY volume depleted secondary to N/V as well as osmotic diuresis
- Antidote is fomepizole (4-methylpyrazole)
    - PO ethanol can be substituted while awaiting 4-MP or transferring to center with 4-MP
- Hemodialysis is for removal of toxic metabolites.
    - Indications: metabolic acidosis, kidney injury, signs of end organ injury (hypotension, shock, etc.)
    - Continue HD until acidosis corrected AND osmolal gap closed or [EG] < 20 mg/dL
- Assess serial blood gases and chemistries to titrate therapy

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