Management of Overdoses:
Deadly or Not?

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Disclosures

- No financial disclosures
- I am not a toxicologist
- This presentation is meant to focus on recognition more than treatment

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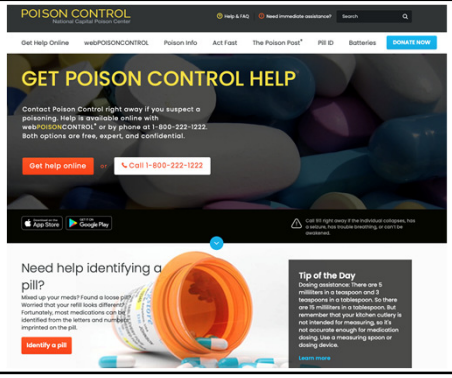

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Poison Center

- Must dial from your area code
- Be careful with 1-800 vs 1-888…

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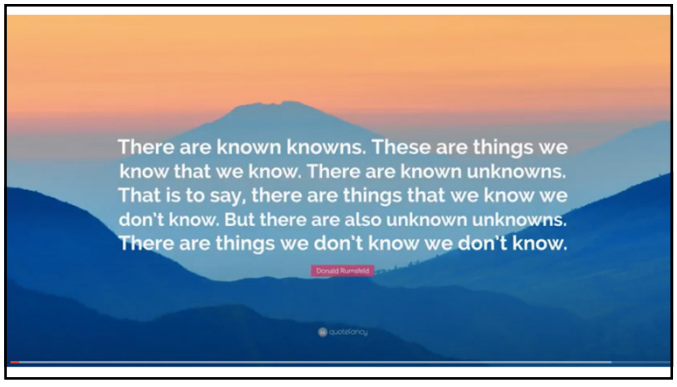

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Outline

- Why is this important?
- Common Overdoses
- Benign Presentations with Deadly Results
- Deadly Presentations with Benign Results
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- Deadly Presentations with Deadly Results

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Importance

- Not always reported by patient
- Only clues are often exam/labs/imaging
- Exam/labs/imaging often not helpful
- Many poisonings have a “benign stage”

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Common Overdoses

- Prescription Medications (Intentional and Unintentional)
- Supplements
- Illicit/Recreational Drugs
- Occupational Exposures

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Benign Presentations with Deadly Results

- Not always “benign”, but can have a latent period

9

Benign Presentations with Deadly Results

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Case 1

- A 4 year old presents after eating mom’s gummy prenatal vitamins
- Ingestion occurred 2 hours prior to arrival
- Patient had 1 episode of vomiting
- Vital Signs are normal
- Kids looks great

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Case 1

- What to do next?

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Iron Toxicity

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Iron Toxicity

- What's toxic
  - Nontoxic: 20mg/kg (elemental iron)
  - Moderately toxic: 20-60mg/kg
  - Severely toxic >60mg/kg
- What Forms
  - Ferrous fumarate (33% elemental iron)
  - Ferrous sulfate (20% elemental iron)
  - Ferrous gluconate (12% elemental iron)
  - Prenatal vitamins typically contain 60-90mg iron

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Iron Toxicity

- Corrosive Toxicity
  - Direct caustic injury to GI mucosa
  - GI damage can lead to hypovolemia
- Cellular Toxicity
  - Iron impairs cellular metabolism
  - Free iron enters cells and concentrates in mitochondria
    - Disrupts oxidative phosphorylation, catalyzes lipid peroxidation, forms free radicals
    - Leads to cellular death

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Stages of Iron Toxicity

Stage	Clinical Effect	Time Frame
Stage I	• GI Irritation	30 min - 6 hrs
Stage II Latent	• Recovery from GI symptoms	6 hrs - 24 hrs
Stage III Shock and metabolic acidosis	• Metabolic acidosis (anion gap) • Dehydration • Lactic acidosis	6 hrs - 72 hrs
Stage IV Hepatotoxicity/Hepatic necrosis	• Fulminant hepatic failure	12 hrs - 96 hrs
Stage V Bowel obstruction	• GI mucosa healing leads to scarring	2 wks to 8 wks

c/o GrepMed.com

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Iron Toxicity

- Evaluation
  - First step is to recognize
  - Most useful lab test is a serum iron level drawn at peak (4-6 hours after ingestion)
    - Depending on preparation, this can be erratic, so repeat at 6-8 hours needed

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Iron Toxicity

- Levels
  - <350 micrograms/dL is generally minimally toxic
  - 350-500 micrograms/dL moderately toxic
  - >500 micrograms/dL severely toxic

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Iron Toxicity

- Levels
  - Iron is quickly deposited into liver so levels after peak can be deceptive

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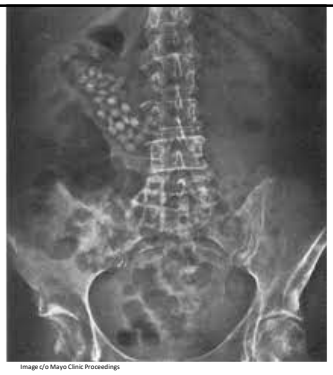

Image c/o Mayo Clinic Proceedings

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Iron Toxicity

- Imaging
  - X-rays may show tablets for 2-6 hours after ingestion, but there is no correlation with tablets seen and severity of poisoning

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Iron Toxicity

- Treatment
  - Severe Toxicity
    - Supportive Care
    - Deferoxamime (chelating agent) removes iron from tissues and free iron from plasma
    - Whole-bowel irrigation
    - Correction of coagulopathy
    - Gastric lavage if pills seen on X-ray
    - Activated charcoal not effective (poor binding)
  - Other Potential Treatments
    - Iron Bezoars can cause bowel obstruction
    - Hemodialysis may be effective

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Case 2

- An 81 year old female PMH of HTN, CAD presents with altered mental status
- Family states “She hasn’t been acting right” and has been having nausea, vomiting, and lightheadedness
- Patient unable to provide any helpful history

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Case 2

- Vital Signs: Temp 38.4, Heart rate 111bpm, Blood pressure 95/68mm Hg, Respiratory Rate 28 respirations per minute (but entered as 20 in EMR), Oxygen saturation 100% on room air
- Physical Exam unremarkable

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Case 3

- EMR gives 15 sepsis alerts
- EMR recommends 30cc/kg IV fluid
- EMR recommends broad spectrum antibiotics
- EMR gives 14 more sepsis alerts
- EMR recommends admission to ICU
- EMR recommends repeat lactate
- EMR pages hospitalist, ICU, and transfer center

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Case 3

- Administration asks if you drew blood cultures
- Medical director gets a sepsis alert on phone and calls you

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Case 3

- Sepsis bundle started and you give 1000mg ceftriaxone

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Serum electrolytes	Reference range	Initial value
Sodium (mEq/l)	137–145	140
Potassium (mEq/l)	3.6–5.0	2.8
Chloride (mEq/l)	98–107	100
Bicarbonate (mEq/l)	22–30	18
Anion gap (mEq/l)	8–12	22
Creatinine (mg/100 ml)	0.6–1.5	1.0
Blood urea nitrogen (mg/100 ml)	10–24	10
Glucose (mg/100 ml)	70–110	100

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Case 3

- Labs
  - Anion gap metabolic acidosis present
    - Easily explain by lactic acidosis from sepsis

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Case 3

- Labs
  - Intensivist wants a repeat lactate to ”finish bundle” and to “find source”

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Case 3

- Imaging
  - Chest x-ray with bilateral infiltrates vs. pulmonary edema vs. atelectasis vs. positional vs. artifact vs. Hantavirus
  - UA negative
  - Repeat lactate unchanged

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Case 3

- Labs
  - Intensivist (running out of delay tactics) asks for ABG

Blood gas		
pH	7.35–7.45	7.50
PCO_2 (mmHg)	35–45	20
PO_2 (mmHg)	80–100	125

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33

Case 3

- Labs
  - Anion gap metabolic acidosis with respiratory alkalosis

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Anion gap (mEq/l)	8–12	22
Creatinine (mg/100 ml)	0.6–1.5	1.0
Blood urea nitrogen (mg/100 ml)	10–24	10
Glucose (mg/100 ml)	70–110	100
Serum APAP (mcg/ml)	<20	0
Serum salicylate (mg/100 ml)	2.0–19.9	35
Serum alcohol (mg/100 ml)	<10.0	0
Blood gas		
pH	7.35–7.45	7.50
PCO_2 (mmHg)	35–45	20
PO_2 (mmHg)	80–100	125

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Case 3

- Labs
  - Anion gap metabolic acidosis with respiratory alkalosis
    - Think salicylate toxicity or trauma

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Salicylate Toxicity

- Presentation
  - Eerily similar to sepsis
  - History often difficult to obtain when patients are severely ill
  - Patient often unaware of common salicylate containing substances
    - Pepto-Bismol
    - Cough/Cold Medications

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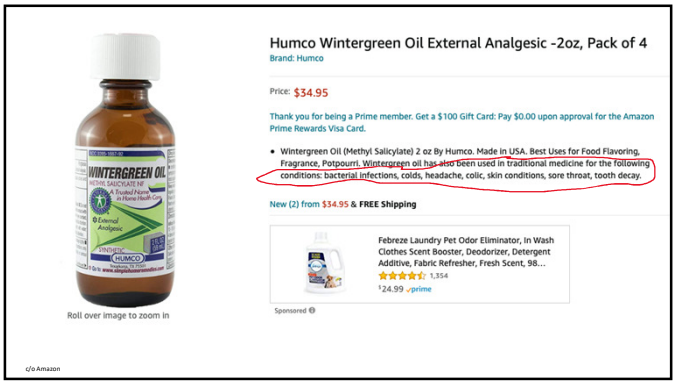

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Salicylate Toxicity

- Salicylates stimulate adrenal medulla causing hyperventilation
  - Results in respiratory alkalosis
- Salicylates uncouple oxidative phosphorylation in the mitochondria
  - Results in lactic acidosis and metabolic acidosis

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Salicylate Toxicity

- Salicylates are metabolized by the liver and excreted in the urine
- Elimination is delayed in patients with liver and renal disease

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Salicylate Toxicity

- Acute overdoses present with symptoms within 3-8 hours and is dependent on amount ingested
  - Mild is generally 40-80 mg/dL
  - Moderate is generally 80-100 mg/dL
  - Severe is >100 mg/dL

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Salicylate Toxicity

- Acute Toxicity
  - Mild poisonings generally present with nausea/vomiting/abdominal pain; may have tinnitus and tachypnea
  - Moderate poisoning generally present with neurologic symptoms such as confusion, slurred speech, and hallucinations; tachypnea more pronounced
  - Severe poisonings present with coma and seizures due to damage to basement membranes (causing cerebral and pulmonary edema)

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Salicylate Toxicity

- Chronic Toxicity
  - Similar to symptoms of acute toxicity

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Salicylate Toxicity

Stage	Timing post ingestion	Symptoms
1	0.5-6 hours	Local Toxicity: Nausea, vomiting (90%), diarrhea; abdominal pain, GI bleeding
2	6-24 hours	Latent Toxicity: Resolution of local toxicity with ongoing cellular toxicity, hypovolemia, poor tissue perfusion (metabolic acidosis, ↑ lactate)
3	12-24 hours	Systemic Toxicity: Shock, acidosis, coagulopathy, coma, multisystem failure
4	2-3 days	Hepatic Failure
5	3-6 weeks	Long term sequelae: Gastric outlet obstruction, small bowel obstruction, CNS sequelae

c/o DownEastEM.org

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Salicylate Toxicity

- Evaluation
  - Levels are helpful for determining toxicity and to trend
  - Electrolytes/ECG
  - Head CT due to possible cerebral edema

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Salicylate Toxicity

- Treatment
  - Volume repletion (hypovolemic due to hyperventilation/increased metabolism)
    - D5 with 3 amps of sodium bicarbonate is a good fluid to use (dextrose treats CNS hypoglycemia, bicarbonate helps correct metabolic acidosis)
    - Serum alkalization increases elimination
  - Try not to intubate
    - If necessary, give extra bicarb first (1-2 amps)
    - Match respiratory rate
  - Charcoal
    - Reduces rate but has not been shown to reduce mortality
    - No role for whole bowel irrigation (may actually increase absorption)
  - Hemodialysis

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Salicylate Toxicity

- Treatment
  - Hemodialysis Indications
    - Levels greater than 100mg/dL
    - Mechanical ventilation
    - End-organ damage
      - Seizure, rhabdomyolysis, pulmonary edema, cerebral edema, renal failure

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Case 4

- A 35 year old male presents to the emergency department after drinking a large amount of ETOH and hydrocodone, cyclobenzaprine, lamotrigine
- Told family he wanted to kill himself and they found him lying on the floor of his home
- Normal vital signs
- Intoxicated appearing; unable to provide history

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Case 4

- Physical examination unrevealing
  - Appears intoxicated without other toxidrome present

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Serum electrolytes	Reference range	Initial value
Sodium (mEq/l)	137–145	140
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Creatinine (mg/100 ml)	0.6–1.5	1.0
Blood urea nitrogen (mg/100 ml)	10–24	10
Glucose (mg/100 ml)	70–110	100
Serum APAP (mcg/ml)	<20	0
Serum salicylate (mg/100 ml)	2.0–19.9	0
Serum alcohol (mg/100 ml)	<10.0	180

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Case 4

- Lactate is normal

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Case 4

- Not sobering, mental status declines

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Case 4

Mnemonic for
Causes of Anion Gap Acidosis
(MUDPILES)

M - Methanol
U - Uremia
D - DKA / AKA
P - Paraldehyde / phenformin
I - Iron / INH
L - Lactic acidosis
E - Ethylene glycol
S - Salicylates

c/o Pinterest user dee

55

Case 4

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c/o Pinterest user dee

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Case 4

Metabolic Acidosis with Acid Gap : KILU

- Ketoacidosis
  - DKA
    - With normal glucose, ask if on SGLT2 inhibitor.
    - Euglycemic ketoacidosis in SGLT2 inhibitors and SGLT2 deficiency mutation
  - Alcohol ketoacidosis
    - 10% have –ve urine ketones (their ketone is B-hydroxy butyrate)
  - Starvation
- Ingestions: ethylene glycol, methanol (for those, check **osm gap**, & alcohol level) salicylates (+ resp alkalosis), APAP (rare in lit), iron (pediatric), paraldehyde
- Lactate: Type A = tissue hypoxia (e.g. shock, dying gut/limb). Type B=a lymphom or leukemia or drug that results in lactate build-up, Beri-Beri, NRTI's, linezolid
- Uremia: The anion is phosphate typically.

c/o GrepMed.com

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Case 4

- Due to unexplained anion gap metabolic acidosis, reluctantly sent toxic alcohol levels and started Fomepizole
- Following day ethylene glycol level was markedly elevated

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Ethylene Glycol Toxicity

- Absorbed in GI tract
- Metabolism by alcohol dehydrogenase
- Lethal dose is 1-2 mL/kg of 95% concentrated solution
- Metabolized to glycolic acid and oxalic acid
- Metabolites are responsible for anion gap
- Oxalic acid deposits in renal tubules causing renal tubular necrosis
- Oxalic acid binds calcium which can lead to hypocalcemia

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Ethylene Glycol Toxicity

- Metabolism happens over 4-12 hours, and can be delayed with ETOH
  - If ANY suspicion, need to monitor for minimum of 12 hours an monitor for anion gap metabolic acidosis
  - Observation can't begin until serum ethanol level is zero
- Osmolar gap can be present early, and then close
  - Can't be relied on

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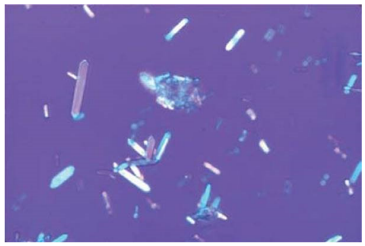
Ethylene Glycol Toxicity



c/o doctorlib.info

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Ethylene Glycol Toxicity

- Treatment Indications
  - Begin treatment with end organ damage, osmolar gap >25 mOsm/kg (some say 50), acidosis
  - Levels >20 mg/dL (varies) with acidosis
    - >62 mg/dL if labs normal

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Ethylene Glycol Toxicity

- Treatment
  - Fomepizole inhibits alcohol dehydrogenase for 12 hours
  - Ethanol can "tie up" alcohol dehydrogenase
    - Difficult to titrate, monitor, and patient becomes intoxicated
    - Protocols exist
    - Only use if Fomepizole note available

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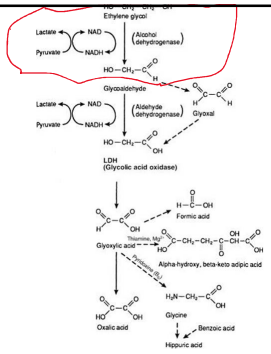

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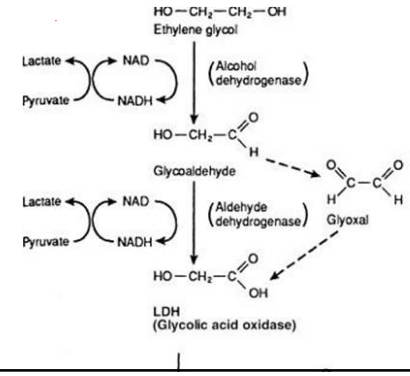

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Ethylene Glycol Toxicity

- Treatment
  - Hemodialysis
    - Indicated with renal dysfunction (otherwise unlikely to be necessary), severe acidosis, or severe metabolic abnormalities
    - Decision should be made with toxicologist
  - Other Treatments
    - Sodium bicarbonate
    - Calcium gluconate
    - Thiamine/Pyridoxine

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Deadly Presentations with Benign Results

- Appear deadly, but unlikely to result is serious morbidity or mortality

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Case 5

- A 39 year old female with no past medical history presents to the emergency department with altered mental status
- Friend states she was with her at work when she suddenly started slurring speech and stumbling
- Vital signs within normal limits

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Case 5

- Physical examination reveals dystaxia, slurred speech

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Case 5

- Stroke Alert initiated
- Neurology consulted
- EMR starts timer for tPA
- EMR asks about tPA contraindications
- Medical director calls and asks if you heard about the stroke alert
- Administration asks what's taking so long on the stroke alert that arrived 4 minutes ago

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Case 5

- CT/CT angiogram started
- tPA at bedside
- Helicopter on standby
- Neurology recommending administration

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Case 5

- Friend sheepishly asks if we think the gummy bears she ate in a hotel room she was cleaning may have contributed to symptoms

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Marijuana Edibles

- Widespread in Decriminalized states
- After legalization in CO, Poison Center had 70% increase in calls for accidental exposure
- Symptoms: nausea, headache, dizziness, ataxia, numbness/tingling, slurred speech

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Marijuana Edibles

- Treatment

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Case 6

- A 24 year old self described “mycophile” presents to the emergency department with nausea/vomiting/abdominal pain after ingesting some delicious mushrooms he found. He is concerned about suffering the same fate as Roman emperor Claudius
- Vital signs: tachycardic but otherwise reassuring
- Examination: Ill, actively retching, diffuse abdominal pain

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Case 6

- Labs

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Image c/o Mushroomexpert.com

Chlorophyllum molybdites

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Mushroom Toxicity

- Despite a huge number of species, only about 100 are toxic
- Clinical presentation depends on which species is ingested

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Mushroom Toxicity

- Acute gastroenteritis
  - The "backyard mushrooms" such as *Chlorophyllum molybdites*
  - Symptoms include nausea/vomiting/abdominal cramping/diarrhea
  - Onset of symptoms is generally within 1 hour

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Mushroom Toxicity

- Hallucinations
  - *Psilocybe*, *Conocybe*, *Gymnopilus*, and *Panaeolus*
  - Altered sensorium, euphoria
  - Onset of symptoms typically within 30 minutes-2 hours
    - lasts 4-12 hours
  - Caused by psilocybin and psilocin toxins

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Mushroom Toxicity

- Cholinergic Toxicity
  - *Clitocybe, Inocybe*
  - Symptoms include abdominal cramping, diaphoresis, salivation, lacrimation, bronchospasm, bronchorrhea, bradycardia
  - Generally starts within 30 minutes
    - Very short lived (unlike cholinergic pesticides)

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Mushroom Toxicity

- Disulfiram-like reaction
  - *Coprinus atramentarius* ("inky cap")
  - Toxins inhibits aldehyde dehydrogenase
  - Symptoms include headache, nausea, vomiting, flushing, tachycardia
    - Only occurs if alcohol is ingested within hours to days of consumption

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Mushroom Toxicity

- Liver Toxicity
  - *Galerina*, and *Lepiota* and *Amanita*
    - Caused by amatoxin
  - Disrupts RNA polymerase II leading to protein deficiency at cellular level
  - GI effects typically 6-12 hours after ingestion
  - Followed byu quiescent interval 24-36 hours post ingestion
  - At 48 hours, can begin to develop liver failure with death in 1 week

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Mushroom Toxicity

- Nephrotoxicity
  - *Cortinarius* genus
  - Orellanine, a nephrotoxic agent
  - *Amanita* species can also cause nephrotoxicity (but another mechanism)
  - Mild GI symptoms progressing to renal injury in 12-24 hours
  - Can also be asymptomatic until 1-2 weeks after ingestion

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Mushroom Toxicity

- Seizures
  - *Gyromitra, Paxina*, and *Cyathipodia micropus* species
  - Toxicity stems from a metabolite, monomethylhydrazine, that leads to pyridoxine (B6) and ultimately GABA depletion
  - May require B6 administration (in addition to anticonvulsants)

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Mushroom Toxicity

- How do we manage these?
  - H&P
    - Identify by asking for color, texture, cap appearance
    - How much
    - Co-ingestions?
    - Location/season of collection
  - Labs
    - Serum electrolytes
    - Kidney function
    - Liver function
    - CK
    - Coags

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Mushroom Toxicity

- How do we manage these?
  - Treatment
    - Activated charcoal
    - Symptom control
    - Atropine for cholinergic symptoms
    - B6 for Gyromitra ingestion (specifically if refractory)
    - Possible NAC for amatoxin

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Mushroom Toxicity

- Prognosis
  - Depends on species
  - Generally do well with supportive care
  - Some require HD, liver transplant, etc.

90

Benign Presentations with Benign Results

- Appear mild, and stay mild
- Still important to know

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Case 7

- A 47 year old male with PMH DM 1, diabetic neuropathy presents for suicide attempt
- States he took 45 tablets of 300mg Gabapentin
- Vital signs within normal limits
- Normal physical exam

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Gabapentin Toxicity

- Dramatic increase in toxic cases in last 10 years

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Gabapentin Toxicity

- Presentation
  - Sedative-Hypnotic medication with unknown mechanism
  - Does NOT act on GABA receptors
  - Bioavailability is inversely proportional to dose
    - 900mg/day of Gabapentin 60%
    - 4800mg/ day of Gabapentin 27%
  - Bioavailability is inversely proportional to dose

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Gabapentin Toxicity

- Acute Toxicity
  - Drowsiness, coma

95

Gabapentin Toxicity

- Acute Toxicity
  - Drowsiness, coma
- Chronic Toxicity
  - Multiple falls
  - Cognitive deficits
  - Kidney injury
  - Gabapentin has no metabolism in the body- entirely renally cleared

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Gabapentin Toxicity

- Treatment
  - Supportive care
  - No reversal agent

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Deadly Presentations with Deadly Results

- Very important to know
- Minutes count

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Case 8

- A 63 year old male with a PMH of atrial fibrillation presents with chief complaint of suicidal ideation
- States he took his entire bottle of Flecainide
- Vital Signs: within normal limits

99

Case 8

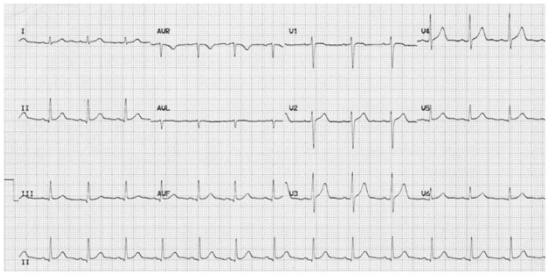

Image c/o ECGguru.com

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Case 1

- One hour later

101

Case 8

- Sudden decompensation
- Wide complex tachycardia, hypotension, altered mental status
- Intubated

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Case 8

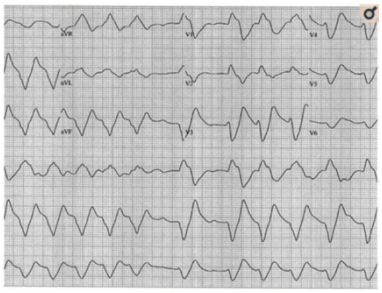

Image c/o ECGguru.com

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Case 8

- Sudden decompensation
- Wide complex tachycardia -> Pulseless V tach -> V fib
- Multiple shocks, magnesium, sodium bicarbonate, lipid emulsion therapy
- ECMO initiation

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Flecainide Toxicity

- Class 1c lipophilic antiarrhythmic agent
- Works by delaying phase 0

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Flecainide Toxicity

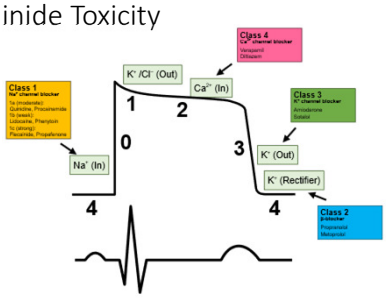

Image c/o Wikipedia

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Flecainide Toxicity

- Results in slowing conduction and increasing refractory period
- Additionally, likely slows conduction slowing which prolongs myocyte refractory period leading to development of reentrant circuits

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Flecainide Toxicity

- Rare, but potentially fatal (>10%, but dose dependent)
- If a fatal dose in ingested, very difficult to manage

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Flecainide Toxicity

- High oral bioavailability (90%)
- Slow rate of elimination
- Not effectively dialyzed (lipophilic and large volume of distribution)

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Flecainide Toxicity

- Treatment
  - Sodium bicarbonate (heart does not like acidic environment)
  - Serum alkalinization (increased sodium and pH reverses effect on Purkinje fibers)
  - Lipid emulsion therapy (sequesters)
  - Pacing
  - +/- Amiodarone and Lidocaine (mechanism not clear)
  - ECMO (treatment of choice)

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Flecainide Toxicity

- Takeaways
  - No matter how ”good” they look, consider early transfer to ECMO facility
  - These can also present in the “deadly” phase
  - Just because the patient looks “good” doesn’t mean they will keep looking this way

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Case 9

- A 31 year old female with no past medical history presents to the emergency department with weakness and nausea after taking “pong-pong”
- Appears ill, wretching

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Case 9

- Vital signs: Hear Rate 36 beats per minute, blood pressure normal
  - After 0.5mg Atropine, heart rate 64, blood pressure 90mm Hg

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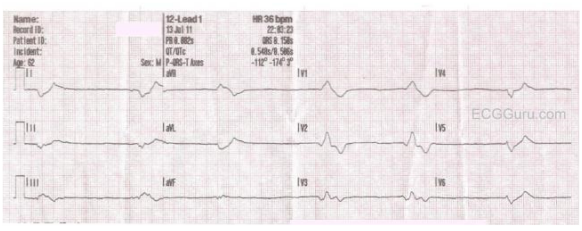
Case 9



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Case 9

- Wide Complex Bradycardia
  - Beta blockers
  - Calcium channel blockers
  - Clonidine/related drugs
  - Cardiac glycoside

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Case 9

- Poison Center called
  - Toxicologist identifies “pong-pong” as a cardiac glycoside
  - A therapeutic dose of “pong-pong” is 1/32 of a nut
  - Poison center recommends 10 vials of Digibind
  - Patient loses pulses and unable to achieve ROSC

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Case 9

- *Cerbera odollam*
  - Also known as suicide tree, mintolla, pong-pong, othalam
  - Grows in South India, Madagascar, and Southeast Asia
  - Kernal is highly toxic due to a toxin known as cerberin, a cardiac glycoside

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Cardiac Glycoside Toxicity

- Cardiac Glycosides
  - Naturally occurring compounds found in various plant and animal species

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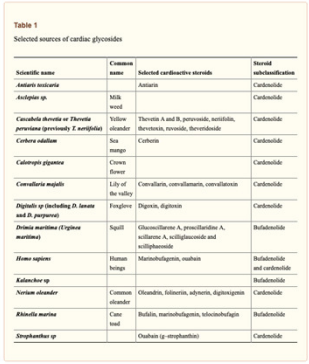

Table 1

Selected sources of cardiac glycosides

Scientific name	Common name	Selected cardioactive steroids	Steroid subclassification
Antiaris toxicaria		Antiarin	Cardenolide
Asclepias sp.	Milk weed		Cardenolide
Cascabela thevetia or Thevetia peruviana (previously T. neriifolia)	Yellow oleander	Thevetin A and B, peruvoside, nerifolin, thevetoxin, ruvoside, theveridoside	Cardenolide
Cerbera odollam	Sea mango	Cerberin	Cardenolide
Calotropis gigantea	Crown flower		Cardenolide
Convallaria majalis	Lily of the valley	Convallarin, convallamarin, convallatoxin	Cardenolide
Digitalis sp (including D. lanata and D. purpurea)	Foxglove	Digoxin, digitoxin	Cardenolide
Drimia maritima (Urginea maritima)	Squill	Glucoscillarene A, proscillaridine A, scillarene A, scilliglaucoside and scilliphaeroside	Bufadienolide
Homo sapiens	Human beings	Marinobufagenin, ouabain	Bufadienolide and cardenolide
Kalanchoe sp.			Bufadienolide
Nerium oleander	Common oleander	Oleandrin, folinerin, adynerin, digitoxigenin	Cardenolide
Rhinella marina	Cane toad	Bufalin, marinobufagenin, telocinobufagin	Bufadienolide
Strophanthus sp		Ouabain (g-strophanthin)	Cardenolide

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Cardiac Glycoside Toxicity

- Cardiac Glycosides
  - Naturally occurring compounds found in various plant and animal species
  - Most common are digoxin, oleander, cane toad, oubain, Lilly of the valley

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Cardiac Glycoside Toxicity

- Mechanism
  - inhibit the Na^+-K^+-ATPase on cardiac and other tissues
    - causing intracellular retention of Na^+, followed by increased intracellular Ca^{2+} concentrations through the effect of the Na^+-Ca^{2+}exchanger. .

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Cardiac Glycoside Toxicity

- Mechanism
  - inhibit the Na^+-K^+-ATPase on cardiac and other tissues
    - causing intracellular retention of Na^+, followed by increased intracellular Ca^{2+} concentrations through the effect of the Na^+-Ca^{2+}exchanger. .
  - The elevated intracellular Ca^{2+} concentration promotes inotropy and bradycardia,
  - and the intracellular accumulation of Na^+ and Ca^{2+} causes partial membrane depolarization which increases automaticity and ventricular ectopy.

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Cardiac Glycoside Toxicity

- Clinical Features
  - GI symptoms
  - Hyperkalemia
  - Cardiotoxicity
    - Bradycardia, high degree blocks, biventricular tachycardia, slow atrial fibrillation
  - Vision changes

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Cardiac Glycoside Toxicity

- Treatment
  - Extrapolated from digitalis poisoning
    - Can ONLY use levels for digitalis poisoning
  - Treat electrolyte disorders (high K levels correlate with higher mortality)
  - Activated Charcoal
  - Anti-digoxin antibodies
  - Atropine
  - Temporary pacing

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Table 2

Summary of treatments for cardiac glycoside poisoning, in addition to supportive treatment

Indications	Treatment	Dose	Use in practice
Known, or potential for, toxicity	Multiple doses of activated charcoal	50 g loading followed by 25 g every 2–4 h for 24 h, but other regimens have also been used.	Unknown, but appears to be common, in particular for yellow oleander poisoning.
Hyperkalaemia, renal failure, bradycardia not responding to atropine, or ventricular arrhythmia.	Anti-digoxin Fab	Two vials (80 mg); incremental dose according to clinical response in acute digoxin poisoning [29].	In practice there is wide variability in treatment thresholds and dosages for digoxin poisoning [42]. Not usually available for use developing countries due to cost.
		One vial (40 mg) in chronic digoxin poisoning, repeat if required in 1 h [29].	
		20–30 vials (800–1200 mg) in acute yellow oleander poisoning [35]	
Hyperkalaemia	Intravenous insulin and dextrose	50 ml 50% dextrose followed by 10 units short acting insulin i.v.	Unknown for digoxin poisoning, but in Sri Lanka, it is frequently used for $K^+ > 6$ mmol l^{-1}.
Bradycardia	Intravenous atropine	0.5–1 mg i.v.	Commonly, as a bridge to other treatments
Bradycardia (and perhaps hyperkalaemia)	Intravenous isoprenaline (isoprenaline) [16] or oral salbutamol		Unknown, except for Sri Lanka where it is used after temporary pacing.
Bradycardia and conduction block	Temporary cardiac pacing	According to usual guidelines	Its use in clinical practice outside of Sri Lanka is unknown, but in the case of digoxin use is thought to be limited in developed countries due to use of anti-digoxin Fab.

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