

# High-Yield Pediatric **Emergency** Toxicology & Ingestions

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## Sources

Cyrus Rangan, MD, Director of the Bureau of Toxicology, Los Angeles County Dept of Public Health, Consulting Medical Toxicologist, Children's Hospital Los Angeles

David Tanen, MD, Associate Director, Residency Training Program, Professor of Clinical Emergency Medicine, Harbor UCLA  
PEM Guide v6, Michael Mojica, MD. 2019

Tenebein, Milton. 'Toxicologic Emergencies'. *Strange and Schafermeyer's Pediatric Emergency Medicine*. McGraw-Hill. 2019

# Compared to adults

Anatomy	Physiology
Smaller weight	Greater minute volume
Larger BSA	Cardiac output: HR dependent (smaller SV)
Smaller airways	Immature kidney & liver function (elimination, lower glycogen)
Volume distribution (high TBW)	Increased BBB permeability

# General Points

History	Workup
Substance	VBG+ (iSTAT/ePOC)
Amount (assume highest)	CMP (AG) + Serum Osm
Timing	Utox + Upreg
Other home substances/poisons	ECG + tylenol/salicylate/EtOH
	+/- CBC, coags, CXR/AXR

- High AG Metab acidosis (>12): Cyanide, Alcohols/Eth Glycol, Toluene
- High Osm Gap (Serum Osm - Calc Osm >10): Alcohols, Acetone

# Immediate Interventions

- ABCs
- NS bolus/IVF
- D10 (or Glucagon 1mg IM)
- BZD
- Naloxone
- Charcoal (<2h)
- Urinary alkinalization
- Poison control hotline  
800-222-1222

One pill kill		
Alcohols (MeOH, EG)	AntiHTN (CCB, BB, clonidine, verapamil)	Sulfonylurea
Opioids	Antidepressant (MAO inhib)	Insecticides (carbamate, organophos)
Caustics (disk battery, ammonia, boric acid)	Benzocaine	Hydrocarbons
Herbals (camphor, oil of wintergreen)	Antimalarial (quinine, chloroquine)	TCA's

	DISPO
Unstable	PICU
Stable	Obs in ED vs Wards
Delayed/XR substance	24h Obs (SU, clonidine, CCB, Li, Methadone, Modified)

# Activated Charcoal

- Black grainy tasteless PO/NG liquid, high surface area
- 25g Peds, 50g Adults - single dose
- <2h, before vomiting or stupor develop

NO binding	GOOD binding	OK binding
Pesticides	Tylenol	Aspirin
Hydrocarbons/Heavy metals	Ibuprofen	Benzo's
Acids/Alkali/Alcohols	TCA's	Cyanide
Iron	Barbiturates	
Lithium	Phenytoin	
Solvents		

# Acetaminophen

Presentation	Workup	Mgmt
Asymptomatic first 6-24h (+/- emeses)	<b>Tylenol level @4h</b> (Rumack-Matthew nomogram) Immediately if time ingestion unknown. Nomogram can't be used if staggered dosing or >8h. Repeat in 4-6h if XR	Charcoal if <2h
BG low if high dose		N-acetylcysteine PO (72h): 140mg/kg > 70mg/kg q4h x17 IV (20h): 150mg/kg over 60min > 50mg/kg over 4h > 100mg/kg 16h
AST/ALT high after 2-3d	VBG, CMP	
PT/Tbili high later	Coags	

# Aspirin (Salicylate)

Presentation	Workup	Mgmt
Mimics DKA older kids, sepsis younger	<b>Salicylate level q2h</b> until peaked then q4h until undetectable (delayed, erratic absorption)  Mild/Mod tox: 150-300mg/kg Lethal: >300mg/kg (severity based on clinical/gas rather than salic level)	Charcoal if <2h
AMS, hyperthermia, diaphoresis, <b>tinnitus</b> , vomiting, tachypnea		IV fluids
AG metabolic acidosis, Low K, high BG	VBG (mixed, but acidotic 2/2 urinary bicarb loss)	Na, K, BG correction
Rarely rhabdo, renal failure	BMP, Udip, Coags (PT inc), AXR	HD: severe acidemia, renal failure, pulm edema, coma, seizure

# Opioids

Presentation	Workup	Mgmt
Triad: CNS and resp depression + miosis*	VBG, BG	Stabilize airway + monitor SpO2
Bradycardia, hypotension	CXR (if suspect lung injury or edema)	<b>Naloxone</b> 0.1mg/kg, or 2mg if >20kg q3min until response SQ, IM, IN, or IV onset 1-2min, duration 20-90min gtt = 2/3 response dose / hr
Seizure	ECG	
Synergistic with EtOH and BZDs	CT head if trauma	Bicarb if acidotic (dose q10min - goal Ur pH 7)
Mixed picture with cocaine and amphetamine		HD: severe acidemia, renal failure, pulm edema, coma, seizure



# Opioid Derivatives & Opioid-Like

<b>Lomotil (diphenoxylate/atropine)</b>	<b>Imodium (Loperamide)</b>	<b>Tramadol</b>
Atropine = anti-muscarinic Diphenoxylate = mepiridine derivative	Anti-diarrheal synthetic opioid	Centrally acting analgesic
Anticholinergic: mydriasis, lethargy, agitation, flushing, dry, ileus	Prolonged QT	Opioid and nonopioid properties (SNRI)
Opioid: CNS/resp depression, bradycardia, hypotension	Widened QRS	Seizure (most common), tachycardia, HTN, resp acidosis
ABC, Naloxone, +/- Physostigmine	ABC, Naloxone, IV Mg if long QT, Bicarb if wide QRS, fix lytes (K+), charcoal if <2h	Observe 6 hours

# NSAIDs

Presentation	Workup	Mgmt
Symptoms develop by 4-6h (toxic >400mg/kg)	VBG, CMP	Charcoal if <2h
CNS: Drowsy, dizzy, headache, coma	CBC, Coags	IV fluids
GI: nausea, vomiting, pain, bleeding	ECG	<b>Admit:</b> AMS, significant metab acidosis, renal dysfunction, XR ingested
AG metabolic acidosis + dehydration	Monitor UOP	
Cardiac: VT, long QT (rare)		

# BZDs

Presentation	Workup	Mgmt
CNS and resp depression	Utox false negative	ABC
Hypotension, hypothermia, rhabdo*	CBC, Coags	Charcoal not recommended (low morbidity, somnolence)
*Even in large dose doesn't cause instability unless co-ingested	ECG	Flumazenil not recommended (risk seizure and re-sedation)
	Monitor UOP	<b>Discharge:</b> ASx 4 hours post-ingestion

# Anti-HTN

Beta Blocker	Calcium Channel Blocker	Clonidine
Myocardial depression (bradycardia, hypotension, AV block, dysrhythmia)	Myocardial depression (bradycardia, hypotension, AV block, dysrhythmia)	Alpha 2 agonist -> decreased sympathetic outflow
<b>Low BG</b> , bronchospasm (esp if asthma), high K, seizure, coma	<b>High BG</b> , metab acidosis, lethargy	Early HTN > Hypotension, bradycardia, AMS/CNS dep, miosis, onset 1h + half life 12h
ABC, ECG, VBG, BMP + Mg	ABC, ECG, VBG, BMP + Mg	ABC, ECG, VBG, BMP
Cautious IVF, Glucagon, Epi gtt, Atropine (brady), BZD (seizure), Bicarb (wide QRS), Intralipid	Cautious IVF, IV <b>CaCl</b> , Atropine (brady), Norepi gtt, BZD (seizure), Intralipid	Cautious IVF, Naloxone, Atropine (brady), Norepi gtt

# Psychotherapeutics

TCA	SSRI	Antipsychotics
SNRI + anticholinergic + alpha 1 blocking + GABA interactions	Serotonin agonist, alpha antagonist	Block dopa, alpha-adrenergic, and muscarinic rec; serotonin agonist
Coma, seizure, dysrhythmia, hypotension, anticholinergic syndrome	<b>Serotonin Synd:</b> AMS + autonomic instability + hyperreflexia (+hyperthermia)	<b>Muscle rigidity</b> , hyperthermia, hypotension, sedation, AMS, dystonic reaction seizure
No levels, ECG (wide QRS), VBG, BMP	VBG, BMP, ECG, Udip	VBG, BMP, Udip
Bicarb, BZD, Norepi gtt	BZD, IVF, cooling, respiratory support, cyproheptadine, bicarb (if QRS or QTc change)	Cooling, BZD, Bromocriptine, NS bolus (Norepi gtt if refractory), Benadryl (dystonia)

# Iron

Presentation	Workup	Mgmt
Metabolic acidosis + preceding GI Sx (free radical generation)	AXR	Aggressive IV fluids most important
Phase 1: corrosive gastroenteritis (nausea/vomiting x6h)	Iron level 4-6h post-ingestion (<300 ug/dL ASx)	Whole bowel irrigation if many on AXR (GoLytely). May need intubation if agitated/unstable
Phase 2: latent (from fluid resuscitation, 6-18h)	VBG, CMP	Bicarb if acidotic or in shock
Phase 3: metabolic acidosis, shock, coagulopathy (w/in 24h)	BG > 150 WBC > 15	Deferoxamine 15mg/kg/hr IV if serum Fe > 500 ug/dL, acidotic or in shock
Phase 4: hepatic injury/failure Phase 5: GI strictures (weeks)	Coags	Can dc only if ASx and peak level <500 ug/dL 6h post-ingestion

# Ethanol

Presentation	Workup	Mgmt
<p>Potentiates GABA(A) receptor and NMDA receptor antagonist. Converted to acetaldehyde &gt; acetate</p>	<p>Blood glucose, BMP</p>	<p>ABCs, Aggressive IV fluids, Banana bag (MV, thiamine, folate, Mg)</p>
<p>Ataxia, slurred speech, drowsy, stupor</p>	<p>Ethanol level*</p>	<p>BZD (agitation), D10 bolus (hypoglycemia), Naloxone if obtunded (co-ingest?)</p>
<p>Child: flushing, mydriasis, GI distress, seizure, hypoventilation, hypothermia, hypotension.</p>	<p>*If level does not correlate to clinical picture, consider co-ingestion</p>	<p>HD for severe refractory (rare)</p>
<p>If &gt;500mg/dL: coma, resp depression. Common co-ingestant</p>		<p>DC if asymptomatic; Elim rate = BAC falls 15-20mg/dL/hr (30 if tolerant)</p>

# Ethanol Withdrawal

Presentation	Mgmt
Diminished GABA(A) synaptic activity and increased NMDA receptor activity	Restore inhibitory tone to CNS: diazepam 10mg IV q5-15min until sedated and VS improved
CNS excitation (tremor, hallucinations, seizure)	Alternative: Librium (chlordiazepoxide)
Autonomic stimulation (tachycardia, HTN, hyperthermia, diaphoresis)	Refractory: phenobarbital 260mg IV load over 5min then 130mg q5-10min (Propofol risks metabolic acidosis)



# Ethylene Glycol

Presentation	Workup	Mgmt
Antifreeze, coolants, detergents Sweet, easy open Metabolized by liver + lethal metabolites ( <b>glycolic acid</b> )	VBG, BG, CMP, CK	ABCs, Aggressive IVF, BZD (seizure), bicarb if pH < 7.2
Onset w/in 30min AG metabolic acidosis (severe); early Osm gap	UA (crystals, protein, blood)	Fomepizole if pH < 7.2 (inhib conversion enzymes) Alt = EtOH (slows metabolism, competitively binds hepatic ADH)
hypocalcemia (prolong QT); AKI (CaOx crystals); multi-organ failure; seizure, coma; dysrhythmia	Serum EG = send out	Ca replacement if both low and e/o hypocalcemia - Ca Gluconate (limit since can induce CaOx crystals) Pyridoxine 50mg IV q6h Thiamine 100mg IV q6h Shunt EG metabolism to less toxic metabolites
Stage 1 (1-12h): mimic EtOH intox Stage 2 (12-36h): cyanosis, pulm edema, ARDS Stage 3: (2-3d): renal injury/failure	ECG; CXR (cardiopulmonary toxicity)	HD indicated if refractory to therapy or end-organ damage or severe acidosis (removes EG <u>and</u> metabolites)

# Methanol

Presentation	Workup	Mgmt
<p>Windshield fluid, cleaners, varnishes, pain solvents. 10ml can cause blindness EG symptoms + <b>visual disturbances (formic acid metabolite)</b></p>	<p>VBG, CBC, BMP, lipase, UA</p>	<p>ABCs, Aggressive IVF, BZD (seizure), bicarb if pH &lt; 7.2</p>
<p>Onset w/in 1-72 (often @12-24h) Half life = 3h <b>Triad</b> = visual Sx + abd pain + AG metab acidosis</p>	<p>Elevated AG metab acidosis and Osm gap (early, unmeasured osm active serum substances)</p>	<p>Fomepizole if pH &lt; 7.2 (inhib conversion enzymes) Alt = EtoH (slows metabolism, competitively binds hepatic ADH)</p>
<p>Visual Sx: blurriness, photophobia, decreased visual field CNS Sx: HA, dizziness, seizure</p>	<p>Serum MeOH = send out <u>Estimate</u>: MeOH = 3.2 x Osm Gap</p>	<p>Folate 50mg IV q4h until acidosis corrected (converts formic acid to CO2/water)</p>
<p>Unlike EtOH, don't have odor and have normal sensorium</p>	<p>Levels &gt;20 toxic; &gt;50 serious; &gt;100 ocular Sx</p>	<p>HD indicated if visual impairment, acidosis not corrected by bicarb, renal failure, level &gt; 25 (removes MeOH <u>and</u> metabolites)</p>

# Anti-Diabetic Agents

Sulfonylurea, Meglitinides, DPP-IV inhibitors	Metformin (biguanide)
Hypoglycemia: dizziness, diaphoresis, HA, confusion, seizure, coma	Decreased hepatic glucose production and intestinal absorption; improves insulin sensitivity
Can be delayed 8-24h. Avoid prophylactic dextrose if normoglycemic (masks/prolongs hypoglycemia)	Lactic acidosis (inhibited hepatic lactate uptake) + AMS, resp depression, hypotension, HYPERglycemia
Blood glucose Q1H	VBG, BG, BMP
ABC, charcoal <1h, D10 5ml/kg. If refractory give octreotide 1ug/kg (stabilize insulin sec) or diazoxide PO	ABC, charcoal <1h, bicarb, HD only if renal impairment. Admit if acidotic (otherwise monitor x6h)

# Anti-Cholinergic v Sympathomimetic

Anti-Cholinergic Presentation	Sympathomimetic Presentation	Mgmt
Benadryl, Unisom, TCA, Atropine, Antipsychotics, Scopolamine, Jimson Weed	Amphetamines (ecstasy, methamphetamine, ephedrine, methylphenidate), cocaine, PCP, LSD, isoproteronol, epi, caffeine	Bicarb (QRS widening), BZD (agitation), Control temp
Mydriasis, Nystagmus, <b>DRY</b> , flushed, decreased tone, urinary retention	Mydriasis, tachycardia, <b>SWEATY</b> , hyperthermia, agitation. No urinary retention	<b>Physostigmine:</b> reversible AChE inhibitor (increases ACh in pre-synaptic channels) Peds 0.5mg, Adult 2mg (5min push) Repeat PRN (peds max 2mg, adult 4mg)
Tachycardia/HTN, dysrhythmia, Delirium ( <b>air swatting</b> )	HTN early/hypotension late (catecholamine depletion)	Duration = 20min Confirms antichol toxicity
Benadryl: GI/cardiotox - TCA-like: QRS widening, VT (12h delay) + antichol (tachycardia, agitation @4-6h). Toxic >7.5mg/kg	<u>Cocaine eval:</u> ECG, Cardiac enz/CXR (chest pain); CBC, BMP, CK (rhabdo), CT (HA, r/o CVA) <u>Cocaine mgmt:</u> BZD (agit/sz/HTN), Nitroprusside (HTN, avoid BB), cooling, IVF, charcoal. If mild, obs 4h and DC	<u>Contraindicated:</u> TCA (hint: wide QRS > 0.1s) Asthma Cardiac conduction disease SBO

# Cholinergics

Presentation	Mgmt
Organophosphates, carbamates, insecticide Inhibit AChE -> ACh accumulation and cholinergic stimulation	ABCs, Remove clothes and irrigate with water, VBG
<u>DUMBELS</u> : diarrhea, urination, mioiosis, bronchospasm, emesis, lacrimation, salivation	Immediate Atropine 0.02mg/kg, can double q5min (no max dose) until secretions dry -> reverses bronchospasm, block muscarinic rec
<u>Muscarinic</u> : exocrine/smooth muscle Salivation, lacrimation, diarrhea, wheeze, bradycardia *Responds to atropine	Organophosphates: Pralidoxime 50 mg/kg IV over 30min -> reactivates AChE
<u>Nicotinic</u> : Mydriasis/Muscle cramp, Tachycardia, Weakness, Twitching, HTN/Hyperglyc, Fasciculation	BZD (seizure); Avoid succ for RSI (normally metabolized by AChE so may cause prolonged paralysis); CXR for pneumonitis (organophos contain hydrocarbon)

# Smoke Inhalation Injury

Carbon Monoxide	Cyanide
House fires (wood, charcoal, gas, heating systems, exhaust). Colorless/tasteless/odorless gas	Burned plastic, clothing (wool, silk, synthetic fabric) or nitroprusside or acetonitrile (sculpted nail removal) or seeds of apple, apricot, peach
Binds heme 240x affinity vs O <sub>2</sub> (functional anemia > reduced O <sub>2</sub> carrying capacity/delivery)	Disrupts mitochondrial ox phosphoryl > dec ATP > impaired O <sub>2</sub> delivery
Fatigue, HA, dizziness, vomiting. Normal VS/sats, decreased attention/recall, +cherry red skin; if severe - delirium, coma, arrhythmia	<b>Rapid onset (mins):</b> CNS (seizure), CV dysfunction, resp dep, vomiting, renal failure
Co-oximetry for carboxyHb (COHb - nl <5%, smoker <15%); PaO <sub>2</sub> falsely nl but accurate acid-base status, ventilation, lactate (cyanide); ECG, troponin, fetal monitor	<b>Severe acidemia, High lactate.</b> Cyanide level send out. Send Co-ox and MetHb level
O <sub>2</sub> via NRB @100% (cuts CO half-life from 300 to 90min). Hyperbaric if >25%; consider early intub; ECMO if severe. DC when <5% or if ASx	<b>No response to O<sub>2</sub>. Hydroxycobalamin</b> (AE = HTN, reddish skin/urine) <b>Na Thiosulfate.</b> Early intubation, fluid resus + pressors; BZD (seizure/agitation)

# Methemoglobinemia

Presentation	Workup	Mgmt
<p>Severe prolonged infant diarrhea (no NADH metHb reductase); benzocaine/lidocaine (teething gels or laced in street opioids)</p>	<p>Co-oximetry (%metHb, carbon monoxide, OxyHb, DeoxyHb)</p> <p>CBC, BMP, VBG</p>	<p><b>Methylene blue 1%</b> if symptoms of O<sub>2</sub> deprivation or metHb &gt; 20%</p> <p>Dose = 1mg/kg (max 50mg) over 3min, rpt @30min if level still &gt;20%</p>
<p>Cyanosis unresponsive to supplemental O<sub>2</sub> (SpO<sub>2</sub> falsely low 2/2 interference with wavelength)</p>	<p>PaO<sub>2</sub> falsely normal (unlike congenital heart disease)</p>	<p>Ineffective if G6PDD since G6PD needed to generate NADPH -&gt; give ascorbic acid as alternative 300-1000mg/day PO div TID</p>
<p>Chocolate brown blood, tachypnea, hypotension, dysrhythmia, lethargy, coma, arrest</p>		<p>Last resort = exchange transfusion</p>



# Corrosives

Alkali	Caustic Eye Injury
Liquefactive necrosis via saponification of fatty acids (detergents/cleaners)	Immediate pH, anesthetic (proparacaine 0.05%), remove FB then irrigate PRIOR to exam
Chlorine bleach depends on amount/concentration (household usually benign, vs industrial-strength)	Morgan Lens or IV bag w/ tubing connected to nasal cannula on nasal bridge for dual irrigation
Pain, vomiting, drooling, dysphagia, hematemesis, cough, upper airway edema, GI perforation (shock)	Lavage 20+ mins with 2L NS then check pH (goal 7.4-7.6). Check IOP - if high, emergent ophtho + consider acetazolamide
ABCs, intubate if stridor/dyspnea/dysphonia; IVF; CXR/AXR (free air); no NG (risk perf); no dilution/milk (risk emeses); no H2 blocker (inc gastric injury)	DC with topical antibiotics (polymyxin B/trimethoprim), pain control, ophtho follow up 24h.
EGD when stable (12-48h). If ASx, no EGD (obs 2-4h). Tide Pods: 8% CNS dep. Obs 24h, NPO, c/s GI for scope (no consensus); irrigate if eye exposure	Complication = vision loss, corneal perforation



# Recreational

Synthetic Marijuana (Spice)	Hydrocarbon Inhalants	Others
100x greater affinity for cannabinoid rec than THC. Inhaled peak @15-30min Ingest peak @30min-3h	Sniffing/huffing volatile solvents, gas, kerosene, lighter fluid, paint thinner, aerosol propellants, turpentine	<b>Nicotine/E-cig:</b> nausea/vomiting, tachycardia/, tachypnea, dysrhythmia, HA, ataxia, sz. Mgmt = BZD PRN
Euphoria v dysphoria (paranoia, agitation, anxiety, psychosis)	<b>Pulmonary, CNS and Cardiac toxicity</b>	<b>Bath salts (cathinone, amphetamine):</b> hallucination, tremor, hyperreflexia, tachycardia/HTN, psychosis, mydriasis, diaphoresis, hyperthermia, bruxism, MI. Mgmt = BZD (agit/tachy/HTN), obs til resolve
Diaphoresis, tachycardia, ataxia, seizure, dry mouth, renal injury, MI, resp depression in large dose	Nausea/vomiting, cough, hypoxemia (surfactant disrupted), ARDS, CNS depression, slurred/drowsy, VF (catechol sensitization of myocardium)	
<b>Young kids:</b> bradycardia, hypotonia, apnea, cyanosis	High aspiration risk! Low viscosity, low surface tension, high volatility. Assume asp if cough/gag/choke/vomit	<b>Ketamine, Phencyclidine (PCP):</b> bidirectional nystagmus, tachycardia/HTN, fluctuation level of consciousness, inc secretions/laryngeal hyperreactivity can obstruct airway. Mgmt = BG, BMP (renal), CK (rhabdo); IVF
Support resps; ECG +/- card enzyme (chest pain); BZD (agitation/sz); Ketamine (combative); Cooling; Obs til resolved	Airway/ventilation, O2, albuterol, CXR, ECG, esmolol (dysrhythmia), BZD (sz), replete lytes. If ASx, can obs 6h	

# Further Reading

- Tenebein, Milton. 'Toxicologic Emergencies'. *Strange and Schafermeyer's Pediatric Emergency Medicine*. McGraw-Hill. 2019
- Klaassen C, Watkins J. *Casarett and Doull's Essentials of Toxicology*. McGraw-Hill. 2017