

A photograph of a large fire burning in a forest. The fire is intense, with bright orange and yellow flames rising from the trees. Thick, dark smoke billows upwards, filling the sky. The foreground shows some green foliage, possibly bushes or smaller trees, which are partially obscured by the fire and smoke. The overall scene is dramatic and dangerous.

Just don't inhale

Why smoke is bad.

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What is smoke?

- Depends on what is burning.....right?
- Generally a mixture of particles from incomplete burning of carbon containing materials.
- Contains the big three: Carbon Monoxide (CO), Carbon Dioxide (CO₂), and particulate matter (soot)

Dependent on...

- The substance that is burning
 - More synthetic polymers in newer buildings: more cyanide
- The burn temperature
- The amount of oxygen available

Historical

- We know a lot about inhalation injury due to airline fires
- Captive audience
- Aviation combustion toxicology
- August 19, 1980 Saudia flight 163, Pilot landed, 301 deaths, 0 survivors. No burns
- Chaturvedi et al. review of 95 fire related civil airline incidents over 26 yrs, 360 individuals had CO levels ≥ 20 , +/- cyanide, enough to impair performance.

Its more than CO and soot

- Aldehydes (like formaldehyde)
- Acid gasses (like Hydrochloric acid, HCN)
- Sulfur dioxide (used in bleaching and as a refrigerant)
- Nitrogen oxides (used to produce rocket fuel)
- Polycyclic aromatic hydrocarbons (found in ashes from forest fires, cancer)
- Benzene (effects bone marrow, anemia and leukemia)
- Toluene (effects CNS and respiratory tract)
- Styrene (liver toxicity)
- Metals
- Dioxins

Cyanide

- Fast acting poison, lethal, painful death
- Several different forms, many different exposure routes
- Hydrogen cyanide is pale blue/colorless at room temp, colorless gas at high temp
- Odor is not a good way to tell if cyanide is present
- Many different routes of exposure, offgasses

Historical cyanide

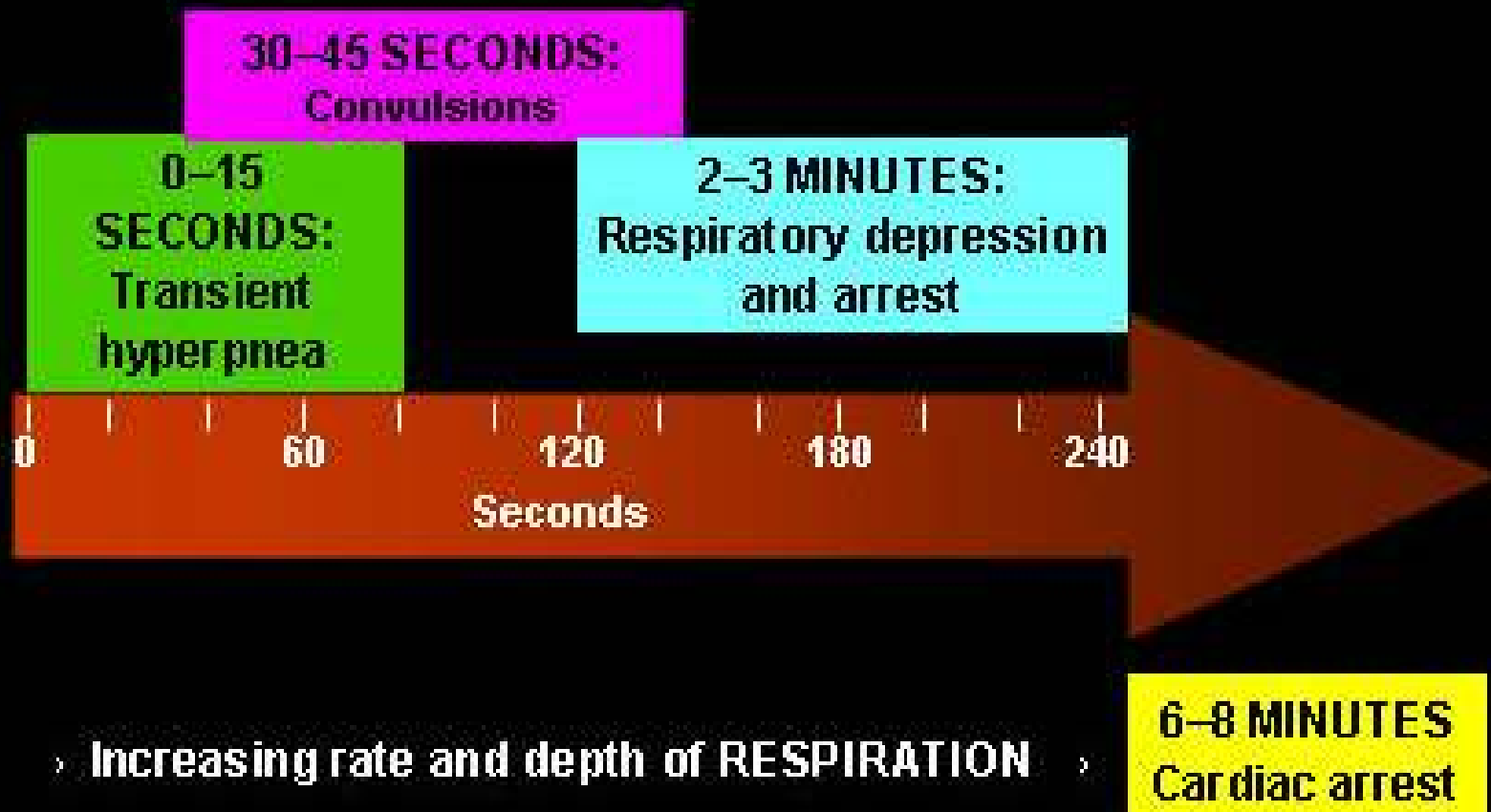
- Emperor Nero carried cyanide cherry water as a poison
- Franco-Prussian war Napoleon III had blade tips dipped in cyanide
- Used as a chemical weapon in WWI, in gas chambers in WWII
- Mass suicide at Jonestown, Guyana 1978
- Tylenol Poisonings 1982
- Subway terrorism Japan 1995



What the body does....

- Binds to cytochrome oxidase system, so inhibits aerobic respiration. (high lactic acid)
- Also binds to metals...think iron in hemoglobin
- Small amounts: CN is changed into thiocyanate and excreted in the urine
- Large amounts: overwhelm the system, circulates around and prevents cells from using oxygen
 - Most effected systems heart, respiratory and CNS

Timeline of Cyanide Intoxication via Inhalation



Inadvertant exposures

- Low levels of cyanide found in
 - bacteria, fungi, algae, cigarette smoke, vehicle exhaust, spinach, bamboo shoots, almonds, lima beans, fruit pits and tapioca

Apple seeds, Cherry pits, apricots and plums are the biggest fruit offenders, contain amygdalin, which breaks down to HCN. Fatal dose can be as little as 1.5mg/kg



Nefarious exposures

- Its why you have to check in with security at Upstate University Hospital
- Dr Yazeed Essa/Rosemary Essa
- Robert Ferrante/Dr Autumn Marie Klein
- Painful aware death

Treatment

There are 4 treatments, we will discuss 1

- Cyanokit: 5g of hydroxocobalamine
- Cobalt binds to cyanide, creating nontoxic cyanocobalamine (vitamin B12), allowing body to use oxygen again
- Should be given within 30 minutes of exposure
- Resolves lactic acidosis from cyanide
- Gives a bump to the blood pressure

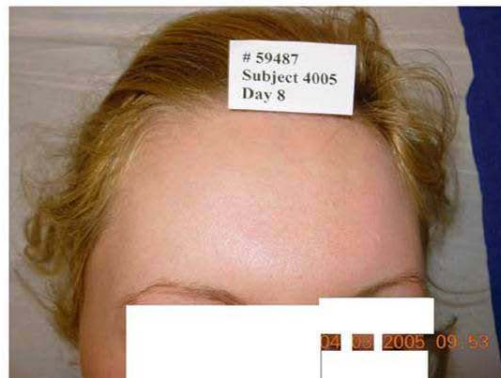


Cyanokit turns patient purple

Day 1



Day 8



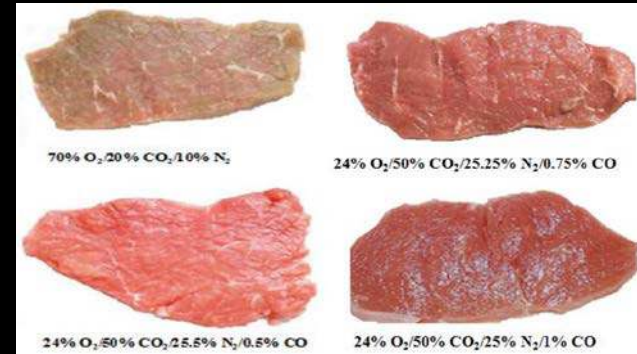
Long term exposures

- Associated with pancreatic derived diabetes
- Hypothyroidism
- CNS illness including Parkinson's

Carbon Monoxide

- Binds to hemoglobin tightly, changing protein formation, reducing its ability to release oxygen
- Binds to fetal hemoglobin more than mom's
- Causes anaerobic respiration of cells
- Increases lactic acid

CO levels



- In smokers, <10%
- Highest CO level in a smoker tested: 24%
- CO induces a cherry red color.
- May make 3rd degree look red and perfused if CO high when burned
- SpO₂ monitors falsely elevated: need CO-Oximetry to test SpCO (Mosimo) or blood test

Treatment

- 100% FiO₂
- t_{1/2} on O₂ 21% 5 hours
- t_{1/2} on O₂ 100% 1-1.5 hours
- t_{1/2} on 3atm hyperbarics 20 min

Hyperbarics

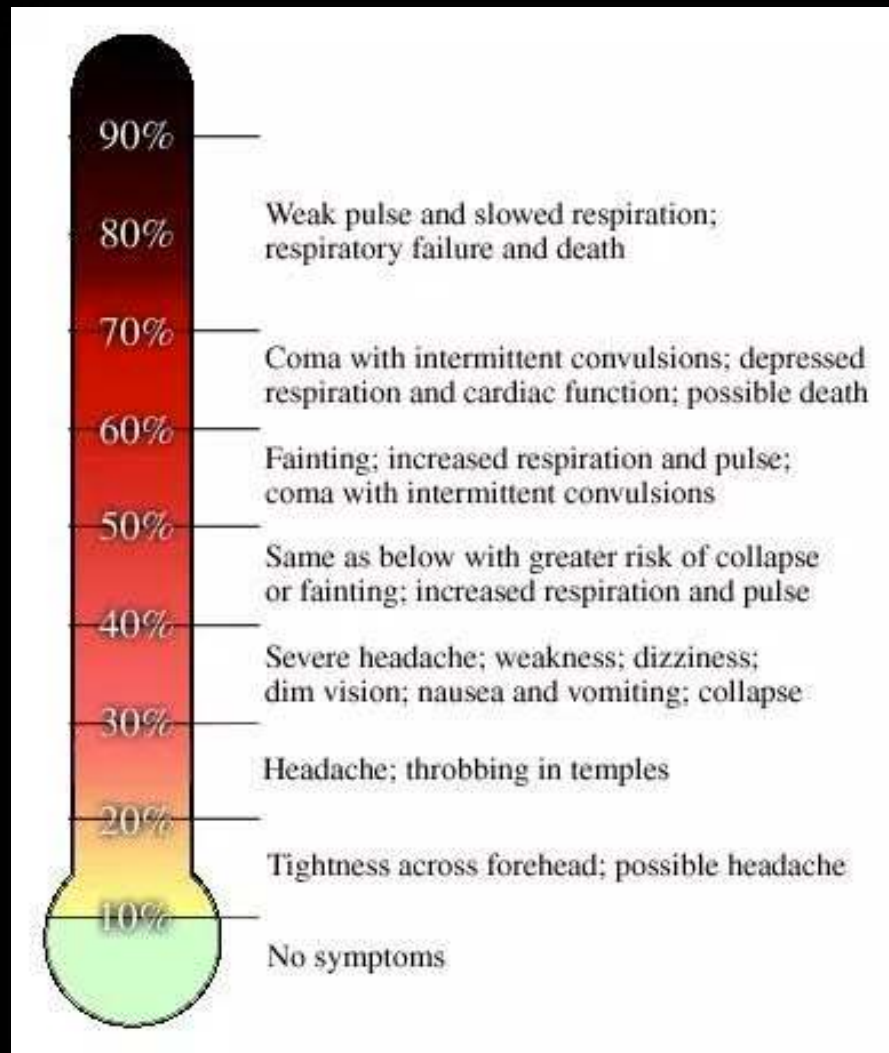
TABLE 1. Indications and contra-indications for HBOT in patients with severe CO poisoning, with reference to the Undersea and Hyperbaric Medical Society

Indication/contra-indication	Description
Indications of HBOT for patients with severe CO poisoning features*	<ol style="list-style-type: none"> 1. LOC or history of LOC suspected to be caused by CO poisoning 2. Evidence of myocardial ischaemia with typical chest symptoms or electrocardiogram changes 3. COHb level >25% on admission (not absolute) 4. Pregnancy
Absolute contra-indications for HBOT	<ol style="list-style-type: none"> 1. Untreated pneumothorax 2. Refusal by patient or their proxies 3. High requirement of oxygen concentration (eg $FiO_2 \geq 0.5$, mechanical ventilation is not a contra-indication) 4. Some selected medications <ul style="list-style-type: none"> • Doxorubicin—cardiotoxicity may occur • Cisplatin—wound healing may be impaired • Disulfiram—blocks the production of superoxide dismutase, which protects against oxygen toxicity • Mafenide acetate—wound healing may be impaired
Relative contra-indications for HBOT	<ol style="list-style-type: none"> 1. Haemodynamically unstable (need for vasopressor/inotropes and at risk during transportation) 2. Asthma (medication required to control the condition) 3. Chronic obstructive pulmonary disease/bullous emphysema 4. Claustrophobia, emotionally unstable or seizures (medications, eg benzodiazepines, for controlling anxiety, insomnia, agitation, or seizures) 5. Ear or sinus surgery 6. Optic neuritis 7. Recent thoracic surgery 8. Upper respiratory infections 9. Pacemakers (their technical specifications should be reviewed prior to treatment to avoid deformation)

Abbreviations: CO = carbon monoxide; COHb = carboxyhaemoglobin; FiO_2 = fraction of inspired oxygen; HBOT = hyperbaric oxygen therapy; LOC = loss of consciousness; PYNEH = Pamela Youde Nethersole Eastern Hospital

* Adopted in intensive care unit of PYNEH since 2008

Carboxyhemoglobin %



Its all additive

- CO, CN, and low oxygen availability leads to death at a lower toxicity level
- Can make baseline cardiac and respiratory status worse, acute MI and COPD exacerbation not uncommon
- CO, thought to be the major cause of death may be at sublethal levels due to other substances such as cyanide
- In animal studies, a CO level of 30% is lethal with a CN level of 0.25, and an ambient O₂ of 8%

Aftermath

- Airway!
- Initial Chest x-rays usually good
- Inhalation injury can be spotted on Chest CT scans with edema around bronchus/bronchioles
- Bronchoscopy
 - Gold standard



Bronchoscopic View: Acute/edematous



Facial Burn: Anoxic carbon monoxide

Inhalation aftermath

- Destruction of type 2 lung cells, that lubricate the lungs
- Loss of cilia, so bacteria stays in the lungs, causing pneumonia
- Cells die off and form casts, plugging larger airways
- Edema forms, interfering with oxygen and carbon dioxide exchange
- If burned, patient become hypermetabolic around day 3, increasing the quantity needed oxygen and carbon dioxide exchange



Answers?

- Prevention is key
- Working smoke detectors
- CO detectors
- Escape plans (school education)
- Mutual aid plan
- Regional Cyanokits
- Have a decontamination plan for staff
- Wear good fitting gear, wash it regularly

Questions?

