Smoke Inhalation and Management

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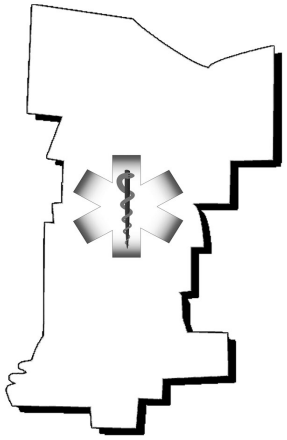

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Why is this necessary?

- Smoke inhalation can involve CO poisoning, Hydrogen Cyanide (HCN) poisoning and burns
- HCN poisoning is under-recognized and under-treated
- The life you save might be that of another responder!

Outline

- Risk factors/prevalence of CO/HCN poisoning
- Signs/symptoms and management of patients with CO/HCN poisoning
- Familiarization with regional resources for management of CO/HCN poisoning
- Review of the Rad-57

Outline continued…

- Introduction to new integrated protocol for smoke inhalation
- Familiarization with use of Cyanokit (for HCN poisoning)
- Familiarization with system distribution of Cyanokit

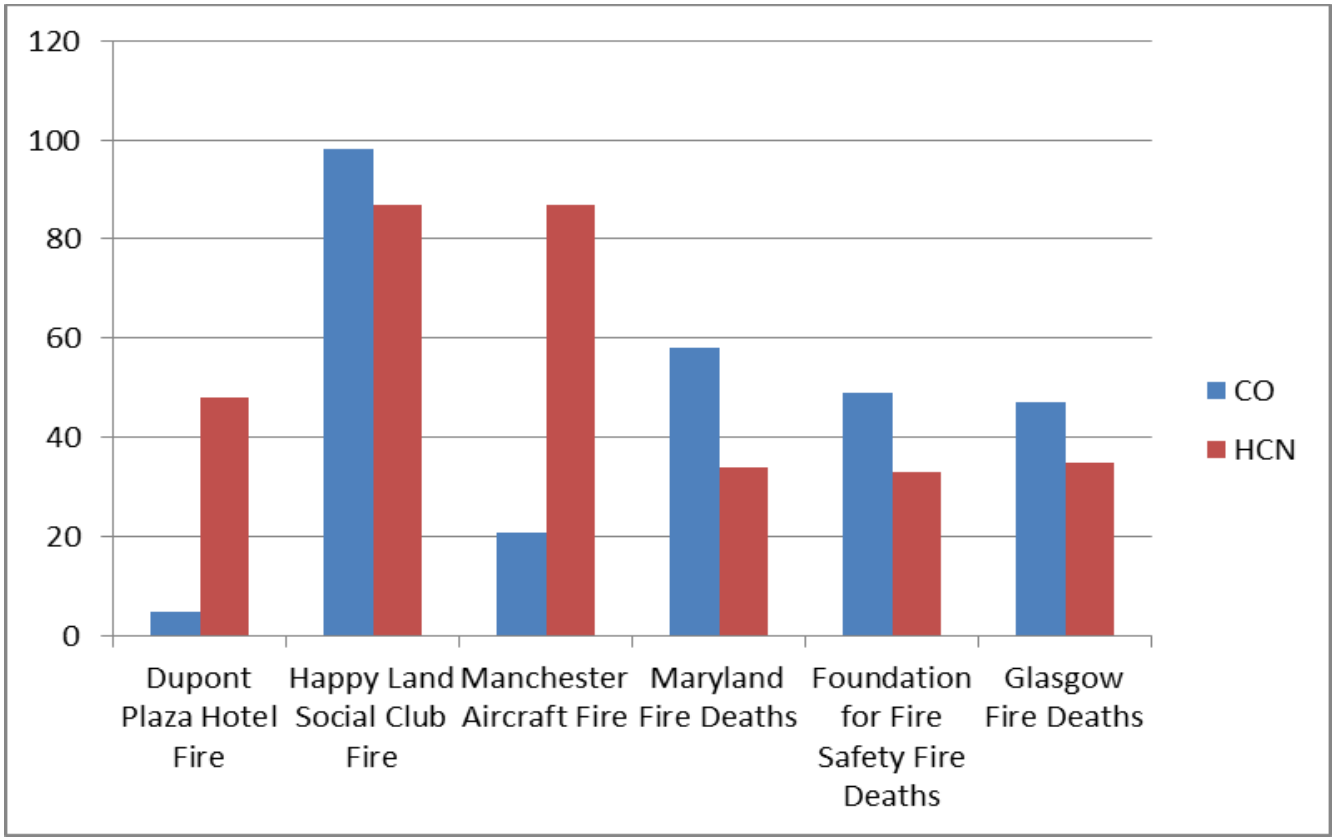
Where is cyanide found?

- Foods (almonds, apple seeds, orange seeds)
- Pesticides and insecticides.
- Gas chambers (Zyklon B – Nazi gas chambers)
- Chemical warfare (Saddaam Hussein – 80's)
- Suicide (Jonestown Cult)
- Terrorism (unsuccessful attempt – Japanese subway system)
- Fire smoke (most common cause) ***and the focus of this training.***

Where does HCN in fire smoke come from? Burning of…

- Plastics
- Cotton
- Wool
- Silk
- Paper
- Polymers

Victims with Lethal Levels of CO/HCN from Smoke Inhalation



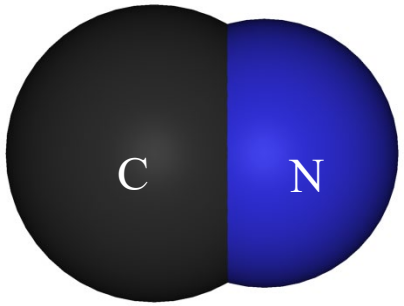
Alaire Y. *Crit Rev Toxicol* 2002, 32 252-289

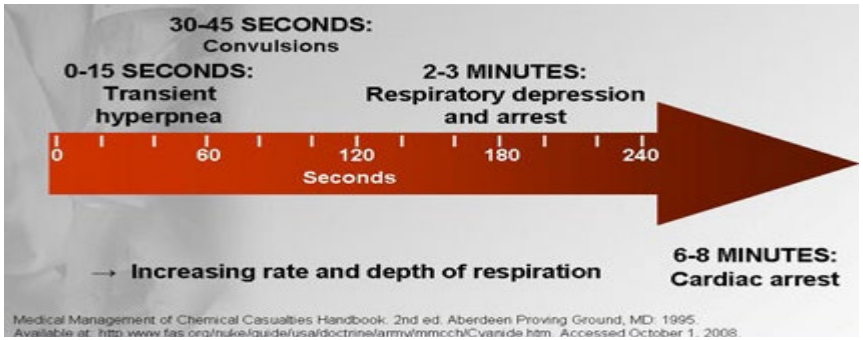
So…

- Smoke inhalation is the ***most common cause of fire-related death*** - Not burns!
- We know the risks of CO poisoning, the leading cause of death from smoke inhalation
- HCN poisoning is one of the leading causes of death from smoke inhalation, but you probably know little about it or how to treat it
- HCN poisoning is lethal **BUT** treatable

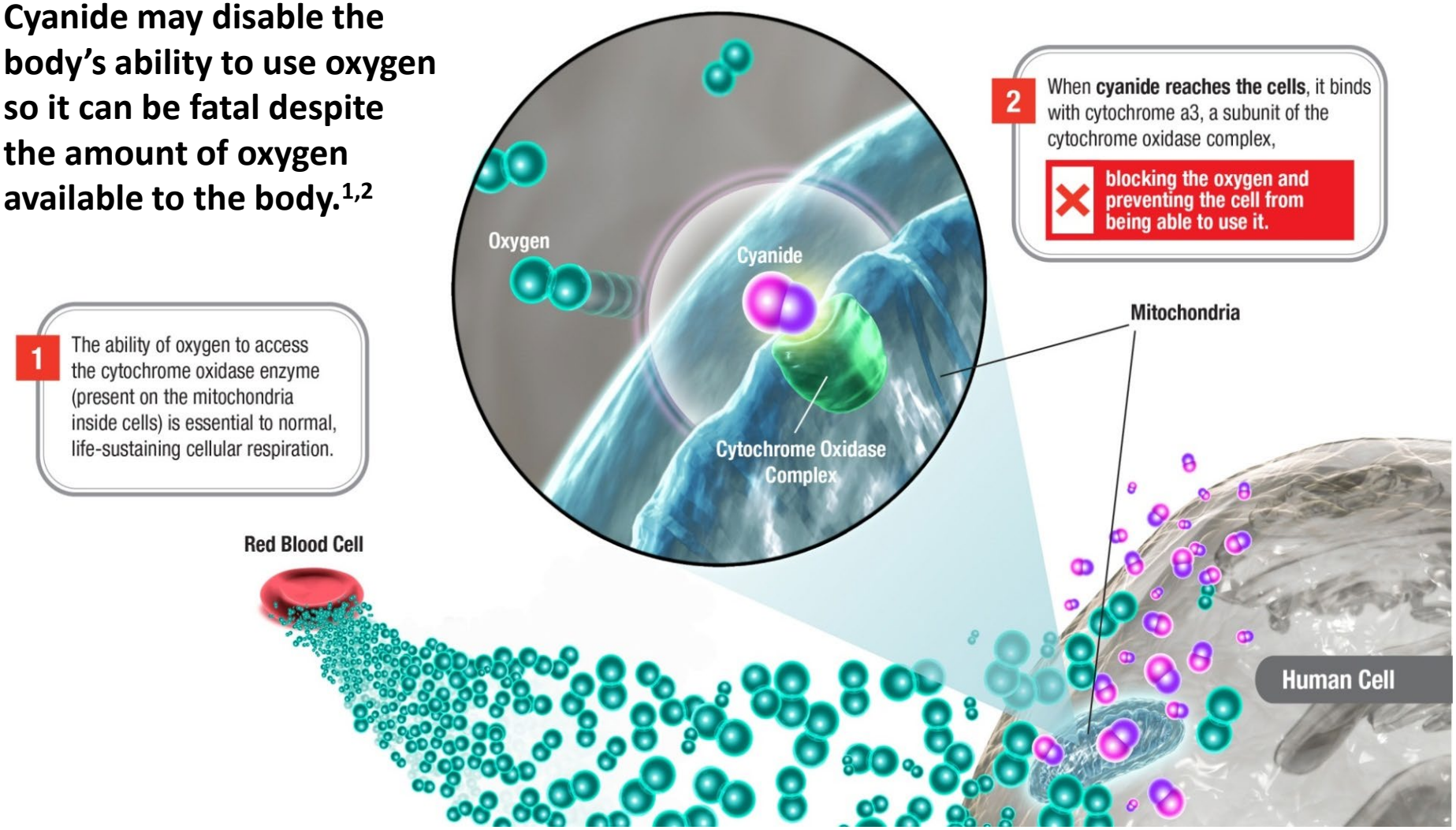
Physiology of HCN Poisoning

- Prevents aerobic ***cellular*** respiration, leading to anaerobic respiration.
- Results in cellular hypoxia and lactic acid production.
- Leads to metabolic acidosis, central respiratory depression, cardiac arrest.





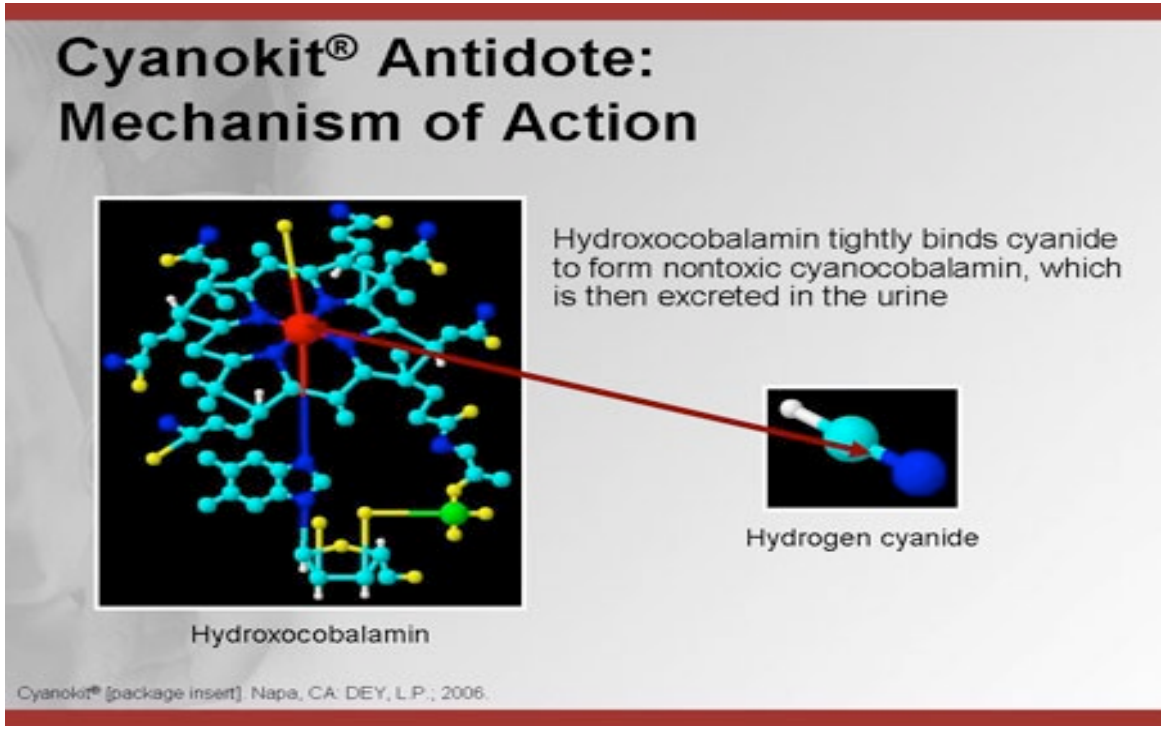
Cyanide may disable the body's ability to use oxygen so it can be fatal despite the amount of oxygen available to the body.[1,2]



1. Cyanokit (single 5-g vial) [package insert]. Columbia, MD: Meridian Medical Technologies, Inc.; 2011.
2. Schnepp R. Where there's fire—there's smoke! In: *Smoke: Cyanide and Carbon Monoxide: The Toxic Twins of Smoke Inhalation. Indianapolis, IN: Cyanide Poisoning Treatment Coalition; 2009:3-8.*

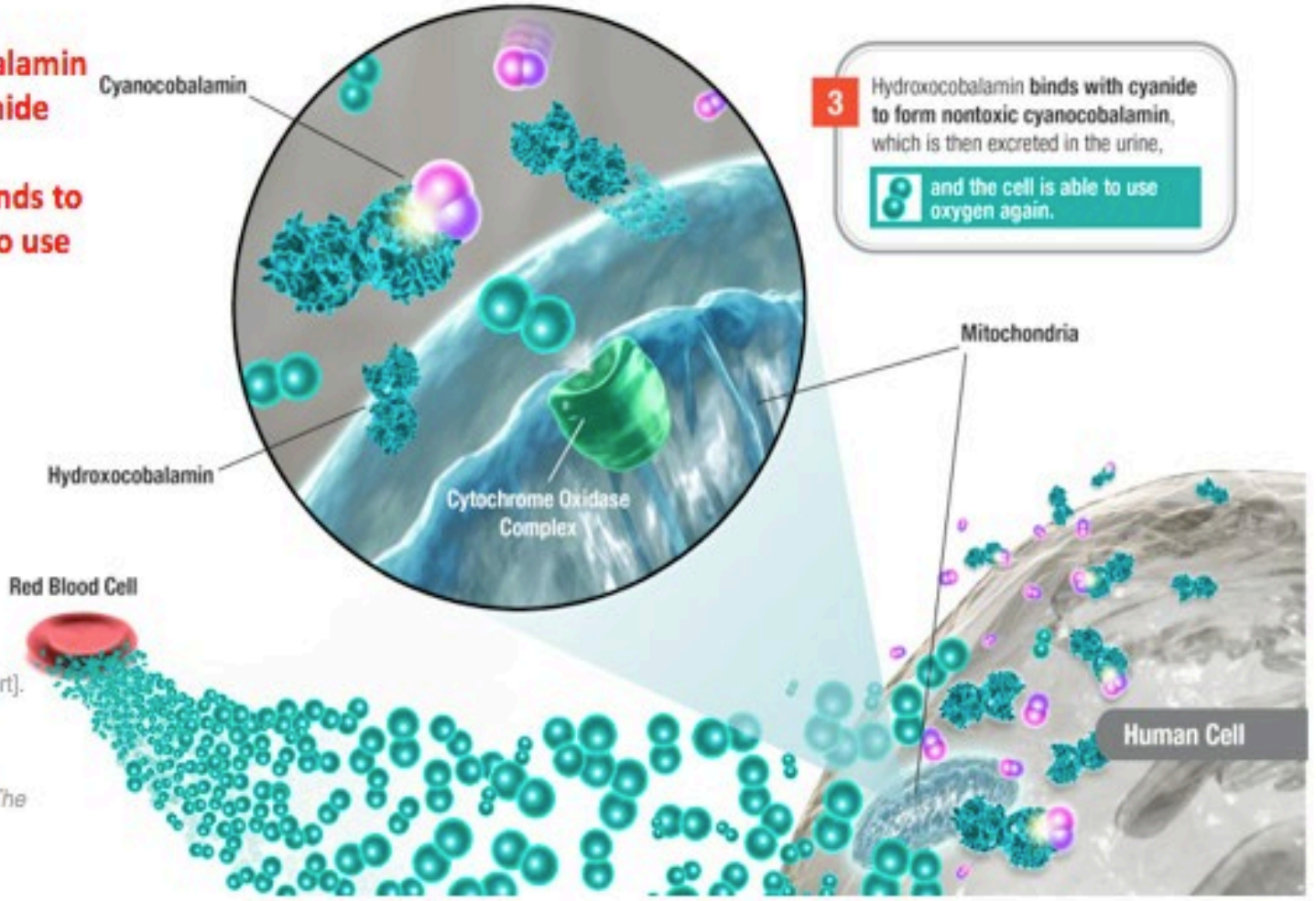
If a smoke inhalation patient experiences ***respiratory/cardiac arrest, shock, or seizures…***

- Presume they have cyanide toxicity and TREAT
- The antidote is hydroxocobalamin



Cyanokit® – How it works

CYANOKIT® 5 g (hydroxocobalamin for injection) is the only cyanide antidote that contains hydroxocobalamin, which binds to cyanide, allowing the body to use oxygen again.[1,2]



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Consider HCN poisoning when…

- A patient/rescuer was exposed to smoke and is experiencing ***cardiac/respiratory arrest, shock, or seizures***:
- ***APPLY OXYGEN AND ADMINISTER CYANOKIT!***

"Sick as s**t - Cyanokit"

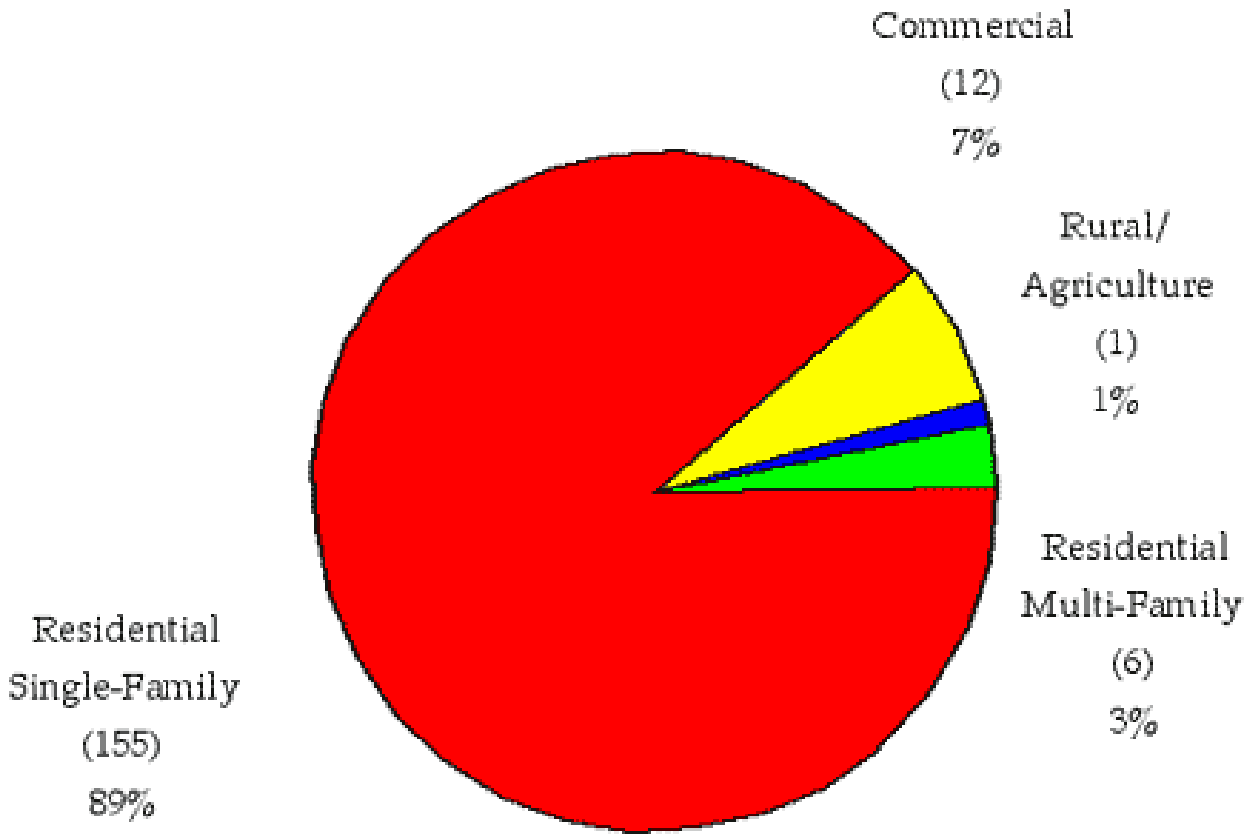
Signs/Symptoms HCN poisoning

Mark Eckstein, MD. *Prehospital Recognition and Management of Cyanide Poisoning.* Medscape

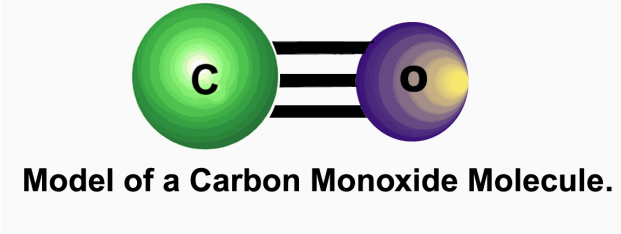
Do those signs/symptoms look familiar?

- The signs/symptoms of HCN poisoning are indistinguishable from CO poisoning
- If your patient does not require immediate administration of Cyanokit, then consider CO poisoning
- So let's talk about CO

CO-Related Deaths in 2000



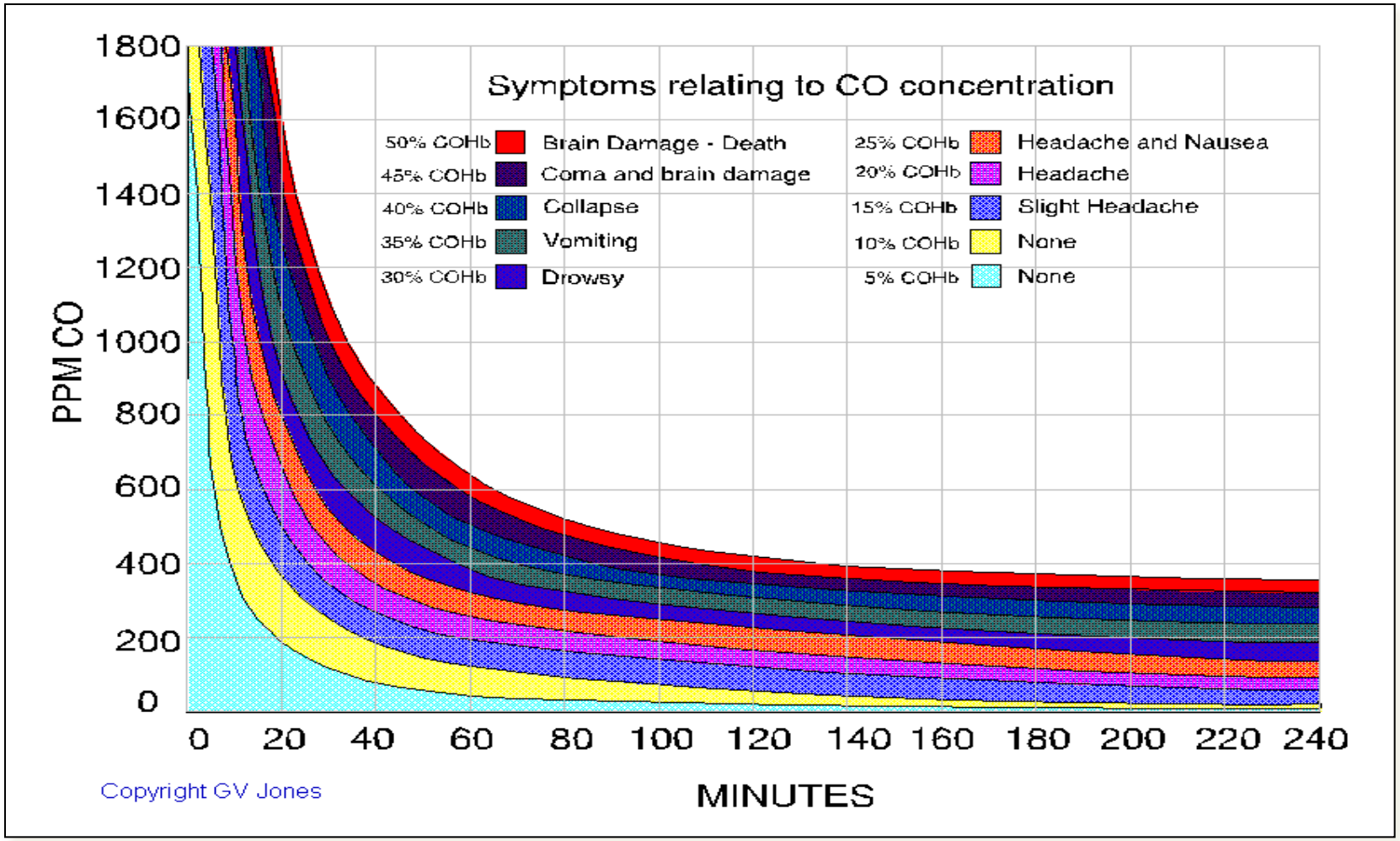
What is it?



Model of a Carbon Monoxide Molecule.

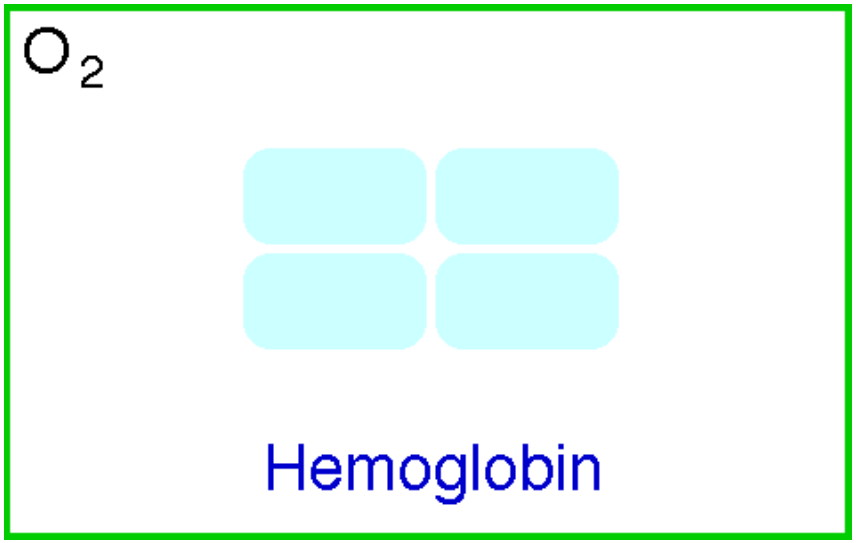
- Carbon Monoxide (CO) is a colorless and odorless gas
- It is poisonous to people and animals, because it displaces oxygen in the blood
- It is produced by the incomplete burning of solid, liquid, and gaseous fuels
- Appliances fueled with natural gas, liquefied petroleum (LP gas), oil, kerosene, coal, or wood may produce CO. Burning charcoal and running combustion engines (cars, motorcycles, generators, etc) produce CO

How much causes symptoms?



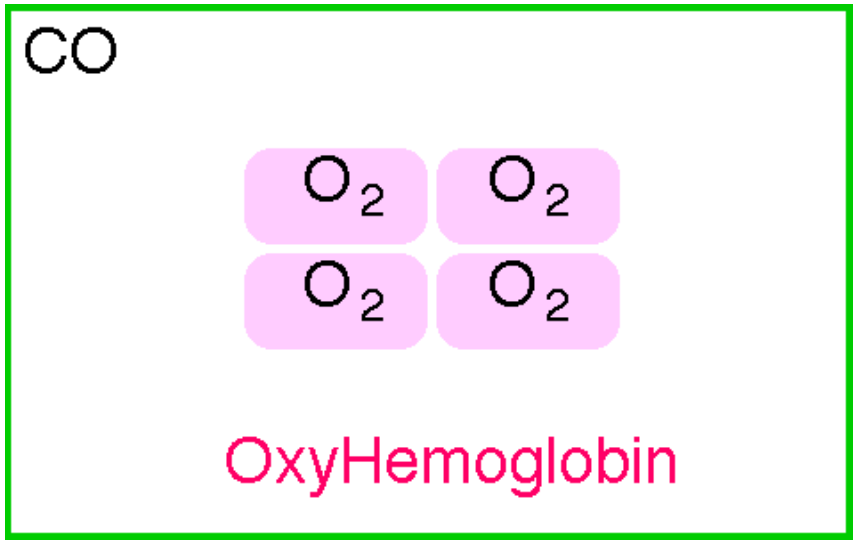
Normal Hemoglobin

- Normal oxygenation of the tetrameric (ie. 4 subunits) hemoglobin molecule
- As it goes from deoxyhemoglobin to oxyhemoglobin the color changes from blue, as in venous blood, then to pink, as in arterial blood



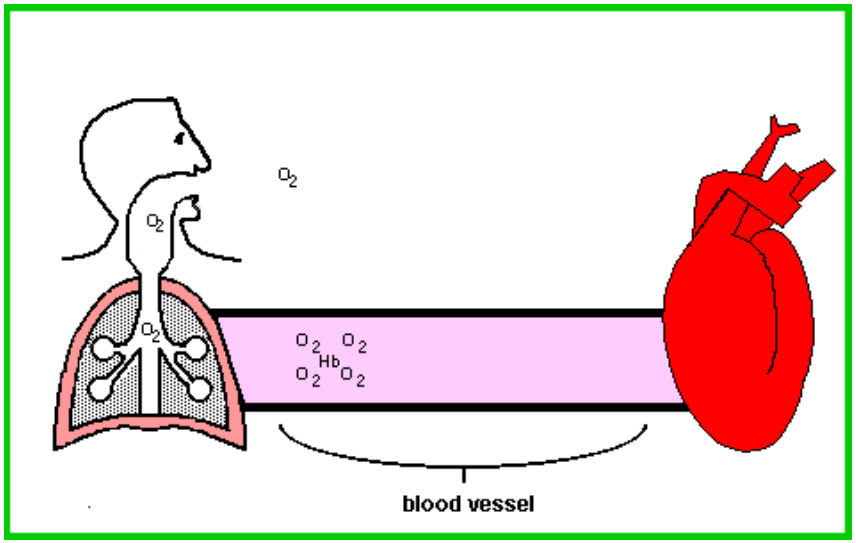
Carboxyhemoglobin

- Here carbon monoxide (CO) enters the picture, and through its very high affinity for hemoglobin, displaces the oxygen from the hemoglobin
- This prevents oxygen being carried to the tissues and organs of the body
- Carboxyhemoglobin is reddish in color



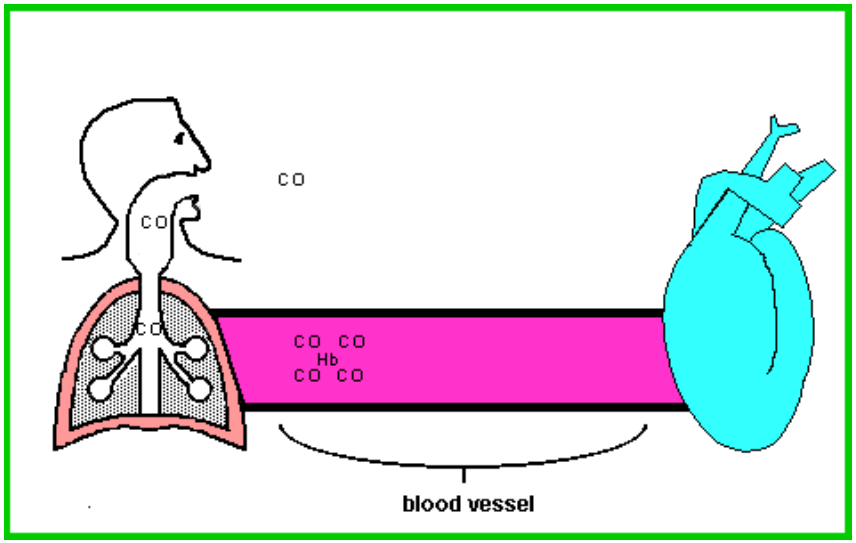
Normal Physiology

- Oxygen is carried from the lungs by the blood hemoglobin to the tissues, here the beating heart is shown, and normal healthy oxidative metabolism goes on



CO Poisoning

- During Carbon Monoxide poisoning, CO is carried from the lungs by the blood hemoglobin to the tissues, preventing oxygen from being carried, and blocking normal oxidative metabolism



Symptoms of CO Poisoning

SpCO Level	Clinical Manifestation
0 – 10 %	Mild headache, SOB with exertion
10 – 20%	Moderate headache, SOB at rest
20 – 30%	Worsening headache, nausea, dizziness, fatigue
30 – 40%	Severe headache, vomiting, vertigo, altered judgment
40 – 50%	Confusion, syncope, tachycardia
50 – 60%	Seizures, shock, apnea, coma

Normal SpCO for non-smoker : <5%
Normal SpCO for smoker: <10%

CO and HCN are the evil twins of smoke inhalation

- CO poisoning stops red blood cells from carrying oxygen
- HCN poisoning prevents cells from using oxygen
- But neither one will reduce SpO_2! We do not have a way to measure blood HCN in the field but that doesn't mean we can ignore it
- We can measure SpCO levels using the Rad-57

Caveat…

- Symptoms DO NOT always correlate with the SpCO level

- If symptomatic, and exposed to smoke, the patient must be transported to the hospital for definitive determination REGARDLESS of the CO level read by the Rad-57

The Rad-57

- Noninvasive measurement of both SpO_2 (pulse oximetry) and SpCO (pulse CO-oximetry)

- DOES NOT REPLACE A GOOD ASSESSMENT

Indications

- Two settings for its use:
  - Screening patients for suspected exposure
  - Screening emergency services personnel during rehabilitation

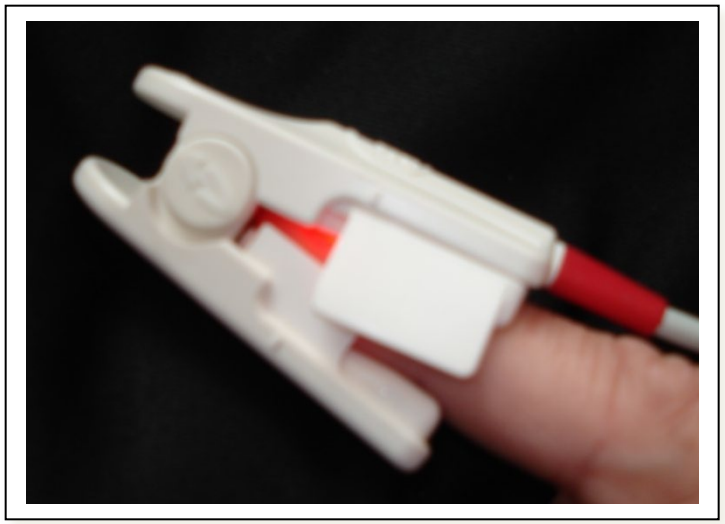
Using the Rad-57

1. Connect the sensor cable to the Patient Cable Connector of the oximeter **before you power on**. Make sure the connection is secure and the cable is not twisted, sliced, or frayed.
2. Remove any substances (nail polish, paint, etc) on the patient's second, third, or **fourth digit** that may interfere with the transmission of light between the sensor's light source and photo detector.

Sensor Placement

3. Attach the sensor to the patient, applying it to the index (second), middle (third), or **ring (fourth)** digits. Only these digits can be accurately used by the CO-Oximiter.

- ***SENSOR PLACEMENT IS VERY IMPORTANT***
  - When possible, use ring (fourth) finger, non-dominant hand.
  - Insert finger until the tip of finger hits the STOP Block.
  - Sensor should not rotate or shift freely on finger.
  - LED's (red light) should pass through mid-nail, *not* cuticle.
  - There is a top and bottom, cable should be on top (nail side).



Turning the device on

4. Press the Power button ON.

- ***POWER***
  - **Press to turn ON.**
  - **Press and HOLD to turn OFF.**

- ***BATTERY INDICATOR***
  - **4 Green LED's.**
  - **Each represents 25% battery life.**
  - **Use only Alkaline batteries.**

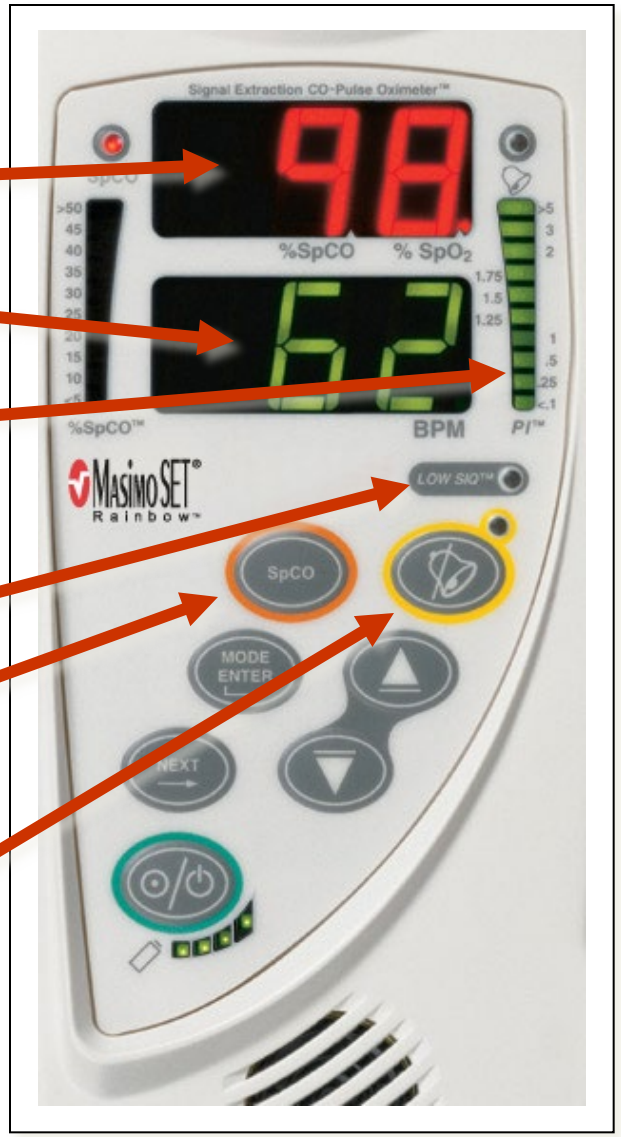
Self-Test

5. The machine will go through a self-test procedure:

- ***POWER ON: SENSOR ON FINGER***
  - All LED's light up.
  - Calibration mode begins
    - Spinning zeroes *0 - 0 – 0.*
    - Completed in 20 second (avg.)
    - DO NOT move sensor during calibration.
    - Acquires reading and displays.
- ***DISPLAY***
  - Defaults to pulse rate and oxygen saturation reading.
  - "PI" bar graph displays strength of arterial perfusion.

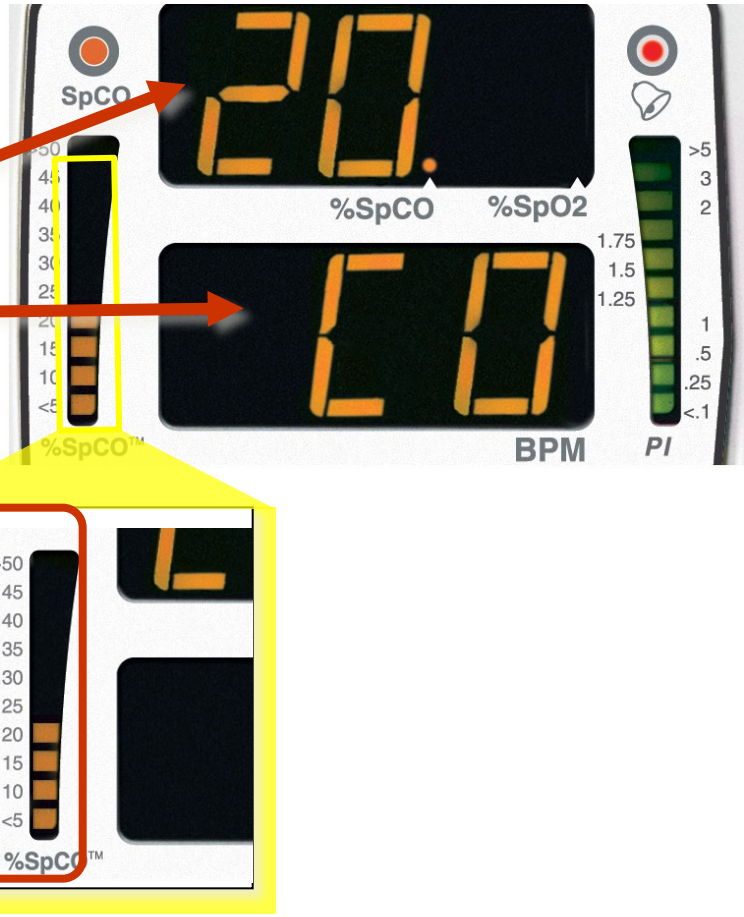
Initial Display

- Oxygen Saturation on top in Red
- Pulse Rate on bottom in Green
- Green PI scale, indicates strength of arterial pulse
- Low SIQ LED indicates poor signal quality
- Press SpCO to display % carboxyhemoglobin
- Press “Bell” to silence alarms



Measuring SpCO

- *PRESS ORANGE SPCO BUTTON*
- Display will toggle to CO mode for 10 seconds
- Carboxyhemoglobin reading in % on top
- "CO" displayed on bottom confirming mode
- **ALWAYS confirm high readings by taking several measurements on DIFFERENT fingers and average**
- Real-time SpCO indicator continuously reads SpCO
  - Green: 1-9%
  - Orange: 10-19%
  - Red: 20% and above



Important Notes!

- The standard probe is indicatedin patients weighing > 30 kg (66 lbs)
- Patients 10 – 50 kg require pediatric probe
- When examining multiple patients, turn the device OFF then ON to recalibrate between patients
  - Failure to do so could give you incorrect readings!!!

Cyanide and Methemeglobinemia

- Cyanide toxicity and methemoglobinemia cannot be readily determined by this device
- The CO-Oximeter should be used in addition to clinical judgment and a normal reading in the setting of a patient with severe respiratory distress or cyanosis should not rule out a significant oxygen-transfer deficit (cyanide, met-hemoglobinemia, sulfhemoglobinemia, or profound anemia) requiring aggressive airway management and high-flow oxygen
- ***Always treat the patient first and not the reading on the CO-Oximeter***

Important Notes

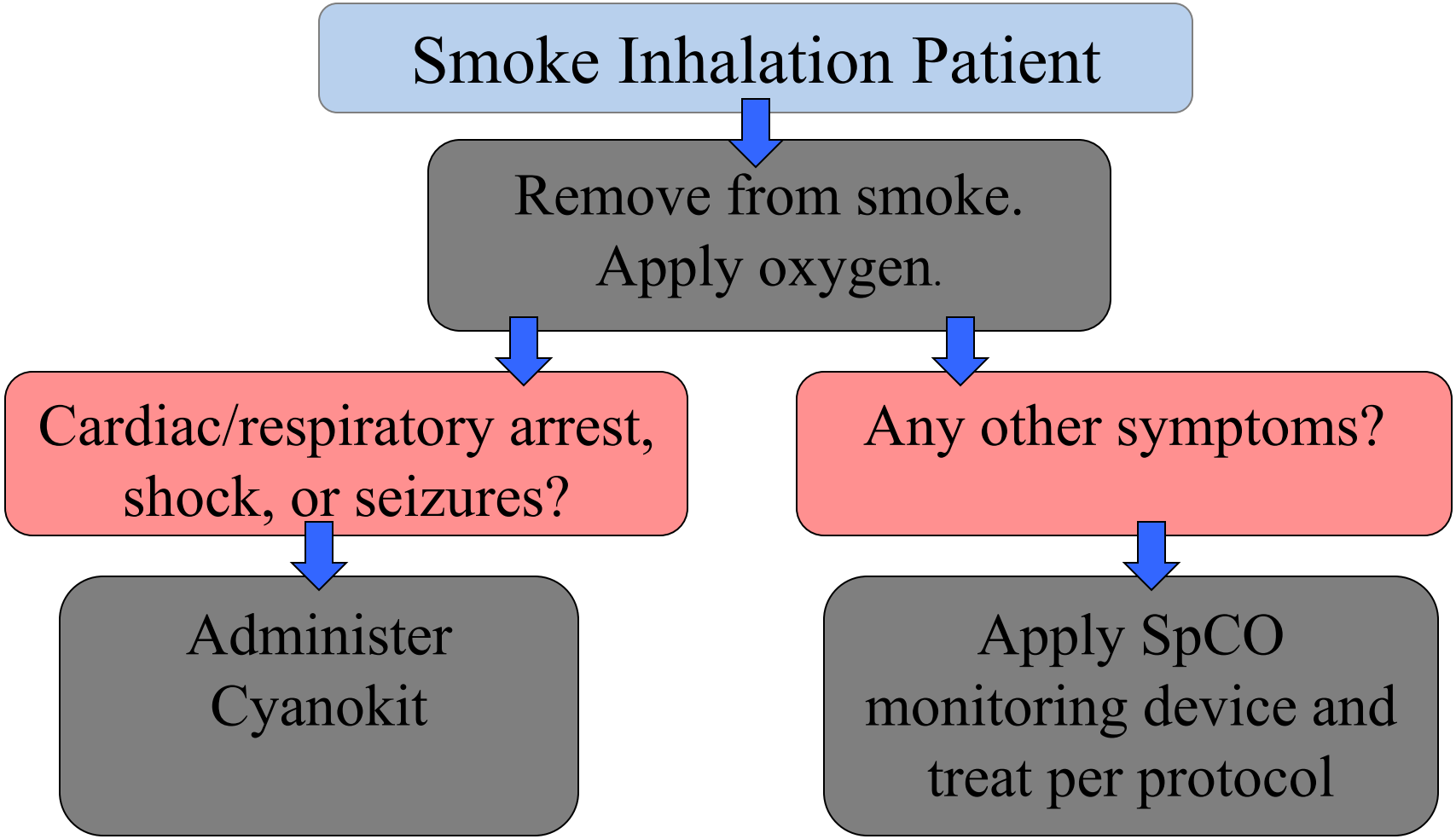
- Pregnant women are at high risk in carbon monoxide exposure.
- The fetus is highly susceptible and the SpCO may be 10-15% higher than maternal readings.
- **All** pregnant women with possible CO exposure should be transported to the emergency department for evaluation.
- Unlike gas meters, the RAD-57 is not intrinsically safe and should not be used in the presence of flammable substances!

More Notes

- There are other SpCO monitoring devices with Masimo technology such as the LIFEPAK 15 and the Zoll E and X series. If your agency carries a monitor capable of SpCO monitoring, familiarize yourself with its use.

What do I do with the numbers?

- All symptomatic smoke inhalation patients MUST be transported, regardless of SpCO reading.
- Any patient with SpCO reading >12% SHOULD be transported, and serial readings should be obtained to assure they are going down.
- Any patient with SpCO reading >25% MUST be transported.



Immediate administration of Cyanokit is essential in suspected severe cyanide poisoning, so SpCO level monitoring will cause unnecessary delay.

Treatment Notes

- Patients with suspected HCN poisoning should be stripped of smoke-impregnated clothing (i.e. firefighters must have their turnout gear removed) prior to transport.

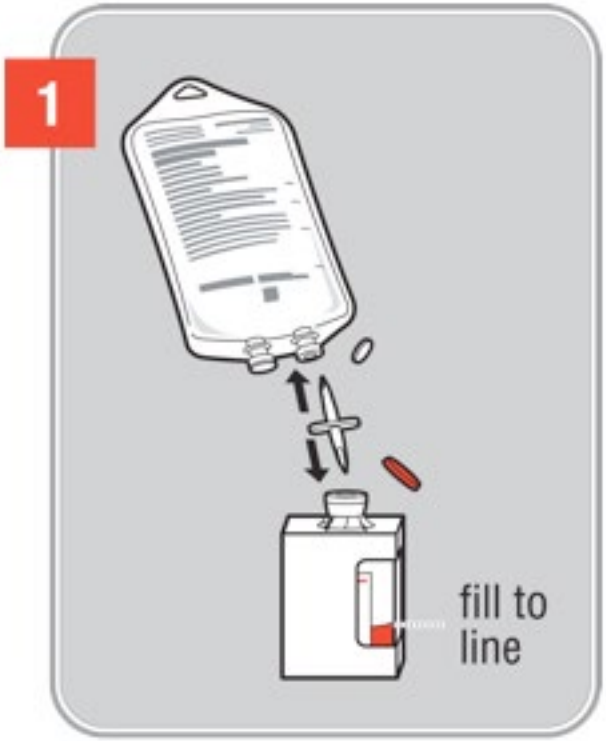
- In a region (like ours) that does not have hyperbaric therapy available, a smoke inhalation patient should be transported to the nearest appropriate facility. Specialty care centers are only necessary to treat concomitant problems such as trauma or burns.

How to administer the Cyanokit®

- 5g and 2.5g x2 vials
- 3 (or 4) steps

Step 1 - Reconstitute

- Add 0.9% sodium chloride to vial using sterile transfer spike
- Add enough to “Fill Line”
- Keep vial in upright position

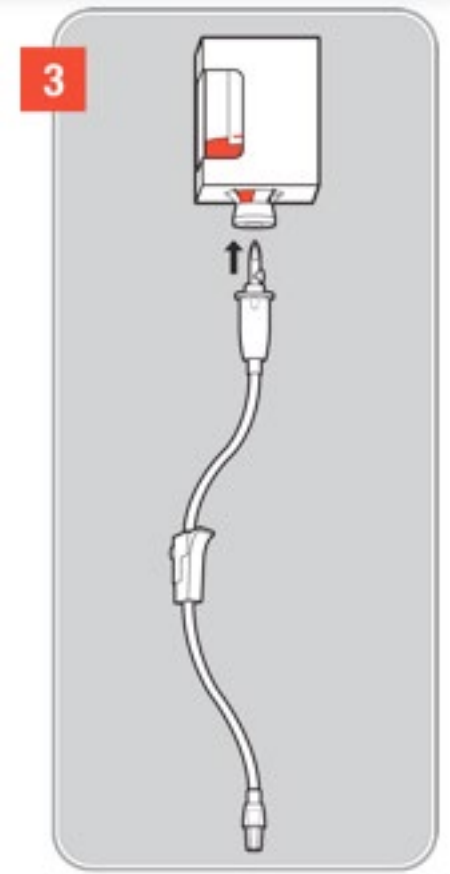


Step 2 - Mix

- Rock or rotate for 30 seconds to mix solution
- DO NOT SHAKE
- Discard if
  - Particulate matter
  - Not dark red

Step 3 - Infuse

- Use dedicated IV line (incompatible with most medications)
- Use vented IV tubing (included in kit)
- If 5g vial – infuse over 15 minutes
- If 2.5g vial, infuse over 7-8 minutes, and repeat steps 1-3 with second vial



Drug notes

- There are no contraindications in the setting of suspected acute HCN poisoning
- Side effects: chromaturia (red urine), erythema (this isn't an allergic reaction), hypertension, nausea, and headache
- Once reconstituted, the medication is stable for up to 6 hours

Pediatric Dosing

- Pediatric dose is 70 mg/kg IV/IO over 15 minutes
  - Pediatric is less than 12 years or 40 kg
  - Use adult dose for any child over 40 kg

Pediatric (<12 years or < 40 kg)				
Hydroxocobalamin Dose				
70 mg/kg administered over 15 mins Base Concentration is 5 g / 200 mL Administer through 20 gtt/mL vented tubing				
lbs	kgs	Total Dose (mg)	Total Volume (mL)	gtts/min
< 10	< 5	350	14	20
11 to 22	5 to 10	525	21	30
23 to 44	11 to 20	1050	42	55
45 to 66	21 to 30	1750	70	90
67 to 88	31 to 40	2450	98	130
> 89	>40	5000	200	270

Integrated Smoke Inhalation Protocol

- Integrates treatment of all smoke inhalation injuries
- Do not follow in order if patient requires Cyanokit for treatment of acute HCN poisoning!

2.39 SMOKE INHALATION

CRITERIA

- Known or suspected smoke inhalation

1. Remove patient from hazardous environment and remove clothing/protective gear and decontaminate as appropriate.

2. Airway management as appropriate.

3. Administer high flow oxygen via non-rebreather mask.

4. If available, apply Masimo RAD-57 per Carbon Monoxide Evaluation Using Handheld Co-Oximetry Policy (9.7). A potentially pregnant patient should be transported with high flow oxygen regardless of SpCO reading.

   Any symptomatic patient must be transported regardless of SpCO reading.

   Any patient with SpCO reading >12% SHOULD be transported to an emergency department. If the patient declines transport, serial SpCO readings should be obtained and transport initiated if CO levels are not decreasing.

   Any patient with SpCO reading >25% MUST be transported to an emergency department.

5. If suspected cyanide poisoning with mild symptoms, rapid transport with ambulance windows open and good ventilation after necessary decontamination completed.

6. Establish IV Access if potentially unstable; see Vascular Access Protocol (2.34).

7. Treat blood glucose as appropriate.

8. If suspected HCN poisoning with ***cardiac/respiratory arrest, SBP <80 with signs of hypoperfusion, or seizures*** administer (if available):

   5 g hydroxocobalamin (Cyanokit) IV/IO over 15 minutes through a dedicated IV line.

   
   70 mg/kg hydroxocobalamin IV/IO (max 5 g) over 15 minutes through a dedicated IV line.

   NOTE: Each vial must be reconstituted with normal saline using the supplied sterile transfer spike. Following reconstitution, the vial should be repeatedly inverted or rocked for at least 30 seconds prior to infusion. DO NOT SHAKE. If the reconstituted solution is not dark red or if particulate matter is visible after appropriately mixed, the solution should be discarded.

9. Provide supportive care directed to the patient's symptoms:

   a. Hypotension – Refer to Hypotension/Shock Protocol (2.18).
   b. Seizures – Refer to Seizures Protocol (2.31).

Where are Cyanokits®?

- City of Rochester
  - BC1, BC2, Car 99, RMMS Supervisor
- Monroe County
  - Car 901 (J Jordan), Car 910 (R Campbell), Henrietta Ambulance, Monroe Ambulance Supervisor, Squad 226 (Barnard Fire), 307 (Brighton Fire), Perinton Ambulance
- Livingston County
  - LCEMS Supervisor, HAZMAT 1, LCEMS Gypsy Lane


2.39 SMOKE INHALATION
CRITERIA
Pediatric (<12 years or < 40 kg)
Hydroxocobalamin Dose
70 mg/kg administered over 15 mins
Base Concentration is 5 g / 200 mL
Administer through 20 gtt/mL vented tubing
lbs. | kgs | Total Dose (mg) | Total Volume (mL) | gtts/min
< 10 | < 5 | 350 | 14 | 20
11 to 22 | 5 to 10 | 525 | 21 | 30
23 to 44 | 11 to 20 | 1050 | 42 | 55
45 to 66 | 21 to 30 | 1750 | 70 | 90
67 to 88 | 31 to 40 | 2450 | 98 | 130
> 89 | >40 | 5000 | 200 | 270
CYANOKIT
(hydroxocobalamin for injection)
5 g per vial
For Intravenous Use
To be reconstituted with 200 mL of 0.9% Sodium Chloride Injection
Diluent Not Included
MERIDIAN
CYANOKIT


CYANIDE
KIT
3
PELICAN
1200 CASE
PELICAN PRODUCTS, TORRANCE, CA USA

Case Study #1

- You respond to a working house fire with multiple patients. The fire department brings you a 16 yo female who has soot around her mouth and is c/o SOB and a headache. Vitals are: HR 122, RR 24, SpO_2 99% on room air.

- What other assessments do you do? What questions do you ask her? What is your treatment plan?

Case Study #2

- You are doing rehab at a warehouse fire when firefighters drag out a FF who is unconscious. He has no pulse and there is soot around his mouth/nose. He has been down for 2 minutes.

- What is your treatment plan?

What didn’t we cover?

- Regional rehabilitation protocol.
- Burns, airway management, and management of other fire-related emergencies.
- Use of hyperbaric chambers.
- Your agency-specific resources (i.e. RAD-57) and policies.

So remember:

- If a patient is suffering from smoke inhalation and is in cardiac/respiratory arrest, shock, or is seizing, they are probably suffering acute cyanide poisoning…apply oxygen and administer Cyanokit!

"Sick as s**t - Cyanokit!"

Questions and Resources

- You have been given the following resources:
  - New smoke inhalation protocol
  - SpCO monitoring policy 9.7
  - Rehab policy 9.14
  - Cyanokit quick reference

Questions?