



# Eatin' Too Much Smoke: The Potential Utility of the Masimo RAD-57 CO-oximeter In Protecting the Protectors

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# Learning Objectives

## **Upon completion of the presentation the participant will:**

1. Understand the leading cause of poisoning deaths in industrialized countries
2. Recognize that the signs and symptoms of CO poisoning are non-specific.
3. Recognize the potential utility of a non-invasive CO-oximeter
4. Understand the limitations and precautions for instituting this technology in your EMS system.

# Carbon Monoxide Poisoning

- **Leading cause of poisoning deaths in industrialized countries:**
  - Over 40,000 emergency room visits in the US annually <sup>1</sup>
  - At least 3,800 deaths in the US annually <sup>2</sup>
  - 1,400-3,000 accidental deaths in the US annually <sup>3,4</sup>
- **Even a single exposure has the potential to induce long-term cardiac and neurocognitive/psychiatric sequelae:**
  - Brain damage at 12 months after exposure is significant <sup>5</sup>
  - Myocardial Injury is a common consequence of CO poisoning and can identify patients at a higher risk for premature death <sup>6</sup>

<sup>1</sup> Hampson NB. Emergency department visits for carbon monoxide poisoning in the Pacific Northwest. J Emerg Med 1998;16(5):695-698.

<sup>2</sup> Mott JA, Wolfe MI, Alverson CJ, MacDonald SC, Bailey CR, Ball LB, Moorman JE, Somers JH, Mannino DM, Redd SC. National Vehicle Emissions policies and practices and declining US carbon monoxide-related mortality. JAMA 2002;288:988-995

<sup>3</sup> Hampson NB, Stock AL. Storm-Related Carbon Monoxide Poisoning: Lessons Learned from Recent Epidemics. Undersea Hyperb Med 2006;33(4):257-263

<sup>4</sup> Cobb N, Etzel RA. Unintentional Carbon monoxide-related deaths in the United States, 1979 through 1988. JAMA 1991;266(5):659.

<sup>5</sup> Weaver LK, et al. N Engl J Med, 2002;347(14):1057-067.

<sup>6</sup> Henry CR, et al. JAMA. 2006;295(4):398-402.

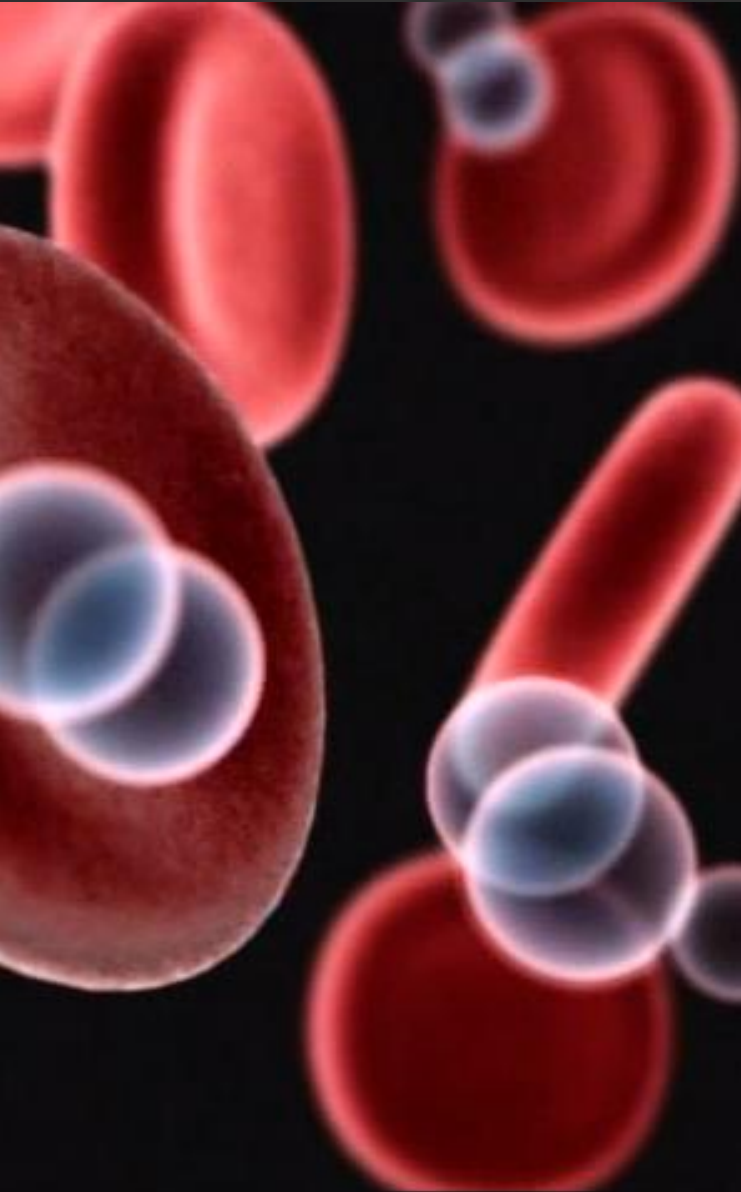
# Common Sources

- **Incomplete combustion of any carbon-based material will produce carbon monoxide. Most common sources are:**

- Automobiles, trucks, buses, boats
- Gas heaters and furnaces
- Small gasoline engines
- Portable / space heaters
- Portable gas-powered generators
- Barbecues / fireplaces
- Structure / wildland fires
- Cigarette smoke
- Methylene chloride (paint stripper)  
—liver converts to CO



# Pathophysiology



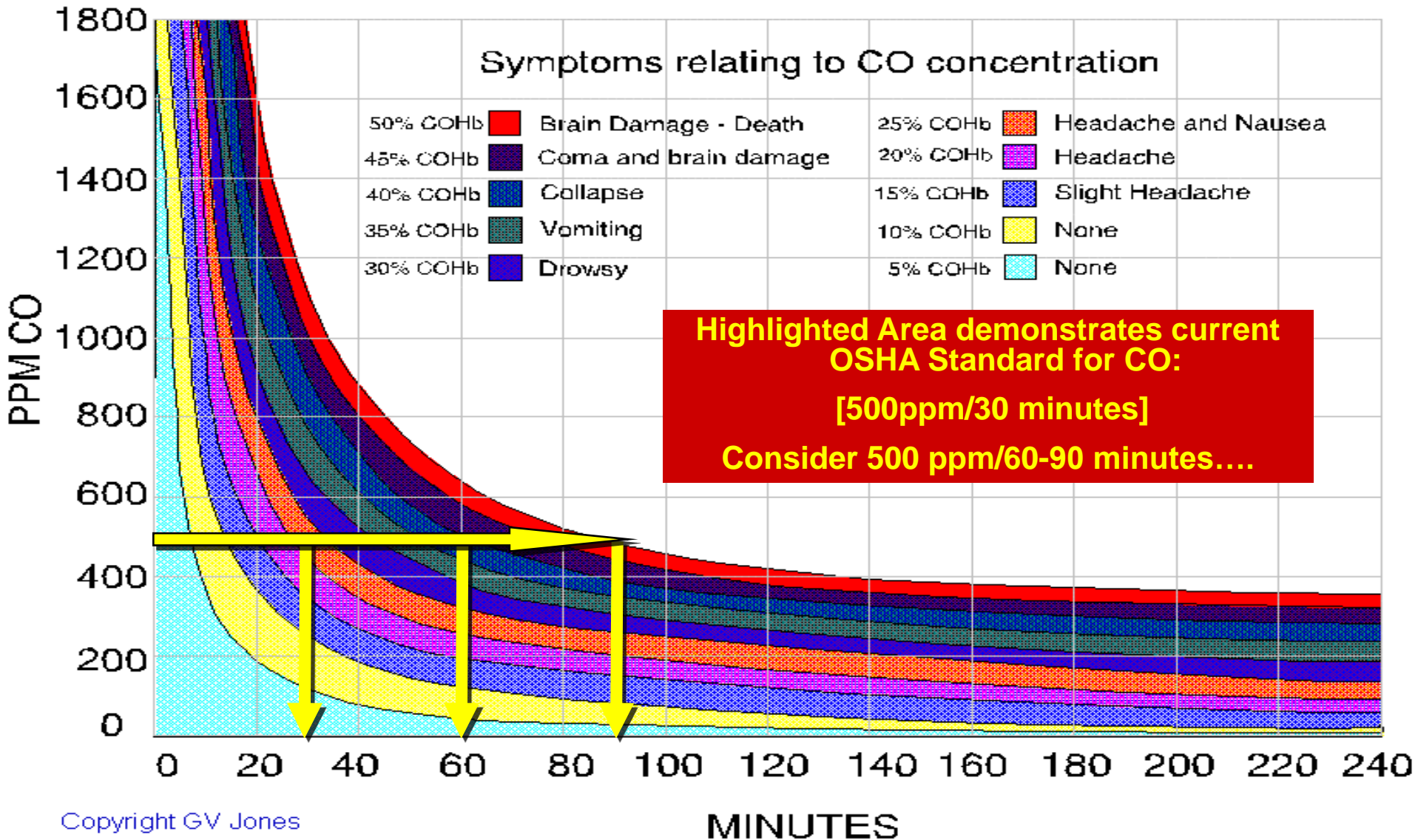
- **Carbon monoxide is inhaled and passed from the lungs to the blood binding to hemoglobin**
  - Produces carboxyhemoglobin
  - Affinity to hemoglobin 210x greater than oxygen
  - Reduces oxygen-carrying capacity of blood
- **Acts as an intracellular toxin**
  - Poisons cells and tissue
- **Binds with myoglobin in muscle**
  - Interferes with heart and skeletal muscle
- **Immediate threat to life**
  - Oxygen starvation
  - Cardiac arrhythmias
  - Alters judgment, reasoning
- **Long-term health effects**
  - Central nervous system damage
  - Cardiovascular damage

# Clinical Effects

- **Severe hypoxemia leading to multiple organ failure, brain damage or death**
- **Neurologic:** NS depression, headaches, dizziness, confusion, permanent neurocognitive, permanent neuropsychiatric sequelae
- **Cardiac:** decreased myocardial function, chest pain, dysrhythmias, long term cardiac sequelae
- **Metabolic:** respiratory alkalosis, hyperventilation, metabolic acidosis in severe cases
- **Pulmonary:** pulmonary edema in 10-30 percent of acute exposures

# Severity of Intoxication:

Morbidity Associated with COHb and Duration



# Signs and Symptoms

SpCO Level	Clinical Manifestations
>5%	Mild headache
6-10%	Mild headache, shortness of breath with exertion
11-20%	Moderate headache, shortness of breath
21-30%	Worsening headache, nausea, dizziness, fatigue
31-40%	Severe headache, vomiting, vertigo, altered judgment
41-50%	Confusion, syncope, tachycardia
51-60%	Seizures, shock, apnea, coma



**Carbon Monoxide Poisoning Presents Like the Flu!**



# CO Poisoning: The Great Imitator



**30-50 % of CO-exposed patients** presenting to  
Emergency Departments **are misdiagnosed**

Barker MD, et al. J Pediatr. 1988;1:233-43

Barret L, et al. Clin Toxicol. 1985;23:309-13

Grace TW, et al. JAMA. 1981;246:1698-700

# Diagnostic Problem

- **Vague symptoms**

- Food poisoning
- Influenza
- Migraines
- Drug abuse

- **Current diagnostic method is invasive, slow, and costly**

- If the proper diagnosis is not made **the patient is often inadvertently returned to the toxic environment**



# Case Study: Even Low Exposure Levels Can Lead to Death

- **52 y/o Male**

- Prominent attorney in Salt Lake City found dead in his home after failing to show up for work
- Had complained to co-workers of nausea and other flu-like symptoms for several days
- Upon discovery of his body, elevated levels of CO were discovered in the home—but levels were relatively low, only 130 PPM
- Faulty boiler discovered

## Prominent attorney dies from carbon monoxide poisoning

By **Wendy Leonard**

Deseret Morning News

After failing to show up for work Tuesday, a prominent Salt Lake attorney was found dead in his home.

A secretary at the downtown law firm called a neighbor around 10:30 a.m. when Bruce H. Jensen didn't show up as usual. The neighbor entered Jensen's home, near 1100 East and 1000 South, and found his body on the bed, said Salt Lake Fire spokesman Scott Freitag.

"I don't know how to describe it, to see your friend lying on the bed," neighbor Bill Dowse told KSL-TV.

Jensen, 52, lived alone and no one else was in the home at the time. Freitag said he had been dead for a few hours and that the medical examiner took the body and performed an autopsy. It was determined Jensen died from carbon monoxide poisoning.

Crews returned to the home to test for the chemical and found it was at 130 parts per million, well above Qwestar's safety standard of 50 parts per million.

"There weren't extremely high levels of carbon monoxide in the home, but he was exposed to moderate levels over several days," Freitag said.

The source of the fumes is believed to be a leak in the boiler heating system.

"It was an older home with an old boiler that hadn't been inspected for a long time," Freitag said.

Had the boiler been working properly, he said, carbon monoxide would not have been a problem. However, Freitag said, a carbon monoxide detector, available for as little as \$20, "would have alerted him there was a problem in the house."

Coworkers reported that Jensen had mentioned not feeling well since Friday. He had told them he was experiencing nausea and other flu-like symptoms, also symptomatic of the poisoning, which slowly takes over red blood cells in the body.



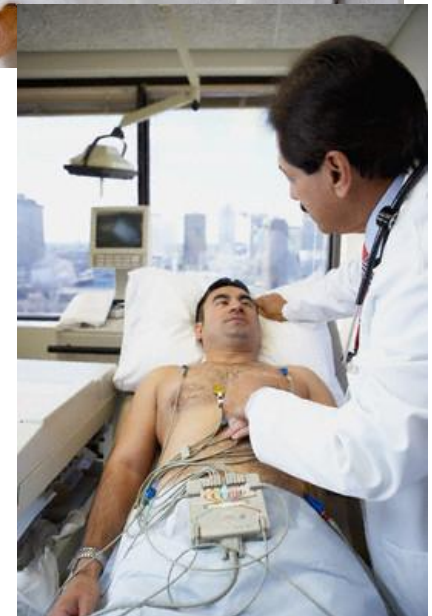
Bruce H. Jensen

**Even 130 Parts Per Million Over a Prolonged Period Can Kill You!**

# High Risk Groups

- **Patients at High Risk for Negative Outcomes**

- Children
- Elderly
- Adults with cardiac disease
- Patients with decreased O<sub>2</sub> carrying capacity (Anemia)
- Patients with chronic respiratory insufficiency
- Pregnant women, with emphasis on fetal damage and death
  - Cerebral palsy
  - Limb and cranial deformities
  - Mental disabilities



# Treatment of CO Poisoning

- **Chemical Half-life of Carbon Monoxide bound to Hemoglobin**

- 4 hours on room air
- 45 minutes on 100% oxygen
- 22 minutes on 100% in Hyperbaric Chamber at 2-4 atmospheres



# **Carbon Monoxide Poisoning: The Silent Killer**

## **Challenges to Detection**

# Why is Detecting CO Poisoning So Difficult?

- Patients present with ambiguous, flu-like symptoms
- COHb levels may not correlate with clinical condition
- Lab CO-Oximetry limitations
- Pulse oximetry limitations



# National Academy of Clinical Biochemistry:

## COHb Recommendations

*“We recommend that clinicians routinely provide POCT of HbCO by CO-oximetry to screen patients with flu-like symptoms or headache in the emergency department for occult CO poisoning, particularly in communities where combustion is used for heating during the heating season. We found at least fair evidence that POCT of HbCO by CO-oximetry will lead to a correct and timely diagnosis of CO poisoning in patients who otherwise would have been missed”*

(Weight of Evidence = Fair; Net Benefit = Substantial; Recommendation = B)





# Laboratory CO-oximetry Limitations



- **Invasive**—requires a blood sample
- **Non-Continuous**—only detects CO levels at a single point in time
- **Variable time to analysis** (can take from minutes to hours to get results)
- **Only found in approximately 50%** of hospital laboratories

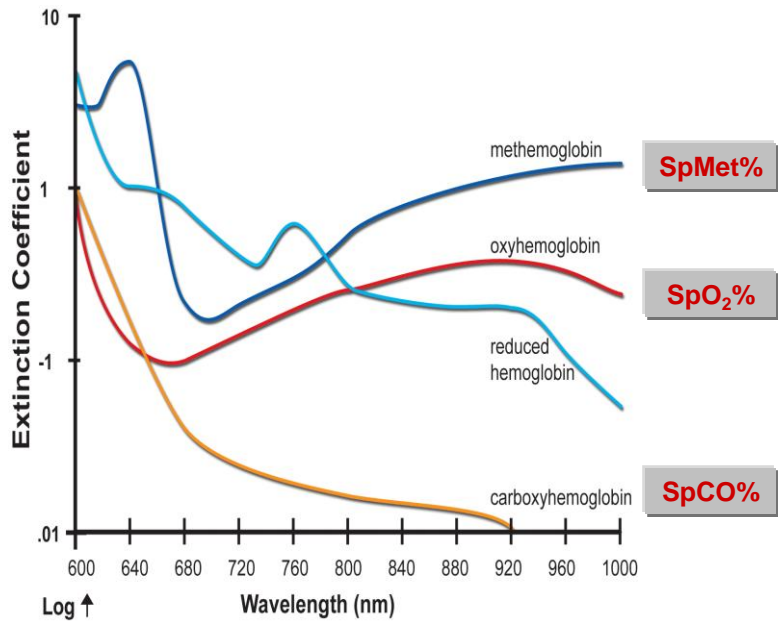
# **Carbon Monoxide Poisoning: The Silent Killer**

## **New Diagnostic Technology**

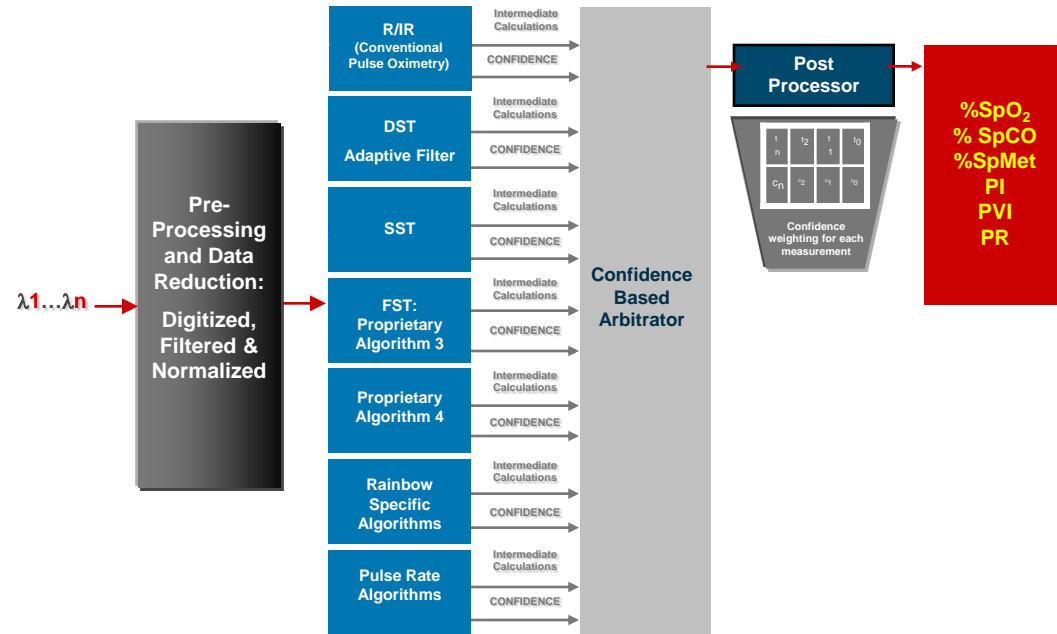
# Noninvasive Pulse CO-Oximetry

- **Noninvasive Pulse CO-Oximetry, the first and only current technology** capable of continuously and noninvasively measuring carboxyhemoglobin (SpCO)
- **In addition to SpCO, Masimo Rainbow SET Pulse CO-Oximetry can also noninvasively and continuously measure methemoglobin (SpMet),** in addition to oxyhemoglobin (SpO<sub>2</sub>), perfusion index (PI), pleth variability index (PVI) and pulse rate

# How Noninvasive Pulse CO-Oximetry Works



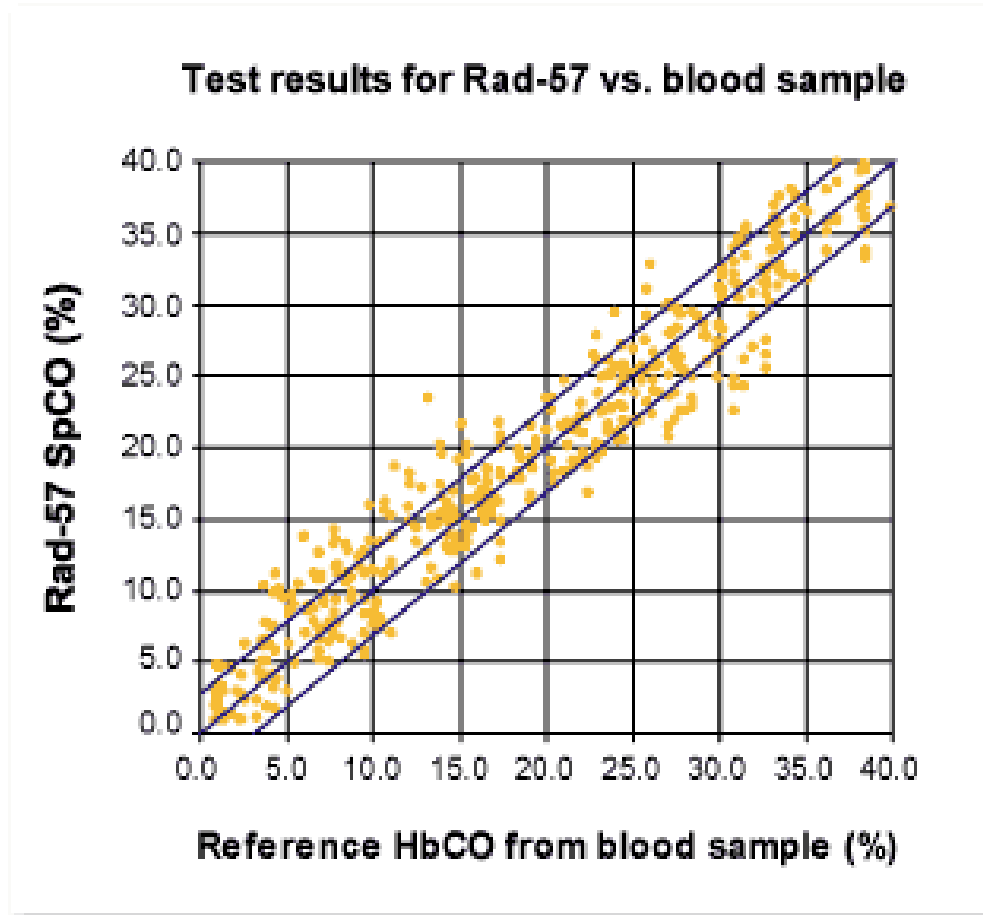
Oxygenated Hb and reduced Hb absorb different amounts of Red (RD) and Infrared (IR) Light  
*(Two-wavelength oximeters cannot measure dyshemoglobins)*



Masimo Rainbow SET Pulse CO-Oximetry Uses Multiple Wavelengths of Light to Read CO and Met  
*(Expanded understanding of your patients' oxygenation status)*

# FDA Validation

## Masimo Rainbow SET Compared to Reference Methodology



Noninvasive measurement provides clinically equivalent results for HbCO without the need for invasive blood draw

Excellent Precision and Accuracy

# Benefits of Pulse CO-Oximetry


- Non-invasive
- Rapid diagnosis
- Immediate treatment
- Continuous
- Portable
- Reduced cost



# Case Study: Detecting CO, Saving Lives and \$\$

- **CO Toxicity caught with Pulse CO-Oximeter**
- Boca Raton FL, young security guard presents to ED with dizziness and headache.
- Astute ED nurse senses fumes and asks if he has been around generators
- Generators being used at condo complex as part of repairs made after damage by Hurricane Katrina
- Haz Mat unit dispatched, 100 people evacuated from 20 story condo after CO levels in lobby found to be 100 times higher than normal
- Quick evacuation saves "untold number of lives"
- One victim severe enough to be transported. Multiple additional transports and ED admissions saved

## BUSINESS

The Miami Herald  SATURDAY, SEPTEMBER 23, 2006 | EDITOR: LISA GIBBS lgibbs@MiamiHerald.com | 305-376-3578

### SAFETY

#### New medical device detects carbon monoxide's toxic effects

■ A small device shows the effects of generators—and leads to the evacuation of a 20-story building, perhaps saving lives.

BY JOHN DORSCHNER  
jdorschner@MiamiHerald.com

When the security guard arrived in the hospital emergency room, he was dizzy and had a headache -- vague symptoms that a nurse could have brushed off easily.

But in this case, the nurse, aided by a new device, triggered a series of events that led to the evacuation of 100 persons from a 20-story condo that had lethal levels of carbon monoxide, perhaps saving untold lives.

"I can't tell you definitely that people could have died, but it came close enough that it shook us up big-time," said Mary Russell, an ER nurse at Boca Raton Community Hospital.

The hospital is in the area where anthrax hit the National Enquirer offices, and its emergency room, as well as the Boca Raton fire department's hazardous materials medical response unit, now are ready for a broad range of threats.

#### CARBON MONOXIDE SUSPECTED

The Boca case began at 1:50 p.m. on Sept. 7. "We had a very astute charge nurse, and when he mentioned he smelled some fumes, she asked if he had been around generators," said Russell, a research preparedness specialist at the hospital. "He said yeah. Construction was going on in

the building. Carbon monoxide was already very much on our radar screen, and we had just gotten this new device, a Masimo Rad-57."

Until the arrival of this device, testing carbon monoxide levels in humans was a long and painful process, involving the removal of blood from an artery and getting a lab result. "That is exquisitely painful," said Russell. "Trust me you don't want to do it." For that reason, most nurses avoid giving the test unless it's absolutely necessary.

#### DEVICE LEADS TO EVACUATION

But Boca had recently purchased the Rad-57, for about \$3,000, which measures carbon monoxide levels by simply attaching a sensor to a finger tip. The first device of its kind, it was introduced less than a year ago, says Tom McCall of the California-based Masimo.

In the case of the security guard, his levels were extremely high. The hospital called Boca Raton Fire Rescue, which rushed its HazMat unit to the building at 2800 S. Ocean Blvd.

"They got a reading of 900 parts per million in the lobby," said Glenn Joseph of Fire Rescue. "That's 100 times higher than normal." Other areas showed readings of 500.

The condo had been undergoing hurricane repairs, and the construction crews had generators going in the garage area, said Joseph. "We had them stop all operations."

Rescue crews went floor by floor, telling the 100 or so persons in the building they needed to leave.

Only one other person was taken to the hospital, said Russell. That person and the security guard were given oxygen and recovered quickly.

#### FLU-LIKE SYMPTOMS

For ER nurses, the problem is that carbon monoxide poisoning can often present itself merely as flu-like symptoms or food poisoning. Once in the ER, patients can tend to recover quickly since they're no longer near the fumes -- complicating the ability to discover the cause.

McCall of Masimo pointed to news reports in June from Ocean City, Md., where several persons in a Days Inn were taken to an emergency room about 9:30 a.m. Neither the ER nor the rescue units thought to check for carbon monoxide, and their illness was blamed on food poisoning.

At 2 p.m., a 40-year-old Pennsylvania tourist and his 10-year-old daughter were discovered dead in an adjacent room. At least one of them was still alive earlier in the day when the first persons complained of feeling ill, according to local news reports.


#### UNITS IN FLORIDA

Masimo now has 41 Rad-57 units in the field in Florida, either in emergency rooms or possessed by "first responders" to the scene, McCall said.

The hospital in Boca Raton has learned to be ready for just about anything. It tested dozens of persons for anthrax after the mail scare in 2001, and after hurricanes Frances and Jeanne, it saw "whole families transported to us" with carbon monoxide poisoning caused by generators, said

#### SAVING LIVES:

The Masimo Rad-57 measures carbon monoxide levels in humans by simply attaching a sensor to a finger tip.



# Clinical Validation after First Year

- **Ten published works from independent clinicians**
  - Five compare Masimo Rainbow SET to invasive CO-Oximetry, all demonstrating measurement accuracy within specifications
  - Four report on the ability to detect CO poisoning and conclude that Masimo Rainbow SET is effective in the noninvasive detection of CO toxicity
  - One case report discusses the effectiveness of Masimo Rainbow SET in continuously monitoring CO levels during the recovery process of a fire victim



# 5,000 Patient Brown University Study

- Dr. Partridge and Dr. Jay of Rhode Island Hospital, Brown University Medical School, performed a study to **assess carbon monoxide (CO) levels of nearly 5,000 patients in the ED**
- **9 unsuspected cases of CO Toxicity (COT) were discovered.**  
13 false positives, 0 false negatives
- **Extrapolated to all US hospitals, this would equal 50,000 cases of unsuspected COT annually**
- They concluded “**unsuspected COT may be identified using noninvasive COHb screening and the prevalence of COT may be higher than previously recognized**”

# Protecting the Protectors: The Potential Utility of Utilizing Co-Oximetry on the Fireground



Should fire departments consider this technology to be the “standard of care” in rehab?



## An early limitation to the technology....

- Early out-of-hospital users of the RAD-57 noted difficulty in obtaining readings at times.
- It was determined that certain ambient light conditions interfered with the sensor's ability to provide readings....
- That light condition just happens to be strobe lights.
- Masimo has now introduced a “strobe inhibitor” which is a hood to cover the finger to prevent strobe lights from interfering with this technology.



# My Major Concern

**“Your carbon monoxide level is normal! So you don’t need to go to the hospital”**

**“Please call your us back if your splitting headache, nausea, vomiting and blood pressure of 220/140 turns out to be an anuerysm and your brain explodes.”**

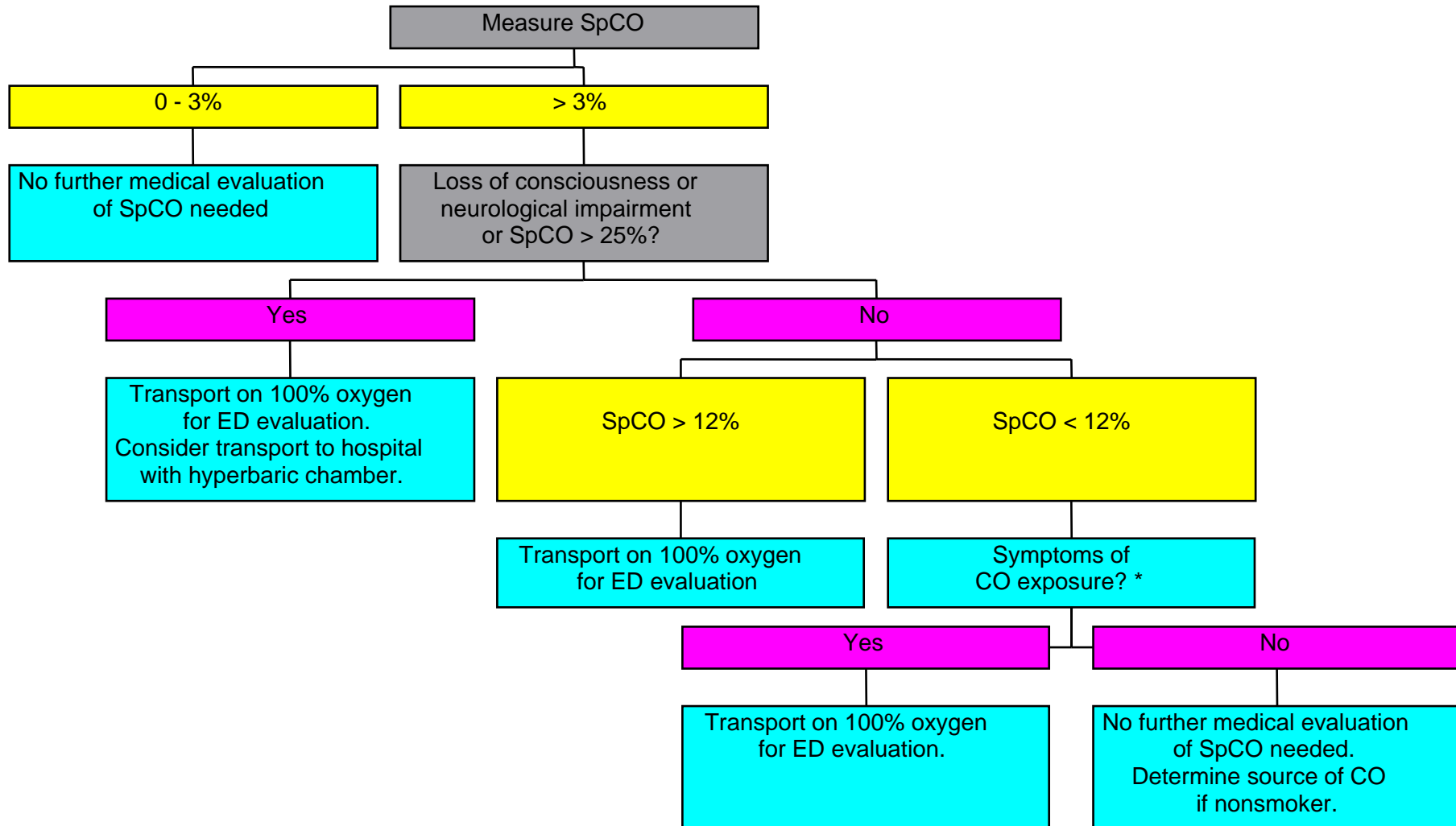


# Are you kidding me?



**EMS protocols regarding the RAD-57 must give medics and firefighters direction for those that patients who have symptoms, but for whom the Co-Oximeter indicates normal carboxy-hemoglobin levels.**

# Pulse CO-Oximeter Treatment Algorithm



# Conclusion

- CO represents a significant and controllable health risk
- In addition to death, permanent damage to the brain and heart are significant risks.
- Permanent damage can be minimized if treated in time
- Symptoms are vague and the condition is often misdiagnosed
- Current diagnostic technique requires a blood sample
- Pulse CO-Oximetry offers rapid non-invasive detection in seconds
- Early problems with the sensor have and will continue to be addressed.
- Good medical direction is required to determine appropriate local EMS protocols regarding the need for further evaluation/treatment.



Thank You for Your Attention !!!

