Controlling the oxygen percentage:

Is EMS harming patients with oxygen? If so, what can you do about it?

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Conflict of Interest Disclosure
Steven C. LeCroy

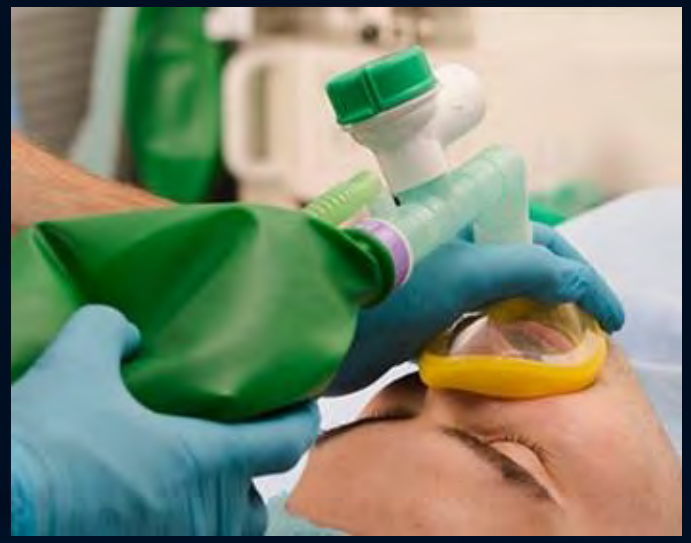
I disclose the following financial relationships with a commercial entity that produces healthcare-related products or services relevant to the content I am presenting:

Company	Relationship	Content Area
Mercury Medical	Director of Clinical Support	Respiratory

Unique What If Situation

Something to Consider:
Under the current conditions and with the increase in backorders and since most medical devices are manufactured offshore are you trained to use different devices?

Bag-Valve-Mask



Hyperinflation Bag

Adult T-Piece Resuscitator

“It seems that giving more oxygen than needed can actually increase death in the hospital”

Waleed Alhazzani, an Associate Professor in Critical Care at McMaster University

Could this also be true pre-hospital?

Scientist tell us the earth’s atmospheric oxygen percentage has been roughly 21% for close to 200 million years and man has been on the earth about 300 thousand years.

Theory: Is it possible that man evolved to the point that 21% oxygen is the ideal percentage and exposure to higher percentages can have damaging effects especially if used for extended periods of time?

Before Getting Started A Few Things To Think About

- How many oxygen administration options do you have?
- Can you effectively titrate the FiO_2?
- What is the maximum recommended oxygen saturation post cardiac arrest?
- What is the maximum recommended oxygen saturation for stroke patients?
- How many transport units have medical air?
- How many transport units have blenders?
- Could administering too much oxygen be harmful?
- What problems if any can too much oxygen cause?
- Is oxygen toxicity a conspiracy theory?

I’m sure someone is thinking if we are talking about too much oxygen this must be a hypoxic drive lecture.

Wrong

Just to clear up the confusion

Effects of O_2 Administration Research

"It was concluded that despite the removal of the hypoxic drive stimulus of O2 inhalation, the activity of the respiratory muscles remained great enough to maintain ventilation at nearly the same degree as that while breathing room air.

Effects of the administration of O_2 on ventilation and blood gases in patients with COPD during acute respiratory failure.
by Aubier, Milic, Touaty, Daghfous, Pariente
PMID: 6778278 (PubMed- indexed for MEDLINE

Effects of O_2 Administration Research

"Statistical analysis showed that the PaO_2 increased significantly when the FIO_2 was increased to 70%, but there was no significant change in $PaCO_2$, dead space, or respiratory drive"

Influence of inspired oxygen concentration on deadspace, respiratory drive, and $PaCO_2$ in intubated patients with COPD
Crossley, McGuire, Barrow, Houston
Department of Anaesthesia, Toronto Hospital
Crit Care Med. 1997 Sep:25(9):1450-1

Effects of O_2 Administration Research

"Based on the mythology that oxygen causes apnea and cardiorespiratory arrest in patients with COPD by turning off the oxygen respiratory drive – might take the path of withholding or delivering inadequate doses of oxygen to meet the metabolic needs of the patient in respiratory failure. **This mistake is generally fatal for the patient, and a treatment tragedy for the misinformed physician."**

Debunking Myths of Chronic Obstructive Lung Disease"

By Dr. John Hoyt
(Sept. 97 issue of Critical Care Medicine)

“A meta-analysis shows significantly higher mortality with liberal use of supplemental oxygen in acutely ill patients.”

Too Much Oxygen Is Harmful
Patricia Kritek, MD, reviewing Chu DK et al. Lancet 2018 Apr 28
McEvoy JW. Lancet 2018 Apr 28

“All too often, a patient's oxygen saturation is maintained at 100%. This is not only unnecessary but also probably harmful. It should become part of our practice to turn down the supplemental oxygen until we see oxygen saturations no higher than 95% for most patients and to stop oxygen use as soon as it is not needed. I suspect that we will learn that a target saturation lower than 95% is safe, but for now, avoiding hyperoxemia makes sense.”

What's the big deal with too much oxygen?

And which one of these are you ok with?

- Nitrogen Washout
- Oxygen Toxicity
- Oxidative Stress

"All things are poisons, for there is nothing without poisonous qualities. It is only the dose which makes a thing poison."

— **Paracelsus**

Nitrogen Washout Leading to Hypoxemia

- Gases that make up room air: Nitrogen, Oxygen and Trace Gases
- Oxygen diffuses from the alveoli into the blood
- Nitrogen remains within the alveoli, why?
- The nitrogen creates enough pressure to keep the alveoli inflated
- Increased Oxygen percentages take the place or washes out the nitrogen causing the alveoli to collapse often called denitrogenation absorption atelectasis, leaving less alveoli for gas exchange. Oxygen concentrations above 50% can cause a significant increase in collapsed alveoli and therefore less gas exchange
- At some point there is ineffective external respiration and hypoxemia develops.
- An increase in inspiratory shortness of breath and work of breathing due to an increase in effort needed to open the alveoli

Nitrogen Washout Leading to Hypoxemia

- Atelectasis increases shunt, decreases compliance, and leads to hypoxemia.
- Shunting is defined as blood that goes from the right side of the heart to the left side of the heart via pulmonary capillaries that are adjacent to unventilated alveoli. A shunt allows blood to enter the left-sided circulation without an increase in oxygen content.
- Compliance refers to the ability of the lungs to stretch and expand.

Oxygen Toxicity

Is this common practice?: A patient with difficulty breathing is placed on oxygen. As the dyspnea increases is it common practice to increase the oxygen percentage if possible? (Regardless of the oxygen saturation)

The increased oxygen percentage can start a vicious cycle of more collapsed alveoli, less diffusion of oxygen, hypoxemia gets worse and what do we do? Increase the oxygen so more!!!!

Too much oxygen can become toxic damaging lung tissue, thickening of the alveoli/capillary membrane, increase in surfactant production all decreasing gas exchange

This process creates a ventilation/perfusion mismatch and the development of ARDS and pulmonary hypertension

The respiratory tract is exposed to the highest concentrations of oxygen in the body, placing airway lining cells and alveoli at the greatest risk for hyperoxic cytotoxicity

Hyperoxia may also increase susceptibility to mucous plugging, atelectasis, and secondary infection by impairing both mucociliary clearance and the bactericidal capacity of immune cells.

Cytotoxicity is the degree to which a substance can cause damage to a cell.

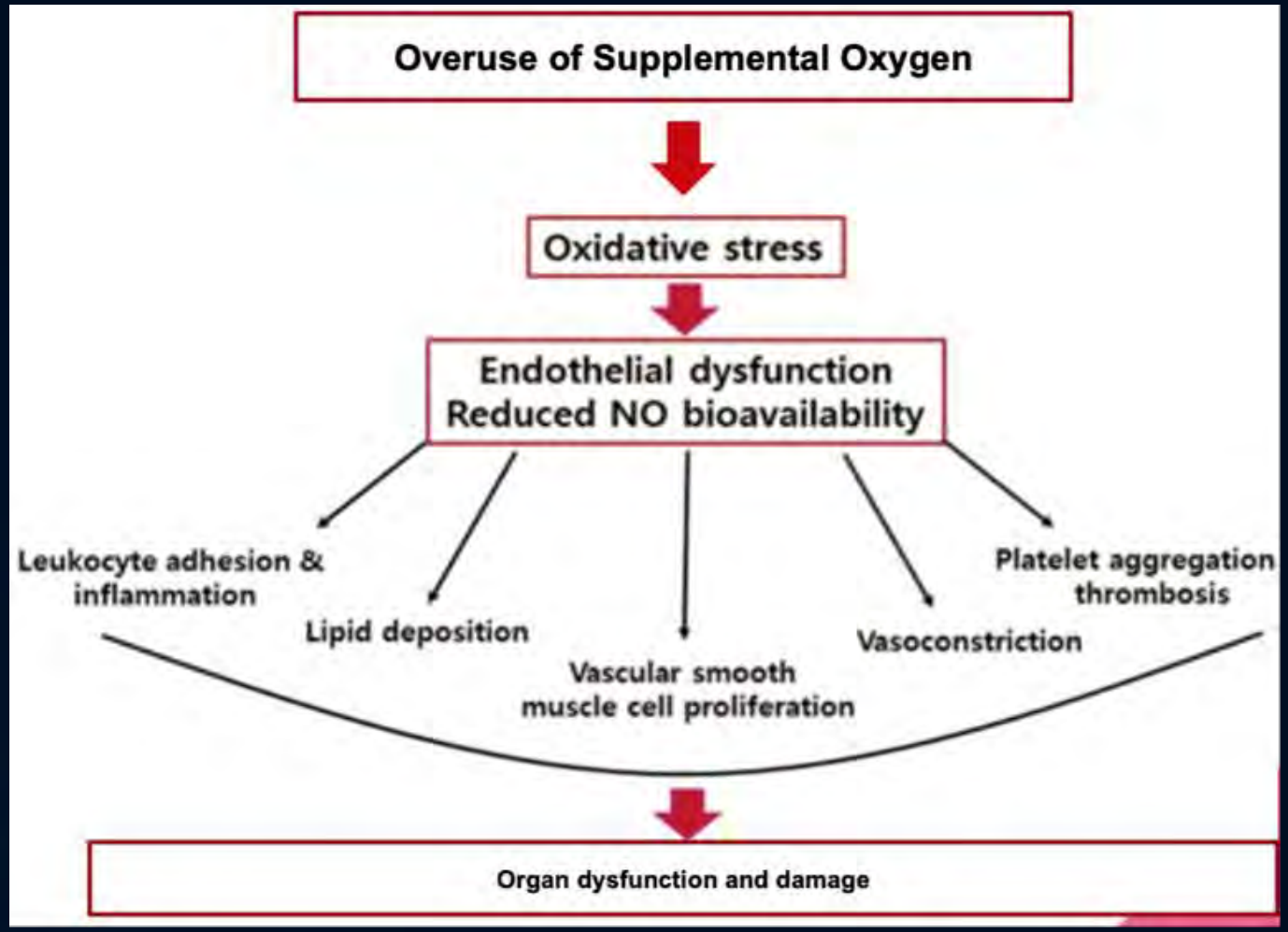
Oxidative Stress: “If things weren’t bad enough”

Oxygen has another side effect rarely mentioned. What’s this thing call “Reactive Oxygen Species” or (ROS)? ROS is a free radical and is an unstable molecule that is controlled by antioxidants. A free radical can react with other cells causing injury. ROS is a byproduct of metabolism and greatly increases at high percentages of oxygen. Cells in the heart, brain and lungs are the most vulnerable.

Cell damage occurs when free radicals outnumber antioxidants, known as oxidative stress. An increase is cell injury is caused by the over production of free radicals.

Cardiac Arrest and Oxidative Stress: Cardiac arrest represents a state of whole-body ischemia with profound shock. Global tissue hypoxia produces an inflammatory reaction that collects in hypo-perfused tissues during arrest and then is distributed upon reperfusion. Reactive oxygen species and inflammatory mediators cause endothelial damage, microvascular thrombosis and multi organ failure

The culprit in brain damage may not be a lack of oxygen
but rather its reintroduction into the body.



Association of Severe Hyperoxemia Events and Mortality Among Patients Admitted to a Pediatric Intensive Care Unit

Sriram Ramgopal, MD; Cameron Dezfulian, MD

JAMA Netw Open. 2019;2(8):e199812.

If too much oxygen is harmful why do athletes breathe almost 100% oxygen during games?
(Current thinking is 100% oxygen reduces recovery time)

"The only place where it may give you some benefit is if you're playing in Mile High Stadium in Denver," where the air is thinner, he said. "If you're playing down in Philadelphia, it's not a big deal.“

Dr. David Gealt
Sport Medicine Physician
Cooper Bone & Joint Institute

If 100% oxygen improves performance why not put them on CPAP since it’s the most efficient non-invasive way to administer oxygen?

College Football considered CPAP on the sidelines to improve performance.

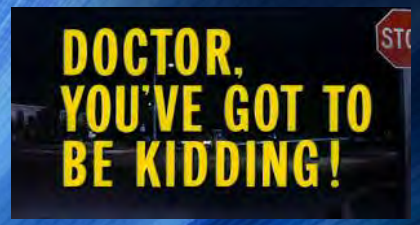
Consider the following when placing high percentages of oxygen on anyone

Studies have shown that hyperoxia reduced cardiac output by 10 to 15 percent in both healthy volunteers and patients with coronary artery disease

Systemic vascular resistance was increased with patients with heart failure

High flow oxygen in uncomplicated AMI may result in a greater infarct size and an increased risk of mortality

"Additional studies have shown that five minutes of supplemental oxygen by non-rebreather mask decreases coronary blood flow by 30 percent, increases coronary resistance by 40 percent due to coronary artery constriction, and blunts the effect of vasodilator medications like nitroglycerine."



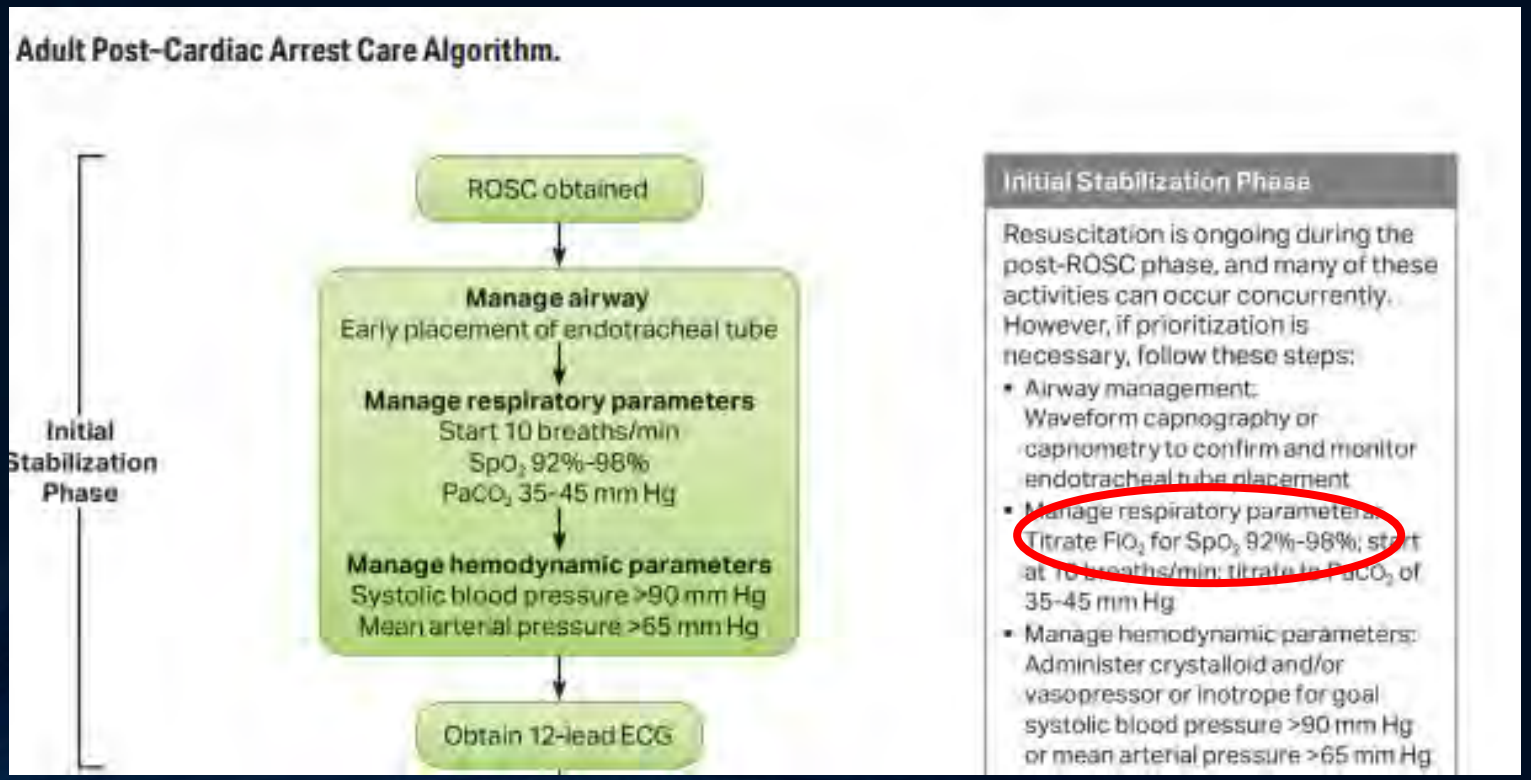
New BMJ Guidance Urges Prudence With Supplemental Oxygen, Especially in Acute MI, Stroke

- Recent studies underscore the potential harms of O_2 after MI or stroke. Experts now say it should not be started in patients with > 92% saturation
- American Heart Association (AHA)/American Stroke Association 2018 guidelines recommend providing oxygen therapy to maintain a saturated oxygen level of > 94% in ischemic stroke patients
- The European Society of Cardiology guidelines changed following the original publication in 2017 to recommend lowering the cutoff for administering oxygen therapy from < 95% to < 90% arterial oxygen saturation in STEMI patients

None of these guidelines provide an upper limit of arterial saturation as to when oxygen therapy should be stopped. The effects of hyperoxia not considered.

AHA 2020 Guidelines

HIGHLIGHTS
of the 2020 AMERICAN HEART ASSOCIATION
GUIDELINES FOR CPR AND ECC



Recommendations from the 2018 AHA guidelines for emergent oxygen treatment in Acute Stroke

- Offer airway and ventilatory support for acute stroke patients with altered mental status that compromises their airway
- Provide supplemental oxygen to maintain oxygen saturation above 94%.
- Supplemental oxygen is not recommended in “nonhypoxic” patients

Taking all three of these recommendations together, it’s possible to understand the goal is to avoid both hypoxia and hyperoxia in caring for acute stroke and post cardiac arrest patients.

Evidence

CONCLUSIONS: Early hyperoxia exposure after resuscitation from cardiac arrest was independently associated with poor neurological function at hospital discharge.

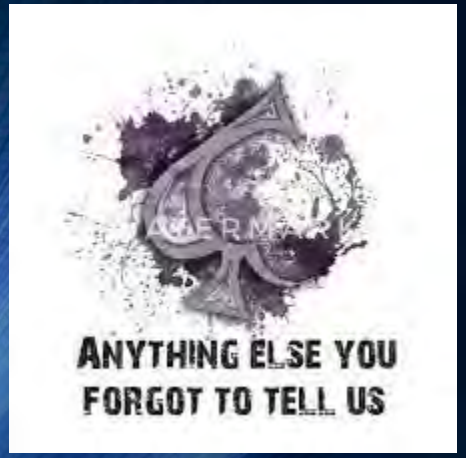
"Supplemental oxygen increased the risk of recurrent myocardial infarction and cardiac arrhythmias and increased myocardial infarct size at 6 months, suggesting that higher Pao_2 levels worsen myocardial reperfusion injury."

"Hyperoxia is postulated to cause harm in the context of reperfusion injury by increasing the formation of reactive oxygen species"

Association Between Early Hyperoxia Exposure After Resuscitation From Cardiac Arrest and Neurological Disability
Brian W. Roberts, MD; J. Hope Kilgannon, MD
Circulation. 2018;137:2114–2124

Evidence

"Tissue hyperoxia does not exist in nature. However, it is a common occurrence in hospitalized patients as clinicians often attempt to provide protection from hypoxia with a supplemental oxygen "buffer." This practice occurs despite the fact that it has been known for over a century that excessive oxygen exposure in the lungs can be toxic."

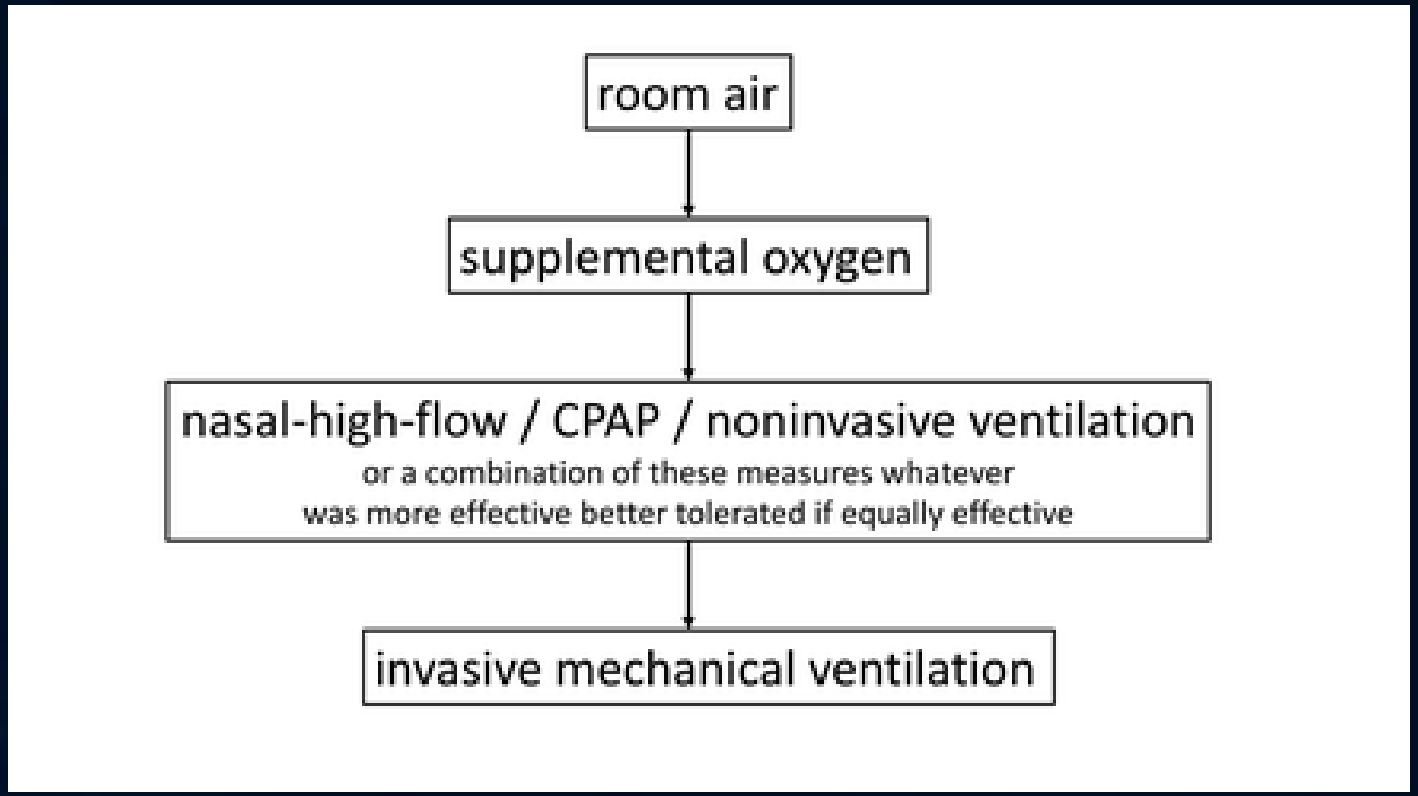


Thomson L, Paton J: Oxygen toxicity. *Paediatr Respir Rev* 2014; 15:120–123

Phenomenon of “happy” hypoxia, or silent hypoxemia

- Hypoxemia is defined as “a decrease in the partial pressure of oxygen in the blood.
- It’s been reported despite low blood oxygen levels, some patients appear to be functioning without serious issues or even shortness of breath.
- This condition has confused clinicians and is considered as defying basic biology.
- While a pulse oximeter is remarkably accurate when oxygen readings are high, it markedly exaggerates the severity of low levels of oxygen when readings are low.”
- It is also possible that the coronavirus is exerting a peculiar action on how the body senses low levels of oxygen and could be linked to the lack of smell that many COVID-19 patients

Phenomenon of “happy” hypoxia, or silent hypoxemia



The first step in reducing oxygen use overall is educate the providers and change administrative protocols

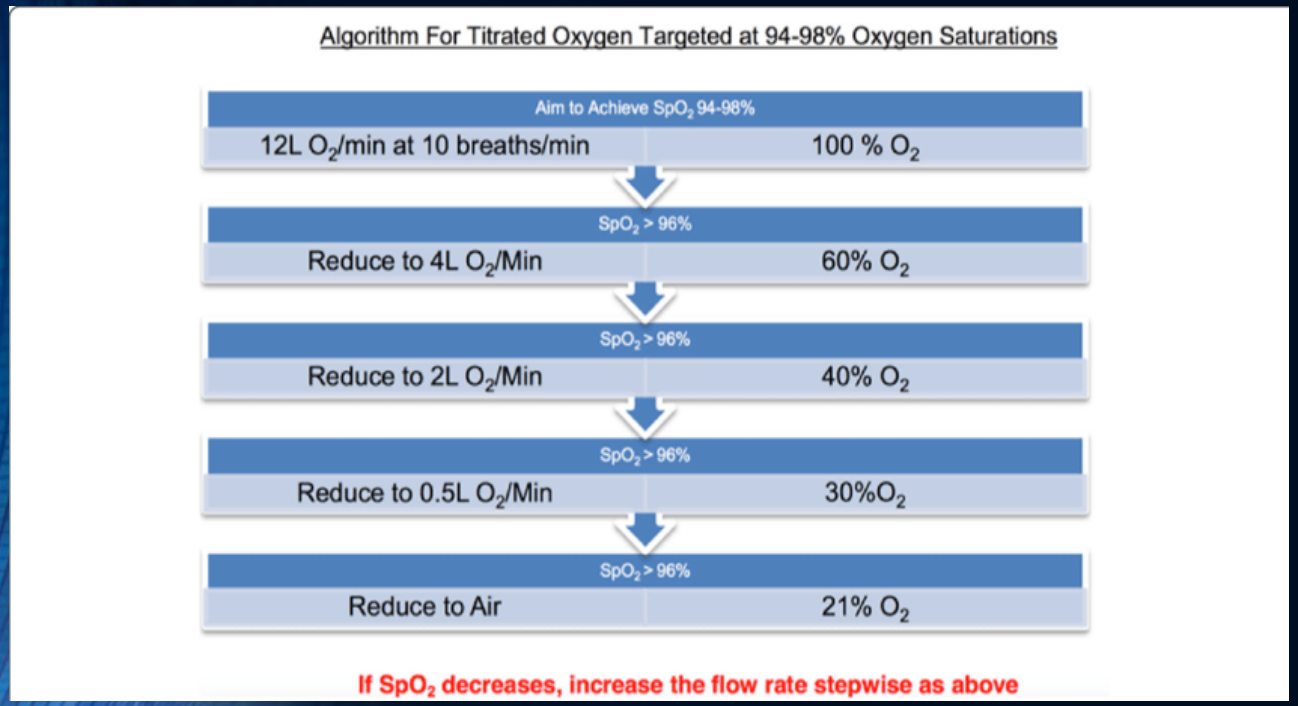
“Oxygen is given much too frequently, and there's not very much thought about who gets oxygen and how much”. “I think that it comes from a belief that oxygen is at best harmless and can only be helpful. But clearly the new evidence is showing that it actually may be killing people, so it's important to pay attention.” “Primarily, a “culture change” is needed in the way the entire care team understands the potential risks involved with oxygen therapy”

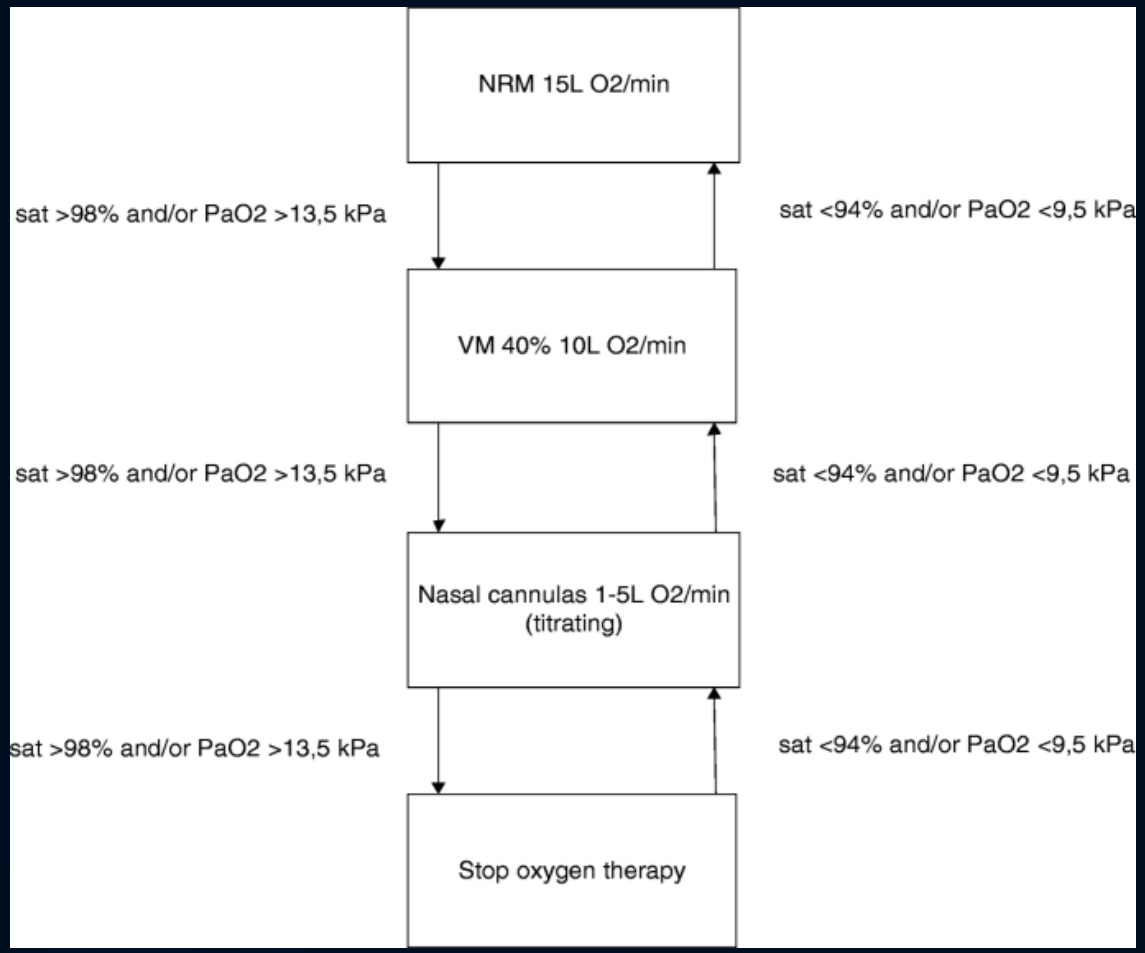
“We need to start thinking of oxygen like any other intervention that we provide where it sometimes has benefit but also has harms”

Reed A.C. Siemieniuk, MD, PhD (McMaster University, Hamilton, Canada)

Titrated Oxygen Protocol

VM – Venturi Mask





Arterial Blood Gas (ABG)

13.5 kPa = 101 mmHg

9.5 kPa = 67 mmHg

Titrating Oxygen in EMS

- Oxygen administration options
  - BVM – 21%, 40% or 100%
  - Nasal Cannula – 24% - 44%
  - Non-Rebreather Mask – 85% - 90%
  - Variety of oxygen masks (Venturi, Oxymask, Oxy Multi Oxygen Mask, Aerosoless)

The accuracy of the FiO_2 claims are questionable without knowing the patient's respiratory rate and tidal volume. Many of these devices can increase the work of breathing since the patient's inspiratory flow demands are not in sync with the device.

Understanding Peak Flows

- Humans must have an inspiratory gas flow equal to their demand, in addition to volume the speed at which the air arrives is critical.
- Raise your hand if you have ever had a patient have an increase in shortness of breath when you changed from a nasal cannula to a non-rebreather mask?
- Most everyone has felt an increase in SOB during the pandemic. Why is that?

Not trying to write protocols just recommendations to consider

- For most acutely ill patients, do not administer supplemental oxygen when SpO_2 >92%.
- If supplemental oxygen is used, the SpO_2 should not exceed 94%-96%.
- For patients with suspected MI, only start supplemental oxygen for SpO_2 <92%

However, over a century of evidence from pathophysiologic experiments and randomized trials across multiple clinical settings have associated hyperoxemia with adverse outcomes and increased mortality

How do you titrate the FiO_2 in the back of ambulance with limited options?

- If your oxygen administration devices are limited to a NC, BVM and NRB mask there are major gaps in the percentages you can offer. Do you go with hypoxia or hyperoxia?
- What about an oxygen analyzer? Too expensive and won't adapt to many oxygen administration devices.
- Most transport units don't have medical air or a compressor so blenders are out. Or are they?

Raise your hand if your transport units have blenders?

Blender options without the need for medical air

One final thought:

"There's a good chance that everything you learned in paramedic/EMT school or in your career will either be proven wrong or will be challenged at some point in your career"

Questions?

Should a question arise regarding hyperoxia and oxygen percentage in the prehospital setting, feel free to contact:

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