Oxygen Administration

Los Angeles County EMS Agency
EMS Update 2013

Objectives

At the end of this education module the viewer will be able to:

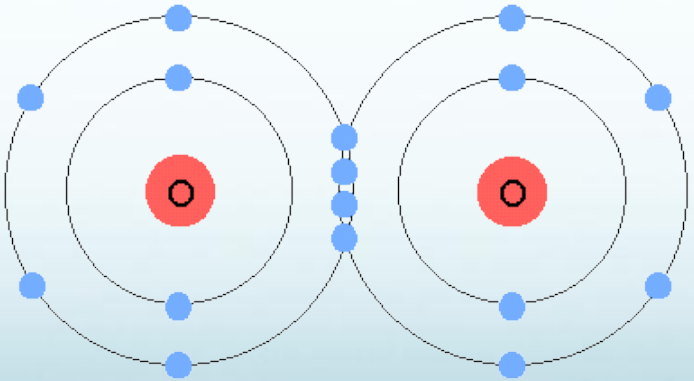
- Define
  - Cellular metabolism
  - Cellular pathways/cell signaling
  - Oxidative stress
  - Reactive oxygen species (ROS)
- Identify patients in critical need of oxygen
- Recognize the patient population that would benefit from oxygen titration
- Distinguish disease processes where oxygen therapy has not been scientifically beneficial

The Good

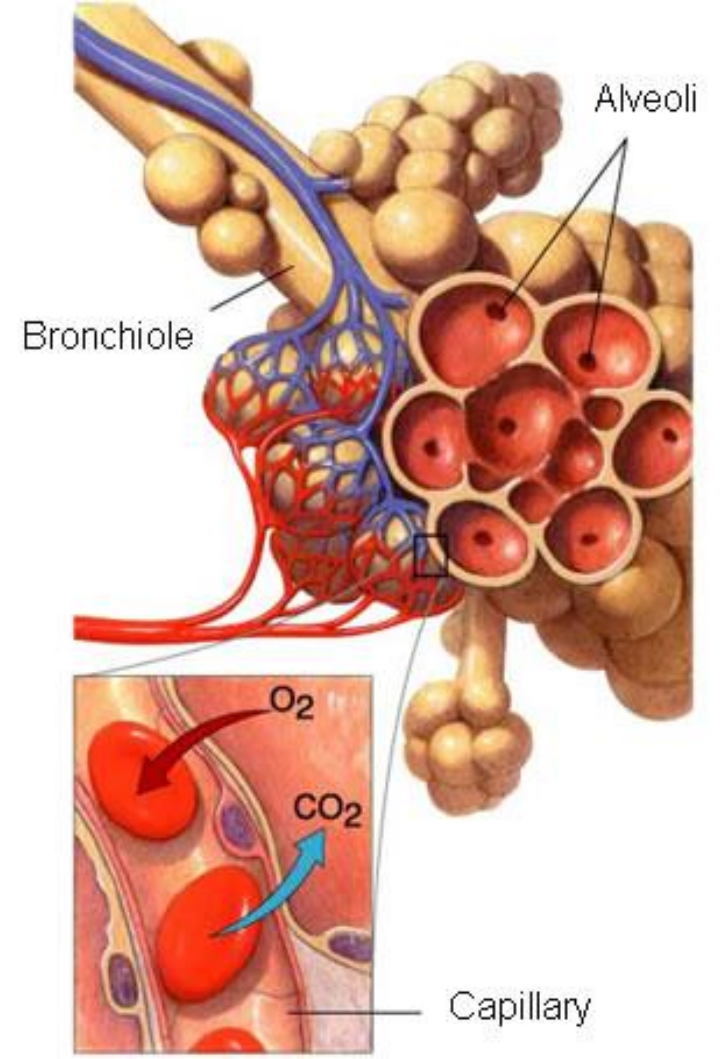
Oxygen is essential for life

Oxygen Molecule

- Diatomic gas
- Colorless and tasteless
- Third most abundant element in the universe
- 21% of the earth's atmosphere



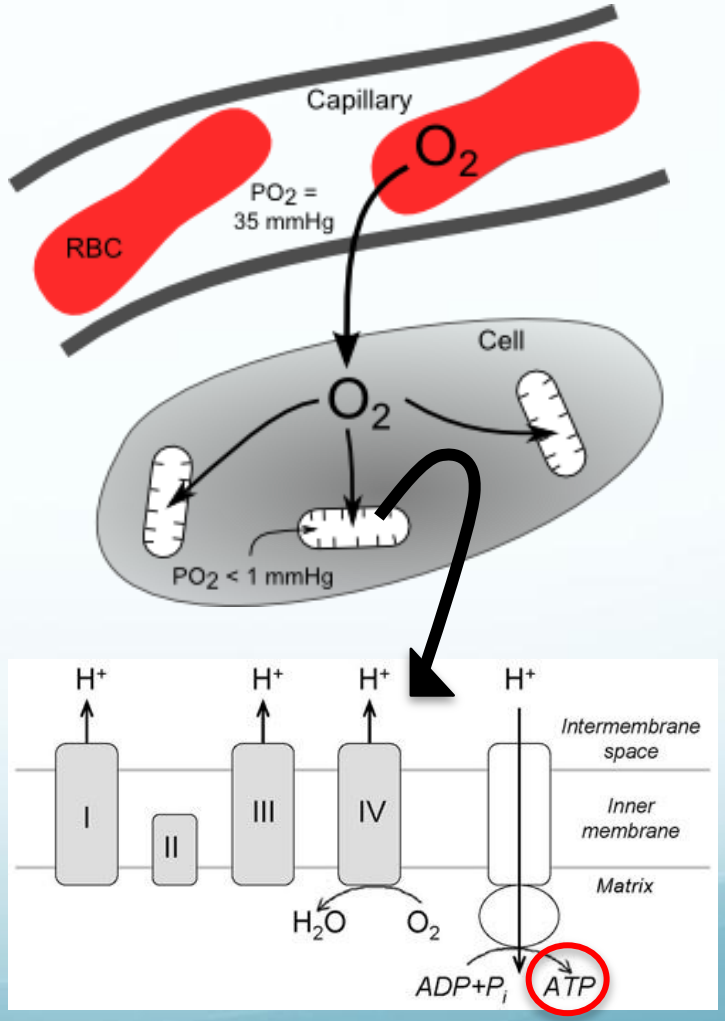
Oxygen in the Body



- Oxygen enters the lungs and diffuses through the alveolar membrane into the capillaries where it attaches to hemoglobin in red blood cells

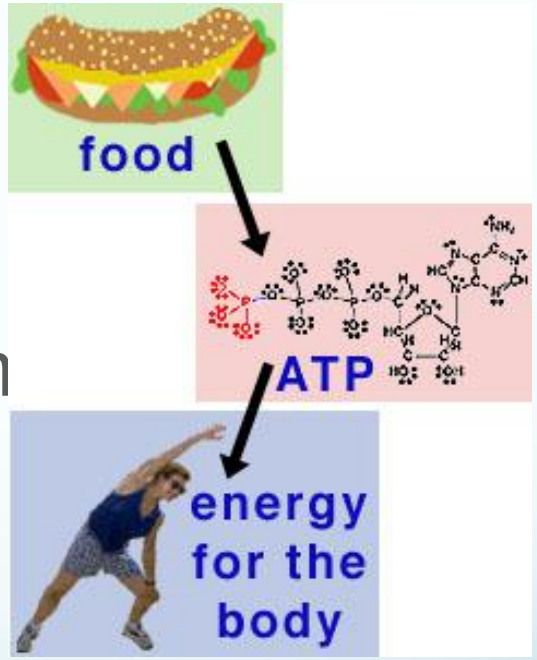
Oxygen in the Body

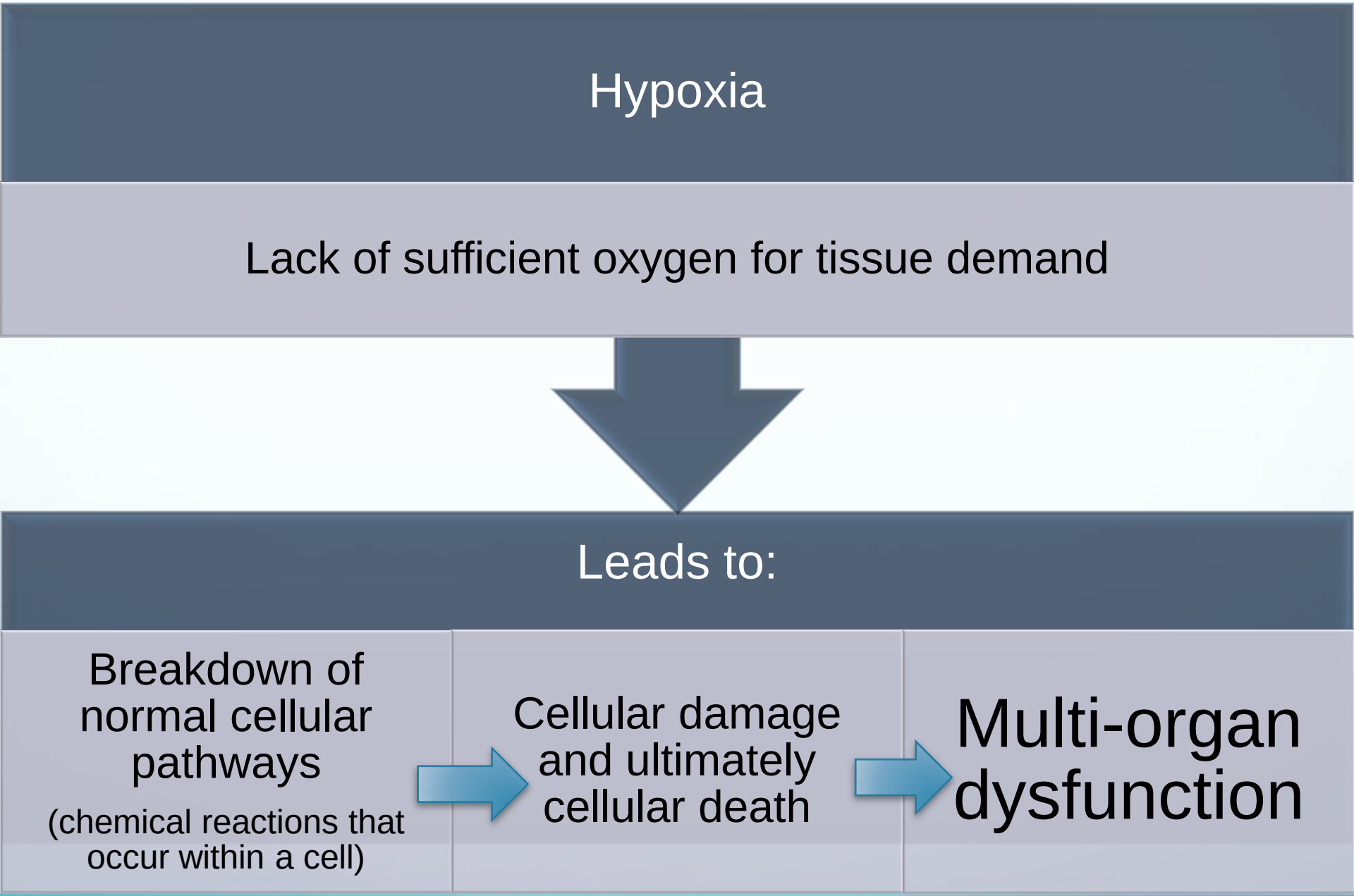
- Oxygen is then transported in the blood to tissues and used in cellular metabolism



Cellular metabolism

- Biochemical reactions involving oxygen take place within a cell
  - Synthesize what the cell needs for energy and function
  - Involve electron transfer (oxidation reduction)



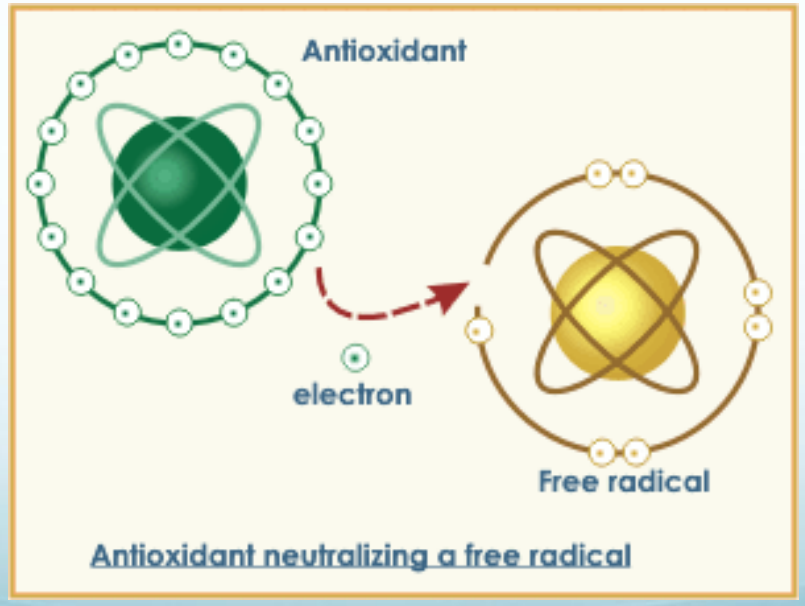

Hypoxia
Lack of sufficient oxygen for tissue demand
Leads to:
Breakdown of normal cellular pathways
(chemical reactions that occur within a cell)
Cellular damage and ultimately cellular death
Multi-organ dysfunction

The Bad

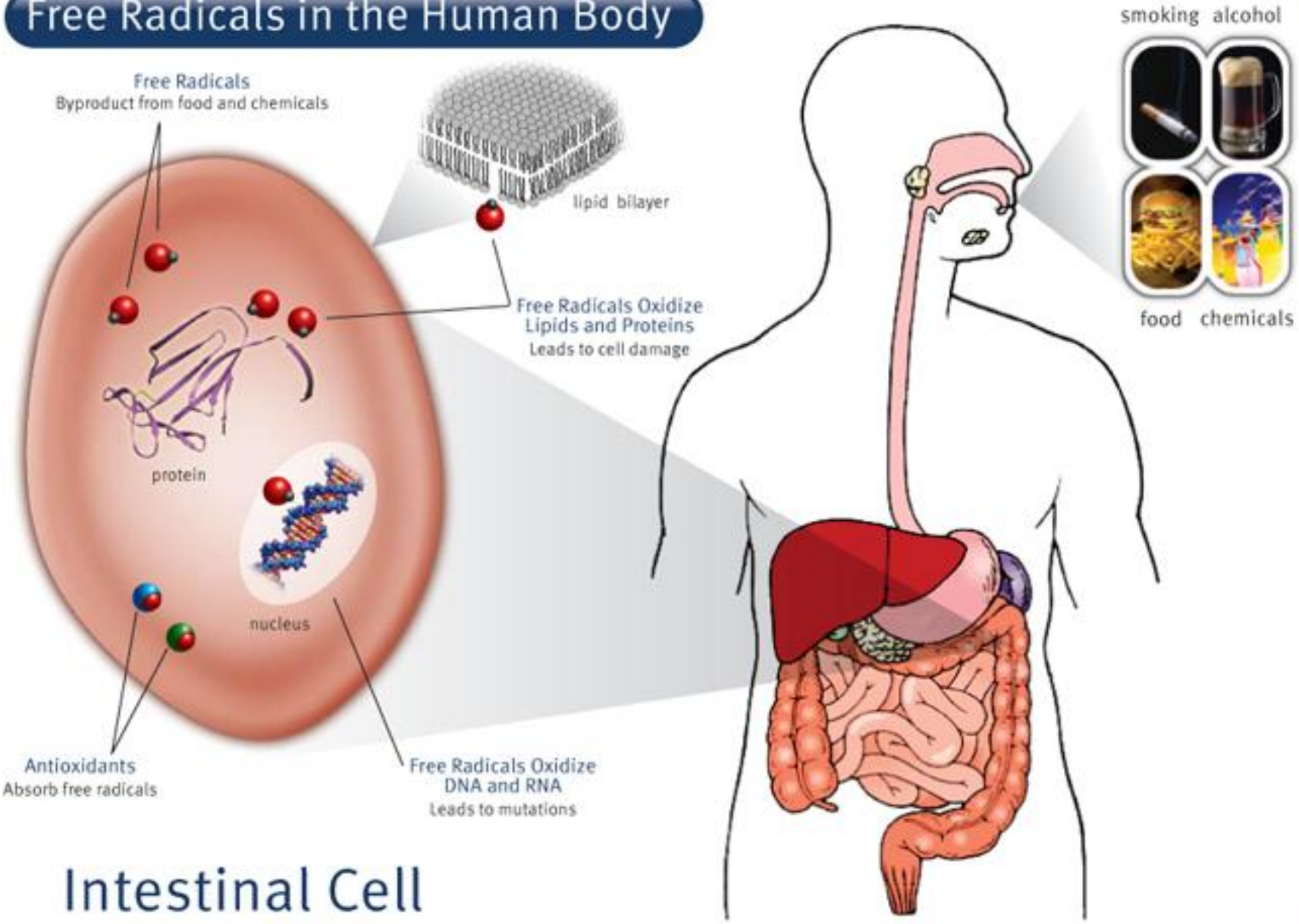
Too much oxygen can also be harmful

Chemical Principles

- Free Radicals
  - Reactive molecules that contain one or more unpaired electrons (negative particles)



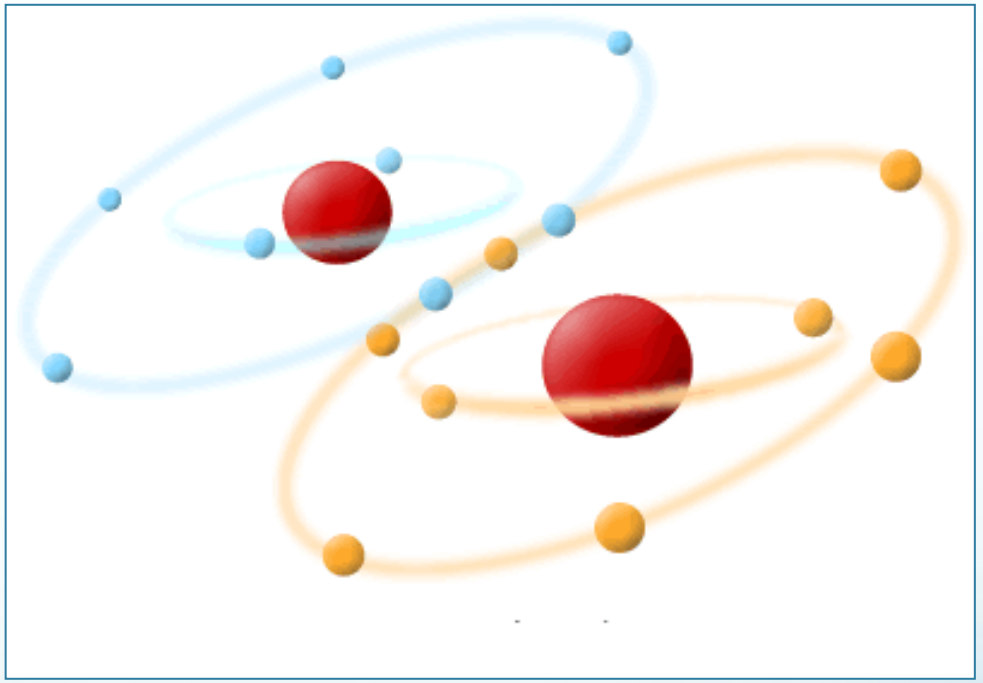
Free Radicals in the Human Body



Intestinal Cell

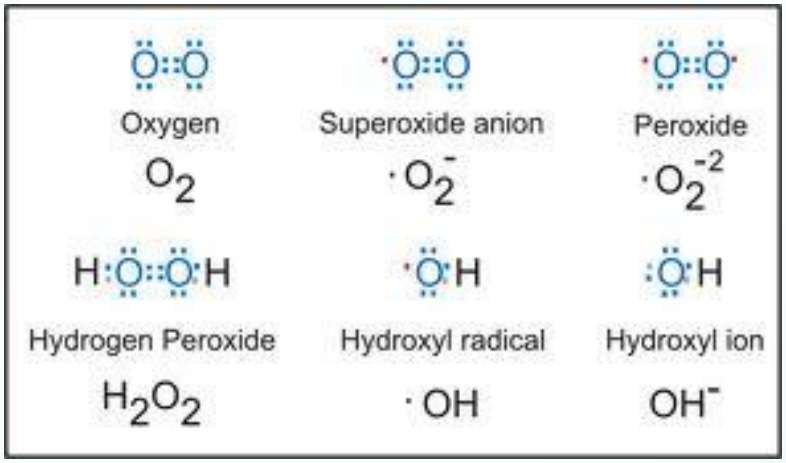
Chemical Principles

- Oxygen is highly reactive in the body
- It shares electrons between two atoms to maintain stability
- It has two unpaired electrons in its orbits



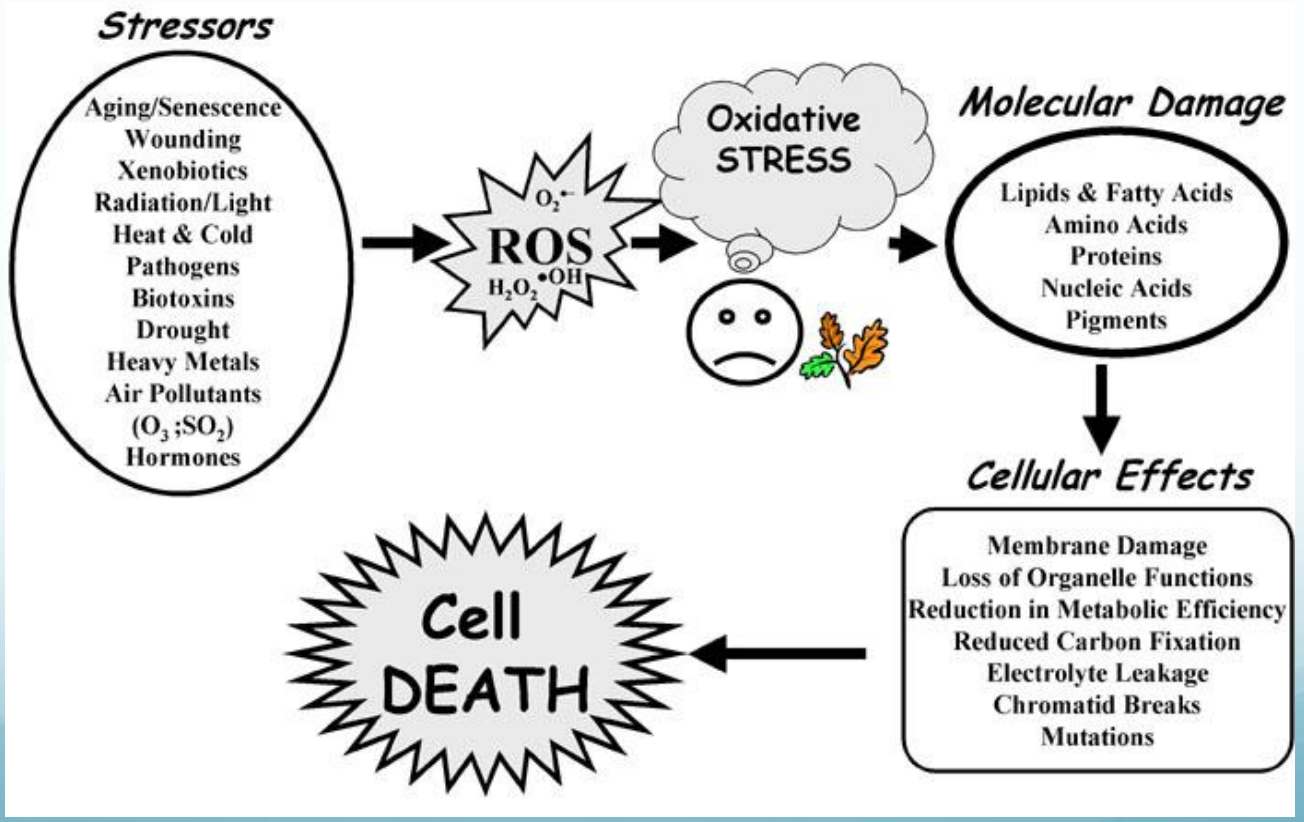
Reactive Oxygen Species (ROS)

- Chemically reactive molecules that contain oxygen
- ROS are generated regularly due to normal metabolism
- They are important for cellular metabolism and host defense mechanisms



Reactive Oxygen Species

- In excess these molecules create oxidative stress on the body



Oxidative stress

- Increased production of oxidizing species
- Decrease in effectiveness of anti-oxidant defenses

Oxidation-gaining of oxygen/hydrogen/electron

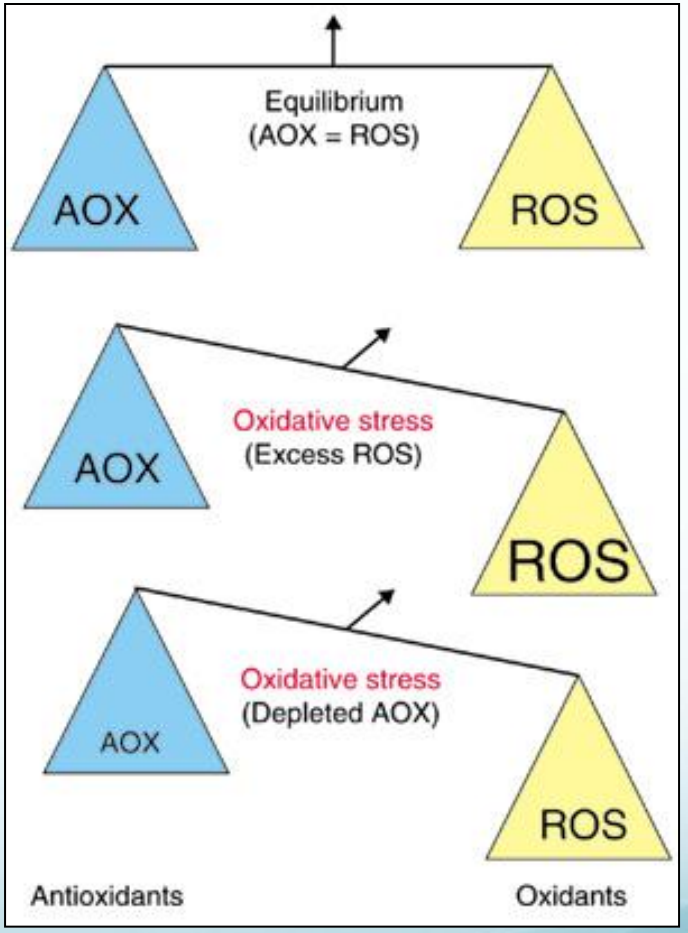
Reduction-loss of oxygen/hydrogen/electron

Do You Take Anti-oxidants?

- Anti-oxidants scavenge free-radicals
- Many foods are sources of anti-oxidants
- Supplements such as fish oil are common
- Herbs have high anti-oxidant properties

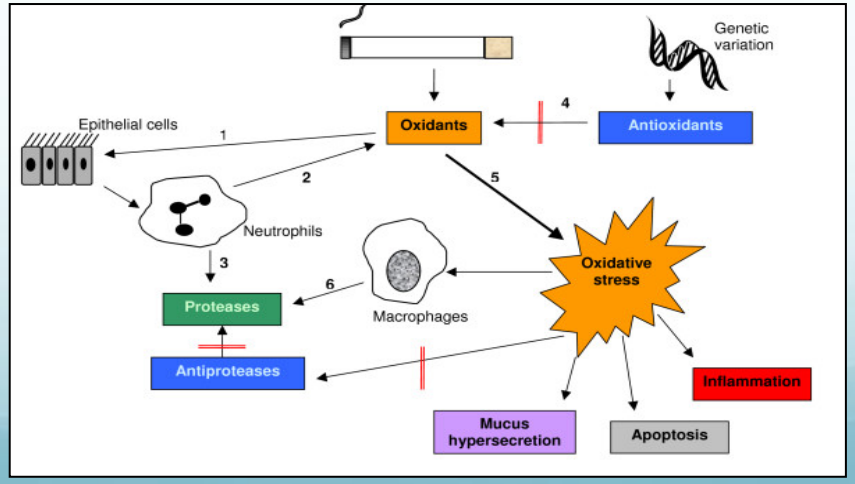
Reactive Oxygen Species

- The body has normal processes of defense to eliminate excess ROS (enzymes, antioxidants)
- Excessive production of ROS results in the defense system becoming overwhelmed
- ROS induce direct cellular damage and initiate a cascade of toxic reactions



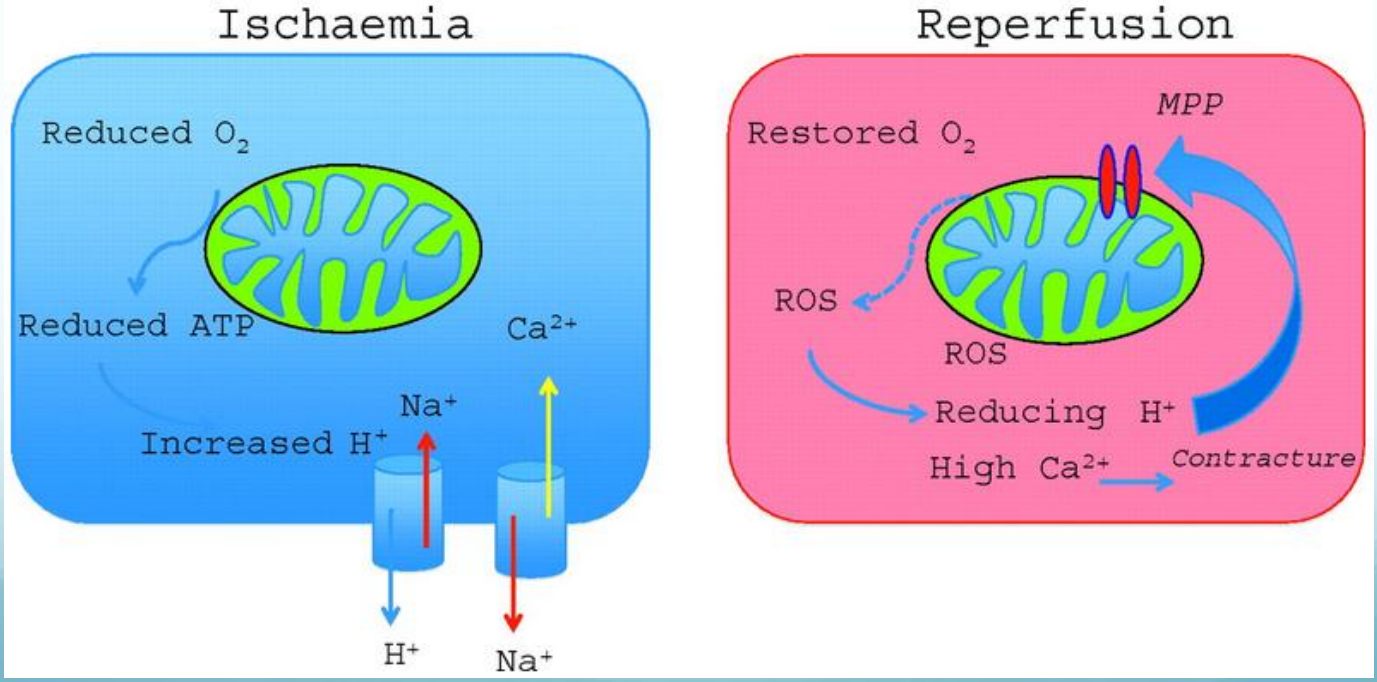
Reactive Oxygen Species

- Damage DNA
- Disrupt mitochondria causing cell energy failure
- Cause a cascade of damage resulting in cell death
- Accelerate progression of aging and disease



Reperfusion Injury

- Oxidative stress occurs most frequently when hypoxic tissues are re-exposed to oxygen and ROS are produced.



Other Adverse Effects

- Delayed recognition of patient deterioration with false reliance on high oxygen saturation
- Rebound hypoxemia with sudden oxygen withdrawal
- Possible decreased myocardial and cerebral perfusion from vasoconstriction
- Elevated CO_2 in susceptible patients (COPD)

Clinical Practice

What does this mean for patient care?

CRITICAL PATIENTS NEED OXYGEN

- Oxygen should not be withheld in any critical patient
- Critical patients are those with impending or actual respiratory or cardiopulmonary arrest
- Start with 100% O_2 and titrate when appropriate

FOR EVERYONE ELSE…

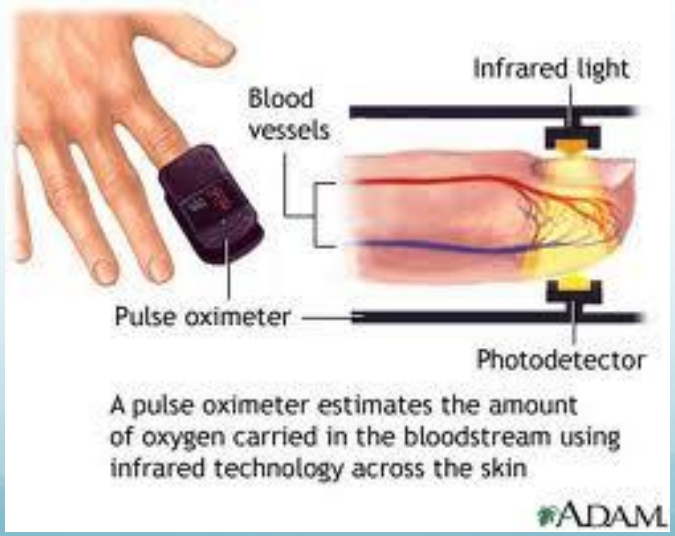
- Use titrated oxygen therapy

Titrated Oxygen Therapy

- The use of pulse oximetry is imperative when administering oxygen
- The goal oxygen saturation for most non-critical patients is 94-98%

Pulse Oximetry Principles

- Uses infrared beams to measure the saturation of hemoglobin
- May reduce the use of oxygen by guiding treatment
- No adverse effects were demonstrated in a Cochrane review of 20,000 patients



Pulse Oximetry

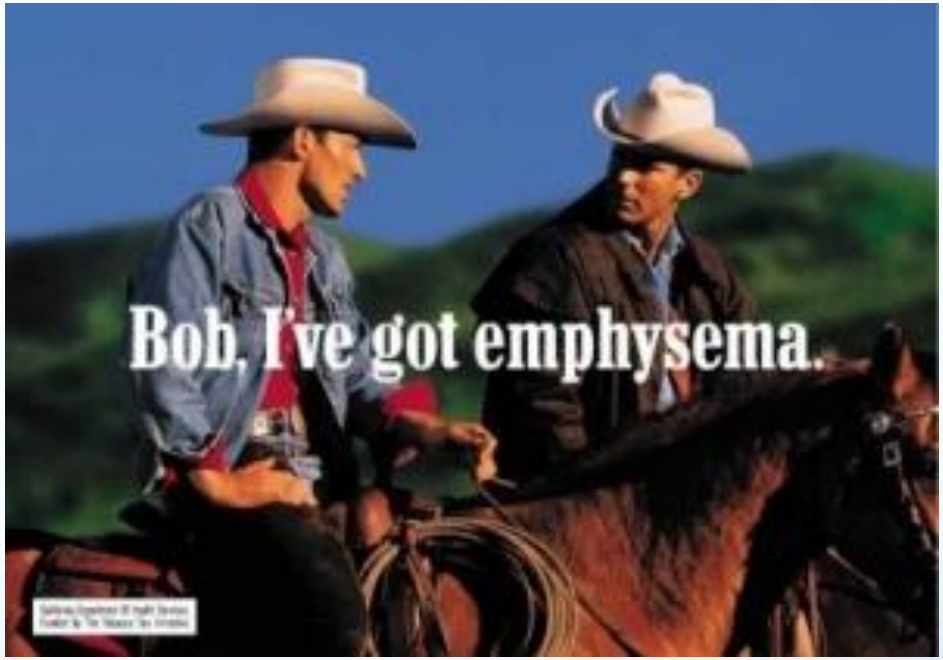
- Mcnabe 1998.
  - Prospective study evaluating the cost of empiric versus titrated oxygen therapy
  - 1787 patients with transport times of ≥ 20 minutes
  - Outcome:
    - 26% reduction in oxygen use
    - Cost saving of $0.20 per patient

Some of the evidence

Specific disease processes

COPD and CO_2 Retention

- Healthy people get the urge to breathe when CO_2 levels climb
- COPD patients have chronic CO_2 elevations
- Back-up systems stimulate respiration with hypoxia



COPD

- Excessive oxygen decreases minute ventilation and worsens ventilation-perfusion mismatch, resulting in increased carbon dioxide
- Prehospital treatment with high-flow oxygen, even for a short period of time, can be harmful
- High-flow oxygen increases mortality, length of hospital stay, and need for ventilation

COPD

- Titrated therapy reduces mortality, acidosis and need for assisted ventilation
- CPAP reduces need for supplemental oxygen. It reduces mortality and the need for intubation
- The recommended goal for oxygen saturation in these patients is 88-92%

COPD

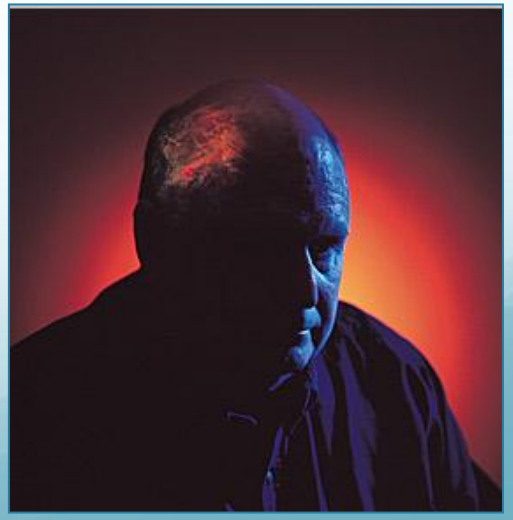
- Conclusion:

  “Our findings … support the British Thoracic Society’s recent guidelines on acute oxygen treatment, which recommend that oxygen should be administered only at concentrations sufficient to maintain adequate oxygen saturations.”

USE TITRATE OXYGEN THERAPY

Stroke

- The brain after a stroke is vulnerable to oxidative stress
- Lactic acid accumulates in the neurons
- The acidic environment has a pro-oxidant effect
- ROS can further damage an already vulnerable neuron



Stroke

- Conclusion:
  - “Supplemental oxygen should not routinely be given to non-hypoxic stroke victims with minor to moderate strokes.”

USE TITRATE OXYGEN THERAPY

Acute Coronary Syndrome

- Although increased oxygen seems theoretically beneficial in MI, studies to date show no conclusive benefit
- Suggested mechanisms of harm with excess oxygen:
  - Increase in blood pressure
  - Lower coronary blood flow
- Despite higher blood oxygen, there may be reduced tissue delivery by these mechanism

Acute Coronary Syndrome

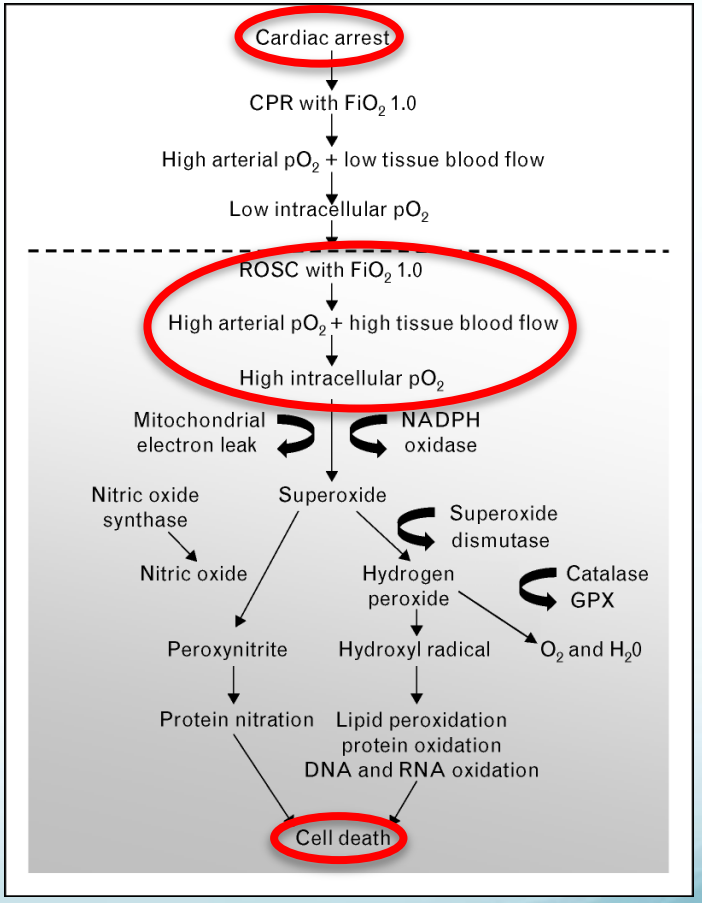
- Cochrane Review 2010
  - 3 studies with a total of 387 patients and 14 deaths
  - Conclusion:

> “There is no conclusive evidence from randomized controlled trials to support the routine use of inhaled oxygen in patients with acute MI.”

USE TITRATE OXYGEN THERAPY

Post-Resuscitation

- Post-cardiac arrest brain injury is a common cause of morbidity and mortality
- The brain has limited tolerance to ischemia and unique response to reperfusion
- A burst of ROS with decreased antioxidant defenses leads to increased oxidative stress and neuronal injury
- Even exposure for 10 minutes can cause long-term injury



Post-Resuscitation

- European Council Guidelines (2010):

  “Initially, give the highest possible oxygen concentration. As soon as the arterial blood oxygen saturation can be measured reliably, titrate the inspired oxygen concentration to achieve an arterial blood oxygen saturation in the range of 94-98%”

USE TITRATE OXYGEN THERAPY

Neonates

- The popular theory is that oxygen is harmful to most neonates
- Transition from intrauterine hypoxic environment to extrauterine normoxic environment leads to an acute increase in oxygenation and development of ROS
- Premature infants are at highest risk because they have not had time to develop the normal defense mechanisms an infant acquires as they are preparing for birth

Neonates

- For neonates in need of positive-pressure ventilation:
  - Consider ventilation for 90 seconds with room air
  - Heart rate >100 is the goal
  - If unsuccessful, use 100% oxygen

Trauma

- There is no evidence that oxygen in the general trauma population has significant benefits
- ROS are produced in hemorrhagic shock and lead to oxidative stress
- Excessive blood oxygen levels can cause even greater increase in ROS
- Traumatic brain injury may be the exception

Trauma

- Conclusion:

  “Our analysis suggests that there is no survival benefit to the use of supplemental oxygen in the prehospital setting in traumatized patients who do not require mechanical ventilation or airway protection.”

USE TITRATE OXYGEN THERAPY

When titrated therapy is not possible

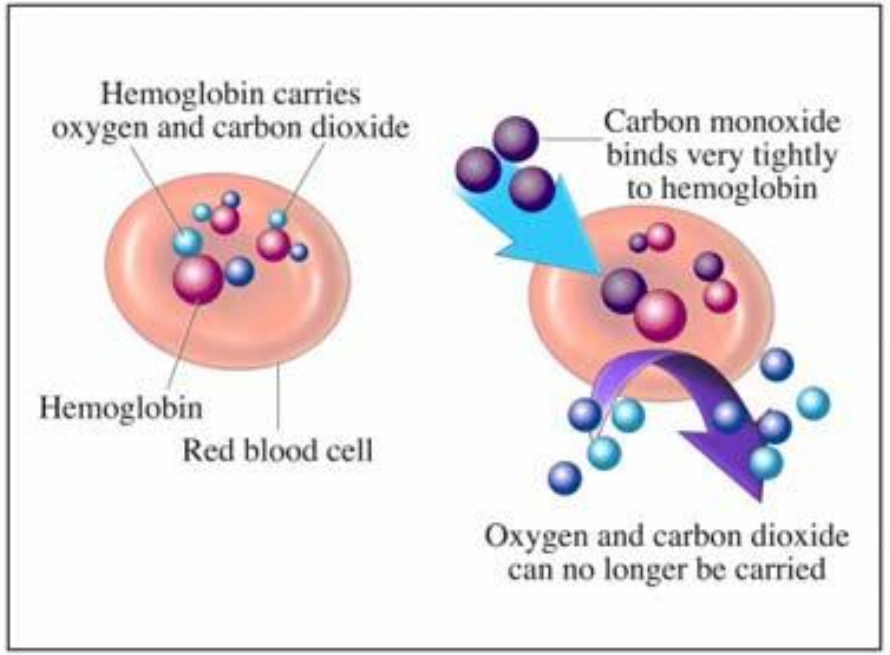
Exceptions to the rule

Traumatic Brain Injury

- Patients may need higher than normal oxygen pressures to provide enough oxygen to the injured brain
- Cannot differentiate with pulse oximetry (100% = PaO_2 ≥ 100)
- Goal O_2 saturation 100%.

Carbon Monoxide Poisoning

- CO binds hemoglobin and displaces O_2
- Standard pulse oximetry cannot distinguish CO from O_2 on hemoglobin
  - Pulse oximetry can read falsely high
- High-flow O_2 results in more rapid elimination of the CO molecules
- Goal O_2 saturation 100%



Conclusion

- Supplemental oxygen therapy has been common practice in the prehospital setting
- There is evidence that excessive blood oxygen has potential harmful effects in many disease processes
- In the non-critical patient, providing the minimum oxygen necessary to treat hypoxia can decrease potential harmful effects while still providing patients with the oxygen they need

Conclusion

- Treat oxygen like any other drug
- Provide each patient with appropriate oxygen therapy
- For critically ill patients, start with O_2 15 LPM and titrate when appropriate
- For all other patients titrate the oxygen saturation to goal and consider starting with nasal cannula or simple mask for stable patients with mild hypoxia

Acknowledgements

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