Can Oxygen Be Bad?

Mike McEvoy, PhD, NRP, RN, CCRN
Professor Emeritus - Critical Care Medicine
Albany Medical College, New York
Chair – Resuscitation Committee – Albany Med Center
EMS Coordinator – Saratoga County, New York
EMS Editor – Fire Engineering Magazine
EMS Director – New York State Association of Fire Chiefs

Class Code: 664

Objectives

• Adverse effects of hypoxia
  – High altitude climbing lessons
• Oxygen free radicals
  – You’ve heard the name; what are they?
  – How they cause harm
• Interventions to prevent harm from hyperoxia

Hypoxia

Mt. Kilimanjaro
5895 m (19340 ft)
Effects of sudden hypoxia
(Removal of oxygen mask at altitude or in a pressure chamber)

• Impaired mental function; mean onset at SaO2 64%
• No evidence of impairment above 84%
• Loss of consciousness at mean saturation of 56%

Notes:
- absence of breathlessness when healthy resting subjects are exposed to sudden severe hypoxia
- mean SpO2 of airline passengers in a pressurized cabin falls from 97% to 93% (average nadir 88.6%) with no symptoms and no apparent ill effects

“Normal” Oxygen Saturation
Normal range for healthy young adults is approximately 96-98% (Crapo AJRCCM, 1999;160:1525)

Previous literature suggested a gradual fall with advancing age…

However, a recent Salford/Southend UK audit of 320 stable adults aged >70 found:
Mean SpO2 = 96.7%
(2SD range 93.1-100%)

“Normal” nocturnal SpO2

• Healthy subjects in all age groups routinely desaturate to an average nadir of 90.4% during the night (SD 3.1%)*

(Gries RE et al Chest 1996; 110: 1489-92)

*Therefore, be cautious in interpreting a single oximetry measurement from a sleeping patient. Watch the oximeter for a few minutes if in any doubt (and the patient is otherwise stable) as normal overnight dips are of short duration.
What happens at 9,000 metres (approximately 29,000 feet)?

It Depends…

**SUDDEN**
Passengers unconscious in <60 seconds if depressurized

**ACCLIMATIZATION**
Everest has been climbed without oxygen

Sudden Acclimatization

Mike 73%
Godlisten 84%
Pete 41%

AMS
Acute Mountain Sickness

Trekker's on the Annapurna Circuit
Is Hypoxia Bad?

“Hypoxia not only stops the motor, it wrecks the engine.”

- John Scott Haldane, 1917
“Not all chemicals are bad. Without chemicals such as hydrogen and oxygen, for example, there would be no water, a vital ingredient for beer.”
-Dave Barry

- Diatomic gas
- Atomic weight = 15.9994 g⁻¹
- Invisible
- Odorless, tasteless
- Third most abundant element in the universe
- Present in Earth’s atmosphere at 20.95%

• Essential for animal life
Oxygen therapy has always been a major component of emergency care. Health care providers believe oxygen alleviates breathlessness.

We began giving oxygen because it seemed like the right thing to do...

**Documented benefits:**
- Hypoxia
- Nausea/vomiting
- Motion sickness

Today, there are numerous textbooks on the reactive oxygen species.
Oxygen

- We are learning that oxygen is a two-edged sword
- It can be beneficial
- It can be harmful

The Chemistry of Oxygen

- Oxygen is highly reactive; it has 2 unpaired electrons
- Molecules/atoms with unpaired electrons are extremely unstable and highly-reactive
- Referred to as “free radicals”

How are free-radicals produced?

- Normal respiration and metabolism
- Exposure to air pollutants
- Sun exposure
- Radiation
- Drugs
- Viruses
- Bacteria
- Parasites
- Dietary fats
- Stress
- Injury
- Reperfusion
Most cells receive approximately 10,000 free-radical hits a day. Enzyme systems can normally process these.

Changes associated with aging are actually due to effects of free-radicals. As we age, the antioxidant enzyme systems work less efficiently.

An excess of free-radicals damages cells and is called oxidative stress.
The Chemistry of Oxygen

Diseases associated with free-radicals:

- Arthritis
- Cancer
- Atherosclerosis
- Parkinson’s
- Alzheimer’s
- Diabetes
- ALS

Neonatal diseases:
- Intraventricular hemorrhage
- Periventricular leukomalacia
- Chronic lung disease / bronchopulmonary dysplasia
- Retinopathy of prematurity
- Necrotizing enterocolitis

The Chemistry of Oxygen

The Chemistry of Oxygen

Oxidative Stress

- Occurs during reperfusion—not during hypoxia (when O₂ enters damaged area)
- Flooding ischemic cells with oxygen worsens oxidative stress (proportionate)
Not a new concept

ACLS Guidelines 2000:
• Supplemental oxygen only for saturations < 90%
• 2005: ditto
• 2010: < 94%

Stroke

Minor or Moderate Strokes | Severe Strokes
---|---
Variable | Oxygen | Control | Oxygen | Control
Survival | 81.8% | 90.7% | 53.4% | 47.7%
SSS Score | 54 (54-58) | 57 (52-58) | 47 (28-54) | 47 (40-52)
Barthel Index | 100 (95-100) | 100 (95-100) | 70 (32-90) | 80 (47-95)

• 1994: AHA Stroke Council concluded no data support routine use of supplemental oxygen in stroke patients
• More recently, oxygen has been suggested to be detrimental
Neonates

- 1,737 depressed neonates:
  - 881 resuscitated with room air
  - 856 resuscitated with 100% oxygen
- Mortality:
  - Room air resuscitation: 8.0%
  - 100% oxygen resuscitation: 13.0%
- Neonatal mortality reduced with room air resuscitation

Cardiac Arrest

- Emphasis on circulation
  - Compression only CPR may be better
  - Known dangers of oxidative stress
- Study on Room Air vs. FiO₂ 1.0
  - In-hospital med/surgical wards
  - Standard ACLS, change only FiO₂ (30 days)
  - Study halted by IRB: use of 100% oxygen harmful to human subjects!

Therapeutic Hypothermia

Post ROSC Survival:
- Post cardiac arrest hypothermia
- 58 patients, all ROSC in OOH CPA
- Cooling protocol: keep sat 92-96%
  - Survival ↓ by 50% when sats < 92%
  - Survival ↓ by 83% when sats > 96%
Trauma

• Charity Hospital (1/1 ➔ 9/30/2002):
• 5,549 trauma patients by EMS

Mortality:

![Oxygen vs. None](chart.png)

OVERALL

<table>
<thead>
<tr>
<th>Oxygen</th>
<th>None</th>
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<tbody>
<tr>
<td>PENETRATING</td>
<td></td>
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<tr>
<td>BLUNT</td>
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Where to from here?
British Thoracic Society

• Issued an O₂ therapy guideline 2008
• All this… and more:
  – Routine administration can be harmful
  – O₂ does not affect dyspnea unless hypoxic
  – Hyperoxia may decrease target organ perfusion (when given needlessly)
  – Unnecessary O₂ delays recognition of deterioration by providing false reassurances with high O₂ saturations

Got oxygen?

British Thoracic Society

O₂ therapy guideline (everywhere):
• Keep normal/near-normal O₂ sats
  – All patients except hypercapnic resp. failure and terminal palliative care
  – Keep sat 92-96%, tx only if hypoxic
  – Use pulse oximetry to guide tx – max 98%

www.brit-thoracic.org.uk
Oxygen?

Implications: Oximetry mandatory

Implications: Venturi Comeback
Take Home Messages

• Oxygen can hurt
• Empiric use is not a good practice - O₂ tx must be focused
• Use oximetry to guide care: prevent hypoxia and hyperoxia

Questions? (Class Code: 664)

www.mikemcevoy.com