Hooray for Hypoxia (or don’t give too much oxygen)

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British Thoracic Society
Guideline for emergency oxygen use in adult patients

Endorsed by:
Association of Respiratory Nurse Specialists
Association for Respiratory Technology and Physiology
British Association for Emergency Medicine
British Cardiovascular Society
British Geriatric Society
British Paramedic Association
Chartered Society of Physiotherapy
General Practice Airways Group (GPIAG)
Intensive Care Society
Joint Royal Colleges Ambulance Liaison Committee
Resuscitation Council (UK)
Royal College of Anaesthetists
Royal College of General Practitioners
Royal College of Midwives
Royal College of Nursing
Royal College of Obstetricians and Gynaecologists (approved)
Royal College of Physicians (London, Glasgow, Edinburgh)
Royal Pharmaceutical Society of Great Britain
Society for Acute Medicine

O'Driscoll BR, Howard LS, Davison AG. Thorax 2008; 63 Suppl VI
Normal range for oxygen saturation

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

SLIGHT FALL WITH ADVANCING AGE

Defining safe lower and upper limits of oxygen saturation
Effects of sudden hypoxia
(e.g. Removal of oxygen mask at altitude or in a pressure chamber)

- Impaired mental function; Mean onset at SaO₂ 64%  No impairment above 84% saturation

- Loss of consciousness at @ saturation of 56%

Aker A et al Eur Respir J. 2005;25:725-30
What happens at 9,000 metres (approximately 29,000 feet) – it depends

<table>
<thead>
<tr>
<th>Atmospheric pO2</th>
<th>6.2 kPa (&lt; 1/3 sea level pO2)</th>
</tr>
</thead>
<tbody>
<tr>
<td>PaO2</td>
<td>~3.3 kPa</td>
</tr>
<tr>
<td>Arterial Oxygen Saturation</td>
<td>~70%</td>
</tr>
</tbody>
</table>

**SUDDEN**

Passengers unconscious in <60 seconds if depressurised

**ACCLIMATISATION**

Everest has been climbed without oxygen
What is the minimum arterial oxygen level recommended in acute illness

**Saturation**

- Critical care consensus guidelines
- Surviving sepsis campaign

**Target oxygen**

- Minimum 90%
- Aim at 88-95%

*These patients have intensive levels of nursing and monitoring*

The BTS guideline recommends minimum of 94% for most non-critically ill patients
Exposure to high concentrations of oxygen may be harmful

- Absorption Atelectasis even at FIO₂ 30-50%
- Intrapulmonary shunting
- Post-operative hypoxaemia
- Risk to COPD patients
- Coronary vasoconstriction
- Increased Systemic Vascular Resistance
- Reduced Cardiac Index
- Possible reperfusion injury post MI
- Worsens systolic myocardial performance
- Oxygen therapy INCREASED mortality in non-hypoxic patients with mild-moderate stroke

The guideline recommends a maximum of 98% for most patients – less for certain situations

Can high dose oxygen be harmful?

- Greater tachycardia and enzyme rise in uncomplicated MI patients [old trial -1976]
- Yet we still give oxygen to MI patients
- Small trial - oxygen in labour can increase cord blood acidosis.
- Oxygen in non-hypoxic stroke patients have higher one year mortality than patients given air alone.
- What is the situation for critically ill?
Hypoxaemia Kills

- **Limited hypoxia:**
  - prolongs neutrophil survival,
  - enhances pro-inflammatory responses (IL-8)
  - increases leukocyte adhesion,
  - reduces lung fluid transport

- **Prolonged/severe hypoxia:**
  - inflammatory response
  - increased capillary leak

DIE

Hirani 2001
Hannah 1995
Madjdpour 2003
Halperin 1996
Can we determine the importance of oxygenation in ARDS?
Outcome and oxygenation in respiratory failure: A study of over 100,000 ICU patients

H Wunsch*, D Young #, K Rowan* G Bellingan

University College London Hospitals
*Intensive Care National Audit and Research Centre
#John Radcliffe Hospital Oxford
Methods

- Intensive Care National Audit and Research (ICNARC) Case Mix Programme data base
- 159 adult ICUs England, Wales, Northern Ireland
- Dec 1995 - June 2003
- Prospective validated data on 1st 24 hours and outcome
Analysis

132,828 patients

- No Respiratory Failure
- ALI
- ARDS

- 27015
- 37064
- 68749
<table>
<thead>
<tr>
<th></th>
<th>ALI</th>
<th>ARDS</th>
<th>No Resp Failure</th>
</tr>
</thead>
<tbody>
<tr>
<td>Age (Med IQR)</td>
<td>66 (52-75)</td>
<td>65 (51-74)</td>
<td>58 (36-72)</td>
</tr>
<tr>
<td>APACHE II (Med SD)</td>
<td>15.4 (6.3)</td>
<td>19.3 (7.1)</td>
<td>13.8 (6.3)</td>
</tr>
<tr>
<td>ICU stay (surv) (Med IQR)</td>
<td>1.8 (0.9-3.7)</td>
<td>3.0 (1.2-8.2)</td>
<td>1.1 (0.8-2.4)</td>
</tr>
<tr>
<td>Hospital stay (Med IQR)</td>
<td>17 (10-32)</td>
<td>21 (12-40)</td>
<td>14 (8-27)</td>
</tr>
<tr>
<td>Hosp mortality (%)</td>
<td>24.7%</td>
<td>41.7%</td>
<td>18.4%</td>
</tr>
</tbody>
</table>
Targeted Oxygenation

Hypoxaemia is bad
The other side of the coin
Hyperoxia is dangerous across species

NATURE
Insects breathe discontinuously to avoid oxygen toxicity.

Hetz SK, Bradley TJ.

Hydroxemia Kills

- 100% oxygen results in:
  - Progressive damage to the pulmonary endothelium and epithelium.
  - Free radical release,
  - Capillary leak
  - Impaired surfactant function
  - Maldistribution of microcirculatory perfusion

Death

Welty-Wolf 1997
Tsai 2003
Huang 1995
Targeted Oxygenation

Mortality of critically ill patients by PaO$_2$

Hypoxaemia is bad

Hyperoxia is bad
Hypoxia and Adenosine are anti-inflammatory
Improving oxygen is not enough

The New England Journal of Medicine

Original Article

Effect of Recombinant Surfactant Protein C–Based Surfactant on the Acute Respiratory Distress Syndrome

Roger G. Spragg, M.D., James F. Lewis, M.D., Hans-Dieter Walmrath, M.D., Jay Johannigman, M.D., Geoff Bellingan, M.D., Pierre-Francois Laterre, M.D., Michael C. Witte, M.D., Guy A. Richards, M.D., Gerd Rippin, Ph.D., Frank Rathgeb, M.D., Dietrich Häfner, M.D., Friedemann J. H. Taut, M.D., and Werner Seeger, M.D.
[PO$_2$/FiO$_2$] ratio / time

= Surfactant administered
Venticute Surfactant Trial: Outcome

2) Oxygenation

Treatment with surfactant increased significantly the area under the PaO₂/FiO₂ vs. time curve.
Venticute Surfactant Trial: Outcome

1) Ventilator Free days

![Bar chart showing the number of ventilator free days for control and surfactant groups. The chart indicates a significant increase in ventilator free days for the surfactant group compared to the control group.](image-url)
Improving oxygen is not enough

- Same for iNO, Oscillation, ECMO....
What is a safe lower Oxygen level in acute COPD?

In acute COPD, pO₂ above 6.7kPa or 50 mm Hg will prevent death.

SaO₂ above about 85% (Keep SpO₂ ≥88% to allow for oximeter error and ensure PaO₂ >85%)

This guideline recommends a minimum saturation of 88% for most COPD patients.

Aims of emergency oxygen therapy

- To correct or prevent potentially harmful hypoxaemia

- To alleviate breathlessness (only if hypoxaemic)

Oxygen has no effect on breathlessness if the oxygen saturation is normal
Fallacies regarding Oxygen Therapy

"Routine administration of supplemental oxygen is useful, harmless and clinically indicated"”

- Little increase in oxygen-carrying capacity
- Renders pulse oximetry worthless as a measure of ventilation
- May prevent early diagnosis & specific treatment of hypoventilation

The guideline only recommends supplemental oxygen when SpO2 is below the target range or CO Poisoning
Prescribing Oxygen
## Oxygen prescription

**Model for oxygen section in hospital prescription charts**

<table>
<thead>
<tr>
<th>DRUG</th>
<th>OXYGEN</th>
<th>(Refer To Trust Oxygen Policy)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Circle target oxygen saturation</td>
<td>88-92% 94-98% Other___</td>
<td>STOP DATE</td>
</tr>
</tbody>
</table>

Starting device/flow rate______
PRN / Continuous

(Saturation is indicated in almost all cases except for palliative terminal care)

SIGNATURE / PRINT NAME

DATE
ddmmmyy
Should high concentration of oxygen be given to all patients who present with severe acute illness in A&E?

21 Royal Colleges and Societies say NO. Gosh a bigger coalition than us. Targeted oxygen and a saturation of 88-94% is usually enough.