Woes to the O's?

Do We Really Need to Use Supplemental O_2?

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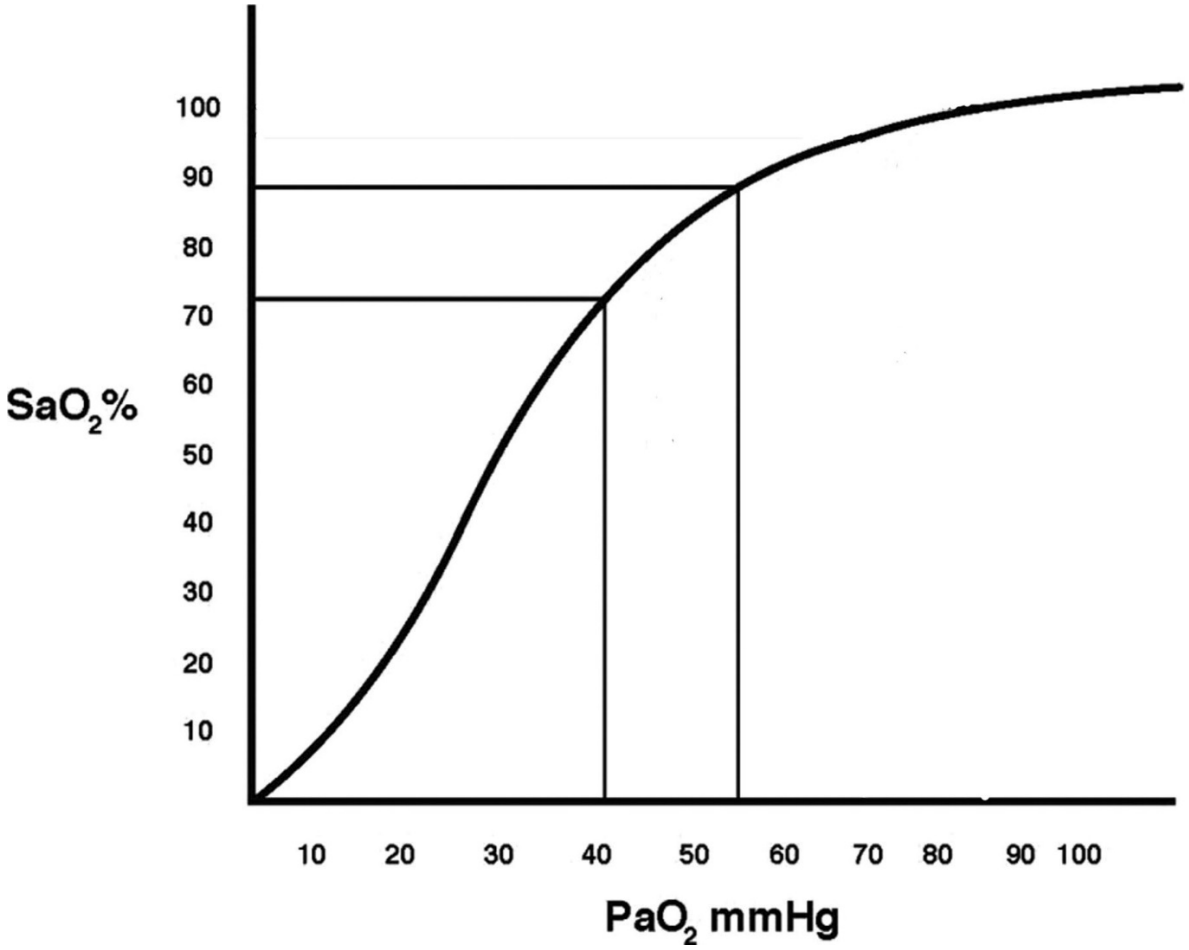
Questions to Ponder

- Do we really need to administer supplemental oxygen?
- Are there medical conditions where supplemental oxygen is harmful?
- Are there traumatic conditions where supplemental oxygen is harmful?

Oxygen-Hemoglobin Dissociation Curve



Myocardial Ischemia and Infarction

Historical Overview

- Oxygen relieved pain during episodes of angina pectoris
  - Steele C. Severe angina pectoris relieved by oxygen inhalations. BMJ 1900, 2:1568.
- Hypoxia of the myocardium described as the cause of angina
  - Keefer CS, Resnik WH. Angina pectoris: a syndrome caused by anoxemia of the myocardium. Arch Intern Med 1928, 41:769-807.

Oxygen Supplementation, 1950

- 100% oxygen either pronounced or prolonged electrocardiographic changes
- Failed to prevent the onset of anginal pain
- Failed to influence the duration of pain

Russek HI, Regan FD, Naegele CF. One hundred percent oxygen in the treatment of acute myocardial infarction and severe angina pectoris. JAMA 1950, 144:373-375.

1964

- Breathing high concentrations of oxygen for at least 30 minutes in the first 24 hours after MI
  - Decreased heart rate
  - Reduced cardiac output
  - Increased systemic vascular resistance
- High concentration – 85% to 90%

MacKenzie GJ, Flenley DC, Taylor SH, McDonald AH, Stanton HP, Donald KW. Circulatory and respiratory studies in myocardial infarction and cardiogenic shock. Lancet 1964, 2:825-832.

1965

- Administration of 40% oxygen for 20 minutes
  - 17% decrease in cardiac output
  - 5% increase in arterial blood pressure

Thomas M, Malmcroma R, Shillingford J. Haemodynamic effects of oxygen in myocardial infarction. Brit Heart J 1965,27:401-407.

1968

- 90% oxygen for one hour
  - Reduced stroke volume
  - Reduce cardiac output
  - Increased arterial pressure
  - Increased systemic vascular resistance

Kenmure ACF, Murdoch WR, Beattie AD, Marshall JCB, Cameron AJV. Circulatory and metabolic effects of oxygen in myocardial ischemia. Brit Med J 1968; 4:360-364.

1969

- Normal subjects
  - Hypoxia does not affect the availability of oxygen for myocardial metabolism until arterial oxygen saturation falls to as low as 50%
- Patients with coronary artery disease
  - Myocardial ischemia is not observed until oxygen saturation fell below 85%
  - Hyperoxia did not improve myocardial oxygen availability
  - Subset of patients with severe triple-vessel disease
    - 6 minutes of high-flow oxygen reduced coronary blood flow sufficiently to induce myocardial ischemia

Neill WA. Effects of arterial hypoxemia and hyperoxia on oxygen availability for myocardial metabolism: patients with and without coronary artery disease. Am J Cardiol 1969, 24:166-171.

Bourassa MG, Campeau L, Bois MA, Rico O. The effects of inhalation of 100 percent oxygen on myocardial lactate metabolism in coronary heart disease. Am J Cardiol 1969, 24:172-177.

2007

- Breathing 100% oxygen for 10 minutes
  - Increases vascular resistance in the left anterior descending artery by 23%
    - Diameter of the large conduit coronary arteries was not appreciably affected
    - Suggests vasoconstriction at the level of the myocardial microcirculation

McNulty PH, Robertson BJ, Tulli MA, Hess J, Harach LA, Scott S, Sinoway LI. Effect of hyperoxemia and vitamin C on coronary blood flow in patients with ischemic heart disease. J Appl Physiol 2007, 102:2040-2045

Etc., Etc., Etc…

First Author	Changes in Coronary Blood Flow (%)	Changes in Coronary Vascular Resistance (%)	Changes in Myocardial Oxygen Consumption (%)
Ganz	-17.1	25	-15.3
Ganz	-8.6	21.5	-16.1
Mak	-7.9	Not reported	Not reported
McNulty	-28.9	40.9	-26.9
McNulty	-19.8	22.2	Not reported

- Ganz W, Donoso R, Marcus H, Swan HJ. Coroanry hemodynamics and myocardial oxymetabolism during oxygen breathing in patients with and without mycardial disease. Circulation 1972; 45(4):763-768
- Mak S, Azevedo ER, LIU PP, Newton GE. Effects of hyperoxia on left ventricular function and filling pressures in patients with and without congestive heart failure.
- McNulty PH, King N, Scott S, Hartman G, McCann J, Kozak M, et al. Effects of supplemental oxygen administration on coronary blood flow in patients undergoing cardiac catheterization. Am J Physiol Heart Circ Physiol 2005;288(3):H1057-H1062.
- McNulty PH, Robertson BJ, Tulli MA, Hess J, Harach LA, Scott S, Sinoway LI. Effect of hyperoxia and vitamin C on coronary blood flow in patients with ischemic heart disease. J Appl Physiol 2007; 102(5):2040-2045.

Cochrane Database of Systematic Reviews, 2013

Analysis 1.1. Comparison 1 Oxygen versus air, Outcome 1 Death in hospital for participants with acute MI.

Review: Oxygen therapy for acute myocardial infarction

Comparison: 1 Oxygen versus air

Outcome: 1 Death in hospital for participants with acute MI

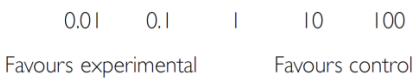
Study or subgroup	Experimental n/N	Control n/N	Risk Ratio M-H,Fixed,95% CI	Weight	Risk Ratio M-H,Fixed,95% CI
Rawles 1976	9/80	3/77		55.8 %	2.89 [0.81, 10.27]
Ukholkina 2005	1/58	0/79		7.7 %	4.07 [0.17, 98.10]
Ranchord 2012	1/68	2/68		36.5 %	0.50 [0.05, 5.39]
Total (95% CI)	**206**	**224**		**100.0 %**	**2.11 [0.78, 5.68]**

Total events: 11 (Experimental), 5 (Control)

Heterogeneity: $Chi^2 = 1.81$, df = 2 (P = 0.40); $I^2 = 0.0\%$

Test for overall effect: Z = 1.48 (P = 0.14)

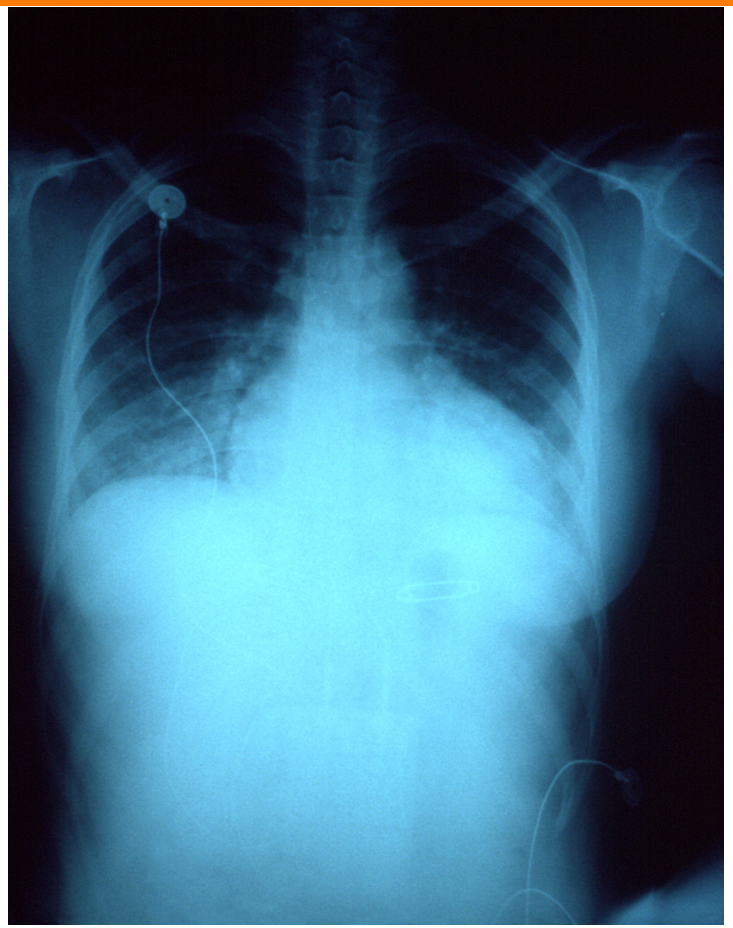
Test for subgroup differences: Not applicable



Respiratory Processes and Oxygen

Congestive Heart Failure

- Patients with stable congestive heart failure
  - Administration of 100% oxygen for 20 minutes
    - Cardiac output decreased by 16%
    - Stroke volume decreased by 16%
    - Systemic vascular resistance increased



Haque WA, Boehmer J, Clemson BS, Leuenberger UA, Silber DH, Sinoway LI. Hemodynamic effects of supplemental oxygen in congestive heart failure. J Am Coll Cardiol 1996, 27:353-357.

COPD

- Titrated oxygen treatment in a pre-hospital setting
- Target SpO_2 of 88% - 92%
- Used compressed air to nebulize bronchodilators

Mortality

Presumed Acute COPD Exacerbation	RR 0.42 (95% CI 0.20-0.89)
Confirmed COPD	RR 0.22 (95% CI 0.05-0.91)

Adverse Outcomes

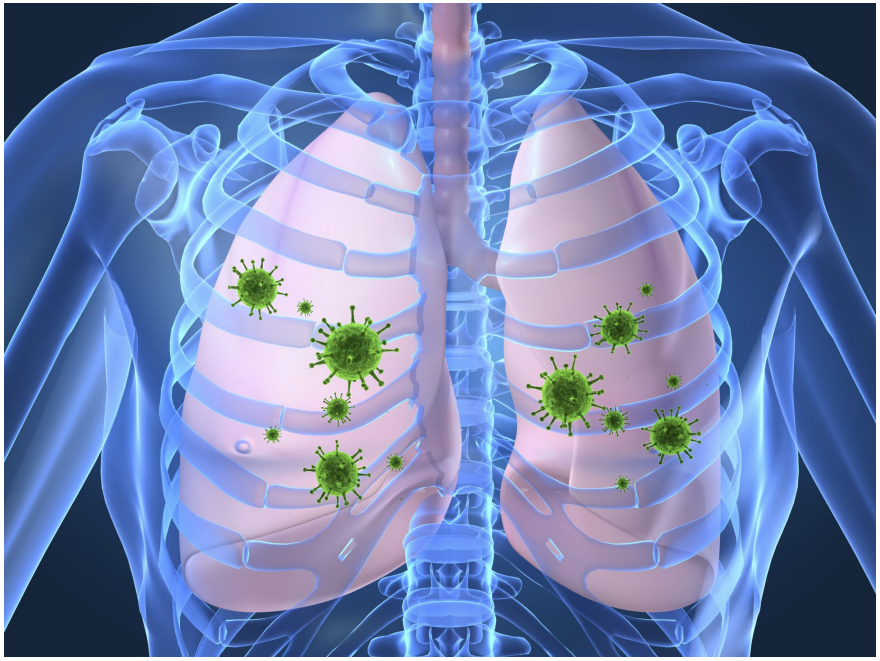
- Hyperoxia OR 9.1 (95 CI 4.08 – 20.6) – SpO_2 > 96%
- Hypoxia OR 2.16 (95CI 1.11 – 4.20) – SpO_2 < 88%

Austin MA, Wills KE, Blizzard L, Walters EH, Wood-Baker R. Effect of high flow oxygen on mortality in chronic obstructive pulmonary disease patients in prehospital setting: randomised controlled trial. Brit Med J 2010, 341:c5462.

Cameron L, Pilcher J, Weatherall M, Beasley R, Perrin K. The risk of serious adverse outcomes associated with hypoxaemia and hyperoxaemia in acute exacerbations of COPD. Postgrad Med J 2012, 88(1046): 684-689.

Pneumonia

- SpO2 < 92% associated with greater mortality/morbidity at 30 days



Majumdar SR, Eurich DT, Gamble JM, Senthilselvan A, Marrie TJ. Oxygen saturations less than 92% are associated with major adverse events in outpatients with pneumonia: a population-based cohort. Clin Infect Dis 2011, 52(3):325-331.

Asthma

- High inspired oxygen leads to hypercapnia
- Should be provided only in the face of hypoxia

Perrin K, Wijesinghe M, Healy B, Wadsworth K, Bowditch R, Bibby S, et al. Randomised controlled trial of high concentration versus titrated oxygen therapy in severe exacerbations of asthma. Thorax 2011, 66(11): 937-941.

Stroke

Oxygen and Cerebral Blood Flow

- Healthy volunteers
- Administration of 100% oxygen for 10 to 15 minutes
  - 20% to 33% decrease in cerebral blood flow
  - Independent of arterial partial pressure of carbon dioxide

Watson NA, Beards SC, Altaf N, Kassner A, Jackson A. The effects of hyperoxia on cerebral blood flow: a study in healthy volunteers using magnetic resonance phase-contrast angiography. Eur J Anaesthesiol 2000, 17:152-159

Floyd TF, Clark JM, Gelfand R, Detre JA, Ratcliffe S, Guvako D, Lambertsen CJ, Eckenhoff RG. Independent cerebral vasoconstrictive effects of hyperoxia and accompanying arterial hypocpania at 1 ATA. J Appl Physiol 2003, 95:2453-2461.

Oxygen and Stroke Outcomes

- No benefit in clinical performance scores or outcome
- Lower survival at 1 year in non-hypoxic patients with mild to moderate strokes
  - OR 0.45 (95% CI 0.23-0.90) if supplemental oxygen administered
  - Nasal cannula for first 24 hours versus room air
- Severe strokes and consequent hypoxemia trend towards increased mortality.

Padma MV, Bhasin A, Bhatia R, Garg A, Singh MB, Tripathi M, Prasad K. Normobaric oxygen therapy in acute ischemic stroke: a pilot study in Indian patients. *Ann Indian Acad Neurol* 2010, 13:284-288.

Ronning OM, Guldvog B: Should stroke victims routinely receive supplemental oxygen? A quasi-randomized controlled trial. *Stroke* 1999, 30:2033-2037.

CPR

Hyperoxia and Outcomes

- Hyperoxia independently associated with higher mortality than normoxia
  - OR 1.8 (95% CI 1.5 – 2.2)
- PaO_2 increase if 25 mm is associated with a 6% increase in the RR if death
- PaO_2 increase of 100 mm is associated with a 24% increase in RR of death

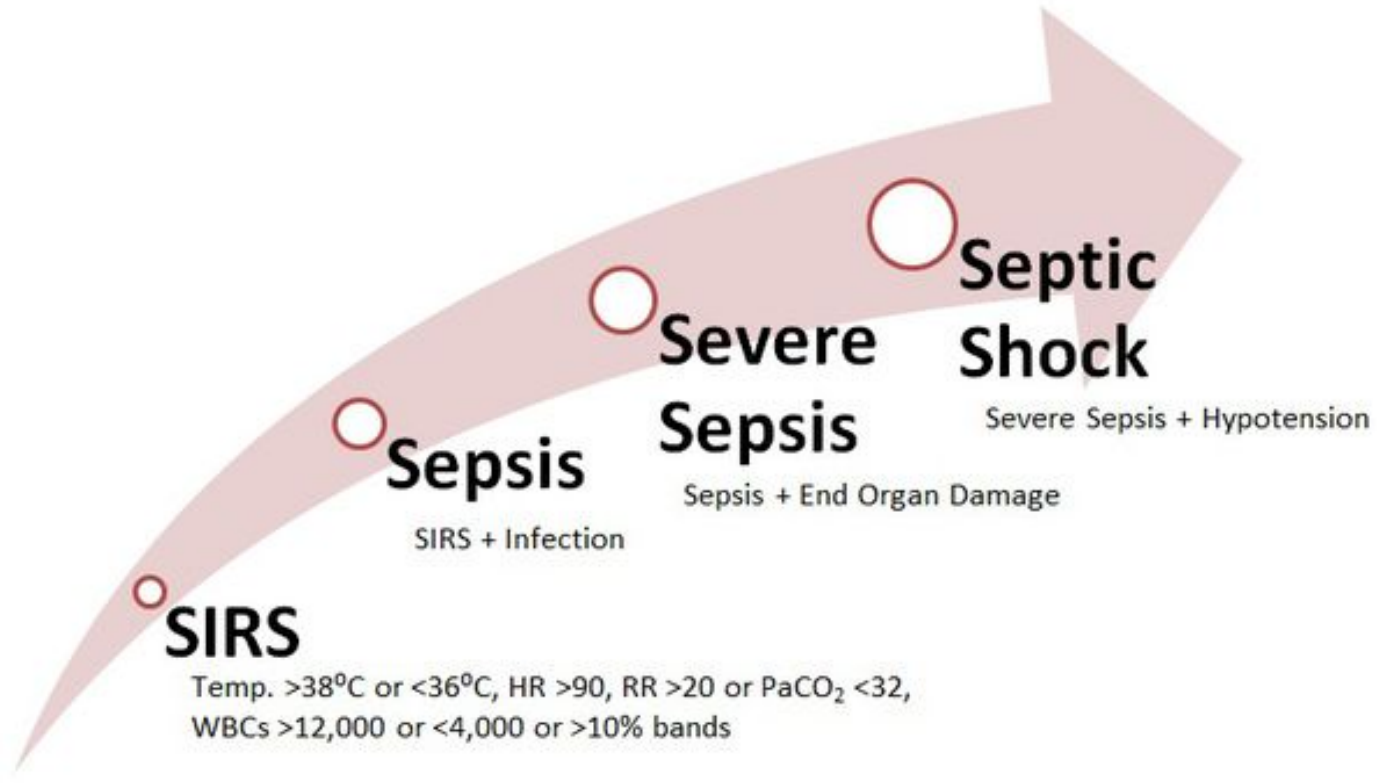
Kilgannon JH, Jones AE, Shapiro NI, Angelos MG, Milcarek B, Hunter K, Parillo JE, Trzeciak S. Emergency Medicine Shock Research Network (EMShockNet) Investigators. Association between arterial hyperoxia following resuscitation from cardiac arrest and in-hospital mortality. *JAMA* 2010, 303:2165-2171.

Kilgannon JH, Jones AE, Parillo JE, Dellinger RP, Milcared B, Hunter K, Shapiro NI, Trzeciak S. Emergency Medicine Shock Research Network (EMShockNet) Investigators. Relationship between supranormal oxygen tension and outcome resuscitation from cardiac arrest. *Circulation* 2011, 123:2717-2722.

Bellomo R, Bailey M, Eastwood GM, Nichol A, Pilcher D, Hart GK, Reade MC, Egi M, Cooper JD. Study of Oxygen in Criticial Care (SOCC) Group. Arterial hyperoxia and in-hospital mortality after resuscitation from cardiac arrest. *Crit Care* 2011, 15:R90.

Medical Illnesses and Oxygen

Sepsis


SIRS
Temp. >38°C or <36°C, HR >90, RR >20 or PaCO2 <32,
WBCs >12,000 or <4,000 or >10% bands
Sepsis
SIRS + Infection
Severe Sepsis
Sepsis + End Organ Damage
Septic Shock
Severe Sepsis + Hypotension

Hyperoxia and Sepsis

- Hyperoxia may impair oxygen deliver in sepsis
- Hyperoxia decreases whole-body oxygen consumption in critically ill patients
- Surviving Sepsis Campaign Guidelines
  - Peripheral oxygen saturation should be maintained between 88% and 95% in patients with ARDS (Does not advocate hyperoxia)

Rossi P, Tauzin L, Weiss M, Rostain JC, Sainty JM, Boussuges A. Could hyperoxic ventilation impair oxygen delivery in septic patients? *Clin Physio Funct Imaging* 2007, 27:180-184.

Reinhart K, Bloos F, Konig F, Bredle D, Hanneman L. Reversible decrease of oxygen consumption by hyperoxia. *Chest* 1991, 99:690-694.

Dellinger RP, Levy MM, Rhodes A, Annane D, Gerlach H, Opal SM, Sevransky JE, Sprung CL, Douglas IS, Jaeschke R, Osborn TM, Nunally ME, Townsend SE, Reinhart K, Kleinpell RM, Angus DC, Deutschman CS, Machado FR, Rubenfeld GD, Webb S, Beale RJ, Vincent JL, Moreno R. Surviving Sepsis Campaign: International guidelines for management of severe sepsis and septic shock 2012. *Intensive Care Med* 2013, 39:165-228.

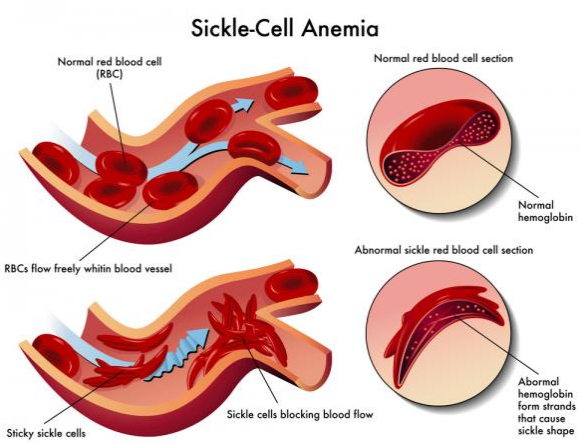
Sickle Cell Crisis

- Oxygen therapy
  - Has not been shown to affect the duration of pain crisis
  - Has not been shown to be useful in patients with acute chest syndrome with normoxemia
- Oxygen should be administered only if hypoxemia is present

Rees DC, Olujohungbe AD, Parker NE, Stephens AD, Telfer P, Wright J; British Committee for Standards in Haematology General Haematology Task Force by the Sickle Cell Working Party. Guidelines for the management of the acute painful crisis in sickle cell disease. Br J Haematol 2003;120(5): 744-752.

Zipursky A, Robieux IC, Brown EJ, Shaw D, O'Brodovich H, Kellner JD, et al. Oxygen therapy in sickle cell disease. Am J Pediatr Hematol Oncol 1992;14(2):222-228.

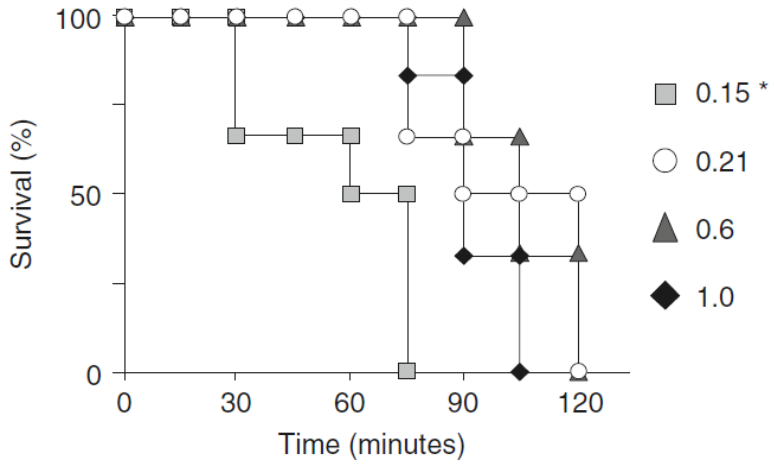
Schulman LL. Oxygen therapy in sickle-cell anemia [letter]. N Engl J Med 1984;311(20):1319-1320.



Hemorrhagic Shock

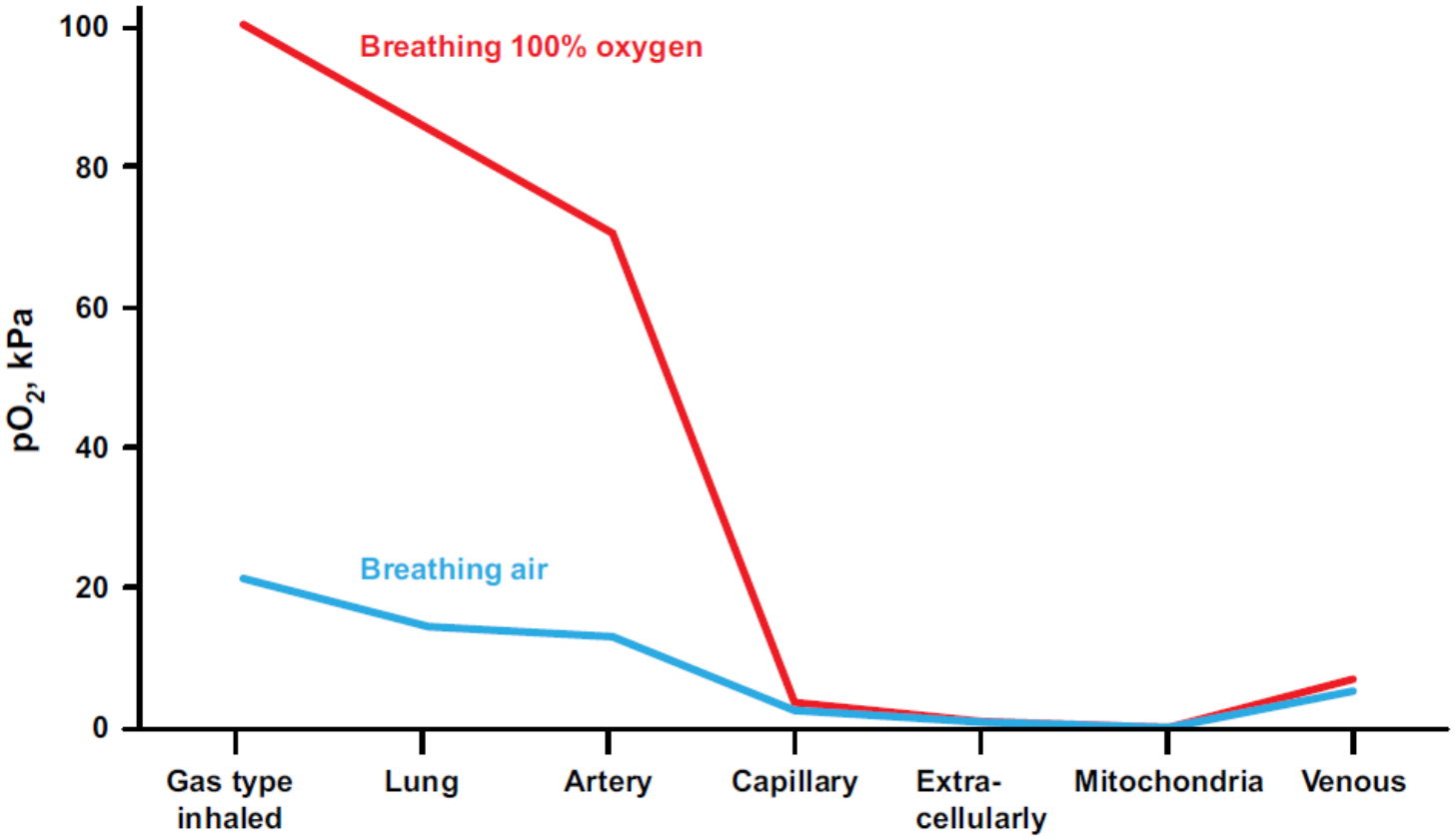
Affects of Increasing FiO_2

- Does not affect survival
- Compromises hemodynamics
  - Increased MAP
  - Decrease aortic blood flow



Dyson A, Stidwill R, Taylor V, Singer M. The impact of inspired oxygen concentration on tissue oxygenation during progressive haemorrhage. *Intensive Care Med* 2009, 35:1783-1791.

The Oxygen Cascade



In Summary

- MI – Avoid hyperoxemia
- CHF – Avoid hyperoxemia
- COPD – Avoid hyperoxemia (SpO_2 88% - 92%)
- Pneumonia – Avoid hypoxemia
- Asthma – Avoid hyperoxemia
- Stroke – Avoid hyperoxemia
- Severe stroke – Avoid hypoxemia
- CPR – Avoid hyperoxemia
- Septic Shock – Avoid hyperoxemia
- Sickle Cell Crisis – No help unless hypoxemia present
- Hemorrhagic Shock – Avoid hypoxemia and hyperoxemia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EMS

Thank You

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