Exceptional Blood Loss Anemia

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Exceptional Blood Loss Anemia

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Exceptional Blood Loss Anemia
Outline

1. Briefly review physiologic effects of EBL
2. Describe the mechanisms whereby HBO works
3. Outline an approach to HBO treatment of the patient with EBL

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Exceptional Blood Loss Anemia

- Why Acute Blood Loss Anemia?
  - There are some patient populations for which transfusion is not an option
  - No commercially available safe and effective RBC substitutes
  - No effective therapeutic options for symptomatic patients in the absence of transfusion
  - Hyperbaric oxygen is effective

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Definition of Terms

- Arterial O_2 Content (CaO_2) = Oxygen bound to Hgb + oxygen physically dissolved in blood.

  = (1.34ml O_2/gm Hgb/dl) x (Hgb gms/dl) x (SaO_2) +

  (0.0031ml O_2/mmHg O_2/dl) x (PaO_2)
- Venous O_2 Content (CvO_2) = as above substituting SvO_2 and PvO_2 respectively.
- A-V O_2 difference = CaO_2 - CvO_2

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Definition of Terms

DO_2(O_2 supply) = $CO(CaO_2)10$

DO_2 critical = O_2 supply = O_2 demand

VO_2 (O_2 consumption) = $CO(A\text{-}VO_2\ diff)10$

Cardiac Index(CI) = CO/BSA

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Normal Values

CaO_2	= 16-22	ml O_2/dl (vol%)
CvO_2	= 12-17	ml O_2/dl (vol%)
A-VO_2 difference	= 3.5-5.5	ml O_2/dl (vol%)
DO_2(O_2 supply)	= 700-1400	ml /min
VO_2(O_2 consumption)	= 180-280	ml /min
Cardiac Index(CI)	= 2.8-4.2	l/min/m^2
SvO_2	= 0.7 – 0.8	%
Lactate	= 0.5 – 2.0	mmol/l

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Physiological Effects of Acute Anemia

1. Decreased oxygen content of blood (CaO_2)
2. Decreased O_2 supply (DO_2)
3. Increased demand (VO_2)
4. Increased O_2 debt → acidosis

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Oxygen Debt

Time integral difference of VO_2 during/after shock and the baseline VO_2 requirement during the same time interval.

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Oxygen Debt

- Expressed in liters of oxygen per body surface area (liters O_2/m^2)
- Continues to accumulate as long as DO_2 is not adequate to meet metabolic demand
- A progressive cumulative oxygen dept can develop.

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Oxygen Debt and Clinical Outcome

1. > 33 L/m^2	Fatal
2. 26 – 32 L/m^2	Multi-organ failure
3. 10 – 21 L/m^2	Single organ failure
4. 9 L/m^2	Expected to survive

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- Dissolved oxygen becomes more important as hemoglobin levels decrease
- Nearly 50% of oxygen may be carried in solution as hemoglobin concentration falls below 2 gms/dl.
- You don't need hemoglobin to survive

Boerema I, et al. Life without blood *J Cardiovasc Surg.* 1960; 182: 133-146

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Effects of Hyperbaric Oxygen in Acute Anemia

1. Increases DO_2 reserve by increasing plasma PaO_2 and dissolved oxygen

   At ambient pressure:

   CaO_2 = 20 cc/dl, CvO_2 = 15 cc/dl

   A-VO_2 difference = 5 cc/dl

   At 3 ATA oxygen

   $PaO_2 \cong$ 2000mmHg, *plasma* O_2 content ≅ 6cc/dl

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Effects of Hyperbaric Oxygen in Acute Anemia

2. Increased RBC elasticity with improved flow through the microcirculation[1]
3. Protects against oxygen free radicals during reperfusion[2,3]
4. Attenuates cytokine induction[4]

1. Mathieu D. et al., (1984) Proceedings of the Eighth International Congress on Hyperbaric Medicine, Long Beach, California, pp 27-28.
2. Nylander G. et. al., *Plastic and Reconstructive Surgery*, 1985;76:596-601
3. Thomas, MP et. al., *American Heart Journal*, 1991; 120:791-800
4. Masatomo, Y and Mamoru, Y, *American J. Endocrinol Metab.* 278: E811-E816, 2000

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Case Review

38 y/o G3P2 J Witness with placental abruption at 39 weeks gestation. In the OR…..patient's Hgb 7.4

Rx: C-section, hysterectomy, syntocinon IV, carboprost

Total blood loss was approximately 3 liters….

IVF 10 L colloid/crystalloid → Hgb…4.2 → 3.

Hyperbaric Oxygen Therapy in the Management of Severe Acute Anemia in a Jehovah's Witness McLaughlin, PL et al. *Anesthesia* 1999, 54; 891-893.

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Case Review continued…

Day1 - coagulopathy…Rx with tranexamic acid/vit K

Day 2 - pH 7.17, EKG changes

swan/IV inotropes/EPO

Day3 - no change pH, EKG changes persistent abdominal pain….HBO was started

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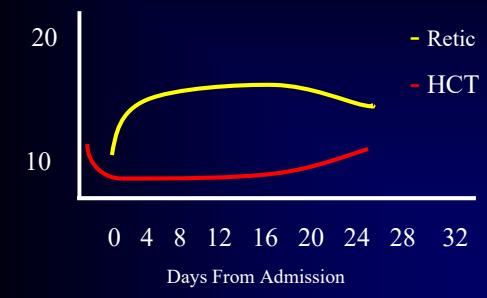
Hgb and Reticulocyte Responses



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- Hyperbaric Medicine Consultation should involve the following:
  1. Initial evaluation
  2. Invasive Monitoring (DO_2 & VO_2)
  3. Determination of utility and timing of HBO
  4. Avoidance of Pulmonary Toxicity

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Case Presentation

74 y/o with posterior epistaxis and Hx of ischemic cardiomyopathy and autoimmune hemolytic anemia. Initial evaluation reveals the following:

Hgb 10	→ Hgb 6.4 g/dl
Retic count	1.0
Chemistries	HCO_3 19, BUN 25, creat 1.5
UA	sp. grav. 1.030
ABG	ph 7.33/44/65
EKG	nonspecific changes

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Case Presentation

Invasive monitoring / laboratory findings

DO_2	= 750 ml/min
VO_2	= 240 ml/min
CI	= 3.1 L/min/m^2
SvO_2	= 69%
lactate	= 1.8 mmol/L

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Case Presentation

repeat evaluation 10 hours later…

DO_2	= 450 ml/min/m^2
VO_2	= 100 ml/min/m^2
CI	= 2.8 L/min/m^2
SvO_2	= 51 %
lactate	= 2.4 mmol/L

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Goal of HBO

Dissolve enough oxygen in the plasma to support basic metabolic needs until an effective circulating volume of red cells is sufficient to meet metabolic oxygen demands

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Guidelines

- *O_2 debt can't be paid with conventional treatment*
- $DO_2 \leq 600cc/min/m^2$, $VO_2 \leq 170cc/min/m^2$
- MAP < 60 or vasopressors are needed
- Clinical evidence of end organ ischemia

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Treatment Protocol

- Initial treatments of 2 -3 ATA
- Duration of treatment dependent upon clinical circumstances.
- Repeat treatments q 4-6 hours as dictated by hemodynamic status

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Additional Considerations

1. Avoid further blood loss
   a) Cell savers
   b) Surgery
   c) Pharmaceutical hemostasis (vasopressin, pitocin)
   d) Treat coagulaopthy
   e) Minimize phlebotomy

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Additional Considerations

2. Stimulate marrow production
   a) Erythropoietin - 150 - 200 U/kg 3x/wk
   b) Vit. B_{12} - 1 mg IM qd
   c) Folate - 10 mg IV qd
   d) Iron dextran - 100 mg IV qd

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Additional Considerations

3. Decrease metabolic oxygen demand
   a) sedation
   b) paralysis
   c) control fever
   d) ? hypothermia
   e) ? induced hypotension

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Additional Considerations

4. Avoidance of Pulmonary Toxicity
   a) Air breaks during HBO
   b) Decrease FIO_2 between HBOT if possible
   c) Addition of PEEP to avoid absorption atelectasis
   d) Administer Antioxidants
- Vitamin E
- Selenium
- Zinc
- Copper
- Manganese

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Adjunctive Hyperbaric Oxygen Therapy

What is the Evidence?

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- Medline Search:
  - Acute anemia and hyperbaric oxygen yielded 41 citations
  - Animal studies >> human studies
  - Animal studies - RCT
  - Human studies - case reports/series

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American Heart Association
Evidence Based Medicine Category
IIb
acceptable and useful

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Endpoints of Hyperbaric Oxygen

- $DO_2 \geq 600$ cc/min/m^2
- $VO_2 \geq 170$cc/min/m^2
- Resolution of acidosis
- No signs or symptoms of end organ ischemia
- Hgb ≥ 6gms/dl and patient is asymptomatic

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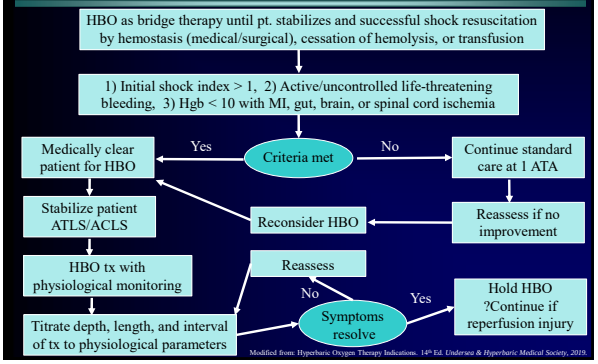
…Treatment Flowchart



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Summary

- HBO is a valuable adjunctive therapy in exceptional blood loss for those who cannot receive blood replacement.
- HBO should be utilized as part of a multidisciplinary approach to the severely anemic patient.
- HBO dosing should be guided by hemodynamic and clinical measures and initiated prior to accumulation of excessive oxygen debt.

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