Hyperbaric In Wound Healing

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Outline

1. Wound Healing
2. Role of Oxygen in Wound Healing
3. History
4. Definition
5. What is hyperbaric Medicine
6. Treatment Profile
7. Mechanism
8. Indications & Contraindications
9. Successful Cases
Wound Healing

- Complex interaction of multiple factors
- Microenvironment of early wound is depleted of O2 (vascular disruption and high O2 consumption by metabolically active cells)
- Temporary hypoxia stimulates wound-healing process (induce cytokine & growth factor production)
- Metabolic and oxygen demands ↑ during the inflammatory & proliferation
- Normal tissue O2 tensions (transcutaneously): 30-50 mmHg
- Chronic wounds: 5-20 mmHg
- Tissue O2 tensions above 30mmHg are needed for collagen synthesis
## Locals & Systemic Factors Affecting Wound Healing

<table>
<thead>
<tr>
<th>Locals</th>
<th>Systemic</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Ischemia/hypoxia</td>
<td>1. Age &amp; gender</td>
</tr>
<tr>
<td>2. Tissue non viable</td>
<td>2. Stress</td>
</tr>
<tr>
<td>3. Bioburden</td>
<td>3. Ischemia/hypoxia</td>
</tr>
<tr>
<td>4. Exudate</td>
<td>4. Diseases</td>
</tr>
<tr>
<td>5. Foreign body</td>
<td>5. Obesity</td>
</tr>
<tr>
<td>6. Edema, elevated tissue pressure</td>
<td>6. Medication</td>
</tr>
<tr>
<td></td>
<td>7. Alcoholism &amp; smoking</td>
</tr>
<tr>
<td></td>
<td>8. Radiation &amp; Chemo Therapy</td>
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<td>9. Nutrition</td>
</tr>
</tbody>
</table>
Chronic Hypoxic Wounds

- Can be due to local or systematic ischaemia
- Several systemic conditions (advancing age & diabetes), can create impaired vascular flow
- Transcutaneous oxygen measurement (ptcO2) < 30 mmHg (non-diabetic), < 40 mmHg (diabetics) persists > 3 months
- Commonest presentation is trauma in the patient with microvascular compromise (DM)

Factors Determining Tissue Oxygen Delivery

1. Saturation of the haemoglobin with O2
2. Haemoglobin concentration
3. Cardiac output
The Role of Oxygen in Wound Healing

1. Increases cell metabolism and energy production
2. Increases rate of cell proliferation and reepithelialization
3. Increases collagen synthesis and tensile strength
4. Increases anti-bacterial activities
5. Increases angiogenesis and promotes revascularization
6. Promotes growth factor signaling transduction
History

1921 – Dr Cunningham used hyperbaric air to treat syphilis, hypertension, DM & CA
1928 – Cunningham Chamber, the largest chamber in the world
1937 – Cunningham Chamber was dismantled, end of the era of hyperbaric air therapy
1956 – Dr Boerema performed first cardiac surgery in a hyperbaric chamber
1961 – Dr Boerema and Brummelkamp used hyperbaric O2 to treat gas gangrene
1963 – First International Congress on Hyperbaric Medicine in Amsterdam
1965 – Whipps Cross Hospital, London Hyperbaric Unit opened
Definition

Hyperbaric
• exposure to pressures greater than 1 atmosphere absolute (ATA)

Hyperbaric Oxygen
• delivery of oxygen at pressures greater than 1 ATA

ATA – atmosphere absolute
• pressure exerted by the weight of air in the atmosphere of earth

1ATA = 760mmHg = 101.3kPa
What is Hyperbaric Medicine?

1. It is the delivery of gases (100 oxygen%) at greater than 1 ATA pressure
2. O2 is administered inside a pressure vessel
3. Requires:
   - an oxygen source
   - a pressure chamber

It is not:
1. Breathing 100% oxygen at normobaric pressure
2. Topical application of hyperbaric oxygen to a limb
Hyperbaric Chambers

1. Multiplace
   - Accommodate several people
   - Compress on air
   - Staff present inside chamber

2. Monoplace
   - One person
   - Compress with oxygen
HBO Treatment Profile

1. Compression of the chamber to 2.0 – 2.8 atmospheres over 5 minutes

2. Breathe oxygen for 60 - 90 minutes

3. Decompress to 1 atmosphere over 15 – 30 minutes

4. Number of treatments: 20 – 30 sessions
How HBOT Works

Hyperoxygenation of tissues
• air pressure is increased to 3 times higher than normal air pressure
• increased oxygen diffusion as a gas gradient occurs between hyperoxygenated blood and tissue, especially hypoxic tissue
• increased oxygen to oedematous tissues
• continue to affect the wound even after treatment has stopped

Diagram showing increased radius of oxygenation around blood vessel
Haldane Perfusion Model

• Different tissues on-gas and off-gas at different speeds
• Fast tissue (muscle) have high perfusion and slow gas solubility – take on gas & release gas quickly
• Slow tissue (cartilage is lipid rich & no blood supply) have poor perfusion and high solubility - longer to take on gas & longer to release gas
# Tissue PO2 Values

<table>
<thead>
<tr>
<th>ATAs</th>
<th>PO2 values</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Air</strong></td>
<td>1.0 Air</td>
</tr>
<tr>
<td>Air</td>
<td>159</td>
</tr>
<tr>
<td>Alveolar</td>
<td>104</td>
</tr>
<tr>
<td>Arterial</td>
<td>100</td>
</tr>
<tr>
<td>Venous</td>
<td>36</td>
</tr>
<tr>
<td>Muscle</td>
<td>29</td>
</tr>
<tr>
<td>Subcutaneous</td>
<td>40</td>
</tr>
<tr>
<td>Chronic Wound</td>
<td>15</td>
</tr>
<tr>
<td>Chest tcpO2</td>
<td>67</td>
</tr>
<tr>
<td>Foot tcpO2</td>
<td>63</td>
</tr>
</tbody>
</table>

Adapted from Sheffield PJ. Measuring tissue oxygen tension: a review. Undersea Hyperb Ned 1998; 25: 179-88
## Indications
ANZHMG (2010)

<table>
<thead>
<tr>
<th>Broad Indication</th>
<th>Specific Indication</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Bubble Injury</td>
<td>Decompression, Arterial Gas Embolism</td>
</tr>
<tr>
<td>2. Acute Ischaemic Conditions</td>
<td>Compromised Flaps/Grafts, Crush Injury/Compartment Syndrome, Reperfusion Injuries, Idiopathic Sudden Sensorineural Hearing Loss, Avascular Necrosis</td>
</tr>
<tr>
<td>3. Infective Conditions</td>
<td>Necrotising Infection, Refractory Osteomyelitis, Malignant Otitis Externa, Intracranial Abscess</td>
</tr>
<tr>
<td>5. Problem Wounds</td>
<td>Chronic Ischaemic, Non Diabetic Wounds, Diabetic Ulcer/Gangrene</td>
</tr>
<tr>
<td>6. Toxic Gas Poisoning</td>
<td>Carbon Monoxide Poisoning</td>
</tr>
<tr>
<td>7. Ocular Ischaemic Injury</td>
<td>Cystoid Macular Oedema, Retina Artery/Vein Occlusion</td>
</tr>
<tr>
<td>8. Miscellaneous</td>
<td>Thermal Burns, Bell Palsy, Frostbite</td>
</tr>
<tr>
<td>9. Adjuvant to radiotherapy</td>
<td>Adjunct to radiotherapy in treatment some solid tumours</td>
</tr>
</tbody>
</table>
Indications

Medicare (2010)

1. Soft tissue radionecrosis
2. Chronic or recurring hypoxic wounds
3. Decompression illness
4. Gas gangrene
5. Air or gas embolism
6. Diabetic wounds (Diabetic Gangrene, DFU)
7. Necrotising soft tissue infections (Necrotising Fasciitis)
8. Prevention & Treatment of Osteoradionecrosis
Contraindications

1. Respiratory tract infection
2. Chronic sinusitis
3. Ear disease or surgery
4. Post surgery (air filled cavities)
5. History of spontaneous pneumothrax
6. History of thoracic surgery
7. Claustrophobia & anxiety
8. Chemotherapy agents: Doxorubicin. Bleomycin
Summary

• HBO is a relatively safe, validated therapy
• It does take time – 30-50 daily sessions
• It works best in tissues that are hypoxic to some degree
• Improved oxygenation
• Enhanced cell function (fibroblasts, angiogenesis)
• Angiogenesis means the benefits of HBO will carry over for several months
• Some indications are approved by Medicare and US FDA
• Contracts with private health insurers
Successful Case:
1. Perianal Abscess
Successful Case

2. Post BKA (PVD)
References

1. Hyperbaric Medicine: A Team Approach. hyperbarichealth 2010
Thank you ...