Disclaimer

Hyperbaric Medicine Unit
Fiona Stanley Hospital

Hyperbaric Oxygen Therapy

Dr Neil Banham
Director: Hyperbaric Medicine

What is Hyperbaric Oxygen Therapy (HBOT) ?

- HBOT is a medical treatment in which the patient is entirely enclosed in a pressure chamber breathing 100% oxygen (O_2) at greater than atmospheric pressure

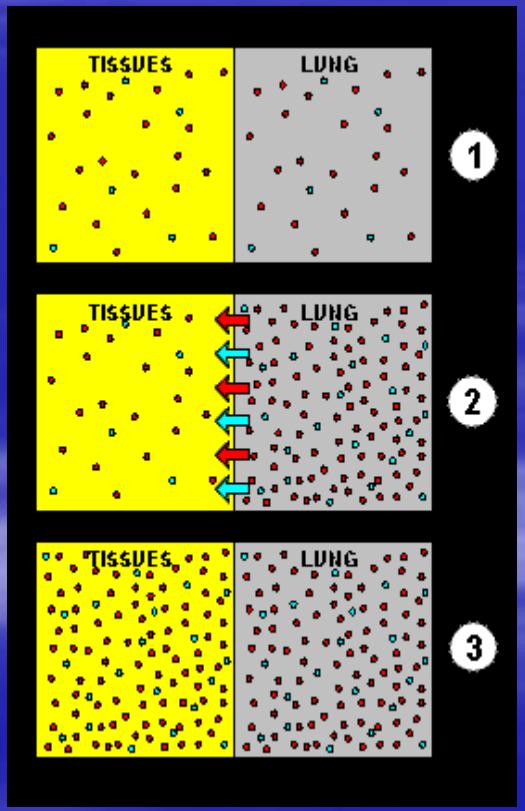
Mechanisms Of Action Of HBOT

- **Direct physical effects of oxygen and other gases under pressure**

- **Delayed secondary physiologic and biochemical effects that are set into motion with each hyperbaric treatment**

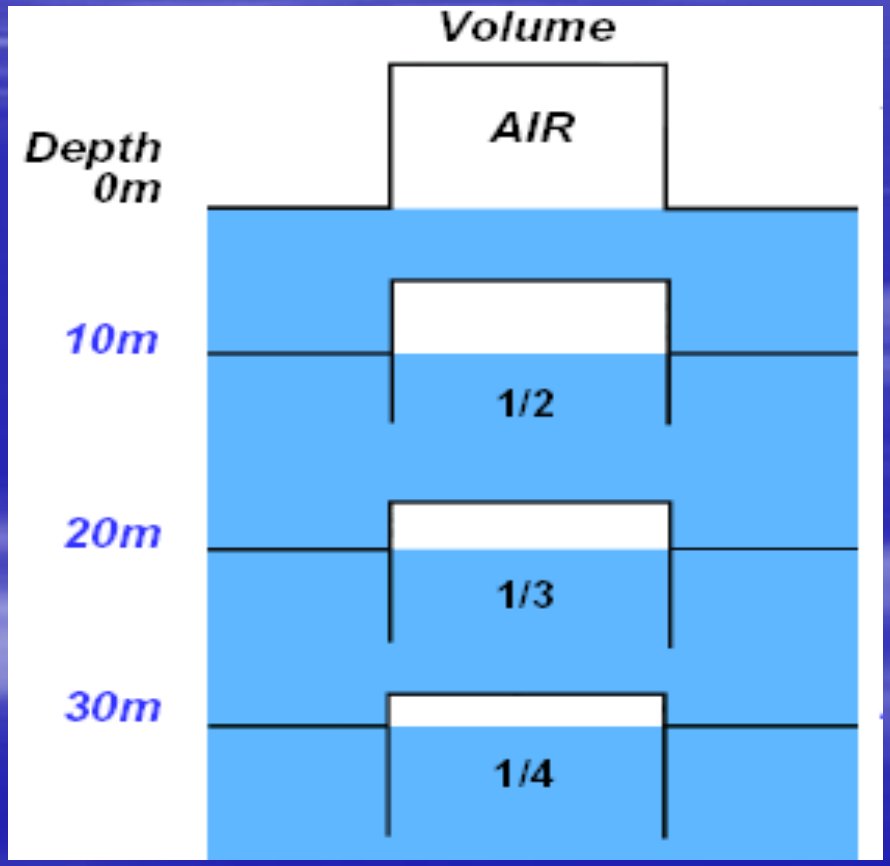
Hyper-oxygenation

- Henry's Law of Physics



"The greater the pressure, the larger the volume of gas dissolved"

Bubble Reduction -Boyle's Law -



"The greater the pressure – the greater the reduction in the volume of a gas"

Secondary Mechanisms

Include:

- **Enhancement of killing ability of leucocytes**
- **Increased fibroblast growth and collagen formation**
- **Increased capillary proliferation (VEGF)**
- **Reduction of tissue oedema**
- **Reduced inflammation (ICAM)**

Indications - Primary

- **Decompression Illness**

- **Air or Gas Embolism**

Other Indications: – Based on Evidence Based Practice

- Problem Wounds
- Delayed Radiation Tissue Injury
- Acute Ischaemic Flaps/Grafts
- Crush Injury
- Compartment Injury
- Anaerobic Infections –
  - Gas Gangrene, Fournier's Gangrene, Necrotising Fasciitis,
- Refractory Osteomyelitis
- Thermal burns
- Carbon Monoxide Poisoning

- Hyperbaric Oxygen 2003: Indications and Results - Hyperbaric Oxygen Therapy Committee Report (June 2009)

Department of Diving and Hyperbaric Medicine

Hyperbaric Chambers


EMERGENCY
EXIT
REBECCA
SECURIST

Fiona Stanley Hospital HMU – opened Nov 2014

Hyperbaric Chambers at
Royal Brisbane Hospital

Hyperbaric Chambers at
Townsville Hospital

Hyperbaric Chambers at
Prince of Wales Hospital Sydney


PREMA STRETCHER


FSH-HYPERBARIC UNIT
COMPARTMENT 1

Decompression Illness

- Estimated to be over 450,000 are active recreational divers in Australia

- Approximately 150 divers are treated in Australia annually for decompression illness

(30-40 treated in Western Australia per year)

How Does Hyperbaric Oxygen Work in DCI and CAGE / AGE ?

Reduction in bubble size

Enhance off-gassing by breathing 100% O_2

Decreased inflammation

Side Effects of HBOT

Include:

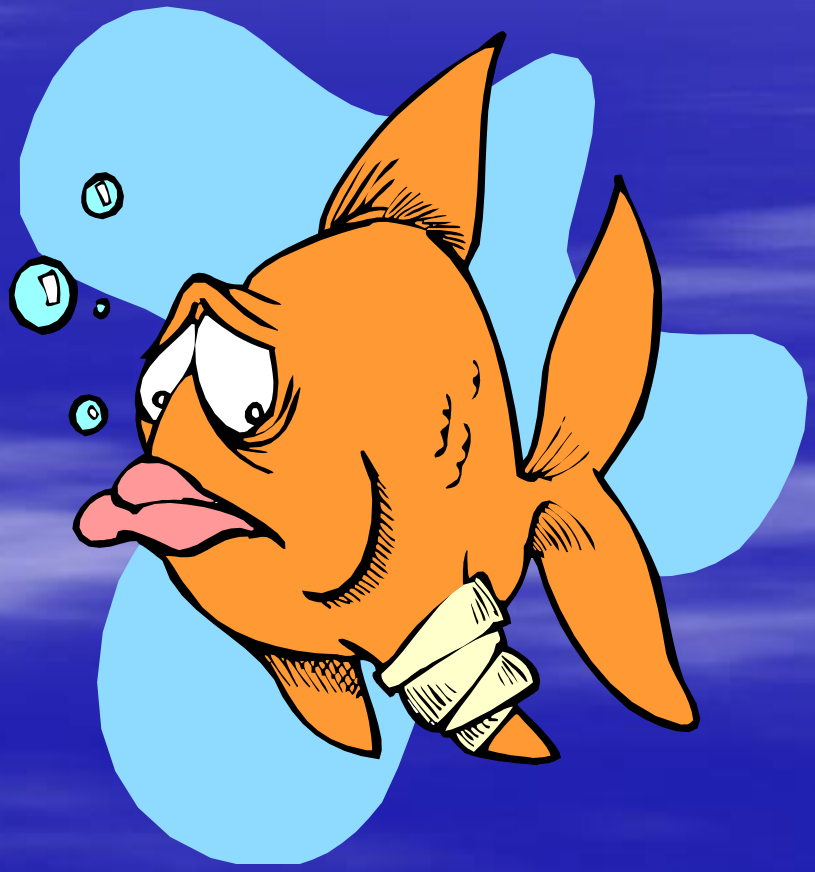
- **Barotrauma**
- **Diabetic patients may have hypoglycaemia during treatment**
- **Oxygen Toxicity –seizures ~ 1/1500-1/5000 HBOT**

Contra-indications

Include:

- **Claustrophobia**
- **Chronic sinusitis / middle ear disorders**
- **Some medications –esp prior Bleomycin**
- **Untreated pneumothorax**
- **Severe COPD with CO_2 retention/ bullae**

HBOT in Wound Healing



HBOT in Wound Healing

Rationale for Use of HBO in Wound Healing

In a hypoxic environment,
wound healing is halted by decreased:-

- –fibroblast proliferation
- –
  collagen production
- –capillary angiogenesis

Rationale for Use of HBO in Wound Healing

- Hypoxia also impairs the ability of oxygen-dependent macrophages to kill bacteria

- HBO restores the conditions under which the cellular processes of wound healing may occur at a normal pace and efficiency

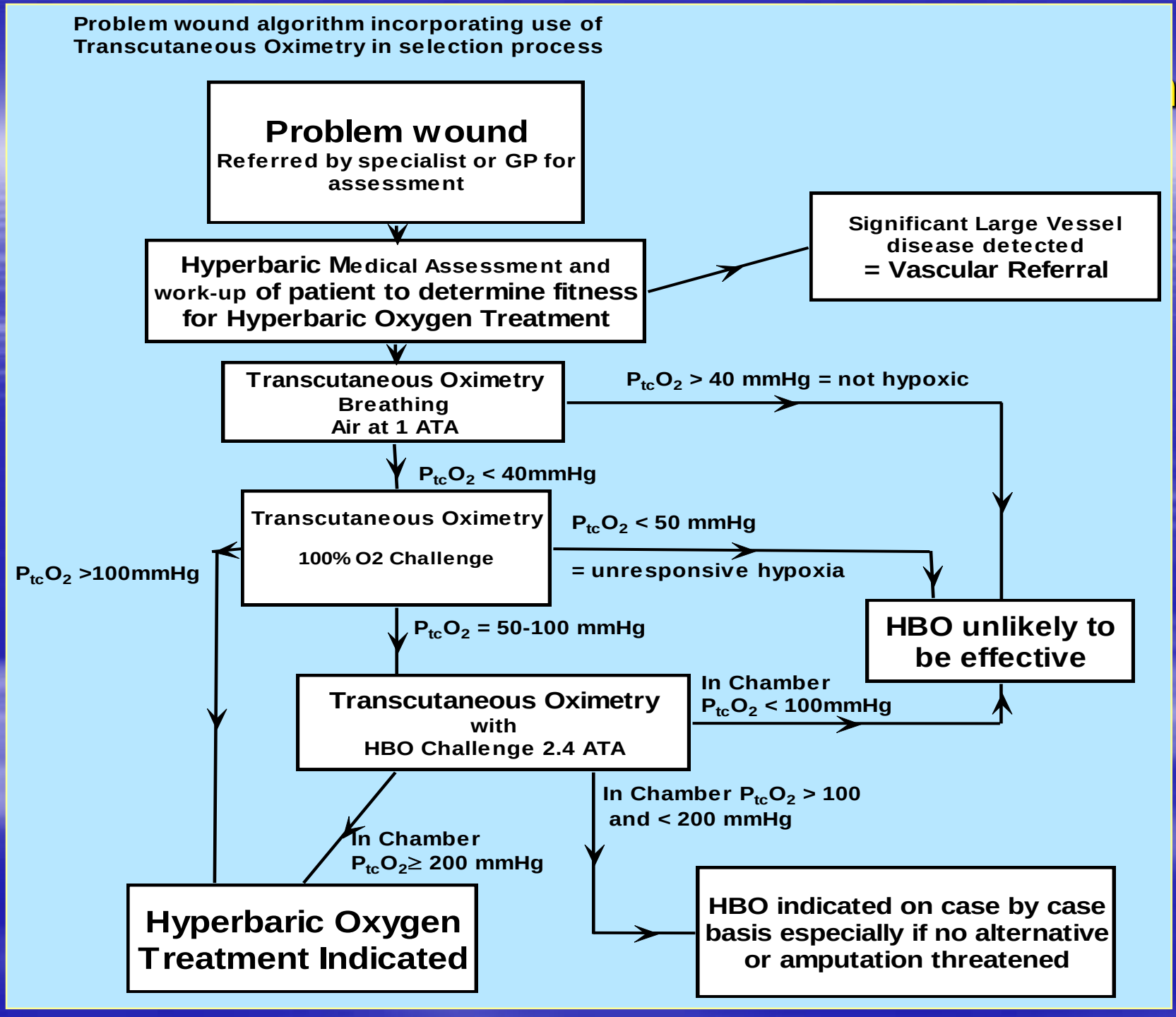
Rationale for Use of HBO in Wound Healing

- Tissue oxygen tension of 30mmHg is required for normal wound healing (Sheffield 1996)
- Exposure to oxygen at 2.5 ATA showed linear improvement of wound in the first 8 days (Meltzer & Meyer 1989)
- $TCPO_2$ of 20mmHg at 1ATA with a doubling on 100% 02 should have a positive response to HBO (Roth & Weiss 1994)

Transcutaneous Oxygen Measurement ($TCPO_2$)


2


TCM30
TCM30
TCM30
TCM30


Problem wound algorithm incorporating use of Transcutaneous Oximetry in selection process
Problem wound
Referred by specialist or GP for assessment
Hyperbaric Medical Assessment and work-up of patient to determine fitness for Hyperbaric Oxygen Treatment
Significant Large Vessel disease detected
= Vascular Referral
Transcutaneous Oximetry
Breathing
Air at 1 ATA
PtcO2 > 40 mmHg = not hypoxic
PtcO2 < 40mmHg
Transcutaneous Oximetry
100% O2 Challenge
PtcO2 < 50 mmHg
= unresponsive hypoxia
PtcO2 >100mmHg
PtcO2 = 50-100 mmHg
HBO unlikely to be effective
Transcutaneous Oximetry
with
HBO Challenge 2.4 ATA
In Chamber
PtcO2 < 100mmHg
In Chamber PtcO2 > 100 and < 200 mmHg
In Chamber
PtcO2≥ 200 mmHg
Hyperbaric Oxygen Treatment Indicated
HBO indicated on case by case basis especially if no alternative or amputation threatened

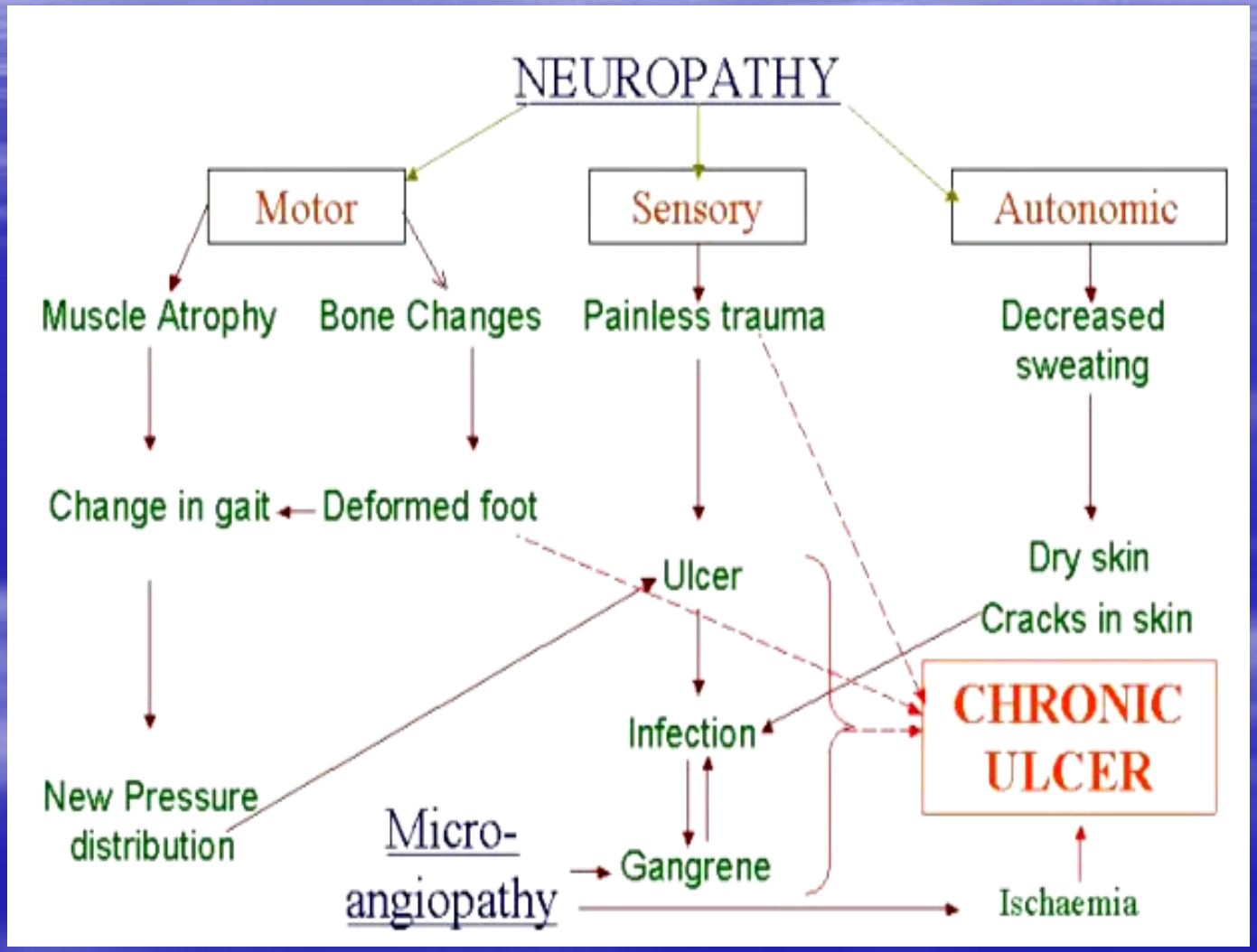
HBO and the Diabetic Wound

Diabetic Non-Healing Wounds

- Diabetic non-healing wounds are one of the major complications of diabetes
- Even if hyperglycaemia is controlled, the vascular pathology of diabetes often continues to progress
- Diabetics with foot ulcers are 2.4 times more likely to die early than diabetics without foot ulcers

(*Diabetes Care* 26:S25-S27, 2003)

The Diabetic Patient



Diabetic ulcers: controlled studies using amputation as the outcome measure

Authors	n	Design	Control
Baroni et al. 12%	28	Pr,C	40%
Diabetes Care 1987;10:81			
Oriani et al. 5%	80	Pr,C	33%
J Hyperbaric Med 1990;5:171			
Doctor et al. 12%	30	Ra,Pr,C	50%
J Postgrad Med 1992;38:112			
Faglia et al. 9%	111	Pr,C	33%
Diabetes Care 1996;19:1338			
Kalani et al. 12%	38	Ra,Pr,C	33%

J of Diabetes and Its Complications 2002;16:153-158

Hyperbaric oxygen therapy improves health-related quality of life in patients with diabetes and chronic foot ulcer.

M. Londahl, M. Landin-Olsson and P. Katzman
Institution for Clinical Sciences in Lund, Lund University, Lund, Sweden

Diabet. Med. 2011;28:186–190.

Londahl et al 2011

- Prospective RCT- double blind
- n=75
- 38 HBOT
- 37 Hyperbaric air (controls)

- 40 sessions for 85 minutes at 2.5 ATA

Results- Londahl 2011 RCT

- Ulcer healing at 1 year:
- HBOT 61% v Control 27% (p= 0.009)
- HBOT- improved measured QOL
- Control- static

Wound Photos


0 1 2 3 4 5 6 7 8 9 10


0 1 2 3 4 5 6 7 8 9 10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10


0
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1
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10

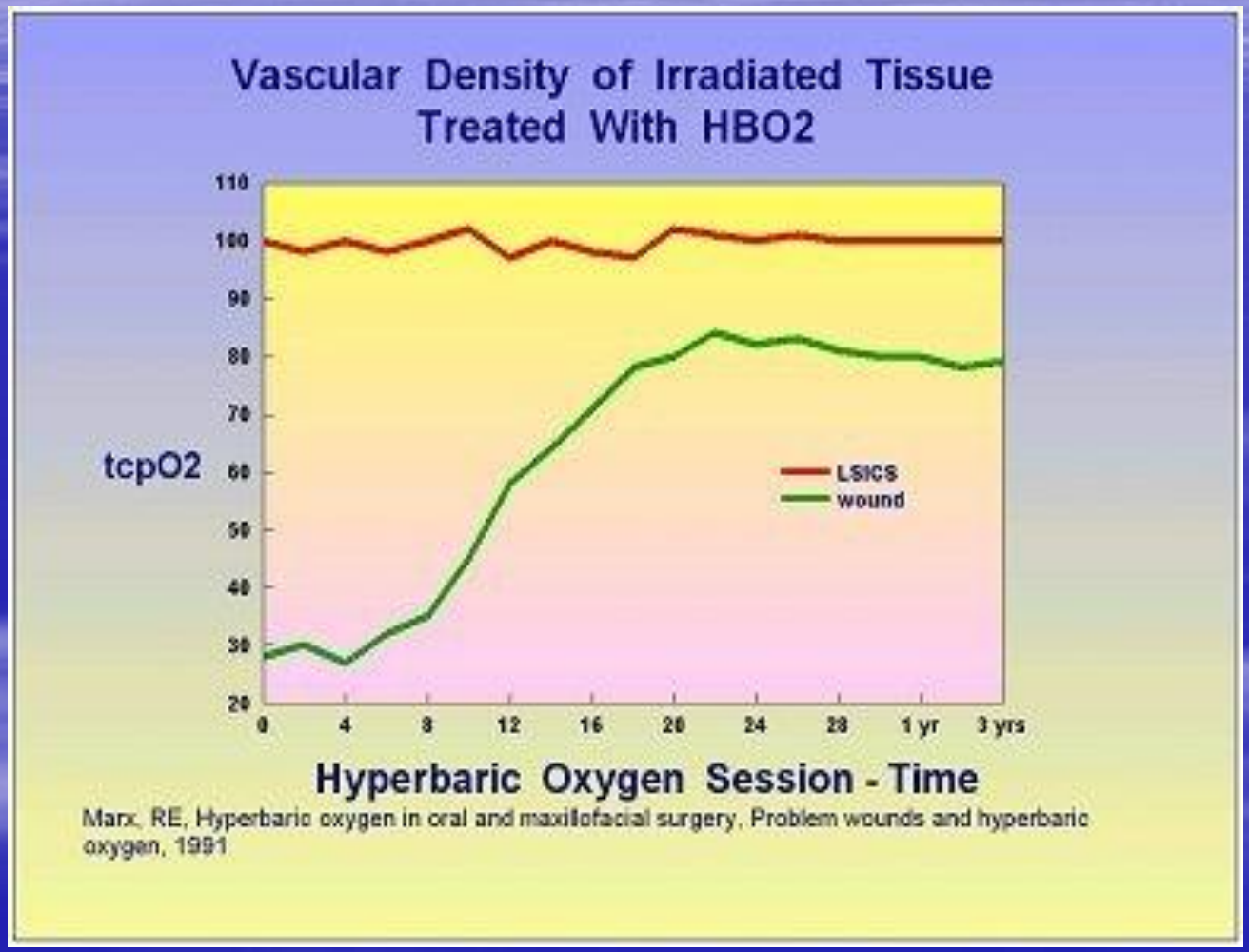
HBO and Soft Tissue Radio-necrosis

HBO and Radiation Necrosis

Marx et al 1983 - Three “H” Factors post radiotherapy:

- Hypoxia
- Hypo-cellular
- Hypo-vascular

HBO and Radiation Necrosis



Marx, RE, Hyperbaric oxygen in oral and maxillofacial surgery, Problem wounds and hyperbaric oxygen, 1991

HBOT and Delayed Radiation

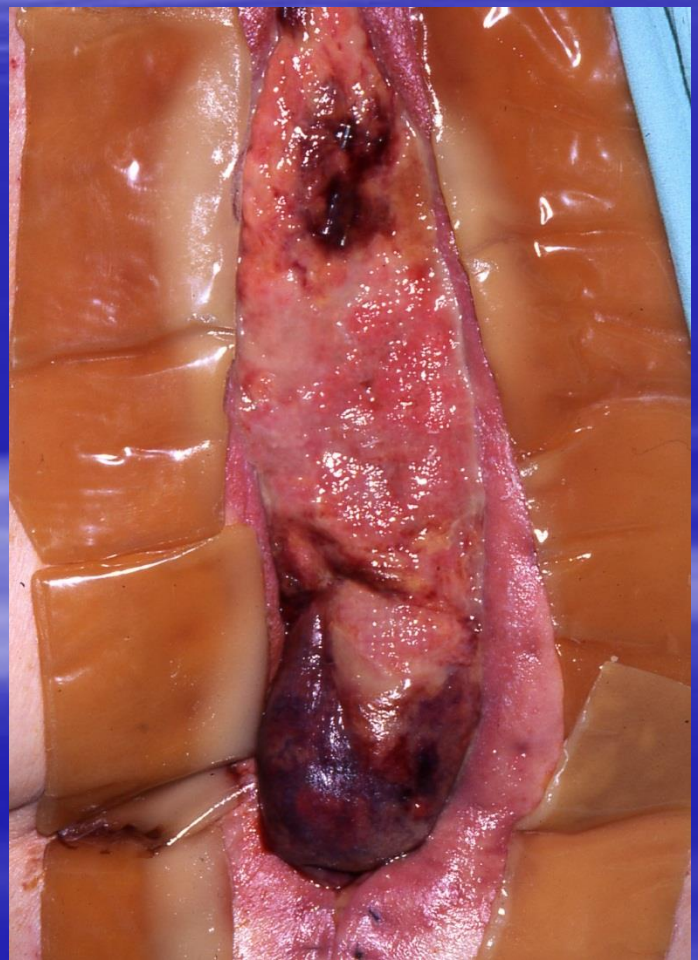
Radionecrosis – soft tissue

- Wound spontaneously broke down 20 years after DXRT for sarcoma. Present 9/12
- Wound healed after 30 HBO and wound care only

Failed flap (back) post DXRT for haemangioma

Failed SSG post excision Merkel tumour May 2012+ post op radiotherapy (diabetic smoker….)

HBOT and radiation necrosis- NHW post CABG- prior DXRT for breast cancer



HBO and Reperfusion Injury

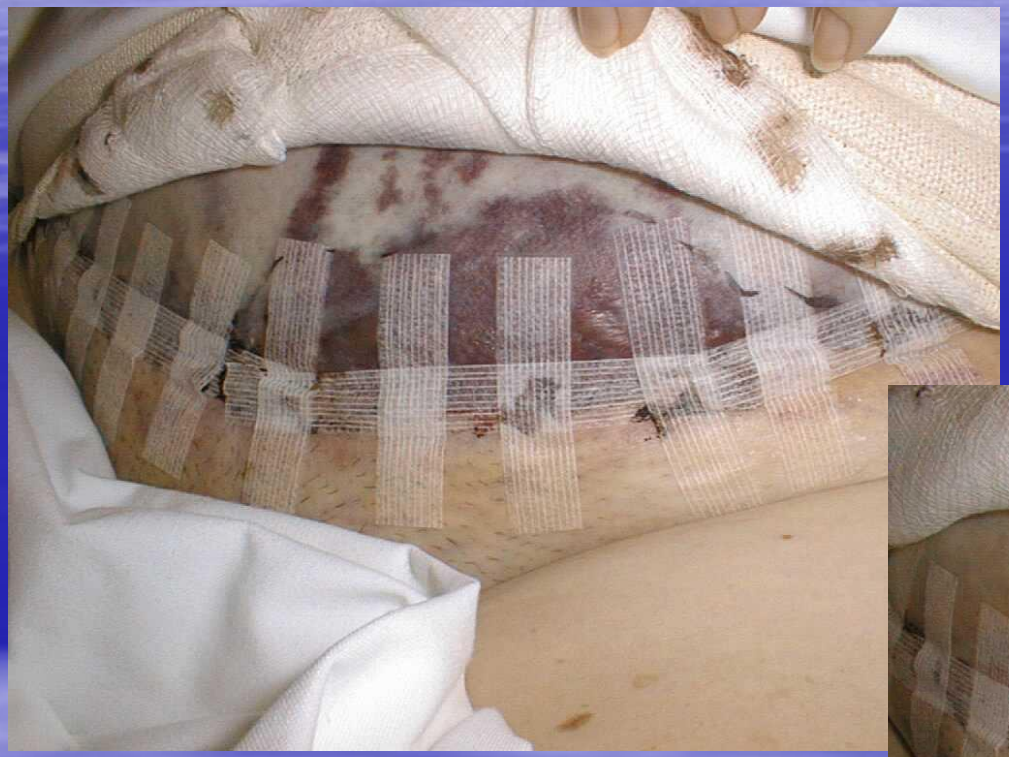
Reperfusion Injury

- Reperfusion can worsen traumatic crush injures and cause skin flaps and re-attachment procedures to fail

- HBOT inhibits the neutrophil adherence and post ischaemic vasoconstriction that has been implicated as primary causes of reperfusion injury

http://www.jacobi-hyperbaric.com/html/physicians-hyperbaric.html

35 y.o female post apronectomy



HBO and Necrotising Fasciitis

Necrotising Fasciitis

- **Necrotising Fasciitis is characterised by a progressive, rapidly spreading inflammatory process located in the deep fascia with secondary necrosis of the subcutaneous tissue and skin**

- **The cornerstone of management is radical surgery, with aggressive debridement of involved tissue down to and including the deep fascia. This must be combined with broad-spectrum antibiotic cover**

Necrotising Fasciitis

- As an adjunct to debridement and systemic antibiotics, HBO adversely affects anaerobic bacterial growth by direct toxic mechanisms and increases white cell bacterial killing

- The use of hyperbaric oxygen in these cases is secondary to other therapy, but it has a long history of successful treatment, reducing morbidity and mortality

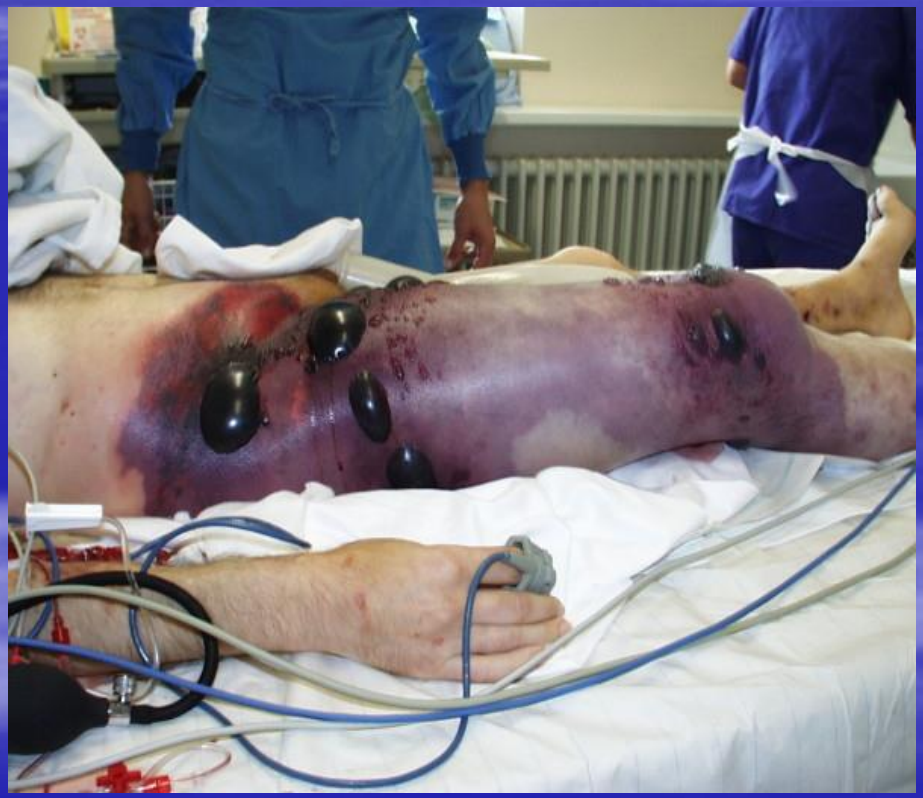
Necrotising Fasciitis

- HBO is most beneficial if utilised early in the disease, both before and after surgery
- These patients are usually critically ill and the difficulties of administering hyperbaric oxygen in these cases should not be underestimated

Necrotising Fasciitis

HBO and Gas Gangrene

Gas Gangrene



Gas Gangrene

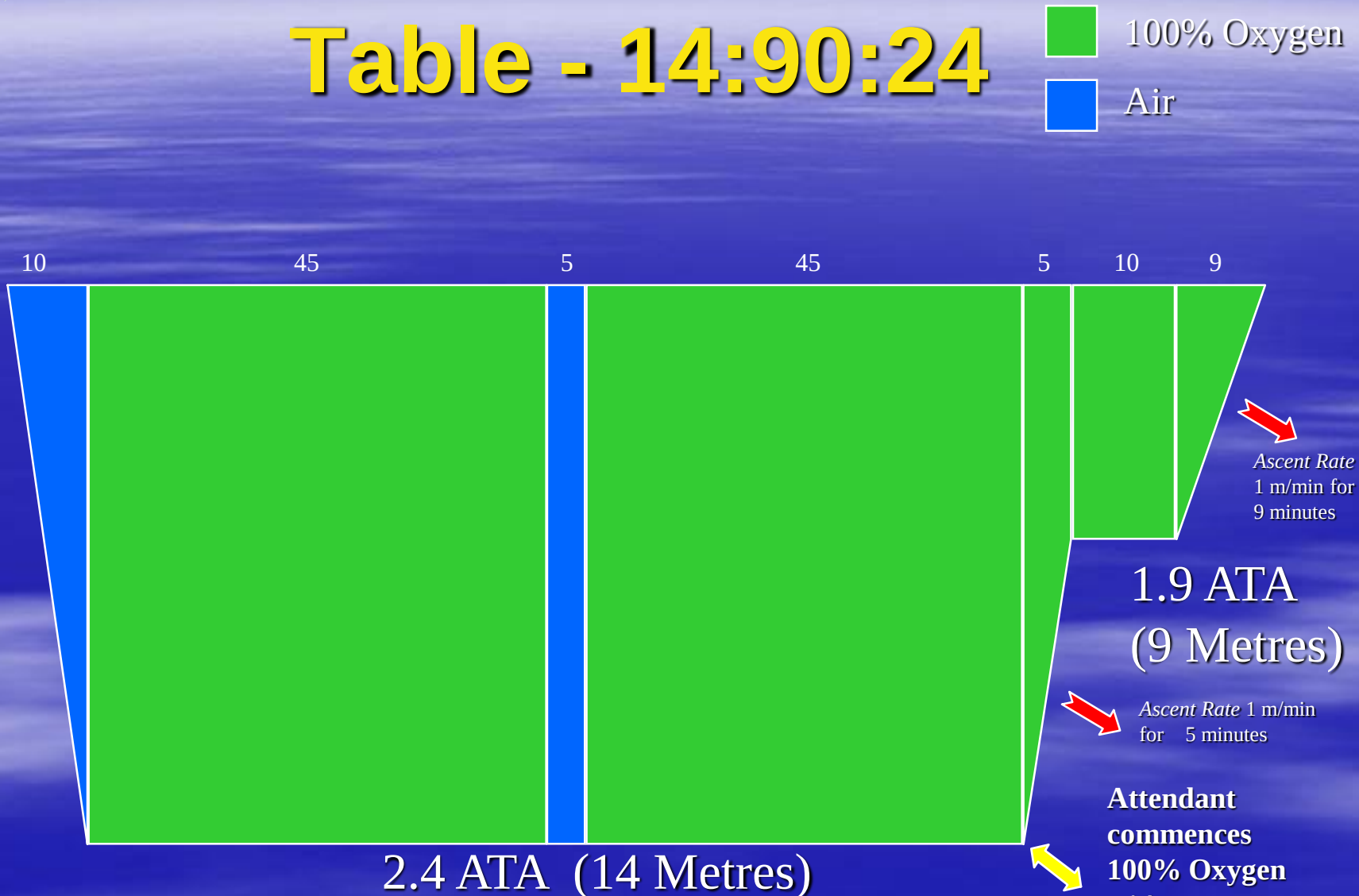
RATIONALE FOR HBO TREATMENT:

- **Clostridial bacteria are anaerobes, and as such high concentrations of oxygen are toxic to them**
- **They grow freely in oxygen tensions of up to 30mmHg and only restricted growth in tensions of up to 70mmHg**
- **When used early and before surgery, HBO can reduce morbidity as there is often less invasive surgery required and results in the rapid cessation of alpha-toxin production.**

Treatment Tables

FIONA STANLEY HOSPITAL

Table - 14:90:24



Total duration 129 mins

Patient Preparation for HBO

Patient Preparation for HBO

- Non-static clothing (we supply)
- No Watches Jewellery etc
- No gel/ointment containing petroleum products
- Enough medication to cover time away from ward

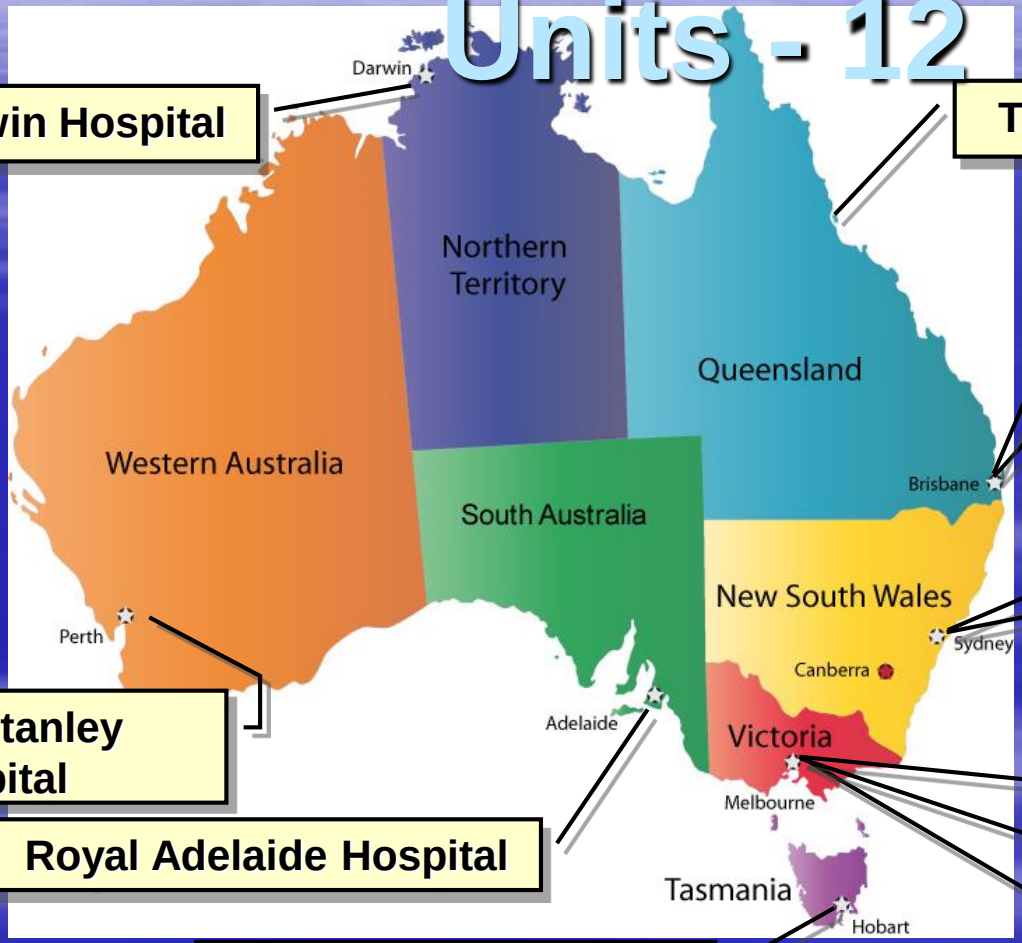
Equipment and HBO

Pressure changes can affect medical equipment so:-

- Only use equipment demonstrated safe for HBO
- Limited types of equipment are pressure safe- we use special pumps/ ventilators/ monitors

- Wound equipment e.g. Negative pressure not able to be compressed
- Most drains OK

Australian Clinical Hyperbaric Units - 12



- Royal Darwin Hospital
- Townsville General Hospital
- Wesley Hospital
- Royal Brisbane Hospital
- Mascot Sydney
- Prince of Wales Hospital
- Fiona Stanley Hospital
- Royal Adelaide Hospital
- Berwick Hospital
- Vaucluse Hospital
- Alfred Hospital
- Royal Hobart Hospital

Controversies

Conditions With Lack of Evidence Based Benefit of HBOT ...

- Sports Injuries
- Multiple Sclerosis
- Cerebral Palsy
- Chronic Fatigue Syndrome
- Lyme Disease –
  (symptoms similar to Chronic Fatigue Syndrome)
- Spinal Injury, Traumatic Brain Injury and Concussion
- Stroke
- Migraine
- Neuropathy
- Autism
- Anti-aging prophylactic
- Skin disorders such as eczema, psoriasis, Rosacea
- ADD/ADHD
- Senility / Alzheimer's Disease
- General wellness

Referral to FSH HMU:

- Phone –Via FSH Helpdesk: 6152 2222

OR

HMU direct: 6152 5222 (during hours)

OR

Fax HMU: 6152 4943

OR

FSH.Hyperbaric@health.wa.gov.au

Private Patients

- No out of pocket expense to patients
- Get free parking!

Summary

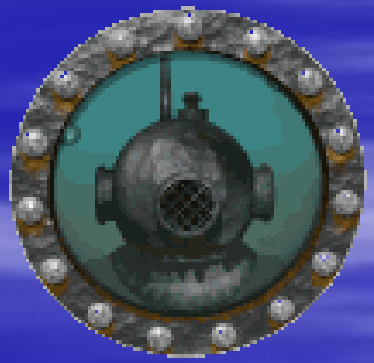
- Hyperbaric oxygen therapy has been shown by evidence based practice to be a beneficial first line or adjunct therapy for a multitude of patient healing problems.
- Because of its minimal side effects, it is a relatively safe therapy
- Its use however, may remain controversial due to its potential for abuse.

Hyperbaric Oxygen Treatment

- Part of multidisciplinary wound care approach
- Being established on a proper research footing
- Major centres adhering to evidence-based guidelines
- Significant role to play in diabetic wounds and soft tissue delayed radiation injury
- Nine major indications reviewed and funded by Medicare
- Further multicentre RCT's ongoing

Department of Diving and Hyperbaric Medicine

Questions?



Gas Gangrene

- Is a tissue infection caused by the organism Clostridium perfringens. It is also referred to as Clostridial Myonecrosis
- For the clostridial organism to grow, certain predisposing factors must be present-
  - These include –
    - vascular compromise,
    - foreign bodies,
    - or tissue necrosis.
    - It may also develop post operatively when there has been surgery to the bowel or gall bladder in patients compromised with diabetes or atherosclerosis

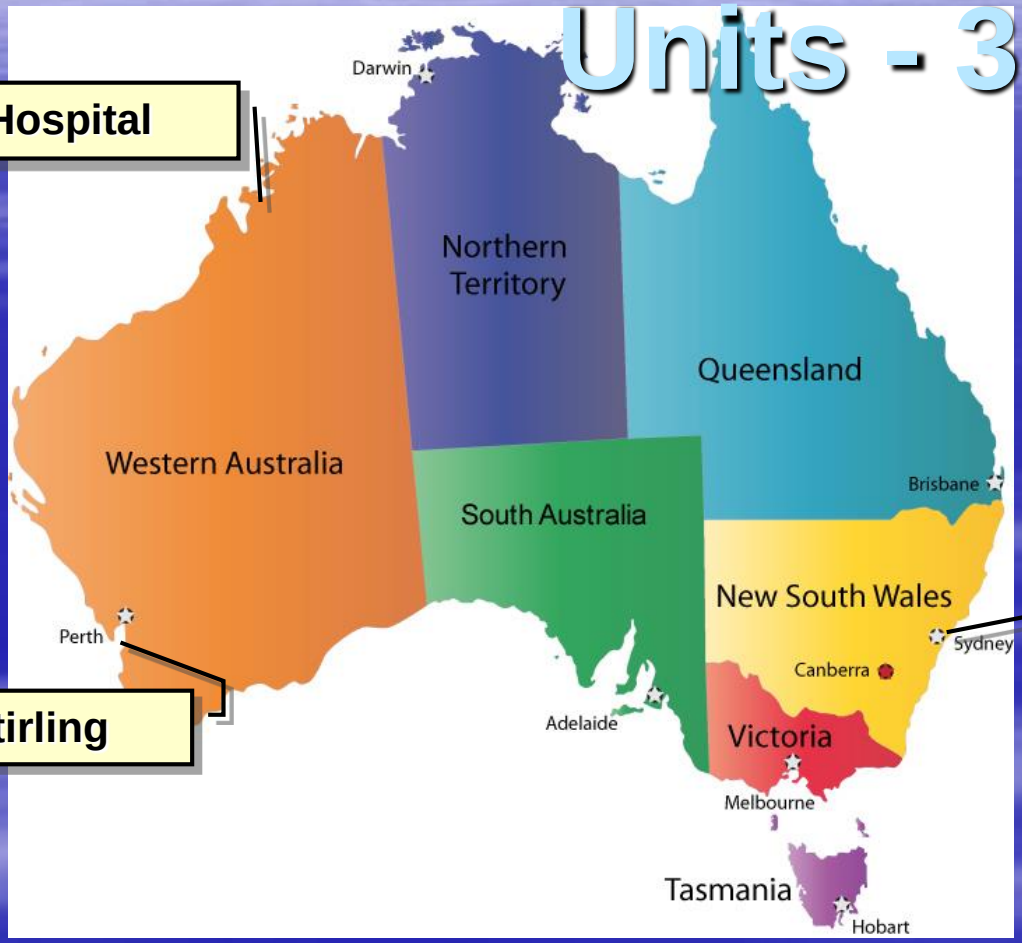
HBOT in the World

Most countries have HBOT centres:

- **Over 1000 HBOT Departments in USA**
- **Said to be >1000 in Russia**

Australian DCI treatment only Hyperbaric Units - 3

Broome Hospital



HMAS Penguin

HMAS Stirling

Wound Care and HBO

- Check products are HBO safe

  e.g **Iodosorb** not allowed to enter the hyperbaric chamber. Its MSDS (No. 173) notes that one should avoid strong oxidizing agents when it has been applied. Oxygen is one of the most potent oxidizers.

  http://mededonline.org/expert_answer.asp?offset=90&id=624

- Remove machinery during HBO e.g. negative pressure pumps. OK to disconnect for HBOT
- Most drains OK

- Usually managed by HMU

- HBO can assist despite poor wound care

The Diabetic Patient

- It is estimated that 3 million Australians have diabetes (It is thought that for every known case of diabetes, there was another undiagnosed case)

- The number has doubled since the early 1980s and is expected to pass 5 million people by 2025

Australian and New Zealand J. of Public Health, Volume 33 Issue 6, Pages 540 - 543 (2009)

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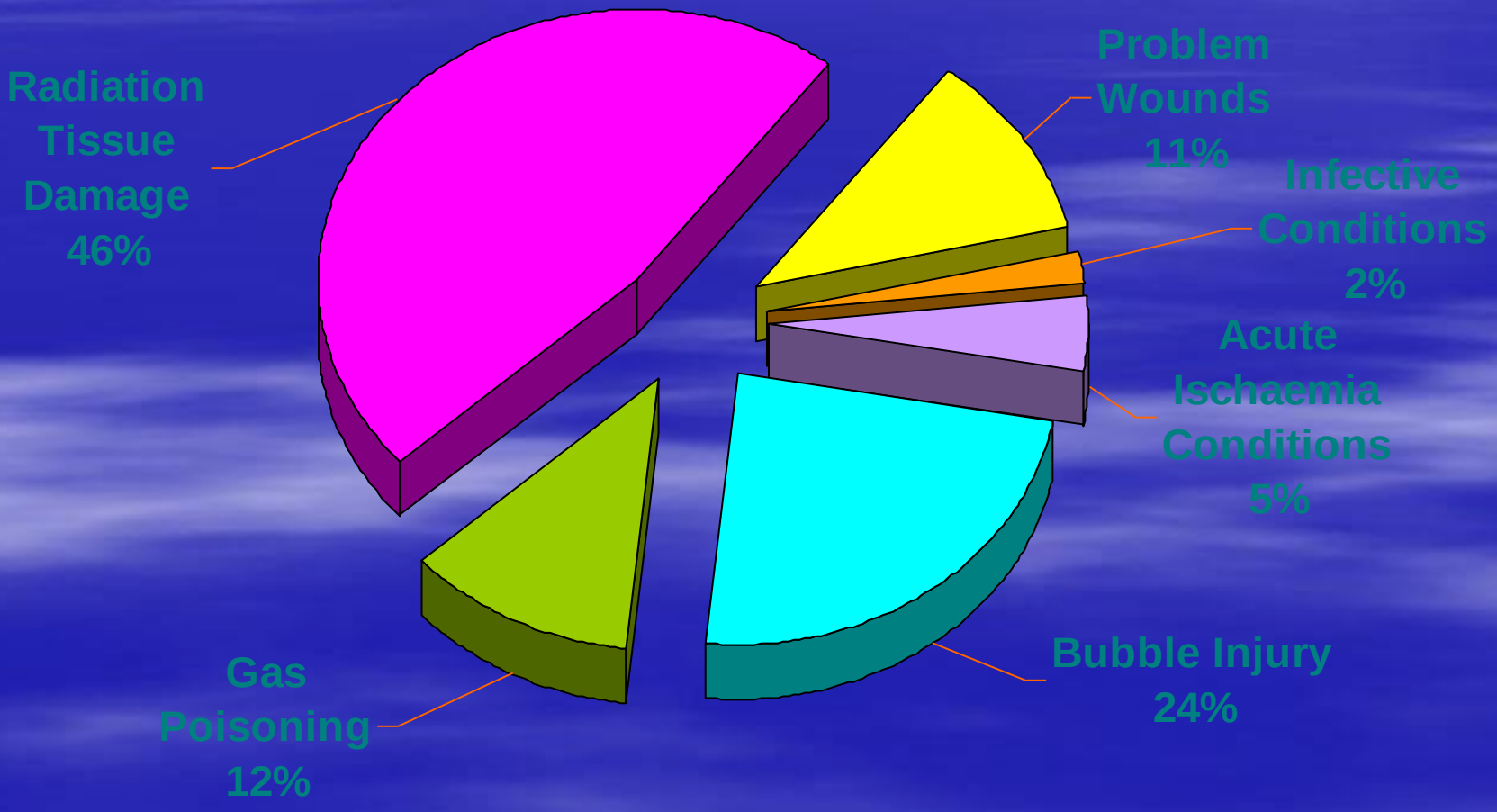
Treatment Statistics - 168 Pts

July 2010 - June 2011



Rationale for Use of HBOT in Wound Healing

- “HBO therapy significantly reduces the length of the patient's hospital stay, amputation rate, and wound care expenses. Thus, it is a cost-effective modality”.

Wang J, Li F, Calhoun JH, Mader JT. The role and effectiveness of adjunctive hyperbaric oxygen therapy in the management of musculoskeletal disorders. J Postgrad Med 2002;48:226-31

Diabetic Non-Healing Wounds

- A “diabetic foot” is characterised by sensory, motor and autonomic neuropathies leading to alteration in pressure distribution, foot deformities and ulceration

Diabetes Care 26:S25-S27, 2003