

TREATING NON-HYPOXIC WOUNDS WITH HYPERBARIC OXYGEN THERAPY

Abstract

Background: Hyperbaric oxygen therapy (HBO) may be a useful adjunct for chronic non-healing wounds when the aetiology includes a hypoxic component. Occasionally, HBO is administered for unusual cases that have no obvious hypoxic involvement. **Aims:** To assess whether HBO would be beneficial for chronic non-healing wounds with no obvious hypoxic component. **Methods:** Three cases of chronic wounds with no apparent hypoxic complications treated with HBO were reviewed. **Results:** All three patient cases reviewed demonstrated improved wound healing during their course of HBO. **Conclusion:** These cases suggest HBO can be beneficial for chronic non-healing wounds with no obvious hypoxic component.

KEY WORDS

- ▶▶ Hyperbaric
- ▶▶ Hypoxic
- ▶▶ Chronic
- ▶▶ Inflammation

Hyperbaric oxygen therapy (HBO) involves the inhalation of 100% oxygen at pressures greater than those present at sea level (Thom, 1992). HBO is administered in a chamber (see *Figures 1 and 2*), which is pressurised to a depth where the partial pressure of oxygen administered to the patient is sufficient to produce the desired effect. For patients with problem wounds, this is between 2.0 and 2.8 atmospheres absolute (ATA). Oxygen is usually administered for 90 minutes, five days a week.

Oxygen is essential in wound healing and all wounds, even those in patients without physiological disorders are hypoxic towards the centre (Bishop, 2008). This central hypoxia allows an increasing oxygen gradient towards the intact tissue to be created, which promotes healing by acting as a stimulus to repair (LaVan and Hunt, 1990). The increased partial pressure of oxygen during HBO elevates oxygen tension in the tissues and so increases the oxygen gradient. This could be of benefit in all wounds that are not healing in a timely manner. Studies suggest that HBO may be a useful adjunct for some patients with chronic non-healing wounds, particularly when the aetiology includes a hypoxic component. The inspiration of high levels of oxygen at increased pressure during HBO have been shown to fully oxygenate the

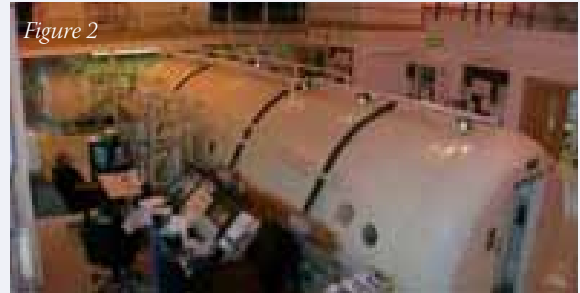
haemoglobin in the circulating blood and lead to more oxygen being dissolved into the plasma, in proportion to the increased partial pressure (Niinikoski, 2004). Oxygen dissolved in the plasma is more readily utilised than that bound to the haemoglobin and, therefore, under hyperbaric conditions, oxyhaemoglobin will pass unchanged from the arterial to the venous circulation (Jain, 2009).

In Plymouth, the Diving Diseases Research Centre (DDRC) receives referrals for the treatment of chronic wounds — occasionally these are for unusual cases of chronic wounds that appear not to have major hypoxic involvement, but are showing no signs of healing. The increased oxygen levels achieved during HBO have been demonstrated to stimulate angiogenesis, increase cell proliferation, facilitate infection prevention and treatment, and reduce oedema (Nylander et al, 1985; Cianci, 2004).

Consultants referring patients with no clear hypoxic aetiology are often hoping that HBO will promote healing by encouraging these processes when other treatments have failed. The treatment and outcomes of three such referrals are discussed. It was hypothesised that the benefits of HBO mentioned above would lead to improvement, despite the wounds having no clear hypoxic involvement.

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Figures 1 and 2: Hyperbaric oxygen therapy chambers.

METHODS

Three cases of chronic wounds with no apparent hypoxic complications treated with HBO were reviewed to assess outcome. The patients' condition and wound history, number of hyperbaric treatments received, wound dimensions and wound photographs were collected from the patient records.

RESULTS

All HBO treatments in these patient cases were delivered once per day, five times a week at a pressure of 2.4 ATA.

Patient A

Patient A was a 72-year-old man with a 36-month-old chronic ulcer on his right achilles. The only past medical history was hypertension for which no medication was required. The ulcer was being treated with short-stretch compression bandaging and the wound had remained static for a few months despite surgical debridement to the area. The consultant felt further surgical interventions would not be successful. The patient presented with 90% slough to the wound bed (Figure 3).

Transcutaneous oxygen monitoring (TcPO₂) is used to assess tissue oxygen tension. Tissue oxygen tension is the measurement of local partial pressure of oxygen in the tissue and is the balance between oxygen perfusion and consumption in the measured tissue at the time of assessment. TcPO₂ can be used to monitor the increase in perfusion during HBO. Patient A continued to receive short-stretch bandaging changed on a weekly basis during his course of HBO. Upon completion of 40 treatments, patient A's wound showed improvement with only 30% slough to the wound bed and a 28% reduction in wound area from 2.6cm² to 3.6cm² (Figure 4). The referring dermatologist reviewed patient A after completing his course of HBO and

considered surgical debridement under local anaesthetic with subsequent grafting to now be of potential benefit. However, as is common in patients who have received HBO, the wound continued to heal and surgical intervention was not required. One year after HBO, the wound was 90% epithelialised (Figure 5). Patient A was pleased with the outcome of HBO and continued progress following completion of the treatment.

Patient B

Patient B was a 72-year-old man with a small pressure ulcer to his right heel following an admission to intensive care following a ruptured oesophagus. The ulcer had been present for 42 months and a small difference in leg length was believed to be delaying wound healing. Three months prior to referral for HBO, surgery with primary closure had failed, despite apparent good circulation to the area. The referring consultant was particularly concerned about recurrent infections to the wound. Magnetic resonance imaging (MRI) had not identified any osteomyelitis to the area. Past medical history was a previous hernia repair, a knee replacement and mild asthma.

Patient B completed 40 HBO treatments and although improvement was initially slow, the wound demonstrated a 75% reduction in depth from 1.2cm to 0.3cm upon completion of the treatment. The wound did not become infected during this time. The consultant was pleased with patient B's progress and discharged him from clinic. Four months after HBO, healing had continued and the wound was superficial (Figures 6-8). Patient B was very happy with the outcome.

Patient C

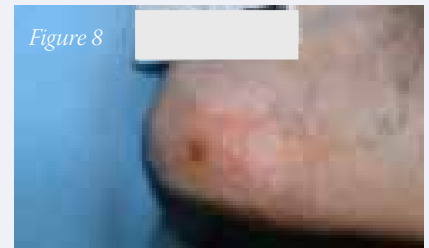
Patient C was a 64-year-old woman



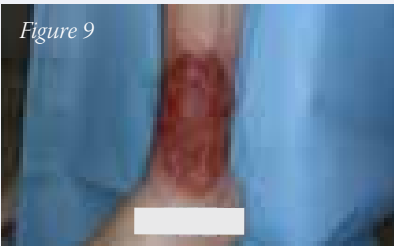
Figure 3: shows patient A at assessment with 90% slough. Figure 4: shows patient A after 40 HBO treatments with 30% slough, while Figure 5: shows the same patient at a one-year follow-up assessment with 90% epithelialisation.

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Figures 6–8: Patient B's wound is shown at assessment (Figure 6) with a depth of 1.2cm, which reduced to 0.3cm (Figure 7) after 40 HBO. Figure 8 shows the wound at one-year follow up, showing 90% epitheliasation.



Figures 9–10: Patient C's left lateral ulcer shown at the start of HBO (Figure 9) and again after 60 HBO.



Figures 11 and 12: A left medial ulcer shown at the start of HBO (Figure 11) and after 60 HBO treatments.

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referred with pyoderma gangrenosum. Pyoderma gangrenosum is an uncommon ulcerative skin condition that generally begins with a painful nodule or pustule that eventually breaks down.

The resulting ulcers usually have a blue-black edge. Patient C's bilateral wounds (two on each leg) had been present for 18 months, while showing signs of deterioration. She was unable to tolerate prednisolone or cyclosporine, and methotrexate had been ineffective, leaving the pyoderma gangrenosum untreated. There were a number of interruptions to patient C's course of HBO in the initial stages due to urinary tract infections and headaches. She also had a break for a holiday. Patient C's extensive medical history included diabetes, hypertension, oesophageal ulcers, a hysterectomy and fibromyalgia. One of the wounds to patient C's right leg was healed after 17 HBO treatments and the other was healed by treatment 40. After a total of 60 treatments, the left lateral wound had reduced in size by 58%, from 86.3cm² to 36.4cm² (Figures 9–10) and the left medial wound was 80% smaller (Figures 11–12) in area (18.4cm² to 3.7cm²). The referring consultant observed a 'dramatic improvement' at review.

DISCUSSION

Chronic wounds fail to heal in a timely manner and do not progress through the wound healing phases as expected. Despite no evidence of hypoxia as a major contributor to wound aetiology in these cases, all three patients with chronic wounds experienced favourable outcomes following HBO. The reasons for this could include reduction of inflammation, enhanced neutrophil function, reduction of oedema, increased neovascularisation and collagen deposition, all of which are known benefits of HBO (Nylander et al, 1985; Broussard, 2003; Cianci, 2004). Rangaraj et al (2011) suggested chronic wounds often have a persistent and

uncoordinated mix of acute and chronic inflammatory response. The effects of HBO can alter a wound's cellular and molecular functions, and it could be hypothesised that this may have provided new coordination to the healing process, allowing the phases of wound healing to progress in an orderly and synchronised manner.

Bacterial activity can cause a significant increase in oxygen consumption in a wound and chronic wounds are believed to have a greater bacterial content than acute wounds, even when not showing clear signs of infection. Therefore, the increased oxygenation of the wound during HBO may have allowed the patients' inflammatory systems to remove the bacteria and, therefore, provide a more optimum healing environment.

Patient B's recurrent infections ceased with the use of HBO, suggesting some change in his ability to fight infection. In such complex chronic cases, complete healing may not be the primary goal of HBO. Often, any improvement after a wound has been static or deteriorating for a long period of time can be sufficient to improve the health and quality of life of the patient. HBO can initiate a series of events at wound level that continues between treatments and following course completion. Therefore, continued wound healing is often observed.

CONCLUSION

These cases infer that HBO can be beneficial for chronic non-healing wounds with no obvious hypoxic component. However, the use of HBO as an adjunct should be carefully considered and outcomes closely monitored. Patient history and comorbidities need to be considered, as well as recent interventions and why they failed. Clear aims must be established and agreed prior to HBO so that outcomes can be evaluated. [WUK](#)