Using a combination of surgical debridement, negative pressure wound therapy and hyperbaric oxygen therapy

KEY WORDS
- Hyperbaric oxygen therapy
- Negative pressure wound therapy
- Surgical debridement
- Ulceration

Complex surgical wounds can be difficult to manage and are usually associated with patients who have other comorbidities and risk factors for non-healing, such as obesity (Guo and DiPiertro, 2010). They have a high risk of ongoing infection and significant psychological effects for the patient as well as being a burden on healthcare and society. Treatment is not straightforward and requires the multidisciplinary team to work effectively together providing a combination of therapies (Moore et al, 2014). This article showcases one case study that involved of surgical debridement for ongoing fat necrosis; negative pressure wound therapy with and without fluid instillation and hyperbaric oxygen therapy.

ALEXANDRA J BISHOP
Senior Clinical Nurse, DDRC Healthcare, Plymouth

SHEENA HUISH
Clinical Lead for Tissue Viability, University Hospitals Plymouth NHS Trust, Plymouth

A case study of a 53-year-old-lady who suffered complications with wound healing, following hernia repair and abdominal wall reconstruction, will be presented. Recurrent hospital admissions and a series of surgical procedures for postoperative wound complications were treated with a combination of surgical debridement for ongoing fat necrosis; negative pressure wound therapy (NPWT) with and without fluid instillation and hyperbaric oxygen therapy (HBOT).

NPWT with foam stimulates angiogenesis, promotes granulation, provides fluid management, reduces oedema, increases blood flow and enhances cell proliferation (Webb and Pape, 2008; Meloni et al, 2015). The application/instillation of a solution (saline or another irrigation fluid of choice) combines traditional NPWT with intermittent instillation of solution to the wound bed (NPWTi). The intermittent therapy allows the fluid to remain in contact with the wound bed for a selected period of time (from 1 minute to 1 hour) depending on clinical need. This is understood to reduce bioburden, improve healing rate and promote granulation (Bobkiewicz et al, 2016).

HBOT is indicated for the enhancement of healing in problem wounds where there are arterial insufficiencies or infection. Defined as the provision of 100% oxygen at pressures greater than atmospheric, it has been used adjunctively to treat problem and chronic wounds for decades. Availability of treatment varies geographically and can also depend upon clinicians' understanding of the treatment as well as the availability and quality of evidence. In areas where HBOT is accessible, it has also been used for wounds not progressing to healing in a timely manner, where there may be limited choices of interventions (Thackham et al, 2008).

PATIENT HISTORY

Mrs C was morbidly obese with a body mass index (BMI) of 47 and had sleep apnoea, for which she was on Continuous Positive Airway Pressure (CPAP) at night. In 2012, she had a mid-line incision for hysterectomy that had healed with no complications. Five years later, in March 2017, Mrs C presented to the hospital with abdominal pain. A CT scan performed the day after admission revealed a loop of bowel in the hernia sac with areas of surrounding inflammation. On the evening of 30/03/2017, the patient had emergency surgery to repair a complex strangulated hernia and underwent reconstruction of her abdominal wall with a mesh. As well as having complex surgical wound needs, her treatment was complicated by repeated wound infections, nausea (leading to poor dietary intake), and persistently low

Figure 1. Wound following hernia repair. March 2017

Figure 2. Wound following surgical debridement

Table 1. Surgical procedures performed

Date	Findings	Procedure
19/4/2017	Necrotic tissue inferior of midline. No abscess. Tissue smelt of anaerobic infection	Small amount of necrotic tissue debrided to healthy tissue. Wound irrigated with 2 litres normal saline (0.9%)
25/4/2017	Necrotic skin with fat necrosis. Seroma anterior to mid wound, dehiscence down to mesh, communication with distal end of wound	Seroma aspirated – fluid sent for microscopy, culture and sensitivity. Necrotic skin and fat excised down to bleeding tissue. NPWT applied at 80 mmHg/continuous
09/05/2107	Patchy necrosis to wound edges. Fat necrosis bilaterally	Skin bridge excised. Fat necrosis excised to bleeding tissue and 2 litres 0.9% sodium chloride. NPWT applied at 80 mmHg/continuous
26/06/2017	Left cutaneous flap with doubtful viability removed to well perfused tissue. 90% of cellis mesh covered with granulating tissue	NPWT dressing with irrigation (saline 0.9%) commenced, and a plan to change dressing in 2 days

haemoglobin for which she required frequent blood transfusions.

Following the surgery in March 2017, Mrs C was discharged home but readmitted 10 days later with a wound infection and feeling generally unwell (pyrexia and nausea and lethargy). Surgical examination revealed a soft, non-tender abdomen, the sub umbilicus/suprapubic area of the wound had dehisced, and there was extending erythema of the wound margins and remaining intact incision *(Figure 1)*. After two days, Mrs C was taken to theatre for debridement of the wound. The findings were: a small amount of necrotic tissue to the wound edges, which was debrided down to healthy bleeding tissue — no abscess noted, but the wound had the 'foul smell' characteristic of the presence of an anaerobic infection. Foam NPWT was used to manage the wound on a continuous setting of 80 mmHg. Post-operatively the plan was for further review by tissue viability at 48 hours.

A tissue viability review was requested on day one post-operatively, a day earlier than planned. On examination, the suture line had two further small areas of dehiscence (2x1x1 cm and 1.5x1.5 x1 cm). The remainder of the suture line was erythematous and had a serous ooze *(Figure 2)*. NPWT was applied to both small cavities and along the suture line to splint those areas that remained intact before being Y-connected to the lower wound. The team planned to see her again after the weekend. Over the weekend, the patient was sent as a surgical outlier to the plastic surgery ward. Follow-up review by tissue viability revealed a deep cavity wound 10x8 cm and 5 cm deep, undermining towards the top of the incision by 7 cm and communicating with the dehisced area to the top of the wound — with a bridge of skin between both areas. The smallest superior wound was probed to a depth of 9.5 cm, without reaching the base of the wound, and there was a large amount of dark brown, but thin, exudate. The patient had a pyrexia of 38.9°C, was hot to touch, had a headache, and felt generally unwell as well as complaining of abdominal pain. Following a CT scan, she was taken to theatre for further debridement of fat necrosis and washout. The abdomen was left open following this procedure and managed with NPWT. A number of surgical procedures followed *(Table 1)*.

A COMBINATION OF THERAPIES

Mrs C was referred for HBOT on the 25th May and completed her first session on the 31st. A total of 40 HBOTs were administered over 9 weeks, completing on the 3rd August. It is usual to administer HBO once a day, with weekends off for problem wounds. Mrs C had some interruptions to treatment due to being too unwell to attend and attending theatre, hence the delay in completing the course. She experienced no complications or side effects from HBOT other than some changes to her vision which resulted in an improvement to her distance vision.

Figure 3a. Wounds pre-HBO (31/05/2017)

Figure 3b. Wound after 20 HBO treatments (5/07/2017)

Figure 3c. Wound after 39 HBO treatments (2/08/2017)

Figure 3d. Wound 2 weeks post-HBO (16/08/2017)

Table 2. Wound measurements during HBOT until healing

Date	Number of HBOT	Measurements	
		Length (cm)	Breadth (cm)
31/05/2017	1 (Start)	35	40
5/07/2017	20 (Half way through course and discharged from hospital)	18	18.5
02/08/2017	39 (End of HBOT course)	17	18
16/08/2017	2 weeks after completion of HBOT	15.5	16
01/11/2017	3 months after completion of HBOT	8.6	6.2
01/2018	5 months after HBOT	Healed	Healed

Treatment was given in a multiplace chamber at a depth of 2.4 atmospheres absolute (ATA) (14 metres of sea water (msw) with three 30-minute cycles of oxygen, separated by five-minute air breaks. The NPWT pump was switched off and disconnected for the duration of the treatment — one hour and 50 minutes — and was reconnected upon completion. This is in line with the guidance offered by the company supplying the NPWT. The pump may be damaged by the pressure changes in the chamber and has not been sufficiently tested under hyperbaric conditions to ensure accuracy of performance and safety.

The benefits of HBO treatment include improving white blood cell function, enhanced fibroblast activity, promotion of angiogenesis, enhanced collagen synthesis, and reduction of oedema (Eggleton et al, 2015).

Dressing changes and wound assessment was managed between the tissue viability team at the hospital and the nurse specialists at the hyperbaric centre. The dressing was changed and the wound reviewed at the centre on a weekly basis with the remaining dressing changes being completed at the hospital.

Three months following the emergency hernia repair, there were signs of improvements to the patient's wound, including significant granulation tissue and a reduction in slough and necrotic tissue evident to the wound bed. Throughout this time Mrs C remained an inpatient. Wound measurements at key points during the course of HBOT were taken *(Table 2). Figures 3a-e* show wound photos at three time points during HBOT, and at two time points after completion. The first note of no signs of infection to the wound was on the 5th July, following 20 HBO treatments.

Following discharge from hospital on the 5th July, the district nursing team took over Mrs C's care from the hospital. At this point, the tissue viability nurse specialist from the hospital also attended the hyperbaric centre for some of the dressing changes in order to observe progress and assist with regular conservative sharp debridement. The wound healed in January 2018. *Figure 4* shows the healed wound one year following completion of HBOT, 17 months after initial surgery in March 2017.

DISCUSSION

During Mrs C's hospital stay she was nursed on three different wards as an outlier. Two of these were plastic surgery and the other orthopaedics. This led to delays in the patient being reviewed, and delays in interventions (CT scans, surgical reviews, prescription of antibiotics). The surgical team also rotated on a weekly basis, with a different consultant responsible for the patient each week leading to a lack of continuity of her care.

The complications experienced by Mrs C could be attributed to the patient being

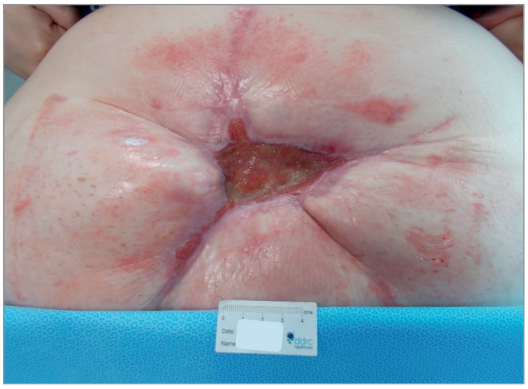

Figure 3e. Wound 3 months post-HBO (1/11/2017)

Figure 4. Healed wound (August 2018)

morbidly obese (BMI 47). It is possible that had a PICO (Smith and Nephew) NPWT device been used for incision management immediately post-operatively, in accordance with National Institute of Clinical Excellence guidelines (NICE, 2018), the wound may not have dehisced. Mrs C also had the added complication of reduced oxygenation due to sleep apnoea and low haemoglobin. Her dietary intake was poor due her nausea — a side effect of her antibiotic therapy. If your diet is lacking in calories, proteins or micronutrients, wound healing can be delayed (Sherman and Barkley, 2011).

The flexibility of NPWT dressings allows it to adapt to the contours of deep and irregularly shaped wounds. The 400–600 micron pore size helps provide uniform distribution of negative pressure at the wound edges and the hydrophobic pore structure helps remove exudate and infectious material from the site. In this case, it also allowed for an accurate fluid balance as the wound exudate was measurable. Due to the size of the wound it would have been difficult to manage with conventional dressings. The integrity of surrounding skin was maintained, as exudate was being managed effectively.

In a retrospective study comparing the effect of saline instillation in NPWTi to NPWT alone in ten patients with acute lower limb wounds, Omar et al (2016) observed decreased hospital stay and improved wound healing in patients who received NPWTi. However, results were not significant.

The hyperoxic environment provided during HBOT ultimately leads to an increase in dissolved oxygen in the plasma (Niinikoski, 2004). Oxygen in the plasma is more available than that attached to the haemoglobin. The benefits of this have been listed above. It is worth noting that the vasoconstriction induced by HBOT does not reduce delivery of oxygen as this continues to reach the wound via the plasma and microcirculation (Bhutani and Vishwanath, 2012).

There is also the advantage of improved social interaction with patients receiving treatment together over a significant course of time getting to know each other quite well. They have been observed to provide emotional support for one another as well as an opportunity to talk about subjects other than their own condition, which is difficult to achieve on a hospital ward. Attending for HBOT also provided variety to Mrs C's day, which had been associated with ward rounds, dressing changes and visiting hours for some time. Mrs C had a time to get up, changed and ready for treatment before leaving the ward, for a complete change of environment and company. McCaughan et al (2018) investigated the experience and perceptions of patients living with surgical wounds healing by secondary intention in some detail. They reported social isolation and that wound associated factors had a negative impact on physical and psychosocial functioning as well as other aspects of daily life. Mrs C remained relatively positive in her attitude regarding the wound during HBOT. However, she reported a strong sense of anxiety and frustration as well as the wound having a negative impact on her activities of daily living when she was assessed

for HBOT. These had improved greatly upon completion of her course of treatment, in line with the improvement to her wound.

A large abdominal wound is particularly difficult to manage, although the accessibility and portability of NPWT has improved outcome for these patients, often allowing them earlier discharge and, therefore, reducing the burden on hospitals and allowing patients to see friends and family more easily. It is also regularly used in patients undergoing HBOT as the mechanisms of action of each treatment appear to support those of the other.

A case report has recently been published describing the benefits observed on an open abdominal laparostomy wound with HBOT (Sarkar, 2018). The patient was a 50-year-old who experienced complications following a laparoscopic cholecystectomy. This case differed from the one described here in a few ways. Sarkar (2018) explained that the patient had just four sessions of HBOT at 2.5 ATA (15 msw) following an exploratory laparotomy and formation of an ileostomy. The wound was left open due to swelling. This case was in India and NPWT was not applied. However, the patient was discharged 20 days after ileostomy formation with a healed abdominal wound.

CONCLUSION

This complex case study demonstrated a positive outcome for Mrs C with healing within 5 months of completion of HBOT and ten months of original presentation to hospital. Use of PICO following initial surgery may have altered the patient's experience by splinting the suture line. This case highlights the importance of good communication and continuity of care, especially in a busy hospital when the patient may be an outlier on another ward.

A combination of HBOT and NPWT to support surgical debridement was effective in encouraging healing and improving quality of life. Clinicians should be mindful that a blend of therapies and interventions are often required in such complex cases. WUK

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