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Successful Post-surgical Wound Management with Hyperbaric Oxygen Therapy

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Authors' contributions

All authors contributed equally in this study. All authors read and approved the final manuscript.

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Case Report

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ABSTRACT

Hyperbaric oxygen therapy (HBOT) is a treatment in which 100% oxygen at a pressure greater than one atmosphere is administered to the patient. It can be used as an adjunctive therapy in many wound care settings.

We present a 41-year-old female, who had a prolonged hospital stay with an open abdominal wall dehiscence and scarring with multiple enterocutaneous fistulas. After her revisional surgery to resect the fistula, the patient developed ulceration and breakdown of her laparotomy wound. Hyperbaric oxygen therapy was initiated in addition to intensive wound care to stop the ulcer progression and promote the formation of granulation tissue. Once therapy was completed, a split-thickness skin graft was performed on the granulation tissue to attain wound closure.

Hyperbaric oxygen therapy exerts its effect mainly by adequate tissue perfusion and oxygenation. It also has a crucial role in neovascularization as well as activating signaling pathways to stimulate wound growth factors. In this case report, a combination of HBOT, wound care, and adequate nutrition resulted in the formation of a healthy granulation tissue bed. Subsequently, this resulted in the successful adherence of the skin graft.

In addition to proper wound care and optimal nutritional support, HBOT can possibly play a role in enhancing wound healing in select cases.

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ABBREVIATIONS

HBOT : Hyperbaric Oxygen Therapy
ATA : Atmosphere Absolute
ICU : Intensive Care Unit
POD : Postoperative day

1. INTRODUCTION

Modern clinical use of hyperbaric oxygen therapy (HBOT) started in the 1950s, when Churchill Davis treated cancer patients with HBOT as an adjunct to radiation therapy [1]. HBOT is a mode of treatment that may be used to accelerate wound healing. Patients are exposed to 100% oxygen inside a hyperbaric chamber, pressurized to be greater than one atmosphere absolute (ATA).

During wound healing, neovascularization occurs, which helps in providing oxygen and nutrients to the injured area, aiding in the formation of granulation tissue [2,3]. HBOT exerts its effects by mainly increasing partial pressure of oxygen in tissues [4]. There is also a significant increase in local wound nitric oxide levels after successful HBOT; hence this mechanism may be an important factor in promoting wound healing and closure associated with this therapy [5,6].

2. CASE PRESENTATION

We present a previously healthy 41-year-old female with a history of two cosmetic abdominoplasties, who presented in September of 2018 to the emergency department with peritonitis and septic shock after undergoing an abdominal liposuction four days prior to presentation.

She underwent an emergent exploratory laparotomy, which showed a perforated ileum and major contamination with enteric content. The patient underwent damage control surgery with subsequent ileostomy creation. She had a complicated and prolonged ICU course with an open abdomen and abdominal sepsis requiring multiple washouts. To achieve closure, an open abdominal wound management system (Abthera) was applied. During her hospital stay, she developed numerous enterocutaneous fistulas. Progressive nutritional and extensive wound care support was provided over a course of 14 months to achieve localized control of the ostomy and fistulas [Fig. 1].

Exploratory laparotomy was done in October 2019, to excise the enterocutaneous fistulas and establish bowel continuity, followed by transversus abdominis muscle release to close the abdominal cavity [Fig. 2]. The abdominal closure was challenging, especially with achieving mobility of the rigid abdominal wall. This is perhaps due to multiple previous abdominal surgeries.

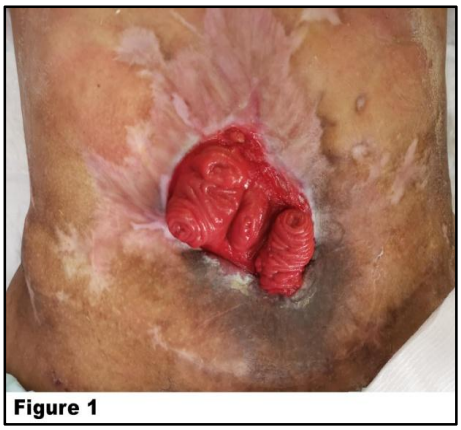

Fig. 1. Ileostomy with multiple surrounding enterocutaneous fistulas

Fig. 2. Post exploratory laparotomy with takedown of the enterocutaneous fistulas, bowel resection and transversus abdominis muscle release to close the abdominal cavity

Following surgery, the central part of the laparotomy wound started to become necrotic on postoperative day 2, progressing to an ulcer at the umbilical area despite adequate perioperative nutrition and meticulous antiseptic dressing applications [Fig. 3].

Hyperbaric oxygen therapy was considered as an adjunct to help enhance wound healing. Clearance from cardiology, ophthalmology, and pulmonology was acquired prior to the treatment. Our patient underwent a total of 15 sessions divided into one hour per session, five sessions per week, for a total of three weeks. At our hospital, the hyperbaric chamber's pressure is set at 1.5 atmospheres. In addition, daily wound care was performed using topical calcium alginate dressing. Furthermore, the patient's diet was enhanced using nutritional supplement shakes. Once an adequate granulation tissue base was attained [Fig. 4], the patient underwent a split-thickness skin graft and excellent adherence of the skin graft was achieved [Fig. 5]. She was then discharged one week after skin grafting, tolerating diet, and having regular bowel movements. She was seen in the clinic over the next three months with no complaints, maintaining adequate wound closure and abdominal wall integrity.

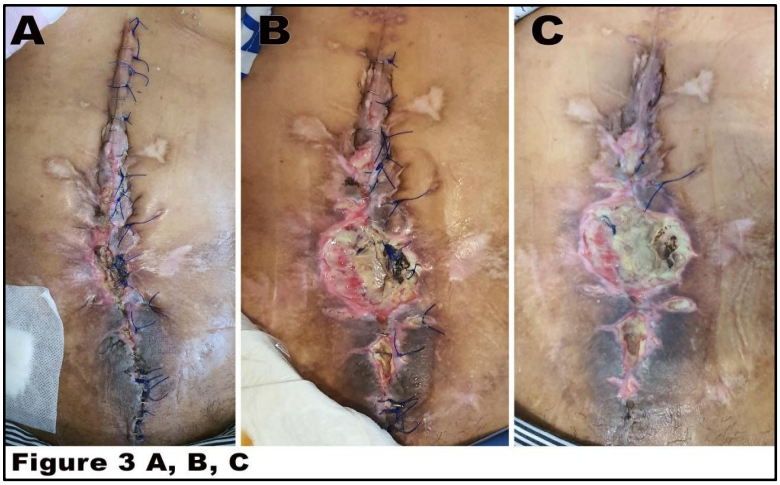

Fig. 3. Postoperative wound with daily dressing care showing progressive ulceration and necrosis of the central portion of the laparotomy wound. A: POD 2. B: POD 5. C: POD 7

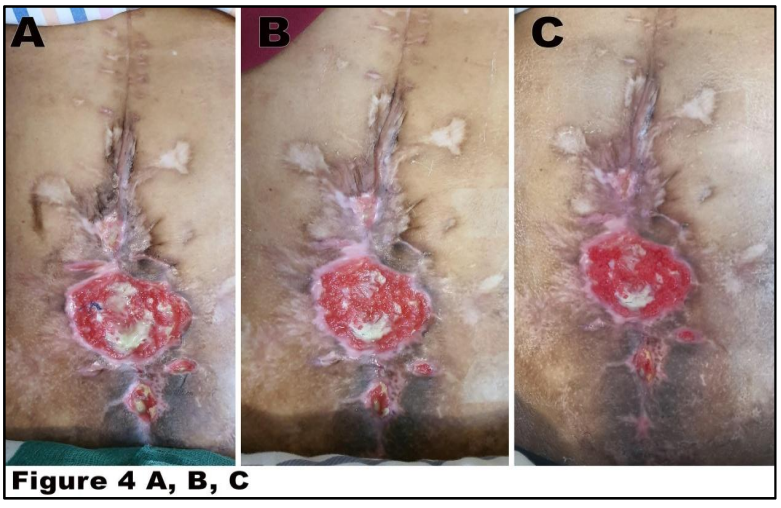

Fig. 4 A, B, C. Post hyperbaric oxygen therapy treatment with daily wound care using calcium alginate dressing. The pictures show the progressive formation of granulation tissue as well as sloughing of necrotic tissue. A: After 5 sessions. B: After 10 sessions. C: After 15 sessions

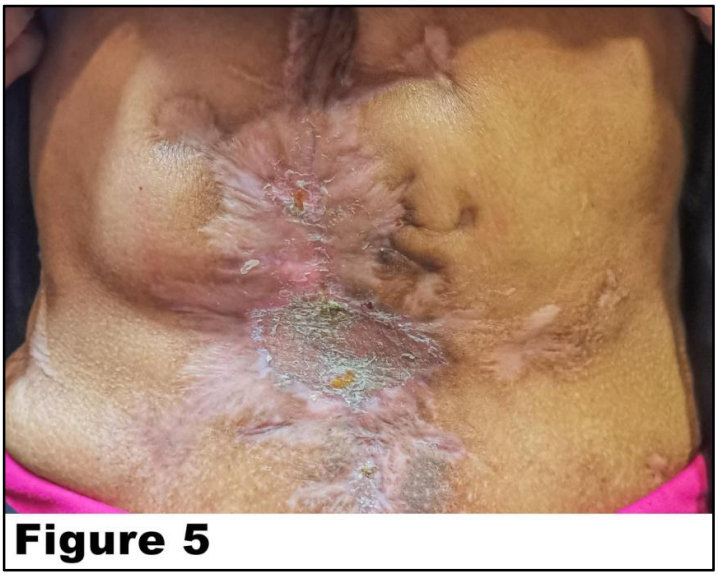

Fig. 5. Complete closure of the wound after placement of the split-thickness skin graft

3. DISCUSSION

For a normal wound healing process to occur, two key factors must be available, namely adequate tissue perfusion and oxygenation [2]. Hyper-oxygenation during HBOT stimulates the generation of both reactive oxygen and nitrogen species. These play a role in the signaling pathways for wound growth factor production, stem cell mobilization, collagen synthesis, and deposition, which enhance wound repair and strength. In addition, it leads to a 40% increase in neovascularization [7]. Moreover, hyper-oxygenation exerts antimicrobial effects by boosting phagocytic bacterial clearance and inducing microbicidal effects by polymorphonuclear lymphocytes. It may also enhance soft tissue penetration of some antibiotics [6,8,9].

In a hyperbaric oxygen chamber, the patient breathes 100% compressed oxygen for the duration of the treatment, which lasts approximately 1-2 hours per session, for multiple sessions that can extend up to 3 months [7,8]. HBOT has been indicated for treatment of many different disorders, including air embolism, decompression sickness, diabetic foot ulcers, and necrotizing soft tissue infections. Complications are minor and reversible, such as barotrauma to ears and sinuses, myopia, and accelerated cataract maturation [2]. Brief interruption in treatment sessions helps prevent irreversible damage that can occur because of the production of the reactive oxygen species [9].

There is a lack of high-quality research regarding the effect of HBOT on the healing of laparotomy wounds. Most of the studies focus on diabetic foot ulcers and peripheral vascular disease. Eskes et al. performed a systematic review evaluating the effect of HBOT on acute surgical and traumatic wounds compared to other interventions and reported no significant difference. However, these trials were small, non-comparable and with methodological limitations [10]. Another systematic review by Dauwe et al. concluded that when combined with standard wound management principles; HBOT can augment healing in complicated acute wounds [1]. Literature surrounding HBOT supports its use in chronic wounds, but its use in acute wounds, flaps, and grafts is less supported. Sarkar [11] had a positive experience with HBOT on open abdominal wounds, where healthy granulation tissue started appearing over the bowel and wound edge after only four sessions of 60-minute HBOT.

After noticing the progressive laparotomy wound ulceration, we became concerned about the detrimental effects of further tissue breakdown and other associated complications. This included loss of abdominal wall coverage, exposed bowel, and recurrence of enterocutaneous fistulas due to the close proximity of the underlying bowel. We started HBOT and continued meticulous wound care with soft calcium alginate dressing. This dressing was preferred due to its antibacterial properties and ability to absorb excess fluids from the

wound [12]. Adequate nutrition was maintained with additional supplemental protein shakes to ensure optimized wound healing [13]. The patient had a very good progression of her wound over the course of three weeks of HBOT, resulting in the progressive gentle sloughing of necrotic tissue with the formation of neovascularization, establishing a healthy base for a planned skin graft [Fig. 4]. By performing the split-thickness skin graft, we ensured complete wound closure and her ability to return to daily function.

4. CONCLUSION

HBOT has been used as an adjunct in the treatment of many clinical disorders and although its role is not well studied in the treatment of abdominal wounds, certain cases might help elaborate its vital role in enhancement of wound healing. Nevertheless, further research is needed to focus on the specific effects of HBOT on postoperative wound healing. It is also important to understand that wound healing is a complex, dynamic process that has many different contributing factors. To ensure adequate results, optimizing nutrition, meticulous wound care, and controlling comorbidities are essential elements in patient management.

CONSENT

Written informed consent was obtained from the patient for publication of this case report and accompanying images.

ETHICAL APPROVAL

Case reports are exempt from ethical approval according to policies of The Ministry of Health in Kuwait.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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