Management of the Chronic Burn Wound

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KEYWORDS

• Chronic wound • Hyperbaric oxygen therapy • Marjolin ulcer • Topical growth factor

KEY POINTS

- There exists little evidence to promote or refute the use of hyperbaric oxygen therapy (HBOT) in acute burn wounds.
- Diabetic foot burns could be separately considered, given the body of evidence in chronic diabetic foot wounds. Further research is necessary to prove the efficacy of HBOT in this setting.
- Marjolin ulcers are malignant degeneration of chronic wounds and occur most commonly in unexcised full-thickness burns.
- Average time from the initial injury to development of a Marjolin ulcer is 30 years. Cancers from Marjolin ulcers tend to be more aggressive than common skin cancers.
- There are many cytokine growth factors available for use on burn wounds. Some promising studies have been performed; additional research will help determine optimum patient selection and treatment regimens.

INTRODUCTION

Perhaps one of the most challenging problems in burn care is obtaining stable, definitive closure of the chronic wound that has failed to heal, using conventional techniques. Although most of the burn literature focuses on management of acute wounds, including timing, depth, and type of excision, as well as method of skin grafting, obtaining permanent closure of chronic wounds can be elusive. This article reviews specific considerations in the workup and management of chronic burn wounds, realizing that resurfacing is not complete until the burn surgeon obtains complete closure of the integument.

Critical to restoring integrity of the skin is obtaining a detailed history about the wound, which helps build a differential diagnosis as to why the wound has failed to close, either secondarily or through surgical intervention. How and when did the burn occur? What previous attempts have been used to facilitate wound healing? Have physical therapy and occupational therapy been involved in executing a plan? Are there environmental or patient-related issues that have prevented the wound from closing? This history, combined with serial physical examination of the wound, will help build a list of possible causes:

- Mechanical: location over tendon or extensor joint
- Metabolic: diabetes, hypothyroidism, autoimmune disorders
- Infectious: acute or chronic
- Vascular: inflow (arterial) and outflow (venous), especially in extremities
- Lymphatic: destruction of regional network causing lymphedema
- Radiation: progressive microvascular fibrosis
- Neoplastic: possible Marjolin ulcer or cutaneous metastasis

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- Personal: smoking, not compliant with splinting or garments, poor wound hygiene
- Social: limited resources and poor access to care (transportation, wound care supplies, caregiver)
- Psychiatric: substance abuse, Munchausen syndrome

This article reviews 3 issues pertinent to management of the chronic burn wound: (1) use of hyperbaric oxygen to facilitate wound closure, (2) application of topical growth factors, (3) and diagnosis and treatment of Marjolin ulcers.

HYPERBARIC OXYGEN THERAPY

Introduction

The Undersea and Hyperbaric Medical Society defines hyperbaric oxygen therapy (HBOT) as "an intervention in which an individual breathes near 100% oxygen intermittently while inside a hyperbaric chamber that is pressurized to greater than sea level pressure."[1] In clinical practice, this pressure typically exceeds 1.4 atm.[1]

The concept of using hyperbaric pressure to treat patients dates back to 1662; a British clergyman named Henshaw thought that hyperbaric pressures could speed healing in acute medical conditions. He created a sealed chamber that he named the Domicilium, using organ bellows to control changes in pressure. Henshaw could not use isolated elemental oxygen in his treatments, however, as it would not be discovered until more than a hundred years later.[2]

Over the course of the late nineteenth and early twentieth centuries, progress was made with the use of oxygen for treatment of decompression sickness, first in normobaric settings and later with the additional of hyperbaric pressures. But it was not until 1955 that Churchill-Davidson and colleagues[3] published "High-Pressure Oxygen and Radiotherapy," using HBOT to potentiate the effects of radiation therapy in patients with cancer, in *The Lancet*. Thus began the era of modern HBOT in medicine.

Current Uses

The use of HBOT quickly expanded to a be used in a wide variety of medical conditions, most of which initially lacked evidence or standard protocols. The Undersea and Hyperbaric Medical Society was founded in 1967 and maintains a current list of accepted medical indications for HBOT use, one of which is acute thermal burn injury (**Box 1**).[4]

Hyperbaric Oxygen and Burns

The theory behind use of HBOT in burn injuries is sound. Animal models have demonstrated that HBOT can increase the partial pressure of oxygen in end organ tissues. This elevation is achieved by increasing the Pa_{O_2} of the blood to 10 to 15 times normal, which creates a steep gradient down which oxygen may diffuse into hypoxic tissues.[5] Theoretically, increasing oxygen tension in burn patients could decrease leukocyte activation, reduce so-called secondary injury, and even reduce tissue edema through an oxygen osmotic effect.

Box 1
2014 Undersea and Hyperbaric Medical Society's indications for hyperbaric oxygen therapy

- Air or gas embolism
- Carbon monoxide poisoning
- Clostridial myositis and myonecrosis (gas gangrene)
- Crush injury, compartment syndrome, and other acute traumatic ischemias
- Decompression sickness
- Arterial insufficiencies
- Severe anemia
- Intracranial abscess
- Necrotizing soft tissue infections
- Osteomyelitis (refractory)
- Delayed radiation injury (soft tissue and bony necrosis)
- Compromised grafts and flaps
- Acute thermal burn injury
- Idiopathic sudden sensorineural hearing loss

Evidence in Burns

Despite this, very little quality research has been done on the effectiveness of HBOT on patients with burn injuries. In the 2004 Cochrane review, Villanueva and colleagues[6] found only 2 quality randomized controlled trials (RCTs) evaluating the effectiveness of HBOT in patients with acute thermal injuries.[6]

1. Hart and colleagues,[7] 1974: 16 patients, 10% to 50% total body surface area (TBSA) burns, randomized to routine burn management and HBOT or routine burn management with sham HBOT
   a. Intervention: 100% oxygen at 2 atmosphere absolute (ATA) for 90 minutes every 8 hours for 24 hours, then every 12 hours until healed
   b. Mean healing times shorter in the intervention group (19.7 days vs 43.8 days, $P<.001$).