

# Hyperbaric Oxygen Therapy in Dermatology

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## PRACTICE POINTS

- Hyperbaric oxygen therapy can be considered for the treatment of failing cutaneous grafts and flaps, chronic ulcerations caused by vasculitis or autoimmune disorders, and vascular compromise, including cutaneous ischemia caused by fillers.
- Hyperbaric oxygen therapy involves 1- to 2-hour treatments, 5 days a week, for as long as 1 month.
- Hyperbaric oxygen therapy is safe and well-tolerated, with few contraindications. The sooner therapy is started, the greater the potential for benefit.

Hyperbaric oxygen therapy (HOT) is a potentially useful technique for certain dermatologic conditions. We review its indications, dermatologic applications, and potential complications.

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Hyperbaric oxygen therapy (HOT) is a treatment modality dating to 1861 in the United States.<sup>1</sup> Today, there are 14 indications<sup>2</sup> for HOT (Table), issued by the Undersea & Hyperbaric Medical Society, which also administers an accreditation program for facilities providing HOT.<sup>3</sup> The 14 indications also are relevant because it is unlikely that HOT will be covered by insurance for unapproved indications.<sup>4</sup>

Although HOT is not commonly seen as a first-line intervention in dermatology, there are scenarios in which it can be used to good effect: compromised grafts and flaps; poorly healing ulceration related to vasculitis and autoimmune disorders; and possibly for vascular compromise, including cutaneous ischemia caused by fillers. We review its indications, dermatologic applications, and potential complications.

## Overview of HOT

Hyperbaric oxygen therapy involves sitting or lying in a special chamber that allows for controlled levels of oxygen (O<sub>2</sub>) at increased atmospheric pressure, which specifically involves breathing near 100% O<sub>2</sub> while inside a monoplace or multiplace chamber<sup>5</sup> that is pressurized to greater than sea level pressure ( $\geq 1.4$  atmosphere absolute).<sup>2</sup>

A monoplace chamber is designed to treat a single person (Figure 1); a multiplace chamber (Figure 2) accommodates as many as 5 to 25 patients.<sup>5,6</sup> The chambers also accommodate hospital beds and medical attendants, if needed. Hyperbaric O<sub>2</sub> is inhaled through a mask, a tight-fitting hood, or an endotracheal tube, depending on the patient's status.<sup>7</sup> Treatment ranges from only 1 or 2 iterations for acute conditions to 30 sessions or more for chronic conditions. Individual sessions last 45 minutes to 5 hours; 120 minutes is considered a safe maximum duration.<sup>7</sup> A television often is provided to help the patient pass the time.<sup>8</sup>

## Long-standing Use in Decompression Sickness

Hyperbaric oxygen therapy is best known for its effectiveness in treating decompression sickness (DCS) and carbon monoxide poisoning. Decompression sickness involves liberation of free gas from tissue, in the form of bubbles, when a person experiences a relative decrease in atmospheric pressure, which results in an imbalance in the sum of gas tensions in tissue compared to ambient pressure.<sup>9</sup>

Decompression sickness has special military significance because it can affect divers and pilots, particularly those flying at high altitude. Over the course of 12 years, approximately 50 pilot trainees at an Air Force training site in Colorado required HOT when ground-level O<sub>2</sub> failed to resolve their DCS symptoms.<sup>10</sup>

Symptoms of DCS range from musculoskeletal pain to severe neurologic and pulmonary complications. First-line

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## Indications for Hyperbaric Oxygen Therapy<sup>2</sup>

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

therapy for DCS is 100% O<sub>2</sub> at ground level. When symptoms are severe or persistent, HOT is the treatment of choice. It works by decreasing the volume of air bubbles (as predicted by Boyle's Law), providing oxygenation to hypoxic tissue and mitigating inflammatory responses implicated in tissue injury<sup>9</sup>; HOT can be considered salvage treatment for rare, severe, or unresponsive complications of DCS during common activities such as diving and flying.

The emergent nature of DCS often necessitates an on-call, on-site HOT facility or contracted community services. Although DCS is a rare complication, it can be devastating, as was the case for a military pilot flying an ultrahigh altitude reconnaissance aircraft.<sup>11</sup> He developed a near fatal case of neurologic DCS during a military mission and required treatment with emergent HOT. Although his symptoms were reduced with therapy, he has persistent cognitive deficits.<sup>11</sup>

### Other Indications

**Dermatologic Flaps and Grafts**—Although less commonly discussed in dermatologic literature, the use of HOT in compromised grafts and flaps has been addressed in the plastic surgery literature. In a large multicenter study, researchers evaluated 20,821 Mohs micrographic surgery procedures and reported 149 adverse events, of which 20.1% were dehiscence and partial or full necrosis.<sup>12</sup> These complications, though rare, are potentially devastating, particularly in cosmetically sensitive locations



**FIGURE 1.** Monoplace chamber with patient. Photograph courtesy of E. George Wolf Jr, MD.



**FIGURE 2.** Multiplace chamber, with patient wearing a hood. These chambers have room for medical attendants. Photograph courtesy of E. George Wolf Jr, MD.

such as the face. Traditional care for compromised grafts and flaps includes local wound care, surgical debridement, and additional reconstructive procedures. These interventions can be expensive and uncomfortable for patients and carry risk for further morbidity.<sup>13</sup>

Grafts become compromised when their metabolic demand outpaces the ability of the recipient bed due to characteristics of the graft or the recipient bed or both. Flaps carry their own blood supply, which can be compromised if the flap is too long or too large for the pedicle, there is notable tension on the wound, or blood flow is mechanically obstructed by kinking or twisting. Under these conditions, HOT can be beneficial, as O<sub>2</sub> dissolves in plasma, thus improving the O<sub>2</sub> tissue cellular diffusion gradient.<sup>7</sup> An increased level of systemic O<sub>2</sub> promotes wound healing and graft or flap survival by improving fibroblast function, blood flow, and vascularity, and by mitigating ischemia-reperfusion injury.<sup>13</sup>

In a study, 105 patients with an ischemic flap or graft were treated with HOT; most (89% of threatened flaps and 91% of threatened grafts) were salvaged. In this series, the duration of latency from the creation of the flap to initiation of HOT was directly proportional to the failure rate of this treatment modality.<sup>14</sup>

**Radiation-Induced Ulceration**—Radionecrosis, a complication of radiotherapy, is caused by progressive obliterating endarteritis with resultant vascular stenosis and fibroatrophy, which eventually cause stromal fibrosis.<sup>15</sup> In a study that looked at 1267 nonmelanoma skin cancers that had been treated with radiotherapy, the ulceration rate was 6.3%. Most of the ulcerated lesions were treatable conservatively, but some were more treatment resistant.<sup>16</sup> Hampson et al<sup>17</sup> reported on 58 patients with cutaneous wounds due to soft-tissue radionecrosis who were treated with HOT as part of a larger observational case series in which investigators looked at multiple types of radionecrosis. They found that 76% of these patients improved: 26% showed complete resolution and the remaining 50% had 50% to 90% improvement.<sup>17</sup>

**Vasculitis or Autoimmune Ulceration**—Vasculitis and vasculopathy can occur independent of, or in association with, connective tissue disease and can result in chronic ulceration. At our institution, a patient with antimelanoma differentiation-associated protein 5 dermatomyositis who had refractory digital ulcerations despite intensive systemic therapy had an excellent response to HOT; ulcerations resolved after 37 treatments.<sup>18</sup>

Efrati et al<sup>19</sup> reported on 35 patients who had chronic nonhealing vasculitic ulcerations despite immunosuppression medication who were treated with HOT. Twenty-eight patients completely healed, 4 had partial healing, and 3 had no improvement.

Mirasoglu et al<sup>20</sup> reported on a case series of 6 systemic sclerosis patients who had ulcerations that persisted despite other treatments. After initiation of HOT, 4 patients experienced complete response and 2 experienced partial response, which is notable because such ulcerations are often extremely difficult to treat and have

usually failed multiple therapies before being addressed with HOT.

**Cutaneous Vascular Compromise**—At our institution, a 36-year-old man was referred to the dermatology clinic 2 days after undergoing embolization of a symptomatic arteriovenous malformation in the right knee (Figure 3A). The procedure was complicated by cutaneous purpura concerning for necrosis, a known complication of this procedure. We referred the patient for evaluation to consider HOT. Although he was outside the ideal window for starting treatment, HOT was initiated. With a late start in treatment, areas of skin had already progressed to full necrosis, which did not respond to treatment; however, contiguous areas that initially looked very similar clinically did respond to treatment (Figure 3B). This case suggests a penumbra-like effect in which vulnerable tissue that would most likely have been lost was salvaged by HOT.

**Ischemia**—Hyperbaric oxygen therapy has been used to treat ischemia caused by injection of cosmetic filler. Henderson et al<sup>21</sup> described a 37-year-old woman who experienced occlusion of the left superficial temporal artery while self-injecting a hyaluronic acid filler around the temples. The problem was complicated by left-sided hearing loss, cutaneous blanching of the left face, and pain. She was treated with enoxaparin, aspirin, dexamethasone, antibiotics, and intradermal lidocaine. Additionally, she was urgently referred to a HOT facility and was treated with 6 HOT treatments in 3 days, with the first treatment provided 15 hours after the initial insult. The patient showed a decrease in ischemic discoloration over the course of the treatment. Eventually, her hearing returned to baseline and she achieved an acceptable cosmetic outcome.<sup>21</sup>

Uittenbogaard et al<sup>22</sup> reported the treatment of a patient who experienced dermal ischemia after receiving calcium hydroxylapatite at an aesthetic clinic. She did not improve with standard treatment but subsequently experienced resolution of symptoms after treatment with HOT. She had an excellent cosmetic outcome at 6-month follow-up.<sup>22</sup>

**FIGURE 3.** A, Purpuric skin at presentation 2 days after the patient underwent embolization of a symptomatic arteriovenous malformation of the right knee. B, Several months after hyperbaric oxygen therapy, the medial aspect of the knee was fully necrosed at presentation, but the lateral aspect of the knee was salvaged.



## Complications and a Contraindication

Hyperbaric oxygen therapy generally is safe, but there is potential for complications.

**Fire**—This rare risk has a catastrophic outcome.<sup>23</sup> Standards for fire prevention in hyperbaric facilities are issued by the National Fire Protection Association, covering construction and building materials, lighting, electrical wiring, exposure to flammable materials, and other possible ignition sources.<sup>24</sup>

**Middle Ear Barotrauma**—The incidence of the most common adverse effect of HOT is reported at 2% to 30%.<sup>7,25</sup> Middle ear barotrauma occurs most commonly during the compression phase of treatment. It is more common in patients treated in a monoplace chamber because they are kept supine and are less able to regulate middle ear pressure.<sup>26</sup> Symptoms of middle ear barotrauma can be relieved by teaching patients autoinflation technique, such as the Valsalva maneuver, or by placing tympanoplasty tubes.<sup>27</sup>

**Reversible Myopia**—Caused by direct O<sub>2</sub> toxicity to the lens, this complication can last for weeks, though it eventually resolves spontaneously. Reversible myopia has been reported to be at least as common as middle ear barotrauma.<sup>27</sup>

**Other Complications**—Central nervous system complications, such as seizures, and pulmonary O<sub>2</sub> toxicity are rare, more serious complications.<sup>27</sup>

**Untreated Pneumothorax**—The only absolute contraindication to HOT, pneumothorax can decompensate during HOT if left untreated. However, HOT can proceed once pneumothorax is addressed.<sup>7</sup>

## Conclusion

Hyperbaric O<sub>2</sub> therapy can make a positive contribution to the dermatologic therapeutic armamentarium, in specific patients, for impending graft or flap failure, chronic wounds and ulcerations, and cutaneous vascular compromise. Although HOT is not a commonly needed treatment in dermatology, it is important to be aware of its potential because delay in treatment can decrease its effectiveness. It is recommended that dermatologists locate the nearest HOT facility and become familiar with its capabilities.

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