Role of Hyperbaric Oxygen Therapy in Spinal Pathologies

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ABSTRACT
Hyperbaric oxygen (HBO) therapy reduces hypoxia in tissues and significantly increases the phagocytic killing capacity of leukocytes. The efficiency of HBO therapy is currently being used in many areas, and has been proven in infections with deep and superficial location and osteomyelitis. Primary and postoperative infections of neurosurgical procedures may be difficult to treat and cause high morbidity and mortality. The efficacy of HBO treatment has been shown in such cases. In this study, we evaluate the place of HBO treatment in spinal infections.

KEY WORDS: Hyperbaric oxygen treatment, osteomyelitis, spine infections

INTRODUCTION
Hyperbaric oxygen therapy is a therapeutic procedure for diseases specified by oxygen and other gases under high atmospheric pressure in strict concordance with principles determined by Undersea and Hyperbaric Medical Society. Hyperbaric Oxygen (HBO) was first used by Dr. Orville to manage syphilis, cancer and rheumatoid arthritis but this therapeutic procedure was banned by the American Medical Society for ethical considerations (25). Albert Behenke published the first clinical study using HBO to treat diver’s disease in 1939 (29).

Boema developed a system in 1956 to use hyperbaric oxygen therapy for a different indication than diver’s disease. In his high-pressure operation room, he carried out surgeries on the brain and other vital organs by arresting the circulation. UHMS issued the therapeutic indications of HBO, after non-evidence based HBO therapies were implemented at many healthcare facilities worldwide (Table 1) (11,29,34).

Equipment of Hyperbaric Oxygen Therapy
HBO systems are divided into two groups as mono-place and multiple-place. Mono-place room systems are characterized by continuous pressure of 3 ATA and 100% oxygen. The most significant disadvantages of these systems include the fire risk and the difficulty in applying the therapeutic procedures. Multi-place systems allow admission of 2 to 14 patients concomitantly and patients inhale 100% oxygen via masks at 6 ATA pressure. Such systems are expensive but the patient’s comfort is better and practitioners may intervene if required.

Both systems include equipment to monitor the vital signs of the patients.

Mechanism of Action:
Briefly, hyperbaric oxygen exerts influence on tissues via four mechanisms (3). First, it increases oxygen saturation in ischemic tissue. Hyperbaric oxygen carried by fluids increases cellular oxygen concentration 3 times, and sustaining microcirculation apoptosis is hindered (18,19). Second, hyperoxygenization exerts a vasoconstrictor effect. Vasoconstriction alleviates vasogenic edema in the ischemic tissue and thus the capillary flow rate increases (5,21). Third, hyperbaric oxygen has a direct effect on infectious agents. Free oxygen radicals exert toxic effects directly on anaerobic bacteria such as Clostridium. This effect has minor significance for anaerobic bacteria. The principal
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Hyperoxygenization effect of HBO on tissues grows rapidly. Increasing the pressure of inhaled oxygen to 2 ATA boosts the blood oxygen concentration approximately 10 fold (34). Phagocytic capacity is normalized or boosted above normal range when intramedullary bone oxygen saturation is increased by HBO therapy (13), and the healing process is accelerated and facilitated by reinforcing neovascularization (6), fibroplasia and bone remodeling (16) in the ischemic tissue.

Side Effects of HBO:

Huang et al. reported a minor complication rate of 19.9% for patients who received HBO therapy for orthopedic pathologies, and added that major complications (epileptic seizure) may develop at a rate of 0.1 percent (18).

HBO therapy may result in various transient complications depending on high pressure. The most frequent ones include minimal and transient middle ear pressure balance problems, loss of vision and tympanic baro-trauma. There may also be potential side effects such as pneumocephalus, seizure and central nervous system toxicity (9,32). The complication rate may increase with increased number of sessions but no severe complication has been reported to date in studies conducted on HBO therapy.

Hyperbaric Oxygen Therapy in Spinal Infections

Spinal osteomyelitis is an important cause of morbidity and mortality. There are local and systemic risk factors. Systemic factors stem from the tendency to infections under immunosuppressive conditions such as immune system diseases, diabetes and chronic renal failure. Spondylodiscitis, osteomyelitis and epidural infections may develop in such cases. A surgical procedure is the primary local factor. All spinal surgeries are a predisposing factor for spinal infections. Spinal instrumentation and prolonged surgical procedures further increase the risk. The spinal infection risk is also an important problem for simple invasive spinal procedures (Table 2) (1,10,13,18,23,35).

Spinal infections cover a wide spectrum, ranging from simple soft tissue infections to epidural abscess, spondylodiscitis and osteomyelitis. Aggressive antibiotic therapy is the mainstay of the treatment in spondylodiscitis and osteomyelitis. Spinal instability, neurological findings of compression, and insufficient response to antibiotic therapy are indications of surgery. Muscle dissection, osteotomy and prolonged surgical procedures will decrease tissue perfusion in spinal surgeries. Surgical implants are important hosts

Table 1: Standardized therapy fields of HBO

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<th>Standardized therapy fields of HBO</th>
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<tr>
<td>• Air or gas embolism</td>
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<tr>
<td>• CO₂ intoxication</td>
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<tr>
<td>• Clostridial myositis and myonecrosis</td>
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<tr>
<td>• Tissue injury, compartment syndromes, acute traumatic ischemia</td>
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<td>• Decompression disease</td>
</tr>
<tr>
<td>• Facilitating wound healing</td>
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<tr>
<td>• Severe anemia</td>
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<tr>
<td>• Intracranial abscess</td>
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<tr>
<td>• Necrotizing fascits</td>
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<tr>
<td>• Refractory osteomyelitis</td>
</tr>
<tr>
<td>• Radiation necrosis</td>
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<tr>
<td>• Postoperative course of flap or tissue transplantation</td>
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<td>• Thermal burns</td>
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Oxygen concentration is lower in infected tissues and surgery wounds in comparison with healthy tissues (15). Low oxygen saturation not only slows down wound healing, but it also challenges controlling the infection, facilitates new bacterial growth and delays healing (7,10,15).
for infective agents. Although prophylactic antibiotherapy substantially minimizes such risks, postoperative infection is still a serious problem. For patients with infection, debridements, removal of the instrument or revision surgery are possible options along with pathogen-targeted antibiotherapy. All those therapeutic approaches can lead to prolonged hospitalization and severe complications.

The efficacy of HBO therapy in osteomyelitis treatment has been well known for a long time. Many case studies have demonstrated evidence for such efficacy (10,13,22,25,27).

Adjuvant HBO therapy is effectively used in primary and iatrogenic spinal infections. HBO reinforces the penetration of immune system elements into the tissue by increasing oxygen saturation at intervertebral disc spaces and osteomyelitis zones, where antibiotic agents can poorly penetrate (24,25,27). The risk of revision surgery is substantially minimized by HBO therapy along with aggressive antibiotherapy, especially for instrumentation cases (1). HBO therapy also minimizes the risk of pseudoarthrosis and possibility of instrument insufficiency in spinal fusion surgeries. Debridement and concomitant antibiotherapy, along with HBO therapy, may increase chances of recovery in spinal infections.

Tuberculosis causes a primary spine infection and is known to be resistant to treatment. It requires multi-disciplinary management because of a prolonged treatment period, resistance to antibiotic agents and morbidity risks. It may require surgical treatment to prevent deformity and neurological damage. HBO therapy is used as an adjuvant treatment in cases with tuberculosis osteomyelitis. Studies have reported a significant reduction in the rate of resistance to chemotherapy (35).

There is no study conducted on humans regarding HBO therapy for spinal cord trauma although its effect has been demonstrated in experimental studies and animal studies (20,36).

**Timing and duration of HBO therapy**

Studies so far have not reached a consensus on when to start the therapy and how long to continue it. At this point, the most important criterion is the lack of clinical and laboratory recovery with conventional therapies (33). Moreover, the presence of extra pathologies that are associated with immune deficiency such as diabetes mellitus, obesity, malnutrition and multi-organ failure etc. will influence the decision to start HBO therapy. There is no consensus on how long the HBO therapy will be maintained. The literature usually reports 10 to 40 sessions (7). Some studies prefer same number of sessions for all cases, whereas some studies report using different numbers depending on the type and severity of the infection (26,33).

**CONCLUSION**

Spinal infections can cause serious morbidity despite antibiotherapy and surgical debridement. Systemic infections and immunosuppressive disease also increase the incidence of spinal infections. Postoperative spinal infections may result in prolonged hospitalization, redo surgery and morbidity, negatively influencing success of the surgery. Infection may progress into osteomyelitis, particularly in spinal instrumentation surgeries. HBO is a reliable adjuvant therapy for osteomyelitis, refractory infection and iatrogenic spinal infections.
REFERENCES


