Original Article

Role of Hyperbaric Oxygen Therapy in Dental Surgery

Wg Cdr Arvind Sharma*

ABSTRACT

Hyperbaric Oxygen Therapy (HBOT) is increasingly being accepted as a beneficial adjunct to diverse clinical conditions. Non-healing ulcers, chronic wounds and refractory osteomyelitis are a few conditions for which HBOT has been extensively tried out. The dental surgeon has also found a good ally in HBOT in managing dental conditions. Between the year 1999 - 2002, 11 dental cases were referred to our centre for HBOT. These 11 cases have been divided in to three groups. Gp I had 3 cases of osteoradionecrosis (ORN) of the mandible. Gp II were 3 cases of post radiotherapy, who contrary to medical advise were in need to undergo dental surgery. Their dental surgeon wanted them to be administered HBOT as a prophylaxis prior to undertaking them for surgery. Gp III comprised 6 cases of refractory mandibular osteomyelitis. A mean of 34 HBO exposures (range 12 to 38), 11 exposures (range 10 to 14) and 28 exposures (range 17 to 40) were administered to Gp I, II and III respectively. All the 11 cases benefitted by HBOT. In Gp I extensive disfigurement and tissue ablation could be avoided, in Gp II there was no post dental extraction complication even 6 months after the surgery and in Gp III in all the 6 cases the discharge from the sinuses stopped with subsequent closure of the sinuses.

IJASM 2003; 47(1) : 23 - 29

KEY WORDS: HBOT, Osteoradionecrosis, Mandibular osteomyelitis, Radiotherapy,

Hyperbaric Oxygen Therapy (HBO) is a mode of treatment in which a patient breathes 100% oxygen intermittently while the treatment chamber's pressure is increased above 1 atmosphere absolute (ATA). The treatment can be carried out in either a mono or multiplace chamber. The Hyperbaric Oxygen Committee of Undersea Medical Society recognised the following medical and surgical conditions as the accepted conditions for Hyperbaric Oxygen Therapy:

Air or gas embolism

Carbon monoxide/cyanide poisoning

Crush injury, compartment syndrome and other acute traumatic ischemias

Decompression sickness

Enhancement of healing of selected problem wounds

Exceptional blood loss

Gas gangrene

* *Graded Specialist (Av Med), No 2 AMTC, AF, C/O AFA, Hyderabad 43*

Necrotizing soft tissue infections

Selected refractory anaerobic infections: actinomycosis

Skin grafts or flaps (compromised)

Osteomyelitis (refractory)

Radiation necrosis (osteoradionecrosis (ORN) and soft tissue radiation necrosis)

The No 2 AMTC has been treating several patients with the above-mentioned indications. This paper presents the experience at 2 AMTC, about the treatment of patients from the field of dental surgery viz. mandibular ORN and osteomyelitis.

Methodology

In last 3 years i.e., from 1998 to 2001, 11 patients were referred by dental surgeons in private practice, for Hyperbaric Oxygen (HBO) Therapy. The patients were evaluated clinically and accepted for HBOT. Baseline investigations were carried out and suitability of the patients was assessed for undergoing HBOT. Trial with oro-nasal mask was also carried out to test patient acceptance. Clinical conditions if any, like Thyroid disease and Insulin dependent Diabetes Mellitus were closely looked for and monitored for these conditions are known to hasten the onset of oxygen toxicity [6] Patients were suitably briefed about the procedure and valsalva manoeuvre was taught to them to help clear their middle ear in case of any requirement.

End points

The cases were regularly monitored, through out the treatment, for progress and improvement of their disabilities. Stoppage of discharge from the sinuses, closure of sinus and appearance of healthy granulation tissue were taken as end points. Care was also taken to monitor for any symptoms of oxygen toxicity.

Results

In the period Sep 1998 to Sep 2001, 03 types of dental cases (n=11) were received for Hyperbaric Oxygen Therapy. They were considered as 03 different groups Group 1 for cases of osteoradionecrosis (ORN); Group 2 for the cases who had undergone radiotherapy for an oral malignancy in the past, were free from ORN and were due for dental surgery at the time of presentation (Table: 1) The period elapsed since

Table 1 : Types of Dental Cases Treated with HBO

Group	Clinical Condition	Number of cases	Mean Time since radiotherapy
1	Osteo-radionecrosis (ORN)	03	6.7 months (range 03 to 10 m)
2.	Post-radiotherapy cases for prevention of ORN	03	54 months (range 08 to 60 n)
3.	Mandibular Osteomyelitis	05	----------

Table 2 : Number of HBO Sessions

Group	Clinical Condition	No. of HBO Sessions (mean)
1	Osteo-radionecrosis (ORN)	34 (range 12 to 38)
2	Post-radiotherapy cases for prevention of ORN	11 (range 10 to 14)
3	Mandibular Osteomyelitis	28 (range 17 to 40)

completion of radiotherapy, ranged from 03 to 10 months (mean = 6.7 m) in the Group 1 and from 08 to 60 months (mean = 54 m) in the Group 2 (Table: 1). Group 3 included 05 cases of mandibular osteomyelitis. All these were treated with HBO at 2.5 ATA for 90 minutes daily for 05 days in a week. The total number of HBO sessions was determined by the indictions of healing and by opinion of the treating surgeon. Table: 2 shows the total number of HBO therapy sessions given to these patients.

There were 3 cases of ORN in Group I. The treatment was found to be successful with Stage I of Marx protocol. A mean of 34 (range 12 to 39) exposures were given to get the required results. The exposed bone was found to soften with visible granulation tissue. This was followed by non-surgical debridement and 10 exposures of HBO.

The second Group comprised 3 post-radiotherapy cases. They had undergone radiotherapy in the past 54 months (range 8 to 60 months). All these cases had been advised against dental surgery to avoid post radiotherapy complications. However, these cases had developed dental problems which necessitated dental extraction. The dental surgeon, prior to accepting them for dental surgery decided to give HBOT as a prophylaxis. All these 3 cases underwent 10 sessions of HBOT followed by dental extraction. HBOT was found to be very beneficial as there was no post operative complication in any of the 3 cases. These cases were followed up for 6 months and no untoward complication was reported in them.

The third Group comprised 5 cases of mandibular osteomyelitis. 04 of these had undergone major surgery on mandible. They had developed features of osteomyelitis within 1 to 4 months of the surgery. These patients had been on treatment with medicines for a period ranging between 01 to 09 months, before being referred for Hyperbaric Oxygen Therapy. These cases were given 17 to 40 HBO sessions (mean = 28). Out of these there were 3 cases of osteomyelitis and in all 3 of them first the discharge stopped and then the sinuses healed and closed up. The fourth case had undergone hemimandibulectomy and reconstructive surgery with bone graft. At the time of presentation, besides the osteomyelitis, the mucosal cover over the graft was lost. After the Hyperbaric Oxygen Therapy, the mucosal defect was fully recovered besides closure of sinus.

The fifth case was an interesting example of how hypovascular tissue is more prone to infection and how Hyperbaric Oxygen Therapy can benefit these cases. This was a case of osteopetrosis, in which bones are known to be dense and brittle. The patient had undergone tooth extraction for dental caries, which led to osteomyelitis in the mandible. She had been on conventional treatment for osteomyelitis for last 03 months and had ended up with osteopetrosis. After 27 sessions of HBO, the sinus was closed without any recurrence.

Thus, in all six cases, what could not be achieved by conventional treatment alone was achieved when HBO complemented the former.

Discussion

The use of HBO has progressively increased in the treatment of osteomyelitis and ORN [2-5]. The beneficial effects of HBO result from an improved vascular supply, increased oxygen tension at the tissues. Adequate tissue oxygen tension also facilitates fibroblast proliferation, new capillary formation, osteogenesis and optimal polymorphonuclear leukocyte function [6-8]. Let us consider the role of HBO based on pathophysiology of the two conditions viz ORN and osteomyelitis.

Osteoradionecrosis

This literally means - bone death related to ionizing radiation. The tissues with a high rate of cell turnover, such as bone marrow and mucosa of GIT are extremely vulnerable to radiation and the injury is manifest early after exposure. Tissues with slower turnover rates-like cortical bones are not affected immediately after irradiation but are depopulated slowly because dividing cells cannot be replaced. The basic pathology of the process is progressive proliferative endarteritis with resultant tissue ischaemia. All these effects result in a tissue which is hypocellular, hypovascular and hypoxic. It is also called 3-H phenomenon. In soft tissue necrosis, surgical techniques allow repair by excision and reconstruction. However, in the radio necrosis involving mandible and maxilla, total surgical ablation would be disfiguring and reconstruction impossible. This necessitated the search for a non-surgical method that may salvage the bone.

Osteoradionecrosis (ORN) can be of 3 types:

1. **Spontaneous**. This occurs when the dose of radiation is high (>7400 cGy) enough to kill the bone cells. In such cases, bone dies and becomes exposed in first year after radiotherapy.

2. **ORN due to trauma preceding radiotherapy**- When radiation injury e.g. tooth extraction within 21 days prior to radiotherapy for oral cancers or mandibulotomy for assessing a cancer followed by radiotherapy.

3. **ORN due to trauma following radiotherapy**- This is the commonest type and is usually seen 3 or more year after radiotherapy, when a tooth is extracted. Due to progressiveness of radiation effects, tissues become 3-H with advancing years. Therefore when tissue is injured by dental extraction, surgery or by relentless infection and inflammation (periodontitis), it can't cope with the increase vascular nutritional and oxygen demands of healing. The bone dies and fails to heal.

Hyperbaric Oxygen Therapy for radiation-damaged tissue was introduced in 1973 by Greenwood and Gilchrist, Mainous et al [9-11] Marx RE in a landmark publication on osteoradionecrosis clarified the underlying pathophysiological process of late radiation tissue injury. This data paved the way for studies, many conducted by the same author(s), to determine the therapeutic mechanism of HBO [12-14]. It is known that hyperbaric oxygen increases the amount of oxygen in tissue fluids by a 10-fold factor [15]. This implies that oxygen can be delivered to the depths of a tissue where vascularity is poor or has been compromised. In addition, the HBO stimulates angiogenesis in the healing tissue. Marx et al produced statistically significant report that with HBO, angiogenesis could be produced in previously

irradiated tissue [16] Granstrom G et al produced the first reported evidence in 1993, about HBO induced angiogenesis in bone as well as soft tissue, by using laser Doppler flowmetry for the intraosseous blood flow measurement after irradiation, bone grafting and hyperbaric oxygen treatment [17].

The research, based on the above pathophysiology, produced a peri-operative HBO protocol. This "Marx Protocol" drives the modern application of HBO Therapy in ORN [18].

Marx protocol for treatment of ORN

Stage I : HBO at 2.4 ATA for 90 minutes. After 30 sessions, observe for softening of exposed bone and granulation tissue. If these are present, non-surgical debridement and follow with 10 more sessions of HBO.

Stage II : If little or no response after 30 sessions, accomplish peripheral resection of non-vital bone to bleeding bone margins. Complete the treatment with 10 post-operative HBO sessions.

Stage III : If the response is poor till stage II, resection of the mandible is done after 30 sessions of HBO. The mandible is stabilized by plates and pins and soft tissue deficit is covered with a flap followed by 10 more sessions of HBO followed by 3 months for healing. After this period, bony reconstruction can be undertaken as any non-irradiated patient.

Unplanned but required surgery in previously irradiated tissue is fraught with a known high incidence of potentially fatal complications [19]. Prophylactic HBO has changed this picture. Marx et al showed a statistically significant reduction in the development of ORN after tooth removal i.e. 29.9% of patients receiving penicillin in the perioperative (extraction) phase developed ORN versus only 5.4% in the HBO-treated group [20]. HBO can prevent most of ORN if used in a planned manner, in coordination with the treating surgeon.

(a) **Before radiotherapy.** For radiotherapy for orodental indications, all mandibular teeth that are in the path of beam are removed. Maxillary teeth need not be removed due to better vascularity. Ideally, radiotherapy should be delayed for at least 21 days after extraction, because the trauma predisposes to ORN. HBO hastens the healing of the injured tissue and prevents the ORN in subsequent radiotherapy.

(b) **After radiotherapy.** Any surgery can be undertaken within first 04 months after radiotherapy, because 3-H phenomenon has not yet fully developed. After 04 months, the normal tissue cells damaged by radiation have lived out their life span and have not been replaced by the daughter cells. This results in 3-H tissue. Any surgery on this tissue is bound to result in necrosis. The preoperative use of HBO will stimulate angiogenesis in the radiated tissue. The following protocol is recommended in post radiotherapy-preoperative period — Before surgery – 2.4 ATA × 90 min for 20 sessions and after surgery – 10 similar sessions.

In this study 3 cases comprised Group I. All the three cases of ORN benefited from HBOT. Stage I of Marx protocol was adequate to give them relief.

Similarly, in Group II, prophylactic use of HBOT in cases undergoing dental surgery following radiotherapy were found to recover without any complication.

Osteomyelitis

In chronic osteomyelitis refractory to the antibiotics and conventional treatment, the primary problem is an interface or barrier between the infection and the host. This barrier may be necrotic bone, suppuration, avascular scar or other oxygen barriers that preclude leucocyte, immunoprotein or antibiotic entry into the infection focus. HBO enhances permeation of the barrier by host factors and antibiotics [21-23]. HBO drives the host factors of leucocytic killing and osteoclastic resorption to occur [24]. Periodic elevation of bone and oxygen tension from hypoxic levels to normal or supranormal levels promotes fibroblastic

division, collagen production [7, 24]. Intermittent oxygen tensions of 30-40 mm Hg are necessary for neovascularisation in an ischaemic environment [25].

Osteoclastic resorption of the microscopic residuals of the dead, infected bone (microscopic surgical debridement) may be the crucial factor in eliminating the osteomyelitis focus and thereby prevent recurrences. The osteoclast has a metabolic activity approximately 100 times greater than that of the osteocyte; hence its function is highly oxygen dependent. The osteoclast function is stimulated by HBO as demonstrated in rabbit models [26]. Aminoglycoside transfer across the bacterial cell wall is oxygen - dependent and in a hypoxic environment, is enhanced by HBO therapy [4]. The surgical removal of all avascular tissue, necrotic bone and sinus tract is essential for treatment success. This is easy to practice where the interface between the dead / infected bone and the viable bone is clearly defined. However, such debridement is not without disfigurement, if facial bones are affected or when the osteomyelitis is of diffuse type. For these types of cases, HBO can obviate the need of such surgery and is the ideal adjunct to conventional treatment. Even if the patient of mandibular osteomyelitis has undergone disfiguring surgery, HBO is ideal to prepare a well vascularised tissue bed for reconstructive surgery. Further in the post-operative period HBO helps in faster healing and integration of the graft.

In this study all 6 cases of osteomyelitis referred for HBOT benefited from the therapy. What could not be achieved with conventional treatment could be achieved by using HBOT as an adjunct to the former.

Conclusion

This study has corroborated the findings of the other international workers that HBO is a valuable adjunct in the field of dental surgery, especially in the treatment of ORN and osteomyelitis. HBO prevents the ORN secondary to trauma, in post-irradiation phase. It is extremely useful in treatment of ORN and osteomyelitis by cutting short the total duration of treatment and obviating the need of repeated surgeries. In the overall analysis, HBO makes the treatment of these two conditions more economical, besides saving the patient from agony of protracted illness, multiple surgeries and resultant disfigurement. In our country, this mode of treatment still remains under utilized in the field of dental surgery. It is recommended that HBO facilities should be utilized for all such cases in the dental practice.

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