

HYPERBARIC OXYGENATION AFTER MICROVASCULAR TRANSFER OF FREE OSTEOCUTANEOUS GROIN FLAP: A PRELIMINARY STUDY

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유리장골 복합조직의 미세혈관이식수술후 고압산소요법에 대한 임상적 고찰

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하악골 골수염 및 방사선상 골괴사에 있어서 수술후 보조적인 요법으로 사용되는 Hyperbaric oxygen (HBO) therapy는 1956년 Boerema가 이에 대한 이론적인 제창 후 급속적인 발전을 해 왔으며, 또한 임상적으로 효과가 있는 것으로 보고되고 있다.

그러나, 이에 대한 미세혈관 수술후의 효과에 대해서는 그 보고가 드문것 같다. 이 보조적인 치료의 원리는 정상 및 허혈조직에서의 적절한 조직내 산소분압은 혈관 증식 및 골 재생에 도움이 되며, 또한 Hyperbaric oxygen에 의해 조직내 산소분압이 약간 증가하거나 또는 정상시에 bacteriostatic or bactericidal action을 가지게 되므로써 허혈성 골 및 연조직 치유를 증진시킨다.

이에 충남대학교 의과대학 구강·악안면외과학 교실에서는 미세혈관 수술에 의한 유리장골 복합조직을 이용한 하악골 재건후 hyperbaric oxygenation을 이용하여 다음과 같은 비교적 좋은 결과를 얻었다.

- 1) HBO therapy에 의한 전이 조직의 산소분압의 증가는 HBO therapy 전후의 전이 상피조직의 peripheral ischemic border의 color change를 reddish purple에서 slight fresh pink로 변화시키는 것으로 보아 vascularity를 증가시킨다.
- 2) HBO therapy는 free vascularized flap의 vascularity와 상피화 및 골 및 연조직 치유를 증진시킨다.

이에 저자들은 이 보조적인 요법이 허혈성조직에서의 조직내 PO_2 를 증진시키며 그것에 의해 microvascular free flap의 조직내 survival rate를 향상시키며 또한 술후의 wound breakdown을 막아준다는 것을 preliminary study로서 보고하는 바이다.

※ 본 논문은 1988년도 충남대학교 병원 임상연구비의 보조를 받은 것임.

INTRODUCTION

Hyperbaric oxygen (HBO) therapy as an adjunct to surgical treatment in the management of mandibular osteomyelitis^{4,6,20,28,30} and osteoradionecrosis^{3,7,11,15,19,22} has been rapidly developed after the theoretical proposal about the application of hyperbaric oxygenation by Boerema in 1956¹) and has been reported to be clinically beneficial.^{20,28})

But effects of hyperbaric oxygen on microvascular free flap have been reported rarely. The effect of hyperbaric therapy in improving healing is based on altered bone and soft tissue physiologic function^{8,25}) and its influence on the bacterial organisms involved.^{10,22})

At the Dept. of Oral and Maxillofacial Surgery of Chungnam National University Hospital, results of recent preliminary investigations of adjunctive hyperbaric oxygen on microvascular transfer of free osteocutaneous groin flaps for mandibular reconstruction have been encouraging.

This paper in preliminary study of 4 cases presents that the adjunctive treatment modality improves tissue PO_2 in a hypoxic wound, thereby enhancing tissue survival rate of microvascular free flap and preventing postoperative wound breakdown.

MATERIALS AND METHODS

The patients studied consisted of 4 individuals who underwent hyperbaric oxygenation after microvascular transfer of free osteocutaneous groin flap pedicled on deep circumflex iliac vessel (DCIV) for mandibular reconstruction.

The patient population include 2 males and 2 females.

Two patients were squamous cell carcinoma, one was verrucous carcinoma, and the last one was mucoepidermoid carcinoma. And the patients were operated and performed HBO therapy by the authors at the Dept. of Oral and Maxillofacial Surgery in Chungnam National University Hospital from 1986 to 1987.

The patients treated were evaluated with the partial pressure of oxygen (PO_2) of the arterial blood gas analysis (ABGA) and color change of peripheral ischemic border of transferred epithelium just before and after performing HBO therapy.

In our studies, 100% oxygen was administered at 2.0 to 2.4 ATA for 35 minutes during postoperative first day to sixth day for 4 to 5 treatments in a one-person chamber that is pressurized in a 100% oxygen environment (Fig. 1).



Fig. 1. One-person HBO chamber that is pressurized in a 100% O_2 environment.

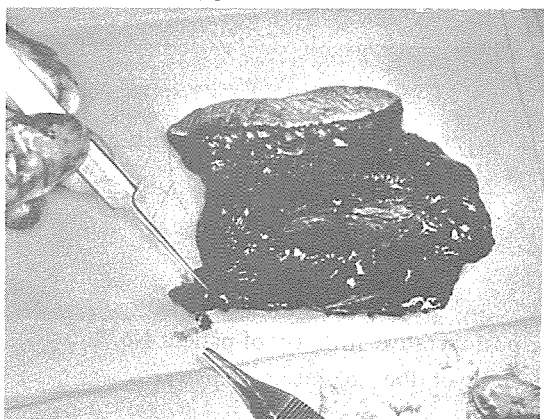
RESULTS

A total of 4 patients were operated by microvascular transfer of free osteocutaneous groin flap based on the deep circumflex iliac vessel (DCIV) for mandibular reconstruction (Fig. 2) and were evaluated with the partial pressure of oxygen (PO_2) and color change of peripheral ischemic border of transferred epithelium just before and after performing HBO therapy.

Collected data were shown in Table 1.

Adjunctive hyperbaric oxygen on microvascular transfer of free osteocutaneous groin flap has been shown relatively favorable results as follows.

1) Increased oxygen tensions in transferred



tissue by HBO therapy increased vascularity as shown in color change of peripheral ischemic border of transferred epithelium from reddish purple to slight fresh pink just before (average PO_2 : 64.5 mmHg) and after (average PO_2 : 106 mmHg) performing HBO therapy (Fig. 3) in all patients.

2) Hyperbaric oxygenation enhanced the vascularity of the free vascularized flap, epithelization and eventually soft tissue healing and osseous repair with preventing postoperative wound breakdown.

3) In severe infection, HBO therapy had no its effect and did not prevent necrosis in one patient.

Fig. 2. Free osteocutaneous groin flap based on the DCIV. The DCIA was identified, dissected free, and preserved in place with the composite graft.

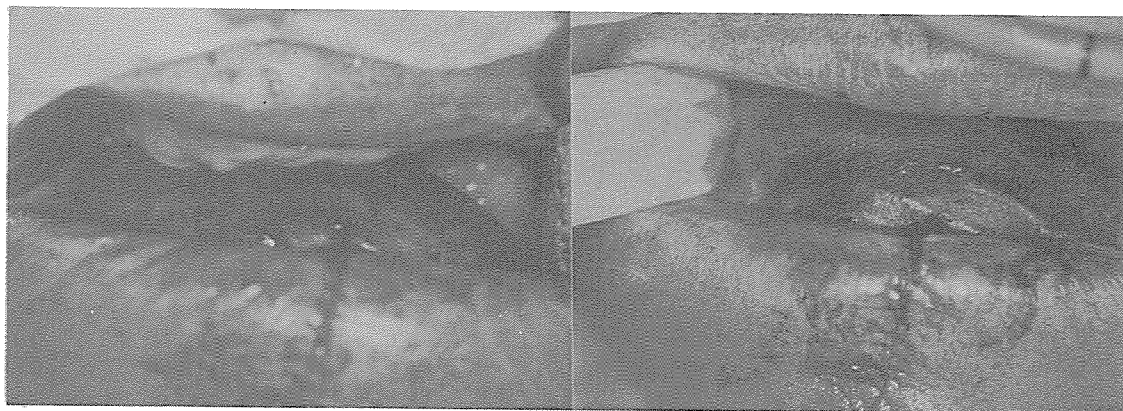


Fig. 3. Color change of peripheral ischemic border of transferred epithelium from reddish purple (left: Pre-HBO therapy) to slight fresh pink (right: Post-HBO therapy).



Fig. 4. Postoperative intraoral view of patient No. 1.
Note good epithelium and bone union.

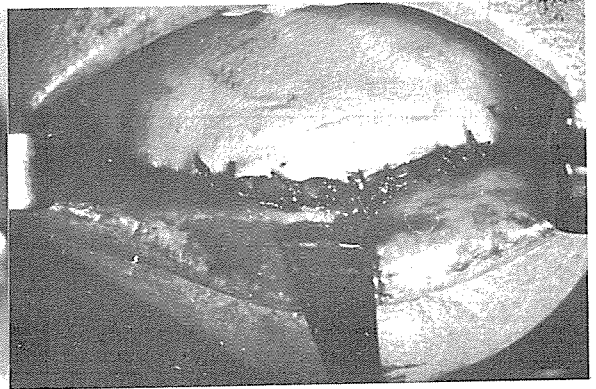


Fig. 5. Immediate-postoperative view of patient No. 2. HBO therapy was performed during postoperative first to fifth day.



Fig. 6. left; Partial skin deepithelization at postoperative fifth day of patient No. 2.
center; In removal of skin, muscle layer of the composite flap was produced sound bleeding.
right; Intraoral view after debridement.



Fig. 7. After debridement, the uneventful healing process of patient No. 2.
left; Mucosa growing over the sound muscle layer at postoperative 3 week
center; Mucosa growing at postoperative 5 week
right; Complete intraoral healing of good epithelization and bone union

Table 1. Clinical Data

Pt	Age/Sex	Diagnosis	Operation	Reconstruction		Microanastomoses		HBO therapy		Complication	Results
				Iliac bone	Groin skin	DCIA	Venae Comita.	PO ₂ (mmHg)			
				Mandible	Cover	End-to-end	End-to-side	Pre.	Post.		
1.	65/M	Sq. cell Ca.	RND Mandibulectomy Tracheostomy	Rt. Coronoid P. -- 3	Buccal mucosa	Lingual A.	Internal jugular V.	68	115	Peripheral skin deepithelization	Good epithelium bone union *
2.	64/F	Verrucous Ca.	Mandibulectomy Tracheostomy	4 - 4	Anterior floor	Facial A.	Facial V.	61	111	Partial skin deepithelization	Good epithelization bone union #
3.	60/M	Recurrent Sq. cell Ca.	RND Mandibulectomy Tracheostomy	Rt. Coronoid P. -- 4	Lateral floor	Superior thyroid A.	External jugular V.	65	106	No	Good
4.	58/ F	Mucoepi- dermoid Ca.	RND Mandibulectomy Tracheostomy Expanded temporal flap	Rt. Ramus - 5	Facial skin	Superior thyroid A.	External jugular V.	64	91	Infection : Removal of skin & bone	Alloplastic graft (Resin + metal)

* : Fig. 4. , # : Fig. 5. 6. 7.

DISCUSSION

Hyperbaric oxygenation refers to the inhalation of oxygen under conditions in which the pressure of the surrounding breathing mixture is greater than atmospheric pressure²⁰⁾ that is to say, intermittent short-term, high-dose oxygen inhalation therapy. Hyperbaric oxygen (HBO) therapy has been rapidly developed after the theoretical proposal about the application of hyperbaric oxygenation by Boerema in 1956.¹⁾ In Oral and Maxillofacial field, Slack performed HBO therapy as an adjunctive treatment of chronic mandibular osteomyelitis in 1965.³¹⁾ The successful use of HBO as an adjunct to intensive surgical and antibiotic therapy in the treatment of osteoradionecrosis of the mandible has also been reported by Mainous, Boyne, and Hart.^{11,19,20)}

In hyperbaric oxygenation, the increase in arterial oxygen tension leads to an increase in tissue oxygen tensions in both normal and ischemic tissues.^{18,19)}

The rationale of HBO therapy is threefold.

First, adequate tissue oxygen tensions are necessary for fibroblast proliferation,³⁰⁾ and new capillary synthesis,^{13,30)} therefore resulting in vascular proliferation.²⁶⁾ Collagen provides the framework for capillary bud formation, capillary arcing, and finally obliteration of avascular or ischemic space. This is a continuous, dynamic process that moves inward from the wound margins.¹⁴⁾ Secondly, optimal oxygen tension is necessary for bone osteogenesis.²⁶⁾ When the partial pressure of oxygen (PO_2) is raised, the rationale for the use of hyperbaric oxygen is based on favorable event. These include osteoclastic and osteoblastic activity to remodel bone, callus formation and mineralization, therefore improving osseous repair.³²⁾ Third, the slightly increased or normal tissue oxygen tensions produced by hyperbaric oxygen

have a bacteriostatic or bactericidal effect.¹²⁾ Growth of aerobic and anaerobic organisms is enhanced in ischemic or avascular tissues. Hyperbaric oxygen under standard treatment pressure has an indirect effect against aerobic and probably anaerobic organisms.²⁷⁾ Molecular oxygen is reduced by autoxidation reactions to superoxide and then reduced to hydrogen peroxide.¹²⁾ Superoxide and hydrogen peroxide are directly toxic to most anaerobic organisms, which lack the protective enzymes superoxide dismutase and catalase.²⁴⁾ Adequate tissue oxygen tensions are necessary for polymorphonuclear leukocytes to kill aerobic and probably anaerobic organisms optimally, but HBO effectiveness may have been disguised because the compound fractures communicated with the oral cavity and allow continual bacterial repopulation of the wound.

The effect of hyperbaric therapy in improving healing is based on altered bone physiologic function^{8,25)} and its influence on the bacterial organism involved.^{10,22)}

Therefore, hyperbaric oxygen in a hypoxic wound produces a favorable response by

- 1) enhancing leukocyte killing
- 2) rapid osteogenesis of large lytic area
- 3) the formation of beds of healthy granulated tissue over the viable bone.
- 4) favoring neovascularization, epithelization, collagen synthesis and eventually reduction in the destruction of hard and soft tissue.
- 5) shortening healing time

In clinical trials, the HBO exposures are usually limited to 2.0 to 2.4 ATA because of the possibility that the oxygen toxicity may develop.

Oxygen toxicity is nonspecific and can affect all tissues of the body if sufficiently high concentrations are used. In clinical use, breathing 100% O_2 2.0 to 2.4 ATA for 35 minutes daily, for 4 to 5 days, has not produced any of the major complications of oxygen toxicity except for otalgia or ear bleeding.

It must be emphasized that hyperbaric oxygen is an adjunctive therapy. Authors stressed that successful treatment of microvascular transfer of free osteocutaneous groin flap was related to a combination of several factors. First, the diameter of anastomosed vessel is large and technique of anastomoses is skillful. Histologically, endarteritis, hyalinization, thrombosis of small vessel and finally fibrosis occurs.⁵⁾ These changes are progressive and result in gradual devitalization of bone. When the blood supply becomes critical, necrosis develops. Second, the periosteum around the resection site is totally intact and thereby is able to provide the basis for osteogenesis.¹⁶⁾

Third, adequate mandibular stabilization should be present during the entire healing phases. This allows for undisturbed vascular and osteoblastic proliferation. Fourth, the infection should be arrested by aggressive, specific, parenterally administered and oral antibiotic therapy, and intensive surgical management with daily irrigations, in combination with hyperbaric oxygen.

At present, our data strongly encourage the use of HBO therapy as soon as possible when microvascular surgery was operated. The use of hyperbaric oxygen therapy appears to have a definite place in the future management of patient with microvascular free bone graft for mandibular reconstruction.

SUMMARY

For successful treatment of microvascular free flap, several factors engage in improving healing. Hyperbaric oxygenation as an adjunct is one of them and its effect is based on altered bone physiologic function and its influence on the bacterial organisms involved.

At the Dept. of Oral and Maxillofacial Surgery of Chungnam National University Hospital, ob-

servations and findings of preliminary investigation of adjunctive hyperbaric oxygenation on micro-vascular transfer of free osteocutaneous groin flap pedicled on deep circumflex iliac vessels were as follows.

1. Increased oxygen tension in transferred tissue increased vascularity as shown in color change of peripheral ischemic border of transferred epithelium from reddish purple to slight fresh pink just before the after performing HBO therapy.
2. Hyperbaric oxygenation enhanced the vascularity, epithelization of microvascular free flap and eventually soft tissue healing and osseous repair by increasing tissue PO_2 in a hypoxic wound.

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