

Ebru Topuz · Ozgur Yigit · Ugur Cinar · Huseyin Seven

Should hyperbaric oxygen be added to treatment in idiopathic sudden sensorineural hearing loss?

Received: 20 February 2003 / Accepted: 1 September 2003 / Published online: 29 October 2003

© Springer-Verlag 2003

Abstract At present, there is still no agreement about the therapy of idiopathic sudden sensorineural hearing loss (ISSHL). Hyperbaric oxygen (HBO) is used in the therapy of ISSHL to increase the partial oxygen pressure and the oxygen concentration in the inner ear and also to improve the blood profile and the microcirculation. In our prospective randomized study, we aimed to investigate the therapeutic effects of HBO therapy in the 1st 2 weeks of the onset of ISSHL. Fifty-one hospitalized patients with confirmed ISSHL who had received therapy were grouped randomly into two groups. Twenty-one patients (group I) received steroids, plasma expander dextrans (rheomacrodex), diazepam, pentoxifylline and salt restriction, and 30 patients (group II) received the same basic treatment with the addition of HBO therapy. Audiological assessments of the patients were performed before and after the treatment. The hearing gains at frequencies of 250, 500, 1,000, 2,000 and 4,000 Hz were calculated separately. The level of hearing loss at the five frequencies was assessed in three groups at the first visit: equal or below 60 dB, between 61–80 dB and equal or above 81 dB. The average of the mean hearing gains at the five frequencies of the patients according to the age groups in group II was compared. The mean hearing gains at the five frequencies were compared between the two groups, and statistically significant improvement was detected in all the frequencies except at 2,000 Hz in group II. The mean hearing gains in group II were found to be significantly high in patients with initial hearing levels up to 60 dB in comparison to patients with initial hearing levels below 60 dB. When age groups and mean hearing gains were compared, there was

no statistically significant difference in group I. In group II, the mean hearing gains were 39.1 ± 18.3 dB in patients younger than 50 years and 22.7 ± 11.3 dB in patients older than 50 years ($P=0.044$). In conclusion, the addition of HBO therapy to conventional treatment modalities significantly improves the outcome of ISSHL, especially at the frequencies of 250, 500, 1,000 and 4,000 Hz and in hearing loss of above 61 dB. Furthermore, HBO therapy was found to be more effective in patients younger than 50 years.

Keywords Sudden hearing loss · Hyperbaric oxygen · Treatment

Introduction

Treatment of idiopathic sudden sensorineural hearing loss (ISSHL) is still a problem for the otologist. When a cause of sudden sensorineural hearing loss is clear, the treatment is specific. When a cause cannot be found, treatment of ISSHL is much more controversial. There are a number of different theories trying to explain the pathophysiology of ISSHL. Infectious, traumatic, neoplastic, immunological, toxic, circulatory, neurological, metabolic and other disorders can produce sudden sensorineural hearing loss. Viral diseases and circulatory impairment are the most popular theories of etiology. Although circulatory impairment of the cochlea would seem to be an obvious cause of ISSHL, definitive proof is lacking [4]. Although many treatment regimens have been proposed for ISSHL, prospective, controlled trials have not yet confirmed a significant benefit from treatment with any medication compared with spontaneous recovery [4]. The empirical use of all drugs is mainly based on improving the blood circulation and restoring the oxygen tension of the inner ear [2].

The use of hyperbaric oxygen in the treatment of ISSHL is intended to increase the partial oxygen pressure and oxygen concentration in the inner ear and to improve the microcirculation and the blood profile [7]. Lamm et al. [8] reported that under hyperbaric conditions, oxygen inhalation increases the oxygen tension of the perilymphatic

E. Topuz · O. Yigit · U. Cinar · H. Seven
Department of Otolaryngology,
Sisli Etfal Teaching and Research Hospital, Istanbul, Turkey

O. Yigit (✉)
Beyazitaga Mah., Kalburcu Cesmesi Sok,
No.19, Sehremini, 34280 Istanbul, Turkey
Tel.: +90-212-5309580, Fax: +90-212-2341121,
e-mail: dryigit@hotmail.com

Table 1 Initial and final mean hearing levels at five frequencies in patients in group I and II

Frequency	Group I			Group II		
	Initial mean hearing levels (dB)	Final mean hearing levels (dB)	Mean hearing gains (dB)	Initial mean hearing levels (dB)	Final mean hearing levels (dB)	Mean hearing gains (dB)
250 Hz	67.6±20.03	54.8±24.97	12.8	70.4±18.48	40.4±23.84	30
500 Hz	72.6±19.97	53.1±23.85	19.5	73.7±22.57	35.9±21.55	37.8
1,000 Hz	70.7±20.39	50.5±24.54	20.2	70.4±24.75	34.6±22.91	35.8
2,000 Hz	69.5±15.48	49.0±16.02	20.5	67.8±31.55	35.9±23.34	31.9
4,000 Hz	72.1±18.13	58.1±20.76	14	69.7±30.79	38.7±22.97	31
Mean	70.5	53.1	17.4	70.4	37.1	33.3

Table 2 Comparison of mean hearing gains at five frequencies in patients in group I and II

Frequency	Group I Mean hearing gains (dB)	Group II Mean hearing gains (dB)	<i>P</i> value
250 Hz	12.85±11.46	30.00±22.49	0.002**
500 Hz	19.52± 8.64	37.79±19.50	0.0001**
1,000 Hz	20.23± 8.58	35.88±19.59	0.0001**
2,000 Hz	20.48±12.44	31.91±24.21	0.083
4,000 Hz	14.05±20.77	31.03±25.09	0.012*

*Statistically significant, **statistically very significant

fluid by 450% of its initial value, and this state remains for 1 h after termination of the HBO. Arterial oxygen is diffused from the capillary into the inner ear fluids, and increased arterial partial oxygen saturation influences the oxygen tension of the inner ear [8]. Nagahara et al. [9] also reported that the perilymphatic oxygen tension decreases in patients with ISSHL. Aslan et al. [2] showed that the addition of HBO therapy to the conventional treatment significantly improves the outcome of ISSHL.

In this study, we aimed to investigate the efficacy of the addition of HBO therapy to conventional treatment in patients with ISSHL.

Materials and methods

Fifty-one hospitalized patients with ISSHL were prospectively grouped at random as group I and group II between 1998–2002. All patients were admitted to the hospital within 2 weeks after the onset of ISSHL. A hearing loss of 30 dB or greater in at least three contiguous frequencies formed the audiometric inclusion criterion. Twenty-one patients (group I) received prednisone at an initial dosage of 1 mg/kg per day for 2 weeks, rheomacrodex 500 ml/d (i.v. infusion in 6 h) for 5 days, diazepam 5 mg p.o twice a day and

pentoxiphyllin 200 mg i.v twice a day. Thirty patients (group II) received the same basic treatment with the addition of HBO therapy. HBO therapy was applied in a double-cabin pressure chamber (Haux Stormed, 1998) with a capacity for 14 patients and a maximum internal pressure of 6 atm. The air pressure in the chamber was maintained at 2.5 atm for 90 min. HBO therapy was administered twice daily for the 1st 5 days and then once a day for 15 days. Group I was made up of 21 ISSHL out of 21 patients, and group II 34 ISSHL out of 30 patients. Audiological assessments of the patients were performed before and 4 weeks after treatment. All patients were evaluated with pure-tone audiometry. The hearing gains at frequencies of 250, 500, 1,000, 2,000 and 4,000 Hz were calculated separately for each patient. Then, mean values of the hearing gains for each frequency were calculated in groups. The mean hearing gains at the five frequencies were compared between the two groups. The level of the hearing loss at the five frequencies was assessed in three groups at the first visit: equal or below 60 dB, between 61–80 dB and equal or above 81 dB. The average of the mean hearing gains at the five frequencies of the patients in groups according to the distribution of the levels of hearing loss was compared. The average of the mean hearing gains at five frequencies of the patients according to age groups in group II was compared. Data of the study was evaluated using descriptive statistical methods (mean, standard deviation) as well as the Student's *t* test, Mann Whitney U test and chi-square test.

Results

The study included 21 patients (12 males, 9 females; mean age 40.4±11.2 years, range 13 to 75 years) in group I and 30 patients (14 males, 16 females; mean age 42.1±13.4 years, range 15 to 71 years) in group II. Initial and final mean hearing levels at the five frequencies of patients in group I and II are presented in Table 1. The mean hearing gains at the five frequencies were compared between the two groups, and statistically significant improvement was detected in all the frequencies except at 2,000 Hz in group II (Table 2). The distribution of mean hearing gains according to initial hearing levels is presented in Table 3. The average of the mean hearing gains at the five frequencies in

Table 3 The distribution of mean hearing gains according to initial hearing levels

Initial hearing levels (dB)	Group I		Group II		<i>P</i> value
	Number of ISSHL (<i>n</i> =21)	Mean hearing gains (dB)	Number of ISSHL (<i>n</i> =34)	Mean hearing gains (dB)	
≤60	6	22.33±9.31	13	22.53±12.68	0.758
61–80	11	16.18±9.00	11	35.45±22.09	0.014*
≥81	4	13.00±6.58	10	50.70±21.54	0.005**

*Statistically significant,

**statistically very significant

Table 4 Comparison of mean hearing gains of patients in group II according to age groups

Age groups	Number of ISSHL (<i>n</i> =34)	Mean hearing gains (dB)	<i>P</i> value
≤50	26	39.12±18.36	0.044*
>50	8	22.75±11.39	

*Statistically significant

group II was found to be significantly high in patients with initial hearing levels up to 60 dB in comparison to patients with initial hearing levels below 60 dB. Comparison of the average of the mean hearing gains of patients at the five frequencies in group II according to age groups is presented in Table 4. In group II patients, the average of the mean hearing gains at the five frequencies was found to be significantly high in patients younger than 50 years in comparison to patients older than 50 years.

Discussion

Various treatments have been applied in ISSHL treatment for the correction of cochlea microcirculation. These are stellate ganglion blockage, vasodilators, anticoagulant agents, plasma expanders and corticosteroids. Diuretics, sedatives, adenosinetriphosphate and antiviral agents have also been used. All these medications are used to improve blood circulation and to increase oxygen pressure in the inner ear.

Pioneer work on the role of HBO in disorders of the inner ear was done by Lamm and Klimpel [5] and by Apaix and Demard [1] in 1970. The therapeutic usefulness of HBO in ISSHL also has also been confirmed by other authors [2, 13]. HBO improves the results of the conventional treatment of ISSHL, and best results are achieved if the treatment is started early after the onset of deafness [11]. The fact that the spontaneous recovery rate is as high as 90% makes the selection of patients for therapy and the evaluation of results particularly difficult.

Lamm et al. [6] showed that HBO increased the pO₂ in the inner ear. In their experimental study, the animals were placed in the hyperbaric chamber and, after it was flooded with oxygen at normal pressure, pO₂ was noted to increase by 204%; when pressure was raised to 1.6 bars, pO₂ increased by 563% as compared with the original value. In their study, Lamm et al. also demonstrated that after the inhalation of pure oxygen under normobaric circumstances, the oxygen tension of the perilymphatic fluid in guinea pigs acutely returned to the initial value. However, under hyperbaric conditions, oxygen tension of the perilymphatic fluid increased to 450% of its initial value, and after termination of the HBO, it was found to be significantly high for 60 min. Goto et al. [3] reported that standard treatment of stellate ganglion blockage and HBO therapy together were most effective in the treatment of ISSHL.

Aslan et al. [2] investigated the therapeutic effects of the addition of HBO therapy to conventional therapy and stellate ganglion blockage with lidocaine in ISSHL. They

reported that the addition of HBO therapy to the conventional treatment significantly improved the outcome of ISSHL, especially in patients younger than 50 years. They also found that additional HBO therapy provided limited benefits in patients older than 50 years and no benefit in patients older than 60 years. Takahashi and Kobayashi [12] also reported that addition of HBO therapy to the conventional therapies improved the outcome of ISSHL. Nakashima [10] showed that HBO therapy as a secondary treatment modality applied after unsuccessful conventional treatment also proved to be unsuccessful.

In our study, the average of the mean hearing gains at five frequencies was found to be 17.4 dB in group I and 33.3 dB in group II. Improvement after treatment was found to be statistically significant in both groups at frequencies of 250, 500, 1,000, 2,000 and 4,000 Hz. The mean hearing gains at the five frequencies were compared between the two groups, and statistically significant improvement was detected at 250, 500, 1,000 and 4,000 Hz of group II. This result indicated that HBO therapy was effective even in high frequencies of ISSHL. The distribution of the average of the mean hearing gains at the five frequencies according to the average of the initial hearing levels at the five frequencies was classified. The average of the mean hearing gains at the five frequencies in group II was found to be significantly high in patients with initial hearing levels up to 60 dB in comparison to patients with initial hearing levels below 60 dB. In patients whose initial hearing levels were between 61–80 dB, the average of the mean hearing gains was found to be 16.18 dB in group I and 35.45 dB in group II (*P*=0.014). In patients whose initial hearing levels at five frequencies were up to 81 dB, the average of the mean hearing gains was found to be 13.00 dB in group I and 50.7 dB in group II (*P*=0.005). This result indicated that HBO therapy was more effective in patients with initial hearing levels at five frequencies up to 60 dB. The average of the mean hearing gains at the five frequencies of patients in group II according to age groups was compared. The average of the mean hearing gains at the five frequencies was found to be 39.12 dB in patients younger than 50 years and 22.7 dB in patients older than 50 years. This result indicated that HBO therapy was more effective in patients younger than 50 years.

Conclusions

The therapeutic usefulness of HBO in ISSHL was confirmed in this study. HBO therapy improved the results of conventional therapy for ISSHL when the treatment was started early after the onset of ISSHL. In conclusion, the addition of HBO therapy to conventional treatment modalities significantly improves the outcome of ISSHL, especially at the frequencies of 250, 500, 1,000 and 4,000 Hz and in hearing loss of above 61 dB. Furthermore, HBO therapy was found to be more effective in patients younger than 50 years. Hyperbaric oxygen should be added to treatment in ISSHL, especially in patients with initial hearing levels at five frequencies up to 60 dB.

References

1. Appaix A, Demard F (1970) Hyperbaric oxygenotherapy and sudden perceptive deafness. *Rev Laryngol Otol Rhinol (Bord)* 91:951–972
2. Aslan I, Oysu C, Veyseller B, Baserer N (2002) Does the addition of hyperbaric oxygen therapy to the conventional treatment modalities influence the outcome of sudden deafness? *Otolaryngol Head Neck Surg* 126:121–126
3. Goto F, Fujita T, Kitani Y, Kanno M, Kamei T, Ishii H (1979) Hyperbaric oxygen and stellate ganglion blocks for idiopathic sudden hearing loss. *Acta Otolaryngol* 88:335–342
4. Hughes GB (1998) Sudden hearing loss. In: Gates GA (ed) *Current therapy in otolaryngology-head and neck surgery*, 6th edn. Mosby, St. Louis, p 41
5. Lamm H, Klimpel L (1971) Hyperbaric oxygen therapy in internal ear and vestibular disorders. Preliminary report. *HNO* 19:363–369
6. Lamm C, Walliser U, Schumann K, Lamm K (1988) Oxygen partial pressure measurements in the perilymph and scala tympani in normo- and hyperbaric conditions. An animal experiment study. *HNO* 36:363–366
7. Lamm K, Lamm H, Arnold W (1998) Effect of hyperbaric oxygen therapy in comparison to conventional or placebo therapy or no treatment in idiopathic sudden hearing loss, acoustic trauma, noise-induced hearing loss and tinnitus. A literature survey. *Adv Otorhinolaryngol* 54:86–99
8. Lamm K, Lamm C, Arnold W (1998) Effect of isobaric oxygen versus hyperbaric oxygen on the normal and noise-damaged hypoxic and ischemic guinea pig inner ear. *Adv Otorhinolaryngol* 54:59–85
9. Nagahara K, Fisch U, Yagi N (1983) Perilymph oxygenation in sudden and progressive sensorineural hearing loss. *Acta Otolaryngol* 96:57–68
10. Nakashima T, Fukuta S, Yanagita N (1998) Hyperbaric oxygen therapy for sudden deafness. *Adv Otorhinolaryngol* 54:100–109
11. Pilgramm M, Lamm H, Schumann K (1985) Hyperbaric oxygen therapy in sudden deafness *Laryngol Rhinol Otol (Stuttg)* 64:351–354
12. Takahashi H, Kobayashi S (1998) New indications for hyperbaric oxygen therapy and its complication. *Adv Otorhinolaryngol* 54:1–13
13. Vincey P (1978) Application and use of hyperbaric oxygenation in ENT. *Rev Laryngol Otol Rhinol (Bord)* 99:619–634