



Original Article

Hyperbaric Oxygen Therapy as Salvage Therapy for Sudden Sensorineural Hearing Loss

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OBJECTIVE: To measure the effect of hyperbaric oxygen (HBO) therapy as salvage therapy after the failure of steroid therapy for sudden sensorineural hearing loss (SSNHL).

MATERIALS and METHODS: Ninety-three patients with SSNHL were unsuccessfully treated with systemic steroid therapy. Following steroid therapy, 43 patients received additional HBO therapy while 50 did not. Hearing levels at 0.25, 0.5, 1, 2, 4, and 8 kHz before and after therapy were measured.

RESULTS: A significant difference in hearing thresholds after HBO therapy was found at all frequencies in patients with a hearing loss of >61 dB. The group of patients with a hearing threshold of ≤60 dB had a significant improvement only at 250 and 500 Hz, while group of patients without additional therapy control group showed no hearing improvement.

CONCLUSION: Hyperbaric oxygen therapy as salvage therapy for SSNHL showed some benefits in hearing improvement. Better results could be expected in patients with severe hearing loss, while in patients with mild-or-moderate hearing loss, recovery should be expected only at low frequencies.

KEYWORDS: Hearing loss, sudden, hyperbaric oxygen therapy, salvage therapy

INTRODUCTION

Sudden sensorineural hearing loss (SSNHL) is defined as hearing loss of greater than 30 dB over three contiguous pure-tone frequencies occurring within a three-day period^[1]. Diverse pathologic processes have been suggested as possible causes of SSNHL: viral infections, circulatory disorders, and autoimmune reactions^[2]. However, in most cases, the real cause of SSNHL remains unknown. Different therapeutic agents such as vasodilator, anticoagulant, plasma expander, steroid, and hyperbaric oxygen (HBO) therapies have been used^[3-7]. Although limited evidence on their effects is available, clinical trials for most of these therapies are rare. Although results regarding their efficacy are inconsistent, steroid therapy is mostly used and is one of the few therapies shown to be successful^[7,8]. While some randomized, double-blind, placebo-controlled studies have reported that steroid therapy is successful, other studies have not confirmed these results^[8-10]. The success rate of the initial steroid therapy depends on many factors such as the severity of the initial hearing loss and time when the therapy is initiated time of the onset of therapy. These factors could be the reason for discrepancies in results. In cases where initial therapy has no result, salvage therapy is used. HBO and intratympanic steroid therapies are mostly used as salvage therapy after the failure of initial steroid therapy.

Hyperbaric oxygen therapy for sudden hearing loss SSNHL was first introduced in the 1970s.^[11] It was found that perilymphatic oxygen tension decreased in patients with SSNHL, while under hyperbaric conditions, oxygen tension in the perilymphatic fluid increased by 450%^[12,13]. These days, HBO therapy is used as primary or as salvage therapy for sudden hearing loss^[14-16]. However, the results of salvage HBO therapy for SSNHL vary among studies, and its efficacy is still unclear. The aim of this study was to compare the effect of HBO therapy as salvage therapy and compare it to patients not receiving additional therapy.

MATERIALS and METHODS

This retrospective study included data obtained from patients admitted to a hospital between 2009 and 2015 for SSNHL treatment. A total of 93 patients with SSNHL were enrolled. Forty-three patients underwent HBO therapy after the failure of steroid therapy. Fifty patients were unsuccessfully treated with steroid therapy and did not undergo HBO therapy as it was unavailable or they refused it. All patients met the criteria for the diagnosis of sudden hearing loss: sudden onset of sensorineural hearing loss, unknown cause of hearing loss, and average hearing level of greater of 30 dB at 250, 500, 1000, 2000 and 4000 Hz. Therapy was initiated within 20 days of the onset of hearing loss. The pure-tone average was calculated prior to and after corticosteroid therapy; a hearing gain of less than 10 dB was considered as therapy failure. All patients received steroid therapy [intravenous methylprednisolone sodium

Table 1. Clinical characteristics of patients with SSNHL

Patients	HBO therapy group	Group without additional therapy
No. of patients	43	50
Age, years (mean)	53.2±19.4	55.5±22.2
Sex (male/female)	21/32	23/25
Initial mean hearing level (dB)	80.57±5.14	75.52±9.42
Days from onset of SSNHL to the initiation of steroid therapy	11.4±8.12	13.2±6.52
Days from the end of steroid therapy to the initiation of HBO therapy	23±19.1	

HBO: hyperbaric oxygen therapy; SSNHL: sudden sensorineural hearing loss

Table 2. Mean hearing levels before and after HBO therapy at six frequencies (43 patients)

Frequency	Initial mean hearing levels (dB)	Mean hearing levels after HBO therapy (dB)	p
250 Hz	64.3±27.52	42.3±29.17	0.0003*
500 Hz	66.1±29.11	46.2±29.26	0.0008*
1000 Hz	49.4±35.23	48.5±31.92	0.828
2000 Hz	47.6±31.94	47.5±34.12	0.97
4000 Hz	51.2±36.72	51.4±33.51	0.97
8000 Hz	43.1±30.71	55.2±32.91	0.04*

*Statistically significant

HBO: hyperbaric oxygen therapy

succinate, 240 mg (Solu-Medrol, Pfizer Manufacturing, Puurs, Belgium) for 2 days; the dose was then tapered till 80 mg, and oral steroid therapy was continued for 6 days]. The 43 patients were treated in a hyperbaric chamber at a pressure of 2.5 atm for 60 min daily for 4 weeks (a total of 20 sessions). The study was approved by the ethics committee of our institution and was conducted in accordance with the ethical principles stated in the Declaration of Helsinki. Written informed consent was obtained from patients who participated in this study.

Statistical Analysis

Statistical differences were analyzed using the χ^2 test and a two-tailed Student's t test. Statistical analysis was performed using MedCalc software (Version 11.2.1© 1993-2010. MedCalc Software bvba Software, Mariakerke, Belgium).

RESULTS

Forty three patients with SSNHL after the failure of primary steroid therapy received HBO therapy (Table 1). The second group of 50 patients with SSNHL after the failure of the primary therapy did not receive additional therapy (Table 1). The mean hearing thresholds at 0.25, 0.5, 1, 2, 4, and 8 kHz were calculated before and after HBO therapy, while in the control group, mean thresholds were calculated after the failure of primary therapy and 1 month later.

After HBO therapy, significant improvement in mean hearing thresholds was found at 0.25 and 0.5 kHz (Table 2). There were no significant differences at 1, 2, and 4 kHz, while at 8 kHz, there was

Table 3. Mean hearing levels before and after HBO therapy at six frequencies in patients with a hearing loss of ≤60 dB (21 patients)

Frequency	Initial mean hearing levels (dB)	Mean hearing levels after HBO therapy (dB)	p
250 Hz	47.2±21.29	29.4±22.61	0.01*
500 Hz	48.3±20.72	31.6±20.72	0.03*
1000 Hz	44.7±28.67	31.9±21.08	0.13
2000 Hz	29.4±12.89	32.5±20.81	0.05
4000 Hz	31.9±18.79	32.7±19.49	0.88
8000 Hz	33.6±19.98	36.9±25.67	0.63

*Statistically significant

HBO: hyperbaric oxygen therapy

Table 4. Mean hearing levels before and after HBO therapy at six frequencies in patients with a hearing loss of >60 dB (22 patients)

Frequency	Initial mean hearing levels (dB)	Mean hearing levels after HBO therapy (dB)	p
250 Hz	71.7±23.04	48.5±29.24	0.0007*
500 Hz	79.1±23.04	56.6±30.38	0.001*
1000 Hz	82.6±22.35	57.6±32.36	0.0002*
2000 Hz	77.2±22.71	63.2±33.35	0.004*
4000 Hz	84.34±19.21	72.2±30.44	0.006*
8000 Hz	88.48±18.95	75.1±30.61	0.002*

*Statistically significant

HBO: hyperbaric oxygen therapy

a small decrease in the mean hearing threshold (Table 2). Patients were divided in those with severe hearing loss (>61 dB) and those with moderate hearing loss (≤60 dB). Patients with a hearing loss of ≤60 dB had significant improvement only at 0.25 and 0.5 kHz (Table 3), while those with a hearing loss of >61 dB had significant improvement at all six frequencies (Table 4). Two patients had Eustachian tube dysfunction during HBO therapy, and myringotomy and ventilation tube installation were required. No other side effects were noticed during HBO therapy. In the patients in the group not receiving additional therapy, there were no significant differences in hearing thresholds 1 month after the failure of primary therapy.

DISCUSSION

The most commonly used salvage therapies for sudden hearing loss are HBO therapy and intratympanic steroid therapy^[17-21]. A comparison of these two methods was recently described^[22, 23]. Both methods have been successful. Although a positive result was shown using both therapies, there is no consensus on which therapy is better. While previous studies showed that younger patients had better response after HBO therapy, in our study, we found no hearing improvement related to age. Our study showed that HBO therapy as salvage therapy significantly improves the outcome in patients with a hearing loss of >61 dB, while some previous studies have found the benefit of HBO therapy only among patients presenting with profound hearing loss (>80 or >90 dB)^[19, 21, 22]. In the group of patients with a hearing loss of ≤60 dB, improvement was noticed only at low

frequencies (0.25 and 0.5 kHz), which is consistent with a previous study on SSNHL that showed that the apical part of the cochlea recover better than the basal parts^[24]. Spontaneous recovery of hearing has been described in the first few weeks from the onset of SSNHL, but hearing recovery after the failure of primary therapy is very low. We used a control group of 50 patients who did not receive additional therapy after the failure of steroid therapy. One month after the initial therapy, hearing levels were measured and no improvement was observed. We are aware that our control group did not receive HBO therapy for the real comparison; however, because of ethical reasons and technical difficulties, it is difficult to perform this kind of research. We used patients who did not receive HBO therapy after the failure of the primary therapy as it was unavailable at that time or they refused the treatment. The high costs of HBO therapy and a lack of randomized studies are the main reason for not using it as the primary therapy for patients with sudden hearing loss. It is very important to start primary and salvage therapies as soon as possible because salvage therapy has no effect if it is used 4 months after the initial hearing loss^[7].

Intratympanic steroid therapy as salvage therapy is more effective at low frequencies than at high frequencies^[19]. Our results suggest that HBO therapy is also more effective at low frequencies in patients if the hearing loss is less severe. An explanation for better hearing recovery at low frequencies is that hearing cells in the apical part of the cochlea are more resistant to ischemia than those in other parts of the cochlea.

Hyperbaric oxygen therapy is used for primary and salvage therapy. Combination of HBO and steroid therapy compared to steroid therapy alone significantly improved hearing outcome^[25]. The addition of HBO therapy to primary conventional therapy improved the results when started early after the onset of SSNHL and was more successful in patients with a hearing loss greater than 60 dB^[15]. A recent study compared four primary therapy protocols for patients with SSNHL: oral steroid therapy, intratympanic steroid therapy, HBO therapy, and HBO therapy combined with oral steroid therapy^[19]. The results showed that the combination of oral steroid therapy and HBO therapy was the most effective.

A high rate of spontaneous recovery, up to 65%, has been described within the first two weeks after the initiation of steroid therapy^[23]. This natural course of the disease could be attributed to the success of primary therapy.

Hyperbaric oxygen therapy is a safe and successful salvage therapy for patients with sudden hearing loss. Our results indicate that HBO therapy as salvage therapy for SSNHL is effective and should be used, particularly in patients with severe hearing loss. Without salvage therapy, no significant changes in the hearing threshold can be expected. We could not have divided the group of patients with a hearing loss of >60 dB into even more groups because the number of patients is small and statistical analyses would be inadequate. Further studies with a larger number of patients and comparison with other types of salvage therapy are needed.

Ethics Committee Approval: Ethics committee approval was received for this study from the ethics committee of University Hospital Centre Sestre Milosrdnice, Zagreb, Croatia.

Informed Consent: Written informed consent was obtained from patients who participated in this study.

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