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OTOLOGY

Prognostic effect of hyperbaric oxygen therapy starting time for sudden sensorineural hearing loss

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Abstract Sudden sensorineural hearing loss is one of the otological emergencies whose pathogenesis is uncertain and associated with total or partial loss of hearing function. The aim of this study was to investigate whether the hyperbaric oxygen therapy starting time affects the management of sudden sensorineural hearing loss. Fifty-nine patients with sudden sensorineural hearing loss admitted to our clinic between 2008 and 2012 were retrospectively included in this study. All patients received hyperbaric oxygen therapy. In addition, each patient received intravenous piracetam and 37 patients received steroid therapy. Hyperbaric oxygen therapy was initiated between 1 and 7 days with 20 patients determined as Group A, between 8 and 14 days with 25 patients determined as Group B and between 15 and 28 days with 14 patients determined as Group C. Hearing gains of these three groups were statistically evaluated. Each of them showed statistically significant improvement. Lowest hearing gain was observed in Group C and the gain of this group was statistically less than the other two groups. There was no significant difference between the hearing gains of the Group A and Group B. Starting hyperbaric oxygen therapy in patients with sudden sensorineural hearing loss within the first 14 days has positive effect on the prognosis of the disease.

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Introduction

Sudden sensorineural hearing loss (SSNHL) is one of the major emergencies of otolaryngology, with unknown etiopathogenesis, and associated with total or partial loss of hearing function. According to the generally accepted definition, SSNHL is defined as sensorineural hearing loss of a minimum of 30 dB, in at least three consecutive frequencies, occurring within a period of 3 days [1]. SSNHL comprises 1 % of sensorineural hearing loss [2]. The incidence has been reported in the literature as 5–20/100,000. Spontaneous recovery has been reported as 32–65 % [3, 4]. Affected patients are typically aged between 40 and 65 years, with an equal sex distribution [5, 6].

Steroids are the most widely used agents in the treatment of SSNHL. In most cases, due to the undetectable underlying causes, which may lead to disease and necessity to begin treatment immediately, multiple drugs are given to patients with SSNHL as soon as possible to treat many pathologies in the same period of time. Steroids may be used in combination with one or more agents such as acyclovir, dextran, ginkgo biloba, nifedipine, magnesium, vitamins (B, E, C), pentoxifylline, carbogen, stellate ganglion block, heparin, histamine, hyperbaric oxygen (HBO). Current treatments aim to make a positive contribution to the inner ear vascular supply and increase oxygen delivery to the damaged cells. HBO therapy is a method which can significantly increase oxygen supply to damaged areas [7, 8].

In this study, HBO therapy starting times of 59 patients with SSNHL were evaluated. For more efficient use of

HBO therapy in patients with SSNHL, the effect of HBO therapy starting time on prognosis was investigated.

Materials and methods

Fifty-nine patients with the diagnosis of SSNHL who were treated in Ankara Numune Education and Research Hospital Otolaryngology Clinic between 2008 and 2012 years were retrospectively included in this study. The ethical committee of Ankara Numune Education and Research Hospital scientific research evaluation committee approved the study, dated 03 October 2012 and the decision number 2012–453. Complete blood count, routine biochemical tests and temporal MRI were performed on all patients with SSNHL for possible pathologies. Patients who were not idiopathic SSNHL were excluded from the study. Audiological examination was performed prior to treatment to determine the hearing status of the patients. Audiological examinations were repeated on the third day, tenth day, and in the first month and third month, after the onset of treatment.

Pregnants and patients with untreated pneumothorax, severe cardiac problems, chronic obstructive pulmonary disease, uncontrolled high fever, acute sinusitis, ear infection, optic neuronitis, retinal detachment, claustrophobia, and previous pulmonary tuberculosis were considered contraindicated for the HBO therapy and excluded from the study.

All patients were treated with HBO. HBO therapy was performed at 2.4 ATA pressure for 20 days, daily as a single session. At each session of 120 min and in the form of three periods per 20 min, 100 % pure O_2 was ventilated. Between periods 20-min breaks were given. Each patient received intravenous piracetam and 37 patients received steroid therapy. Patients with no known contraindications to steroid were treated with an initial dose of iv. 1 mg/kg methylprednisolone and terminated in a reduction of 10 mg every 2 days. Intratympanic steroids were not used in this study. During or after treatment, no adverse effects were detected in the patients due to HBO therapy and medical treatment.

According to the time of initiation of HBO therapy, patients were categorized into three groups as Group A, Group B and Group C. After the beginning of symptoms, HBO therapy was initiated between 1 and 7 days for 20 patients determined as Group A, between 8 and 14 days for 25 patients determined as Group B and between 15 and 28 days for 14 patients determined as Group C.

The average pure tone hearings were calculated as the average thresholds of the bone chain at 500, 1,000 and 2,000 Hz. Hearing gains of patients were identified by determining the difference between the initial and the third month audiograms.

Groups A, B and C were compared statistically in terms of age, sex, affected side, presence or absence of tinnitus and pre-treatment hearing loss severity.

Hearing gains of the groups which were created according to sex, age, affected side, presence or absence of tinnitus, steroid usage and HBO initiation time were statistically compared.

Statistical analysis

Data analysis was performed using "SPSS for Windows 14.0" package program. Statistical analyses were performed with Kruskal–Wallis, Chi-square, analysis of variance, Tukey's test and *t* test. Results were considered significant if the p value was <0.05.

Results

26 (44.1 %) patients were female and 33 (55.9 %) were male. The mean age of the patients was 47.7 years. The minimum age was 22 years and the maximum 79 years.

HBO therapy was initiated between 1 and 7 days for 20 patients determined as Group A, between 8 and 14 days for 25 patients determined as Group B and between 15 and 28 days for 14 patients determined as Group C (Table 1).

Hearing loss had occurred in the right ear in 25 (42.4 %) patients and in the left ear in 34 (57.6 %) patients. Tinnitus accompanied the SSNHL in 48 patients, whereas 11 patients had no symptoms of tinnitus.

Average pre-treatment hearing loss was 54.51 dB and post-treatment average gain was 18.88 dB. There was 1 patient with hearing loss of ≤30 dB, 10 patients between 31 and 40 dB, 16 patients between 41 and 50 dB, 10 patient between 51 and 60 dB and 22 patients between 61 and 70 dB. Patients hearing loss was determined according to the groups A, B, C (Table 2).

Groups A, B and C were compared statistically in terms of age, sex, affected side, presence or absence of tinnitus and pre-treatment hearing loss severity.

Age, sex, affected side and pre-treatment hearing loss relationship between groups A, B and C did not differ statistically ($p = 0.795$, $p = 0.564$, $p = 0.732$, $p = 0.114$).

Table 1 The number of patients in Groups A, B, C, according to HBO therapy initiation time

Groups	HBO starting time (days)	Number of patients (%)
A	1–7	20 (33.9)
B	8–14	25 (42.4)
C	15–28	14 (23.7)

Table 2 Pre-treatment distribution of hearing loss in Groups A, B and C

Pre-treatment hearing loss (dB)	Groups			Total number of patients
	A	B	C	
≤30	1	–	–	1
31–40	2	6	2	10
41–50	4	10	2	16
51–60	2	4	4	10
61–70	11	5	6	22
Total number of patients	20	25	14	59

Tinnitus distribution was different between the groups ($p = 0.034$). Number of patients with tinnitus was significantly lower in Group C than in Group B.

When we look at the hearing gains of patients, in Group A 8 patients obtained 0–10 dB, 2 patients obtained 11–20 dB, 3 patients obtained 21–30 dB, 1 patient obtained 31–40 dB, 1 patient obtained 41–50 dB, 2 patients obtained 51–60 dB and 3 patients obtained >60 dB hearing gains.

In Group B, 8 patients obtained 0–10 dB, 1 patient obtained 11–20 dB, 3 patients obtained 21–30 dB, 8 patients obtained 31–40 dB, 3 patients obtained 41–50 and 2 patients obtained 51–60 dB hearing gains.

In Group C, there were 7 patients with 0–10 dB hearing gain, 6 patients with 11–20 dB hearing gain and 1 patient with 21–30 dB hearing gain (Table 3).

The mean hearing gains were found to be 23.55 dB in Group A, 22.92 dB in group B and 5.00 dB in group C (Table 4).

It was investigated statistically whether there were any differences of hearing gains between the HBO therapy groups formed according to the initiation time. Hearing gains were found to be different between the groups ($p = 0.024$). The lowest hearing gain was observed in Group C and the gain of this group was statistically different from the other two groups. Between Group A and Group B, there was no significant difference in terms of hearing gains. For those patients who started HBO treatment after 14 days of onset, hearing gains were found to be statistically less than the other patients who started the treatment within the first 14 days.

According to the pre-treatment, third day, tenth day, and first month and third month audiograms of the patients, in Group A and C a gradual recovery was determined. In Group B, third day mean pure tone hearing thresholds were found to be higher than the initial level. Despite this, a gradual improvement was observed after third day. Of all patients evaluated, a gradual improvement was determined (Table 5).

Table 3 Hearing gains of the patients in Group A, B and C

Hearing gains (dB)	Groups			Total number of patient
	A	B	C	
0–10	8	8	7	23
11–20	2	1	6	9
21–30	3	3	1	7
31–40	1	8	–	9
41–50	1	3	–	4
51–60	2	2	–	4
>60	3	–	–	3
Total number of patients	20	25	14	59

Table 4 Mean hearing gains in Group A, B and C

	Groups		
	A	B	C
Hearing gains (dB)	23.55	22.92	5

Table 5 Pre-treatment, third day, tenth day, and first month and third month mean pure tone hearing thresholds

Groups	Audiograms				
	0 (dB)	3rd day (dB)	10th day (dB)	1st month (dB)	3rd month (dB)
Group A	58.1	54.2	52	42.9	34.5
Group B	50.4	50.7	36.6	32.5	27.5
Group C	56.8	54.9	54.9	53.5	51.8
Total	54.5	52.9	46.1	41.0	35.6

Age, sex and affected side groups were compared and hearing gains between the groups were found to be statistically identical ($p = 0.075$, $p = 0.217$, $p = 0.654$).

Hearing gains of the groups which were created according to presence or absence of tinnitus and steroid usage were compared and found to be statistically identical ($p = 0.149$, $p = 0.153$).

Discussion

For many years, SSNHL has been a controversial issue in many ways, such as etiology, treatment and still continues to be discussed today. The 32–65 % reported spontaneous recovery rate suggests the assumption that some patients may have this disease without visiting any physician [4, 5].

Older age is considered a poor prognostic factor for patients with SSNHL [8, 9]. At the ages of 40 and 65 years, SSNHL incidence is higher than other age groups [2]. Linssen and Schultz-Coulon [10] found that the mean age

of their patients with SSNHL was 46.7 years (age range 29–67 years). In contrast to many studies in the literature, they reported that older age was a statistically significant positive prognostic factor for hearing recovery at low frequencies. Byl [11] found that the mean age of their patients with SSNHL was 40.9 years (age range 13–70 years). There was no significant difference compared to hearing gains of the age groups. Muzzi et al. [12] reported that the mean age of their patients with SSNHL was 48 years (age range 19–78 years). Similar to the literature, the mean age of patients in this study was 47.7 years. The minimum age was 22 years and the maximum 79 years. Hearing gains of the patients were assessed according to age groups and no statistically significant difference was found.

In general, patients with SSNHL have an equal sex distribution [13]. 47.5 % female and 52.5 % male cases with similar hearing gains were reported by Byl [11] in his study. Holy et al. [14] reported 37.2 % female and 62.8 % male cases in their study. 26 (44.1 %) female and 33 (55.9 %) male patients were included in our study. Similar to the literature, there was no significant difference between male and female hearing gains.

More commonly unilateral SSNHL occurs [2, 15–18]. Oh et al. [18] reported 4.9 % unilateral and 95.1 % bilateral involvement. Patients with bilateral involvement showed lower recovery rate. Byl [11] reported that SSNHL was seen 45 % in right ear and 55 % in the left ear. Hearing gains of the patients with right- and left-sided SSNHL were statistically similar. Cekin et al. [19] reported 51.8 % right-sided and 48.2 % left-sided involvement. In our study, all patients have unilateral SSNHL. 25 (42.4 %) patients had SSNHL in right ear and 34 (57.6 %) patients in left ear and hearing gains were found to be statistically similar.

Approximately 70 % of patients with SSNHL are accompanied by tinnitus [16]. Gordin et al. [20] reported that 62 % of cases had tinnitus and patients with tinnitus had better prognosis. There are also studies showing that tinnitus is a poor prognostic factor for SSNHL [21]. Tinnitus accompanied the SSNHL in 48 (81.4 %) patients and 11 (18.6 %) patients had no symptoms of tinnitus in this study. We found that the existence of tinnitus statistically has no effect on recovery.

Degree of hearing loss is considered to be an important prognostic factor in SSNHL. If the initial degree of hearing loss is lower, hearing improvement is expected to be much more [9]. Inci et al. [22] reported the pre-treatment mean pure tone audiogram result as 75.3 dB. Pre-treatment mean pure tone audiogram was 54.51 dB in this study.

The erythrocyte alterations detected could be responsible for the sudden hearing loss, taking into account that it appears in most cases attributed to this entity. Piracetam has been reported to be used in SSNHL treatment since it regulates microcirculation and membrane deformability of blood cells, and especially of erythrocytes [23]. Piracetam is cheap and has a low potential for side effects, and we have been using it in our clinic in the treatment of SSNHL as an additional agent.

Because of its anti-inflammatory, anti-allergic and immunosuppressive effects, steroids are the most commonly prescribed agents for SSNHL. Moskovitz et al. [24] found 89 % recovery rate in the corticosteroid used group and 44 % in control group. Although systemic steroids are well tolerated, there are many contraindications [25]. Cvorovic et al. [26] reported that intratympanic steroids and HBO treatments were effective in patients who do not respond to steroid therapy. Moreover, in the study of Yang et al. [27] combined intratympanic and HBO therapy provided better hearing gains as salvage treatment in patients with SSNHL after failure of systemic therapy. A case with SSNHL who failed to respond to systemic and intratympanic steroid treatments but subsequently recovered after HBO therapy was reported in the literature [28]. In a study by Alimoglu et al. [29], patients with SSNHL were treated with HBO therapy plus oral steroid, oral steroid alone, intratympanic steroid alone and HBO therapy alone in four groups. The oral steroid and HBO combined therapy group had the highest mean hearing gain among all groups. Steroid treatment alone or addition of HBO therapy to steroid treatment for SSNHL showed no significant difference in the study of Cekin et al. [19]. Aslan et al. [30] treated 25 patients with betahistine hydrochloride, prednisone, and daily stellate ganglion block in group 1 and other 25 patients with the addition of HBO therapy in group 2, and no statistically significant difference was found between the two groups. In a study by Topuz et al. [31], patients were treated with steroids, plasma expander dextrans, diazepam, pentoxifylline and salt restriction in a group and with HBO therapy in addition to the treatment protocol in another group. Better results were achieved in the group treated with HBO therapy. In this study, 37 patients received oral steroid treatment, whereas 22 patients did not. Hearing gains were found to be statistically similar.

Current treatments intend to make a positive contribution to the inner ear vascular supply and they increase oxygen delivery to damaged cells. HBO therapy can significantly increase oxygen supply to damaged areas [6, 7]. Positive effects of oxygen therapy for wound healing have been known since the beginning of the first centuries of the written history. Clinical practice was begun firstly with the use of HBO for patients with gas gangrene by Boereme and Brummelkamp in 1961 [32, 33]. The use of HBO has been tested in many otolaryngological diseases such as acoustic trauma, malignant external otitis, Meniere's disease, maintenance of head and neck flaps, chronic inflammation, sudden hearing loss, migraine and other headaches [34–37].

The only absolute contraindication to HBO therapy is completely untreated pneumothorax. Furthermore, pregnants and patients with severe cardiac problem, chronic obstructive pulmonary disease, uncontrolled high fever, acute sinusitis, ear infection, optic neuronitis, retinal detachment, claustrophobia, previous pulmonary tuberculosis were considered as contraindicated [38, 39]. In this study, we did not apply HBO therapy for patients with severe cardiac problem, chronic obstructive pulmonary disease or acute infection.

In which period of the disease and how the HBO therapy should be used for SSNHL are still not clear. In a review study by Murphy-Lavoie et al. [40], although the proposed HBO treatment depended on the severity and duration of disease and response to treatment, the treatment recommended was 10–20 sessions of 100 % oxygen at 2–2.5 ATA pressure for 90 min daily. Alimoğlu et al., Aslan et al. and Goto et al. treated patients in 20 sessions, Ohno et al., Suzuki et al. and Cekin et al. in 10 sessions and Topuz et al. in 25 sessions of HBO therapy in their studies [40]. In this study, HBO therapy was performed at 2.4 ATA pressure for 120 min daily for 20 days. In a study by Inci et al. [22], patients who had not responded to medical treatment during the first 14 days were treated with HBO and about 55 % showed improvement. There are also some other studies which show that HBO therapy is useful in the early period. Muzzi et al. [12] reported that starting HBO therapy during the first 10 days was more effective. Nakashima et al. [41] reported that hearing gain would be better if HBO therapy was added to the conventional treatment in the first week of SSNHL when compared with the cases that received HBO therapy after the first week.

In this study, 59 patients with SSNHL were categorized into three groups according to the time of initiation of HBO therapy. Recovery rates were similar in groups in whom HBO therapy was initiated between 1 and 7 days and 8 and 14 days. Hearing gain was statistically lower in the group in whom HBO therapy was initiated after 14th day. We found that starting HBO therapy in the first 14 days for patients presenting with SSNHL is statistically more useful than starting it after 14 days.

Conclusion

HBO therapy is a safe and effective treatment for SSNHL. In this study, hearing gains were found better in groups in whom HBO therapy was started in the first 14 days of the disease than the group in whom HBO therapy was started after the 14th day. Starting HBO therapy at an early stage of the disease increases the success of treatment.

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