

Sudden sensorineural hearing loss: role of hyperbaric oxygen therapy

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Abstract

Sudden sensorineural hearing loss is defined as an acute hearing reduction of 30 dB or more, in at least three consecutive frequencies, occurring within 3 days of symptom onset. There is no consensus on the best treatment option. The aims of this paper were to evaluate the effectiveness of a treatment protocol based on medical therapy combined with hyperbaric oxygen therapy and to examine the factors that influence the recovery of hearing (age, gender, the amount of time between the onset of symptoms and the initiation of treatment – time since onset –, audiometric curve type and objective vertigo). Audiometric results were evaluated according to Siegel's criteria. In patients treated also with hyperbaric oxygen therapy we observed complete resolution in 44.1% of the patients, partial resolution in 37.2%, slight improvement in 10.5% and no improvement in 8.2% of the patients. This resolution pattern was significantly different from that observed in the patients treated only with medical therapy. The factors associated with a better prognosis were young age, rapid intervention, upward sloping or pantonal audiometric patterns and the absence of objective vertigo. Gender appeared to be an insignificant factor. Medical treatment associated with hyperbaric oxygen therapy gives better results in terms of hearing gain compared to exclusive medical treatment.

Introduction

Sudden sensorineural hearing loss (SSNHL) is defined as an acute hearing reduction, typically unilateral, of 30 dB or more in at least three consecutive frequencies, occurring within 72 hours of symptom onset.¹ It was first described in 1926 as Citelli's acute cochlear block and is currently more commonly referred to as idiopathic sudden sensorineural hearing loss (ISSNHL).² There are approximately 5-20 cases per 100,000 people each year, and men and women are equally affected.³

Sudden hypoacusis can be caused by viral infections,⁴ vascular or metabolic problems,^{5,6} autoimmune diseases,^{7,8} or traumatic accidents.

Due to the variability of the etiopathogenetic mechanisms, there is no single treatment of choice for sudden hearing loss,⁹ and the literature reports the use of many different drugs and therapies, including the following.

Antiflogistic steroids are used for their anti-edemic and immunoregulatory effects. The most commonly used drug is prednisone, which is used in oral high-dose therapy (60 mg/day and gradually reduced over 14 days).¹⁰ Some authors have used oral high-dose prednisone in association with intratympanic dexamethasone and achieved better hearing outcomes.¹¹ Recently, Filippo *et al.* reported that systemic corticosteroid therapy and intratympanic therapy produced comparable hearing results.¹²

Osmotic diuretics (*e.g.*, mannitol and glycerol): are given to reduce edema and pressure in the labyrinth liquids¹³

Hyperbaric oxygen therapy (HBO) involves administering 100 per cent oxygen at pressure greater than 100 kPa to increase partial pressure of oxygen within blood and capillaries,¹⁴ which stimulates oxygen diffusion from the capillaries into the surrounding tissue, including hypoxic parts of the cochlea.¹⁵ Moreover, it causes nitrogen bubble dissolution in the labyrinthine and cochlear artery. As a result, increased perfusion to the inner ear stimulates cell repair.^{14,15} In addition, research shows that hyperbaric oxygen therapy inhibits blood coagulation and pro-inflammatory cytokine production.¹⁵

Drugs with rheological properties, *e.g.*, low-molecular-weight heparin, are used to improve intravascular flow.¹⁶

The aims of our research were to examine and discuss 171 cases of SSSL and to evaluate the efficacy of HBO in combination with medical therapy.

We also determined whether factors including age, gender, the amount time

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between the onset of symptoms and the initiation of treatment (time since onset), audiometric curve type and the presence of vertigo had any effect on the prognosis.

Materials and Methods

In this study, we describe the case histories of 171 patients who were admitted to Ear Nose Throat (ENT) units of Cardarelli Hospital and University of Naples Federico II for sudden unilateral hearing loss between January 2009 and January 2016. Since October 2011, the hyperbaric oxygen therapy unit has been active.

Upon admission, objective otiatric test, hematochemical tests and machine-based tests, including pure-tone audiometry, vocal audiometry, tympanometry, vestibular evaluation and brain-NMR were performed. The inclusion criteria were as follows: unilateral sensorineural hearing loss and the time since onset was less than 15 days. We excluded patients with retrocochlear hearing loss, Meniere disease, acute or chronic otitis, pregnancy, and head trauma.

Patients admitted before October 2011

(Group A: 85 patients) were treated with dexamethasone (8 mg, 1 vial/day intravenous), pantoprazol (40 mg vials, 1 vial/day intravenous in 100 cc of physiological solution), 10% glycerol (1 250-mL bottle/day intravenous with an infusion rate of 180 ml/h), and enoxaparin sodium (4.000 U.I. fl, 1 vial/day subcutaneous; only in patients >60 years of age). As home therapy, patients were given Methylprednisolone capsules (1 mg/kg/day oral, in progressively decreasing doses, *i.e.*, halved every 3 days, for fifteen days) and ticlopidine capsules (1 capsule/day for a month; only in patients >60 years of age).

Patients admitted after October 2011 (Group B: 86 patients) were treated with the same medical therapy in combination with daily sessions of hyperbaric oxygen therapy applied as 100% oxygen inhalation in mask at 2.5 ATA pressure for 90 minutes (every 25 minutes the patients had a period of break of 5 minutes in compressed air for 3 times), once a day for 15-21 days.

The demographic and clinical features of the two groups of patients are listed in Table 1.

Four Group A patients and five Group B patients had contraindications for high-dose corticosteroids and thus were not administered these drugs.

All patients regularly underwent clinical examinations and tests at the following times: daily during their stay in the hospital; when they finished home therapy; every three months for the first year; and every six months thereafter.

Hearing improvements was defined using Siegel's criteria as follows: complete recovery: final hearing better than 25 dB; partial recovery: more than 15 dB gain, final hearing 25-45 dB; slight improvement: more than 15 dB gain, final hearing poorer than 45 dB; and no improvement: less than 15 dB gain, final hearing poorer than 75 dB.

For each therapy group, the relationships between hearing gain and factors that included age, gender, time since onset, audiometric pattern and vertigo were examined. Every patient provided written informed consent, and this study was approved by local ethic committee.

The statistical analyses were performed using a chi-square (χ^2) test.

Results

The comparison between the two therapy groups that differed in the use of hyperbaric oxygen therapy (HBO) in first-line revealed greater recovery in the patients who were treated with HBO and medical

therapy compared with the patients who were treated medical therapy alone (Table 2). The tympanometry results were normal in all patients. Vestibular examinations revealed vestibular unilateral deficits in 19% of the patients, benign paroxysmal positional vertigo in 4% of patients, and central signs in 1% of the patients. We observed no cases of retrocochlear disease on MRI.

The relationships between the significant factors (*i.e.*, age, time since onset, audiometric curve type, and vertigo) and hearing gain class for each therapy group are reported below in Table 3.

Approximately 4% of the patients whose treatment included HBO had barotraumatic otitis; therefore, oxygen therapy was stopped for these patients.

Long-term follow-up revealed that approximately 2% of the cases were in the initial stages of Meniere's disease.

Discussion

The results of our research revealed a higher percentage of recovery in the patients who were treated with medical therapy (*i.e.* systemic corticosteroid, glycerol, and low-molecular-weight heparin) plus hyperbaric oxygen therapy than in the patients who were treated only with the identical medical therapy. Complete resolutions were observed in 44.1% of the patients of group B and 31.8% of the patients of group A, and partial resolutions were observed in 37.2 and 29.4% of the patients in groups B and A, respectively. In accordance with the literature, these results confirm the positive effects of HOT for sudden hearing loss.¹⁷

Gender

Only Roman *et al.*¹⁸ examined the influ-

Table 1. Demographic and clinical features of the patients.

	Group A	Group B
Gender	50 men; 35 women	45 men; 41 women
Age	45.32±14.53 years range 20-85 years	46.97±15.47 years range 18-88 years
Side of hearing loss	41 right (45.6%); 49 left (54.4%)	44 right (48.9%); 46 left (51.1%)
Extent of hearing loss	Average 52.27 dB±29.8 dB; range 15-105 dB	Average 55.39 dB±28.4 dB; range 15-110 dB
Time from onset to treatment	6.8± 5.9 days; range 1-14 days	7.2± 4.7 days; range 1-15 days
Vertigo	Yes 24.7%; no 75.3%	Yes 23.5%; no 76.5%
Curve type	Pantonal 38.9%; upward sloping 27.8%; downward sloping 20%; anacusis 12.3%	Pantonal 41.1%; upward sloping 28.9%; downward sloping 16.7%; anacusis 13.3%

Table 2. Comparison between groups A and B (P=0.027, $\alpha=0.05$).

Siegel's criteria	Group A (%)	Group B (%)
I	31.8	44.1
II	29.4	37.2
III	17.6	10.5
IV	21.2	8.2

Table 3. Correlations of some of the factors with recovery.

Factor	P		Significant
	Group A	Group B	
Age	0.022	0.030	Yes
Gender	0.116	0.162	No
Time since from onset	0.009	0.010	Yes
Audiometric pattern type	0.012	0.002	Yes
Vertigo	<0.001	0.001	Yes

ence of gender finding that the latter had no prognostic value. This finding was confirmed by our study in which the results were comparable for men and women in both groups.

Age

Among the patients suffering from sudden hypoacusis in this study, age was confirmed to be a significant factor in both therapy groups. Similarly, other authors have identified age as an important prognostic factor;¹⁹ the results are worse for older patients,²⁰ particularly those with cardiovascular risk factors. Vascular degeneration increases with age and thus decreases the peripheral blood supply. Cochlear blood flow decreases with age, which reduces the rates of recovery from otologic diseases.²¹

On the other hand, some studies^{18,22} have found that age is not a significant factor. Leong and Lon²³ suggested that being over sixty has a negative influence, but they also observed unsatisfactory results in patients under the age of nineteen years. Kiris *et al.*²⁴ also identified children as the age group that exhibited the worst levels of hearing recovery.

Time since onset

The time lapse between onset of symptoms and the beginning of treatment significantly affects prognosis.^{25,26} As stated in other studies^{10,17,22,23,27} sudden hypoacusis requires hospitalization and medical treatment as soon as possible.^{28,29} In contrast, Massen *et al.*³⁰ observed improvements in hearing even when the beginning of the treatment was delayed, and Baujat *et al.*²⁰ stated that sudden hypoacusis is a false medical emergency because the results are disappointing even when treatment is prompt.

Audiometric pattern type

The patients who achieved the best results in our series were those with hearing deficits that were localized in the low frequencies or pantonal. Such curves can be interpreted as audiometric representations of endolymphatic hydrops, which cause compression of the cilia cells and can be treated with appropriate anti-edemic treatments. In contrast, in patients with downward sloping audiometric patterns or anacusic patterns, it is easy to imagine that irreversible damage has been caused to the cochlear epithelium, which indicates that the condition will not respond to treatment regardless of how quickly it is started. There are many examples of this phenomenon in the literature.^{18,20,22,23,27,31}

Vertigo

In our study (as reported by many other

Authors)^{18,20,22-24,27-29,31} with the exception of Lissens *et al.*³² the presence of objective vertigo (which indicates complex damage to the inner ear) must be considered as a negative prognostic factor of hearing recovery. Therefore, the importance of initial record-taking cannot be sufficiently stressed in terms of its prognostic value. Such records are vital for differentiating real vertigo caused by labyrinth problems from a basic sense of instability.

Some authors³³ have reported that the recovery rates of patients with vertigo are lower than those of patients without vertigo and that the prognosis of SHL is worse in patients with vertigo.²⁴ Cho reported that the clinical characteristics of patients with vertigo do not directly affect hearing improvement in cases of SSNHL; however, vertigo influences SSNHL via an interaction with the initial hearing levels.³⁴

Our research results also supported this association; we observed greater recovery among patients without vertigo.

Hyperbaric oxygen therapy

The purpose of hyperbaric oxygen therapy in SSNHL treatment is to increase partial oxygen pressure in blood and inner ear fluids. HBO treatment also decreases cyclooxygenase 2 and prostaglandin E2 production, and serves as an anti-inflammatory agent equivalent to 20 mg/kg diclofenac.³⁵ Fujimura *et al* claimed that HBO therapy had a significant additional effect when used in combination with systemic steroid therapy compared to exclusive steroid treatment. In patients with initial hearing levels of ≥ 80 dB, the hearing improvement rate was significantly higher in the HBO therapy group than in the steroid group, whereas in patients with initial hearing level of < 80 dB, the hearing improvement rate was not statistically different between the two groups.³⁶ Conversely, Alimoglu *et al* consider HBO therapy as a salvage treatment for SSNHL after unsuccessful medical therapy, the main gain seems to be marginal, but some patients may have better recovery.³⁷

According to Fujimura the Authors used the combined therapy as first-line treatment; HBO treatment was interrupted before time if patients had complete resolution; after 15 days of HBO therapy if no were improvement; on the contrary the HBO treatment was extended in cases of partial resolution after 15 days.

According to the authors this results are encouraging, so they propose the HBO and medical therapy as first-line treatment for sudden sensorineural hearing loss.

Conclusions

Sudden sensorineural hearing loss is a real medical emergency, but there is no consensus on its treatment, which changes according to the practitioner's school of thought. The most of authors in literature seem to advocate high doses of corticosteroids at least for the first few post-lesion days. The aims of our research were to analyse the results obtained from treatment protocols involving medical therapy and hyperbaric oxygen therapy and to assess the influences on hearing recovery of factors such as gender, age, the time interval between onset of symptoms and initiation of treatment and the presence of objective vertigo.

Our work revealed that 44.1% of the patients treated reported clearly satisfactory improvements in hearing. Factors predicting better results were: the time interval between the onset of symptoms and the initiation of treatment was ≤ 3 days; no objective vertigo or signs of labyrinth problems were present; the patient was younger than 50 years old; the audiometric pattern was upward or pantonal.

Gender was not found to have any effect on prognosis. In all cases, it is important to recognize these variables when a patient with sudden hearing loss is admitted to predict with some degree of certainty the type of results that are feasible with any given treatment.

In conclusion, our treatment protocol for SSNHL provides for i) patients younger than 60 years: HBO, corticosteroids (unless contraindications), pantoprazole, 10% glycerol; ii) patients older than 60 years: HBO, corticosteroids (when it is possible), pantoprazole, 10% glycerol and enoxaparin sodium.

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