RESEARCH ARTICLE

Hyperbaric oxygen therapy in treatment of sudden sensorineural hearing loss: finding for the maximal therapeutic benefit of different applied pressures

Zdenka Krajčovičová [1], Vladimír Meluš [1], Rastislav Zigo [2], Iveta Matišáková [1], Ján Večeřa [2], Eva Králová [1]

[1] Faculty of Healthcare, Alexander Dubček University of Trenčín, Trenčín, Slovak Republic

[2] Department of Otolaryngology, Faculty Hospital Trenčín, Trenčín, Slovak Republic

CORRESPONDING AUTHOR: Zdenka Krajčovičová – *zdenka.krajcovicova@tnuni.sk*

ABSTRACT

We compared the efficacy of hyperbaric oxygen (HBO_2) therapy used in the treatment of sudden sensorineural hearing loss (SSNHL) as a supplementary therapy to the first-line medical treatment according to the different applied pressures used in HBO_2 treatment while maintaining the same number of sessions, periodicity and exposure times.

We evaluated data from 115 patients suffering from SSNHL within seven days of hearing loss: 35 patients received the standard treatment protocol (control group), and 80 individuals were treated with additional application of HBO_2 therapy pressured to 2.0 ATA (H2.0; n=49) or 2.5 ATA (H2.5; n=31), respectively. Treatment success was assessed using pre- and post-treatment audiograms.

We found significant differences in both HBO_2 groups compared to the control group. In low frequencies the most significant differences can be seen in both H2.0 and H2.5. In spoken speech frequencies only the H2.0 group was statistically significant. In high frequencies the therapeutic benefits were the lowest.

Furthermore, we found a notable difference in the therapeutic effect of HBO_2 therapy according to the different applied pressure. At low frequencies, the use of 2.5 ATA pressure was more efficient. However, in the higher frequency ranges, the better hearing gains were obtained at the 2.0 ATA pressure.

Our results support the possibility of optimizing treatments individually, depending on the type and frequency range of hearing impairment (shape of the audiogram) in favor of using the 2.0 ATA. This is important in terms of an individual approach to each patient as well as to minimize the burden of a patient in order to obtain the maximum therapeutic effect.

INTRODUCTION

According to the latest data from the World Health Organization [1] about 466 million people worldwide suffer from disabling hearing loss, and 34 million of them are children. It is estimated that by 2050 more than 900 million people will suffer from disabling hearing loss.

Sudden sensorineural hearing loss (SSNHL) is acute hearing loss that develops within 72 hours. The overall incidence of SSNHL ranges from five to 20 per 100,000 subjects a year, both male and female, typically between 30 and 60 years of age [2]. SSNHL is thought to be the clinical manifestation of various pathologic conditions, and is not a simple disease entity. It is defined as 30 dB or more of sensorineural hearing loss over at least three consecutive frequencies within three days [3-5]. The etiology for sudden sensorineural hearing loss is defined in only 10% of cases, whereas the rest are labeled as idiopathic (ISSNHL) [6,5].

Although the pathogenesis of ISSNHL remains largely unknown, there are several hypotheses that may explain the origin of this disease. The most commonly discussed hypotheses include the following: decreased cochlear blood flow with cochlear hypoxia; viral infection; intralabyrinthine membrane rupture; and immune-mediated inner ear disease [7,8]. Because of the multifactorial etiopathology of ISSNHL, many different regimens have been applied in the treatment of this disease [4], and more than 60 protocols have been described. However, when the three most efficacious treatments – corticosteroids, vasodilators and hyperbaric oxygen therapy (HBO_2) – were revised from the Cochrane Collaboration, only the use of HBO_2 received multiple, positive, objective and critical reviews [8].

KEYWORDS:sudden sensorineural hearing loss; hyperbaric oxygen therapy; pressure; audiometry; average hearing threshold

HBO_2 has been used successfully in the management of SSNHL based on the concept that HBO_2 increases the partial pressure of oxygen (pO_2) in the inner ear; improves hemorheology and contributes to improved microcirculation; lowers the hematocrit and entire blood viscosity; and improves erythrocyte elasticity [4, 9]. In addition, research has shown a potential advantage of HBO_2 performed for ISSNHL to increase pO_2 in the blood. By means of diffusion, pO_2 rises in the inner ear fluids which supply the sensory and neural elements in the cochlea. HBO_2 induces cell metabolism in the inner ear, even if the blood supply is insufficient [2, 10, 11].

However, a specific treatment for SSNHL is still missing, and the technical conditions for the use of this method are still unclear. According to the recommendations of the European Consensus Conference on Hyperbaric Medicine 2016 this therapy is recommended within the time of exposure of 90 to 120 minutes at pressures between 2.0 and 2.5 ATA once a day, up to 20 exposures. Reassessment of the patient's condition is recommended after 10 exposures, and pure-tone threshold audiometry results help determine whether the treatment should be discharged or continued for a further 10 exposures. An average hearing gain of more than 10 dB can be used as a selection criterion [12]. The recommended treatment profile by the Undersea and Hyperbaric Medical Society consists of daily sessions breathing 100% O_2 for 90 minutes at 2.0 to 2.5 ATA for 10 to 20 treatments. The 2.4-ATA treatment pressure is probably most practical, especially for facilities with multiplace chamber operations [13].

Most authors who publish in this area manage HBO_2 by a 60- or 90-minute continuous treatment of breathing 100% oxygen once a day for 10 to 20 days – mainly at a pressure of 2.5 ATA (Table 1) [7, 14-29]. In contrast, in our previous study [30] patients underwent a 90-minute HBO_2 treatment once a day for 10 days pressured only at 2.0 ATA. Based on review of the patient's health status after 10 exposures, our experience showed that a 10-exposure treatment was sufficient. The efficiency of both treatment protocols used (control group received steroids supported with hemorheological therapy; the HBO_2 group was treated with additional application of HBO_2) was statistically significant ($p < 0.001$) in both groups of patients, but the supplementation of the therapy with HBO_2 statistically significantly increased the effect of pharmacotherapy ($p < 0.001$) by 11.5 dB up to the final hearing gain of 20 dB.

As we noted, the main purpose of our present study was to compare the efficacy of HBO_2 used in the treatment of SSNHL as a supplementary therapy to the first-line medical treatment according to the different applied pressures used in HBO_2 therapy while maintaining the same number of sessions, periodicity and exposure times.

MATERIALS AND METHODS

In our prospective study we have evaluated the data of 115 patients (59 males, 56 females; mean age of the group 47 ± 15 years). They suffered from SSNHL (IDC-10-CM code H91.2 – Sudden idiopathic hearing loss) within seven days of hearing loss and were admitted to the Department of Otolaryngology, Faculty Hospital Trenčín, Slovakia, between July 2015 and June 2018. The study was approved by the Ethics Committee of the institution under code n. 26210120019. Oral and written information about the study was provided, and informed consent from all patients was obtained before participation.

The patients were grouped according to therapy as those with pharmacotherapy (control group) and those with additional application of HBO_2 (groups H2.0 and H2.5). Not included in the study were: pediatric patients; patients with pre-existing Menière's disease, tumors, barotrauma, acoustic trauma, retrocochlear disease, bilateral hearing loss; patients with a history of chronic otitis in the same ear; and patients with a history of surgery of the same ear. Another inclusion criterion was unilateral sensorineural hearing loss. All patients were hospitalized within seven days of hearing loss and received standard treatment protocol of our department.

Pharmacotherapy consisted of the systematic administration of steroids, supported with hemorheological therapy. For the first five days of hospitalization patients received intravenous application of solumedrol as follows:

- first and second days – 250 mg;
- third and fourth days – 125 mg;
- fifth day – 80 mg ;

Then for the next 10 days the patients received prednisone per oral application:

- sixth to 10th days – 40 mg; and
- 11th to 15th days – 20 mg.

Other medications were: agapurin 2 **x** 100 mg; and betahistine 3 x 16 mg. H2.0 and H2.5 groups underwent a 90-minute continuous treatment of breathing 100% oxygen once a day for 10 days in a multiplace hyperbaric chamber (HAUX-Starmed 2200/2.2S) pressured to 2.0 ATA (H2.0 group) or 2.5 ATA (H2.5 group). Our study was carried out in accordance with the recommendations of the European Consensus Conference on Hyperbaric Medicine 2016:

Table 1 Overview of the variability in the use of HBO_2 treatment protocols for SSNHL

year of the publication	name of the first author	pressure	time of exposure	periodicity	number of sessions	list of references
2018	Toroslu T.	2.0-3.0 ATA	120 min.	once a day	20	[14]
2018	Khater A.	2.0 ATA	60 min.	once a day	20	[15]
2018	Sun H.	2.0 ATA	90 min.	once a day	15	[16]
2018	Xie S.	2.5 ATA	60 min.	twice a day	4-34	[20]
2018	Gülüstan F.	2.5 ATA	120 min.	once a day	21	[21]
2018	Hosokawa S.	2.0 ATA	60 min.	once a day	10	[22]
2017	Ricciardiello F.	2.5 ATA	90 min.	once a day	15-21	[27]
2017	Olex-Zarychta D.	2.5 ATA	60 min.	once a day	15	[17]
2017	Ajduk J.	2.5 ATA	60 min.	once a day	20	[18]
2017	Ergun Taşdöven G.	2.5 ATA	90 min.	once a day	10	[19]
2016	Sevil E.	2.4 ATA	75 min.	once a day	20	[25]
2016	Sherlock S.	2.4 ATA	90 min.	once a day	10	[26]
2016	Lamm H.	2.5 ATA	2x30 min.	once a day	10-33	[23]
2015	Attanasio G.	2.4 ATA	90 min.	twice a day	10	[24]
2015	Psillas G.	2.2 ATA	80 min.	once a day	15	[28]

HBO_2 therapy for SSNHL is recommended for 90 to 120 minutes at pressures between 2.0 and 2.5 ATA once a day, up to 20 exposures with the reassessment of the patient's condition after 10 exposures.

The patients were evaluated by certified audiologists by the standardized methods for pure-tone threshold audiometry (PTA) before and after the treatment. PTA was calculated as an average threshold measured at 250, 500, 1,000, 2,000, 4,000, 6,000, and 8,000 hertz (Hz). Further, the audiological results were defined in terms of three ranges of frequencies: (1) low frequencies (250 – 500 Hz), (2) medium (spoken speech) frequencies (1000 – 2000 Hz) and (3) high frequencies (4000 – 8000 Hz). The treatment responses were divided into two groups: (1) hearing gain (change in PTA) of 10 dB and over (improvement) and (2) hearing gain less than 10 dB (no improvement).

Statistical analysis was performed with the program InStat 3.1 (GraphPad Software, Inc., U.S.). Basic statistical characteristics of the both groups are given by sample size, median, minimum and maximum values. Minimal values can also comprise negative numerical data because they represent therapeutic benefit – i.e. the difference in hearing status before and after therapy. To compare the numerical variables of the three groups of individuals, Kruskal-Wallis non-parametrical test was used with the Dunn's post-test of the partial pairs of groups. Nominal data were processed with the aid of contingency tables based on the chi-square test. In each category, we also calculated the expected numbers of individuals and compared them to the observed numbers. A p-value less than 0.05 was considered to be statistically significant.

As part of the pre-analytical verification of data parameters we tested the rate of benefit of HBO_2 in individuals with hearing impairments of different severity, and we found that the outcome of therapy was not limited within a fixed range.

RESULTS

We evaluated the data for 115 patients with ISSNHL, including 59 men (51.30%) and 56 women (48.70%), with an average age of 49 years (range 20 - 87). The patients were divided into three groups:

- Control group consisted of 35 individuals treated with standard pharmacotherapy;
- H2.0 (49 individuals); and
- H2.5 (31 patients) groups were treated with the same pharmacotherapy and additional HBO_2.

The data presented in Table 2 shows that there was indeed a significant difference in the efficacy of therapeutic methods in terms of overall classification by three

Table 2 Differences in the extent of hearing gain between individuals with H2.0, H2.5 and control groups

frequency (Hz)	*group*	*n*	$\bar{x}$	*sd*	x_m	*min.*	*max.*	*p*	P_D
250-500	H2.0	49	21.9	21.1	18.0	-8	68	0.008	■/-/e*
	H2.5	31	21.1	20.0	18.0	-15	63		-/■/e*
	control	35	8.4	20.1	5.0	-33	65		l*/l*/■
1000-2000	H2.0	49	20.1	18.7	13.0	-10	66	0.03	■/-/e*
	H2.5	31	14.5	20.4	10.0	-20	65		-/■/-
	control	35	9.2	17.6	5.0	-33	53		l*/-/■
4000-8000	H2.0	49	12.5	14.2	13.0	-15	48	0.05	■/-/-
	H2.5	31	13.8	18.7	7.0	-20	53		-/■/-
	control	35	5.8	13.3	3.0	-18	65		-/-/■

n: number of patients $\bar{x}$: arithmetical mean *sd*: standard deviation x_m: median *min.*: minimal value *max.*: maximal value; *p*: probability value of the Kruskal-Wallis test P_D: Dunn´s post-test of the individual pairs of groups: * $P_D < 0.05$; l - statistically significant decreasing; e - statistically significant elevating; - dashes indicate statistical insignificance; ■ - no comparison of the particular group with itself

frequency ranges. The highest arithmetic means and medians can be observed in the H2.0 group, and the lowest means were observed in the control group. The most significant differences can be seen in the 250 to 500 Hz frequency range, where both H2.0 and H2.5 groups were dominant. In the 1000 – 2000 Hz frequency range (spoken speech), only the H2.0 group had statistically significant results, while the H2.5 group compared to the control group was not statistically significant. In the high frequencies of 4,000 – 8,000 Hz, the differences are at the borderline of statistical significance, while the therapeutic benefits were the lowest.

Consequently, we focused on comparing the degree of benefit of treatment among the studied groups. Treatment responses were divided into two groups, the first one with individuals who did not benefit from the therapy: The improvement did not reach a 10 dB difference within this group. The second group consisted of individuals who showed an improvement of 10 dB and over. Subsequently we compared three ranges of analyzed frequencies. The results are shown in the contingency Tables 3–5 that contain two parts. The upper part is computational. In this section, the observed numbers are marked in bold. In brackets, there are expected numbers, which we would expect in the case of absence of differences in the effectiveness of the three therapeutic procedures. The lower part of the tables shows the percentage deviations of the observed abundance from the mathematically expected ones. To sum it up, the greater the absolute value of these numbers (regardless of the sign), the larger the difference between the observed and expected number. The sign indicates the direction, i.e. whether the number of observed individuals is larger (+) or smaller (-) than the expected number counted mathematically.

The data presented in Table 3 shows the comparison of therapeutic response in the 250 – 500 Hz frequency range. The H2.5 group clearly dominated, with improved hearing gain in +27.3% patients based on the assumption, that all therapeutic approaches have the same effectiveness. The second best treatment response was observed in the H2.0 group. In contrast, pharmacotherapy without HBO_2 exposures (control group) had impact on -26.2% of patients.

Table 4 contains statistical evaluation of the efficacy of therapeutic modalities on the 1,000 – 2,000 Hz frequency range (spoken speech) with the null hypothesis of the statistical test was again based on the presumption of the quantitatively identical effect of the three therapeutic approaches. Even in this case, our assumption has not been confirmed. The H2.0 group was evaluated as the most effective therapeutic intervention (+20.9%). Interestingly, in the H2.5 group balanced results were observed, slightly disposed toward the detriment of its effectiveness.

In the high-frequency range of 4,000 – 8,000 Hz the H2.0 group clearly dominated by its success rate (+33.7% in addition to the expected counts of individuals with therapeutic benefit), followed by the H2.5 group. The pharmacotherapy without HBO_2 (control group) has traditionally been shown to be the least effective, with only -64.3% observed counts compared to theoretically expected numbers (Table 5).

Table 3: Therapeutic gain in frequency range 250 – 500 Hz

Range of frequencies 250-500 Hz	No improvement	Improvement	Total
H2.0	**18** (20.45)	**31** (28.55)	49
H2.5	**8** (12.94)	**23** (18.06)	31
Control	**22** (14.61)	**13** (20.39)	35
Total	48	67	115

χ^2=10.16, *d.f.*=2; p=0.006. Expected numbers are shown in brackets. Observed frequencies are in **bold**.

Range of frequencies 250-500 Hz	No improvement	Improvement	
H2.0	-12%	+8.6%	Percentage deviations in individual cells: % = (observed - expected) / expected x 100
H2.5	-38.2%	+27.3%	
Control	+50.6%	-36.2%	

Table 4. Therapeutic gain in frequency range 1,000 – 2,000 Hz

Range of frequencies 1,000-2,000 Hz	No improvement	Improvement	Total
H2.0	15 (20.88)	34 (28.12)	49
H2.5	14 (13.21)	17 (17.79)	31
Control	20 (14.91)	15 (20.09)	35
Total	49	66	115

χ^2=5.99, *d.f.*=2; p=0.05. Expected numbers are shown in brackets. Observed frequencies are in **bold**.

Range of frequencies 1,000-2,000 Hz	No improvement	Improvement	
H2.0	-28.2%	+20.9%	Percentage deviations in individual cells: % = (observed - expected) / expected x 100
H2.5	+6.0%	-4.4%	
Control	+34.1%	-25.3%	

Table 5. Therapeutic gain in frequency range 4,000 – 8,000 Hz

Range of frequencies 4,000-8,000 Hz	No improvement	Improvement	Total
H2.0	22 (28.80)	27 (20.20)	49
H2.5	16 (18.22)	15 (12.78)	31
Control	29 (19.98)	5 (14.02)	34
Total	67	47	114

χ^2=14.42, *d.f.*=2; p=0.001. Expected numbers are shown in brackets. Observed frequencies are in **bold**.

Range of frequencies 4,000-8,000 Hz	No improvement	Improvement	
H2.0	-23.6%	+33.7%	Percentage deviations in individual cells: % = (observed - expected) / expected x 100
H2.5	-12.2%	+17.4%	
Control	+45.1%	-64.3%	

DISCUSSION

Existing literature on HBO_2 for SSNHL includes studies that utilized various different treatment pressures ranging from 1.5 ATA to 3.0 ATA [7,14-29]. In their study Uzun, et al. [29] discovered practice differences in the treatment of SSNHL with HBO_2 among European hyperbaric centers through a nine-question survey completed by the medical directors of HBO_2 centers. Altogether 192 centers were invited to take part in the study: 80 (41.6%) centers from 25 countries responded. A total of 70 centers of 80 were using HBO_2 for SSNHL: 43 of 56 used one session a day, while 13 centers reported that they used sessions twice a day for at least part of the HBO_2 course. Of these, 10 were using HBO_2 twice a day exclusively in the first three to five days, and afterward they shifted to once-daily exposures. Total number of HBO_2 sessions delivered per patient ranged from five to 40. Treatment duration varied between 60 and 140 minutes, and treatment pressure between 1.5 and 2.5 ATA, respectively. The majority of centers (48/56) were using a treatment pressure of 2.4/2.5 ATA, four were using 2.0 ATA, two 1.8 ATA and two others 1.5 ATA. Twenty-nine of 56 centers reported using between 90 and 105 minutes of HBO_2, 20 between 120 and 140 minutes, and seven 60 to 75 minutes of HBO_2. The most frequently used treatment protocol was 90 minutes at 2.4/2.5 ATA by 19 of 56 centers. Furthermore, 44 of 55 centers expressed their interest in participating in studies that would compare the effectiveness of different HBO_2 protocols in treating SSNHL.

There were published papers in which HBO_2 had an important function in the group of patients with SSNHL in whom primary treatment with corticosteroids did not reach overall improvement of hearing. In these cases HBO_2 was administered as a "rescue therapy"

within three months of the onset of hearing impairment. Czech authors treated a small group of patients using rescue HBO_2 therapy (3 ATA / 90 minutes / 10 sessions / once a day) initiated 30 to 60 days (average 44 days) from onset of ISSNHL. Patients had previous ineffective vasodilating infusion and corticosteroid therapy. Within this set of HBO_2-treated patients, significant improvement at frequencies of 1,000 Hz and 2,000 Hz was apparent [31].

To our best knowledge, there has been only one study that compared the effectiveness of HBO_2 at different treatment pressures [32]. In this retrospective study, mean hearing gain levels in patients who received no HBO_2 or HBO_2 at 1.5 ATA were similar (2.6 ± 15 dB and 3.1 ± 9 dB respectively), but was significantly better with HBO_2 at 2.5 ATA (19.7 ± 23 dB). Because the baseline peripheral arterial tonometry levels (no HBO_2 32.5 ± 26.3 dB; HBO_2 at 1.5 ATA 32.3 ± 27.8 dB; HBO_2 at 2.5 ATA 76 ± 27.5 dB) differed significantly between the groups, a firm conclusion could not be deduced from this study. In this study we would like to draw attention to the fact that this study was carried out as a salvage therapy for SSNHL, while the aim of our study was the first-line medical treatment (within seven days of hearing loss). Authors concluded that HBO_2 at 2.5 ATA in patients with SSNHL after unsuccessful conventional treatment yields significant improvement of hearing, but the mean hearing gain is higher when time delay before HBO_2 is shorter.

Regarding possible mechanisms for the positive results achieved, some aspects are discussed. Corticosteroids are still the mainstay of treatment for SSNHL, with statistically provable effects especially on medium frequencies (spoken speech). Their effect is important to improve microvascular circulation, decrease inflammation processes in the inner ear, and to suppress the immune response [30]. Randomized controlled trials concerning the benefit of anti-inflammatory treatment with corticosteroids in patients with SSHNL are contradictory in outcome. A meta-analysis published and recently updated in the Cochrane library concludes that the value of steroids in the treatment of ISSNHL remains unclear [33]. The predicted mechanism of HBO_2 action is to increase the partial pressure of oxygen in the blood, which in turn increases the partial pressure of oxygen through diffusion in the inner ear fluids [30]. A synergistic effect of steroids and HBO_2 has been proposed in order to explain the gain of threshold. On one side, steroids reduce inflammation in the inner ear that may be contributing to hearing loss, while on the other, HBO_2 increases intracochlear aid in the recovery of hearing. Furthermore the synergistic effect of steroids and HBO_2 is the reduction of edema in the inner ear. Lamm, et al. [33] assume that HBO_2 changes the permeability of the round window membrane that allows the increase influx of steroids by intratympanic steroid application into the perilymph, especially into the basal turn of the cochlea. This may explain the recovery of hearing not only in the low frequencies but also in the high frequencies that are more refractory to recovery treatment. Furthermore, the partial pressure of oxygen in the scala tympani achieved by HBO_2 in an experimental setting increased the protection of neurosensory cells and restoration of the oxidative metabolism in the vascular strip. In addition, HBO_2 improves rheology and microcirculation by lowering the blood viscosity and improving erythrocyte elasticity.

Our results suggest significant favorable impact of HBO_2 on the overall healing process at all the tested frequencies. If we evaluate the profit of the therapy, in the case of a quantitative comparison of the average therapeutic gains on tested frequency ranges, we find statistically significant differences in both HBO_2 groups compared to the control group. In terms of median sizes (non-parametric tests were used) in the medium- and high-frequency ranges (1,000 – 2,000 Hz and 4,000 – 8,000 Hz), the hearing gains of the H2.0 group show the dominance in the form of maximal remedial benefit. On the other hand, in the low-frequency range of 250 – 500 Hz, the results of both HBO_2 groups that used the pressures of 2.0 ATA and 2.5 ATA, respectively, were very similar statistically.

If we consider results from the perspective of categories we obtain interesting results. We divided obtained data in all tested groups into two categories. The applied therapeutic approach:

- "did not help" (i.e., hearing gain less than 10 dB; no improvement); or
- "helped" (i.e., change in PTA of 10 dB and over; improvement).

Again, we find statistically significant differences of both HBO_2 groups compared to the control group in all the tested frequency ranges. In the 250 – 500 Hz range the best hearing gains were obtained in the H2.5 group, but in two higher frequency ranges (1,000 – 2,000 Hz and 4,000 – 8,000 Hz, respectively) the best therapeutic response was observed in the H2.0 group.

The above results represent the key period necessary to optimize the conditions of application of supplementary HBO_2 therapy in treatment of SSNHL. To summarize, patients in the H2.5 group were exposed to a 90-minute

HBO_2 treatment once a day for 10 days at 2.5 ATA, while patients in the H2.0 group were treated using the same protocol but at 2.0 ATA. The effectiveness of HBO_2 in the treatment of SSNHL at different treatment pressures was different between these two groups. At low frequencies (250 – 500 Hz), the use of 2.5 ATA pressure was more efficient than 2.0 ATA. However, in the higher frequency ranges (1,000 – 2,000 Hz and 4,000 – 8,000 Hz), the better hearing gains were obtained at 2.0 ATA pressure. The obtained 2.0 ATA positive results may be in accordance with the results of several experimental works on the effect of HBO_2 on central nervous system damage. According to these works glucose metabolism is optimal at 1.5 – 2.0 ATA, with concurrent cerebral blood flow and intracranial pressure decrease at 2.0 ATA. Also observed was the balance between the production of O_2 radicals and antioxidant capacity as well as the optimal balance between benefit and risk of hyperoxia [34-37].

Our results support the possibility to optimize the use of HBO_2 in SSNHL treatment to individually meet each person´s needs. The applied technical conditions (pressure, number of sessions, periodicity and exposure times) should depend on the type and frequency range of hearing impairment (shape of the audiogram) in favor of using 2.0 ATA. This is very important in terms of taking an individual approach to each patient while noting the degree of his or her illness. It also helps to minimize the burden of a patient in order to obtain the maximum beneficial effect of the therapy.

However, our findings open other key questions for the future: *What should be the optimal concentration of the steroids used? What are the key factors in the pre-treatment process of patients that can positively or negatively influence the resulting therapeutic effect?* Further investigations are warranted to explore the mechanisms of action in the treatment of SSNHL.

CONCLUSIONS

In the view of the quantitative assessment of efficacy of HBO_2 based on the results of our study we can conclude the following: There is a notable difference in the therapeutic effect of HBO_2 according to different applied pressures while maintaining the same number of sessions, periodicity and exposure times. Further comprehensive clinical trials are needed in the development of standardized therapeutic procedures with defined sequences of treatment interventions and estimated range of laboratory-determined parameters. The task for our project is to add the missing data to this area of knowledge with emphasis on the needs of the local population.

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