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Long-term effect of hyperbaric oxygenation treatment on chronic distressing tinnitus

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Tinnitus is still a phenomenon with an unknown pathophysiology with few therapeutic measures. During the last two decades, hyperbaric oxygenation therapy (HBO) has been used in the treatment of sudden deafness and chronic distressing tinnitus. In this study, we prescribed HBO to 20 patients who had had severe tinnitus for more than one year and who had already had other forms of tinnitus therapy with unsatisfactory results. Four patients could not cope with the pressure gradient. The effect of HBO was assessed using subjective evaluation and VAS scores before and after HBO. Follow-up continued until one year after treatment. Six patients had a reduction of tinnitus and accompanying symptoms, eight patients did not notice any change and two patients experienced an adverse effect. Any outcome persisted with minor changes until one year after treatment. HBO may contribute to the treatment of severe tinnitus, but the negative effect on tinnitus should be weighed carefully.

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Introduction

Tinnitus aurium is the perception of sound in the absence of those sounds perceived. The etiology of tinnitus remains elusive despite increased knowledge of the anatomy and function of the cochlea and the brain. Multiple factors, such as age, exposure to noise, and ototoxicity, appear to play a role in the cause and persistence of tinnitus (Axelsson, 1992). In the past two decades, various hypotheses have been proposed with increasing emphasis on central processing. Since Hippocrates wrote down his thoughts on paper (relating tinnitus to vascular noise, Littré, 1962), many treatment modalities have been presented with mixed results. Only two forms of tinnitus rehabilitation are currently prescribed in general to patients suffering from tinnitus, i.e. tinnitus masking and psychological treatment (included counselling), both being symptomatic forms of treatment. Masking the tinnitus with external sounds diminishes hindrance and is moderately successful in up to 80% of patients (Vernon et al., 1992; Hallam, 1987; Hazell, 1990; Hazell & Wood, 1981). Since Fowler (1941) suggested that the patient should be educated to rationalize his symptoms and accept them at their face value, management of tinnitus through counselling and psychological treatment has been the keystone of tinnitus treatment (Hazell, 1990; Jacobs & Tromp, 1994).

The absence of a clear-cut pathophysiological explanation for tinnitus hampers the development of a causative treatment. Furthermore, the subjective character of tinnitus requires indirect testing with visual analogue scales (VAS) or questionnaires. Therefore, the outcome of different studies may be difficult to compare. Despite these impediments, an effective treatment is eagerly awaited by a large number of patients who did not respond satisfactorily to any treatment modality. According to various studies

(Leske, 1981; Coles, 1984; Axelsson & Ringdahl, 1989; George & Kemp, 1991), between 1% and 2.5% of the population suffer from tinnitus, and approximately 50% of these consider a normal life impossible. Some authors point to tinnitus as a major factor in sleep disturbance (Hallam, 1996), chronic depression (Harrop-Griffith et al., 1987; Lewis, 1995) or even suicide (Lewis et al., 1994; Lewis, 1995).

Recent studies have shown that hyperbaric oxygenation treatment (HBO) can suppress recent (Pilgramm & Schumann, 1985) and even longer existing tinnitus (Schumann et al., 1989), but these did not include a long-term follow-up. One study reported a positive effect in 33% of the patients in a group with various otologic diagnoses, but noted a regression of the positive effect of HBO in time, even within hours after the HBO (Granström et al., 1991).

The aim of this study was to evaluate the effect of HBO in patients with severe complaints of tinnitus aurium by means of a questionnaire and a VAS up to 1 year after HBO.

Material and methods

HBO protocol

Twenty patients with severe complaints of tinnitus underwent HBO. This consisted of 10 sessions with a descent phase, going from 1 ATA (atmosphere absolute) to 3 ATA in 15 min, staying 90 min at 3 ATA. The ascent phase went from 3 ATA to 1.6 ATA, a decompression stop for 5min, followed by a decompression stop at 1.3 ATA for 32 min. The hyperbaric session was developed in accordance with the Canadian Forces decompression tables. During these sessions the patients breath 100% oxygen through a Mecomfa mask (8 liters oxygen/minute) compensated for compression and decompression.

Patient selection

All patients had previous treatment (e.g. masking, counselling, Gingko biloba, acupuncture) which was either inadequate or not effective in the long term. They suffered from distressing tinnitus for more than 1 year. Patients were screened for any contraindication for HBO.

Evaluation

Before treatment, 1 week post-treatment, 3 months and 1 year after HBO the level of tinnitus was assessed by means of a VAS and a subjective evaluation form. The VAS consisted of lines of 100 mm, where the patient had to indicate the level of hindrance, social impact, loudness, mood, sleeping, concentration, relaxation and adaptation. The effects over time were tested using Friedman analysis of variance (non-parametric data).

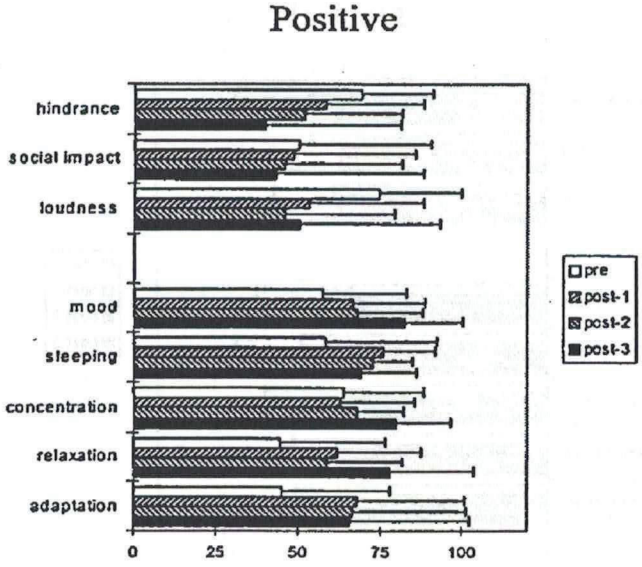

Fig. 1. Graphic representation of the VAS scores in the positive group before HBO, 1 week (post-1), 3 months (post-2), and 1 year after HBO (post-3). Standard deviation is indicated by bars.

Results

Four patients encountered problems (rhinitis, tuba dysfunction, otitis) during the descent phase of the treatment and could not finish the HBO despite conservative measures. In the 16 patients who completed the HBO successfully, 6 experienced a decrease in tinnitus distress with 2 noticing almost total disappearance of the tinnitus (Fig. 1, positive group); 8 patients did not sense a change (Fig. 2, neutral group); and in 2 patients the distress level worsened (Fig. 3, negative group). The mean age of the positive group was 57.7 years (47–69 years; 4 men, 2 women). In one patient the tinnitus started with a sudden deafness. The other patients were diagnosed with tinnitus aurium as an accompanying symptom of high-frequency perceptive hearing loss. The neutral group had a mean age of 41.9 years (24–56 years; 8 men). In this group one patient was diagnosed with sudden deafness, the

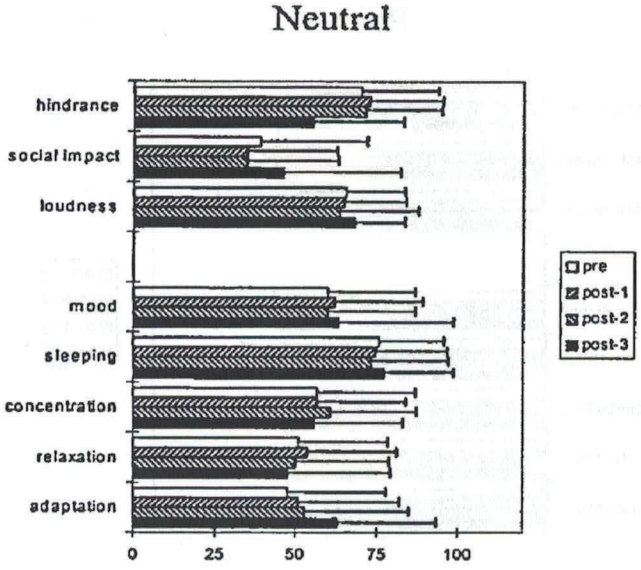

Fig. 2. Graphic representation of the VAS scores in the neutral group.

others had perceptive hearing loss without a clear cause. The negative group (40–55 years; 2 men) consisted of high-frequency perceptive losses due to noise exposure

The averaged group results of each indicator are depicted graphically (Figs 1–3). Positive effects are shown by lower VAS scores of the hindrance, social impact and loudness indicators, and by higher VAS scores of the other indicators.

Positive effect

In the positive group, all indicators (Fig. 1) except social impact showed an increase in the VAS score, which agreed with the subjective finding that HBO had a positive effect. Remarkably, some of these indicators (e.g. hindrance) improved even up to 1 year after HBO (Fig. 1).

Neutral effect

The neutral group displayed VAS scores which remained approximately at the pretreatment level (Fig. 2). In this group, three patients noted a positive effect of the HBO after each session, but this disappeared after a few hours.

Negative effect

The indicators in the negative group showed a tendency consistent with the subjective finding, except for tinnitus loudness (Fig. 3a, b). Both indicators showed improvement in contrast to the subjective finding in one patient.

In general, all three categories of effect of HBO appear stabilized directly after treatment and remain at the same level during the follow-up period. The indicator scores of all three groups ($n = 16$) added together showed a general decrease in hindrance and loudness with an increased score in mood, relaxation and adaptation (Fig. 4). There were no differences in smoking habits, diagnosis, noise exposure or exposure to ototoxic agents among the three patient groups.

In the positive group, the effects of relaxation and hindrance were significant at $p < 0.05$. Weak trends were found for adaptation and mood ($p < 0.10$). For the neutral group, only hindrance reduced significantly ($p < 0.05$).

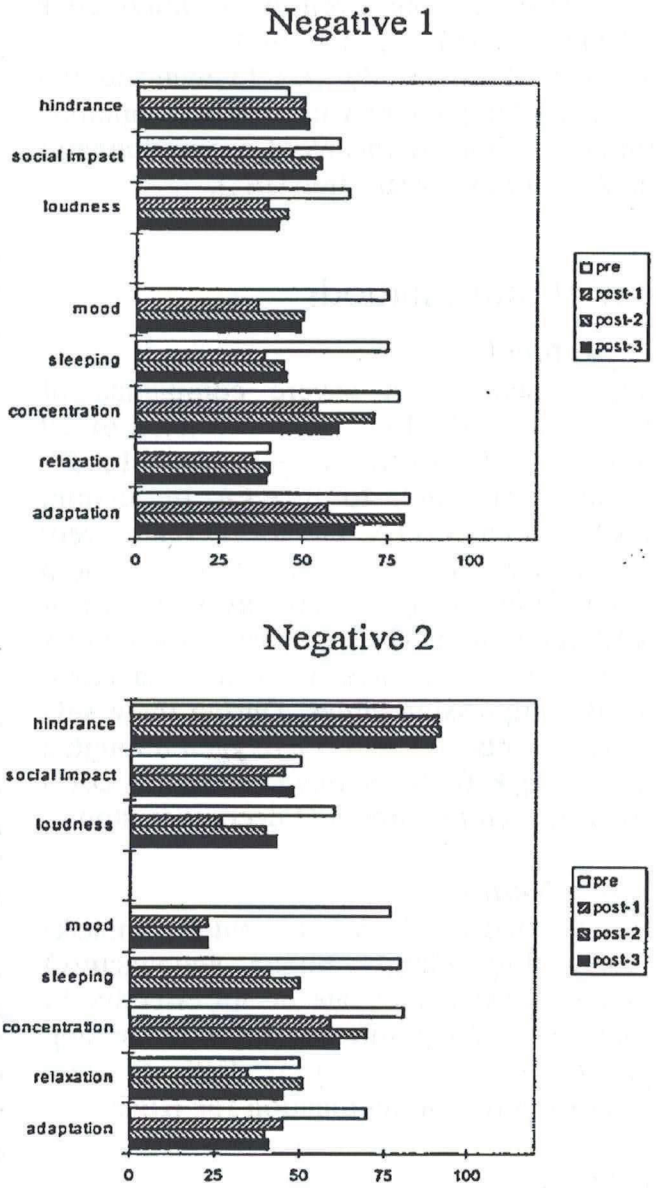

Fig. 3. Individual graphic representations of the VAS scores of both patients in the negative group.

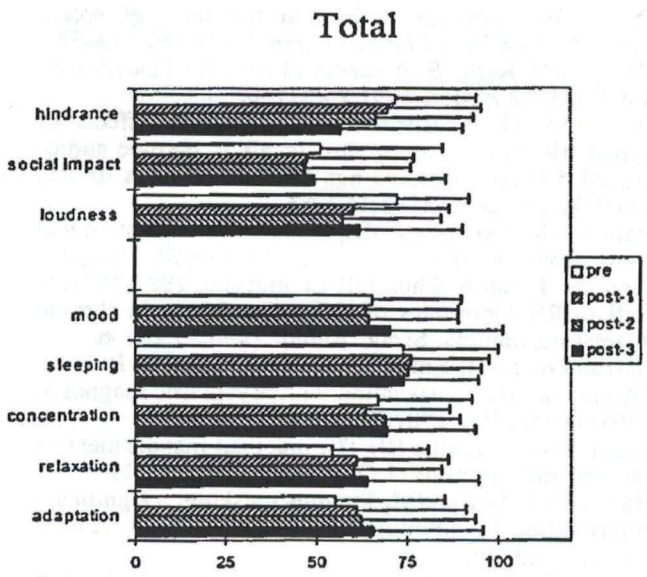

Fig. 4. Graphic representations of the VAS scores of all patients.

Discussion

A considerable number of therapies (such as HBO) have been proposed since the first written accounts on tinnitus. At first, HBO was used for the treatment of sudden deafness (Appaix & Demard, 1970), either as a monotherapy or as adjuvans. Some authors reported promising results with longer-existing hearing loss (Mori et al., 1970; Lamm & Klimpel, 1971; Takahashi et al., 1989). A similar strategy was followed in patients with chronic distressing tinnitus with similar outcome (Pilgramm & Schumann, 1985; Schumann et al., 1989).

HBO increases the partial oxygen pressure in the cochlear perilymph (Lamm et al., 1988a, b). Cochlear damage, due for instance to excessive noise, could arise from insufficient activity of oxygen-dependent enzymatic Na+/K+ pumps of cortic cells due to decrease of peri- and endolymphatic oxygen level (Thorne & Nuttall, 1989; Schumann & Fischer, 1992). A rise in intracellular sodium and extracellular potassium may lead to edema and structural cell damage (Lamm et al., 1988a, b; Zenner, 1990). However, the precise relationship between hyperbaric oxygen physiology and tinnitus remains speculative.

The results of this study indicate that HBO can reduce tinnitus even when it has been present for a long time. We also agree with the current literature that some of these patients will suffer a worsening of the tinnitus (Schumann et al., 1989). In our patient group, both patients showed that the main negative effect of HBO concentrated on the psychological indicators (mood, sleeping, concentration, adaptation). This would indicate that HBO is only suited for tinnitus patients accepting the risk of a worsening of their problem. The absence of a clear explanation to the working mechanisms of HBO and the elusive pathophysiology of tinnitus implies the impossibility of assessing the individual risk of worsening.

Noise-induced tinnitus responds well to HBO if applied within a few days (Pilgramm & Schumann, 1985). In our patient groups, two in the positive group had a history of exposure to noise, three in the neutral group and both patients in the negative group. In all patients, the exposure occurred more than 1 year prior to the HBO. So, our results not confirming the relatively favourable findings in noise-induced hearing loss may be due to the long delay between onset of the damage and treatment.

Previous studies on the effect of HBO have not included double-blind case control studies, nor did they include longer-term observations. In this study we were primarily interested in the longer-term results of HBO. We reassessed the effect up to 1 year. In the positive group, the positive effect after 3 months stabilized and remained at the same level until 1 year after treatment. Some of the non-responding patients whose scores are depicted in Fig. 2 did not notice any change in the tinnitus, but they may have had an increased tolerance to the tinnitus distress (indicators of hindrance and adaptation show a positive score; Fig. 2). In the negative group we observed a tendency to return towards pretreatment levels after 3 months. Both patients experienced an increase of tinnitus with adaptation to the new situation after 1 year, but this presents a warning signal that HBO is not without longer-term pitfalls. It is unclear why the tinnitus loudness in the negative group (Fig. 3) shows a positive effect. One of the patients indicated an increase of the tinnitus but persisted in the contradictory VAS score. The poorer total outcome of our study compared with previous reports (e.g. Schumann et al., 1989) may originate in the negative selection of our patient group and the use of HBO as monotherapy.

Spontaneous longitudinal fluctuations in tinnitus may play a role in the assessment of any result of treatment. However, this tinnitus

behaviour has only been investigated in people older than 70 years of age (Rubinstein et al., 1992).

We did not include a control group since case control in this set-up is difficult to accomplish. A case control study would imply that one patient received the actual HBO, while the other would breathe an air mixture with the partial oxygen pressure remaining at outside levels. Hyperbaric treatment itself without oxygen may increase the partial oxygen pressure twofold (Lamm et al., 1988a). Also it is hard to match the test and control group in accordance with an equivalent level of tinnitus distress. Furthermore, this set-up would not eliminate the (psychological) influence of the hyperbaric chamber itself.

Assessing the level of distress remains the primary impediment in the appraisal of tinnitus studies because of its subjective nature. Both attributes also hamper the development of an animal model, although some attempts have been made (see Jastreboff & Sasaki [1994] for a review). In patient studies, differences in level of tinnitus, duration, medical history and involvement of etiological factors in the initiation and mental habituation may obscure any correlation with a treatment outcome.

Our tinnitus form has already been used to show patients the development of their psychological treatment with reliable results and therefore used for this study. According to the results, the VAS and questionnaires are suited to indicate the discomfort level of the patients. Further studies to evaluate the actual effect of HBO should concentrate on development of case control trials and on an experimental animal model.

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