

## Hyperbaric oxygen therapy for tinnitus

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**Key-words.** Hyperbaric oxygenation; tinnitus

**Abstract.** *Hyperbaric oxygen therapy for tinnitus. Objective:* To assess the effect of hyperbaric oxygenation on tinnitus.

*Methodology:* A Medline search from 1960-2007 yielding 22 studies.

*Results:* No significant effect could be demonstrated in four prospective studies. Retrospective studies indicate greater improvement in tinnitus in acute cases (49-85%) compared with tinnitus episodes exceeding three months (34-38%). One study, however, showed significantly more improvement in patients with positive expectations before therapy (60.3%) compared with those with negative expectations (19%).

*Conclusions:* There are no significant data about the effect of hyperbaric oxygenation for tinnitus, but there are indications of a better effect in acute cases. However, a major psychological component and a low risk of enhancement of the tinnitus should be considered.

### Introduction

Hyperbaric oxygenation (HBO) is the administration of 100% oxygen at environmental pressure higher than one atmospheric absolute (ATA). It has been used for the treatment of idiopathic sudden sensorineural hearing loss (ISSHL) and tinnitus since the late 1960s. Its rationale is based on the hypothesis that inner ear disorders such as ISSHL or tinnitus result from cochlear hypoxia. Lamm *et al.*<sup>1</sup> conducted experimental studies of guinea pigs. During hyperbaric oxygenation at 2.5 ATA, the perilymphatic partial oxygen pressure (pO<sub>2</sub>) increased by  $453.1 \pm 150\%$  and was still  $58.4 \pm 14\%$  higher one hour later. Oxygen diffuses from the cochlear capillary network into the perilymph and cortilymph, supplying the inner ear's sensory and neuronal structures, which have no direct vascular supply. The pO<sub>2</sub> of the perilymph will only rise constantly when there is

an extreme increase in the arterial-perilymphatic difference in oxygen concentration.<sup>1</sup> Isobaric oxygen inhalation resulted in only a temporary increase of perilymphatic pO<sub>2</sub> of 16%.<sup>1</sup>

The conclusion of a recent Cochrane review<sup>2</sup> of hyperbaric oxygenation for ISSHL was that, for people with early presentation of ISSHL, the application of HBO led to a significant hearing improvement but that the clinical significance of the level of improvement is not clear.

It is easy to document the degree of hearing loss and hearing improvement. However, the assessment of tinnitus is difficult. The subjective character of tinnitus requires indirect testing with visual analogue scales (VAS) or questionnaires. There is not always a correlation between the subjective loudness of the tinnitus and the impact on daily life, since psychological factors may play a role. On the other hand, HBO is a

very intensive therapy. The patient has to spend 1 to 2 hours a day over a period of 10 to 15 days in a hyperbaric chamber. This environment and the special care given may also have an effect that is not linked to the oxygen, hampering randomised controlled trials.

### Materials and Methods

A Medline search for 1960 to 2005 yielded 55 clinical studies involving 5438 ISSHL patients treated with HBO.<sup>3</sup> Only a few of these studies also considered tinnitus. A Medline search for 1960 to 2007 yielded 22 clinical studies considering tinnitus improvement for this paper, two of which were reviews.<sup>2,4</sup>

### Results

HBO treatment involves pressurisation to between 1.5 and 2.5 ATA for periods of between 60 and 120 minutes with a compression

and decompression time of ten to twenty minutes once or twice daily. During isocompression patients breathe 100% oxygen, sometimes with a short interval of air breathing. A typical course involves ten to twenty treatment sessions of this kind.<sup>2,5</sup>

Only four of the twenty-two clinical studies were prospective randomised trials (Table 1). The control groups were treated at 2.2 ATA with oxygen,<sup>6</sup> at 1.5 ATA with normal air breathing,<sup>7</sup> or they received no therapy.<sup>8,9</sup> The therapy groups received HBO at 2.5 ATA<sup>6,9</sup> or 1.5 ATA.<sup>7,8</sup> All prospective studies were conducted for acute tinnitus (less than 3 months), except for the study of Hoffmann *et al.*<sup>7</sup> (more than 6 months). Two studies<sup>8,9</sup> showed more improvement in tinnitus on a VAS. However, this difference was not significant.

The results of the major retrospective studies<sup>4,5,10-13</sup> are summarised in Table 2. It is not easy to compare the results because of differences in analyses and patient populations. The majority of the publications deal with acute tinnitus (less than three months), showing an improvement of the tinnitus in 49-85%. For tinnitus episodes exceeding three months,

improvement was achieved in 34-38% (Table 2). Only Delb *et al.*<sup>5</sup> compared groups of patients with tinnitus with (n = 80) and without hearing loss (n = 113). They found no difference in tinnitus improvement between the two groups. Nor did they observe a correlation of the level of hearing and tinnitus improvement.

Long-term results were only reported in two studies<sup>12,13</sup> of chronic tinnitus.

Fürst *et al.*<sup>12</sup> described a stable result, with 38% of patients (n = 45) reporting tinnitus improvement immediately after HBO and 33% one year after treatment. In Tan's study,<sup>13</sup> six out of sixteen patients reported a persisting tinnitus improvement after one year.

The influence of psychological factors on the results of HBO for tinnitus was investigated by Stiegler *et al.*<sup>6</sup> They allocated 360 tinnitus patients at random to two treatment protocols, one at 2.2 ATA and one at 2.5 ATA. Patients were asked to fill in a questionnaire before, and one month after, the HBO to assess the subjective impact of the tinnitus and their expectations for HBO. There was no difference in tinnitus improvement after HBO between both groups: 3.3% expe-

rienced complete remission of the tinnitus, intensity lessened in 33.9%, and 12.2% found there was a subjectively agreeable change in noise characteristics. However, 60.3% of 68 patients with positive expectations about HBO stated that the tinnitus had improved. On the other hand, of the patients who underwent the therapy with indifferent (n = 271) or negative (n = 21) expectations, only 47.2% and 19% respectively reported an improvement. This effect was statistically significant (p < 0.05).

## Discussion

A recent Cochrane review<sup>2</sup> considered three prospective studies.<sup>7-9</sup> It arrived at the conclusion that the routine application of HBO for tinnitus could not be justified by this review because of the modest number of patients and the impossibility of assessing the effect with pooled data. The control group also received treatment in the hyperbaric chamber with oxygen at 2.2 ATA<sup>6</sup> or normal air at 1.5 ATA<sup>7</sup> in two of the trials only. This approach minimises a possible psychological effect of the intensive treatment in a hyperbaric chamber environment. However,

Table 1

Prospective randomised trials of hyperbaric oxygenation for tinnitus  
(HBO: hyperbaric oxygenation, VAS: visual analogue scale)

Authors	study design	n	duration of tinnitus	results
Schwab <i>et al.</i> , 1998 <sup>9</sup>	HBO 2.5 ATA versus no treatment	75	<2 weeks	greater tinnitus improvement on a VAS in HBO arm: 3.1 units
Hoffmann <i>et al.</i> , 1995 <sup>8</sup>	HBO 1.5 ATA versus no treatment	20	<3 months	greater tinnitus improvement on a VAS in HBO arm: 0.4 units
Hoffmann <i>et al.</i> , 1995 <sup>7</sup>	HBO 1.5 ATA versus normal air 1.5 ATA	44	>6 months	no difference between HBO arm and the control
Stiegler <i>et al.</i> , 2007 <sup>6</sup>	HBO 2.5 ATA versus HBO 2.2 ATA	360	<6 months	no difference between the two groups

Table 2  
Retrospective studies of hyperbaric oxygenation for tinnitus

authors	study design	n	Duration of tinnitus	results			
				cured	improved	unchanged	worse
Lamm <i>et al.</i> , 1998 <sup>4</sup>	Review 7 stud. secondary HBO	1223	<6 weeks	4%	81.3%	13.5%	1.2%
Kau <i>et al.</i> , 1997 <sup>10</sup>	secondary HBO	192	<3 months	6.7%	44.3%	44.3%	4.7%
		163	>3 months	none	34.4%	62%	3.6%
Höing <i>et al.</i> , 1996 <sup>11</sup>	primary HBO	109	<1 month	33%	46%	21%	none
	secondary HBO	221	>3 months	6%	29%	60%	5%
Delb <i>et al.</i> , 1999 <sup>5</sup>	secondary HBO	193	<100 days	10.4%	39%	50.6%	none
Fürst <i>et al.</i> , 1994 <sup>12</sup>	secondary HBO	45	>3 months	none	38%	58%	4%
Tan <i>et al.</i> , 1999 <sup>13</sup>	secondary HBO	16	>1 year	none	38%	50%	12%

inhalation of normal air under hyperbaric conditions also results in a small increase of tissue oxygen pressure and cannot be considered to be a placebo therapy.<sup>3</sup>

The treatment group in the two prospective studies we conducted<sup>7,8</sup> received HBO at 1.5 ATA. There are no experimental data for the effect on the pO<sub>2</sub> of the perilymph, but it is less than the classical 2.5 ATA, where a 450% increase in perilymphatic pO<sub>2</sub> was shown experimentally.<sup>1</sup> A retrospective comparison of a patient group with ISSHL treated with 1.5 ATA with a group treated with 2.5 ATA and a control group that was not treated showed a statistically significant greater hearing gain in the 2.5 ATA group compared with the 1.5 ATA group.<sup>3</sup> No statistically significant difference was found between the 1.5 ATA and the control group.<sup>3</sup> This may be an indication that the hyperbaric arm of the two prospective studies at 1.5 ATA<sup>7,8</sup> was not effective. Future prospective randomised trials should be conducted with HBO at 2.5 ATA.

Retrospective studies indicate more tinnitus improvement in acute tinnitus (<3 months), both as primary<sup>11</sup> and secondary thera-

py<sup>4,5,10</sup> after ineffective treatment with corticosteroids and/or hemodilution. The tinnitus improved in 49-85% of the acute cases and in 34-38% of the patients with a tinnitus episode exceeding three months.<sup>10-13</sup> However, these results should be interpreted with care, because Stiegler *et al.*<sup>6</sup> found a major psychological effect. They found that the expectations of the patients before therapy about the results of HBO had a significant effect. An improvement of tinnitus was reported by 60.3% of the patients with positive expectations, compared to 47.2% of the patients with indifferent expectations and 19% of those with negative expectations ( $p < 0.05$ ). This also hampers the comparison of HBO with no treatment, since the hyperbaric chamber environment and the special care given may also have a psychological effect.

Several studies show that tinnitus worsens in up to 12% of the patients treated with HBO (Table 2). It seems to be more frequent in chronic tinnitus patients. Tinnitus worsening after HBO was reported in all studies dealing with tinnitus episodes exceeding three months in 3.6 to 12% of

patients and in two of the four studies of acute tinnitus (1.3-4.7%) (Table 2). This should also be an element in HBO counselling for tinnitus patients.

## Conclusions

There are no significant data based on randomised controlled trials about the effect of hyperbaric oxygenation for tinnitus, but there are indications that outcome is better if the tinnitus has been present for less than three months. However, a major psychological element and a low risk of enhancement of the tinnitus should be considered.

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