

Treating Tinnitus with Hyperbaric Oxygenation

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Abstract: Hyperbaric Oxygenation permits a controlled increase of the partial oxygen pressure in the blood. This technique can be used in cases of tinnitus and sudden deafness when the development in the inner ear and the brain lead to a lack of oxygen and so to a limited energy provision. The results to date allow the recommendation to apply an oxygen high pressure therapy when standard treatments have failed. One can work on an improvement rate of 60-65% with tinnitus. HBO therapy should start as soon as possible. Especially in cases of sudden deafness the success depends on a speedy application of HBO. The HBO therapy broadens the spectrum of treatment possibilities for tinnitus and sudden deafness.

Although the pathophysiological pathways of tinnitus have not yet been fully explained, a series of findings indicate that often a malfunction of blood transfer to the inner ear impairs the oxygen content of the affected cells [1]. Presumably the metabolism of the stria vascularis is particularly affected [2]. This tissue sees to the correct composition of the endolymph and thus also safeguards the sustenance of the hearing cells [3]. To this purpose a continuous, extremely high aerobic energy turnover is required [4]. The anaerobic energy metabolism is of lesser importance [5]. Together with cells of the retina, the cell of the stria vascularis belong to the tissues having the highest concentration of oxygen in the human organism. Therefore the blood flow is high in these tissues [6,7].

Studies which showed that the stria vascularis of the basal turns of the cochlea consumes three to four times as much oxygen than in the apical turns are noteworthy [8,9]. Even though the method of determining the absolute oxygen counts are now outdated, they give an important indication of the connection between a malfunction of the high tone area and a lack of oxygen in the basal turns locality. The close relationship between aerobic energy metabolism and the function of the inner ear becomes obvious through a high ATP synthesis rate of sound wave influence in the physiological area. With sounds of 89-90 dB the oxygen pressure rises up

to 20% in the perilymph [10]. An increase in blood circulation was also observed. A very high intensity however, reduces the blood supply and leads to a lowering of the desoxy-glucose supply [11,12]. There are informations that also neural impulses may influence the blood flow of the cochlea [13].

The partial oxygen pressure (pO_2) in the endolymph is remarkably high. It was quoted as 55-79 mmHg for the scala media [14]. With a normal pO_2 of 90-95 mmHg in the blood, the difference to the endolymph is distinctly lower when compared to the muscular system, where we found values of 35-45 mmHg [15]. The difference in pressure is however, besides the diffusion stage, of central importance for the transfer of oxygen from blood into the cell.

Hyperbaric Oxygenation

The effectiveness of high pressure oxygen therapy is based on raising the partial pressure of oxygen in the blood and thus the pressure difference to tissue. According to biophysical laws (gas laws) the pressure of oxygen in the blood depends directly on the pO_2 of inhaled air.

At a surrounding pressure of 2.0-2.5 bar and breathing oxygen one can expect a 5-8 fold rise of the pO_2 level in the blood and a 3-4 fold rise in the tissues. Prerequisite for an oxygen therapy is intact lung tissue and regular cardiac and cerebral functions. The microcirculation in the damaged tissues must also be sufficient in order to ensure that oxygen is received [16].

As a sudden dysfunction of the inner ear presumably will cause an interruption of the blood supply to the stria vascularis and thus to the organ of Corti and by

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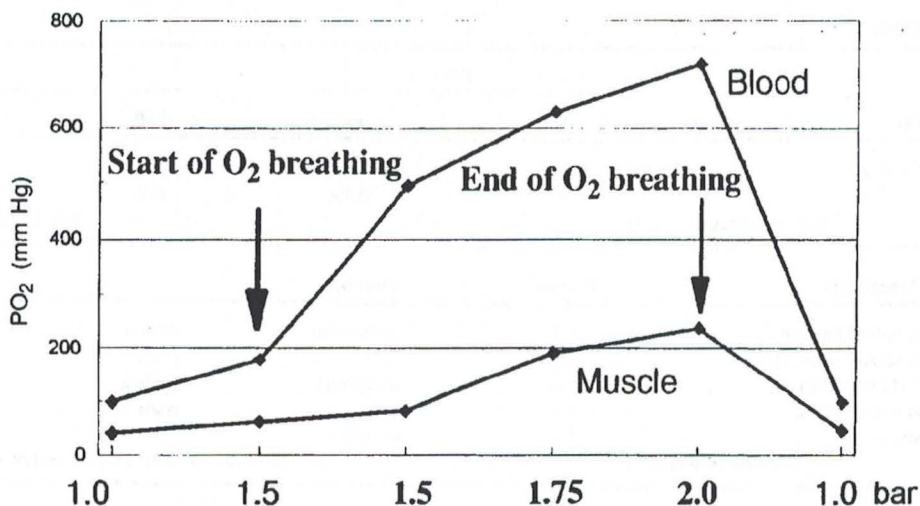


Figure 1. Oxygen partial pressure in the blood and muscular system under different chamber pressures.

this a lack of oxygen, it was a reasonable supposition to use HBO to influence this factor.

Investigations

For the first prospective study 47 patients received an HBO therapy within 3 months of tinnitus first occurring. In each case they already had received standard treatment with infusions and often combined with cortisone. The necessary medical examinations all were undertaken by the ENT center (Prof. v. Ilberg) at Frankfurt University.

In 64% of the cases an improvement was attained. During the follow-up examinations 27% of the patients confirmed a further decrease of the ringing in their ears during the 2 months following treatment [17].

In a retrospective study, patients who had been treated with infusions with no success and then received HBO therapy (n = 250) were compared to a group that had not received oxygen therapy. They were

under observation for 21 months. Here also 60% ascertained a steady tinnitus improvement [18].

Due to the good results we made tinnitus an indication for hyperbaric oxygenation treatment. The number of tinnitus patients rose during the last few years and we now have circa 550 patients a year.

The data of the 1994 patients was statistically analyzed. Out of a total of 450 patients the data for 381 patients were complete and could be evaluated.

On average 15 single treatments for 90 minutes with a pressure of 2.2–2.5 bar abs. (12–15 m diving depth) were carried out. Due to the pre-therapy examinations for suitability for treatment no severe complications during the therapy were registered. The patients with tinnitus often occurring difficulties with the tubal function occasionally caused irritations at the external auditory canal which however faded away after 2–3 days. The patients were asked to daily, and always at the same time of day, note down their subjective perceptions regarding sound volume and also how they feel.

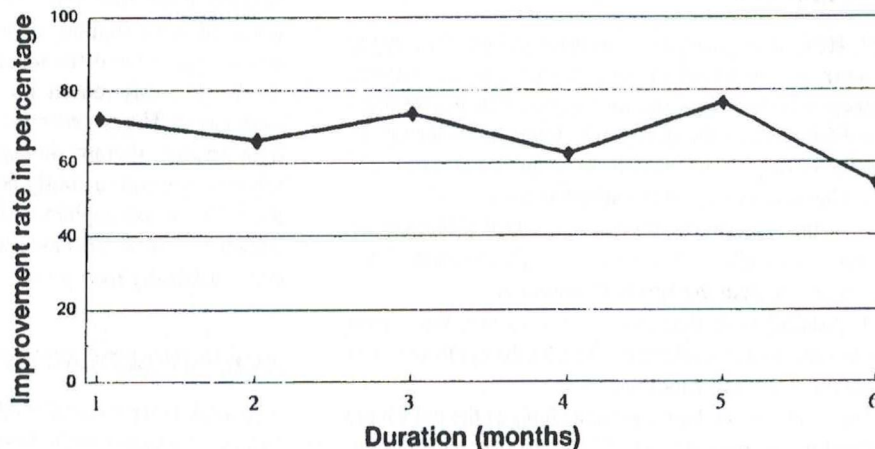


Figure 2. Duration of tinnitus from beginning of HBO.

Table 1.

Age:	Sex:		Ear		
	f	m	Left	Bilat.	Right
11-81 y.	113	268	99	164	118
ø 45,2 y.	29,7	70,3%	26%	43%	31%
Tab.: Biodatas (n = 381)			Tab.: Localization of tinnitus		

Changing in	Percent	Tinnitus	Before	After	
completely healed	3,9	unbearable	grade 4	11	2
noticeable improvement	34,1	loud	grade 3	163	70
slight improvement	31,8	fairly loud	grade 2	188	162
no improvement	28,1	quiet	grade 1	19	120
worsening	2,1	no noises		0	27
Tab.: Results of treatment		Tab.: Subjective sensation degree before and after HBO-therapy			

The improvement of the tinnitus sounds with HBO treatment summarized from "becoming less" to "being completely healed" is noticeable in the first 6 months after tinnitus first occurs. The major advances starting with "unbearably loud" to "bearable" were made during the first 2-3 months. This also applies when tinnitus occurred in conjunction with sudden hearing loss or as a result of the same.

The improvement of tinnitus sound with HBO treatment summarized from "becoming less" to "being completely healed" is noticeable in the first 6 months after tinnitus first occurs. The major advances starting with "unbearably loud" to "bearable" were made during the first 2-3 months. This also applies when tinnitus occurred in conjunction with sudden hearing loss or as a result of the same. If the patients under 40 years of age could not be treated within the first months after tinnitus occurred, the changes of successful improvement were distinctly lower than with older patients. There was no worsening of the condition in young people. The 8 patients who registered an increase in noises during HBO were all over 40.

Nearly every patient felt better during or after the HBO treatment; particularly those who suffer under mental distress.

DISCUSSION

With HBO it is possible to increase the partial oxygen pressure in the blood in accordance with the oxygen pressure of inhaled air and thus obtain a sufficient pressure difference to the tissue pO₂ tissue, so ensuring the transfer of oxygen to the cell. Prerequisite is a satisfactory microcirculation in the affected area.

A disturbance in the blood supply will affect the inner ear, especially the extremely sensitive tissue of the cochlea more than the cerebral structure.

A possibility is that the various factors that cause tinnitus run to a disturbance of the Krebs cycle and thus a decline in the cell function.

This process can be reversed as long as the cells have suffered no serious damage. The more affected cells are

however, the more they require a significantly higher O₂ pressure than normal for the healing process [19].

Other HBO centers also report good clinical results [20-23]. In nearly all cases a normal therapy had been carried out with no success before applying HBO. Comparisons are only possible up to a certain point as the tinnitus data is subjective and the scale of the sensations felt is varied. However, it seems that during the first 6 months an HBO treatment has a positive and promising effect on tinnitus [24,25].

With experimentally created disturbances in hearing one could measure a lack of oxygen in the perilymph. Additional oxygen significantly accelerated the healing process [26].

It is unfortunately not possible to distinguish with which tinnitus patients lack of O₂ plays an essential part in sustaining tinnitus. As HBO after a thorough pre-examination and anamnesis carries little risk, it should be liberally applied when infusion therapy shows no success. Even after 4-6 months successful results were obtained with tinnitus patients, however, for sudden deafness patients there seems to be a time limit of 4-6 weeks. For this reason no time should be wasted in such cases. The experiment of carrying out an oxygen high pressure therapy during the infusion phase did not produce any convincingly better results, not even when the infusion was applied in the hyperbaric chamber during HBO. These test cases were, however, not planned and statistically monitored.

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