

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 Even though the method of determining the absolute oxygen counts are now outdated, they give an important indication of the connection between a malfunction of the high tone area and a lack of oxygen in the basal turns locality.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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and nutrition of the affected organs become disturbed and the function of these organs is adversely affected.

Tinnitus, hypacusia and vertigo can appear separately or together; suddenly or as the worsening of chronic complaints. The causes of vertigo, hypacusia and tinnitus can appear as central or peripheral lesions. Without exception the patient must be examined immediately, and appropriate treatment applied.

In the examination of complaints the task of oto-neurologists take

- detailed anaemnesis (which can be the 60% of diagnosis)
- clinical ENT examination
- otoneurological examination
- X-ray (Stenvers, Schüller, neck spine)
- Ct, MR
- hemorheological examination (viscosimetry)
- consultation (if it is necessary) with
 - *neurologist
 - *ophthalmologist
 - *internal specialist
 - *orthopedist
 - *rheumatologist.

Strategy:

1. Complex examination of complaints.
2. Suitable improvement of the pathological parameters.
3. Follow up of clinical state.

MATERIALS AND METHODS

The patients were selected during 9 months between 1991 and 1992 from the ENT Outpatient Department of Buda Military Hospital on purpose to examine:

- what kind of parameters are pathological among the cases,
- in which proportion was the improvement of pathological parameters successful during the adequate therapy,
- in which proportion was clinical improvement proved in the different groups (tinnitus, vertigo, hypacusia)?

Patients: 30 persons (25 males and 5 females). Average age: 50.3 years. The treatment of patients, in consequence of acute complaints or of the sudden worsening of chronic complaints, were needed. The data of these are in tabular form.

An effort was made to preclude the toxic, neoplastic and inflamed diseases. So beyond the customary ENT examination radiological, neurological, ophthalmological

Table 1. The Types of the Complaints in Different Syndromes

	Tinnitus	Hypacusis	Vertigo
Acute	5	7	3
Worsening of an already existing condition	19	17	7

cal and medical consultations were also needed. The following rheological examinations were made:

- Total Blood Viscosity /TBV/ at three speed gradients (10, 40, 90 sec⁻¹) with the help of HEVIMET-40 heat-protected (37°), computerized viscosimeter, which is suitable for mass-measurement (HEMOREX, Budapest) [2]
- Plasma Viscosity /PV/ at 37° with HEVIMET-40 viscosimeter
- Triglyceride of serum
- Cholesterin of serum
- Hematocrit /Ht/
- Plasma Fibrinogen /FIB/ according to the modified method of Klauss (Multifibren, Behringwerke AG, Hamburg)
- Blood Sedimentation /Rate/ESR/.

Hemorheology has a lot of experience in angiology, in the fields of cerebrovascular diseases [3] and in hematology [4]. It would be useful if this discipline could gain ground in those ENT diseases which can be traceable to circulatory causes [5].

RESULTS

The occurrence of pathological rheological values was found in 24 patients in our examined group. The normal hemorheological values in our laboratory are:

- PV < 1.40 mPas
- TBV 10 sec⁻¹ < 8.5 mPas
 - 40 sec⁻¹ < 5.5 mPas
 - 90 sec⁻¹ < 5.0 mPas
- FIB 1.8-3.5 g/l
- Ht 0.37-0.45 g/l

Such a high number of pathological values can derive from the relatively high average age of examined patients and from the high number of risk factors (in 60% appeared diabetes, hypertension, hypercholinesterinemia and smoking).

On the other hand, the occurrence of pathological neck spine alterations were found in 22 cases. In these cases the following additional physiotherapies were applied according to the conditions:

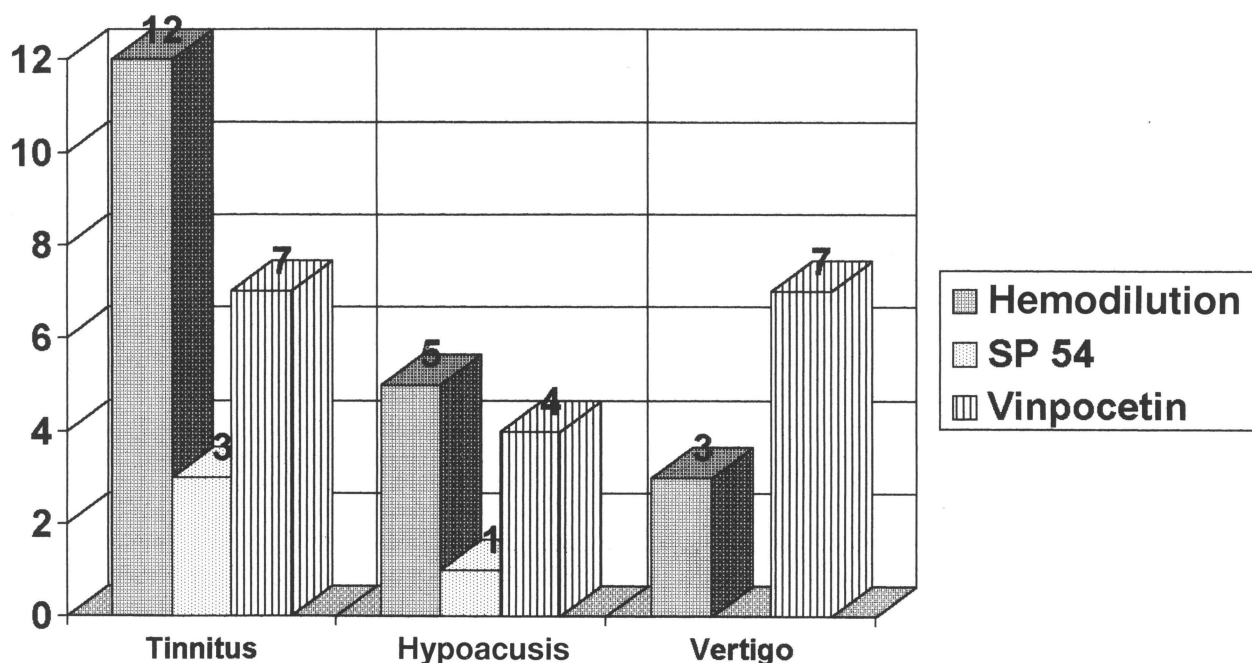


Figure 1. The types of rheological treatments I.

- ultrasound
- iontophoresis
- massage
- therapeutic exercises
- balneotherapy.

The following differences were found in the 24 rheological pathological cases:

1. Increase of TBV in 6 rheological normal hematocrit value (with 0.37-0.45 Ht) patients. Crystalloid solution with Vinpocetine (Cavinton, Richter Gedeon) 50 mg/day or Pentoxifyllin (Trental) 400 mg/day were applied in infusion.
2. Common occurrence of TBV increase and Ht level above 0.45 were found in 12 patients. In these cases isovolemic hemodilution /IHD/ was adopted (puncture of 300 ml blood by phlebotomy giving simultaneously 500 ml Gelifundol) every second day. This procedure was applied until the value of Ht have reached 0.37-0.45 because this domain of Ht improves the oxygen supply of tissues through the correction of fluidity [6].
3. The increase of PV was found only in 6 patients. Therefore, Natrium-pentosopolysulfuricum (SP 54) 100 mg/day was applied with 500 ml crystalloid solution for 10 days - with controlling the number of platelets - then it was changed for pills of SP 54 50 mg 3 times daily. Under this treatment it not only reduced the PV, but also decreased the plasma fibrinogen.

Regarding the complaints, 24 patients had got *tinnitus* and of these in 20 cases pathological hemorheological values were found. The patients were given directed treatment (in 11 persons IHD, in 4 persons SP 54, in 5 patients Pentoxifyllin were applied). As a result of treatment, tinnitus lessened in 11 patients and disappeared in 9 persons.

24 patients had got *hypacusia*. After the treatment, hearing improvement with 5 - 10 dB was achieved only in 1 case but it was not statistically significant. In some cases, the patients explained that they were able to observe certain sounds and noises (e.g.: ticking of a clock, warbling of birds, opening of the door, etc.) after treatment, whereas demonstrable change of threshold of hearing was not registered. This phenomenon was named "subjective" hearing improvement, in which the improvement of cerebral blood circulation probably also plays role. In spite of unchanged threshold of hearing the experience of hearing becomes perfect because of the better processing of sound information. 19 patients had pathological rheological parameters. These parameters became normal in 14 cases after the treatment, and in 10 out of the 14 subjective hearing improvement.

In 10 cases there were complaints about vertigo. The rheological values were pathological in each of them. The consecutive ENG signs of central blood circulation failure characterized nearly all of the cases (e.g.: broken pursuit eye-movement, in calorimetry dysmetria, dysrhythmia, stepped slow phase and petite ecriture). By hemorrheolog-

metric Society, Haifa, Israel, April 6–10, 1997, and at the Satellite Meeting, The Dead Sea, April 11, 1997.

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