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Eustachian tube function in sudden hearing loss and in healthy subjects

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Abstract

The relationship between sudden hearing loss and an ipsilateral patulous tube was tested in our Eustachian tube laboratory. Fifty patients suffering from sudden hearing loss were examined by the pressure chamber impedance method, giving objective data on Eustachian tube function. Results were compared to those obtained from 56 healthy volunteers in a preceding investigation. Our investigation did not show any associations between patulous tube syndrome and sudden hearing loss, as had been claimed by several authors previously. There was even indication of a decreased patency of Eustachian tube in our patients in active and passive tubal tests. We could demonstrate a high reproducibility of values obtained by our method, indicating that results are representative in healthy persons as well as in patients.

In a case report the importance of objective diagnostic methods in differential diagnostics of Eustachian tube pathology is emphasized.

Introduction

A patulous Eustachian tube (ET) is usually associated with autophony and breathing-synchronous tinnitus. Recent observations proposed a relationship between ET dysfunction and cochleovestibular disturbances. Heermann (1988) observed a higher incidence of patulous tubes among patients suffering from unilateral sudden hearing loss particularly in the left ear. Robinson and Hazell (1989) described vestibular symptoms and chronic sensorineural hearing loss in patients with patulous tubes. In these studies ET function was evaluated from the case history and by otoscopic examination of tympanic membrane movements during forced nasal respiration and Valsalva's manoeuvre.

In order to examine the epidemiology of patulous tubes among subjects affected by sudden hearing loss, we evaluated ET function among patients suffering from sudden hearing loss and among healthy volunteers, using objective analytic methods. In a preceding investigation normal values and reproducibility of tubal function were determined.

Patients and methods

a) Patient group

Fifty subjects suffering from sudden hearing loss were consecutively examined in our ET laboratory in a prospective study. Only patients without a history of infectious, traumatic, hereditary or retrocochlear ear disease were included. Both tubes were examined simultaneously using the pressure-chamber impedance method as described by Münker (1972). A short description of this method is as follows: A rubber plug connected to a probe with three boreholes is inserted in each ear canal while the patient is sitting in the pressure chamber. One borehole contains a loudspeaker (220 hz), the other a microphone and the third hole is open, guaranteeing equalization of the pressure in the ear canal with that in the chamber. The microphone registers the sound reflected by the tympanic membrane, indicating the impedence of the middle ear. Impedance and air pressure in the chamber are noted by an X/Y-plotter.

First, the static examination of ET was carried out. Keeping the pressure in the chamber at normal ambient atmospheric pressure, the impedance of both middle ears was measured while the patient performed a defined schedule of ET tests including forced nasal breathing and Valsalva's manoeuvre over a period of one minute. Second, we examined both tubes altering ambient air pressure in the pressure chamber (dynamic examination). The chamber pressure was diminished continuously by 13 kPa at a rate of 10 kPa/min. The tubal opening pressure (TOP), corresponding to the positive pressure in the middle ear forcing up the ET passively for the first time, and the tubal closing pressure (TCP), describing the tubal resistance against a positive pressure in the middle ear, were analyzed. Finally, the ambient air pressure was adjusted to the normal atmospheric level at a rate of 10 kPa/min with the patient equalizing negative middle ear pressure by repeated swallowing. Residual negative pressure (RNP) in the middle ear after repeated swallowing was recorded. A comparison both between diseased and healthy ears as well as between right and left ears was

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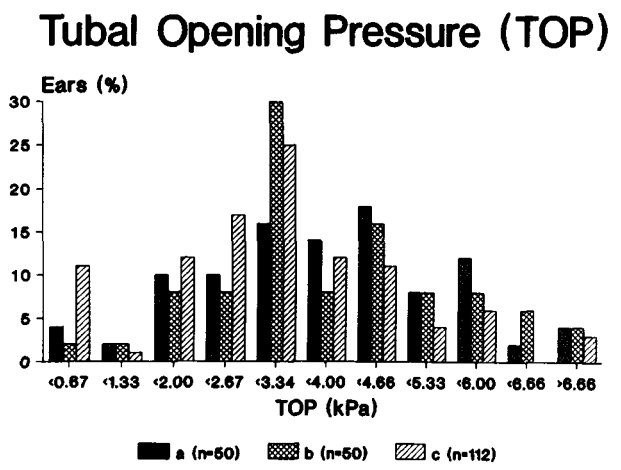

FIG. 1

Distribution of tubal opening pressure (TOP).
a) TOP in ears affected by hearing loss (patient group).
b) TOP in healthy ears (patient group).
c) TOP in ears of healthy subjects (volunteer group; first measure cycle).

carried out for the parameters described above using Student's t-test.

b) Volunteer group

In a earlier investigation ET function of 56 healthy volunteers (= 112 ears) was evaluated as described above. TOP, TCP and RNP were recorded and mean values were calculated. All tests were repeated four times on the same day and once more on the subsequent day. Results were compared in order to verify the reproducibility of ET function tests. The statistic evaluation was performed by the F-test.

Results

a) Patient group

In the static examination we did not find any ear exhibiting impedance changes synchronous with forced nasal respiration.

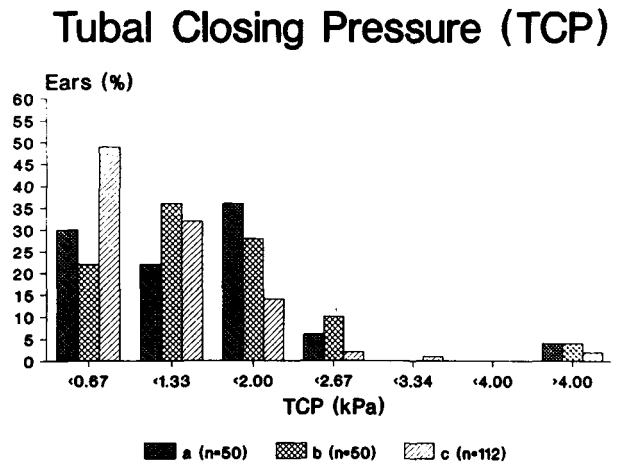

FIG. 2

Distribution of tubal closing pressure (TCP).
a) TCP in ears affected by hearing loss (patient group).
b) TCP in healthy ears (patient group).
c) TCP in ears of healthy subjects (volunteer group; first measure cycle).

A TOP below 1.33 kPa was present in five ears (5 per cent), three of which were affected by hearing loss. We found a mean TOP of 3.60 kPa for the diseased and 3.63kPa for the healthy ears. The right ears had a mean TOP of 3.76 kPa, the left ears 3.47 kPa, in all 3.61 kPa. There was no significant difference between right and left nor between diseased and healthy ears ($p>0.05$). Only one ear, affected by sudden hearing loss, expressed a TOP of 0 kPa. Figure 1 shows the distribution of TOP in the patient group and volunteer group. The TCP of 26 ears was below 0.66 kPa (26 per cent), eight of which had a TCP of 0 kPa, four of them affected by sudden hearing loss. The mean value was calculated at 1.05 kPa for the diseased and 1.26 kPa for the healthy ears. The right ears had a mean TCP of 1.17 kPa the left ears 1.13 kPa, overall 1.15 kPa. Here too, no significant difference could be demonstrated between the diseased and healthy ears or between the right and left ears ($p>0.05$). The distribution of TCP is illustrated in Figure 2.

We found a mean RNP value of 1.97 kPa for all ears, 2.11 kPa for the diseased and 1.84 kPa for the healthy ears. The right ears showed a mean RNP of 2.15 kPa and the left ears 1.80 kPa. Student's t-test did not reveal significant differences for any of the comparisons performed. Figure 3 illustrates the distribution of RNP.

b) Volunteer group

In the first measured cycle we found a TOP below 1.33 kPa in 13 out of 112 ears (11.6 per cent), the mean TOP was calculated at 3.05 kPa. Fifty-five out of 112 ears (49.1 per cent) expressed a TCP below 0.66 kPa, the mean TCP came to 0.78 kPa. The mean RNP of all ears amounted to 1.60 kPa. The distribution of TOP, TCP and RNP is illustrated in Figs. 1–3. The statistic evaluation revealed a significant difference ($p<0.01$) in TOP between the first and all subsequent measurements on the first day with a mean value of 2.65 kPa and a high reproducibility ($p>0.05$) in cycles 2–5. There was no significant difference in TOP when comparing the single measurement on the second day with the first measurement on the first day ($p>0.05$). Comparisons of TCP and RNP showed a high reproducibility of these parameters in

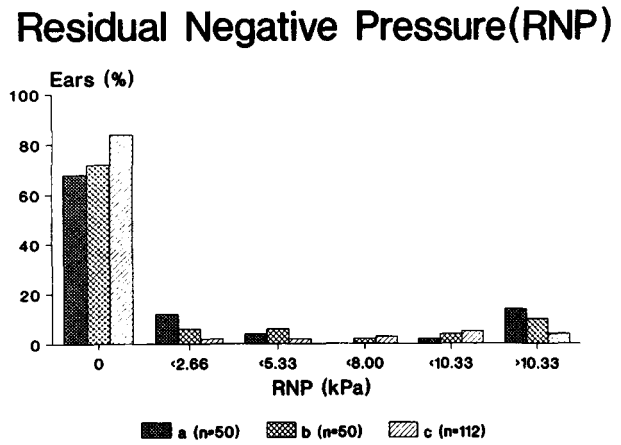

FIG. 3

Distribution of residual negative pressure (RNP).
a) RNP in ears affected by hearing loss (patient group).
b) RNP in healthy ears (patient group).
c) RNP in ears of healthy subjects (volunteer group; first measure cycle).

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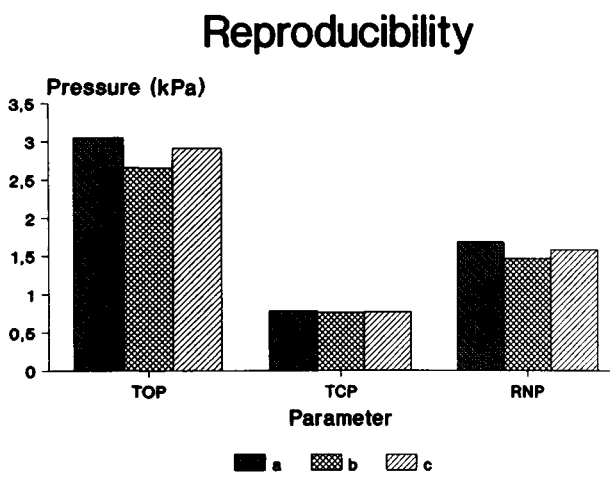

FIG. 4

Mean values of parameters of tubal function in healthy volunteers.
a) First test cycle on the first day.
b) Second test cycle on the first day.
c) Single test cycle on the subsequent day.

all results of the first day as well as in comparisons between the first and the second day ($p>0.05$). Figure 4 demonstrates the results of our reproducibility tests.

In a single volunteer lacking the characteristic symptoms of a patulous tube, an intermittently patulous ET could be demonstrated. She was tested twice in our laboratory with an interval of one week. Analysis at constant ambient air pressure did not reveal any respiration-synchronous alterations of the impedance during forced nasal breathing. Valsalva's manoeuvre was always positive on both ears. Dynamic analysis revealed a TOP and a TCP reduced to 0 kPa on the right side during the first examination. On reexamination one week later we found the TOP increased to a level of 1.3 kPa, whereas the TCP remained at 0 kPa. In Figure 5 the impedance curves of both examinations are illustrated and contrasted with the curve obtained from the left ear with a normal tube.

Discussion

In 1988, Heermann first suggested a relationship between ET dysfunction and sudden hearing loss. He observed an increase in frequency of patulous tubes among patients suffering from unilateral sudden hearing loss. Prevalence on the left side tended to be higher, and he confirmed this diagnosis by anamnesis and otomicroscopic observation of the ear drum during Valsalva's manoeuvre and forced nasal respiration.

A patulous tube is characterized by a reduction in passive tubal opening parameters (TOP and TCP) to zero and breathing-synchronous movements of the tympanic membrane during forced nasal respiration, whereas RNP is of little diagnostic value in this respect (Münker, 1972;

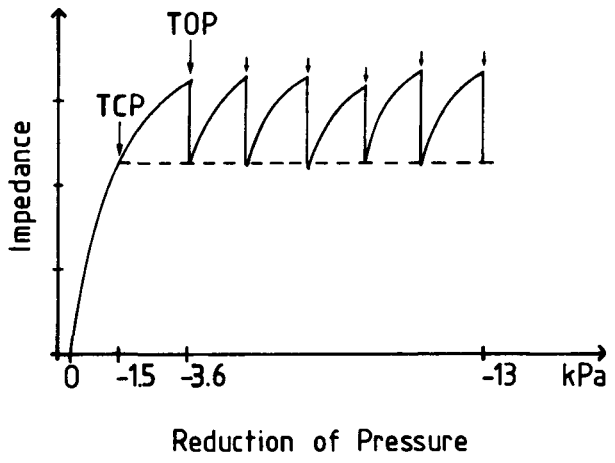

FIG. 5a

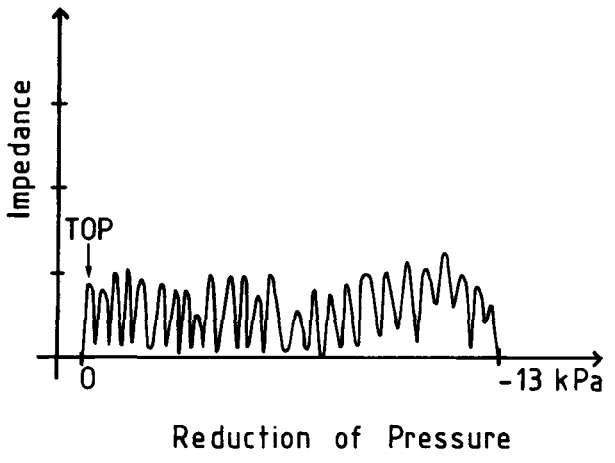

FIG. 5b

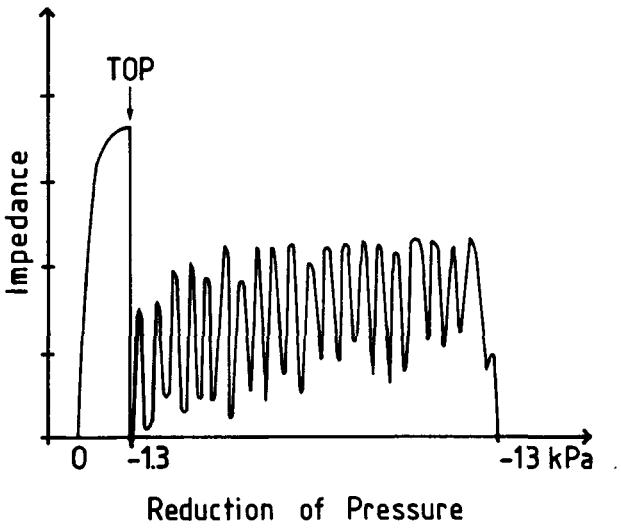

FIG. 5c

FIG. 5

Diagrams obtained during reduction of pressure from a test person suffering from an intermittently patulous tube on her right side.

a) The impedance curve measured on the healthy left ear shows the first passive tubal opening at a reduction of pressure by 3.6 kPa (TOP). Regular passive openings follow at certain intervals (small arrows). The TCP (1.5 kPa) is found by projecting the impedance measured at the points of tubal closing to the ascending limb of the curve (interrupted line).

b) The right tube is currently open on the first day with the TOP and the TCP at 0 kPa.

c) On the right side, re-examination on a subsequent day shows the TCP constantly at 0 kPa, proving the disposition to a patulous tube, while the TOP is raised to 1.3 kPa with the tube being currently closed.

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1980). We did not observe significantly reduced tubal opening parameters in ears affected by sudden hearing loss compared to the unaffected side, nor was there a significant difference between right and left ears. A higher prevalence of patulous tubes in left ears or ears affected by hearing loss cannot be confirmed. Only one patient out of fifty suffering from sudden hearing loss exhibited a patulous tube. Diagnosis was made by finding a TOP reduced to zero, but even this ear did not show movements of the tympanic membrane during forced nasal respiration. So we could not discover any ear with typical breathing-synchronous alterations of impedance. Elner *et al.* (1971) diagnosed patulous tubes in four out of 102 healthy volunteers.

A low TOP in combination with a TCP reduced to zero indicates a potential tendency towards a patulous tube which is currently closed. When comparing the mean values of TOP and TCP in our patients with the results obtained from healthy volunteers, we were not able to find lower mean values in the patient group. In the latter group, we measured very low values of TOP in five out of 100 ears, three of which were affected by sudden hearing loss. In the volunteer group we observed these low values in 11.6 per cent of healthy ears. Our results concerning TCP, too, suggest a higher incidence of low values in the volunteer group. They are in line with results obtained by Münker (1972), who, applying the same method to healthy ears, found even more ears with a TCP lowered to zero (28 per cent) than we did among our patients (8 per cent).

Our investigations into RNP show higher values in the patient gorup, indicating a reduced capability in active equalization of negative pressure in patients affected by sudden hearing loss. On the other hand our investigations into the reproducibility of results obtained by the pressure-chamber impedance method show that measurements performed on one day and repeated on the following show a good reproducibility of dynamic tubal parameters. This has been shown before by Ingelstedt *et al.* (1974) using a microflow method for investigations into the ET function. Groth *et al.* (1982) observed a high reliability of the impedance method in several consecutive test cycles. So we may suggest that our investigations into patients with sudden hearing loss are representative of tubal function of these patients on any day. We found higher values of TOP in the first compared to subsequent measurements. This phenomenon has been described by several authors before (Groth *et al.*, 1982; Cantekin *et al.*, 1976; Rapport *et al.*, 1975). It may be interpreted as a drainage of the tube during the first measurement cycle with a subsequent facilitation of tubal opening. A restitution by the following day is proved by our results.

The results described above reveal that there is no higher incidence of patulous tube syndrome among ears affected by sudden hearing loss than among healthy ears.

Movements of the tympanic membrane during respiration are sometimes missing in subjects with a patulous tube, on the other hand persons with breathing-synchronous movements often do not report symptoms of a patulous tube (O'Connor and Shea, 1981; Tolley and Phelps, 1990). We suggest that otomicroscopy and evaluation of history are insufficient methods for accurate investigation of problems associated with Eustachian tube function, even if tympanometry is carried out (which usually gives normal curves in ears with a patulous tube). Moreover Valsalva's manoeuvre, used by Heermann (1988) in an attempt to select wide open tubes, gives positive results in 80 per cent of healthy subjects (Magnusson and Falk, 1988) and does not show any correlation to tubal function (Elner *et al.*, 1971).

The permanently wide open tube which may often be easily diagnosed accounts for only a small percentage of those tubes which are patulous at least for a short period of time (Magnusson and Falk, 1988). An example of an intermittently patulous tube was mentioned above. In the pressure chamber we revealed the pre-disposition to a patulous tube by measuring a TCP of zero kPa in both investigations with a currently patulous tube on one day. No associated symptoms were detected by clinical examination. We conclude that reliable tubal diagnostics should be based on objective methods in doubtful cases.

Conclusion

The examination of Eustachian tube function in patients suffering from sudden hearing loss did not show increased incidence of patulous tube syndrome in these hearing-impaired subjects. Effects of ET function and middle ear pressure on the inner ear could not be excluded totally by our investigation, giving indication of a decreased patency of ET in patients suffering from sudden hearing loss when compared with healthy subjects.

Reexamination of healthy volunteers showed a high reproducibility of tubal parameters obtained by the pressure chamber impedance method, demonstrating objectivity and reliability of our results.

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