Differentiations in Tinnitus with Respect to Their Neurootological Parameters

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Abstract:

Tinnitus is a special psycho-physical complaint up to a difficult illness with people of two kinds of gender is very much burdening and represents an economic load further for patients affected.

The previous medical and non medical therapy is not yet sufficient in wide fields up to now. Origin, cause and course are still inadequately clarified in many aspects. Nevertheless very new insight into special activity places in connection with the origin turned out in recent times through the procedure of the vestibular evoked brain potentials (VbEP) in connection the cortical EEG reaction evaluation through the Brain Electrical Activity Mapping (BEAM) and the Single-Photon-Elektro-Computer-Tomogram (SPECT) from Tinnitus patients at their human cerebral cortex.

On the one hand this to was developed by the team around Claussen, who increasingly found beginning at 1985 hints to a special activity focus in the upper gyrus of the temporal lobe of the human brain. This was underlined by additional SPECT-findings by Shulman.

This paper deals with a field study of 823 patients, being investigated and treated for different kinds of tinnitus at the 4-GF Institute at Bad Kissingen. The number of males is about three times as high (77.53 %) than the number of females (22.47 %). The age range extends between 18.81 up to 73.10 years. The mean age lies at 50.47 years with a spread of 8.68 years.

Key words: tinnitus, ear noise, subjective noise, endogenous tinnitus, exogenous tinnitus, bruits, maskable tinnitus, hearing projections, vestibular evoked potentials, SPECT, audiometry, tinnitology.

Introduction:

Ear noises (tinnitus) are acoustic phenomena that can be perceived also without external cause. They become among other things as singing, roaring, humming, whistling, hissing and pulsating described. After American observations ear noises occur in 80% of the cases combinedly with hearing-troubles. Own investigations show that many patients show vestibular disturbances simultaneously. This gives a reference to major trouble of the entire statoacoustic pathways between the receptors in the inner ear up to the statoacoustic end projection in the temporal lobes of the brain.

Tinnitus is a special psycho-physical complaint up to a difficult psychophysical illness that can be dangerous as it drives patient at last to commit suicide. It can be a symptom of most different pathological events, degenerations and irritations in the phase of the first aging of the humans, i.e. especially frequently between the 45th and 65th year.
The beginning of severely influencing tinnitus can start slow and creeping or sudden and abrupt with a severe impact on the personal life. Phased improvements and subsequent deteriorations in the majority of the patients lead to an increase of the anxieties and the depressions. Also their professional activities are more strongly reduced in multiple ways.
Scientific observations prove that the feeling of the hardship and the strength of the tinnitus correlate with each other closely. Furthermore stress is very significant for the intensity and the degree of the impact of the subjectively experienced tinnitus.

The neuro-otologic team around Prof. Dr. Claussen, at the University of Würzburg and the 4GF-Institut Bad Kissingen, carried out a practical and theoretical classification of different types of tinnitus:

I.) „Bruit", called also objective tinnitus: physical-mechanical noise that arises within the head, e.g. through blood turbulences, through vibrations of muscles in the middle ear or through widely opened ear trumpets from the mouth to the middle ear, and so forth. This type is physically measurable with the aid of microphones.

II.) Endogenous tinnitus, is from outside not audible but can psycho-physically matched with audio-metric methods, i.e. maskable tinnitus: Ear noises which are projected into the hearing-system subjectively by the patient. They are audiometrically masked through defined sounds ringing comparably and being comparably loud. The patient answers to the question about this tinnitus especially when it is best to be endured, that this is the situation in some noisy surroundings for the covering (masking) of his ear noises.

III.) Exogenous tinnitus, named formerly also as a syndrome of the over-sensitive ear. (This is falsely called the so-called hyperacusis by some authors. The term hyperacusis would mean, however, that these patients better and more sensitively hear than the standard men. That however, is not the case.) These patients describe their hearing trouble in the following manner: Whenever they are in some noisy, it results in the triggering of a tinnitus perception. In a conversation situation they are strongly hindered also at the telephone and so forth, If they withdraw themselves into a quiet house or into a cellar, this withdrawal stops tinnitus or however it reduces itself significantly.

IV.) Tinnitus type of the so-called slow brainstem syndrome: In this case it is a question of an ear noise which mainly arises with older people with whom one can prove by neuro-otometric methods , that the vestibulo-ocular reactions run too slow. The same brain stem slow-down is measurable with the so-called acoustically evoked brain stem potentials.

As long as the aetiology of one tinnitus is unsolved as a diagnosis, the deficits are explained between psychogenic reasons up to simple simulation. Tinnitus is often not only externally normally measurable and thus medically easy to verify.

It requires the use of more modern neurootological diagnostic methods. Through the procedure of the vestibular evoked brain potentials in connection the “brain electrical activity mapping” (BEAM) the “vestibular evoked brain potentials” (VestEBP) showed very new insights into special activity places in connection with the origin of Tinnitus on the human cerebral cortex. The Claussen-team found by using the VestEBP and their since 1985 an overactive focus in the upper gyrus in the rear end of the temporal lobe, where the statoacoustic projections are placed. Ear noises characterizingly specific for these epiphenomena express themselves by shortening of the latency times of the wave I, II and partially III of the vestibular evoked late brain potentials and a very high DC shift of the electric EEG potentials are typical. These functional failures occur with the Tinnitus patients frequently on the ipsilateral , partially, however, also on both of the temporal fields of overactivities.
A further important proof with regard to the involvement of the human temporal lobes in the origin of certain types of tinnitus was delivered in particular from the Metric Center at the State University New York through Shulman and his team. These authors carried out investigations with the Single-Photon-Emission-Computer-Tomography (SPECT). They found amongst others that an especially high blood circulation and metabolism activity occurs in certain tinnitus patients in the temporal lobe of the human brain.

Also a further procedure is used investigating the phenomena of tinnitus in relation with dysregulations of the human temporal lobe. This is for example the modern “quantitative electroencephalogram” (QEEG).

According to estimates of the American Tinnitus Association about 36 million US citizens suffer from a tinnitus. In about 80% of the cases they suffer from a maskable tinnitus. 90% of the patients need treatment. In neurootology tinnitus belongs next to vertigo, instability and nausea as well as hearing loss to the most important disorders to call for a modern diagnosis and systematic therapy. Accordingly it is assumed that in Germany about 10-20% of the population is permanently affected. Just 40% at least once in the life experience such an ear noise. About one third of all older people expect to perceive ear noises continuously. Especially in the last decades the number of the tinnitus-patients rose strongly.
This paper deals with clinical neurootological findings of modern neuro-otometric data of tinnitus patient.

Material & Methods

In a sample of 823 tinnitus patients who came for being treated with different methods, we have completed a study. All the patients were investigated by the neurootological questionnaires NODEC and ASOAC. This gives a good spectrum of the individual complaints. Additionally, all the patients underwent a thorough audiometric analysis. The clinical audiometry generally includes:

1.) threshold audiometry,
2.) discomfort levels,
3.) tinnitus masking
4.) stapedial reflex
5.) acoustic brainstem evoked potential (ABEP)
6.) acoustic late evoked potential (ALEP)

In this paper we refrain from the last 3 techniques for better describing our attempt in a model.

The equilibriometric investigations include:

-caloric butterfly with trinary coding
-rotatory intensity damping test (RIDT) with trinary coding
-vestibular stimulus response intensity comparison (VESRIC) with trinary coding
-cranio-corpo-graphy of the stepping test
-cranio-corpo-graphy of the sanding test

In this paper we refrain from the 3rd technique for better describing our attempt in a joint stato-acoustic model.

All the data were received and transferred in a digital manner into a big spreadsheet data bank of Excel.

The results are presented in tables in the next section.

Results

The results of a thorough investigation of 823 patients, being investigated and treated for different kinds of tinnitus, are evaluated numerically and digitally by means of a modern neurootological NOASC databank system available at the 4-GF Institute at Bad Kissingen.
For beginning with the results are comprising the basic biological data of the neurootological patients in Table 1.

Table 1: Basic biological data of 823 tinnitus patients.

	Male	Female	Total	Mean	Standard deviation	Minimum	Maximum
n	638	185	823				
%	77.53	22.47	100				
Age				50.48	8.68	18.81	73.10
Height				171.68	13.51		
Weight				80.58	13.52	45	138
Systolic blood pressure				135.83	121.23	12	200
Diastolic blood pressure				82.79	22 .00	10	140

The table shows, that the number of males is about three times as high (77.53 %) than the number of females (22.47 %). The age range extends between 18.81 up to 73.10 years. The mean age lies at 50.47 years with a spread of 8.68 years.

Table 2: Basic subjective complaints of 823 tinnitus patients.

Parameters	n	%
Headache	568	69.01

Loss of efficiency	652	79.22
Disturbances in awakeness	707	85.90
Psychic lability	57	6.92
Vertigo complaints	593	72.05
Vegetative symptoms	241	29.38
Vertigo symptoms	409	49.69
Subjective tinnitus	788	95.74
Sequelae after ear surgery	13	1.57
Tinnitus complications	212	25.75
Smell disorders	30	3.64
Disorders of taste	10	1.21
Disturbances of vision	637	77.39

Table 3: Major background disorders of 823 tinnitus patients.

Parameters	n	%
Status after head neck trauma	188	22.84
Major neurological diseases	5	0.61
Orthopaedic disorders	27	3.28
Cardiovascular disorders	330	40.10
Diabetes mellitus	43	5.22
Kidney dysfunctions	9	1.09
Stomach disorders	2	0.24
Hormonal dysfunctions	0	0.00
Severe sequelae after infectious disorders	4	0.49
Tumours	1	0.12

Table 4: Pure tone audiometry, bone conduction, right ear of 823 tinnitus patients.

	Right ear Mean	Right ear Standard deviation
500 Hz	15.01	13.07
750 Hz	15.44	13.06
1,000 Hz	17.68	13.74
2,000 Hz	22.21	16.71
4,000 Hz	31.37	20.11
8,000 Hz	38,75	37,72

Table 5: Pure tone audiometry, bone conduction, left ear of 823 tinnitus patients.

	Left ear Mean	Left ear Standard deviation
250 Hz	11.83	11.61
500 Hz	15.94	18.25
750 Hz	15.53	14.03
1,000 Hz	16.71	14.03
2,000 Hz	24.29	17.92
4,000 Hz	33.65	20.53
8,000 Hz	52.50	29.96

Table 6: Average values of occurrence of the measurable discomfort level of 823 tinnitus patients.

Parameters	n	%
Right ear	728	88.46
Left ear	723	87.86

Table 7: Values of the average discomfort threshold as being measured in relation to the test frequency, right ear of 823 tinnitus patients.

	Right ear Mean	Right ear Standard deviation
500 Hz	93.69	15.18
750 Hz	93.27	20.29
1,000 Hz	95.91	19.60
2,000 Hz	97.06	20.62
4,000 Hz	98.94	38.11
8,000 Hz	87.87	16.33

Table 8: Values of the average discomfort threshold as being measured in relation to the test frequency, left ear

	Left ear Mean	Left ear Standard deviation
500 Hz	94.23	20.49
750 Hz	94.18	21.32
1,000 Hz	96.46	20.15
2,000 Hz	98.39	20.11
4,000 Hz	99.54	20.11
8,000 Hz	88.28	17.11

Table 9: Maskable Tinnitus; occurrences of the maskable tinnitus as existing in the whole sample of 823 tinnitus patients.

Parameters	n	%
Right ear maskable tinnitus	372	45.20
Left ear maskable tinnitus	389	47.27

Vestibulo-ocular testing by means of electronystagmography by means of the 5-channel-ENG

ENG frequencies measured during 30 seconds of representative “central evaluation times” are reported as the “central nystagmus beat rate”, which is given in digital figures.

Table 10: ENG frequencies measured during 30 seconds of representative “central evaluation periods” of 823 tinnitus patients.

ENG parameters	Mean	Standard deviation
Spontaneous nystagmus in supine	20.39	8.25

position beating towards right		
Spontaneous nystagmus in supine position beating towards left	17.90	8.53
Caloric nystagmus		
Right ear, 44°	42.12	14.62
Right ear, 30°	42.11	15.67
Left ear, 44°	42.66	15.03
Left ear, 30°	43.80	16.16
Rotatory intensity damping test (RIDT)		
Perrotatory right beating	47.89	16.55
Perrotatory left beating	42.26	18.65
Postrotatory right beating	54.88	19.96
Postrotatory left beating	55.21	17.59
Standing test cranio-corpo-graphy		
Longitudinal sway	37.66	7.89
Lateral sway	33.20	8.01
Coverage of forehead marker	842.86	397.13
Torticollis angle	7.37	173.25
Stepping test cranio-corpo-graphy		
Longitudinal sway	75.45	35.21
Lateral sway	18.95	11.84
Angular deviation	2.32	42.86
Body spin	1.66	51.98
Count of steps	62.77	18.85

When evaluating the vestibular equilibriometric tests, for instance by means of a trinary coding, the following test results have been received

Table 11: Trinarily coded vestibulometric test results of 823 tinnitus patients summarizing vestibular pathology.

Normal butterfly schemes	49.30 %
Pathological butterfly schemes	50.70 %
Normal step test cranio-corpo-graphy	29.32 %
Pathological step test cranio-corpo-graphy	70.68 %

Discussion & Conclusions

The field study of 823 tinnitus patients is showing that these patients coming to Bad Kissingen for a special tinnitus rehabilitation therapy are a specially selected group.

The age of these 823 tinnitus patients has a mean of 50.48 with a standard deviation of 8.68. The minimum is 18.81 years and the maximum age is 73.10 years. Out of the total sample of 823 tinnitus patients, 636 (77.53 %) are male and 185 (22.47 %) are female. The mean height of the total sample of male and female amounts to 171.68 cm with a standard deviation of 13.51 %.

The mean weight covers a broad range with a minimum of 45 and a maximum of 138 kilograms per person with a mean of 80.58 kilograms and a standard deviation of 13.52 %. Accordingly, the systolic blood pressure has a very broad span from a nearly unmeasurable blood pressure up to 200 mm/Hg systolically and the upper boarder of 140 mm/Hg diastolic blood pressure. The systolic blood pressure lies with his mean of 135.83 and a standard deviation of 21.23 mm/Hg above the normal border. The diastolic blood pressure arrives at 82.79 mm/Hg with a standard deviation of 22.00 mm/Hg.

When lifting the subjective complaints in the 823 tinnitus patients of both genders as described above, the most frequent complaint is tinnitus with 95.74 % at the moment of the investigation. It has to be stated that then 4.25 % of this sample does not suffer from tinnitus when they are questioned and investigated. A second frequent complaint deals with sleep disorders and especially disturbances in awakeness. This complaint comprises 85.90 % of the sample. The third frequent complaint deals with loss of efficiency in daily life. This is reported by 69.22 %.

In nearly three quarters of the whole sample, the patients are complaining of different types of vertigo in 72.05 %. This is shortly followed by complaints of headache in 69.01 %. The disturbances of vision are very high with 77.39 %. There are also double vision included as well as pain in the eyes and problems with loss of visual acuity.

A high incidence rate is found in relation to tinnitus complications like complications in getting to sleep, loss of capacity pf permanently sleeping, subjective depressions, fear of committing suicide, acute hearing loss, etc.

Only very few patients underwent ear surgery prior to this investigation and treatment (1.57 %). 6.92 % of the patients are in psychological or psychiatric treatment for psychic lability.

The analysis of the major background disorders in the sample of 823 tinnitus patients is displayed in table 3.

The most frequently named background disorders deal with cardiovascular disturbances (40.10 %). It is interesting that this group is followed by 22.84 % of patients complaining of the sequelae of head and neck traumas, especially due to car accidents with a whiplash trauma.

About 5.22 % report about diabetes mellitus and 3.28 % about orthopaedic disorders. However infectious disorders like meningitis, encephalitis, hepatitis are very rare with 0.49 %. Also complaints about an ongoing tumour therapy are reported by only 1 person (0.12 %).

When measuring the hearing threshold (table 4 and 5) by means of pure tone audiometry with bone conduction, we find a trend in the whole sample on both the sides to high tone perceptive reduction. This is more prominent in the left ear than in the right ear, especially at the highest reported frequency of 8 kHz.

Due to the reports of the patient about the tinnitus in all the cases, we performed an audiometric measurement of the discomfort level. This, however, only worked out in 88.46 % in the right ear and 87.86 % in the left ear (see table 6).

The exact values of the discomfort level between 500 and 8.000 Hz is described in table 7 for the right ear and in table 8 for the left ear. The mean values show for all the frequencies of the audiogram being investigated that the mean always lies above the critical threshold of 85 dB. However, when going into the spread, we find in all the frequencies, the left side of the standard deviation dips below this critical value when being subjected from the mean values. This then would indicate there is well a tendency towards a reduced acoustic dynamics. This is an important parameter for the definition of an exogenous tinnitus.

We also applied the modern acoustic procedures for masking tinnitus. In the whole sample of 823 tinnitus patients, we found an existing maskable tinnitus in the right ear in 372 cases, which is 45.20 %, and in the left ear in 389 cases, which is 47.27 %.

This indicates that little less than half of the sample only shows maskable tinnitus. The maskable tinnitus can be defined into the group of the so called endogenous tinnitus, as this kind of tinnitus also is open for the treatment with a masker.

Nowadays, we know that not a monosensorial disease is standing in the foreground. But also in tinnitus, it usually is a multisensorial disorder.

The first way for looking in for combined pathologies is to compare other parameters of the statoacoustic system. Therefore, we investigate the vestibulo-ocular equilibriometry by means of polygraphic electronystagmography with 5 channels. This is used together with recordings and evaluations of the spontaneous nystagmus, the caloric nystagmus, the perrotatory and the postrotatory nystagmus. On the other hand, we are also investigating the vestibulospinal axis by means of the standing test (Romberg) the stepping test (Unterberger/Fukuda) and the stepping test craniocorpography.

Table 10 exhibits the results of the polygraphic electronystagmography recording. For evaluating the results, we first go into the rows of identifiable nystagmus events. They are usually counted during a period of 30 seconds. Then, they are compared with standard values.

The spontanoeus nystagmus in lying supine position beating towards the right side shows a mean of 20.39, which is slightly above the normal range. But the standard deviation, when it is added upon this, shows cases where already the right beating spontaneous nystagmus is over that normal range. The same holds for the spontaneous nystagmus in supine position beating towards the left side. The mean is still in the normal range. However, when adding on the standard deviation, we come into a pathological range. When going through the caloric nystagmus for the right ear warm (44° Celsius), right ear cold (30° Celsius), left ear warm (44° Celsius) and left ear cold (30° Celsius) responses, we see that the means are all in normal ranges, and even putting on top or subtracting the standard deviation, all the values lie in normal ranges. Here, we have further to discriminate the configurations of the caloric butterfly in a trinary code manner. Then, however, we find patterns which, in a differentiated manner, show pathologies in the peripheral as well as in the central pathways. The same hold for the perrotatory right-beating nystagmus and the perrotatory left-beating nystagmus. However, the postrotatory right-beating and left-beating nystagmus is normal in the mean, but when adding on the standard deviation, we reach already central desinhibitions.

In the cranio-corpo-graphy of the standing test (Romberg) and the stepping test (Romberg/Fukuda), we are metrically measuring the longitudinal sway and the lateral sway as well as angularly the torticollis angle, the angular deviation and the body spin. There, we observe that already the standing test craniocorpograms are pathological indicating hat many of the tinnitus patients are suffering from distaxic regulationary disturbances. Even their lateral sway during the stepping test is in its mean above the border value of 17.5 cm. This indicates that we see much central vestibulospinal pathology. This occurs in the lower brainstem as well in the midbrain, whereas the longitudinal and lateral overshooting sway in the standing pathology indicates pathologies in the inferior peduncle of the cerebellum, the upper brainstem and the basal ganglia in the brainstem and the higher centres.

When summarizing the results of the equilibriometric vestibular tests as being performed in table 11, we find that the caloric differentiated butterfly test comes all in all to demonstrate pathology in the statoacoustic pathways in 50.70 %. However, when looking for a pathology in the step test craniocorpography, we find an incidence rate for demonstrating pathology of 70.68 %.

All in all, we can judge now that we regularly should investigate the complete set of statoacoustic pathways. And the simple craniocorpography with light markers or, nowadays, with ultrasound procedures, is very helpful for detecting a concomitant pathology in the sphere of the equilibrium regulation. This then can help us again to plan and design a modern therapy for our neurootological patients suffering from tinnitus, which needs to be treated.

The details presented in this paper will be further analysed in a medication way in an upcoming series of international studies and papers.

We are thanking Prof. Dr. Monika Reuss-Borst from the Rehabilitation Clinic of the LVA Baden-Württemberg in Bad Kissingen for her cooperation in this study.

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