Cortical and Brainstem Topognostic Testing in Tinnitus Patients - A Preliminary Report

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Abstract: Preliminary electrophysiologic topognostic test findings suggest a method for the functional localization and quantification of tinnitus; and provides a basis for the selection and monitoring of treatment. Numerous and different locations of the tinnitus symptom have been identified. In our series approximately 24% of tinnitus patients were identified to have a peripheral origin; 35% originated in the brainstem; and 41% at a supratentorial level.

Key Words: Brainstem Evoked Potentials; Brain Electrical Activity Mapping; Auditory Evoked Potentials; topognostic tinnitus testing.

INTRODUCTION

The topodiagnosis and treatment for the symptom of tinnitus have been difficult in neurotology. Neurotologic diagnostic techniques of the past provided an ability to identify and establish a diagnosis of the topography of peripheral tinnitus and of some tinnitus of central origin.[1]

Our statistics have presumed that approximately 40% of tinnitus patients have supratentorial dysfunctions. New electrophysiologic recording techniques of Brain Mapping and Mapping of Evoked Potentials provide an ability to measure responses of the cerebral cortex to sensory stimuli; and to evaluate its cortical temporospatial distribution. The statistical analysis - Z-Score of the individual patterns of response in tinnitus patients have been correlated with normal parameters of identification of cortical responses in the general population.[2]

Electroencephalographic (EEG) Mapping utilizes the same methodological procedure as in conventional recording. The Evoked Potentials (EP) however are recorded with multiple electrodes.

Differences between the conventional EEG and EPs include the following: a) the transformation of data from the time and frequency domain to the spatial domain by interpolation techniques; b) statistical and other measures which evaluate individual and group abnormalities in various disease states; and c) multiple electrode recording sites of EPs.

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In this paper preliminary electrophysiologic topognostic test findings identified in tinnitus patients are reported.

MATERIAL AND METHODS

The purpose of this study was to develop a topography of central tinnitus based upon objective neurophysiological tests.

A total of 180 patients seen in neurotologic consultation for the chief complaint of tinnitus were included in this study (Fig. 1).

The neurotologic evaluation included the following:

1) A detailed history was obtained using the NODEC system.[3]

2) Craniocorpography (CCG).[4]

The test consists of a video digitalization of the stepping test (Unterberger Test); and the static standing test (Romberg).

3) Computer Nystagmography (CNG) - a test of the vestibulo-ocular and retino-ocular systems[5]

4) Brain Stem Evoked Potentials (BsRA)[6]

The data is derived from two channels. Electrodes are distributed with Vertex Mastoid placement and contralateral mastoid reference. The auditory stimulus was an alternating click tone of 20 Hz, at 80 dB intensity, 100 μs duration. The contralateral side was masked with "white noise". The recordings of 2000 stimulations were averaged.

5) Brain Electrical Activity Mapping (BEAM)[7]

Cortical brain responses are measured by means of BEAM. Twenty one monopolar electrode sites, referred bilateral to the mastoids are linked through resistances both at rest and following auditory stimulation.

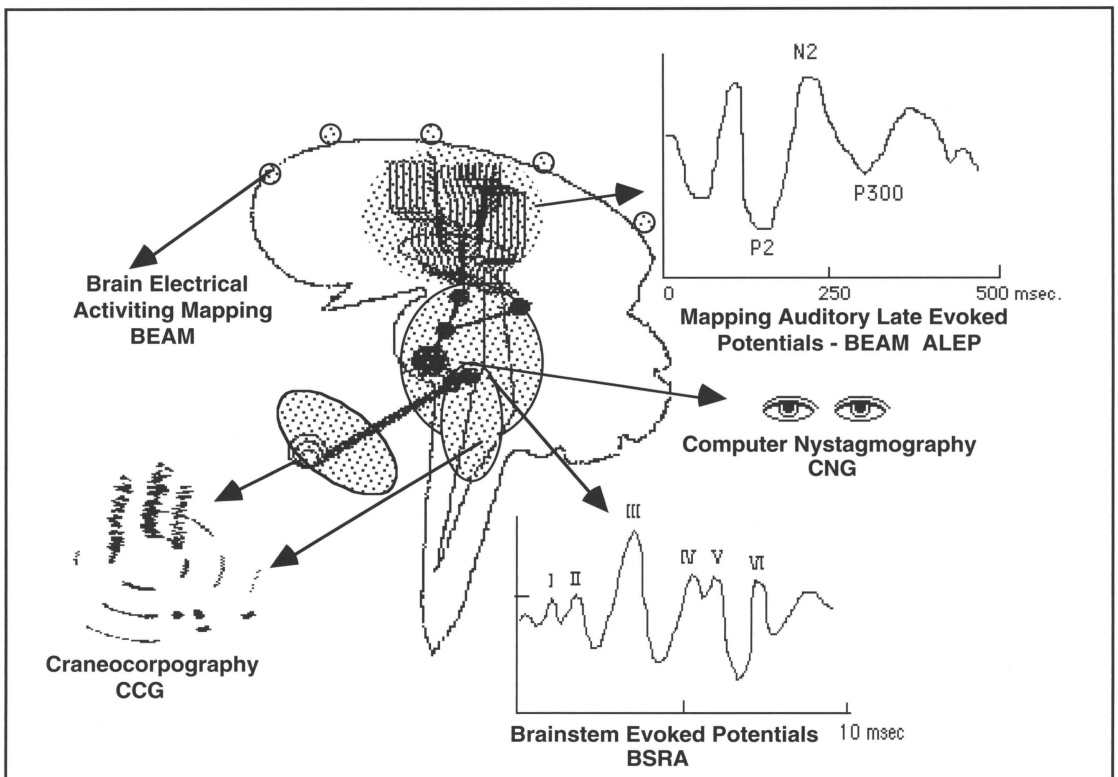


Fig. 1. Cortical and Brainstem neurophysiological tests

Bilateral auditory stimulation was performed with "tone bursts" randomized at a frequency of 20 Hz and intensity of 70 dB. The analysis time was 20 seconds.

6) Auditory Late Evoked Potentials (ALEP)[8] - a mapping technique for Late Evoked Potentials for the responses of N2, P2 and P300 to auditory stimulation. The latencies and spatial distribution of the components of the responses are evaluated. A "burst tone" is used as a stimulus with 30 ms of "plateau" with random variation of the frequency. Frequent stimulation was at 1 KHz; random stimulation at 4 KHz - at 70 dB intensity; and masking the contralateral side with white noise.

Electrodes are distributed according to the international 10-20 system.

Eight derivation channels are registered for the evoked potentials F3, F4, C3, C4, P3, P4, 01, 02 - referred to A1 and A2 linked by resistance. The quantitative statistical results obtained and have been compared with the statistical data of the general population in our Data Bank.

RESULTS

One hundred and eighty patients (180) with the chief complaint of tinnitus were tested.

The average age was 51.56 ± 13.76 years.

Sex distribution was male 97; female 83.

All patients completed the neurotologic evaluation as described.

Hypoacusis was demonstrated in 20.39%. All cases of hypoacusis are considered to reflect presbyacusis. (Table 1)

Table 1. Incidence of Tinnitus and Associated Complaints of Hearing Loss and Vertigo (N=180)

Symptoms (N = 180)	%
Tinnitus	100.00
Tinnitus right	68.25
Tinnitus left	51.00
Tinnitus right and left	49.20
Hypoacusis right	9.52
Hypoacusis left	9.52
Hypoacusis right and left	15.87
Vertigo	59.09

Correlation of the neurotologic symptoms of hearing loss, tinnitus, and vertigo with the clinical history of this group of patients is considered to be reflected in the positive history of cardiovascular disease, particularly hypertension.

Conditions considered to precede the development of complaint(s) of hearing loss, tinnitus, vertigo include the following in the order of importance (Table 2).

Table 2. Conditions antecedent to development of complaints of hearing loss, tinnitus, vertigo (N=180).

Antecedents	%
Hypertension	30.15
Hypotension	15.87
Neurological disease	39.68
Metabolic disease	23.80
Head and neck trauma	11.10

CCG testing revealed a correlation of the symptom of tinnitus with vestibulospinal testing with central patterns in 39.12%; and peripheral patterns in 23.92% (Figure 2).

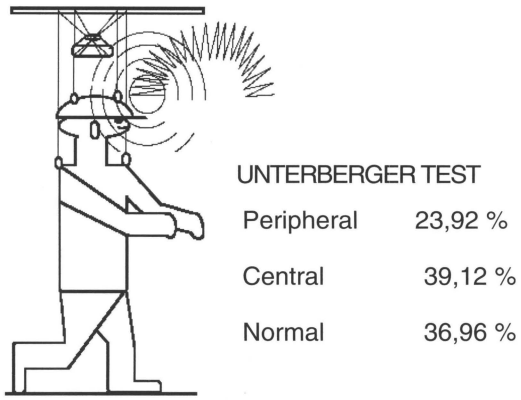


Fig. 2. Craniocorpography (CCG) patterns

Computer-Nystagmography (CNG) recordings of vestibulo-ocular and retino-ocular tests identified central patterns in 52.30%; peripheral patterns 19.02%. (Fig. 3)

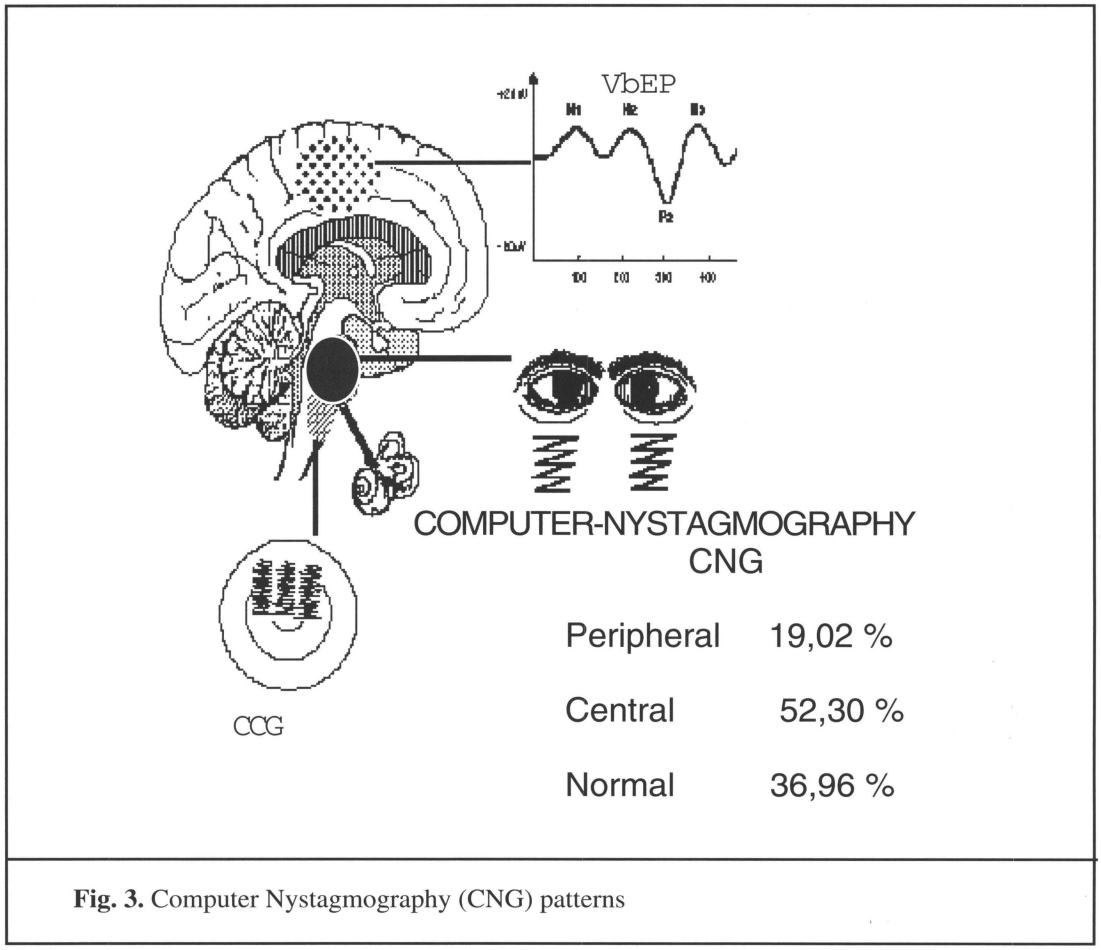


Fig. 3. Computer Nystagmography (CNG) patterns

Brain Stem Evoked Potentials (BSRA) results in tinnitus patients, with reference to its topographical location, revealed an incidence of occurance of a latency delay of interpeak I-V (23.93%); I-III (13.23%); and III-V (10.29%). The interpeak latency delay was ipsilateral to the tinnitus for I-III (34.78%); III-V (21.73%); and I-V 47.82%). Overall, of the 180 patients presenting with the chief complaint of tinnitus, 35.21% revealed pathology, as reflected in the BSRA recordings (Figure 4).

Brain Electrical Activity Mapping (BEAM) results presented at this time highlight statistical information only of those values corresponding to central generators considered to be sites from which the ALEP are primarily generated. [9,10,11]

In the resting state, comparison of BEAM test results of both tinnitus patients with the database of the general population do not reveal significant changes in the electroencephalographic rhythm. Following auditory stimulation, a significant increase in the beta rhythm has been observed in tinnitus patients. The general population demonstrate an increase in alpha rhythm following auditory stimulation (Figure 5).

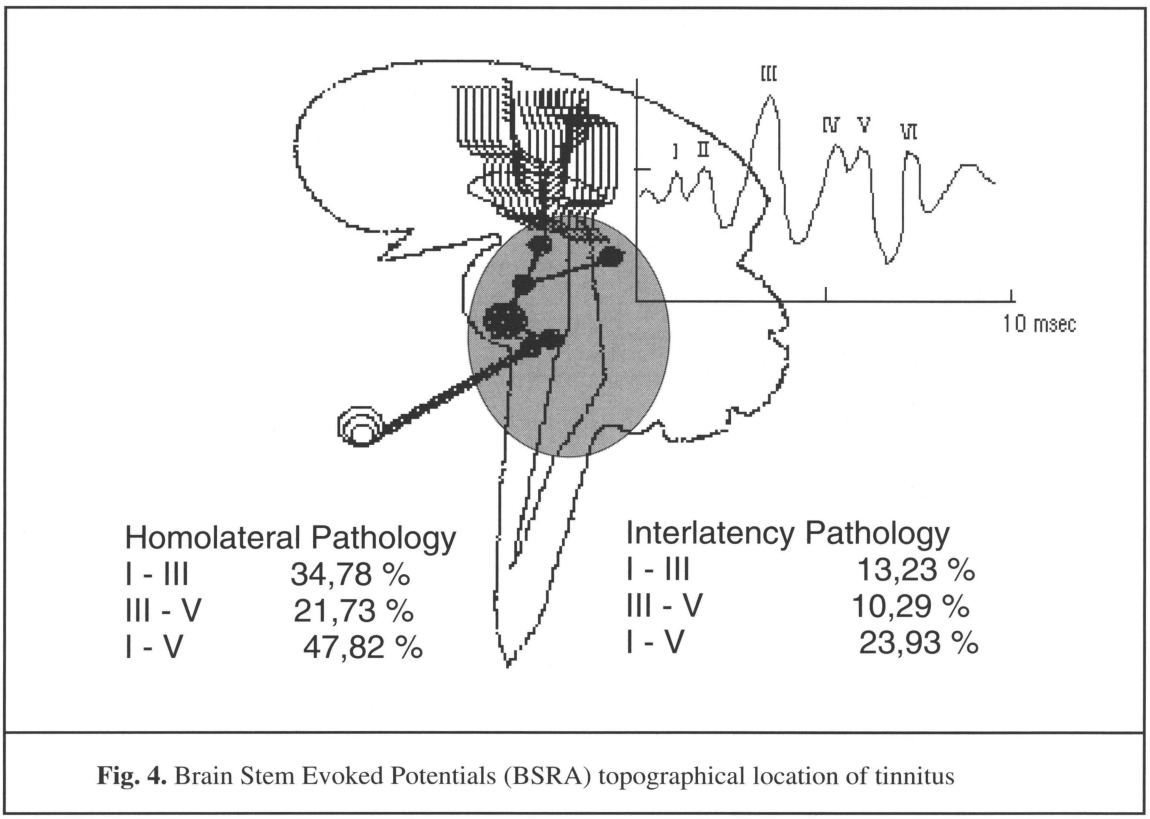
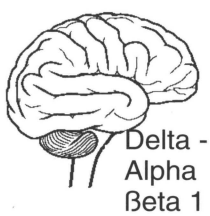


Fig. 4. Brain Stem Evoked Potentials (BSRA) topographical location of tinnitus



		Tinnitus patients		Patients General (380 P)	
		Rest state	Auditory stm.	Rest state	Auditory stm.
Delta - Theta	%	34,42	27,08	40,55	39,34
Alpha	%	39,34	26,26	37,83	42,62
ßeta 1 - 2	%	26,24	46,66	21,62	18,04

Fig. 5. Brain Electrical Activity Mapping (BEAM) in tinnitus patients, overall tinnitus patients following auditory stimulation reveal alterations in BEAM of 34.92%

Mapping of Auditory Late Evoked Potentials (ALEP) revealed fluctuation in the spatial distribution of the different components of the ALEP consistent with the age of the patient. The results are considered to reflect the inter-individual underlying electroencephalographic pathology. It has been observed that the N1-N2 component is generated in young patients predominantly in the frontal cortex areas. The aged population demonstrated a physiologic decrease in frontal cortical activity. The origin of the N 1 -N2 component has been observed in the parieto-cortical areas.

The P2 component of the ALEP, in normals, revealed a bilateral response and distribution in the central recording areas C3 and C4. However, pathology in some of these areas resulted in a unilateral formation of this component with an abnormal distribution. The P300 response was identified in a temporo-central location. It was modified in a similar manner consistent with the pathology of the patient as was the P2.

The ALEP comparative study between the tinnitus patient group and that of the general population revealed an increased latency and alteration in morphology of the N2-P2 complex in the tinnitus patients. In the general patient population, the P300 wave revealed an increased incidence of pathology (Figure 6).

The ALEP was interpreted as a pathological response in 42.85% of tinnitus patients.

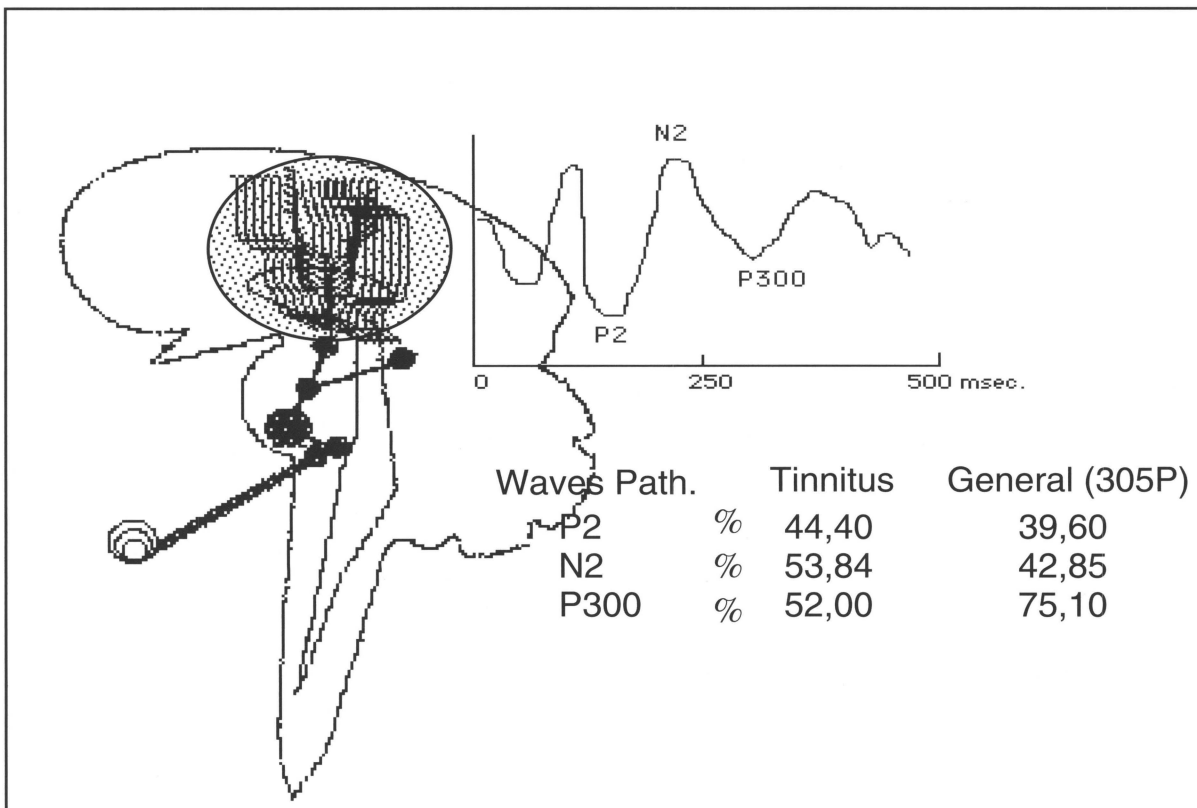


Fig. 6. Auditory Late Evoked Potentials (ALEP), percentage of pathological wave forms in tinnitus patients

DISCUSSION

Statistical analysis of the BSRA findings has been found to be pathological for 35.21% of the tinnitus patients. The I-V interlatency is considered the most sensitive for the detection of any kind of pathology.

Significant is considered to be the results with CCG testing where central patterns of the lesion were observed in 39.12% of the patients. Both the BSRA and the CCG tests have demonstrated that abnormal findings have been demonstrated both ipsi and contralateral to the tinnitus as described by the patient. CCG findings reveal peripheral patterns of vestibular abnormality in 23.90% of patients. The abnormal findings were always homolateral to the tinnitus location.

Computer Nystagmography (CNG) revealed peripheral patterns in 19.02%. Central patterns of site of lesion were observed in 52.30% of tinnitus patients. The abnormal findings were found ipsilateral and/or contralateral to the tinnitus.

BEAM testing revealed abnormal findings in 34.92% of tinnitus patients. Of this number of abnormal BEAM findings, 42.85% revealed abnormal ALEP. The abnormalities were ipsi and/or contralateral to the tinnitus. (Fig. 7)

The positive results suggest that the recording of slow evoked potentials from the cerebral cortex require brain mapping in both resting and activity states in order to have diagnostic value. The variations in electroencephalographic recordings are considered to denote important changes in brain rhythm and modulation consistent with the pathology of the patient.

It is speculated that the report of tinnitus patients that they perceive their tinnitus to be increased in a resting state; and that the tinnitus is reduced or disappears when they are involved in other activities, reflects not only tinnitus masking secondary to external noise, but also that supraliminal stimuli by modulation and improvement in brain activity positively influence the tinnitus.

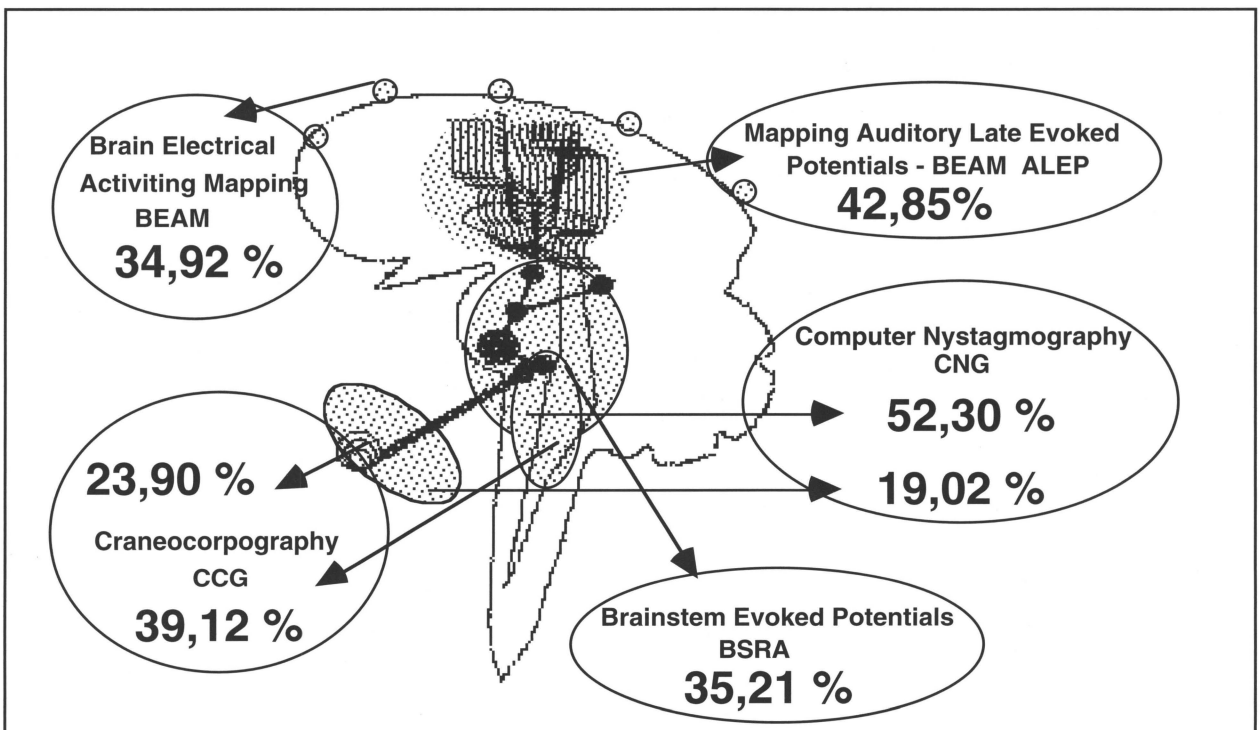


Fig. 7. Summary - Statistical Results (N=180) - Auditory and Vestibular Cortical and Brain Stem Topognostic Testing in Tinnitus Patients

Recently, electronic circuits have been identified, which using a constant source of noise stimulation results in a reduction in the tinnitus complaint. It is suggested that the preceding speculation based on the BEAM and ALEP findings could well be one of the operating mechanisms for tinnitus relief.
Modulators of cortical activity have been the basis of very good results of drug therapy for tinnitus patients.
The electrophysiologic findings reported at this time of Auditory and Vestibular Cortical and Brain Stem Topognostic Testing in Tinnitus Patients indicate multiple and different locations of the tinnitus symptom.

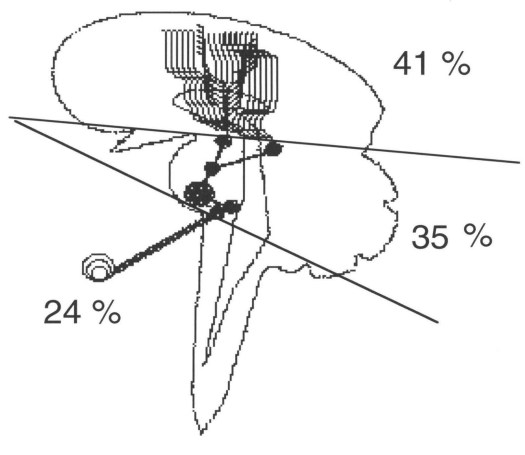


Fig. 8. Topographical locations of the tinnitus symptom

We believe the findings reported at this time support tinnitus to have a peripheral origin in approximately 24% of tinnitus patients; in brain stem of approximately 35%; and is at a supratentorial level in 41% (Figure 8).

CONCLUSIONS

Tinnitus can be functionally measured and localized by sensory motor and neurosensory tests.
The results of electrophysiological and vestibular testing provides a basis for a systematic pharmacological treatment for the symptom of tinnitus .
The electrophysiologic findings reported at this time indicate numerous and different locations of tinnitus. This has been demonstrated in approximately 24% of the patients.
Neurotologic medical treatment for functional neurosensory disease is recommended to follow two directions: a) improvement of neuronal metabolism and b) systematic stimulation and/or depression of principal neurotransmitter activities.
Specific recommendations for tinnitus therapy is considered to be individual and based on the goal of attempting to achieve optimal tinnitus control.
Auditory and Vestibular Cortical and Brain Stem Topognostic Testing in tinnitus patients improves the accuracy of tinnitus diagnosis; provides a basis for a plan of treatment; and an ability to monitor the efficacy of recommendations attempting tinnitus control.

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