



CLINICAL STUDY

TYMPANIC MEMBRANE TEMPERATURES OF VERTIGINOUS PATIENTS

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SUMMARY

Objective: This study aimed to determine the differences between the right and left ear temperatures of patients with vertigo. It also aimed to correlate the results in order to develop definitions for the pathophysiology of the diseases based on the data. Thus, we designed a study to record bilateral tympanic membrane temperatures on 137 vertiginous patients who were seen at our vertigo clinic.

Materials and Methods: The study was carried out in patients who applied to Istanbul Florence Nightingale Hospital Ear, Nose and Throat Diseases Clinic with the complaint of dizziness. After confirming that there was no abnormality in the otoscopic examination, the temperature of both ears were measured with a thermometer, prior to the vestibular examination being carried out in the vestibular laboratory with the presumptive diagnosis of true vertigo. The data recorded include the patient's demographic information, examination findings, and the results obtained from the vestibular laboratory. Mean, standard deviation, median, minimum, maximum value frequency, and percentage were used for descriptive statistics.

Results: A total of 137 patients were included in the study. No significant ($p > 0.05$) difference was observed between pathologic Side and other Side measurements in the benign paroxysmal positional vertigo (BPPV) group, Ménière's disease group, or vestibulopathy group. Nystagmus at presentation in the group without otologic pathology, i.e. those patients without overt vestibular pathology, was significantly ($p < 0.05$) higher than in the BPPV, Meniere's, or vestibulopathy groups.

Conclusion: Our study failed to disclose any significant difference of tympanic membrane temperatures in patients with vertiginous complaints.

Keywords: Vertigo, Tympanic membrane, Benign paroxysmal positional vertigo, Meniere

VERTİJİNÖZ BELİRTİLERİ OLAN HASTALARDA KULAK ZARI ISILARI

ÖZET

Amaç: Bu çalışmada vertigosu olan hastaların sağ ve sol kulak ısılarının arasındaki farkların incelenmesi amaçlanmıştır. İkinci bir amaç da hastalıkların patofizyolojileri ile elde edilmiş veriler arasında korrelasyon araştırılması olmuştur. Bu amaçlara yönelik olarak kliniğimizde görülmüş olan 137 vertigolu hastanın bilateral kulak ısıları üzerine bir çalışma tasarlanmıştır.

Materyel ve Metod: Bu çalışma İstanbul Florence Nightingale Hastanesi Kulak Burun Boğaz Hastalıkları Kliniğine baş dönmesi yakınması ile başvuran hastalarda yapılmıştır. Otoskopik olarak herhangi bir patoloji olmadığı saptandıktan sonra termometre ile her iki kulak ısı ölçülmüş ve gerçek vertigo ön tanısı ile hastalar vestibüler laboratuvara alınmışlardır. Edinilen veriler hastaya ait demografik bilgiler, muayene bulguları ve vestibüler laboratuvarında elde edilenlerden ibarettir. Ortalama, standart sapma, ortanca, minimum ve maksimum değer sıklığı ve yüzdeler tanımlayıcı istatistiksel olarak çalışılmıştır.

Sonuçlar: Toplam 137 hasta çalışılmıştır. Benign paroksizmal pozisyonel vertigo (BPPV) grubu, Meniyer hastalığı grubu veya vestibulopati gruplarında patolojik kulak ile diğer kulak arasında istatistiksel anlamlı fark saptanmamıştır ($p > 0.05$). Otolojik patoloji saptanmamış olanlarda, yani vestibüler sistemin patolojisi olmadığını düşündüğümüz hastalarda nistagmus varlığı BPPV, Meniyer veya vestibulopati gruplarına göre istatistiksel olarak daha sık görülmüştür ($p < 0.05$).

Yorum: Çalışmamızda vertijinöz belirtileri olan hastalarda kulaklar arası ısı farklılığı gösterilememiştir.

Anahtar Sözcükler: Vertigo, Kulak zarı, Benign paroksizmal pozisyonel vertigo, Meniyer hastalığı, İşlevsel lateralizasyon

INTRODUCTION

Vertigo presents as a sensation of movement of the environment around the patient, affecting their quality of life. Vertigo is a commonly encountered symptom in clinical

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practice and emergency rooms, and has an estimated lifetime prevalence of up to 10%.¹ Vertigo is caused by a lesion affecting the vestibular pathways at any point from the labyrinth to the vestibular nuclei or its central connections.²

The etiology of vertigo generally consists of either central or peripheral causes. The common causes of vertigo seen in primary care are benign paroxysmal positional vertigo (BPPV), vestibular neuronitis, vestibular migraine (VM), and Ménière's disease.³⁻⁵ It is possible that the key mechanism of vertigo in migraine is related to the sterile inflammation of intracranial vessels, vasodilatation, and plasma



extravasation in and around the inner ear.⁶ It is also known that vestibular receptors are pressure-sensitive.⁷

One of the diagnostic tests utilized for the differential diagnosis of vertigo, the caloric stimulation test, first described by Robert Barany in 1906, uses changes in ear temperature by applying water or air.^{8,9} This diagnostic tool is used to understand the origin of vertigo by causing vertigo in patients in a clinical setting and measuring the response rate of each ear while comparing them to each other.

Caloric testing is the only procedure that assesses each labyrinth separately. It helps find the affected side and provides information about the extent of the vestibular lesion. Caloric stimulation of the labyrinth causes a flow of endolymph within the semicircular canals, which causes polarization or depolarization of the hair cells of the ampulla, which becomes visible through the vestibular-ocular reflex.¹⁰ Caloric testing is most useful for diagnosing certain diseases, including Meniere's disease and VM.¹¹ The most consistent laboratory finding in VM is a unilaterally reduced caloric response.⁶

Measurement of tympanic membrane temperatures (TMTs) using infrared thermometry has become an invaluable tool for measuring the core body temperature. It has been shown that TMTs demonstrate strong correlations with concurrent temperature measures in the pulmonary artery, rectum, and mouth.¹²

TMT is also accepted as a good index of brain temperature, as its variations reflect changes in brain core temperature. As Propper et al. stated in their study, hemispheric activity affects ear temperature, although the mechanisms by which TMT may be related to hemispheric activity are not completely known.^{13,14} TMT is greatly influenced by the internal carotid artery and the jugular vein, and it shows considerable circadian changes parallel to the core body temperature.^{15,16} In one study in Japan, the effects of Meniere's disease on ear temperature were shown on one patient whose TMT varied widely after the attack of vertigo.¹⁵

In this current study, based on the research, we expected to determine the differences between the right and left ear temperatures of vertigo patients, and while

correlating the results, to develop definitions for the pathophysiology of the diseases based on this information. Thus, we designed a study to record TMTs on a series of vertiginous patients who were seen at our vertigo clinic.

MATERIAL and METHODS

This study adheres to the principles of the Declaration of Helsinki. It was carried out in accordance with the Ethics Committee of Demiroğlu Bilim University (Protocol no: 44140529/ 8748, approved on 02.11.2021). Written informed consent was obtained from all patients.

Study design

The study was carried out in patients who applied to Istanbul Florence Nightingale Hospital Ear, Nose and Throat Diseases Clinic with the complaint of dizziness. Standard outpatient procedures of the patients were performed, and vertigo-specific inquiries were made in addition to the otoscopic examination. After confirming that there was no abnormality in the otoscopic examination, the temperature of both ears was measured with a thermometer, prior to the vestibular examination being carried out in the vestibular laboratory with the presumptive diagnosis of true vertigo. During the follow-up of these patients, TMTs were measured again. The steps involved in this study are given in a flow chart at Figure 1. The data sought included patient's demographic information, examination findings, and the results obtained from the vestibular laboratory (Table 1). The vestibular laboratory uses Micromedical by Interacoustics Aqua Stim (Interacoustics A/S, Denmark) to examine the following parameters: spontaneous nystagmus, Dix-Hallpike maneuver, supine roll, gaze horizontal, gaze vertical, saccade random, pursuit, and optokinetic fixed. A Genius 2 (Covidien, Ireland) tympanic temperature measuring device was used to measure TMTs. The measurements were taken with the patient seated in a chair and prior to any caloric testing. The same thermometer was used for each patient to ensure consistency in ear temperature measurement, and the calibration of the measuring instrument was checked regularly by the department of Biomedical Engineering of the hospital.



Study group

The study group involved adult patients who applied to the Istanbul Florence Nightingale Hospital Ear Nose and Throat Department with the complaint of dizziness between 15 November 2021 and 30 April 2022. A patient was excluded from the study if there were no findings compatible with true vertigo that required examination in the vestibular laboratory, or if the patient did not want to volunteer, had a febrile or infectious disease, or the tympanic membrane and otoscopic findings were not within the normal limits.

Statistical analysis

Mean, standard deviation, median, minimum, maximum value frequency, and percentage were used for descriptive statistics. The distribution of variables was checked with a Kolmogorov-Smirnov test. ANOVA, Kruskal-Wallis and Mann-Whitney U tests were used to compare quantitative data. A Wilcoxon test was used for the repeated measurement analysis and a Chi-Square test was used for the comparison of qualitative data. SPSS 28.0 was used for statistical analyses.

RESULTS

A total of 137 patients were included in the study. Patients' distribution according to age, gender, and pathology are given in Table 2. The presence vs. absence of significant medical issues and/or physical findings were noted as well and are given in Table 3.

Patients were grouped according to their clinical diagnosis. The clinical diagnoses were established according to the patient's history, physical findings (presence or absence of nystagmus), and the results obtained from the vestibular laboratory. These diagnoses were then grouped by BPPV, Meniere's disease, vestibulopathy, and no vestibular pathology. The term vestibulopathy was used for cases where it was not possible to make a clear diagnosis,

however patients' findings were highly suggestive of a vestibular pathology, with a significant portion of them possibly having either Meniere's disease without cochlear symptomatology or vestibular neuritis.

These groups were then compared according to the temperature values obtained. No significant ($p > 0.05$) difference was observed between the Pathologic Side and other Side measurements in the BPPV group, the Meniere's group ($p > 0.05$), or the vestibulopathy group. No significant ($p > 0.05$) difference was observed between the Pathologic Side and other Side measurements in all patient groups (Table 4 and Figure 2).

There was no significant difference ($p > 0.05$) between the non-pathological, BPPV, Meniere's, and vestibulopathy groups in terms of age, gender distribution, general medical history, or history of ear problems (Table 5).

Nystagmus at presentation in the group without pathology was significantly ($p < 0.05$) lower than in the BPPV, Meniere's, and vestibulopathy groups. This group of patients with nystagmus at presentation, though without vestibular pathology, was considered to be consisting of patients with a possible neurologic disorder. These patients were later referred to the neurology department. The nystagmus at presentation rate in the BPPV group was significantly ($p < 0.05$) lower than in the Meniere's and vestibulopathy groups (). It must be noted that those patients whose final diagnosis was BPPV and that had nystagmus at presentation, upon further evaluation including neurological examination and MRI, were found to have lateral semicircular cupulo- and/or canalo-lithiasis, with geotropic or ageotropic responses. Thus, even though these patients had nystagmus at presentation, this nystagmus was considered as pseudo-spontaneous nystagmus.

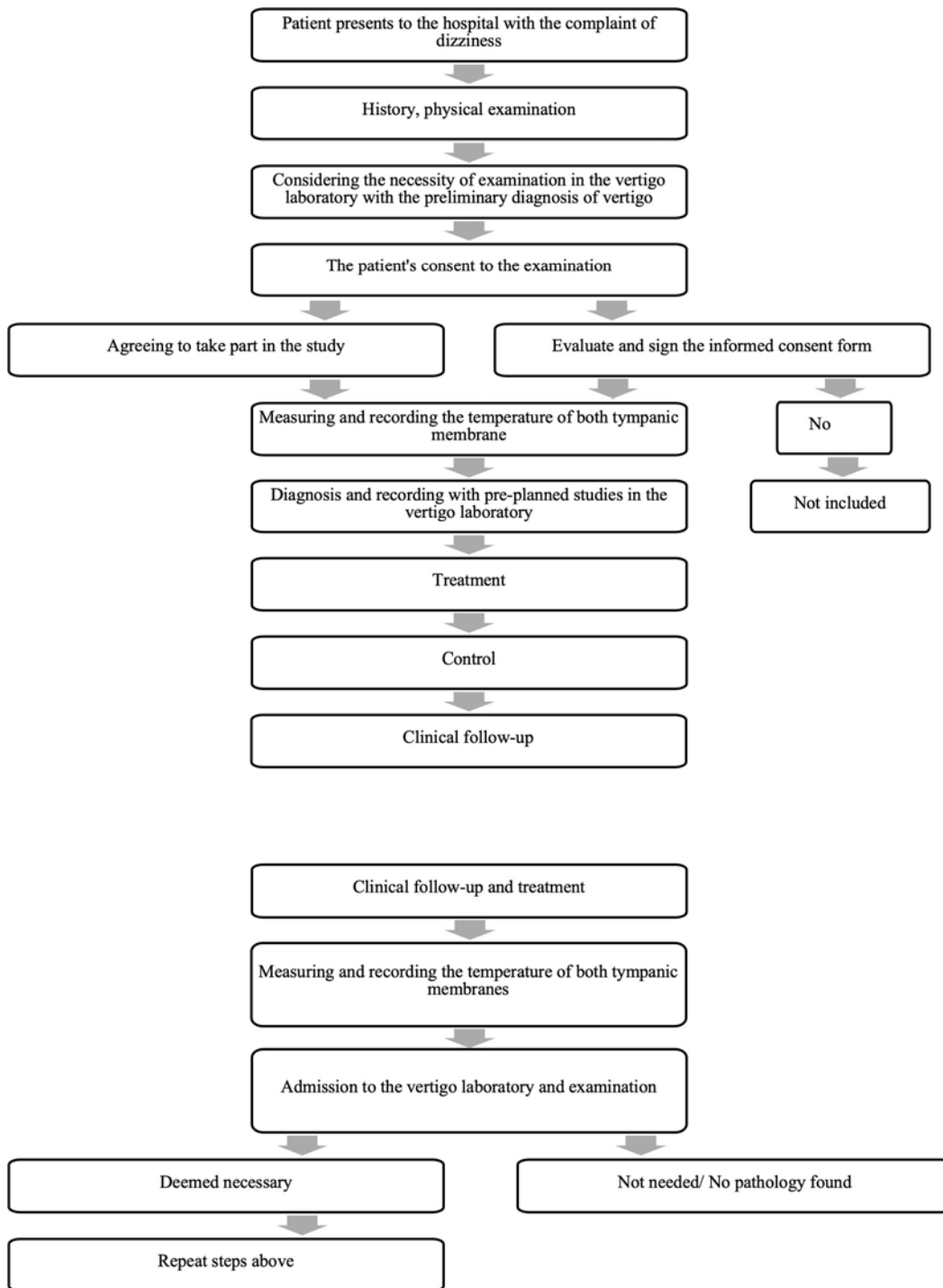


Figure 1: The Flow Chart of The Study



Table 1. Study Data Items

General demographic information

Gender
Age
Occupation
Social Life

Clinical evaluation

Complaint
History
Duration and Positionality
Physical findings
Treatment

Tympanic membrane temperature

Right
Left

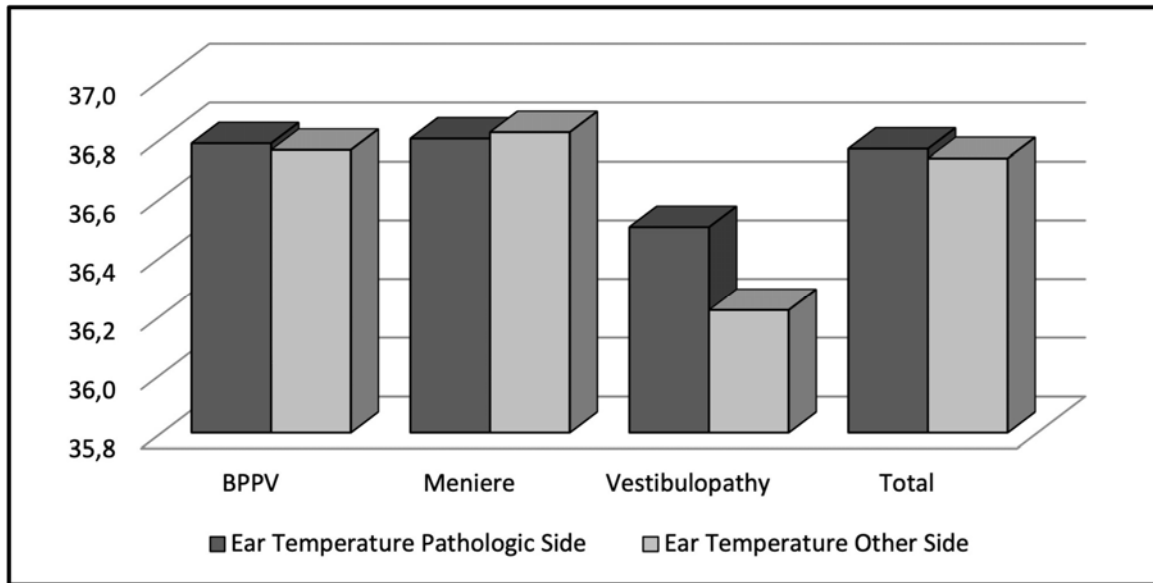


Figure 2: Chart demonstrating ear temperature differences according to the pathology.



Table 2. Patients' distribution according to age, gender, and pathology.

Table-2		Min-Max	Median	Mean±sd/n-%
Age		18.0 - 95.0	56.0	55.3 ± 16.0
Gender	Female			80 58.4%
	Male			57 41.6%
Ear Temperature				
Pathologic Side		35.8 - 37.5	36.8	36.8 ± 0.3
Other Side		35.3 - 37.5	36.8	36.7 ± 0.4
Total		35.6 - 37.5	36.8	36.8 ± 0.3
Pathology	No Pathology			42 30.7%
	BPPV			75 54.7%
	Meniere			14 10.2%
	Vestibulopathy			6 4.4%

Table 3. The presence vs. absence of significant medical issues and/or physical findings

Tablo-3

	n	%
Past Medical History		
N.O.S.*	108	78.8%
S.H.**	29	21.2%
Hypertension	9	31.0%
Diabetes Mellitus	6	20.7%
Thyroid Patient	4	13.8%
Allergy	1	3.4%
Alzheimer's	1	3.4%
A Mass In The 4th Ventricle	1	3.4%
Ankylosing Spondylitis	1	3.4%
Bilateral Tympanoplasty	1	3.4%
Bypass Operation	1	3.4%
Cervical Surgery	1	3.4%
Cholecystectomy	1	3.4%
Chronic Diseases	1	3.4%
Cholesterol	1	3.4%
Ear Surgery	1	3.4%
Essential Tremor	1	3.4%
Follow-Up MS Patient	1	3.4%
He Experienced Cyanide Poisoning Due To Broad Bean, Lumbar Spine	1	3.4%
Laminectomy Operation, Hyperthyroidism	1	3.4%
Intense Cocaine Use	1	3.4%
Lumbar Spine Laminectomy Operation	1	3.4%
Meniere's Disease	1	3.4%



<i>Migrane</i>	1	3.4%
<i>Multiple Neuropathy</i>	1	3.4%
<i>Postop Lung Tumor</i>	1	3.4%
<i>Vertebral Compression Fracture</i>	1	3.4%
Auditory Problem		
Absent	133	97.1%
Present	4	2.9%
<i>Bilateral Hearing Loss</i>	1	25.0%
<i>Hearing Loss</i>	1	25.0%
<i>Hearing Loss In The Right Ear</i>	1	25.0%
<i>Left Total Hearing Loss</i>	1	25.0%
Nystagmus At Presentation		
Absent	89	65.0%
Present	48	35.0%
<i>Left Spontaneous Nystagmus</i>	15	31.3%
<i>Right Spontaneous Nystagmus</i>	15	31.3%
<i>Left Pseudospontaneous Nystagmus</i>	10	20.8%
<i>Right Pseudospontaneous Nystagmus</i>	4	8.3%
<i>Down Beat Nystagmus</i>	2	4.2%
<i>Pseudospontaneous Nystagmus</i>	2	4.2%
*N.O.S.: Nothing of significance **S.H.: Significant history		

Table 4. Comparison of ear temperatures according to the pathology side vs. normal ear.

Table-4	Pathologic Side		Other Side		P
	Mean±sd	Median	Mean±sd	Median	
Ear Temperature					
BPPV	36.8 ± 0.3	36.8	36.8 ± 0.4	36.8	0.792 ^w
Meniere	36.8 ± 0.2	36.8	36.8 ± 0.2	36.8	0.686 ^w
Vestibulopathy	36.5 ± 0.4	36.6	36.2 ± 0.5	36.3	0.114 ^w
Total	36.8 ± 0.3	36.8	36.7 ± 0.4	36.8	0.508 ^w
^w Wilcoxon test					



Table 5. General distribution of patients

Table-5		No Pathology	BPPV	Meniere	Vestibulopathy	p				
Age	Mean±sd	55.0 ± 20.7	53.7 ± 14.2	61.1 ± 8.7	62.7 ± 7.7	0.277 ^A				
	Median	57.0	52.0	59.0	63.5					
Gender										
Female	n-%	20	47.6%	49	65.3%	8	57.1%	3	50.0%	0.299 ^{X²}
Male	n-%	22	52.4%	26	34.7%	6	42.9%	3	50.0%	
Ear Temperature										
Pathologic Side	Mean±sd		36.8 ± 0.3	36.8 ± 0.2	36.5 ± 0.4	0.281 ^K				
	Median		36.8	36.8	36.6					
Other Side	Mean±sd		36.8 ± 0.4	36.8 ± 0.2	36.2 ± 0.5	0.030 ^K				
	Median		36.8	36.8	36.3					
Total	Mean±sd	36.8 ± 0.4	36.8 ± 0.3	36.8 ± 0.2	36.5 ± 0.4	0.458 ^K				
	Median	36.8	36.8	36.8	36.6					
Past Medical History										
N.O.S.*	n-%	36	85.7%	55	73.3%	12	85.7%	5	83.3%	p>0.05 ^{X²}
S.H.**	n-%	6	14.3%	20	26.7%	2	14.3%	1	16.7%	
Auditory Problem										
Absent	n-%	40	95.2%	75	100%	13	92.9%	5	83.3%	p>0.05 ^{X²}
Present	n-%	2	4.8%	0	0.0%	1	7.1%	1	16.7%	
Nystagmus At Presentation										
Absent	n-%	36	85.7%	51	68.0%	2	14.3%	0	0.0%	0.000 ^{X²}
Present	n-%	6	14.3%	24	32.0%	12	85.7%	6	100%	

*N.O.S.: Nothing of significance **S.H.: Significant history

^A ANOVA / ^K Kruskal-wallis (Mann-whitney u test) / ^{X²} Chi-square test (Fischer test)

DISCUSSION

True vertigo is most likely caused by a disorder of the vestibular system, which is a sensory system comprised of sensory transducer organs in the inner ear with its three orthogonal semicircular canals and two otolith organs.¹⁷ Research shows that the vestibular system is sensitive to thermal stimuli, which has become one of the commonly used vestibular tests through bithermal caloric testing.^{9,18} As such, this test is utilized for diagnostic purposes of peripheral vestibular disorders, such as Meniere's disease, VM, vestibular neuritis, as well as for central vestibular disorders, such as multiple sclerosis, and lacunar infarcts.¹⁹

Researchers who have done postmortem studies have postulated that Meniere's disease is associated with an increase of the endolymph within the inner ear membranous labyrinth, yet not all cases of increased endolymph produce the same clinical picture, leaving part of the pathogenesis yet to be discovered.³ The cause of another vestibular disorder, VM, also remains unclear.⁶

TMT has been in clinical use for several decades.²⁰ It has been shown that the major supplier of the ear drum's vascularization is the external carotid artery, however a proportion would be derived from the internal carotid artery. That artery perfuses both the hypothalamus,



which is involved in psychobiological stress responses, and the frontal cortex, which is involved in the processing of emotional information.^{12,21}

TMT was also found to represent a measure of the temperature of proximal brain tissue and possibly hemispheric activation.^{13,22,23} It is accepted that an absolute difference between left and right TMT is indicative of relative hemispheric activation.¹³ According to Helton, a consistent elevated temperature in ipsilateral ear drum can reflect cortical temperature, overall resting state, or residual activation in the ipsilateral hemisphere.²⁴ TMT measures have been associated with lateralized cognitive and emotional/motivational states, including fear and stress.^{16,25,26,27}

The absolute mechanisms by which TMT may be related to hemispheric activity are not completely known.¹³ In one study, researchers found evidence for a link between increased TMT and increased ipsilateral hemispheric activation after mood-induction.¹³ Another explanation is that decreased TMT is thought to be associated with increased hemispheric activation on the ipsilateral side of the brain. As the ipsilateral carotid artery is the main source of ipsilateral hemisphere and tympanic membrane, the same side skull and related structures demonstrate characteristics of heat dissipation. The blood flow around the tympanic membrane is thought to be cooler than blood being actively recruited by the brain during neuronal activity; in other words, increased hemispheric activity is associated with decreased TMT ipsilaterally.²⁴

Besides the level of the hemispheric activity, TMT might be reflecting other factors locally or might be affected by external issues such as postural changes of the subject, head tilt, age, tympanic membrane pathology, cerumen and excessive hair, humidity, cooling of the face (especially in hyperthermia), cerebrovascular disease (stroke), and cold ambient temperatures.^{21,23,26} One single-patient study showed that Meniere's disease had an effect on the patient's TMT after an attack of vertigo.¹⁵

Our results failed to disclose any relationship between TMT and common vestibular disorders, namely BPPV, Meniere's

disease, or unspecified vestibular pathologies. As shown in Table 4 and Figure 2, TMT tended to be higher in the involved ear in the vestibulopathy group; however this difference did not reach statistical significance; more so, the ear that was not involved seemed to have a comparably lower temperature (median 36.3° C) than the ear with the pathology (median 36.6° C).

However, our study has shown that nystagmus at presentation was significantly less common among patients without vestibular pathologies, yet among the vestibular pathologies group, patients with BPPV seemed to have more accounts of nystagmus at presentation compared to the Meniere's disease and vestibulopathy groups. As those patients with a final diagnosis of BPPV originating from lateral semicircular canal were found to have pseudo-spontaneous nystagmus, it is possible to say that nystagmus at presentation was significantly more common among patients with Meniere's disease and vestibulopathy. This is in correlation with the literature.²⁸ An exception to this theory is that healthy normal controls without vestibular or autonomic symptoms may exhibit low velocity nystagmus.²⁹

Our study had some limitations. One limitation could be the reading quality of the device used for measuring TMT. While TMT is accepted as a reliable and accurate method for measuring core temperature,³⁰ the measurement accuracy is dependent on the correct positioning of the probe.³¹ Different ear anatomy and probe designs that are not compliant with the external ear shape might cause some inaccurate readings.²⁰

In our study we used a tympanic thermometer which is reportedly highly accurate and which had been regularly checked for functionality and calibrated by our biomedical department. All of the patients had a prior ear examination and cerumen removal if needed, after which the study had started. The patients had all their tests done in a well air conditioned space and the tests were done between 9:00 a.m. and 5.00 p.m. Yet, there might still be factors that affect TMTs that have been missed throughout the study. Another limitation could



be the relative absence of further diagnostic tools to help confirm the diagnosis and the relative activity levels of the cerebral hemispheres.

CONCLUSION

This study failed to find any difference between TMTs of patients with vestibular disorders. Thus, it can be concluded that with the present devices no temperature differences were detected in patients with vertiginous complaints.

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