

SUB-CLINICAL EFFECTS OF CHRONIC NOISE EXPOSURE ON VESTIBULAR SYSTEM

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Abstract

Aim: to investigate the effect of chronic noise exposure on vestibular function of subjects without clinical evidence of vestibular disorders and with documented cochlear damage from noise.

Subjects and methods: 25 patients with chronic noise-induced hearing loss (NIHL) and without vestibular complaints (group A) and 25 matched controls with sensorineural hearing loss without noise exposure (group B), underwent **audiological and vestibular test including caloric and cervical vestibular-evoked myogenic potentials tests (cVEMPs).**

Results: In subjects **chronically exposed to noise, similarly to that of the auditory threshold, an increase in the evocation threshold of VEMPs has been documented, statistically significant** ($p < 0.05$) and independent of the performance of the auditory threshold. p1-n1 amplitude values showed a significant difference between group A and group B. No significant difference for p1-n1 latencies between the two groups was found.

Conclusion: **We have documented the possibility of vestibular lesion, along with cochlear damage, related to chronic acoustic trauma.**

Keywords: chronic noise-induced hearing loss; acoustic trauma; vestibular damage; cVemps.

I. INTRODUCTION

Noise induced hearing loss (NIHL) is an insidious and cumulative disease that worsens over time. Over the last years, literature showed a large and increasing interest in NIHL^{1,2}, while the effect of noise on vestibular system has been given less attention and remained only a secondary aspect of acoustic trauma^{3,4}.

Currently, few clinical studies have been performed about vestibular function and noise exposure, many of these studied⁵⁻⁷ only complaints of vestibular symptoms and disequilibrium without instrumental examination and the results are often highly controversial^{8,9,10}.

From an anatomical point of view, there are three fundamental issues for the rationale of a vestibular acoustic damage similar to NIHL: the proximity of vestibular organs to the acoustic-energy delivery system^{11,12} the similarity of cellular structure of cochlear and vestibular receptors and the common blood supply of cochlear and vestibular organs⁴.

Animal research showed that vestibular organs may be damaged by noise exposure just like the cochlea^{13,14}, typically the saccule is more affected than utricle and semicircular canals¹⁵⁻²⁰. It's well known that acoustically responsive saccular afferents determine acoustic reflexes of the sternocleidomastoid (SCM) muscle and the measurement of these reflexes reflects well the saccular function^{21,22}. So, the most useful tool to evaluate saccule's function is cervical vestibular evoked myogenic potentials (cVEMPs)^{23,24}.

Focusing on this rationale, the aim of this study is to evaluate saccular function using cVEMPs in subjects with documented NIHL from chronic occupational noise exposure and without vestibular symptoms.

The Chi-Square test showed a significant difference for threshold values between the two groups. ($p < 0,05$). In any patients of group A it wasn't possible to obtain an evoked response at 100 dB SPL. In most ears, threshold values were evoked at 120 dB SPL. In six ears it was not possible to evoke VEMPs at 130 dB SPL. On the contrary, in almost all patients of group B it was possible to evoke VEMPs response at 100 dB SPL.

The amplitude of p1 and n1 (p1-n1 amplitude) and their latency (p1/n1 latencies) for each group is showed in table 2.

	p1 right (ms)	p1 left (ms)	n1 right (ms)	n1 left (ms)	p1-n1 right (μ v)	p1-n1 left (μ v)
Group A	18,58	18,76	25,41	25,50	42,15	36,90
	mean 18,67		mean 25,46		mean 39,52	
Group B	17,45	17,23	23,94	23,83	32,35	35,53
	mean 17,34		mean 23,89		mean 23,94	

Table 2: Average values of cVEMP's p1/n1 latencies (ms) and the p1-n1 amplitude (μ v) for right and left ear in each group.

The T-Student test found no significant difference for p1-n1 latencies between the two groups. Conversely, p1-n1 amplitude values showed a significant difference between group A and group B.

V. DISCUSSION

From an anatomical point of view, there are three fundamental issues for the rationale of a vestibular acoustic damage similar to NIHL: the proximity of vestibular organs to the acoustic-energy delivery system, the similarity of cellular structure of cochlear and vestibular receptors and the common blood supply of cochlear and vestibular organs. On the other side the "limiting membrane" between saccule and the rest of vestibule (utricle and semicircular canals) may protect a great part of sensory cells in the labyrinth from acoustic trauma²⁸. In fact, McCabe et al.²⁹ showed on animal model, that a high level sound (136–150dB SPL) for 20 min affect saccule and pars inferior of cochlea despite utricle and pars superior of semicircular canals. This difference between pars superior and inferior is probably due to the presence of the membrana limitans, that acts as a barrier, causing different sensitivity of cochlear and vestibular sensory epithelia to the pathogen noxa like acoustic exposure. Embryologically the semicircular ducts arise from utricle and the cochlear duct develop from a comparative large saccule as evidenced in the lower species which can serve as an acoustic receptor. In the literature there are studies on VEMPs following acute

acoustic trauma for almost all only on experimental animal, while limited experiences on chronic exposure in humans are reported. Several studies showed evidence of associated damage of cochlea and vestibular organs^{4,19,30} and Ylikoski¹⁹ suggests a resemblance between type of damage in the two structures.

The aim of this study was to evaluate saccular function by cVEMPs in a sample of NIHL patients with normal caloric tests comparing to patients affected by bilateral sensorineural hearing loss never exposed to acoustic trauma. Our results showed that chronic noise exposure produces subclinical saccular damage as confirmed by elevated threshold values and reduced p1-n1 amplitude of VEMPs in group A comparing group B. No significant difference we have found between two groups for p1-n1 latencies values.

Our results are partly in accordance with other studies available in the literature. Tseng and Young¹⁰ noted that patients subjected to NIHL decrease order of abnormal percentages in the function of the cochlea, saccule, utricle and semicircular canals. Giorgianni et al.³⁰ reported that in 60 subjects with NIHL cVEMPs were abnormal or absent in 64.9%, specifically, cVEMPs were absent in 28.3%, latency was increased and peak- to-peak amplitude was reduced in 36.6%. Wang et al.³¹ (2007) reported that patients with bilateral 4-kHz notched audiogram and hearing threshold of 4 kHz > 40 dB show abnormal (absent or delayed) cVemps, indicating that the vestibular part, especially the sacculo-collic reflex pathway, has also been damaged. Same results are showed by Kumar et al.³² they reported that in NIHL, as the pure tone average increased, the latency of p1-n1 cVEMPs was prolonged, and peak to peak amplitude was reduced in experimental group when compared to control group (normal hearing). Abd El-Salam et al.³³ reported that cVEMPs latency was increased and cVEMPs amplitude was reduced in NIHL subgroups versus the control group consisting of 20 healthy volunteer adults with normal hearing thresholds and no history of noise exposure.

The only different data in our work with respect to those mentioned is the longer p1-n1 latencies, which was not statistically significant compared to the control group. This is probably due to the fact that in the previous studies the control group is composed by normal hearing patients, while in our study the control group includes subjects affected by sensorineural hearing loss. Furthermore, the last two Authors mentioned^{32,33} did not perform vestibular tests including caloric stimulation in order to exclude a canal damage and inferior vestibular nerve injury that, as it is known, may affect the sacculo-collic reflex evaluated by cVEMPs.

The results of our study confirm the starting hypothesis: the sensitivity of the saccule and some particular anatomical conditions make this portion of the posterior labyrinth susceptible to noise damage almost like the cochlear receptor. On the one hand the raising of the VEMPs thresholds in subjects chronically exposed to noise, statistically significant compared to the control group, and on the other the demonstration that it is not