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Evaluation of the Auditory Pathway in Traffic Policemen

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Abstract

Background: Traffic policemen working at heavy traffic junctions are continuously exposed to high level of noise and its health consequences.

Objective: To assess the hearing pathway in traffic policemen by means of brainstem evoked response audiometry (BERA), mid-latency response (MLR), and slow vertex response (SVR).

Methods: In this observational comparative study, BERA, MLR, and SVR were tested in 35 male traffic policemen with field posting of more than 3 years. 35 age-matched men working in our college served as controls.

Results: Increase in the latencies of waves I and III of BERA, and IPL I-III were observed. Compared to controls, the MLR and SVR waves showed no significant changes in studied policemen.

Conclusion: We found that chronic exposure of traffic policemen to noise resulted in delayed conduction in peripheral part of the auditory pathway, *ie*, auditory nerve up to the level of superior olivary nucleus; no impairment was observed at the level of sub-cortical, cortical, or the association areas.

Keywords: Evoked potentials, auditory, brain stem; Auditory pathways; Hearing loss, noise-induced; Neurophysiology; Acoustic stimulation; Auditory fatigue

Introduction

Occupational noise-induced hearing loss (NIHL) is a major cause of disability throughout the world. The rapid expansion of many Indian cities has led to a subsequent rise in the use of motor vehicles, increasing the level of noise pollution.[1] The nuisance of traffic noise is especially aggravated by the lack of strict legislations regarding the usage of horns as well as the indiscriminate blowing of horns by drivers.[2] The police personnel who are engaged in controlling the vehicular movement at heavy traffic junctions are continuously exposed to high level of noise from these vehicles.[3] Exposure to sound above a level of approximately 85 dB initially manifests as a temporary hearing loss or dullness of hearing that is known as "temporary threshold shift" (TTS), which may have fast resolution within 10–15 days of exposure. However, repeated or sustained exposure to noise of the hair cells and associated nerve fibres leads to degenerative changes and the damage becomes permanent and is termed "permanent threshold shift" (PTS).[4]

Many studies investigated the ill effects of noise in different categories of occupationally exposed persons.[5-7] However, there are only few studies that have been done on the auditory effects of noise among Indian traffic policemen. It has been observed

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TAKE-HOME MESSAGE

- Long-term exposure of traffic policemen to noise causes delayed conduction in the peripheral part of the auditory pathway.
- In traffic policemen with chronic exposure to noise, the noise-induced hearing loss is bilateral and symmetrical.
- Use of personal protective equipment and regular check-up examinations should be emphasized in traffic policemen.

that a majority of these policemen remain unaware of the health effects of noise on their hearing ability.[8,9] In 2010, a survey on the effects of noise pollution in traffic policemen in Hyderabad city, conducted by the Society to Aid the Hearing Impaired (SAHI), revealed that 76% of studied participants had NIHL.[10]

Earlier studies done on traffic policemen, analyzed the ill effects of traffic noise by taking history, pure tone audiometry (PTA), and clinical examination.[2,11-14] Alterations in auditory brainstem response (ABR) indicating altered auditory conduction up to the level of the brainstem in traffic policemen, have been reported earlier.[15] Literature is however, scant on the assessment of complete auditory pathway (*ie*, cochlea to auditory cortex) in traffic policemen who are constantly exposed to loud noise.

Auditory evoked potential can be used to trace the signal generated by a sound through the ascending auditory pathway. The evoked potential is generated in the cochlea, goes through the cochlear nerve, through the cochlear nucleus, superior olivary complex, lateral lemniscus, to the inferior colliculus in the midbrain, to the medial geniculate body, and finally to the cerebral cortex.

In addition to ABR, which is obtained within 0–8 ms of the application of a stimulus, we planned to evaluate the middle latency response (MLR), which is between 8 and 50 ms, and slow vertex response (SVR), which is >50 ms of the stimulus, so as to scan a wide tract of auditory pathway, *ie*, from auditory nerve to auditory cortex and the association areas.[16]

The present study was thus conducted to assess the hearing status (complete auditory pathway) in traffic policemen of East Delhi, India.

Materials and Methods

The present observational comparative study was carried out in Electrophysiology Lab in the Department of Physiology, University College of Medical Sciences, Dilshad Garden, Delhi, India.

The sample size was calculated based on an earlier similar study where the SD of wave V latency of ABR in controls and cases were 0.067 and 0.345, respectively.[17] To study a difference of 0.2 units, the required sample size for each group was calculated to be 35. The calculated sample size is based on assumption of a type 1 error of 5% and study power of 90%.

Simple random sampling was used for the selection of subjects and controls. Subject group included traffic policemen aged between 25 and 40 years with field posting of more than three years. Those with any ear disease in the past or those who underwent any ear surgery or previous exposure to accidental explosion were excluded from the study. Control group included 35 people working in our college with no exposure to noise for long durations.

Test Protocol

All the study participants underwent three tests—brainstem evoked response audiometry (BERA), mid-latency response (MLR), and slow vertex response (SVR). All the subjects were informed of the procedure prior to the recording. The recording was done using a 4-channel Octopus-EMG.

Table 1: The mean (SD) absolute peak latencies of BERA waves I to V in both controls and subjects

	Right ear			Left ear		
Wave latency (ms)	**Controls**	**Policemen**	**p value**	**Controls**	**Policemen**	**p value**
I	1.43 (0.29)	1.66 (0.17)	<0.01	1.34 (0.29)	1.69 (0.20)	<0.01
II	2.54 (0.26)	2.63 (0.28)	0.19	2.57 (0.23)	2.62 (0.25)	0.43
III	3.50 (0.32)	3.69 (0.25)	0.01	3.45 (0.29)	3.67 (0.23)	<0.01
IV	4.60 (0.42)	4.53 (0.53)	0.55	4.63 (0.35)	4.61 (0.57)	0.84
V	5.50 (0.27)	5.46 (0.45)	0.61	5.50 (0.25)	5.53 (0.25)	0.56

NCS.EP machine (Biostar health care, India). The recording was done in a sound-proof room, using silver-silver chloride disk electrodes placed at standard scalp locations of the 10-20 International system. The electrodes were placed on the vertex of the skull (the reference electrode), on forehead (ground electrode), and on ear lobes (active electrodes) after cleaning the scalp and skin site with alcohol followed by Skinpure™ skin preparation gel and EEG paste Elefix™. The skin electrode contact impedance was kept at less than 5 kΩ.

Informed written consent was taken from all study participants prior to the test procedure. Ethical approval was taken from the Ethics Committee.

The common recording setting used included a stimulus intensity of 90 dB, and a mask level set to 60 dB. For all recordings, one amplifier was used.

Settings for recording of BERA

Settings for recording BERA included a high-cut pass of 3 kHz and a low-cut pass of 100 Hz. The stimulus was of alternate click type; the rate was adjusted to 11.1 Hz with a beep frequency of 1000 Hz and an average count of 1000. Absolute peak latencies of waves I, II, III, IV, and V and inter-peak latencies of I-III, III-V, and I-V were determined for each ear separately. The amplitudes of waves I and V and their ratio (V/I) were measured.

Settings for recording of MLR

Settings for recording MLR included a high-cut pass of 500 Hz and a low-cut pass of 20 Hz. The stimulus was of rare click type; the rate was adjusted to 5.3 Hz with a beep frequency of 1000 Hz and an average count of 500. Latencies of negative and positive waves, *ie*, N_o, P_o, N_a, and P_a were recorded. N_o-P_o amplitude was recorded peak to peak.

Settings for recording of SVR

Settings for recording SVR included a high-cut pass of 100 Hz and a low-cut pass of 2 Hz. The stimulus was of rare click

Table 2: The mean (SD) inter-peak latencies of BERA waves of the right and left ears in both controls and subjects

	Right ear			Left ear		
Inter-peak latencies (ms)	**Controls**	**Policemen**	**p value**	**Controls**	**Policemen**	**p value**
I-III	2.03 (0.31)	2.42 (0.31)	<0.01	2.02 (0.40)	2.04 (0.45)	<0.01
I-V	3.88 (0.31)	3.92 (0.51)	0.69	0.39 (0.47)	3.96 (0.38)	0.91
III-V	1.86 (0.33)	1.83 (0.37)	0.74	2.12 (1.04)	1.92 (0.47)	0.32

Table 3: The mean (SD) amplitudes and V/I amplitude ratio of BERA waves in both controls and subjects

	Right ear			Left ear		
Amplitudes	Controls	Policemen	p value	Controls	Policemen	p value
$I-I_a$ (µv)	0.45 (0.15)	0.40 (0.20)	0.81	0.53 (0.13)	0.41 (0.17)	0.59
$V-V_a$ (µv)	0.67 (0.15)	0.40 (0.20)	0.13	0.39 (0.14)	0.46 (0.18)	0.47
V/I (%)	157.1 (78.2)	182.0 (59.6)	0.14	144.3 (79.3)	175.3 (76.9)	0.10

type; the rate was adjusted to 0.5 Hz with a beep frequency of 1000 Hz and an average count of 100. Absolute peak latencies of negative and positive waves, *ie*, N_1, P_2, and amplitude N_1-P_2 were recorded.

Statistical Analysis

SPSS ver 20.0 statistical package was used for data analysis. The two groups were compared by *Student's t* test for independent data. Data were presented as mean (SD). A p value of <0.05 was considered significant.

Results

The absolute peak latencies of waves I to V of BERA are shown in Table 1. The increase in peak latencies of waves I and III was statistically significant ($p<0.05$) when

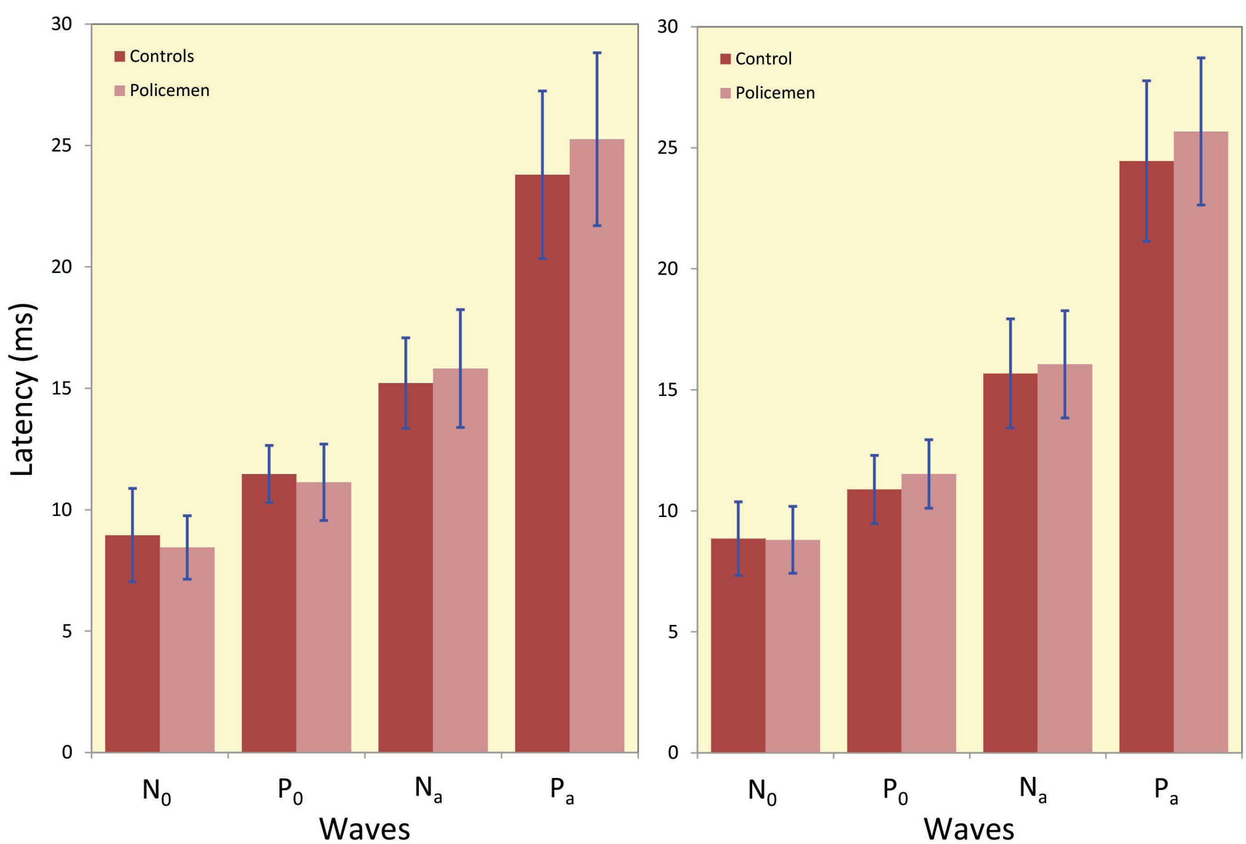

Figure 1: Latencies of MLR waves in the left ear (left panel) and the right ear (right panel) in controls and subjects. Error bars represent SD.

Table 4: The mean (SD) latencies of SVR waves of the right and left ears in both controls and subjects

	Right			Left		
SVR/LLR	Controls	Policemen	p value	Controls	Policemen	p value
N_1 (ms)	75.93 (18.90)	75.47 (15.77)	0.33	79.63 (14.70)	77.52 (16.20)	0.57
P_2 (ms)	141.19 (26.83)	145.91 (22.50)	0.43	142.35 (26.04)	144.17 (18.07)	0.73
N_1-P_2 (µv)	3.42 (1.69)	4.62 (2.35)	0.02	3.23 (2.08)	5.28 (2.19)	0.90

the values between subjects and controls were compared. The latencies of other waves did not show any significant change. Table 2 shows the values of inter-peak latencies (IPL) of both the control and subject groups of each left and right ear. It revealed a significant ($p<0.05$) increase of IPL I-III amongst traffic policemen as compared to controls. Inter-peak latencies I-V and III-V were not significantly different in the two groups. Table 3 depicts the amplitudes of waves I and V of BERA and V/I amplitude ratio in both subjects and controls. There were no statistically significant changes between the two groups.

Latencies of MLR waves N_o, P_o, N_a, P_a, and MLR amplitude N_o-P_o were not significantly different between controls and subjects (Fig 1). The latencies of SVR waves N_1 and P_2 and amplitude N_1-P_2, which shows no significant changes in traffic policemen as compared to controls (Table 4).

Discussion

The results obtained in the present study revealed that there was a significant ($p<0.05$) increase in the latencies of waves I and III of BERA in the traffic policemen. The increase was seen in both left and right ears. An increase of wave II latency was also observed, however, it was not statistically significant. ABR (BERA) serves as a non-invasive clinical tool in characterizing the electrophysiological phenomenon of neural excitation, conduction, and transmission across auditory pathway in the brainstem. The BERA wave I is believed to reflect activity in the auditory nerve; waves II and III reflect activity in the cochlea and superior olivary nuclei, and waves IV and V show activity in the lateral lemniscus and inferior colliculus.[18] Our results showed that the long-term exposure of traffic policemen to noise resulted in delayed conduction in the peripheral part of the auditory pathway, *ie*, auditory nerve up to the level of superior olivary nucleus.

This study showed significant increase in I-III inter-peak latency of studied policemen, suggesting an increase in conduction time of impulse from the auditory nerve to the superior olivary nucleus.

There was no significant change in the amplitudes of BERA waves. The amplitude of the BERA waveforms depends on the number of neural elements activated by the sound stimulus and the degree of synchronized activity of these neural elements.[19-22] A systematic trend of decreased wave I amplitude with increasing noise exposure backgrounds (NEB) was observed by Stamper and Johnson in 2015.[23]

In patients with NIHL, many authors have observed a significant extension of the waves I, III, V and I-III inter-peak latencies,[17,24] with results similar to that of the present study. They concluded that, besides the cochlear damage, there are damages to the neural synapses of the hair cells and the neural fibers of the cochlear nerve. These studies suggest anatomical and functional involvement of the neural pathways from the cochlear nucleus to the lateral meniscus; and that there is a greater functional involvement of the neuronal pathways to the left ear. A higher NIHL prevalence in the left ear of urban bus drivers of front engine buses in the city of São Paulo was also reported.[25]

Noorhassim, *et al*, also observed PI, PIII and PV, and LIPI-V and LIPIII-V latency extensions, however, because of the age range studied (60 [SD 8.7] years), the possibility of presbycusis could not be ruled out.[26] In our study, in order to avoid such bias, we tried to assess subjects younger than 40 years.

Our study results were in agreement with a prospective study of the changes in BEAP traces in 10 male machine operators exposed to noise >112 dB for eight hours daily, for 14 months. They observed that there are modifications in the absolute latencies of the early waves, however, without significant influence on the central neural conduction.[27] Few studies in patients with NIHL have shown a significant prolongation of the latency of wave V with IPL I-V prolongation.[24] In the present study, we did not observe a significant change in these latencies. Differences between results of the previous studies and the present one may be due to differences in selection of cases. In our study, we selected policemen with more than 3-year exposure to noise, whereas previous studies selected those with more than 5-year exposure.

We could therefore infer that besides the damage to the hair cells of the organ of Corti, there was an early functional involvement of the neuronal auditory pathway of the lower brainstem, and that the extent of these alterations was probably proportional to the level of sound exposure.

The mean latencies of MLR waves (N_a, P_a, and N_b) were not significantly different in the two groups. The MLR is thought to reflect a combination of muscle reflex activity and neural activity, possibly arising in the thalamocortical radiations, the primary auditory cortex, and early association cortex.[18]

The neural generators of MLR waves may be multiple.[28] Some studies have pointed to the primary auditory cortex as the neural source,[29,30] whereas other has suggested the ascending reticular activating system or other subcortical structures[31]. In human, the MLR response may consist of overlapping potentials originating from cortical and subcortical structures.[32]

We observed that only the cochlear (and not the retrocochlear) part of the auditory pathway was affected. An earlier study of NIHL on ground crew at airport also reveals no significant changes in MLR.[17] Therefore, we could show the hearing loss amongst traffic policemen involved up to the level of cochlea and not beyond.

SVR waves in this study showed no statistically significant changes. The long latency responses or SVR consists of P_1, N_1, P_2, and N_2; they are widespread in their distribution over the fronto-central scalp area. Vaughan and Ritter suggest that these potentials arise from primary auditory cortex and temporo-parietal association area and have a latency of 50–300 ms.[33] The primary auditory cortex exerts a control over the association cortex response through cortico-cortical and cortico-thalamo-cortical connections. There was a non-significant prolongation of the latency of SVR waves in traffic policemen. Due to paucity of literature on SVR in traffic policemen findings of our study could not be compared to results of other studies.

NIHL is usually bilateral and symmetrical affecting higher frequencies early and lower frequencies later.[34] Many factors might contribute to the impairment of auditory conduction in traffic policemen. Apart from noise arising from traffic, several other factors like lack of awareness

For more information on preventing noise-induced hearing loss see http://www.theijoem.com/ijoem/index.php/ijoem/article/view/627 about protective measures, duration of exposure for more than the allotted hours, *etc*, may have contributed to the development of hearing impairment in our subjects.

Higher prevalence of early NIHL in the left ear of stone crushing workers in Ghana was also reported.[35] This was attributed to the fact that engines of machines used for cutting purpose were positioned on the left side of the workers. A higher NIHL prevalence in the left ear of urban bus drivers was also reported.[17] This suggests that lateralization of hearing loss is evident in occupational NIHL. In the present study, the BERA abnormalities were present in both ears. We did not observe any lateralization, probably because both ears were equally exposed to the traffic noise.

With increased latencies and inter-peak latencies of BERA waves among our subjects, we can conclude that traffic policemen are at higher risk of developing NIHL with early involvement of peripheral/sensory/cochlear components of the auditory pathway. None of the studied policemen were using any kind of personal protective equipment. Most of the study subjects were in the economically productive age group and, if they suffer from hearing impairment at this age, they would have to live with this difficulty throughout the rest of their lives. There should be regular check-up examinations of traffic constables posted at heavy traffic junctions. Use of personal protective equipment should also be emphasized.

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Conflicts of Interest: None declared.

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