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A Comparative Study on Noise-Induced Hearing Loss among Truck Drivers and Non-Exposed Control Groups

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Abstract

Background: Occupational noise exposure is an important cause of auditory dysfunction, particularly among transportation workers. Long-haul truck drivers are exposed to prolonged engine, cabin, road and intermittent horn noise, which may affect the auditory pathway. Brainstem Auditory Evoked Potentials (BAEPs) can provide objective information about auditory brainstem conduction.

Objective: To evaluate BAEP abnormalities in professional truck drivers and compare absolute and interpeak latencies with those of healthy controls.

Methods: A case-control study was conducted on 100 male subjects, comprising 50 truck drivers and 50 age-matched controls. Truck drivers were classified according to noise exposure duration into <10 years (n=18) and >10 years (n=32) groups. Pure-tone audiometry and BAEP recordings were performed. Absolute latencies of Waves I–V, interpeak latencies I–III, III–V and I–V, and the Wave V/I amplitude ratio were assessed. Data were analyzed using the unpaired Student's t-test, with $p<0.05$ considered statistically significant.

Results: Truck drivers showed prolonged absolute latencies, particularly for Waves III–V, compared with controls. Significant prolongation was observed for several waves, with changes generally more evident with longer noise exposure. Interpeak latencies I–III, I–V and III–V were also increased among truck drivers. Age-wise analysis demonstrated increased absolute and interpeak latencies in several age groups. The Wave V/I amplitude ratio was reduced, particularly in the right ear, from 2.03 ± 0.76 in controls to 1.60 ± 1.04 and 1.61 ± 0.94 in the <10-year and >10-year exposure groups, respectively.

Conclusion: Chronic occupational noise exposure in truck drivers is associated with measurable alterations in auditory brainstem function, manifested mainly by prolonged absolute and interpeak latencies and changes in the Wave V/I amplitude ratio. BAEP may be useful for detecting functional auditory pathway changes associated with prolonged occupational noise exposure.

Keywords: NIL

Introduction

Noise is commonly defined as unwanted sound, although its perception is subjective. Environmental and occupational noise are important public health concerns and are major contributors to hearing impairment. The World Health Organization (WHO) estimated that approximately 250 million people worldwide had hearing disability in 2001.[1,2] Significant proportions of the European population are exposed to road traffic noise above recommended levels, which is associated with sleep disturbance and other adverse health effects .[3,4]

Noise pollution extends beyond auditory effects. Chronic exposure has been associated with impaired cognitive performance, sleep disruption, increased stress hormone levels, alterations in immune function, and cardiovascular disorders, even at levels below those causing immediate hearing damage .[5] Occupational exposure remains one of the most important causes of Noise-Induced Hearing Loss (NIHL), with industrial and transportation workers being particularly vulnerable.[6]

Occupational NIHL generally develops following prolonged exposure to noise levels exceeding approximately 85 dB Sound Pressure Level (SPL) for 8 hours per day over several years.[7] Persistent high-intensity noise initially produces a Temporary Threshold Shift and, with continued exposure, may progress to an irreversible Permanent Threshold Shift. Pathologically, prolonged exposure can cause damage to the stereocilia and hair cells of the cochlea and eventually the Organ of Corti, resulting in permanent hearing impairment.

The problem is particularly relevant in developing countries with expanding transportation systems. Long-haul truck drivers are exposed to continuous cabin noise generated by diesel engines, transmission and exhaust systems, structural vibration, and tire-road interaction. In addition, frequent use of pressure horns on highways can produce sound levels of approximately 100–105 dB. Truck drivers may therefore experience prolonged cabin noise of around 85–92 dB for 10–14 hours daily, combined with intermittent high-intensity noise exposure.[1] Because NIHL develops gradually and usually without pain, affected individuals may remain unaware of progressive auditory damage until substantial and irreversible hearing impairment has occurred.

Conventional pure-tone audiometry is widely used for evaluating hearing sensitivity; however, it primarily assesses peripheral hearing thresholds and may not identify subtle abnormalities in neural conduction along the auditory pathway. Objective electrophysiological methods can provide additional information regarding the functional integrity of the auditory system.

Auditory Evoked Potentials (AEPs) represent bioelectrical responses generated following auditory stimulation and reflect sequential activation of the cochlea and ascending auditory pathways.[8-10] Brainstem Auditory Evoked Potentials (BAEPs) are short-latency responses occurring within approximately 10 milliseconds of auditory stimulation and primarily reflect activity within the auditory nerve and brainstem pathways. BAEPs are widely used in audiology and neurology for assessing the integrity of peripheral auditory pathways and brainstem structures.[11]

The BAEP waveform typically consists of seven waves, with waves I, III, and V being the most clinically significant. Wave I represents the distal auditory nerve, wave III primarily reflects activity within the cochlear nucleus/superior olivary complex, and wave V is generated predominantly at the level of the lateral lemniscus and inferior colliculus .[12-14] BAEPs are evaluated using absolute wave latencies, amplitudes, interpeak latencies (I–III, III–V, and I–V), and interaural latency differences. Among these parameters, absolute and interpeak latencies are particularly useful for identifying abnormalities in auditory pathway conduction .[15-16]

BAEP recording is non-invasive, requires only surface electrodes, and does not generally require sedation or anesthesia, making it suitable for occupational screening and large-scale field studies. [17] Although pure-tone audiometry has been extensively used to assess occupational hearing loss, comparatively limited research has evaluated electrophysiological auditory function among long-distance transportation workers. Most previous studies have focused on urban transport workers such as taxi and auto-rickshaw drivers.

Long-haul truck drivers experience a unique combination of prolonged diesel-engine noise, cabin vibration, wind noise, and intermittent high-intensity horn exposure. Such chronic exposure may potentially affect auditory neural conduction before clinically significant hearing threshold abnormalities become apparent on conventional audiometry. Therefore, objective electrophysiological assessment may help identify early auditory pathway dysfunction in this occupational group.

The present study was undertaken to evaluate Brainstem Auditory Evoked Potentials (BAEPs) in professional long-haul truck drivers by comparing the absolute latencies of waves I–V and interpeak latencies (I–III, III–V, and I–V) with those of healthy age- and sex-matched control subjects.

Materials And Methods

Study Design and Population:

A case-control study was conducted in the Clinical Neurophysiology Unit, Department of Physiology, from September 2009 to November 2010, after approval from the Institutional Ethics Committee. The study included 100 male subjects: 50 commercial truck drivers with 8–10 years of occupational exposure and 50 age-matched healthy controls without significant occupational noise exposure.

Exclusion Criteria:

Subjects with CSOM, OME, otosclerosis, Ménière's disease, diabetes mellitus, hypertension, ototoxic drug exposure, previous head injury, or neurological/auditory disorders affecting BAEP were excluded.

Sampling and Ethical Considerations:

Truck drivers were selected by purposive sampling. Written informed consent was obtained from all participants after explaining the study procedures and its non-invasive nature.

Occupational Data and Noise Assessment:

Demographic and occupational information was collected using a structured questionnaire, including driving experience, daily driving hours, working days, vehicle characteristics, cabin condition, maintenance, awareness of noise hazards, and use of hearing protection. Noise levels inside the driver's cabin were measured at ear level using a calibrated digital sound level meter during stationary and moving conditions and with windows closed/open. Measurements were expressed in A-weighted decibels (dBA).

Audiological Evaluation:

Pure tone audiometry was performed in a soundproof room. Air conduction thresholds were assessed at 250–8000 Hz and bone conduction at 500–4000 Hz. Pure Tone Average (PTA) was calculated at 500, 1000, and 2000 Hz; PTA >25 dB HL was considered hearing loss.

BAEP Recording:

BAEPs were recorded in a quiet room using the RMS EMG-EP MARK II system. Electrodes were placed according to the International 10–20 system, with A1/A2 as active electrodes, Cz as reference, and the forehead as ground. Electrode impedance was maintained below 3000 Ω.

Alternating click stimuli were presented at 11.1 clicks/s and 90 dB SPL, with 40 dB contralateral white-noise masking. Filter settings were 100–3000 Hz, with 2000 sweeps averaged over a 10-ms analysis window.

BAEP Analysis:

Absolute latencies of Waves I–V, interpeak latencies I–III, III–V and I–V, and peak-to-trough amplitudes of Waves I and V were measured. The V/I amplitude ratio was also calculated. Waves VI and VII were excluded due to inconsistent identification.

Statistical Analysis

Data were analyzed using EPI INFO. Unpaired Student's t-test was used to compare audiometric and BAEP parameters between groups. Pearson's correlation was used to assess associations between occupational exposure, cabin noise levels, and BAEP parameters. A $p<0.05$ was considered statistically significant and $p<0.01$ highly significant.

Result

Study population
A total of 100 male subjects were studied: 50 truck drivers (TDs) and 50 controls. Most participants were aged 31–40 years (71%). The mean age was 35.02 ± 4.09 years in TDs and 37.98 ± 5.48 years in controls.

Noise exposure and absolute latencies
Truck drivers were divided according to noise exposure into Group 1 (<10 years; n=18) and Group 2 (>10 years; n=32). Compared with controls, TDs showed increased absolute latencies, particularly for Waves II–V. Significant increases were observed mainly for Wave III, Wave IV (left ear), and Wave V in both exposure groups, with greater prolongation generally seen in Group 2.

Absolute latencies by age
Age-wise analysis showed higher absolute latencies in TDs than controls, particularly for Waves III–V. Several differences were statistically significant ($p<0.05$ or $p<0.01$), with the most consistent prolongation observed in the 31–40-year group.

Interpeak latencies and noise exposure
Interpeak latencies were generally prolonged in TDs compared with controls. Wave I–III latency increased

from 2.02 ± 0.20 ms in controls to 2.20 ± 0.18 ms in Group 1 and 2.17 ± 0.24 ms in Group 2 in the right ear. Wave I–V and Wave III–V latencies also showed increases, particularly with longer noise exposure.

Interpeak latencies by age
Age-wise comparison demonstrated increased Wave I–III and Wave I–V interpeak latencies in TDs across age groups, with several statistically significant differences. Wave III–V latency showed comparatively smaller changes.

Wave V/I amplitude ratio
The Wave V/I amplitude ratio was lower in TDs than controls, particularly in the right ear. In the right ear, the ratio decreased from 2.03 ± 0.76 in controls to 1.60 ± 1.04 in Group 1 and 1.61 ± 0.94 in Group 2 ($p<0.05$). In the left ear, Group 1 showed a significant reduction (1.41 ± 0.69 vs 2.15 ± 0.81; $p<0.01$), whereas Group 2 showed 2.13 ± 2.20.

Discussion

Brainstem auditory evoked potential findings in the present study indicate that chronic occupational noise exposure among truck drivers is associated with changes in auditory brainstem conduction. The study included 50 truck drivers and 50 controls, with truck drivers further classified according to duration of noise exposure.

Truck drivers showed prolongation of absolute latencies, particularly for Waves III–V. Significant prolongation of Wave III, Wave IV and Wave V was observed in several comparisons, suggesting delayed neural transmission along the auditory pathway. Similar prolongation of ABR wave latencies, particularly Waves III and V, has been reported in individuals with occupational noise exposure.[18,19]

Interpeak latencies were also increased in truck drivers. Wave I–III, I–V and III–V intervals showed increases compared with controls, with several statistically significant differences, particularly in the group with longer exposure. These findings are consistent with previous reports suggesting that occupational noise exposure may produce measurable alterations in auditory brainstem conduction.[18,20]

Age-wise analysis showed that several absolute and interpeak latencies were higher among truck drivers, with significant differences in multiple age groups. Thus, both age and occupational noise exposure may influence auditory brainstem responses. Age is an important potential confounding factor in the assessment of occupational hearing effects.[21]

The Wave V/I amplitude ratio was reduced in truck drivers, especially in the right ear and in the group with shorter exposure. Changes in ABR amplitudes and amplitude ratios have been investigated as possible indicators of noise-related auditory dysfunction, although results across studies have been variable.[18,22]

Overall, the findings suggest that prolonged occupational noise exposure in truck drivers is associated with measurable alterations in auditory brainstem responses, reflected by prolonged absolute and interpeak latencies and changes in the Wave V/I amplitude ratio. ABR may therefore have potential value in identifying functional changes in the auditory pathway associated with chronic occupational noise exposure.[18,19]

Summary

The study evaluated 100 male subjects, comprising 50 truck drivers and 50 controls, to assess the effects of occupational noise exposure on auditory brainstem responses. Truck drivers were further divided according to noise exposure duration into <10 years (n=18) and >10 years (n=32) groups.

Truck drivers demonstrated prolonged absolute latencies, particularly for Waves III–V, with several statistically significant differences compared with controls. The prolongation was generally more evident with longer noise exposure.

Similarly, interpeak latencies (I–III, I–V and III–V) were increased among truck drivers, indicating delayed conduction along the auditory brainstem pathway. Several of these changes were statistically significant, especially with longer exposure.

Age-wise analysis also showed increased absolute and interpeak latencies among truck drivers, with significant differences in several age groups.

The Wave V/I amplitude ratio was reduced in truck drivers, particularly in the right ear, suggesting alterations in auditory brainstem response amplitude characteristics.

Overall, the findings suggest that chronic occupational noise exposure in truck drivers is associated with measurable changes in auditory brainstem function, characterized mainly by prolonged absolute and

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interpeak latencies and alterations in the Wave V/I amplitude ratio.

Conclusion

Chronic occupational noise exposure among truck drivers is associated with measurable alterations in auditory brainstem function, characterized by prolongation of absolute and interpeak latencies and changes in the Wave V/I amplitude ratio. These findings suggest delayed auditory brainstem conduction with prolonged noise exposure. Brainstem auditory evoked potentials may therefore be useful for detecting early functional changes associated with occupational noise exposure.

Ithical Issues:

Research project approved by the ethics committee of Pacific Institute of Medical Sciences Udaipur-313005, Rajasthan, INDIA

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