Original Article

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Physiology Section

Detrimental Effects of Traffic Noise in Traffic Policemen as Assessed by Auditory Brainstem Evoked Response: A Cross-sectional Observational Study

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ABSTRACT

Introduction: Loud noise is a global occupational health hazard with substantial social and physiological impacts, especially pronounced in traffic policemen who are engaged at heavy traffic junctions. Apart from its overt effect on sensorineural hearing, loud noise has been also implicated, albeit covertly, as a causative factor for disturbances in sleep, learning and depression. Due to the insidious nature of hearing impairment, manifestations are often masked and hence testing through Auditory Brainstem Evoked Response (ABER) should be resorted to, for assessment of functional status of auditory pathway objectively.

Aim: To assess and compare the effect of traffic noise in traffic policemen with age-matched apparently healthy males using ABER.

Materials and Methods: The present study was a cross-sectional, comparative type of observational research conducted in the Department of Physiology, SMS Medical College, Jaipur, Rajasthan, India, from June 2019 to May 2020, on 45 apparently healthy male traffic policemen, aged 25-40 years, engaged at heavy traffic junctions of Jaipur city, with an average field posting of five years or more. An equal number of age and sex matched apparently healthy subjects living in Jaipur city, were recruited as controls. Before commencing with the test procedure, ethical clearance was obtained from the Institute's Ethics Committee and Research review board and written informed consent was obtained from all the participants. ABER assessment was done via RMS EMG SALUS 2C machine on each subject using click stimuli presented mono-aurally via an overhead headphone resulting in harvest of variables in form of absolute wave latencies (I-V) and Interpeak Latencies (IPL) (I-III, I-V and III-V). Unpaired Student's t-test was used to derive the level of significance using Statistical Package for the Social Sciences (SPSS) version 16.0. Level of significance was set at p-value <0.05.

Results: The results obtained in the present study demonstrated pronounced delay (p-value <0.01) in all absolute wave latencies (I-V) in both ears in traffic policemen. A statistically significant delay was also observed in IPL I-V (p-value <0.01) when a comparison of left ABER was made between traffic policemen and controls.

Conclusion: The findings of the present study indicate that the hidden footprints of loss in auditory acuity in traffic policemen exposed to traffic noise can be unearthed objectively via using ABER assessment and therefore periodic ABER assessment along with usage of preventive equipment should be the strategy for prevention of imminent hearing loss.

Keywords: Evoked potentials, Hearing loss, Interpeak latency, Noise-induced, Sleep disturbances

INTRODUCTION

Sound is a sensory perception wherein the intricate pattern of its constituent waveform governs its quality as noise, music, speech etc. In terms of its physical signature, there appears to be no obvious difference between sound and noise however noise can be described as an undesirable sound purely in terms of its utilitarian value [1]. The effect of noise on hearing depends on factors such as noise levels, exposure time, noise frequency, individual sensitivity, environmental factors and physiological factors [2]. According to World Health Organisation (WHO), approximately 250 million individuals in the world suffer from hearing disability, moderate or severe hearing impairment in the better ear and two-third of such population lives in the developing countries like India. According to WHO Prevention of Blindness and Deafness (PBD) Report of 2002, adult-onset hearing loss ranks very high (15th) amidst the foremost causes contributing towards Global Burden of Disease (GBD), and 2nd in the leading causes of Years Lived with Disability (YLD) [3]. It has been observed that half of all the deafness and hearing impairments are rather preventable; hence early diagnosis and cognisance of the hearing impairment have paramount importance in averting the progression and culmination towards development of irreversible hearing loss.

The ABER or Brainstem Evoked Response Audiometry (BERA) or Brainstem Auditory Evoked Response (BAER) is the recording of the synchronous electrical potential signals emanated by a far field on presentation of a sound stimulus to cochlea and recording the changes via an electrode placed on the scalp for assessment of the functioning of auditory pathway [4]. It is a set of seven positive waves recorded during 10 milliseconds after a click stimulus, labelled as I-VII by Jewett DL and Williston JS, hence called as Jewett Bumps [5]. The basis of the test lies in the tenet, that when a sensorineural structure is presented with a stimulus, it emits a bioelectrical potential in response. In the same way, the acoustic stimulation of the human auditory apparatus triggers variety of electrical responses, or evoked potentials, which end in the successive activation of structures forth cochlea while faithfully mirroring the auditory pathway alongside in form of sequence of five major waves namely; wave I (reflecting proximal auditory nerve), wave II (reflecting cochlear nuclei), wave III (mirroring superior olivary nucleus), wave IV (mirroring lateral lemniscus) and wave V (mirroring inferior colliculus). Beyond these, wave VI (reflecting medial geniculate body) and wave VII (mirroring auditory radiation from the thalamus to temporal cortex) can also be classified, but these are usually absent in all normal subjects [6]. The so obtained evoked potentials of the ABER are the averaged electrical responses of the Central Nervous System (CNS) following the repetitive acoustic stimulation [7].

The ABER can also be seen as a measure of electrical activity that is orchestrated via nervous system while an auditory stimulus is presented and responses are recorded in a time-locked manner. It helps in assessment of the functioning of auditory pathway and can portray the staid damage in both auditory nerve and central nervous system pathway, if any [7].

Occupational Noise Induced Hearing Loss (ONIHL) is still amongst the most prevalent occupational diseases despite various preventive measures taken in vogue to reduce the harmful effects of noise [8]. The traffic policemen who are constantly exposed to traffic noise, especially those, who are deployed at heavy traffic junctions are especially exposed to the pesters of traffic noise and hence belong to the high-risk group who are vulnerable towards the hazards of noise [9]. Although many studies had investigated the ill-effects of noise among different categories of the occupationally exposed persons, the studies aimed specifically towards exploring the harmful effects of noise pollution on traffic policemen are astonishingly scarce [10-12]. However, few studies that have documented the effect of noise pollution on auditory pathway among traffic policemen in India, stated, that vast majority of the affected policemen were surprisingly unaware towards the detrimental effects of traffic noise on their auditory perception [13-15]. In 2010, the Society to Aid the Hearing Impaired (SAHI) studied the outcome of noise in traffic policemen deputed in Hyderabad city and, documented that 76% of the studied participants showed signs of various grades of NIHL [16]. Although Pure Tone Audiometry (PTA) can be employed for assessing the hearing acuity, it falls short in unmasking the latent damage that is underway and it also falls short in elaborating the probable site of damage [6,7]. The subjective nature of the test also precludes its usage for stating the hidden changes in the auditory acuity objectively and conclusively [17], hence compelling the use of ABER for assessing the auditory acuity in the present study.

The present study derives its inspiration from the fact that 2nd tier cities like Jaipur have become tremendously populated of late with an unprecedented increase in number of vehicles running on road alongside with increasingly prevalent traffic congestion and other traffic related hassles. Due to their work schedule, involving manning the traffic for 8-12 hours a day, the traffic policemen are specially placed at a higher risk towards the hazards caused by noise pollution emanating from traffic.

The primary focus of the study was directed towards determination and demonstration of the baleful effects of traffic noise on traffic policemen in an objective and quantifiable fashion and assessing the potential risk regarding the damage to auditory pathway in traffic policemen as aided by a comparison with age-matched apparently healthy male controls by means of ABER in an endeavour towards providing a pilot instructional module for creating awareness about health risks associated with traffic noise. The study commenced with a hypothesis that traffic policemen deployed at heavy traffic junctions in Jaipur city will demonstrate a significant delay in the ABER wave latencies in comparison to age and gender matched healthy control subjects not exposed to traffic noise.

MATERIALS AND METHODS

The present cross-sectional, comparative type of observational study was conducted in the Department of Physiology, SMS Medical College and Attached Hospitals, Jaipur, Rajasthan, India, from June 2019 to May 2020, after obtaining the desired clearance from the Institutional Research Review Board (IRRB) and Ethics Committee (letter No. 346/MC/EC/2020 Dated: 08/06/2020). Informed written consent was taken from participants prior to the start of the study.

Inclusion criteria: The study enrolled apparently healthy traffic policemen aged between 25-40 years with field posting of atleast five years with an exposure to heavy traffic noise at traffic junctions in Jaipur city, Rajasthan, India. The eligible subjects were interviewed further for their duration of field posting at heavy traffic junctions. An equal number of age-matched apparently healthy male employees of SMS Medical College and Attached Hospital living in Jaipur city served as controls.

Exclusion criteria: Subjects with history of upper airway disease, ear disease, family history of deafness, use of medication supposedly interfering with auditory functioning, acute or chronic illness, being alcoholic and/or smoker were excluded from the study.

Sample size calculation: Sample size was calculated at 95% confidence level and α error 0.05 assuming expected SD of 0.05 in wave III latency within the two groups as found in reference study [18]. To detect a difference of atleast 0.03 ms in wave III latency at a study power of 80% the required sample size was 45 subjects in each group.

Study Procedure

Before proceeding with ABER recording, height and weight measurements of the subjects were taken for calculation of Body Mass Index (BMI). ABER was recorded by using RMS EMG SALUS 2C machine in physiology department in a quiet room. A stimulus was generated by using 100 microsecond square wave pulse or click. Sensitivity of the recording apparatus was set at 0.5 μv/div and the sweep speed was set at 1 ms/div.

Single channel ABER was sought and clicks were presented to each ear separately with the intensity of 80 dB, at 4 KHz through a binaural over-the-ear headphone at a repetition rate of 11.1/s. Masking of the contralateral ear was done with a white noise of 60 dB for obtaining a better response. Averaging of the responses towards 2000 click presentations was done in order to obtain a single wave form using a filter of 100 Hz to 3 KHz bandwidth. The filter was selected to prevent aliasing effects on the recorded signal necessary to reject physical and physiological noise falling outside the spectrum of the ABER.

The wave forms of impulses generated upto the level of brainstem are recorded by the placement of surface electrodes over the scalp. The standard electrode placement for ABER involved placing a reference electrode at the vertex (Cz), ground electrode (G) over the forehead and active electrode placed over the mastoid process. The electrode impedance was kept below 5 KΩ.

The ABER results were interpreted for the latencies of waves I, II, III, IV, V and IPL I-III, III-V, I-V in milliseconds (ms) [5]. For all the absolute and IPL variables mean and standard deviation values were calculated.

STATISTICAL ANALYSIS

In order to analyse the statistical difference in the right and left ears in between traffic policemen and age-matched controls, unpaired Student's t-test was used to derive the level of significance using SPSS version 16. Significance level was set at p-value <0.05.

RESULTS

The mean age of traffic policemen was 31.93±3.95 years and 30.82±3.39 years for controls, all falling within a range of 25-40 years. The mean BMI (kg/m^2) of control subjects was 23.9±1.52 and 23.6±1.39 for cases (traffic policemen). The average number of years of exposure to noise among traffic policemen was 8.11±2.52 years. Among the 45 traffic policemen included in the study, 37 traffic policemen had a history of exposure to noise for 5-10 years while eight traffic policemen had a history of more than 10 years of exposure to traffic noise.

When an assessment was made for absolute wave latencies of ABER, the group comprised of traffic policemen demonstrated a pronounced delay (p-value <0.01) in all absolute wave latencies (I-V) in left and right ears [Table/Fig-1] in comparison to controls. The IPL I-V demonstrated a statistically significant prolongation (p-value <0.01) in traffic policemen group when left ear ABER data was compared with controls on same side [Table/Fig-2].

ABER wave latencies (ms)	Side involved	Control group	Traffic policemen group	p-value#
I	Left	1.67±0.17	1.81±0.15	<0.01*
	Right	1.67±0.16	1.81±0.14	<0.01*
II	Left	2.72±0.19	2.86±0.16	<0.01*
	Right	2.77±0.22	2.94±0.13	<0.01*
III	Left	3.49±0.24	3.65±0.20	<0.01*
	Right	3.57±0.20	3.74±0.17	<0.01*
IV	Left	4.75±0.20	4.92±0.19	<0.01*
	Right	4.74±0.17	4.85±0.16	<0.01*
V	Left	5.63±0.19	5.89±0.11	<0.01*
	Right	5.61±0.16	5.84±0.11	<0.01*

[Table/Fig-1]: ABER wave latency (ms) at 4000 Hz of control group and traffic policemen.
ABER: Auditory brain stem evoked response, SD: Standard deviation, ms: Milliseconds; *Significant, #Unpaired student's t-test

ABER inter-peak latencies (ms)	Side involved	Control group	Traffic policemen group	p-value#
I-III	Left	1.82±0.26	1.84±0.26	0.72
	Right	1.91±0.24	1.92±0.21	0.83
I-V	Left	3.96±0.25	4.08±0.18	0.01*
	Right	3.95±0.23	4.03±0.16	0.06
III-V	Left	2.13±0.31	2.24±0.23	0.06
	Right	2.04±0.25	2.10±0.20	0.21

[Table/Fig-2]: ABER Inter-peak Latency (ms) at 4000 Hz of control and traffic policemen group.
ABER: Auditory brain stem evoked response, SD: Standard deviation, ms: Milliseconds, *Significant, #Unpaired student's t-test

The IPL I-III and III-V were also found to be similarly prolonged in traffic policemen group but the increase was not statistically significant. The findings so obtained by the present study may be interpreted as a beacon for involvement of both cochlear and retrocochlear structures in the auditory pathway.

DISCUSSION

Traffic noise is distinctively annoying due to the lack of stringent rules and legislations regulating the usage of vehicular horns as well as the unwanted and unwarranted blowing of horns by vehicle drivers. The resultant is the incessant exposure of traffic policemen to the high levels of traffic noise emanated from these vehicles, particularly pronounced at junctions where traffic load is more and where the traffic policemen are kept busy in manning and streamlining the high traffic load [19]. Not only these traffic policemen, who work outdoors, are exposed to the nuances of traffic noise, they also pose themselves especially vulnerable towards the risk of subsequent development of photosensitive dermatitis, arthropathy, nasopharyngitis, heat stroke etc, in comparison to those police personnel's who work primarily indoors [20].

The ABER serve to provide a reflection of the health and state of auditory conduction pathway sequentially beginning right from the auditory receptor (cochlear nuclei) and unmasking till the level of auditory cortex, hence, have a potential for mirroring any structural and/or functional change along the pathway. ABER has a potential not just to unearth the possible abnormality in the auditory pathway, but, to conclusively specify the site and location of damage as well with great confidence, hence also enabling classification of the defect as sensory, neural and sensory-neural. The classification is based on the following criteria: The defect can be called "sensory" or "cochlear" if delay is observed in the peak latency of wave I only, while other waves demonstrating normal peak latencies and Inter Peak Latencies (IPL). It can be called "neural" or "retrochochlear" if the latency of wave I comes out to be normal while the IPL of I -III and III -V are prolonged. The defect can be called "sensory-neural" when there happens to be a delay in the peak latency of wave I alongside a delay in the IPL of I -V denoting an involvement of both cochlear and retrocochlear pathways [21].

In the present study, the group comprising traffic policemen demonstrated a pronounced delay (p-value <0.05) in all absolute wave latencies (I to V) in left and right ears, respectively in comparison to control group. The left ABER also shows a delay in IPL I-V (p-value <0.05) with non significant prolongation of IPL I-III and III-V in traffic policemen as compared to controls. Such a result points towards a possible involvement of both cochlear and retrocochlear structures in the group who faced the detriments of traffic noise.

A study done by Venkatappa KG et al., similarly, documented that when ABER assessment was performed on traffic policemen and the results were compared with controls, a significant prolongation of all wave latencies (I, II, III, IV and V) and non significant prolongation of IPL I-III, III-V and I-V was observed. The results were inferred to have been caused due to the long-term exposure to traffic noise consisting of sound of high pressure level [18]. On the same lines, a study performed by Manish G et al., demonstrated a significant prolongation in the absolute peak latencies of I, II, III, IV and V waves, prolongation in IPL I-III and non significant prolongation of IPL (III-V, I-V) in traffic policemen who were posted at heavy traffic intersections in comparison to those traffic policemen who were posted at low traffic areas like residential areas in the city of Delhi [22].

In the present study, the mean value of I-V IPL was significantly more delayed in traffic policemen in comparison to the controls when specifically the comparison was made for the left ear, which was in accordance to a similar observation by Santos AS and de Castro Júnior N [23]. On the contrary to this, Venkatappa KG et al., observed non significant prolongation of mean values of IPL I-III, III-V and I-V [18].

The NIHL results primarily from damage to cochlear hair cells, particularly the outer hair cells situated and seated in the basal turn [24,25]. Prior studies have proposed that the possible mechanism leading to such damage may be primarily classified as - Mechanical, Ischaemic, or Metabolic [26]. It is also pertinent to know at this point that there is evidence stating that hair cells in the mammalian species do not possess the capacity to regenerate once they are destroyed, hence the resultant noise induced hearing loss have a propensity to become permanent [25].

In consideration of the mechanical damage, the pathophysiology revolves around the proposal proffered by prior studies that loud noise causes overstimulation of the cochlea resulting in damage to the hair cell stereocilia or resulting in hair cells getting decoupled from the tectorial membrane. The damage can be made worse even further by loud sound intensities since they might damage the supporting pillar cells or hair cells themselves. High sound intensities might lead to disruption of the junctions between cochlear cells and even higher sound intensities might lead to disruption of the organisation of the organ of Corti, detaching it from the basilar membrane and rupturing the separate compartmentalisation of perilymph and endolymph [24,25,27].

When the damage is thought to have resulted due to ischaemic or vascular mechanism, the manifestation is gradual and the pathogenesis involves noise induced constriction of the blood vessels supplying the cochlea and swelling of the stria vascularis. Due to reduction in the cochlear blood flow, hair cell functions get altered manifesting in form of increments in the values of hearing thresholds. These vascular aberrations also result in reductions in the endocochlear potential that are essential for physiological amplification of the auditory signals hence further denting the hearing thresholds. Long standing swelling in the stria vascularis might even lead to destruction of intermediate cells causing stria vascularis to shrink even further and producing the damage that is irreversible [24,25].

Apart from the more obvious and overt effects of very high intensity noise mediating the damage primarily via mechanical pathways and more subtle and chronic damage by the long-term exposure of noise operating via ischaemic or vascular pathways, most of the cases of cochlear damage have been proposed to have taken place due to metabolic oxidative stress pathways operating via generation of Reactive Oxygen Species (ROS) that lead to damage of essential cellular constituents culminating ultimately in cell death. These ROS are essentially the by-products of cellular respiration but their number has been shown to have increased due to long-term exposure to noise [27].

Limitation(s)

The present study employed ABER for objective assessment of the detriment in hearing acuity, however, ABER does not provide any frequency specific information, hence for holistic assessment of loss in auditory capacity, relevant tests like Auditory Steady State Response (ASSR) should be added before extrapolating the test result for general use. Also another limitation was that subjects were not divided based on the years of exposure.

CONCLUSION(S)

In the present study, excessively noise-exposed traffic policemen engaged at various heavy traffic junctions of Jaipur city, working for 10-12 hours daily, were recruited and were assessed for a possible derangement of their auditory pathways objectively and elaborately by ABER. The results exposed the covert damage demonstrating significant delays in the absolute peak latencies, significant prolongation of the IPL I-V and delay in IPL I-III, III-V. These findings clearly points towards an involvement of both cochlear and retrocochlear structures denoting widespread deleterious effects on the auditory pathway due to exposure to traffic noise.

Since there is no definitive treatment of NIHL as of now, the best strategy available in our hand is to avert and prevent its development at the first place as far as possible. Since the onset and progression of the loss in auditory acuity is insidious in the cases of hearing impairment caused by exposure to traffic noise, regular health surveillance of the traffic police personnel should be made periodically along with promoting and implementing hearing protective strategies.

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