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# AUDITORY EVOKED FUNCTIONS IN GROUND CREW WORKING IN HIGH NOISE ENVIRONMENT OF MUMBAI AIRPORT

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**Abstract :** The continuous exposure to the relatively high level of noise in the surroundings of an airport is likely to affect the central pathway of the auditory system as well as the cognitive functions of the people working in that environment. The Brainstem Auditory Evoked Responses (BAER), Mid Latency Response (MLR) and P300 response of the ground crew employees working in Mumbai airport were studied to evaluate the effects of continuous exposure to high level of noise of the surroundings of the airport on these responses. BAER, P300 and MLR were recorded by using a Nicolet Compact-4 (USA) instrument. Audiometry was also monitored with the help of GSI-16 Audiometer. There was a significant increase in the peak III latency of the BAER in the subjects exposed to noise compared to controls with no change in their P300 values. The exposed group showed hearing loss at different frequencies. The exposure to the high level of noise caused a considerable decline in the auditory conduction upto the level of the brainstem with no significant change in conduction in the midbrain, subcortical areas, auditory cortex and associated areas. There was also no significant change in cognitive function as measured by P300 response.

**Key words :** auditory evoked response BAER MLR P300 audiometry

## INTRODUCTION

Noise has been depicted as a health hazard (1) and exposure to a high level of noise for a period of >15 yrs. may cause an elevation in the blood pressure (2, 3). Exposure to noise also causes a shift of threshold of hearing in the individual. Daily exposure to noise of 120 dB may be the cause of permanent deafness in an individual (4). Noise of sufficient intensity elicits an increase in heart rate, which habituates rapidly stimuli (5). The airport area presents an ambience with noise at a very high intensity caused by the incoming and outgoing flights. The incidence of noise induced hearing loss among the jet aircraft maintenance personnel was assessed (6). These ground personnel of different airlines used to work in that noisy environment at an airport. These employees on an average work for at least 7–8 hours daily for a duration of 25 years or more. Therefore, these people working in the noisy

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environment of the airport area may develop some dysfunction in their auditory system and cognitive function. The Auditory Evoked Potentials are a simple and non-invasive tool to assess noise induced changes in auditory function especially retrocochlear conduction and P300 response measure cognitive function. Auditory Evoked Potentials have been used for the assessment of noise induced hearing loss (7). The present study aimed to evaluate the effect of high intensity background noise on BAER (Brainstem Auditory Evoked Response), MLR (Mid Latency Response) and P300 (Cognitve Potential) in order to assess its effect on auditory and cognitive functions.

## METHODS

Thirty-eight male workers were randomly selected from the different departments of Air India, Mumbai Airport. They were working in the various departments since a duration of 15–30 years. The physical characteristics are given in Table I. They were explained in detail about the study and an informed written consent was obtained from each participant. The study was approved by the ethic committee of the laboratory. The tenets of declaration Helsinki were followed in carrying out the work.

### Noise Exposed Group

The exposed group consisted of 24 male participants working at Mumbai airport 7–8 hrs per day for more than average 25 years (range 15–30 yrs). The noise exposed group was selected from job type Engine Technician, i.e. Engine Over haul department, Major maintenance department, Accessories over haul department, Component over haul department, Line Maintenance department etc. In this environment the average noise level recorded was between 95–110 dBA. (decibels A-weighted).

### Control Group

The unexposed group consisted of 14 male participants who had been working in the Store, Administration and Accounts departments where the noise level recorded was less than 80 dBA. These participants had no previous exposure to chronic or occupational noise at any point of time during service or prior to it. So the control group consisted of the normal and healthy participants who were normal audiometrically and had never been subjected to a noise level of >80 dBA ever before.

### Recording of Brainstem Auditory Evoked Response (BAER)

Recording of BAER was carried out in a sound proof and dimly lit room with the subject resting in a comfortable supine position. Electrodes were attached at the vertex (Cz) and the ear lobes with the ipsilateral lobe serving as the reference and the contralateral lobe as the ground. Monaural auditory stimuli consisting of clicks of 100 micro second square pulses were delivered through an electrically shielded earphone at a rate of 15/sec. The intensity of the stimulus was 70 dB above the click hearing threshold. The evoked electrical activity was amplified 10,000 times, a bandpass of 150–3000 Hz was used to filter out the undersired frequencies and the response to 2000 click presentations was averaged for 10 msec sweep time by a computer averager, Nicolet Compact 4 (Nicolet, USA) and printed. At least two trials were obtained from each ear and superimposed to obtain the peak latencies of wave I, III and V and the interpeak latencies of I–III, III–V and I–V were analysed.

#### Recording of P300

The event related potential P300 was recorded using Evoked Potential Recorder (Compact 4, Nicolet USA). P300 was measured from vertex (Cz and Pz) in response to random application of two types of sound stimuli, presented monaurally through head phones, applied to subject's ear. Standard auditory 'odd ball' paradigm was used in application of more frequent (non target) and the other less frequent (target) stimuli and asking the subject to count whenever the target stimulus was presented. A total of 300 event related responses obtained were analysed by the evoked potential averaging method. Silver-Silver chloride disc electrodes were used for recording P300 with the electrodes placed at Cz and Pz and reference electrodes at ear lobules (Al and A2). The ground electrode was placed at FPz. The input impedance was kept below 5 Kohms. Click stimuli of 100 micro second duration, intensity 70 dB and 0.7/s rate were used as target stimuli. Eighty percent of total (240) clicks were 1 kHz (frequent) and twenty percent were 2 kHz (rare). The stimulus sequence was random. The evoked responses to the frequent and rare stimuli were filtered with a band pass 1-30 Hz and averaged simultaneously for 300 responses. Data from two trials were obtained to compute the latency and amplitude of P300 response.

#### Recording of Mid Latency Response (MLR)

The Mid Latency Response of the subjects was also recorded in a sound proof room with the subject in supine position. Silver and Silver chloride electrodes were placed in the Cz position (as positive) and the two ears (as negative) with the FPz as ground. The electrode impedances were kept below 5 Kohms. Click stimuli of 75 dB above nHL (normal hearing level) with a rate of 39.1/sec of 100 micro second duration were used. The evoked responses were filtered with a band pass of 10–250 Hz and averaged simultaneously for 1000 responses. Two trials were recorded in order to establish the reproducibility of the trials. Latency of positive peak (Pa, Pb & Pc), Negative peak (Nb & Nc) and Amplitude of positive to negative peak (Pa-Nb), (Nb-Pb), (Pb-Nc) and (Nc-Pc) were analysed. The above nomenclature of the peaks is internationally accepted for a standard MLR curve.

#### Monitoring of Audiometry

The subjects were otologically examined by ENT specialist of Lok Manya Tilak Municipal Medical college, Sion, Mumbai. Their audiometry was monitored with the help of GSI 61 Audiometer (Grason Steadler) in a sound proof room at frequencies of 0.5, 1, 2, 4 and 8 KHz in air conduction mode. The ambient noise level was measured in different departments of the airport working environments, including Engine Overhaul department, Major Maintenance department, Accessories department and others.

The data collected were subjected to statistical analysis using unpaired Student's t test.

## RESULTS

The physical characteristics of the subjects are given in Table I. The age, weight and height of the subjects in both the groups were comparable and there was no significant difference between exposed and unexposed group. All the evoked potentials were recorded between 0900 hrs to 1300 hrs. The Fig. 1 shows a typical recording of the BAER showing the waveforms I, III and V as well as

TABLE I: Physical characteristics of the subjects.

| | *Age (Yrs.)* | *Weight (Kg)* | *Height (Cms)* |
|---|---|---|---|
| Control group (n = 14) | 43.0±8.218 | 61.4±9.087 | 159.2±8.108 |
| Exposed group (n = 24) | 48.0±7.593 | 68.8±11.372 | 163.5±10.129 |

Values are Mean ± SD; n = No. of Subjects.

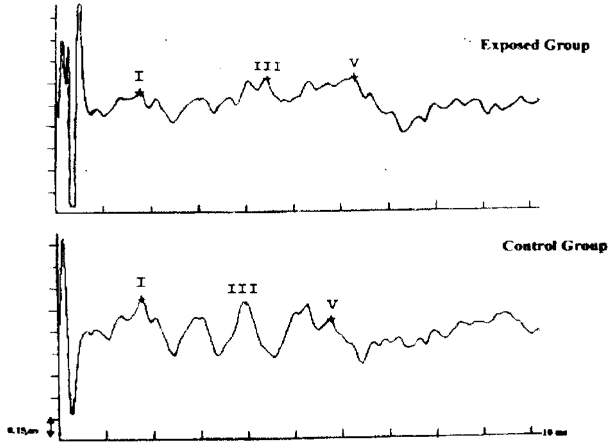


Fig. 1: The representative wave forms of the BAER of a control & exposed subject.

TABLE II: Right ear brainstem auditory evoked responses (BAER) in noise exposed and control subjects.

| | *Peak latencies (ms)* | | | *Interpeak latencies (ms)* | | | *Ratio of amplitude (µv)* |
|---|---|---|---|---|---|---|---|
| | *I* | *III* | *V* | *I-III* | *III-V* | *I-V* | *V/I* |
| Control group (n = 14) | 1.76±0.150 | 3.91±0.301 | 5.62±0.331 | 2.15±0.265 | 1.91±0.307 | 4.06±0.361 | 3.30±5.833 |
| Exposed group (n = 24) | 1.77±0.94 | 4.11±0.238* | 5.99±0.384 | 2.33±0.252 | 1.88±0.277 | 4.22±0.395 | 2.39±1.334 |

Values are Mean ± SD; *P<0.05; n = No. of Subjects.

TABLE III: Left ear brainstem auditory evoked responses (BAER) in noise exposed and control subjects.

| | *Peak latencies (ms)* | | | *Interpeak latencies (ms)* | | | *Ratio of amplitude (µv)* |
|---|---|---|---|---|---|---|---|
| | *I* | *III* | *V* | *I-III* | *III-V* | *I-V* | *V/I* |
| Control group (n = 14) | 1.75±0.139 | 3.79±0.229 | 5.69±0.067 | 2.04±0.236 | 1.90±0.230 | 3.95±0.142 | 1.87±0.95 |
| Exposed group (n = 24) | 1.78±0.082 | 4.09±0.199*** | 5.90±0.345* | 2.31±0.232** | 1.81±0.303 | 4.13±0.373 | 2.72±1.957 |

Values are Mean ± SD; *P<0.05; **P<0.01; ***P<0.001; n = No. of Subjects.

TABLE IV : Different fractions of the cognitive functions (P300) of the noise exposed and control subjects.

| | Frequent (non-target) | | | Rare (target) | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | *N1* | *P2* | *AMP2* | *N1* | *P2* | *N2* | *P3* | *AMP2* | *AMP3* |
| | *(ms)* | | *(µv)* | *(ms)* | | | | *(µv)* | |
| Control group (n = 14) | 90.06±9.039 | 160.23±18.165 | 8.23±3.593 | 95.77±14.823 | 170.06±26.739 | 229.71±27.533 | 322.74±22.968 | 7.54±3.194 | 13.68±16.619 |
| Exposed group (n = 24) | 94.10±8.798 | 162.96±8.556 | 6.52±2.583 | 91.61±10.047 | 166.87±20.638 | 226.25±24.091 | 336.36±27.419 | 6.96±0.623 | 10.76±4.731 |

Values are Mean ± SD; n = No. of Subjects; P - Positive peak; N - Negative peak;
AMP2 - Amplitude of positive peak 2; AMP3 - Amplitude of positive peak 3

TABLE V : Right ear mid latency response (MLR) in noise exposed and control subjects.

| | Peak latency (ms) | | | | | Amplitude (µv) | | | |
|---|---|---|---|---|---|---|---|---|---|
| | *Pa* | *Nb* | *Pb* | *Nc* | *Pc* | *Pa-Nb* | *Nb-Pb* | *Pb-Nc* | *Nc-Pc* |
| Control group (n = 14) | 34.94±2.058 | 45.79±2.219 | 58.73±1.319 | 71.40±2.419 | 83.86±1.799 | 1.09±0.249 | 1.06±0.266 | 1.13±0.305 | 1.09±0.372 |
| Exposed group (n = 24) | 34.24±2.35 | 45.39±3.014 | 58.74±2.939 | 70.72±3.796 | 83.68±3.045 | 1.11±0.480 | 1.13±0.484 | 1.03±0.351 | 1.05±0.368 |

Values are Mean ± SD; n = No. of Subjects; P - Positive peak; N - Negative peak; a,b,c : Nomenclature of positive and negative waves

TABLE VI : Left ear mid latency response (MLR) in noise exposed and control subjects.

| | Peak latency (ms) | | | | | Amplitude (µv) | | | |
|---|---|---|---|---|---|---|---|---|---|
| | *Pa* | *Nb* | *Pb* | *Nc* | *Pc* | *Pa-Nb* | *Nb-Pb* | *Pb-Nc* | *Nc-Pc* |
| Control group (n = 14) | 34.67±2.365 | 46.27±3.157 | 59.36±2.988 | 70.60±3.284 | 83.31±2.154 | 1.10±0.378 | 1.12±0.342 | 1.14±0.366 | 1.09±0.383 |
| Exposed group (n = 24) | 35.24±2.674 | 46.36±3.187 | 59.44±3.612 | 70.78±2.724 | 84.00±2.742 | 1.09±0.363 | 1.44±0.362 | 1.06±0.389 | 1.09±0.372 |

Values are Mean ± SD; n = No. of Subjects; P - Positive peak; N - Negative peak; a,b,c : Nomenclature of positive and negative waves morphological changes in waveforms recorded from representative of both groups of a subject. The peak latencies of wave I, III, V and the interpeak latencies of I–III, III–V and I–V of both right and left ear BAER and the ratio of the amplitudes of V and I are given in Tables II and III. The right ear peak latency of wave III showed an increase in the exposed group as compared to unexposed group ($P<0.05$). The left ear peak latency of waves III and V and the interpeak latency of I–III recorded a significant increase (Table III). The change in wave III was highly significant ($P<0.001$) whereas the change in the other two was significant at $P<0.05$ and $P<0.01$ in exposed group compared to unexposed.

The right and left ear MLR of the subjects did not show any significant change (Table-V and VI).

The P300 of the subjects also did not show any significant changes. (Table IV). A majority of the population included in the study showed a greater percentage of hearing loss in both the ears in the higher frequency (Table VII). A greater percentage has suffered a mild loss whereas the percentage of subjects suffering a severe loss in the higher frequencies is only 5 to 8%. The control group of participants did not have any hearing loss.

TABLE VII : Percentage of noise exposed group showing hearing loss under different frequencies in the right and left ear.

| | *Low frequency range : 500 Hz - 2 kHz* | | *High frequency range : 4 to 8 kHz* | |
|---|---|---|---|---|
| | *Right ear* | *Left ear* | *Right ear* | *Left ear* |
| Mild | 33% | 32% | 44% | 39% |
| Moderate | 3% | | 19% | 31% |
| Severe | | | 8% | 5% |

## DISCUSSION

Hearing loss in industrial workers exposed to continuous noise of high intensity has been extensively studied (8, 9, 10). In the present study noise exposed group were working for a 7–8 hrs daily in the ambience of an international airport exposing themselves to different degrees of noise. This exposure may have caused changes in the auditory function evidenced by the changes in the peak III latency of the BAER. BAER is a measure of the auditory conduction from the receptor (cochlear nuclei) to the auditory cortex. Any structural or functional change along the pathway will be reflected in the BAER. The different abnormalities of the BAER have been classified as sensory, neural and sensory-neural loss based on the following criteria. If the peak latency of wave I shows delay, with a normal peak latency and interpeak latency (IPL) of other waves, the condition has been termed as “sensory” or cochlear involvement. These subjects have also elevated threshold of hearing as depicted in Table VII. On the other hand, when the peak latency of wave I is normal and IPL of I–III and III–V are prolonged, the condition is termed as “neural” or retro-cochlear. If the delay occurs in both peak latency of wave I as well as in IPL of I–V, then it is termed as “sensory-neural” or involving both cochlear and retro-cochlear pathways.

The BAER recorded in the control subjects were within the standard values reported (11, 12, 13). The exposed subjects manifested pronounced delay in wave III and V and IPL I–III. The latency of wave I however remained unchanged. This indicates the deterioration in the retro-cochlear neural conduction. The left BAER showed delay in latency III and V and also a delay in IPL I and III. This finding may be interpreted as an indication of involvement of both cochlea and retro-cochlear structure.

The MLR was not significantly altered in the noise exposed. The neural generators of MLR may be multiple (14). Some studies have pointed to the primary auditory cortex as the neural source (15, 16) whereas other have suggested the ascending reticular activating system (17) or other subcortical structure (18). In humans the MLR response may consist of overlapping potentials originating from cortical and subcortical structures (19). Moreover MLR is affected by important cortical components including attention. The lack of any significant change on MLR in the present study could be attributed to factors like level of attention and arousal and the fact that the neural source of the response is multiple.

These findings also corroborate the lack of any significant change in the P300 response, measure of information processing including expectancy, attention, cognition decision making and memorisation (20) and a good index to quantify mental function (21). There is no evidence of a major effect of hearing acuity on cognitive functions over time in the group of healthy elderly subjects (22). Steady car engine does not affect the cognitive abilities of normal as well as sleep apnea syndrome subjects (23). The noise effects were not altered by changes in the priority, difficulty or probability of the two tasks (24). It is difficult to explain the lack of any significant change in P300 in the present study but it appears that factors such as level of arousal may contribute to the difference in findings.

The high noise exposed subjects working at Mumbai airport showed alteration in BAER indicating altered auditory conduction upto the level of the brainstem with no significant change in MLR and P300 response.

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