A cross sectional study of effects of mobile phone exposure on Brainstem evoked response audiometry (BERA)

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Abstract
Human physiology creates a framework for understanding how the human body adapts to stresses, physical activity and disease. Best example is usage of mobile phones for daily routine. An attempt was made to study the effect of exposure to mobile phone on functions of ear. Hence, the objective of our study was to find out the effects of exposure of mobile phones on BERA in mobile phone users for long time. 18–30 years aged 100 normal healthy volunteers were considered for the study. Two groups of 50 each participant, who used mobile phones for 4 years for 60 minutes in each day and who used mobile phones since a year for 60 minutes per day respectively. Concise click acoustic stimuli alternating in polarity were presented by an earphone on the ear with 40 and 90 dB intensities. Recording of peak BERA latencies (I, III and V) and calculation of interpeak latency I - V were done. Analysis reveals significant prolongation of latencies in wave III and wave V in Group I participants and also significant prolongation of inter peak latency I - V in Group I participants. On comparison of various latencies of BERA in participants of both the groups, in Group I, a significant increase in latencies of the wave III and V was observed. This damage to the ear can be at various levels of auditory pathway and can be proportional to the amount and duration of exposure.

Keywords: BERA, Interpeak latencies, Auditory pathway.

Introduction
One of the necessities in day to day life is the mobile phones. These have been regarded as a crucial instrument for an individual to remain informed and associated with the external World. And because of the innumerable uses a mobile phone provides, they have become an indispensible tools of communication. In the last 20 years, there is a transient increase in mobile phone subscriptions from 12.4 million to over 5.6 billion, which involves around 70% of the world's population.[1]

Mobile phones transmit radiations at a frequency of about 900 MHz and receive microwave radiations at a frequency of 1,800 MHz which excite rotation of water molecules and some organic molecules.[2] These electromagnetic radiations are absorbed by the body and are proven to be harmful to various organ systems of human body. The amount of damage is directly relative to the amount of exposure to radiations. Side effects due to exposure of electromagnetic radiations include thermal and non thermal side effects. Sensations of burning or warmth around the ear, disturbance of sleep, headache, alteration of cognitive functions and neural activity, in addition to alteration in the blood brain barrier and a modification in the regional cerebral blood flow have been reported as effects resulting from mobile phone usage.[3]

Without a doubt, because of the close proximity of mobile phones to the ear, there can be probable damage to the auditory functions.[4] To understand the functional status of auditory nerve and brainstem auditory sensory pathway, Brainstem Evoked Audiometry Response (BERA) is a simple and an efficient procedure. It is a non invasive and reproducible method that is easy to administer and needs minimal co operation of the patient and measures the specific appropriate functions of the auditory pathway. BERA is also not significantly affected by the state of consciousness, drugs and a variety of environmental factors including other sensory inputs to the cortex.[5]

Hence, BERA is extensively used as an objective diagnostic tool in modern neurophysiology in this perspective. The electrical responses from BERA include several waves which consecutively reflect the neural conduction velocity at corresponding levels of the auditory brainstem. There is also very limited statistics available about the effect of long term and short term usage of mobile phones on ears and its assessment by BERA. As a result, our study aims to understand the effect of mobile phone exposure on auditory functions which was assessed with the help of BERA.

Human physiology creates a framework for understanding how the human body adapts to stresses, physical activity and disease. One of the best examples is usage of mobile phones for daily routine. Our study will emphasize the possible important interactions between mobile phone usage and its effects on hearing, with the help of BERA. Hence, an attempt will be made to study the effect mobile phone exposure on ears functions.

Review of Literature
As a part of current life style, there has been a swift boom in the number of mobile phones in the recent decade. This speedy worldwide growth of mobile phones raises questions concerning the probable effects of the radiofrequencies emitted on the health of users.

BERA is a neurologic test of auditory brainstem function in response to auditory (click) stimuli. It refers to an evoked potential generated by a brief click transmitted from an acoustic transducer in the form of an insert earphone or headphone. The elicited waveform response is then measured by surface electrodes typically placed at the ear lobes and vertex of the scalp. The amplitude (μv) of the signal is averaged and charted against the time (msec), which is much similar to EEG. The waveform peaks are labeled I-VII. These waveforms usually occur within a 10 millisecond time period after a click stimulus presented at high intensities (70-90 dB normal hearing level).[6]

BERA is a significant non invasive technique to access the functioning of auditory pathway and also the assessment of brainstem function is difficult by other traditional techniques. BERA helps in diagnosing the lesion ranging from VIII cranial nerve to the auditory cortex. It is based upon the study of electrical potentials arising from the auditory pathway in response to external stimuli by means of surface electrodes over scalp.

According to the literature, the main clinical aims of BERA are,[6]

1. To establish a minimal auditory response level
2. To characterize the type of hearing loss
3. To assess the maturity of the central auditory system in neonates
4. To define the site of auditory nerve or brainstem injury
5. To monitor surgery of the posterior fossa, and to monitor patients in intensive care units.

In a study done on evaluation of long term effect of mobile phone usage on hearing faculties using BERA on 60 non users and 60 users, it was noticed that latencies of wave I and wave III were significantly increased in total users, and attained significance statistically.

One of the research on effects of mobile phones on hearing by pure tone audiometry and BERA revealed that there was no difference reported in the interpeak latencies of interpeak latencies of I-V, I-III, III-V in users and nonusers of mobile phones.[7]

An animal study investigating the effect of long term transcranial electromagnetic stimulation on auditory brainstem and cortical evoked response for a period of 12 months on rabbits, showed a difference in the amplitude and the latency of wave III was reported. No significant changes were noticed in the amplitude and latency of other waves before and after exposure. Histological examination of the cochlear nucleus and inferior bigeminal bodies following exposure revealed no structural and morphological changes.[8]

One more experimental study carried on time related changes in auditory pathway during mobile phone electromagnetic exposure reported that absolute latency of wave III, and interpeak latencies of I-V and III-V were significantly prolonged after exposure to electromagnetic frequencies in a time dependent manner.[9]

Objectives

To study the effects of long term mobile phone exposure on Brainstem Evoked Respone Audiometry (BERA).

Materials and Methods

The study was carried out after obtaining the Institute's Ethical Committee clearance and also after every participants gave their written informed consent.

The present study was undertaken on 100 normal healthy volunteers aged 18–30 years of age. They were divided into two groups of 50 each participants. Group I included 50 subjects who were using mobile phones for > 4 years and their duration of exposure to mobile phone for > 60 minutes in each day. Group II consisted of 50 subjects who were using mobile phones since a year and their exposure is < 60 minutes per day.

Procedure of Recording

After collecting the details regarding the extent of mobile use and exposure time per day, use of which ear predominantly (left ear or right ear), history regarding medical and ontological morbidities was also taken. Candidates fulfilling the inclusion criteria were then subjected to BERA on the dominant ear.

A shielded room was used to record BERA using Digital data acquisition and analysis system RMS model. The subjects were made to sit comfortably and were instructed not to sleep during the procedure.

Three disc electrodes were placed as follows

1. Ground electrode was placed at the forehead in the midline.
2. Active electrode, at the mastoid process ipsilateral to the acoustic stimuli.
3. Reference electrode was placed at the vertex of the skull.

The dominant ear was tested first and the contralateral ear was masked with white noise 40 dB below the ipsilateral click stimuli in order to get a proper response.

Brief click acoustic stimuli (square wave pulse of 0.1ms duration) alternating in polarity were presented by an earphone on the ear with 40 and 90 dB intensities. With a filter setting of 100 Hz (low filter) to 3000 Hz (high filter), 2000 sweeps were averaged. Sweep speed was 1ms/div with sensitivity at 0.5μv/ div. Skin to electrode impedance was kept below 5kohm.

Peak BERA latencies (I, III and V) were recorded and interpeak latency I – V was calculated.

Data Analysis

The data was entered in Microsoft Excel sheets and analyzed by using SPSS version 8.0. The continuous variables were compared by using ANOVA among the groups and a 'p' value of < 0.05 was considered as significant.

Analysis of results shows statistically significant prolongation of latencies in wave III and wave V in Group I participants in comparison with Group II participants. The results reveal a significant prolongation of inter peak latency I – V in Group I participants with Group II participants.

Table 1: Comparison between the age of participants in Group I (Mobile phone usage > 4 years) and Group II (Mobile phone usage < 1 year).

	Group I (Mobile phone usage > 4 years)	**Group II (Mobile phone usage < 1 year)**
Number of individuals	50	50
Average age (in years)	22.2 ± 3.2	19.4 ± 1.6

Table 2: Evaluation of results of BERA at 90 dB between Group I (Mobile phone usage > 4 years) and Group II (Mobile phone usage < 1 year)

Parameter	**Group I (Mobile phone usage > 4 years)**	**Group II (Mobile phone usage < 1 year)**
Wave I	1.794±0.146	1.740±0.154
Wave III	3.883±0.190*	3.724±0.116*
Wave V	5.636±0.247*	5.420±0.219*
IPL I-V	3.841±0.216*	3.699±0.270*

*$p < 0.05$ – Statistically significant.

Discussion

Now a day's mobile or cell phones are an integral part of modern telecommunications in every individual life. Because of the increased number of mobile phone calls per day with also increase in the length of each call and the quantity of time people use mobile phones are some of the important factors which augment the health related risk.[10] There is a quick worldwide growth of mobile phone usage in the recent years which raises the questions with respect to the possible effects of the radiofrequencies emitted by the same.

BERA is an objective way of eliciting potentials from brain stem in response to an audiological click stimulus. The waves are recorded by placing the electrodes over the scalp. It is also considered as an effective screening instrument in the evaluation of suspected retrocochlear pathology like acoustic neuroma.

In the present study, comparison of latencies of wave I, III, V and interpeak latency of I – V between group I (n = 50) which included participants exposed to mobile phone usage for > 4 years for more than 60 minutes in a day and group II (n = 50) which included participants exposed to mobile phone usage for < 1 year for less than 60 minutes in a day. It was observed that there was significant increase in latencies of wave II and V in group I subjects compared with group II subjects. Though there was increase in latency in wave I in group I participants, it was not statistically significant.

In a study conducted on rabbits revealed a significant prolonged absolute latency of wave III and interpeak latencies of I – V and III – V for time related changes in auditory pathway during mobile phone electromagnetic exposure.[9]

One researcher reported a 0.2ms delay in the wave V of BERA caused by pulsed electromagnetic field by a cellular phone for 15 min.[11]

An increase in latencies of wave I and III in total users compared with nonusers was reported in one more research.[3]

While there are some studies which have shown the effects of mobile phones on hearing pure tone audiometry and BERA have reported no significant change in all the wave forms and interpeak latencies between the users and nonusers of mobile phones.[7,12]

There was a found statistically significant increase in latencies of wave III and V in mobile phone users of more than 4 years compared with subjects exposed to mobile phone usage for less than a year in our study. Comparatively increased interpeak latency I – V in mobile users of more than 4 years was observed. Wave III and V latencies are increased if there are damage to the different parts of auditory pathway mainly superior olivary complex and inferior colliculus respectively. Since these parts are in the range of exposure to electromagnetic field of mobile phone, it is presumably that superior olivary complex and inferior colliculus can be at the various stages of getting damaged, thus explaining the reason behind increased latencies of III and V.

Conclusion

On comparison of various latencies of BERA in participants exposed to mobile phones for more than 4 years and participants exposed to mobile phones for less than a year, a significant increase in latencies of the wave III and V was observed. These results show that there is a definite damage to the neurons exposed to electromagnetic radiations at various auditory pathway levels. So from our study we can conclude that, exposure to electromagnetic radiations of mobile phones have harmful effects on human auditory functions. This damage to the ear can be at various levels of auditory pathway and can be proportional to the amount and duration of exposure.

Nevertheless, our study alone cannot effectively comment about the amount of damage and safety limit for mobile phone usage. More research needs to be engaged which can define about the safety hours of usage and to decrease the emissions of radiations from mobile phone.

Conflict of Interest: None.

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