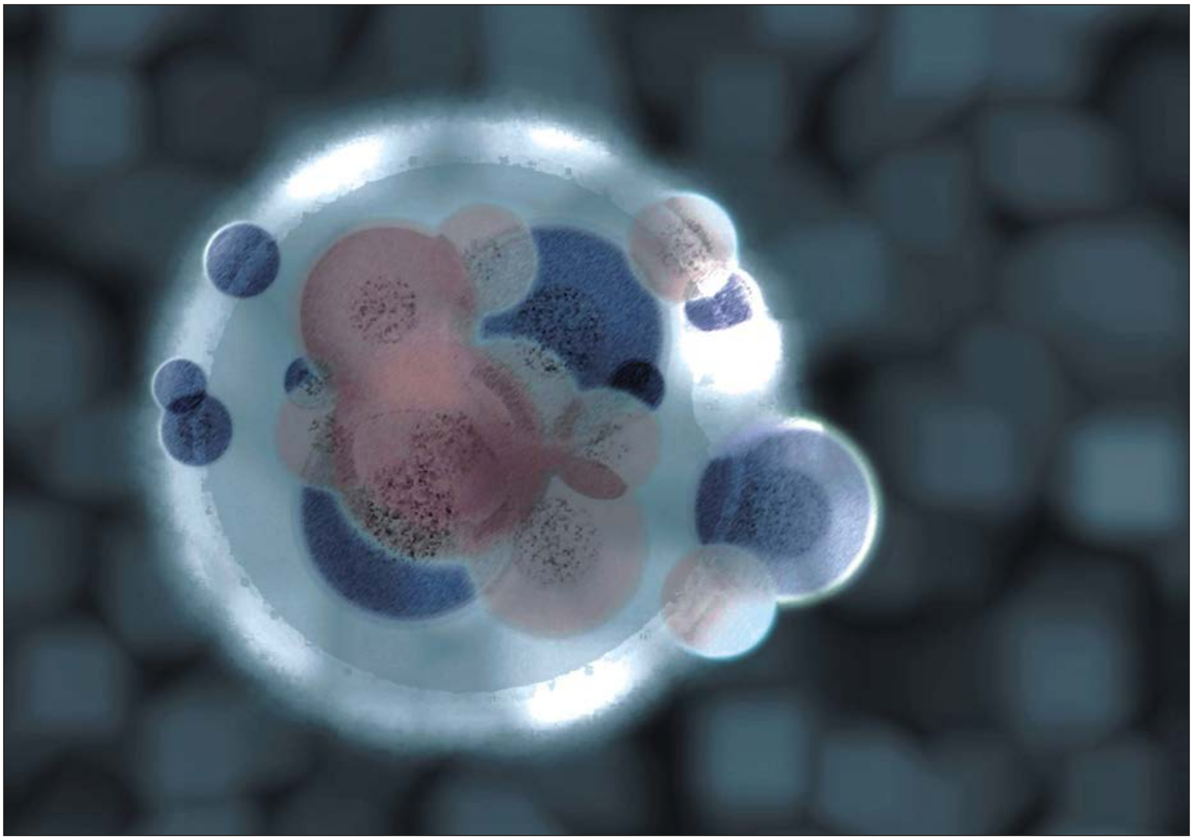

Journal of Biological Sciences

ISSN 1727-3048

Journal of Biological Sciences 7 (1): 200-204, 2007
ISSN 1727-3048

Effects of Mobile Phone System (GSM-900) on the Rabbit Hearing with Auditory Brainstem Response

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Abstract: A rapid worldwide expansion of mobile telephones raises questions regarding possible effects of the emitted radiofrequencies on the health of the consumers. The mobile phone system (GSM-900) works in the range of 890-960 MHZ in the electromagnetic spectrum. The present study was performed to investigate the effect of mobile phone radiation on auditory system of rabbit. The auditory brainstem response (ABR), was studied before and after using a mobile phone in the hearing of rabbit. After measuring of click and tone burst at different frequencies (500, 1000, 2000, 4000 and 8000 HZ) with two intensities of 70 and 100 dB, the animals were exposured to electromagnetic waves from a simulator of mobile phone one week exposure and 16-19 h rest. The ABR tests were shown that the latency time of wave V (ms) have some changes in the frequencies of the experiments. The latency time of wave V (ms) at the frequencies of 500 and 1000 HZ was almost unchanged, but at the frequencies of 2000, 4000 and 8000 HZ were decreased at the end of second week of exposure. Statistical analysis have not any significant changes between time latency of wave in pre and post exposures.

Key words: Mobile phone, hearing, ABR, rabbit, electromagnetic waves

INTRODUCTION

Mobile telephones, sometimes called cellular phones or handies, are now an integral part of modern telecommunications. Given the immense numbers of users of mobile phones, even small adverse effects on health could have major public health implications (Uloziene *et al*., 2005; Lawrentschuk and Bolton, 2004). Current mobile phone systems operate at frequencies between 800 and 1800 MHZ. It is important not to confuse such radiofrequency (RF) fields with ionizing radiation, such as X-rays or gamma rays. Unlike ionizing radiation, RF fields cannot cause ionization or radioactivity in the body (Elder and Chou, 2003). For the reason, RF fields are called non-ionizing. RF exposure to a user of a mobile phone is far higher than to a person living near a cellular base station. Mobile phone handsets are low powered RF transmitters, emitting maximum powers in the range of 0.2 to 0.6 watts. Other types of hand held transmitter, such as walkie talkies, may emit 10 watts or more. The RF field strength (and hence RF exposure to a user) falls off rapidly with distance from the handset. Therefore, the RF exposure to a user of a mobile phone located 10s of centimetres from the head (using a hands free appliance) is far lower than to a user who places the headset against the head (Ozturan *et al*., 2002). RF exposures to nearby people are very low. RF fields penetrate exposed tissues to depths that depend on the frequency-up to a centimeter at the frequencies used by mobile phones. RF energy is absorbed in the body and produces heat, but the body's normal thermoregulatory processes carry this heat away. All established health effects of RF exposure are clearly related to heating (Repacholi, 2001). While RF energy can interact with body tissues at levels too low to cause any significant heating, no study has shown adverse health effects at exposure levels below international guideline limits. Most studies have examined the results of short term, whole body exposure to RF fields at levels far higher than those normally associated with wireless communications (Kundi *et al*., 2004). With the advent of such devices as mobile phones, it has become apparent that few studies address the consequences of localized exposures to RF fields to the head. Audiologists involved in the assessment of some hearing are often unable to obtain reliable behavioral information regarding hearing sensitivity. In such instances, ABR testing is used to obtain further information (Krause *et al*., 2004). The auditory brainstem response (ABR) remains the most widely and successfully used auditory evoked potential in clinical practice (Maby *et al*., 2004). Part of this success stems from the relative ease in which the ABR is analysed, that

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is most clinicians simply identify the peaks of interest (primarily peaks I, III and V) and then compare their latencies and occasionally their amplitudes, to matched normative data. Whilst the standard ABR analysis process is relatively simple, it is also manual, usually being completed by an audiologist or ABR technician. However, manual peak labelling results in at least two significant limitations. First, there is the potential for failure when too many ABR waveforms must be analysed either in too short a period of time, as in neonatal threshold assessment or intra-operative monitoring, or over too long a period of time, as in intensive care unit neurological monitoring (Maby *et al*., 2005; Kizilay *et al*., 2003). Second, there is the potential for mislabeling in the hands of a novice operator. A possible solution to these problems is to automate, or semi-automate, the peak labelling process. Previous attempts to automate ABR wave labelling have varied depending on whether the aim was simply to as in any hearing evaluation, when a hearing loss is identified through ABR testing, it is important to estimate the degree of cochlear involvement. In behavioral testing, this is normally accomplished through bone conduction testing; however, bone conduction ABR testing is not routinely done in the clinic. Latency measures obtained from the ABR to air conducted stimuli provide a potential source of information not available from the behavioral air conduction audiogram (Hossmann and Hermann, 2003). Latencies increase as stimulus intensity decreases and conductive hearing loss reduces the effective intensity arriving at the cochlea. Consequently, ABR latencies are often prolonged in cases of conductive hearing loss. It is a commonly held belief that these ABR latency shifts can be used to predict the extent of conductive involvement with reasonable accuracy (Koivisto *et al*., 2000). The present study was designed to search the effect of mobile phone on rabbit hearing with ABR test.

MATERIALS AND METHODS

Animals: New Zealand White rabbits were used for the experiments. There was control group for each experimental group. The animals were fed with standard diet, water and keeping them in the room ambient temperature of 20-22°C, with relative humidity of 50%. They were housed in plastic cages containing wood chip bedding with three or four rabbits per cage. Experiments were carried out under animal care protocols of the Tarbiat modarres university.

Sound generator and cabin: The generator, amplifier (800-950 MHZ, 3-5 w) and arial designed and constructed in Electrical Engineering Faculty of Khaje Nasiredine Tosi University and the animal restrainer Plexiglass cylinder (30 cm diameter and 30 cm height) was mounted inside the chamber (110×110×110 cm) with absorber material.

Electrophysiological studies: The ABR responses was recorded, during anesthesia, before and 72 h after the contact with the frequencies. In the pretreatment phase the animals were (I) anesthetized, (ii) ABR responses were acquired. The ABR responses were recorded by three platinum iridium needle electrodes, placed subdermally over the vertex (positive), the mastoid (negative) and the cabin whose walls and ceiling were covered by phono absorbent material. The calibration of the sound was done using a microphone, placed 4 cm above the animal's head and facing the loudspeaker. The ABRs were amplified and filtered from 500 to 8000 Hz. The ABRs were generated in response to 100 Ws alternated clicks and 500, 1000, 2000, 4000 and 8000 Hz tone pips, in the range 70 and 100 dB. The sound transducer, was placed 4 cm away the rabbits ear. Threshold was based on the visibility and reproducibility of waves. At the minimum threshold level two recordings were acquired. No responses were present below a stimulus level of 40 dB, which was considered the threshold level for our experimental set-up. During all measurements the body temperature of the animal was constant. Ear plugs were used to occlude the contra-lateral ear in order to avoid a binaural stimulation at high stimulus intensities. The animals were anesthetized with ketamin and xylazine administered intraperitoneally and placed in a prone position with their head fixed in a head-holder. Body temperature was kept at constant temperature by a heating pad. A stainless steel screw electrode was placed on the vertex as a recording electrode. A reference electrode was placed on the right temporal portion and a ground electrode was placed at the midpoint between the two external auditory canals in the occipital portion. A click or a tone-burst stimulus was delivered to the right ear through an ear bar with a closed sound system. The threshold was defined as the minimum sound intensity at which a visible ABR wave was seen in two runs. The latency of each wavelet was measured by the cursor mode of the analyzer. The animals were exposured to electromagnetic waves from a simulator of mobile phone (915 M HZ frequency and 3 W power). After this exposure (one week) and 16-19 h rest (for elimination of short term effects), ABR test was conducted again. Before exposuring of the animals, latency time of the fifth wave of ABR (the wave needed for and hearing loss) were measured and recorded, with two stimuli, click and tone burst at different frequencies (500-1000-2000-4000 and 8000 HZ) and in two intensities of 70 and 100 dB. The EEG was amplified and filtered. The EEG was monitored on an oscilloscope throughout the test session and testing proceeded only when subjects were asleep. Responses were recorded to high-intensity rarefaction clicks presented. Responses to air conducted clicks or 2000 Hz tones were recorded at lower intensities either to establish normal hearing or to determine ABR thresholds. Brainstem responses to bone-conducted 2000 Hz tones were recorded either to determine bone conduction ABR thresholds or to establish normal cochlear sensitivity. Wave V latency was measured for each subject's data. Latency delays were calculated using the laboratories' normative database, which was obtained from a larger group of normal subjects who are not included in this study. Latency delay was calculated by subtracting from each subject's wave V latency the mean of the normative data for a given rate/intensity combination. The magnitude of the conductive component was determined for each ear. Because bone-conduction threshold searches were not carried out for ears with conductive hearing loss, bone-conduction results were not used for the determination of the magnitude of conductive components. For the conductive hearing loss categories (otitis media and atresia), the conductive component was calculated as the air conduction threshold minus 10 dB, as ABR thresholds tend to overestimate the behavioral thresholds by approximately 10 dB. For the group with mixed hearing loss only, the difference between the air conduction and bone conduction ABR thresholds was used to estimate the magnitude of the conductive component. A conductive component of 0 dB was used for ears in the normal hearing and sensorineural hearing loss categories. Linear regression analyses were carried out on the combined data for normal ears and those with conductive hearing loss, using wave V latency delay and the conductive component as the variables.

RESULTS AND DISCUSSION

In the present work, the effects of mobile phone system (GSM-900) on the rabbit hearing sensitivity (indicated by the ABR threshold) and on the amplitude and latency of the waves of the ABR induced by a stimulus of high intensity (70 and 100 dB) were tested for the post ictal period in the rabbits stimulated. ABRs were obtained for alternating polarity clicks presented at 70 and 100 dB. The forehead electrode served as the active electrode and the mastoid as reference with the contra lateral mastoid electrode as ground. Clicks were presented at a rabbit of 19/sec with a 15 m sec recording window and a pass band of 30-3000 Hz. At least two recordings were made as each presentation level. The normality of ABR peaks and ABR interpeak latency intervals was judged on the basis of the normative data shown below:

I: <1.88 ms, III: <4.06 ms, V: <6.02 ms, I-III: <2.35 ms, III-V: <2.22 ms, I-V: <4.37 ms, If a peak could not be identified or was not repeatable upon successive recordings, the peak was classified as abnormal. When the interaural latency difference was examined as a measure in an analysis separate from the overall analysis described above, an interaural latency difference greater than 0.3 m sec was considered abnormal. The thresholds of ABR are shown in Fig. 1. All the recordings of the present study were performed in animals anesthetized with a ketamine/xylaxine solution. In agreement with the effects of this anesthetic solution on the EEG and on the ABR with time previously reported in the rat (Goss-Sampson and Kriss, 1991; de la Cruz and Bance, 1999). We have found that in the rabbits the amplitude and latency of the ABR wave components evoked by the 70 and 100 dB stimulus are not changed after anesthesia. Our results also show that anesthesia does not change the ABR threshold in the rabbit with time. Analysis of the parameters of the different waves of the ABR evoked by the auditory stimulus of high intensity before (Table 1) and after (Table 2) the contact with different frequencies (500-8000 HZ) reveals that the increase in the auditory threshold exerted by the frequencies, suggesting that

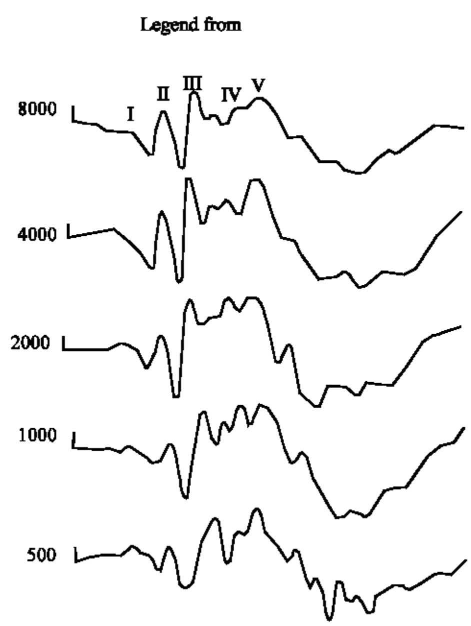

Fig. 1: ABR waveforms representative of tone-burst stimuli waveform morphology in frequencies 500- 8000 Hz

Table 1: Analysis of the parameters of the different waves of the ABR by the tone burst and click stimulus of high intensity before the contact with different frequencies (500-8000 HZ)

			Latency time of wave V (ms)	
Intensities (db)	Stimulus	Frequencies	Average	Standard deviation
70	Tone burst	500	5.40	0.158±
		1000	5.28	0.287±
		2000	5.28	0.245±
		4000	5.23	0.229±
		8000	5.14	0.228±
	Click		4.92	0.2200±
100	Tone burst	500	5.100	0.180±
		1000	4.89	0.172±
		2000	4.89	0.214±
		4000	4.86	0.215±
		8000	4.80	0.241±
	Click		4.63	0.114±

Table 2: Analysis of the parameters of the different waves of the ABR by the tone burst stimulus of high intensity after the contact with different frequencies (500-8000 HZ)

			Latency time of wave V (ms)	
Intensities (db)	Stimulus	Frequencies	Average	Standard deviation
70	Tone burst	500	5.56	0.404±
		1000	5.52	0.2350±
		2000	5.74	0.604±
		4000	5.52	0.451±
		8000	5.58	0.639±
	Click		5.25	0.423±
100	Tone burst	500	5.23	0.183±
		1000	5.07	0.267±
		2000	5.25	0.523±
		4000	5.07	3722/0±
		8000	5.27	8339/0±
	Click		4.91	3164/0±

these retro-cochlear changes are linked with the reduced hearing sensitivity. According to a number of studies in the literature, the ABR are considered good indicators of hearing (Klein and Djaiani, 2003; Roosli *et al*., 2004). WHO has identified research needs to make better health risk assessment and promoted the research to funding agencies. Current scientific evidence indicates that exposure to RF fields, such as those emitted by mobile phones and their base stations, is unlikely to induce or promote cancers (Galeev, 2000). Several studies of animals exposed to RF fields similar to those emitted by mobile phones found no evidence that RF causes or promotes brain cancer. Several studies are underway to confirm this finding and determine any relevance of these results to cancer in human beings. Three recent epidemiological studies found no convincing evidence of increase in risk of cancer or any other disease with use of mobile phones. Scientists have reported other effects of using mobile phones including changes in brain activity, reaction times and sleep patterns. These effects are small and have no apparent health significance. More studies are in progress to try to confirm these findings. Research has clearly shown an increased risk of traffic accidents when mobile phones (either handheld or with a hands-free kit) are used while driving (Hyland, 2000). When mobile phones are used close to some medical devices (including pacemakers, implantable defibrillators and certain hearing aids) there is the possibility of causing interference. There is also the potential of interference between mobile phones and aircraft electronics.

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