The Effect of Mobile Phone to Audiologic System

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Mobile phones have come into widespread use. There are a lot of possible adverse effect to health. Use of mobile phone generate potentially harmful radiofrequency electromagnetic field (EMF) particularly for the hearing aspect. 98 subjects underwent hearing evaluations at Department of Otolaryngology, Faculty of Medicine, King Chulalongkorn Memorial Hospital, Chulalongkorn University. 31 males and 67 females, mean age was 30.48 +/- 9.51 years old, All subjects were investigated the hearing level by audiometry, tympanometry, otoacoustic emission (OAE) and auditory brain stem evoked response (ABR). The average of using time were 32.54 $\pm$27.64 months, 57 subjects usually used the right side and 41 the left side. Average time of use per day was 26.31 $\pm$ 30.91 minutes (range from 3 to 180 mins). When the authors compared the audiogram, both pure tone and speech audiometry, between the dominant and nondominant side, it indicated that there is no significant different. When the authors focused on the 8 subjects that used the mobile phone more than 60 mins per day. It indicated that the hearing threshold of the dominant ears was worse than the nondominant ears.

Keywords: *Mobile phone, Audiologic system, ABR, OAE, Audiogram*

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In recent decades, mobile phones have come into widespread use. It is the one of the fastest growing technology. The development of the analog to the modern digital system took a few years.. There are a lot of possible adverse effects to health. Use of mobile phone generate potentially harmful radiofrequency electromagnetic field (EMF). Digital cellular telephones transmit in bursts of microwave of 900 mHz. In rat, direct effect of radiofrequency electromagnetic energy on DNA molecules can damage DNA and reduces the repair mechanisms in brain cells[1]. Brain tumors, including malignant brain tumor in human are associated to EMF from mobile phones[2-4]. There are many reports of the developed symptoms such as headache, sensation of burning skin, fatigue, hot ears, increase blood pressure, ear pain and hearing loss[5]. The study about people exposed to very low-intensity microwave energy, report hearing sound like buzzes, chicks and tones, change in blood brain barrier function, but the most worrisome concern raised with mobile phone use in increased cancer risk[6].

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There are a lot of questions from patients that visited otolaryngologists about the effect of mobile phone to the hearing. Most clinicians cannot answer definitely. Anatomically, ear is in closed proximity to the mobile phone during use, there are no study about the effect of EMF to the hearing. There are a lot of factors that can involve the hearing level such as noise and medication. But most factors effect hearing on both sides of the ears. On the basis that most people use a mobile phone in the usual side (called dominant side) so the EMF in that side will be effected more than another one (called the nondominant side). The authors measured any change in hearing level and compared the dominant side to the nondominant side. The authors also studied the respond of out the hair cell function in the cochlear end organ, and the cochlear nerve function.

Material and Method

Between August 2001 and April 2003, 112 subjects underwent hearing evaluations at the Department of Otolarngology, Faculty of Medicine, King Chulalongkorn Memorial Hospital, Chulalongkorn University. 14 subjects used the mobile phone bilateral

sides, these The authorsre excluded from the present study. Therefore 98 subjects were eligible for analysis and formed the subjects of the present report.

The mean age was 30.48 +/- 9.51 years old (range 20 to 67), 31 males and 67 females. All subjects were investigated by history taken about the system of mobile phone, brand, the use of small talk (extension hearing cord), timing of use, preferable side, medication taking, personal history of diseases particularly the ear diseases, and asked for the associated change of hearing with or without using the mobile phone.

The hearing level of all the subjects were investigated by experienced audiologist by:

1. Audiometry by Beltone 2000 audiometry.

Subjects The authorsre recorded the pure tone threshold in 250, 500, 1000, 2000, 4000, 8000 Hz respectively, and speech reception threshold (SRT) and speech discrimination score (SDS) on both sides.

2. Tympanometry Model GSI 33 Middle Ear-Analyzer.

3. Otoacoustic emission (OAE) both transient OAE (TOAE) and distorsion product OAE (DPOAE) betThe authorsen 1k to 6k Hz.

4. Auditory brain stem response (ABR) by Smart E.P. Model 104s at 90 dB the results were recorded on both sides and analysised by x2 test programe.

Descriptive statistics (mean, SD and range) were presented.

Results

98 subjects were studied, 31 were males, 67 were females. The mean age were 30.48 +/- 9.51 years old. 40 cases were employees, 29 were students, 12 were government officials, others were nurses, housewife, doctors, and dentists respectively.

The most popular type of mobile phones was the GSM system, that were54 cases, 27 subjects used the D-tac system, GSM 1800 were13, and 3 for the Orange system, and each for 800 mHz, 900 mHz system.

The average of using time was 32.54 +/- 27.64 months. (range from 4 months to 12 years). 57 subjects usually used right side , and 41 in left side.

The average timing use per day The authorsre 26.31 +/- 30.91 minutes (range from 3 to 180 mins). In this groups of study 62 subjects used mobile phone more than 10 mins per day, and 8 subjects used more that 60 mins per day. (Table 1)

The adverse symptoms were vertigo, pain in the ear, tinnitus, nausea and hearing loss. When the authors compared the audiogram, both pure tone and speech audiometry, between the dominant and nondominant side. (Table 2) It indicated that there was no significant difference between the hearing threshold on the dominant side compared to the nondominant side ($p > 0.05$).

When the authors focused on the 8 subjects that used the mobile phone for more than 60 mins per day, it was observed that the hearing threshold of the dominant ears were worse than the nondominant ears (Table 3). Because of too small samples size (8 cases), The authors could not conclude the statistic figure.

Discussion

It has been estimated that over 400 million people worldwide now use mobile phones, and by 2005 that number will rise to 1.3 billion. This technology has progressed so quickly. At the same time, the important questions about the health effect of these devices have arisen.

The electromagnetic fields (EMFs), that are composed of waves of electric and magnetic energies that travel together at the speed of light. The electromagnetic (EM) radiation into two types: the ionizing radiation have energy levels high enough to strip electrons from atoms and molecules. So exposure to ionizing radiation can cause serious biological damage, including the production of cancers. And the second non-ionizing radiation, which is the radiation that insufficient energy to cause ionization. Radiofrequency radiation includes bands used in radio and television,

Table 1. Using time

Mean timing in use :	Range 4 months - 12 years
	Mean 32.54 +/- 27.64 months
The average timing use per day :	
	Range 3 to 180 minutes
	Mean 26.31 +/- 30.91 minutes
In this groups of study :	62 subjects used mobile phone more than 10 mins per day
	8 subjects used more than 60 mins per day
Right side usage 57 cases	
Left side usage 41 cases	

Table 2. Result of the audiometry

	Mean pure tone threshold	Mean speech discrimination
Dominant ear	16.89	96.33
Undominant ear	16.46	97.31

Table 3. 8cases that use mobile phone more than 60 mins per day

Sex	Age	System	Brand	Symptoms	Timing (minute)	Threshold (dB)		OAE	ABR (wave V) (msec)
M	21	DTAC	Nokia	No	60	Dominant ear (Rt)	25	Low tone loss	5.74
						Nondominant ear	21.67		5.58
F	22	2 W	Ericson	No	60	Dominant ear (Rt)	20	Normal	5.32
						Nondominant ear	20		5.21
F	21	2 W	Nokia	No	60	Dominant ear (Rt)	23.33	High tone loss	5.44
						Nondominant ear	21.66		5.15
M	48	2 W	Nokia	n/v	120	Dominant ear (Lt)	41	No response	5.97
						Nondominant ear	26		5.48
F	22	2 W	Nokia	ti, n/v, vg	120	Dominant ear (Rt)	15.33	High tone loss	5.56
						Nondominant ear	15.33		5.48
F	25	GSM	Siemens	hl, ti, n/v, vg	120	Dominant ear (Lt)	13	Low tone loss	5.46
						Nondominant ear	12		5.44
F	34	2 W	Nokia	hl, ti, n/v, vg	180	Dominant ear (Rt)	26.67	No response	5.35
						Nondominant ear	25		5.29
F	35	DTAC	Nokia	n/v	180	Dominant ear (Rt)	25	High tone loss	5.27
						Nondominant ear	12		5.15

n/v = nausea and vomiting, ti = tinnitus, hl = hearing loss, vg = vertigo

mobile phones, and microwaves are in the non-ionizing EM. Its energy can heat biological tissue, this thermal effect can cause harm by increasing body temperature, and damage the biological tissue. there are also other effects from non-thermal part of RF that is produced by mobile phone.

The cellular phone can be categorized into 3 types based on the RF at which they transmit.

-Analog : that operates at frequency between 824 mHz to 900 mHz, the energy produces 8 times than digital phone.

-Digital cellular phone : that operates between 800 mHz and 900 mHz.

-Digital personal communication system that operates between 1800 mHz and 1990 mHz.

(Global System Mobile (GSM) : that operates worldwide outside the United State at 900 mHz and 1800 mHz in Asia and Europe, 1900 mHz in United State).

The amount of radiation from cellular phones depend not only from the types of the cellular, but also from the manufacturer and model of cellular. The Specific Absorption Rate (SAR) is amount of RF energy absorbed from the phone into the local tissues, in US the maximum SAR should less than 1.6 watts per kilogram (W/Kg), so higher rate is more dangerous. The fewer the numbers of the base station and available channels, the more energy the cellular produces.

There have been a lot of reports about the effect of cellular energy on human organ. Brain is the main area of concern to the effect of the cellular. In 1998 Eulitz reported EMF induced change in human activity[7]. Some reported the effect of the cellular on the other surrounding organ like eye,but there is no report about the effect of the hearing level, in spite of the ear being the nearest contact to the cell phone, there have been some complain is about the symptoms of hot ear, ear pain or hearing loss. But there is no scientific data to confirm that experience.

The authors tried to answer all these questions. The present study showed that the hearing of the user not significantly effect by the EMF from the cell phone. But The authors observed that users who exposed to cell phones more than 60 mins per day show decline in hearing threshold. Because of too small numbers in this group, so The authors can't indicate the significant of this finding. The authors suggest to do more study should be carried out about the hearing of the cellular user was spend more than one hour per day and find the relationship of other factors.

There are a lot of factors that can affect the hearing of the users. The sound energy is not high enough to damage the auditory organ like cochlear or auditory nerve. So when focus in the EMF that produces by cellular, it can indicate that the effect of hearing are the heat that produce in the tissue, Leszczynski et al reported the thermal change in nerve fiber that exposed to cellular EMF that is enough to damage the nerve cell. [8]. In some aspect of the study about the

blood brain barrier (BBB) on change in EMF expose. Lai et al found few substants that toxic and initiate the damage in brain and nerve tissue after expose to EMF [1,9,10,]. It may be effect to auditory organ like cochlear and auditory nerve in the same ways.

From the conclusion of the present study the authors suggest that the user should use the cellular only when necessary to prevent the long time exposure to EMF. The area that low signal should be avoid. Loud speaker is preferred to prevent near contact to the cellular antenna.

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ผลกระทบของโทรศัพท์เคลื่อนที่ต่อระบบการได้ยิน

วีระชัย คีรีกาญจนะรงค์, ภาคภูมิ สุปิยพันธุ์, จันทรา นราตรีคูณ, ปริญญา หลวงพิทักษ์ชุมพล

ปัจจุบัน การใช้โทรศัพท์เคลื่อนที่ (mobile telephone) ได้เป็นที่แพร่หลายทั่วไป คลื่นแม่เหล็กไฟฟ้าจากโทรศัพท์เคลื่อนที่อาจจะเป็นอันตรายต่ออวัยวะรับการได้ยินได้ ผู้เข้าร่วมวิจัย 98 รายได้รับการตรวจวัดระดับของการได้ยินที่ภาควิชาโสต ศอ นาสิกวิทยา คณะแพทยศาสตร์ จุฬาลงกรณ์มหาวิทยาลัย มีผู้ชาย 31ราย ผู้หญิง 67 ราย อายุเฉลี่ยเท่ากับ30.48 +/- 9.51 ปี ทั้งหมดได้รับการตรวจวัดระดับของการได้ยิน ตรวจหาการเคลื่อนไหวของแก้วหูและการทำงานของหูชั้นกลาง ตรวจวัดการทำงานของ ขนโบกพัดส่วนนอกในหูชั้นในและการทำงานของเส้นประสาทการได้ยิน ผลปรากฏว่า ผู้เข้าร่วมวิจัย ใช้โทรศัพท์เคลื่อนที่เฉลี่ย 32.54 +/- 27.64 เดือน 57 รายหูที่ใช้โทรศัพท์ข้างขวา 41 รายหูที่ ใช้โทรศัพท์ข้างซ้าย อัตราการใช้โทรศัพท์เฉลี่ย 26.31 +/- 30.91 นาทีต่อวัน(3-180 นาที) เมื่อเปรียบเทียบระดับของการได้ยินของหูที่ใช้โทรศัพท์ กับข้างที่ไม่ใช้โทรศัพท์ ไม่พบความแตกต่างอย่างมีนัยสำคัญ แต่เมื่อพิจารณาผู้เข้าร่วมวิจัย 8 รายที่ใช้โทรศัพท์มากกว่าวันละ 60 นาที พบว่า หูข้างที่ใช้โทรศัพท์เคลื่อนที่มีการเสื่อมของการได้ยินมากกว่าข้างที่ไม่ใช้โทรศัพท์