Mobile Radiofrequency Does Not Interfere With Antiarrhythmic Drugs in Patients with Ischemic Heart Disease

Various studies suggested that electromagnetic radiation (EMR) directly affects neurons by reducing the neuronal reactivity, increasing the neural membrane conductivity and prolonging their refractory period. The average latent period of excited single neuron is significantly decreased during exposure to the EMR of cell phone.\textsuperscript{[1,2]} The low-frequency (50 Hz) magnetic field exposures affect the neuronal cell excitability while chronic exposure to high frequency (30 MHz) magnetic field induced cytotoxicity.\textsuperscript{[3,4]} The cardiovascular system may be a potential target for the EMR emitted by the phones. The signals produced by the phone operating functions (turning on/off, ringing, and conversation) contain components of low frequencies that may interfere with implanted pacemakers.\textsuperscript{[5,6]} It is interesting to investigate the effect of ringing mobile placed on the precordium on the electrocardiogram (ECG) parameters, particularly the conduction impulse interval, in patients with myocardial ischemia treated with antiarrhythmic drugs.

This study conducted in Departments of Medicine and Physiology-Medical Physics, College of Medicine, Diyala University in cooperation with Department of Pharmacology, College of Medicine, Al-Mustansiriya University in Iraq. This study was approved by the Scientific Committee of the College and a verbal consent form was obtained from each patient prior to the admission to the study.

A total number of 161 patients (46 male and 115 female) with ischemic heart diseases with sinus rhythm were allocated randomly (using randomized tables) and enrolled in this study. Patients were grouped into:

Group I ($n = 101$): Patient with history of ischemic heart disease treated with one or more of the followings: nitrates, acetylsalicylic acid, clopidogrel, angiotensin converting enzyme inhibitors, and angiotensin receptor blockers. These drugs do not interfere with cardiac conduction system or sinoatrial and atrioventricular nodes function.

Group II ($n = 60$): Patients with ischemic heart disease treated with one or more of the followings: nitrates, acetylsalicylic acid, clopidogrel, angiotensin converting enzyme inhibitors, and angiotensin receptor blockers. These drugs do not interfere with cardiac conduction system or sinoatrial and atrioventricular nodes function. Patients with risk factors including essential hypertension and diabetes mellitus were included in this study while those with acute coronary syndrome were excluded from the study. The diagnosis of ischemic heart diseases based on the medical history, physical examination, electrocardiographic, and echocardiographic findings.

Each patient allowed to lie on the supine position and after a stabilizing period of 10 min, the ECG was done to him without application of cell phone and this ECG is considered as a baseline ECG. Then the cell phone was placed on the left side of lower abdomen at the belt level and allowed to ring once for 40 s (ringing mode) with simultaneous recording ECG. This ECG is considered as ECG with cell phone ring at belt level. After 5 min the cell phone placed in the left side chest pocket (over the precordial region) and allowed to ring once for 40 s (ringing mode) with simultaneous ECG recording. The radiofrequency of cell phone is 900 MHz and the duration of each ring is 40 s.

The following ECG variables (which are calculated electronically) are studied: heart rate (beat/min), R-R interval (ms), P-R interval (ms), QRS period (ms), QTm (measured) interval (ms), QTc (corrected) interval (ms), the amplitude of R wave in lead V5 (mV), the amplitude of S wave in lead V1 (mV) and the voltage summation of R wave in V5 and S wave in V1 (mV).

The results were analyzed using Excel 2007. The results are presented as mean ± SD. The data were analyzed using two tailed paired Student’s ‘$t$’ test taking $P \leq 0.05$ as the lowest limit of significance.

The mean age of Group I did not significantly differ from that of Group II ($55.9 \pm 12.5$ years vs with $57.9 \pm 11.7$ years). History of hypertension and/or diabetes mellitus was reported in 80 patients (Group I) and 55 patients (group II). Table I shows that the radiofrequency of cell phone (turn ON mode) placed at belt level significantly interfered with conduction velocity and the voltage criteria of the heart presented with prolonged QTc interval and reducing the amplitude of R wave in lead V5 in female patients related to Group I. These changes were not observed when the cell phone
placed in the chest pocket over the precordial region. In male patients (Group I) the radiofrequency of mobile phone did not induce significant changes on the ECG whether it placed at the belt level or in the chest pocket [Table 1]. In Group II females the radiofrequency of mobile significantly decreased the voltage amplitude whether the mobile placed at the belt level or over the precordial region [Table 2]. Variable ECG changes were observed in male patients of Group II. Prolongation of QT interval was observed when mobile placed at the belt level and over the precordial region [Table 2] and the amplitude of R wave in lead V5 was significantly increased by 2.4% when the mobile placed over the precordial region [Table 2]. Group I patients without clinical evidence of risk factors including hypertension and diabetes mellitus did not show any significant effect of mobile radiofrequency on the ECG [Table 3]. Significant prolongation of QTm and QTc intervals (the mobile at the belt level) and reduction of the R wave amplitude (the mobile over the precordial region) were observed in patients with positive risk factors, that is, hypertension and/or diabetes mellitus [Table 3]. Group II patients without clinical evidence of risk factors including hypertension and diabetes mellitus showed significant prolongation of PR interval when the mobile over the precordial region [Table 4]. Significant prolongation of QTm interval and reduction of the S wave amplitude (the mobile at the belt level) and reduction of the S wave amplitude (the mobile over the precordial region) were observed in patients with positive risk factors, that is, hypertension and/or diabetes mellitus [Table 4].

The results reported in this study show that the effects of mobile radiofrequency on the ECG are not influenced

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### Table 1: Effect of mobile frequency on the electrocardiograph parameters in Group I patients

| Parameter               | Female (n = 77) | Male (n = 24) |
|-------------------------|-----------------|--------------|
|                         | Baseline values | Cell phone (ringing mode) at belt level | Cell phone (ringing mode) over precordium | Baseline values | Cell phone (ringing mode) at belt level | Cell phone (ringing mode) over precordium |
| Heart rate (beat/min)   | 77.29±17.19     | 77.53±17.08  | 77.14±16.74  | 83.16±20.67 | 83.66±21.8  | 83.5±21.15  |
| R-R interval (ms)       | 806.83±169.69   | 803.14±168.93 | 807.87±168.66 | 757.20±180.11 | 756.83±186.95 | 755.62±176.59 |
| P-R interval (ms)       | 160.09±27.19    | 159.29±28.20 | 158.54±22.71 | 177.62±59.26 | 160.0±53.99 | 174.58±52.7  |
| QRS period (ms)         | 102.01±17.21    | 102.45±17.65 | 101.83±16.67 | 108±14.28  | 109.08±14.89 | 107.04±15.17 |
| QT interval (ms)        | 398.19±47.98    | 398.97±47.56 | 396.71±49.84 | 375.04±41.22 | 372.91±45.37 | 372.37±42.35 |
| QTc interval (ms)       | 445.97±31.66    | 447.41±30.94** | 443.25±30.65 | 434.58±28.01 | 432.20±27.8 | 431.7±25.8    |
| R wave-V5 (mV)          | 1.245±0.6       | 1.249±0.601* | 1.310±0.611* | 1.496±0.798 | 1.452±0.808 | 1.457±0.819  |
| S wave-V1 (mV)          | 0.949±0.491     | 0.931±0.497  | 0.952±0.492  | 0.934±0.444 | 0.953±0.435 | 0.949±0.428  |
| R (V5) + S (V1)         | 2.197±0.874     | 2.192±0.897  | 2.282±0.929  | 2.430±1.004 | 2.408±1.008 | 2.407±1.014  |

The results are expressed as mean ±SD (n = 77), *P < 0.05, **P < 0.02, compared with baseline values.

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### Table 2: Effect of mobile frequency on the electrocardiograph parameters in Group II patient

| Parameter               | Female (n = 38) | Male (n = 22) |
|-------------------------|-----------------|--------------|
|                         | Baseline values | Cell phone (ringing mode) at belt level | Cell phone (ringing mode) over precordium | Baseline values | Cell phone (ringing mode) at belt level | Cell phone (ringing mode) over precordium |
| Heart rate (beat/min)   | 80.94±14.80     | 81.60±15.26  | 81.36±15.07  | 79.59±14.67 | 79.86±14.6  | 79.40±13.89  |
| R-R interval (ms)       | 764.92±169.97   | 761.07±178.79 | 742.28±206  | 772.77±138.85 | 769.81±137.51 | 773.36±133.29 |
| P-R interval (ms)       | 154.44±20.69    | 152.13±24.34 | 155.31±23.72 | 156.81±31.51 | 156.22±27.97 | 155.63±25.77 |
| QRS period (ms)         | 101.81±20.92    | 102.89±19.23 | 102.39±19.28 | 105.22±12.04 | 106.5±11.88 | 106.54±12.85 |
| QT interval (ms)        | 384.47±39.02    | 385.92±41.21 | 385.47±37.67 | 381.94±45.48 | 384.72±43.87** | 370.95±87.38 |
| QTc interval (ms)       | 444.68±32.81    | 445.97±27.98 | 444.86±26.99 | 435.45±28.44 | 457.45±105.87 | 438.9±32.38† |
| R wave-V5 (mV)          | 1.269±0.465     | 1.272±0.476  | 1.252±0.462  | 1.314±0.585 | 1.332±0.609 | 1.376±0.554* |
| S wave –V1 (mV)         | 0.975±0.486     | 0.938±0.484*** | 0.951±0.492† | 0.894±0.478 | 0.881±0.463 | 0.872±0.469  |
| R (V5) + S (V1)         | 2.243±0.712     | 2.206±0.727* | 2.203±0.732* | 2.205±0.851 | 2.218±0.861 | 2.232±0.824  |

The results are expressed as mean ±SD, *P<0.05, **P<0.01, ***P<0.001, †P<0.02 compared with baseline values.
with using antiarrhythmic drugs that act on SA node, AV node, and cardiac conductive system. Gender, position of mobile phone and risk factors; hypertension and diabetes mellitus are the determinant factors of mobile radiofrequency in patients using antiarrhythmic drugs. All patients were responded to enroll in the study because there was no therapeutic or surgical intervention and all the patients used mobile phones for communication.

Regarding the gender, the number of females was higher than corresponding males, which may not be related to specific cause because patients were randomly allocated.

Cardiovascular system is a potential target for the electromagnetic fields emitted by the phones. Signals produced by their operating functions (turning on/off, ringing, and conversation) contain components of low frequencies that may interfere with sinoatrial node rate or implanted pacemakers. It was reported that electromagnetic interference from a charging mobile phone connected to the same socket with the exercise device turned the recording of a patient to that of pseudosinus tachycardia at approximately twice the rate of actual basal heart rate. Brande and Martens reported pseudo-cardiac arrhythmias in females that induced by a cell phone. It was shown that the call with a mobile phone may change the autonomic balance

### Table 3: Effect of mobile frequency on the electrocardiograph parameters in Group I patient according to the risk factors of diabetes mellitus and/or hypertension

| Negative history diabetes mellitus and/or hypertension (n = 21) | Positive history of diabetes and/or hypertension (n = 80) |
|---------------------------------------------------------------|----------------------------------------------------------|
| Baseline values                                              | Cell phone (ringing mode) at belt level                  |
| Cell phone (ringing mode) over precordium                    | Cell phone (ringing mode) over precordium               |
| Heart rate (beat/min)                                        | 81.38±21.18                                             | 77.93±17.12                                              |
| R-R interval (ms)                                            | 778.09±179.3                                            | 800.53±169.74                                            |
| P-R interval (ms)                                            | 164.42±52.42                                            | 161.81±25.83                                             |
| QRS period (ms)                                              | 106.38±17.09                                            | 102.2±16.22                                              |
| QT interval (ms)                                             | 382.52±45.23                                            | 393.13±50.08                                             |
| QTc interval (ms)                                            | 437.14±27.04                                            | 441.4±30.66                                              |
| R wave-V5 (mV)                                               | 1.50±0.958                                              | 1.08±0.565                                               |
| S wave –V1 (mV)                                              | 0.99±0.528                                              | 0.94±0.484                                               |
| R (V5)+S(V1)                                                 | 2.49±1.232                                              | 2.26±0.859                                               |

The results are expressed as mean ±SD, *P < 0.05, **P < 0.01 compared with baseline values

### Table 4: Effect of mobile frequency on the electrocardiograph parameters in Group II patient according to the risk factors of diabetes mellitus and/or hypertension

| Negative history diabetes mellitus and/or hypertension (n = 5) | Positive history of diabetes and/or hypertension (n = 55) |
|---------------------------------------------------------------|----------------------------------------------------------|
| Baseline values                                              | Cell phone (ringing mode) at belt level                  |
| Cell phone (ringing mode) over precordium                    | Cell phone (ringing mode) over precordium               |
| Heart rate (beat/min)                                        | 86.0±13.94                                              | 79.94±14.73                                              |
| R-R interval (ms)                                            | 708±102.55                                              | 773.23±161.76                                            |
| P-R interval (ms)                                            | 137.2±25.44                                             | 156.96±24.49                                             |
| QRS period (ms)                                              | 107.6±12.64                                             | 102.65±18.58                                             |
| QT interval (ms)                                             | 365±29.74                                               | 385.21±41.82                                             |
| QTc interval (ms)                                            | 434.6±16.53                                             | 441.9±32.39                                             |
| R wave-V5 (mV)                                               | 1.72±0.298                                              | 1.246±0.506                                              |
| S wave –V1 (mV)                                              | 1.15±0.461                                              | 0.926±0.482                                              |
| R (V5) + S (V1)                                              | 2.88±0.546                                              | 2.170±0.751                                              |

The results are expressed as mean ±SD, *P < 0.05, †P < 0.02, ††P < 0.01, **P < 0.002, compared with baseline values P > 0.05 for all measurements

### Table 4: Effect of mobile frequency on the electrocardiograph parameters in Group II patient according to the risk factors of diabetes mellitus and/or hypertension
in healthy subjects. Changes in heart rate variability during the call with a mobile phone could be affected by electromagnetic field but the influence of speaking cannot be excluded.[9]

Mobile phone has caused changes in heart rate variability indices and the change varied with its position. An increase in heart variability is observed when mobile phone is kept close to the chest and a decrease when kept close to the head.[10] In this study significant differences were observed in ECG parameters when the mobile phone placed at belt level compared with that over precordium. Braune et al., found that exposure to electromagnetic fields did not increase sympathetic vasoconstrictor activity, and the changes in blood pressure, the release of norepinephrine and heart rate variability were independent of the electromagnetic field exposure.[11] This study adds new information that the radiofrequencies of mobile phone do not interact with the antiarrhythmic drugs which act at different levels of generation and conduction of cardiac impulses. In this study patients with risk factors are more prone to the effect of electromagnetic energy on the heart compared with those without risk factors. This observation is of great importance because recent advances in management of hypertension and diabetes are using tele-technology in monitoring those patients.[12,13] Therefore frequent ECG records are necessary to do in hypertensive and/or diabetic patients used tele-management system to control their illnesses. It concludes that mobile EMR interferes with the cardiac impulses in patients with ischemic heart disease and this effect not interacts with using antiarrhythmic drugs. Hypertensive or diabetic patients are more prone to the effect of mobile EMR.

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