

The cardiac effects of a mobile phone positioned closest to the heart

Cep telefonunun en yakın pozisyonda kalbe etkileri

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ABSTRACT

Objective: The aim of this study was to evaluate the effect of mobile phone (MP) on cardiac electrical activity by examining the heart rate variability (HRV), QT, P dispersions and blood pressure (BP) while the MP is located on the precordium.

Methods: A total of 24 healthy volunteers were included in this prospective study. In the first step; 12-lead electrocardiogram (ECG) and BP recordings of the subjects without MP, while the MP is off, on, and ringing were recorded. In the second step; rhythm and BP were recorded for 30 minutes with the Holter without MP, and when the MP was "on" at the precordial location. P-wave and QT interval dispersions were measured from 12-lead ECG, while Holter 24-hour recordings were used for HRV analysis. Statistical analysis was performed using paired t test for comparison of hemodynamic and HRV variables without MP and during MP on. ANOVA for repeated measures was used to compare hemodynamic and ECG variables through baseline and 3 experimental settings: MP on, off and ringing.

Results: There were no statistically significant differences between the groups in the BP, heart rate, P-wave dispersion, QT dispersion and QT corrected dispersion parameters ($p>0.05$) in the first step of the study. In the second step, there were no significant differences between two groups in the BP, heart rate and HRV parameters ($p>0.05$).

Conclusion: We conclude that MP has no effect on hemodynamic (heart rate, blood pressure) and cardiac electrical activity (P-wave and QT dispersions) parameters when it is positioned on the chest in immediate proximity to the heart, and it does not cause cardiac autonomic dysfunction examined by HRV analysis in healthy adult subjects. (*Anadolu Kardiyol Derg 2009; 9: 380-4*)

Key words: Mobile phone, blood pressure, heart rate, P-wave dispersion, QT dispersion, heart rate variability

ÖZET

Amaç: Bu çalışmanın amacı cep telefonu (CT) prekordiyal bölgedeyken kalp hızı değişkenliği (KHD), QT ve P-dalga dispersiyonu ve kan basıncı (KB) değerlerini kullanarak kardiyak elektriksel aktiviteye CT'nun etkisini değerlendirmektir.

Yöntemler: Bu prospektif çalışmaya 24 sağlıklı gönüllü alındı. İlk aşamada, CT olmaksızın, CT prekordiyal bölgede kalbin üzerinde kapalı, açık ve aranırken modlarında 12 derivasyonlu elektrokardiyografi (EKG) ve KB değerleri kaydedildi. İkinci aşamada; CT olmaksızın ve CT açık ve prekordiyal bölgedeyken 30'ar dakikalık Holter-EKG ve tansiyon-Holter ölçümleri yapıldı. P-dalga ve QT dispersiyonu 12 derivasyonlu EKG kayıtlarından hesaplandı, KHD ise 24-saat Holter kayıtlarından ölçüldü. İstatistiksel analizde, cep telefonu olmaksızın ve CT açık modunda, hemodinami ve KHD parametrelerinin karşılaştırılması için eşleştirilmiş t testi kullanıldı. Cep telefonu olmaksızın, kapalı, açık ve aranırken modlarında, hemodinami ve EKG parametrelerinin karşılaştırılması için tekrarlayan ölçümler için ANOVA testi kullanıldı.

Bulgular: Çalışmanın ilk aşamasında; gruplar arasında KB, kalp hızı, P-dalga ve QT dispersiyonu parametreleri açısından anlamlı ilişki tespit edilmedi ($p>0.05$). İkinci aşamada; 2 grup arasında KB, kalp hızı ve KHD parametreleri arasında anlamlı ilişki saptanmadı ($p>0.05$).

Sonuç: Sağlıklı erişkin bireylerde CT farklı modlarda kalbe en yakın pozisyonda kalp hızı, kan basıncını etkilememekte ve kardiyak otonomik disfonksiyona neden olmamaktadır. (*Anadolu Kardiyol Derg 2009; 9: 380-4*)

Anahtar kelimeler: Cep telefonu, kan basıncı, kalp hızı, P-dalga dispersiyonu, QT dispersiyonu, kalp atım hızı değişkenliği

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Introduction

A number of studies investigating the effect of mobile phones (MP) on human health (on reproductive system, central nervous system, human auditory brainstem, cardiovascular system (CVS), cognitive functions and carcinogenesis etc.) have recently been published (1-5).

The effects of MP on heart rate (HR), blood pressure (BP), and heart rate variability (HRV) parameters were evaluated from a particular distance, at headset or handset position while MP was on or off position, and different results had been obtained (6-10). However, the effects of MP have not been evaluated at the position closest to the heart and the ringing mode of MP.

In this study, we aimed to evaluate the effects of MP (on, off and ringing mode) on cardiac electrical activity, including dispersion of atrial conduction by means of P wave dispersion analysis, spatial dispersion of repolarization using QT dispersion analysis, and cardiac autonomic modulation by examining the HRV in healthy subjects when the MP is in immediate proximity to the heart.

Methods

Participants

A total of 24 healthy volunteers were included in this prospective study. Their age, sex, body-mass index (BMI), attitudes, and previous medical history were recorded.

Exclusion criteria; Participants who had disorders such as known anemia, electrolyte imbalance, ischemic or rheumatic heart disease, left ventricular dysfunction, hypertension, diabetes mellitus, thyroid disorders, participants taking drugs affecting cardio-respiratory responses (such as anti-psychotics, anti-depressants, anti-arrhythmic drugs), smoking or using alcohol were excluded.

The protocol was in agreement with the ethical guidelines of the Research Committee and the relevant standards of the revised Declaration of Helsinki (1983). Informed consent was obtained from the all participants.

Study protocol

Nokia 2600 MP (95 g. 900-1800 Mhz Dual band, 2.0 W/kg, Nokia Corporation, Helsinki, Finland) was used, and it was put in a short pocket suspended from the neck, and placed in the left parasternal area between the second and fifth intercostal spaces of anterior chest wall. Mobile phone was set into silent mode (not vibrate or illuminate) so that the participants were not able to understand if it was on, off, or ringing.

Participants were asked not to eat chocolate or drink tea, coffee, cola-containing, or alcoholic beverages, and not to take a long cellular or wireless call (longer than 60 min). The effect of electromagnetic field of the MP on rhythm and hemodynamics was evaluated by Holter electrocardiographic (ECG), 12-lead ECG analyses and BP measurement. In the first step; 12-lead ECG and BP recordings of the participants without MP (base-

line) were recorded. Then the MP was kept on precordial location of chest for one minute, and 12-lead-ECG and BP recordings of the participants while the MP is off (MP off), on (MP on), and ringing (MP ringing) (dialer is outside the room) were recorded. In the second step; the rhythm and BP were recorded with the Holter for 30 minutes without MP (baseline), and then MP was set to "on" position at the precordial location, and recordings were repeated (MP on).

ECG Analysis

The 12-lead ECGs were recorded from each participant with sinus rhythm (25 mm/s rate and 1 cm/mV amplitude). Electrocardiographic measurements were made by one of the authors who was unaware of the individuals that the ECGs had been obtained from. Electrocardiograms were transferred to a personal computer via a scanner, magnified 400 times by Adobe Photoshop software, and then the duration of P wave, QT and RR intervals were measured.

The starting point of P wave was referred as the positive deflection crossing the isoelectric line and the end-point was referred as the end of the deflection crossing the isoelectric line. The participants were excluded if these points were not clear. The P wave dispersion (Pdisp) was calculated by subtracting the minimum P wave (Pmin) duration time from the maximum duration (Pmax). QT interval, which is the duration from beginning of QRS complex to the end of T wave, was measured in all derivations in which T wave was clearly seen and not mixed with a U wave. Derivations in which the beginning and endpoint of QT could not be distinguished were excluded from analysis. Cases of which at least 8 derivations and at least 3 precordial derivations could be measured were included in the study. QT dispersion (QTd) was defined as the difference between the longest QT interval (QT max) and shortest QT interval (QT min). Measured QT intervals were corrected by Bazett's Formula (QT/\sqrt{RR}), and defined as corrected QT interval (QTc). The difference between the longest QTc (QTc max) and shortest QTc (QTc min) was defined as corrected QTd (QTcd).

Holter Analysis

Holter ECGs were analysed using the Del Mar Reynolds Pathfinder Holter system (USA). The HRV was analyzed over a 30-minute period of ECG recording and time-domain measures were assessed according to European Society of Cardiology/ North American Society of Pacing and Electrophysiology guidelines (11). The following time-domain parameters were calculated: mean of all normal RR intervals (mean RR); standard deviations of all normal-to normal (NN) intervals (SDNN); mean of the standard deviations of all NN intervals for all 5-minute segments of the entire recording (SDNNI); standard deviation of the averages of NN intervals in all 5-minute segments of the entire recording. (SDANN); the square root of the mean of the sum of the squares of differences between adjacent NN intervals (rMSSD); count of the total number of differences between adjacent RR intervals that were greater than 50 ms (sNN50 total); the number of all RR intervals divided by the number of RR

intervals of the most frequent RR interval length, triangular index (TAI). In addition to HRV analysis, QT analysis was automatically performed.

Heart Rate and Blood Pressure Analyses

In the first step of the study; HR was recorded by automatic measurement from ECG recordings. Blood pressure was measured manually in standard fashion using the Schiller BR-102 plus semi-automated device, and systolic and diastolic BP results were recorded. In the second step during the 30-minute Holter recordings, 10- minute interval was used for repetitive BP recordings which were taken automatically by Schiller BR-102 plus semi-automated device. Mean systolic and diastolic BP, mean arterial pressure (MAP), mean HR, minimum HR, maximum HR and pulse pressure (PP) were recorded.

Statistical Analysis

Statistical analysis was performed using the Statistical Package for Social Sciences (SPSS, Chicago, IL, USA), version 11.0 software for Windows. Descriptive statistics were made and all data were expressed as mean±standard deviation and percentages. Paired t test was used for comparison of hemodynamic and HRV variables without MP and during MP on. ANOVA for repeated measures was used to compare hemodynamic and ECG variables through baseline and 3 experimental settings: MP on, off and ringing. P value of < 0.05 was considered as statistically significant in all cases.

Results

A total of 24 healthy male participants (mean age 32±5 years;) were included in the study. All participants were in sinus rhythm throughout the recording period. In the first step; there were no significant differences between the groups in the systolic and

diastolic BP, HR, Pdisp, QTd and QTcd parameters (p>0.05). In the second step, there were no significant differences between two groups in the BP, HR, QTd, QTcd and HRV parameters (p>0.05). Results are summarized in Table 1 and Table 2.

Discussion

In this study, the effects of MP (on, off and ringing mode) on cardiac electrical activity, including P wave and QT dispersion analysis, HRV, HR, and BP parameters were evaluated at the position closest to the heart in healthy adult subjects. We conclude that MP has no effect on these parameters in different modes.

Many MP provocation studies have been conducted since the question of increased health risk from extended use of MPs has become a social issue. Most studies about MPs are related to their effects on cardiovascular system, which have first started with evaluating the impact on cardiac pacemakers (12). Following studies tried to demonstrate the effects on cardiac tissue, HR, BP and HRV parameters. Özgüner et al. (13) showed that MP increased the oxidative stress in heart tissue. Different results about this subject were obtained in previous studies. Vangelova et al. (14) found that electromagnetic radiation exposure increased BP. Szmigielski et al. (15) reported BP and HR changes in subjects working in electromagnetic fields.

Effects of signals from a MP handset on the BP of normal volunteers were first reported by Braune et al. (16), and he showed an increase of 5-10 mmHg. Hietanen et al. (7) found that MP effected BP and HR among healthy adults. Another study in pregnant women revealed an increase in fetal and neonatal HR, and decrease in cardiac output (17). However, this relationship has not been confirmed by studies evaluating the acute effects of MP on HR and BP (6, 8, 10, 18, 19).

In studies evaluating the effects of electromagnetic field on HR and BP, the MP was used in "on" mode and as handset,

Table 1. Comparison of electrocardiographic, heart rate and blood pressure parameters of subjects in the first step

Variables	Baseline	MP off	MP on	MP ringing	F*	p*
SBP, mmHg	119.9±8.9	120±8	119.2±8.3	115.6±15.3	0.530	0.667
DBP, mmHg	71.6±8.7	71.2±7.8	72.2±6.9	72.7±14.6	0.684	0.572
MHR, bpm	69.5±9.1	70.2±10.3	70±10.8	70.7±9.7	1.574	0.225
Pmin, ms	64.6±9.5	63.5±7.7	65±8.8	62.6±9.9	0.529	0.667
Pmax, ms	96.8±12.9	101.1±13.4	102.3±9.7	99.5±11.8	1.834	0.172
Pdisp, ms	32.1±8.3	37.6±12.1	37.3±7.3	36.8±13.3	1.542	0.233
QTmin, ms	321.3±16	322.1±18.6	317.5±23.3	319.3±19	0.774	0.522
QTmax, ms	363.6±22.3	365±21.5	364.1±20.6	365±22.1	0.101	0.959
QTd, ms	43.1±20.6	42.1±19.6	46.5±19.4	45.1±17.5	0.662	0.584
QTcmin, ms	10.9±0.5	11±0.7	10.9±0.9	10.8±0.8	0.745	0.537
QTcmax, ms	12.4±0.6	12.4±0.6	12.5±0.7	12.4±0.5	0.289	0.832
QTcd, ms	1.4±0.5	1.4±0.7	1.5±0.7	1.7±0.6	1.046	0.393

Data are represented as Mean±SD

*ANOVA for repeated measures test

DBP - diastolic blood pressure, MHR - mean heart rate, MP - mobile phone, Pmin P wave minimum duration, Pmax P-wave maximum duration, Pdisp - P wave dispersion, QTmin QT interval minimum duration, QTmax - QT interval maximum duration, QTd QT dispersion, QTcmin - QT corrected interval minimum duration, QTcmax - QT corrected interval maximum duration, QTcd - QT corrected dispersion, SBP - systolic blood pressure

Table 2. Comparison of blood pressure, heart rate, QT dispersion and heart rate variability in the second step

Variables	Baseline	MP on	p*
SBP, mmHg	120.1±9	118.8±9.6	0.647
DBP, mmHg	73±5.8	72.8±6.6	0.889
MAP, mmHg	92.5±12.4	92.8±8.3	0.923
Pulse pressure, mmHg	46.9±7	46.7±7.4	0.901
Mean heart rate, bpm	71±9.9	69.7±10.8	0.674
Mean RR, ms	857.8±133.2	848.7±122.5	0.807
SNN50total, count	13.982±13.425	16.226±13.334	0.564
SDNN, ms	66.9±27.9	79.2±29.5	0.145
SDNNI, ms	57.6±17.9	65.1±24.4	0.230
SDANN, ms	24.2±18.8	36.9±31.1	0.094
RMSDD, ms	36.4±18.6	40.8±19.3	0.425
TAI	16±7.8	16.2±7.1	0.908
QT, ms	366.4±23	364.5±28.2	0.806
QTd, ms	14.2±6.5	13.7±4.8	0.765
QTc, ms	396.1±32.6	397.1±31.4	0.915
QTcd, ms	21.5±9.2	20.5±6.5	0.665

Data are represented as Mean±SD

*Paired t test

DBP - diastolic blood pressure, MAP - mean arterial pressure, MP - mobile phone, QTmin - QT interval minimum duration, QTmax - QT interval maximum duration, QTd - QT dispersion, QTcmin - QT corrected interval minimum duration, QTcmax - QT corrected interval maximum duration, QTcd - QT corrected dispersion, SBP - systolic blood pressure, SDANN - standard deviation of the averages of NN intervals in all 5-minute segments of the entire recording, SDNN - standard deviations of all normal-to normal (NN) intervals, SDNNI - mean of the standard deviations of all NN intervals for all 5-minute segments of the entire recording, rMSSD - the square root of the mean of the sum of the squares of differences between adjacent NN intervals, sNN50 total - count of the total number of differences between adjacent RR intervals that were greater than 50 ms, TAI - triangular index

headset or at a particular distance for a similar time to our study. In our study the MP was much closer than the previous studies to the heart, and it was in "off", "on", and "ringing" mode momentarily, and no differences were detected in BP and HR parameters.

It was shown that fetal and neonatal HR was affected while the MP was ringing (17). However, there is no any other study evaluating its effects in "ringing" mode, and in a position close to the heart. Our study supports the studies, which concluded that MP use had no effect on HR and BP parameters of healthy adults.

P wave dispersion shows atrial electrical activity, and it is a noninvasive indicator that enables the calculation of atrial fibrillation risk on the 12-lead surface ECG (20, 21). Increased QTc and QTd on the surface ECG reflect different aspects of abnormal ventricular repolarization. Several large prospective studies published (22, 23) assessed the predictive value of QTc and QT dispersion on cardiac and all-cause mortality in the general population. These parameters have not been used in studies evaluating the effects of MP on cardiac electrical activity. In this study, we measured P and QT intervals to evaluate the cardiac effects of MP in a close position to heart during off, on and ring-

ing mode. Mobile phone has no effect on those parameters in any of those 3 modes.

Analysis of HRV has been used to assess autonomic function and/or to quantify risk in a wide variety of both cardiac and non-cardiac disorders (24). Decreased HRV is a reflection of enhanced sympathetic overdrive and decreased vagal activity, which has a strong association with the pathogenesis of ventricular arrhythmias and sudden cardiac death in the general population, especially in cardiac patients (11).

In studies evaluating the effects of MP on HRV parameters Sastre et al. (25) and Tabor et al. (9) found that electromagnetic field affects the HRV parameters. Parazzini et al. (26) showed mild relationship with SDNN and TAI parameters, but this relationship is thought to be due to sympathetic response to standing. Huber et al. (27) found a mild relationship between MP usage and HRV parameters. However, this relationship has not been supported by other studies (6, 28, 29). In these studies, effect of MP in on, awake or sleep mode, headset, handset and the effect from a particular distance were evaluated. In our study, there was no difference between HRV parameters in the absence of MP on precordial location, and in the presence of an "on" mode MP on top of the chest closest to the heart within a similar time period of previous studies. These results also show that, similar to most of previous studies, electromagnetic field due to MP does not affect cardiac electrical activity.

It is possible for an MP to affect the ECG machine resulting in a wrong or inadequate diagnosis (30, 31). In our study quality of results from ECG or Holter machines were not affected from this field.

Study Limitations

- 1- Electrocardiograms were only interpreted by one observer unaware of the ECGs.
- 2- The number of cases included in the study is relatively low.
- 3- We could not measure frequency-domain parameters of HRV. But, it has been stated that each of the frequency domain spectral measures has an equivalent time-domain variable, which is highly correlated with it, because both are influenced by the same physiological inputs and because of mathematical relationships (11, 24).

Conclusion

We conclude that MP has no effect on hemodynamic (heart rate, blood pressure) and cardiac electrical activity (P-wave and QT dispersions) parameters when it is positioned on the chest in immediate proximity to the heart, and it does not cause cardiac autonomic dysfunction examined by HRV analysis in healthy adult subjects.

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