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Effect of MRI on ECG Parameters of Patients

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ABSTRACT

Background and Objective: Increasing exposure to magnetic and electromagnetic fields is inevitable. This study evaluates effect of MRI on ECG parameters of patients.

Methods: This is an analytic study conducted in 2015 in the Gonabad MRI center. Eighty-four patients referred to the MRI center were recruited by convenient sampling. Two-lead ECG was measured before and after MRI. MRI was done by Neusoft machine, made in China, with 0.35 Tesla magnetic fields. Data analysis was done by SPSS, version 14.5, using pairwise t-test and Wilcoxon test ($p<0.05$).

Results: Heart rate was 80.63 ± 10.41 beat/minutes before MRI and 71.58 ± 10.22 beat/minutes after MRI. QT interval was 9.70 ± 1.60 mm/s before MRI and 10.95 ± 0.93 mm/s before MRI ($p<0.001$). P-wave duration was 2.16 ± 0.47 mm/s before MRI and 2.12 ± 0.38 mm/s after MRI ($p=0.45$). QRS wave duration was 1.88 ± 0.51 mm/s before MRI and 1.88 ± 0.51 mm/s after MRI ($p=0.64$). PR interval was 4.33 ± 0.92 mm/s before MRI and 4.33 ± 0.78 mm/s after MRI ($p=0.89$).

Discussion: Findings showed that 0.35-tesla MRI can increase QT interval and reduce heart rate; however, it is ineffective on P-wave duration, QRS and PR interval. To control the limitation, patients referred to MRI center for the second time were selected for the study. Moreover, the patients were kept under similar conditions before MRI to avoid moderate and severe anxiety.

Conclusion: This study showed that 0.35 tesla MRI can reduce heart rate and increase QT interval. However, it is ineffective on P-wave duration, QRS and PR interval. Thus, it is suggested to measure these parameters before and after MRI.

Keywords: MRI, electrocardiography, heart rate.

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INTRODUCTION

Electrical impulses originating from sinoatrial node of the heart travel through heart muscle to stimulate heart contraction. Waves resulting from this contraction are recorded by electrocardiograph. Wave recording of electrical activity of the heart done by electrocardiograph is called electrocardiography.[1,2] Since invented by Eindhoven, electrocardiography (ECG) had significantly contributed to medicine and early diagnosis of heart diseases.[3] Over 30 years, magnetic resonance imaging (MRI) has shifted from a method with great potential to one of the primary diagnostic methods for many clinical problems.

Its application was first nerve-centric and now covers all areas of the body.[4] Currently, MRI is one of the most important and most functional medical imaging techniques based on magnetic field. MRI can provide very precise and clear imaging of internal organs. In fact, MRI produces images of tissues and organs in full details without using X-rays; this advantage differentiates it from other techniques.[5]

Advances in the field of electronics and computer software of MRI have increased applications of imaging. MRI provides high-resolution images of organs. Replacing previous techniques, MRI is widely used worldwide.[6] MRI devices, telecommunication and radar devices, wireless transmitters, mobile phones, wireless phones, microwave ovens, video devices and computer monitors are sources of electromagnetic fields.[7] Research has shown that electromagnetic fields generated can cause biological disorders.[8]

Electromagnetic fields impose physiological effects such as increased metabolism, expansion of vessels, pigmentation, and effect on sensory nerves, effect on muscle tissue, damaged cells and tissues, general increase in body temperature, decreased blood pressure and ultimately increased activity of sweat glands on the body.[9]

There are numerous epidemiological and laboratory reports on effects of these fields on biological systems. Studies have shown that electromagnetic fields are effective on many vital phenomena such as growth and cell differentiation, ionic transport, production of free radicals, apoptosis, enzyme activity, changes in hormone levels, changes in some membrane and intracellular proteins, angiotensin II, chromosome damages, blood nitric oxide and immune system.[10]

Table 1 Characteristics of patients referred to MRI center

Age Mean	BMI Mean±SD (kg/m2)	Duration Mean±SD (min)	Site N(%)				Sex N(%)	
			Spine	Head	Knee	Other	Male	Female
40.29±11.91	16.79 ±28.34	17.49±6.70	49(58.3)	9(10.7)	8(9.5)	18(21.5)	38(45.2)	46(54.8)

Table 2 Comparison of ECG parameters before and after MRI

Variable	Before	After	Result
P duration (mm/s)	2.16 ± 0.47	2.12 ± 0.38	Z=0.79 P=0.43
QRS duration (mm/s)	1.85 ± 0.52	1.88 ± 0.51	Z=0.50 P=0.62
PR duration (mm/s)	4.33 ± 0.92	4.33 ± 0.78	Z=0.38 P=0.70
QT duration (mm/s)	9.70 ± 1.60	10.95 ± 0.93	Z=6.56 P<0.001
Heart rate (beat/min)	80.63 ± 10.41	71.58 ± 10.22	T=11.91 P<0.001

In this regard, cardiovascular system is no exception; normal cardiac function which is well coordinated is dependent on electric currents of the heart. Any disruption in automatic functions and electrical current of heart leads to disorders such as arrhythmia. A relatively large current of heart generates about 1×10^{-6} gauss magnetic field around the chest. Experimental and epidemiological studies have shown that exposure to magnetic fields has an effect on heart rate variability.[11] Thus; this study determines the effect of MRI on ECG parameters of patients referred to a MRI center.

METHODS

This analytic study was conducted in 2015 in MRI center of 22th Bahman Hospital, Gonabad. To determine sample size, a pilot study was conducted for variables including heart rate, QT interval and PR. Sample size was calculated by using a formula for comparing means of two dependent populations considering 0.95 interval confidence and 80% test power for all variables.

A larger sample size was obtained for PR interval; thus, 84 samples were recruited for the study by considering 10% chance of attrition. By convenient non-probability method, samples were selected from people referring to the hospital for non-contrast MRI.

In order to eliminate confounding factors, inclusion criteria included consent to participate, 10-30 minutes MRI, one previous experience of MRI, age 20-60 years, non-pregnant patients, not taking drugs such as beta blockers which may alter vital signs, absence of mental disorders and known severe anxiety, no history of underlying disease, no or mild anxiety in Beck anxiety inventory before and after MRI, no comment of MRI personnel in MRI result. Exclusion criteria included lack of consent for participation and interrupted MRI for any reason. By approval of the Research Ethics Committee of Gonabad University of Medical Sciences (code 90. 1393. CER. UMG), the qualified patients referred to the MRI center were recruited for the study.

Objectives of the study were explained for the patients. Written consent was obtained. Beck anxiety test was done. Then, ECG was done before and after MRI. To avoid temperature changes, patients were kept in the center for at least 15 minutes at 25-30°C and 40-50% relative humidity.[12] ECG was done for all patients both before and after MRI in the supine position. The patients were in prone position for at least 5 min before MRI. After MRI, ECG and anxiety test were redone immediately. Patients were excluded if anxiety test ranged from moderate to severe after MRI. A 0.35-tesla MRI Neusoft, China, which was available in the hospital, was used for the study.

Two-lead ECG, heart rate, P-wave duration, QRS complex, PR and QT intervals were measured. Heart rate was determined by dividing 1500 by the number of small squares between two complexes on ECG (note that, none of the subjects had dysrhythmia). ECG parameters were simultaneously checked by two people; parameters were controlled again by both if there was any difference.

Data was analyzed by SPSS, version 14.5. Mean and standard deviation were used for quantitative variables; absolute and relative frequencies were used for qualitative variables. Kolmogorov-Smirnov test was used to determine normality of data. Wilcoxon nonparametric test was used to compare non-normally distributed quantitative variables (P-wave duration, QRS duration, PR interval and QT duration) before and after MRI. Pairwise t-test was used to compare normally distributed quantitative variables (heart rate) in a minute before and after MRI (P<0.05).

RESULTS

As shown in Table 1, participants included 84 patients who were mostly female (54.8%) (Mean age = 40.29 years; mean BMI = 25.36 kg/m^2; mean

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MRI duration = 17.49 min). MRI was mostly taken from spinal cord (58.3%).

There was no significant difference in P-wave duration (p=0.43), QRS (p=0.62) and PR (p=0.70) before and after MRI, while there was a significant difference in QT duration (p<0.001) and heart rate (p<0.001) before and after MRI. QT duration increased and heart rate decreased after MRI (Table 2).

DISCUSSION

This study reviewed and compared ECG of patients before and after MRI. Results showed that 0.35-tesla MRI can increase QT interval and reduce heart rate; however, it is ineffective on P-wave duration, QRS and PR interval.

This is inconsistent with Chakeres et al.[13] who studied normal people under 8-tesla magnetic field and Yang et al.[14] who studied healthy people and patients under 8-tesla MRI; they both found no significant difference in ECG. Sayedyzadeh et al.[15] evaluated electrocardiographic changes in humans exposed to 50 Hz electromagnetic fields. By considering variables such as age, work experience and time-weighted average, they found that exposure to electric and magnetic fields increase QT and PR intervals. This is consistent with current results regarding QT interval. Chakeres et al.[13] who studied normal people under 8-tesla magnetic field, Kim et al.[16] who studied adolescents and adults under 60 Hz magnetic field and Sait et al.[17] who studied effect of 50 Hz magnetic field on human heart rate found no significant change in heart rate; this is inconsistent with current findings.

Through a meta-analysis, Graham et al.[18] showed a significant increase in heart rate under magnetic field; this is inconsistent with current findings. Yang et al.[14] who studied people under 8-tesla MRI and Scherlag et al.[19] who studied dogs under magnetism and cardiac arrhythmia showed that heart rate significantly decreased; this is consistent with current study. Koppel et al.[20] experimentally studied 116 people under 150-micro tesla magnetic field to evaluate effect of static magnetic field on heart rate. They found no significant difference in HRV (heart rate variations); this is inconsistent with current study.

The difference in findings may result from the field used and subjects studied. This study used 0.35 magnetic field on patients. One important limitation of this study is the lack of control group due to ethical considerations. To control this limitation, the patients referred to MRI center for the second time were selected for the study. Moreover, the patients were kept under similar conditions before MRI to avoid moderate and severe anxiety.

CONCLUSION

Findings showed that 0.35-tesla MRI could reduce heart rate and increase QT interval; however, it is ineffective on P-wave duration, QRS and PR interval. Thus, it is suggested to measure these parameters before and after 0.35-tesla MRI.

Studies have shown that international standards of MRI magnetic field are mainly focused on effect of the field on metal objects inside the body or surroundings of the patients, while it is essential to control ECG and heart rate. Because MRI magnetic field may influence health, reduce blood pressure, increase QT interval and increase subsequent arrhythmia.

REFERENCES

1. Suzanne C, Brenda G. Textbook of Brunner and Suddarth's Medical-Surgical Nursing. Translated by Fathollahy AR. 1st ed. Tehran: *Arjmand publication*; 2008.
2. Cohen BJ. Medical Terminology. 6st ed. Philadelphia; Wolters Kluwer. 2011.
3. Omidifar N, Yamani N, Yousefi A. The Effect of ECG Training Workshop on Medical Students' Knowledge of ECG Reading and Interpretation. *Strides Dev Med Educ*. 2007; 3:118-125.
4. Katti G, Ara SA, Shireen A. Magnetic Resonance Imaging (MRI) – A Review. *International journal of dental clinics* .2011;3:65-70.
5. Aliabadi M, Oliaee M, Nowroozi M, Farhadian M, Kamalinia M. Study of occupational exposure to health effects in some magnetic. *Iran Occupational Health* 2013; 10: 45-53.
6. Zolfkhane H, Asgari M. The effect of electromagnetic waves on the brain [MSc Thesis]. *Zanjan: Zanjan University*; 2013.
7. Zare S, Hayat Ghibi H, AlivandeFarkhad S, Taghezadeh A. The effects of extremely low frequency electromagnetic fields on the level of liver enzymes in guinea pigs. *Olomfononhasteie* 2006; 38: 25-30.
8. Khaki A, Behrouz M. Effect of low density electromagnetic on heart tissue of male Rat. *Journal of Gorgan University of Medical Sciences* 2012; 14: 40-46.
9. Jafar A, Sarkar S, Oghabian M. Effects of RF radiation and electromagnetic fields from M.R.I radiation on the process of follicles in adult rats. *Medical Laser* 2009; 3: 13-17.
10. Shahbazi D, Kouhiyan F, Kouhiyan M, Sadeghi B. Effects of M.R.I on sex hormones and other fertility parameters in adult male rats. *ShahrekordUniv Med Sci*. 2011; 13: 35-41.
11. KavyanNesuad R, Hadezadeh N, Mohammad Taghe R, Gharibi F. The effect of electromagnetic waves of mobile phones on blood pressure, heart rate and cardiac arrhythmia. *Journal of Gorgan University of Medical Sciences* 2009; 11: 22-26.
12. Shellock FG, Crues JV. Temperature, heart rate, and blood pressure changes associated with clinical MR imaging at 1.5 *T. Radiology*. 1987; 63: 259-262.
13. Chakeres DW, Kangarlu A, Boudoulas H, Young DC. Effect of static magnetic field exposure of up to 8 Tesla on sequential human vital sign measurements. *J MagnReson Imaging*. 2003; 18: 346-352.
14. Yang M, Christoforidis G, Abduljali A, Beversdorf D. Vital Signs Investigation in Subjects Undergoing MR Imaging at 8T. *AJNR Am J Neuroradiol*. 2006; 27: 922–928.
15. SayedyZadeh A, Nasire P, Zeraate H, Jahangire R. Study of electrocardiogram changes in contact with electromagnetic fields of 50 Hz. *Iranian Journal of Physics*. 2007; 3: 52-43.

16. Kim KS, Choi JL, Kwon MK, Choi JY, Kim DW. Effects of 60 Hz magnetic fields on teenagers and adults. *Environmental Health*. 2013, 12: 1-8.
17. Sait ML, Wood AW, Kirsner RL. Effects of 50 Hz magnetic field exposure on human heart rate variability with passive tilting. *Physiol Meas*. 2006; 27(5): 73-83.
18. Graham C, Cook MR, Sastre A, Gerkovich MM, Kavet R. Cardiac Autonomic Control Mechanisms in Power-Frequency Magnetic Fields: A Multistudy Analysis. *Environmental Health Perspectives* 2001; 108: 737-742.
19. Scherlag BJ, Yamanashi WS, Hou Y, Jacobson JI, Jackman WM, Lazzara R. Magnetism and cardiac arrhythmias. *Cardiol Rev*. 2004; 12: 85-96.
20. Koppel T, Vilcane I, Carlberg M, Tint P, Priiman RK. Riisik, Haldre H, Visnapuu L. The effect of static magnetic field on heart rate variability –an experimental study. *Agronomy Research*. 2015; 13: 765–774.

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