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Original Article

Comprehensive Study about Mobile Phone Radiation Effects on Body Weight and Body Composition

Ramin Rahimnia[1], Alireza Namazi Shabestari[2], Mahdi Khoshchehreh[3], Maryam Aghai[4], Gholamreza Mesbah[5], Parisa Zahmatkesh[6], Leila Zareian Baghdadabad[7], Narges Noori[8], Alireza Khajavi[9], Vahid Abedi Yarandi*[10]

[1]*Department of Medical Nanotechnology, School of Advanced Technologies in Medicine, Tehran University of Medical Sciences, Tehran, Iran*

[2]*Department of Geriatric Medicine, School of Medicine, Tehran University of Medical Sciences, Tehran, Iran*

[3]*Department of Pathology, University of California, Los Angeles, USA*

[4]*Islamic Azad University, Tehran, Iran*

[5]*Department of Comparative Pathology, Urology Research Center, Tehran University of Medical Sciences, Tehran, Iran*

[6]*Department of Genetics, Medical Branch, Islamic Azad University, Tehran, Iran*

[7]*Department of Biology, Medical Biotechnology Research Center, Yazd University, Yazd, Iran*

[8]*Iran Telecommunication Research Center, Tehran, Iran*

[9]*Student Research Committee, Faculty of Paramedical Sciences, Shahid Beheshti University of Medical Sciences, Tehran, Iran*

[10]*Sina Hospital, Tehran University of Medical Sciences, Tehran, Iran*

HIGHLIGHTS

- No significant differences were detected in fat mass, lean mass, and total mass of exposure and control groups at the end of the study.
- In addition, no significant difference was found in histopathology of kidney and liver between exposure and control groups.
- Mobile phone radiation has no harmful effects.

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***Corresponding Author**:
Vahid Abedi Yarandi
Email: drvahidabedi@gmail.com
Address: Sina Hospital, Tehran University of Medical Sciences, Tehran, Iran.

ABSTRACT

Introduction
The present study was a comprehensive study that assessed the effects of exposure to mobile phone radiation on body weight and body composition as well as assessing the critical indicators associated with body composition.

Methods
Twenty rats weighing 200+10g at 4 to 6 weeks of age were individually housed in cages. The rats were randomly divided into the following two groups of 10 animals each: the control group and an exposure group that underwent electromagnetic wave radiation for 4 hours once a day for five weeks. The exposure was given by mobile phone having a specific absorption rate (SAR) of 0.90 watts/kg.

Results
There were no significant differences in mean changes in weight, height, lee index, and chest between the two groups. No significant differences were detected in fat mass, lean mass, and total mass of exposure and control groups at the end of the study. There were no significant differences among groups in FBS, lipid profile, thyroid hormone, kidney function, and appetite-regulating hormones.

Conclusions
The current study showed that exposure to mobile phone radiations for 4 hours once a day for five weeks (SAR of 0.90 Watt/kg) has no adverse effects on the thyroid, kidney functions, and hormonal profiles as well as body weight and body composition.

Keywords: Mobile Phone; Cell Phone; Weight; Body Mass Index; Body Composition

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Introduction

Nowadays, the development of technological devices has dramatically affected the daily life of humanity. Electromagnetic waves or electromagnetic radiations (EMRs), which are emitted by many artificial sources such as x-rays, radio and television stations, and mobile phones, are invisible phenomena having a day effect on people worldwide (1-3). Mobile phones are used near bodies, and the time of usage has been quickly increasing lately. Additionally, data showed the usage of mobile phones has increased not only in adulthood but also among the elderly and youth people, and young children. Thus, there is significant concern about the potential biological effects of electromagnetic radiation liberated from mobile phones. But, data are deficient on the feasible effects of electromagnetic radiation on organisms liberated from mobile phone usage.

Research shows that constant exposure to EMRs could affect human health, such as causing headaches, cancer, and other health hazards (4-7). Exposure to EMR from mobile phones could affect people's health (8). The previous document revealed the significant association between EMR and reproduction, cancer, and neurobehavioral diseases (9-11). Some studies evaluated the effect of EMRs on body weight and literature results are inconsistent (12, 13). These studies assessed only weight index and other anthropometric indices did not evaluate(14) , also it has not been considered the organs function such as thyroid, kidney, and pancreas that can directly or indirectly affect body weight that document shows the EMRs might have a harmful effect on these organs function (15-19). Therefore, no comprehensive study assesses the effects of exposure to mobile phone radiation on body composition and body weight and body composition by considering the indicators related to body mass.

So, the present comprehensive study assessed the effects of exposure to mobile phone radiation on body weight and body composition as well as assessing the critical indicators associated with body composition including thyroid, kidney function, and hormonal profiles.

Methods

All rats cared for according to the principles guidelines of Animal Care and the Ethical Committee of Tehran University of Medical Sciences approved the study (IR. TUMS.SINAHOSPITAL.REC.1399.017). Twenty rats weighing 200+10 g at 4 to 6 weeks of age and were randomly divided into the following two groups of 10 animals each: the control group and the intervention group that underwent electromagnetic wave radiation for 4 hours once a day for five weeks. To make mobile phone waves radiation, we used a wave transmitter with a wavelength equal to a current mobile phone in the standard markets. At the time of wave transmission, the cages of rats were entered into an aluminum box that was located adjacent to the wave transmitter. The exposure was given by mobile phone having a specific absorption rate (SAR) of 0.90 watts/kg. The amount of SAR used in the experiment was the mean of the mobile phone SARs in various mobile modes including calling, listening, airplane mode, and talking. All rats were given unrestricted access to a standard rodent chow.

Anthropometrical parameters and food intake

The weight, length of the body (nose-to-anus), thoracic circumference (immediately behind the foreleg), and abdominal circumference (AC) (immediately anterior to the forefoot) were measured in all rats at the same time of the day at weekly intervals during the 5-week study period. Body mass index (BMI) was calculated as body weight in grams divided by the length in centimeters squared (g/cm^2), and lee index was calculated as the cube root of body weight in grams divided by the length in centimeters. Anthropometric parameters were measured under intraperitoneal ketamine-xylazine anesthesia. Food intake was assessed every day at the same time.

Biochemical parameters

The rats were fasted overnight (10–12 h), and whole blood was sampled directly from the heart of the rats. Fasting blood glucose (FBS) (Biorex, Iran), lipid profile (Biorex, Iran), and insulin (Raybiotech, USA) were assayed. The leptin (MOB00B, R&D, USA), adiponectin (MBS068220, MyBioSource, USA), and ghrelin (CSB-E09816r, cusabio, USA) were assessed using a mouse enzyme-linked immunosorbent assay. Uric acid (Biorex, Iran), creatinine (Biorex, Iran), and thyroid hormones including T3 (MyBioSource, USA), T4 (GenWay Biotech, Inc), and TSH (Creative Diagnostics, USA) were assessed.

Body composition by micro-CT

The three-body composition components, including lean mass, fat mass, and total mass, were measured by micro-CT scanner (LOTUS-inVivo, Advanced Medical

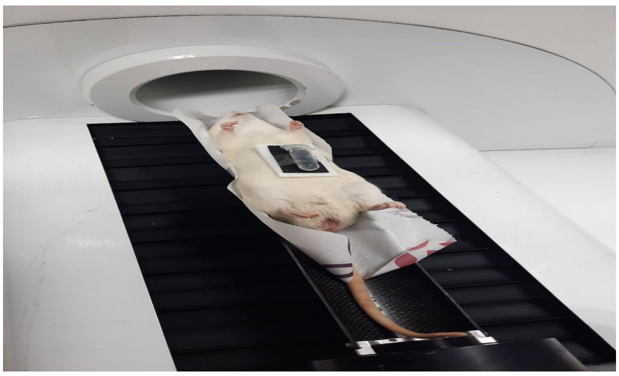

Figure 1. The position of rat on the LOTUS-in Vivo Micro-CT table

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Technologies & Equipment Institute, Tehran University of medical sciences, Tehran, Iran) (Figure 1).

Histopathological evaluation

All rats were sacrificed at the end of the period. Some internal organs such as the kidney and liver were prepared for histopathological examination. For this assessment, 10% neutral-buffered formalin was utilized as a fixative and tissue sections were immersed in it. After fixing the tissues, paraffin embedding in paraffin wax and slide preparation were done before H&E (Hematoxylin and Eosin) staining. Then, all slides were monitored under a light microscope in the comparative pathology laboratory.

Statistical analysis

The continuous variables were reported using mean (standard deviation (SD)) or median (interquartile range (IQR)), depending on whether the distribution is concordant with the normal distribution or not, respectively. The t-test and Mann-Whitney test were used in these two scenarios, in turn. Moreover, the longitudinal mixed-effects models were fitted to measure the gradual changes in the response variables, over the replications. The statistical software Stata (ver. 13) was used to perform the analyses. The statistical significance was set at 0.05.

Results

At the end of the study, the median serology variables in the exposure and control groups were shown in Table 1. The fbses were 125mg/dl and 154mg/dl in exposure and control groups, respectively and there was no significant difference between two groups (P-value=0.1). Also, , no significant differences were observed among exposure and control groups in lipid profiles. The median of T4, T3, and TSH were 3.3µg/dl, 3.5ng/ml, and 3.4ng/ml in the exposure group and 3.7µg/dl, 3.6ng/ml, and 3.7ng/ml in control groups, respectively and no significant differences found among groups (P-value<0.05). Hormonal profiles including leptin, adiponectin, and ghrelin were 336pg/ml, 7.25ug/ml, and 7.15pg/ml, respectively in the exposure group at the end of the study, and were 316pg/ml, 8.7ug/ml, and 7.9pg/ml, respectively in the control group. The results show there were no significant differences between exposure and control groups in the hormonal profile (P-value<0.05). at the end of the study, there were no significant differences between the two groups in Cr, BUN, and Urea (P-value<0.05).

Table 2 showed the median of fat mass, lean mass, and total mass in exposure and control groups at the end of the study. in the exposure group, the fat mass, lean mass, and total mass were 19.34gr, 145.08 gr, and 182.77gr, respectively, and were 13.56gr, 160.54gr, and 176.98gr in the control group, respectively. The findings showed no significant differences in fat mass (P-value=0.1), lean mass (P-value=0.9), and total mass (P-value=0.5) between control and exposure groups at the end of the study.

Table 3 showed the mean of anthropometric indices in exposure and control groups during the study. Significantly, the weight of rats in the exposure group increased from 145.2gr at baseline to 230.67gr at the 5th week and in the control group from 152.34gr to 227.78gr. But there was no significant gradual change between the two groups (P-value=0.133). The mean height increased significantly in exposure (from 16.2cm to 19.93cm) and control group (from 16.37cm to 19.87cm) but no significant difference was found in mean changes of height between the two groups (P-value=0.4). Significantly, the lee index rises from 2.07 gr/cm to 2.25 gr/cm in the exposure group and in the control group from 2.9gr/cm to 2.25gr/cm. there was no significant difference in mean changes of the lee index between the two groups (P-value=0.2). Also, no significant differences were found in mean changes in chest and BMI between the two groups (P-value<0.05).

Figures 2 and 3 showed histopathological sections of the kidney and liver in exposure and control groups. There were no significant differences in histopathology of the kidney and liver between exposure and control groups.

Discussion

The present study assessed the effect of exposure to mobile phone radiation on body weight and body composition in rats by considering the critical indicators associated with body composition. Exposure to an 885-MHz mobile phone did not significantly change the body weight and body composition in five weeks. In addition, thyroid, kidney, and pancreas functions, and the level of adiponectin, leptin, and ghrelin are critical indicators in

Table 1. Effect of cell phone radiation on serology variables

Variables	Exposure group	Control group	P-value
FBS (mg/dl)	125 (115,135)	154.5 (143,166)	0.1
TG (mg/dl)	57.5 (48,67)	54.5 (49,60)	0.9
HDL (mg/dl)	42.75 (41.5,44)	35.75 (32.5,39)	0.1
LDL (mg/dl)	13.9 (10.8,17)	10.2 (9.6,10.8)	0.2
Chol (mg/dl)	58 (58,58)	43.75 (40,47.5)	0.1

Numbers are expressed as median (IQR), p-values from the Mann-Whitney test

Table 2. Effect of cell phone radiation on body composition

Variables	Exposure group	Control group	P-value
Fat mass (g)	19.34 (18.22,37.8)	13.56 (11.15,26.1)	0.1
Lean mass (g)	145.08 (133.01,176.41)	160.54 (130.21,189.08)	0.9
Total mass (g)	182.77 (152.23,213.24)	176.98 (141.37,215.19)	0.5

Numbers are expressed as median (IQR), p-values from the Mann-Whitney test

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Table 3. Effect of cell phone radiation on anthropometric indices

Variables	Base line		Week 1		Week 2		Week 3		Week 4		Week 5		P-value+	P-VALUE ++	p-value+++
	Exposure	**Control**	**Exposure**	**Control**	**Exposure**	**Control**	**Exposure**	**Control**	**Exposure**	**Control**	**Exposure**	**Control**			
Weight (gr)	145.22 (22.64)	152.34 (31.01)	158.94 (28.46)	169.39 (32.78)	186.11 (41.29)	177.76 (35.9)	201.59 (51.62)	199.94 (26.39)	222.54 (44.44)	213.21 (32.72)	230.67 (52.1)	227.78 (41.87)	<0.001	<0.001	0.133
Height (cm)	16.2 (1.02)	16.37 (1.11)	17.9 (1.17)	18.21 (0.83)	18.89 (1.18)	18.73 (0.84)	19.17 (1.21)	18.9 (0.79)	19.02 (1.53)	19.06 (0.85)	19.93 (1.54)	19.87 (0.88)	<0.001	<0.001	0.476
BMI (gr/cm2)	0.55 (0.04)	0.57 (0.09)	0.49 (0.04)	0.51 (0.06)	0.51 (0.06)	0.5 (0.06)	0.54 (0.08)	0.56 (0.06)	0.61 (0.05)	0.58 (0.05)	0.57 (0.04)	0.57 (0.06)	0.192	0.250	0.424
Lee index (gr/cm)	2.07 (0.08)	2.09 (0.11)	2.06 (0.08)	2.09 (0.11)	2.13 (0.12)	2.11 (0.11)	2.17 (0.15)	2.19 (0.08)	2.26 (0.1)	2.23 (0.09)	2.25 (0.11)	2.25 (0.11)	<0.001	<0.001	0.231
Chest (cm)	11.78 (1.16)	11.31 (1.33)	12.85 (0.89)	12.8 (1.19)	13.11 (1.06)	12.43 (1.04)	12.92 (1.24)	12.49 (1.26)	12.99 (0.71)	12.56 (1.07)	13.05 (1.22)	13.09 (1.27)	0.008	0.06	0.543
Waist (cm)	13.5 (1.47)	12.89 (1.64)	13.75 (1.08)	13.52 (1.2)	14.22 (1.35)	13.49 (1.07)	13.96 (1.38)	13.39 (1.51)	13.91 (1.09)	13.63 (1.18)	13.96 (1.31)	14.34 (1.7)	0.342	0.562	0.059

Numbers are expressed as mean (SD);
+: t-test compared the baseline and week 5 of the exposure group;
++: t-test compared the baseline and week 5 of the control group;
+++: longitudinal model compared the gradual change between the two groups

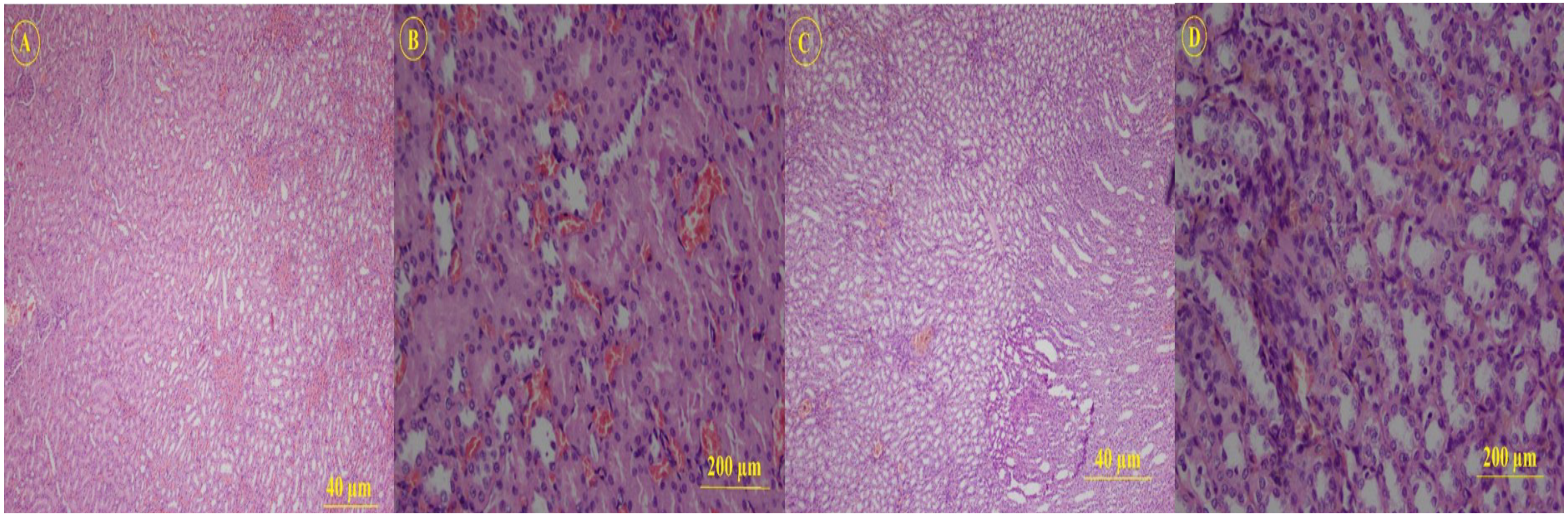

Figure 2. Histopathological sections of the kidney. Photomicrographs of the case group (A, B), and control group (C, D)

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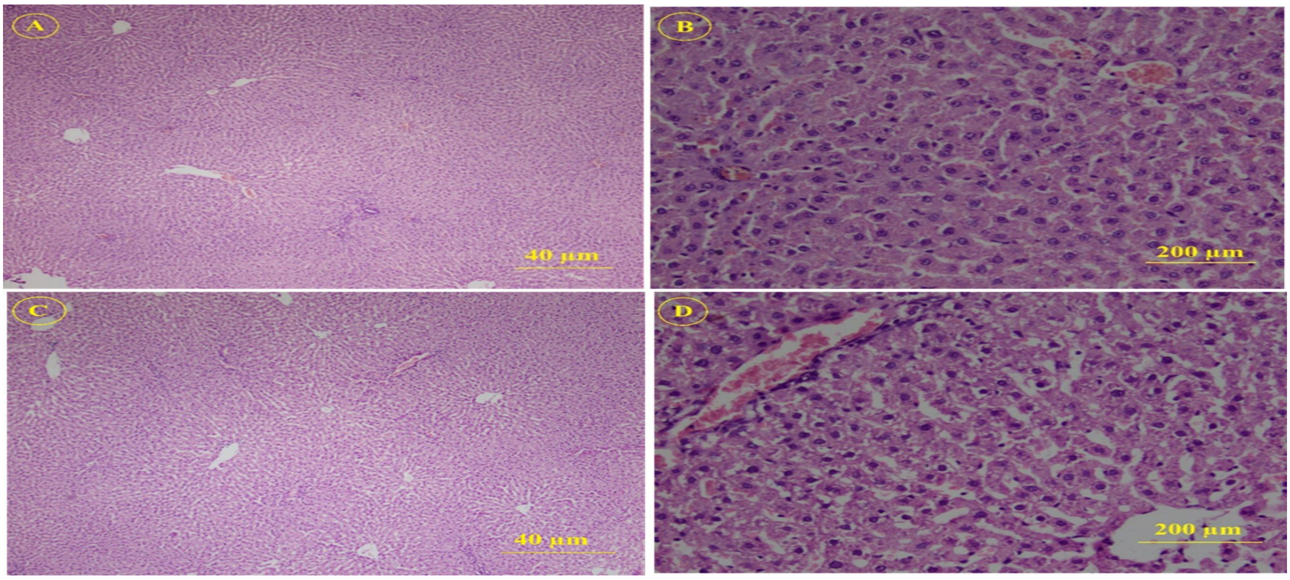

Figure 3. Histopathological sections of the liver. Photomicrographs of the case group (A, B), and control group (C, D)

regulating glucose levels, the fatty acid breakdown and regulating appetite did not significantly change in the exposure group.

The findings of previous studies are inconsistent in assessing the effect of mobile phones on body weight. In this study, no significant differences were found in weight, BMI, or lee index between exposure and control groups; and the micro-CT indicated that the fat mass and lean mass did not significantly differ between exposure and control groups. These findings are consistent with previous studies (20-23). However, it was observed that body weight following exposure to mobile phone radiation decreased (24, 25). Alternatively, Gerardi et al., indicated an increase in body weight after long-term exposure (26). Differences in outcomes between the studies might be caused by differences in study design such as study duration, SAR rate, and sample size.

There were no significant differences in lipid profile and insulin level between the control and exposure groups in the present study. These findings agree with the results of previous studies (27, 28). However, some document shows that extremely low-frequency radiation increases the insulin level, which was associated with the increased size of pancreatic Langerhans islets (29). The primary variations in the methodology might explain these different results. In our study, 855 MHz GSM mobile phone radiation was used, and the duration of exposure was five weeks, but in the mentioned study, 50Hz extremely frequency electromagnetic fields were used for 135 days. The mobile phone radiation did not change the thyroid and kidney function in the current study, and the TSH, T3, and T4 levels and creatinine, uric acid, and BUN were in the same range in the exposure and control groups. On the other hand, there were no significant differences between the levels of adiponectin, ghrelin, and leptin between the two groups. These factors are the indicators that directly or indirectly affect body composition such as fat mass and lean mass (30-33). Due to the no significant change in these indicators, it is to be expected that there was no significant change in anthropometric and body mass indices.

Conclusions

The current study showed that exposure to mobile phone radiations for 4 hours once a day for five weeks (SAR of 0.90 Watt/kg) has no adverse effects on the thyroid, kidney functions, and hormonal profiles as well as body weight and body composition.

Authors' contributions

All authors contributed equally.

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Conflict of interest

All authors declare that there is no conflict of interest.

Funding

There was no funding.

Ethics statement

This study was approved by the Ethical Committee of the Tehran University of Medical Sciences (IR.TUMS. SINAHOSPITAL.REC.1399.017).

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Data availability
Data will be provided on request.

Abbreviations

AC	Abdominal circumference
BMI	Body mass index
EMR	Electromagnetic radiations
FBS	Fasting blood glucose
IQR	Interquartile range
SAR	Specific absorption rate
SD	Standard deviation

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Author (s) biosketches
Rahimnia R, Assistant professor, Department of Medical Nanotechnology, School of Advanced Technologies in Medicine, Tehran University of Medical Sciences, Tehran, Iran.
Email: rrahimnia@tums.ac.ir
Namazi Shabestari A, Associate professor, Department of Geriatric Medicine, School of Medicine, Tehran University of Medical Sciences, Tehran, Iran.
Email: namazialireza109@yahoo.com
Khoshchehreh M, Associate professor, Department of Pathology, University of California, Los Angeles, USA.
Email: mkhoshchehreh@mednet.ucla.edu
Aghai M, PhD, Islamic Azad University, Tehran, Iran.
Email: ma.aghaii@yahoo.com
Mesbah GH, PhD, Department of Comparative Pathology, Urology Research Center, Tehran University of Medical Sciences, Tehran, Iran.
Email: mesbah.gr@gmail.com
Zahmatkesh P, MSc, Department of Genetics, Medical Branch, Islamic Azad University, Tehran, Iran .
Email: parisa.zhmtksh@gmail.com
Zareian Baghdadabad L, PhD, Department of Biology, Medical Biotechnology Research Center, Yazd University, Yazd, Iran.
Email: l-zareian@farabi.tums.ac.ir
Noori N, PhD, Iran Telecommunication Research Center, Tehran, Iran.
Email: nnoori@itrc.ac.ir
Khajavi A, PhD, Student Research Committee, Faculty of Paramedical Sciences, Shahid Beheshti University of Medical Sciences, Tehran, Iran.
Email: alireza.khajavi.student@gmail.com
Abedi Yarandi V, MD, Sina Hospital, Tehran University of Medical Sciences, Tehran, Iran.
Email: drvahidabedi@gmail.com

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