1. **Alhusseiny, A., Al-Nimer, M., & Majeed, A. (2012). Electromagnetic energy radiated from mobile phone alters electrocardiographic records of patients with ischemic heart disease. *Annals of Medical and Health Sciences Research, 2*(2), 146–151**
doi:**10.4103/2141-9248.105662**
ABSTRACT: "BACKGROUND: Electromagnetic energy radiated from mobile phones did not show significant effect on the blood pressure, heart rate, and electrocardiographic (ECG) parameters in animals and humans.AIM: This study aimed to investigate the effect of radiofrequency of mobile phone on the electrocardiographic parameters in patients with history of ischemic heart disease, taking into consideration the gender factor.SUBJECTS AND METHODS: A total number of 356 participants (129 males and 227 females) were admitted in this study. They were grouped into: subjects without cardiac diseases (Group I), patients with ischemic heart disease (Group II), and patients with history of cardiac diseases not related to myocardial ischemia (Group III). Electrocardiogram was obtained from each patient when the mobile phone was placed at the belt level and over precordium in turn-off mode (baseline) and turn-on mode for 40 sec ringing. The records of ECG were electronically analyzed.RESULTS: Prolongation of QTc interval was significantly observed in male gender of Groups I and III (P < 0.001). Male patients of Group II showed significant QTc interval prolongation (P = 0.01) and changes in the voltage criteria (P = 0.001). These changes were not observed in female patients with ischemic heart disease. The position of mobile at the belt level or over the precordium showed effects on the heart.CONCLUSIONS: The radiofrequency of cell phone prolongs the QT interval in human beings and it interferes with voltage criteria of ECG records in male patients with myocardial ischemia."

2. **Andrzejak, R., Poreba, R., Poreba, M., Derkacz, A., Skalik, R., Gac, P., … Pilecki, W. (2008). The influence of the call with a mobile phone on heart rate variability parameters in healthy volunteers. *Industrial Health, 46*(4), 409–417**
ABSTRACT: "It is possible that electromagnetic field (EMF) generated by mobile phones (MP) may have an influence on the autonomic nervous system (ANS) and modulates the function of circulatory system. The aim of the study was to estimate the influence of the call with a mobile phone on heart rate variability (HRV) in young healthy people. The time and frequency domain HRV analyses were performed to assess the changes in sympathovagal balance in a group of 32 healthy students with normal electrocardiogram (ECG) and echocardiogram at rest. The frequency domain variables were computed: ultra low frequency (ULF) power, very low frequency (VLF) power, low frequency (LF) power, high frequency (HF) power and LF/HF ratio was determined. ECG Holter monitoring was recorded in standardized conditions: from 08:00 to 09:00 in the morning in a sitting position, within 20 min periods: before the telephone call (period I), during the call with use of mobile phone (period II), and after the telephone call (period III). During 20 min call with a mobile phone time domain parameters such as standard deviation of all normal sinus RR intervals (SDNN [ms]--period I: 73.94+/-25.02, period II: 91.63+/-35.99, period III: 75.06+/-27.62; I-II: p<0.05, II-III: p<0.05) and standard deviation of the averaged normal sinus RR intervals for all 5-mm segments (SDANN [ms]--period I: 47.78+/-22.69, period II: 60.72+/-27.55, period III: 47.12+/-23.21; I-II: p<0.05, II-III: p<0.05) were significantly increased. As well as very low frequency (VLF [ms2]--period I: 456.62+/-214.13, period II: 566.84+/-216.99, period III: 477.43+/-203.94; I-II: p<0.05), low frequency (LF [ms(2)]--period I: 607.97+/-201.33, period II: 758.28+/-307.90, period III: 627.09+/-220.33; I-II: p<0.01, II-III: p<0.05) and high frequency (HF [ms(2)]--period I: 538.44+/-290.63, period II: 730.31+/-445.78, period III: 590.94+/-301.64; I-II: p<0.05) components were the highest and the LF/HF ratio (period I: 1.48+/-0.38, period II: 1.16+/-0.35, period III: 1.46+/-0.40; I-II: p<0.05, II-III: p<0.05) was the lowest during a call with a mobile phone. The tone of the parasympathetic system measured indirectly by analysis of heart rate variability was increased while sympathetic tone was lowered during the call with use of a mobile phone. It was shown that the call with a mobile

phone may change the autonomic balance 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."

3. **Atlasz, T., Kellényi, L., Kovács, P., Babai, N., Thuróczy, G., Hejjel, L., & Hernádi, I. (2006). The application of surface plethysmography for heart rate variability analysis after GSM radiofrequency exposure. *Journal of Biochemical and Biophysical Methods*, *69*(1–2), 233–236** doi:**10.1016/j.jbbm.2006.03.017** ABSTRACT: "The aim of the present study was to test whether the electromagnetic field emitted by standard GSM mobile phones results in changes in heart rate (HR) and heart rate variability (HRV) of 35 healthy young male and female subjects. Two parallel signals, electrocardiogram and infrared surface plethysmogram were recorded and compared to test their validity for the analysis. Plethysmographic recording is proved to be a fast and reliable method for HRV measurements. In the radiofrequency (RF) exposure study, there was no significant difference in the values of HR and HRV between the RF and the sham groups. Our preliminary study demonstrates that, in our experimental conditions, RF fields emitted by cellular phones do not cause observable effects on the regulation of heart rate of healthy, young adults."

4. **Barker, A. T., Jackson, P. R., Parry, H., Coulton, L. A., Cook, G. G., & Wood, S. M. (2007). The effect of GSM and TETRA mobile handset signals on blood pressure, catechol levels and heart rate variability. *BEM Bioelectromagnetics*, *28*(6), 433–438** ABSTRACT: "An acute rise in blood pressure has been reported in normal volunteers during exposure to signals from a mobile phone handset. To investigate this finding further we carried out a double blind study in 120 healthy volunteers (43 men, 77 women) in whom we measured mean arterial pressure (MAP) during each of six exposure sessions. At each session subjects were exposed to one of six different radio frequency signals simulating both GSM and TETRA handsets in different transmission modes. Blood catechols before and after exposure, heart rate variability during exposure, and post exposure 24 h ambulatory blood pressure were also studied. Despite having the power to detect changes in MAP of less than 1 mmHg none of our measurements showed any effect which we could attribute to radio frequency exposure. We found a single statistically significant decrease of 0.7 mmHg (95% CI 0.3-1.2 mmHg, $P = .04$) with exposure to GSM handsets in sham mode. This may be due to a slight increase in operating temperature of the handsets when in this mode. Hence our results have not confirmed the original findings of an acute rise in blood pressure due to exposure to mobile phone handset signals. In light of this negative finding from a large study, coupled with two smaller GSM studies which have also proved negative, we are of the view that further studies of acute changes in blood pressure due to GSM and TETRA handsets are not required. Bioelectromagnetics 28:433-438, 2007. © 2007 Wiley-Liss, Inc."

5. **Barutcu, I., Esen, A. M., Kaya, D., Turkmen, M., Karakaya, O., Saglam, M., … Kirma, C. (2011). Do mobile phones pose a potential risk to autonomic modulation of the heart? *Pacing and Clinical Electrophysiology: PACE*, *34*(11), 1511–1514** doi:**10.1111/j.1540-8159.2011.03162.x** ABSTRACT: "BACKGROUND: It has long been speculated that mobile phones may interact with the cardiac devices and thereby cardiovascular system may be a potential target for the electromagnetic fields emitted by the mobile phones. Therefore, the present study was designed to test possible effects of radiofrequency waves emitted by digital mobile phones on cardiac autonomic modulation by short-time heart rate variability (HRV) analysis.METHODS AND RESULTS: A total of 20 healthy young subjects were included to the study. All participants were rested in supine position at least for 15 minutes on a comfortable bed, and then time and frequency domain HRV parameters were recorded at baseline in supine position for 5 minutes. After completion of baseline records, by using a mobile

GSM (Global System for Mobile Communication) phone, HRV parameters were recorded at turned off mode, at turned on mode, and at calling mode over 5 minutes periods for each stage.CONCLUSION: Neither time nor frequency domain HRV parameters altered significantly during off mode compare to their baseline values. Also, neither time nor frequency domain HRV parameters altered significantly during turned on and calling mode compared to their baseline values. Short-time exposure to electromagnetic fields emitted by mobile phone does not affect cardiac autonomic modulation in healthy subjects."

6. **Black, D. R., & Heynick, L. N. (2003). Radiofrequency (RF) effects on blood cells, cardiac, endocrine, and immunological functions. *Bioelectromagnetics, Suppl 6*, S187-195** doi:**10.1002/bem.10166** ABSTRACT: "Effects of radiofrequency electromagnetic fields (RFEMF) on the pituitary adrenocortical (ACTH), growth (GH), and thyroid (TSH) hormones have been extensively studied, and there is coherent research on reproductive hormones (FSH and LH). Those effects which have been identified are clearly caused by heating. The exposure thresholds for these effects in living mammals, including primates, have been established. There is limited evidence that indicates no interaction between RFEMF and the pineal gland or an effect on prolactin from the pituitary gland. Studies of RFEMF exposed blood cells have shown that changes or damage do not occur unless the cells are heated. White cells (leukocytes) are much more sensitive than red cells (erythrocytes) but white cell effects remain consistent with normal physiological responses to systemic temperature fluctuation. Lifetime studies of RFEMF exposed animals show no cumulative adverse effects in their endocrine, hematological, or immune systems. Cardiovascular tissue is not directly affected adversely in the absence of significant RFEMF heating or electric currents. The regulation of blood pressure is not influenced by ultra high frequency (UHF) RFEMF at levels commonly encountered in the use of mobile communication devices."

7. **Bortkiewicz, A., Gadzicka, E., Szymczak, W., & Zmyślony, M. (2012). Heart rate variability (HRV) analysis in radio and TV broadcasting stations workers. *International Journal of Occupational Medicine and Environmental Health, 25*(4), 446–455** doi:**10.2478/s13382-012-0059-x** ABSTRACT: "OBJECTIVES: The aim of the study was to assess the mechanism of cardiovascular impairments in workers exposed to UHF-VHF radio frequency electromagnetic fields (EMF).MATERIALS AND METHODS: Heart rate variability (HRV) was analysed using 512 normal heart beats registered at rest. The analysis concerned time-domain (STD R-R) and frequency-domain (VLF, LF, HF) parameters of HRV. Fifty nine workers (group I) with low-level and 12 workers (group II) with high-level exposure were examined. The mean age of the subjects was 47 ± 9 years and 41 ± 14 years, and mean exposure duration 19.1 ± 8.8 years and 13 ± 4 years, in groups I and II, respectively. The groups were divided according to: E(max), E(dose), E(mean) for frequencies UHF, VHF and UHF+VHF: The control group consisted of 42 non-exposed subjects, aged 49 ± 8 years. Statistical analysis comprised one-way analysis of variance, covariance analysis and logistic regression models.RESULTS: In the exposed groups, the heart rate was higher than in the control one. Standard deviation of R-R intervals (STD R-R) was found to be significantly ($p = 0.0285$) lower in group I (42.5 ± 24.7 ms) compared to the control group (62.9 ± 53.5 ms). The risk of lowered STD R-R was significantly increased (OR = 2.37, $p = 0.023$) in group II. Both exposed groups presented significantly higher VLF and LF values than the control group ($p = 0.005$ and $p = 0.0025$, respectively). The EMF-exposed groups were characterised by the dominance of the sympathetic system (LF/HF 1.3 ± 0.35).CONCLUSIONS: The results indicate that exposure to radiofrequency EMF may affect the neurovegetative regulation."

8. **Cherry, N. J. (2002). Cardiac effects of natural and artificial EMR** Retrieved from https://researcharchive.lincoln.ac.nz/handle/10182/4003

9. Colak, C., Parlakpinar, H., Ermis, N., Tagluk, M. E., Colak, C., Sarihan, E., … Acet, A. (2012). Effects of electromagnetic radiation from 3G mobile phone on heart rate, blood pressure and ECG parameters in rats. *Toxicology and Industrial Health, 28*(7), 629–638 doi:**10.1177/0748233711420468** ABSTRACT: "Effects of electromagnetic energy radiated from mobile phones (MPs) on heart is one of the research interests. The current study was designed to investigate the effects of electromagnetic radiation (EMR) from third-generation (3G) MP on the heart rate (HR), blood pressure (BP) and ECG parameters and also to investigate whether exogenous melatonin can exert any protective effect on these parameters. In this study 36 rats were randomized and evenly categorized into 4 groups: group 1 (3G-EMR exposed); group 2 (3G-EMR exposed + melatonin); group 3 (control) and group 4 (control + melatonin). The rats in groups 1 and 2 were exposed to 3G-specific MP's EMR for 20 days (40 min/day; 20 min active (speech position) and 20 min passive (listening position)). Group 2 was also administered with melatonin for 20 days (5 mg/kg daily during the experimental period). ECG signals were recorded from cannulated carotid artery both before and after the experiment, and BP and HR were calculated on 1st, 3rd and 5th min of recordings. ECG signals were processed and statistically evaluated. In our experience, the obtained results did not show significant differences in the BP, HR and ECG parameters among the groups both before and after the experiment. Melatonin, also, did not exhibit any additional effects, neither beneficial nor hazardous, on the heart hemodynamics of rats. Therefore, the strategy (noncontact) of using a 3G MP could be the reason for ineffectiveness; and use of 3G MP, in this perspective, seems to be safer compared to the ones used in close contact with the head. However, further study is needed for standardization of such an assumption."

10. Devasia, T., Nandra, A., Kareem, H., Manu, M. K., & Thakkar, A. S. (2014). Acute Effect of Mobile Phone on Cardiac Electrical Activity in Healthy Volunteers. *International Journal of Clinical Medicine, 05*(05), 167–170 doi:**10.4236/ijcm.2014.55029**

11. Ekici, B., Tanındı, A., Ekici, G., & Diker, E. (2016). The effects of the duration of mobile phone use on heart rate variability parameters in healthy subjects. *Anatolian Journal of Cardiology* doi:**10.14744/AnatolJCardiol.2016.6717** ABSTRACT: "OBJECTIVE: This study aimed to estimate the influence of the duration of mobile phone use on heart rate variability (HRV) in healthy individuals.METHODS: One hundred forty-eight individuals without any established systemic disease and who had undergone 24-h ambulatory ECG monitoring were included in the case-control study. All the individuals had been using mobile phones for more than 10 years. Three-channel 24-h Holter monitoring was performed to derive the mean heart rate, standard deviation of normal NN intervals (SDNN), standard deviation of 5-min (m) mean NN intervals (SDANN), the proportion of NN50 divided by the total number of NNs (pNN50), the root mean square differences of successive NN intervals (RMSSD), high (HF)-, low (LF)-, very low (VLF)-frequency power, total power components, and the LF/HF ratio. Individuals were divided into four groups according to their duration of mobile phone use [no mobile phone use (Control group), <30 min/day (Group 1), 30-60 min/day (Group 2), and >60 min/day (Group 3)].RESULTS: All the groups had similar features with regard to demographic and clinical characteristics. No significant arrhythmias were observed in any of the groups. The LF/HF ratio was higher, whereas the SDNN, SDANN, RMSSD, and pNN50 values were lower in the study groups than in the control group ($p<0.05$). No significant differences were identified among groups with respect to heart rate, VLF, and total power values ($p>0.05$).CONCLUSION: In this study, it was shown that the duration of mobile phone use may affect the autonomic balance in healthy subjects. The electromagnetic field created by mobile phone use may induce HRV changes in the long term."

12. Elmas, O. (2013). Effects of electromagnetic field exposure on the heart: a systematic review. ***Toxicology and Industrial Health*** doi:**10.1177/0748233713498444** ABSTRACT: "The use of electrical devices has gradually increased throughout the last century, and scientists have suggested that electromagnetic fields (EMF) generated by such devices may have harmful effects on living creatures. This work represents a systematic review of collective scholarly literature examining the effects of EMFs on the heart. Although most works describing effects of EMF exposure have been carried out using city electric frequencies (50-60 Hz), a consensus has not been reached about whether long- or short-term exposure to 50-60 Hz EMF negatively affects the heart. Studies have indicated that EMFs produced at cell-phone frequencies cause no-effect on the heart. Differences between results of studies may be due to a compensatory response developed by the body over time. At greater EMF strengths or shorter exposures, the ability of the body to develop compensation mechanisms is reduced and the potential for heart-related effects increases. It is noteworthy that diseases of heart tissues such as myocardial ischemia can also be successfully treated using EMF. Despite the substantial volume of data that has been collected on heart-related effects of EMFs, additional studies are needed at the cellular and molecular level to fully clarify the subject. Until the effects of EMF on heart tissue are more fully explored, electronic devices generating EMFs should be approached with caution."

13. Esmekaya, M. A., Ozer, C., & Seyhan, N. (2011). 900 MHz pulse-modulated radiofrequency radiation induces oxidative stress on heart, lung, testis and liver tissues. ***General Physiology and Biophysics, 30*****(1), 84–89** doi:**10.4149/gpb_2011_01_84** ABSTRACT: "Oxidative stress may affect many cellular and physiological processes including gene expression, cell growth, and cell death. In the recent study, we aimed to investigate whether 900 MHz pulse-modulated radiofrequency (RF) fields induce oxidative damage on lung, heart and liver tissues. We assessed oxidative damage by investigating lipid peroxidation (malondialdehyde, MDA), nitric oxide (NOx) and glutathione (GSH) levels which are the indicators of tissue toxicity. A total of 30 male Wistar albino rats were used in this study. Rats were divided randomly into three groups; control group (n = 10), sham group (device off, n = 10) and 900 MHz pulsed-modulated RF radiation group (n = 10). The RF rats were exposed to 900 MHz pulsed modulated RF radiation at a specific absorption rate (SAR) level of 1.20 W/kg 20 min/day for three weeks. MDA and NOx levels were increased significantly in liver, lung, testis and heart tissues of the exposed group compared to sham and control groups ($p < 0.05$). Conversely GSH levels were significantly lower in exposed rat tissues ($p < 0.05$). No significantly difference was observed between sham and control groups. Results of our study showed that pulse-modulated RF radiation causes oxidative injury in liver, lung, testis and heart tissues mediated by lipid peroxidation, increased level of NOx and suppression of antioxidant defense mechanism."

14. Faust, O., Acharya, U. R., Nergui, M., Ghista, D. N., Chattopadhyay, S., Joseph, P., … Tay, D. (2011). Effects of mobile phone radiation on cardiac health. ***Journal of Mechanics in Medicine and Biology, 11*****(05), 1241–1253** doi:**10.1142/S0219519411004186** ABSTRACT: "Mobile phones (MPs) progressed from a tool of the privileged few to a gadget for the masses. However, the physical effects, which enable wireless information transmission, did not change; MP technology still relies on pulsed high-frequency electromagnetic (EM) fields. Therefore, the health risks, associated with EM fields, remain. Studies that investigated these health risks have reported dizziness, numbness in the thigh, and heaviness in the chest. This study investigates neurological effects that are caused by EM fields radiated from MPs. The heart rate variability (HRV) can be used as a measure for these neurological effects, because the automated nervous system modulates the HRV. We measured the HRV of 14 healthy male volunteers. We used the following nonlinear parameters to quantify the MP radiation effects on HRV: approximate entropy (ApEn), capacity dimension (CaD), correlation dimension (CD), fractal dimension (FD), Hurst exponent (H), and the largest Lyapunov exponent (LLE). The results indicate that there is a

measurable difference in the parameter values when the MP is kept close to the chest and when it is kept close to the head. However, these differences are very small and statistical analysis showed that they have no clinical significance. Furthermore, the result analysis does not show a consistent trend, which indicates that there is no underlying pathological effect."

15. **Green, A. C., Scott, I. R., Gwyther, R. J., Peyman, A., Chadwick, P., Chen, X., … Tattersall, J. E. H. (2005). An investigation of the effects of TETRA RF fields on intracellular calcium in neurones and cardiac myocytes. *International Journal of Radiation Biology, 81*(12), 869–885** doi:**10.1080/09553000600555389** ABSTRACT: "PURPOSE: This study aimed to determine whether Terrestrial Trunked Radio (TETRA) fields can affect intracellular calcium signalling in excitable cells.MATERIALS AND METHODS: Intracellular calcium concentration ([Ca(2 +)](i)) was measured in cultured rat cerebellar granule cells and cardiac myocytes during exposure to TETRA fields (380.8875 MHz pulse modulated at 17.6 Hz, 25% duty cycle). [Ca(2 +)](i) was measured as fura-PE3, fluo-3 or fluo-4 fluorescence by digital image analysis.RESULTS: Granule cells exposed at specific absorption rates (SARs) of 5, 10, 20, 50 or 400 mW x kg(-1) showed no significant changes in resting [Ca(2 +)](i). Increases in [Ca(2 +)](i) in response to potassium-induced depolarization were significantly different from sham controls in TETRA-exposed cells, but the majority of the difference was attributable to initial biological variation between cell cultures. No difference was found between fura-PE3 (UV excitation) and fluo-3 (visible light excitation) measurements in these cells. Exposure to TETRA (50 or 400 mW x kg(-1)) had no significant effect on either the rate or amplitude of spontaneous Ca(2 +) transients in cardiac myocytes. The cells showed normal responses to salbutamol (50 microM) and acetylcholine (10 microM).CONCLUSIONS: Overall, these results showed no evidence of any consistent or biologically relevant effect of TETRA fields on [Ca(2 +)](i) in granule cells and cardiac myocytes at any of the SAR tested."

16. **Havas, M., & Marrongelle, J. (2013). [retracted] Replication of heart rate variability provocation study with 2.4-GHz cordless phone confirms original findings. *Electromagnetic Biology and Medicine, 32*(2), 253–266** doi:**10.3109/15368378.2013.776437** ABSTRACT: "This is a replication of a study that we previously conducted in Colorado with 25 subjects designed to test the effect of electromagnetic radiation generated by the base station of a cordless phone on heart rate variability (HRV). In this study, we analyzed the response of 69 subjects between the ages of 26 and 80 in both Canada and the USA. Subjects were exposed to radiation for 3-min intervals generated by a 2.4-GHz cordless phone base station (3-8 $\mu W/cm^2$). A few participants had a severe reaction to the radiation with an increase in heart rate and altered HRV indicative of an alarm response to stress. Based on the HRV analyses of the 69 subjects, 7% were classified as being 'moderately to very' sensitive, 29% were 'little to moderately' sensitive, 30% were 'not to little' sensitive and 6% were 'unknown'. These results are not psychosomatic and are not due to electromagnetic interference. Twenty-five percent of the subjects' self-proclaimed sensitivity corresponded to that based on the HRV analysis, while 32% overestimated their sensitivity and 42% did not know whether or not they were electrically sensitive. Of the 39 participants who claimed to experience some electrical hypersensitivity, 36% claimed they also reacted to a cordless phone and experienced heart symptoms and, of these, 64% were classified as having some degree of electrohypersensitivity (EHS) based on their HRV response. Novel findings include documentation of a delayed response to radiation. Orthostatic HRV testing combined with provocation testing may provide a diagnostic tool for some sufferers of EHS when they are exposed to electromagnetic emitting devices. The protocol used underestimates reaction to electromagnetic radiation for those who have a delayed autonomic nervous system reaction and it may under diagnose those who have adrenal exhaustion as their ability to mount a response to a stressor is diminished."

17. Havas, Magda. (2010). Provocation study using heart rate variability shows microwave radiation from 2.4 GHz cordless phone affects autonomic nervous system. *European Journal of Oncology Library, 5*, 273–300

18. Havas, Magda. (2011). Pick of the Week 24: Microwave Radiation Affects the Heart. *Havas Website:* *Http://Www.magdahavas.com/Microwave-Radiation-Affects-the-Heart-Are-the-Results-Real-or-Are-They-Due-to-Interference/*

19. Henry, L., Salvatore, & Treadway. (2014). Statement of Retraction: Havas M, Marrongelle J. "Replication of heart rate variability provocation study with 2.4-GHz cordless phone confirms original findings." *Electromagn Biol Med.*

20. Huber, R., Schuderer, J., Graf, T., Jütz, K., Borbély, A. A., Kuster, N., & Achermann, P. (2003). Radio frequency electromagnetic field exposure in humans: Estimation of SAR distribution in the brain, effects on sleep and heart rate. *Bioelectromagnetics, 24*(4), 262–276 doi:**10.1002/bem.10103** ABSTRACT: "In two previous studies we demonstrated that radiofrequency electromagnetic fields (RF EMF) similar to those emitted by digital radiotelephone handsets affect brain physiology of healthy young subjects exposed to RF EMF (900 MHz; spatial peak specific absorption rate [SAR] 1 W/kg) either during sleep or during the waking period preceding sleep. In the first experiment, subjects were exposed intermittently during an 8 h nighttime sleep episode and in the second experiment, unilaterally for 30 min prior to a 3 h daytime sleep episode. Here we report an extended analysis of the two studies as well as the detailed dosimetry of the brain areas, including the assessment of the exposure variability and uncertainties. The latter enabled a more in depth analysis and discussion of the findings. Compared to the control condition with sham exposure, spectral power of the non-rapid eye movement sleep electroencephalogram (EEG) was initially increased in the 9-14 Hz range in both experiments. No topographical differences with respect to the effect of RF EMF exposure were observed in the two experiments. Even unilateral exposure during waking induced a similar effect in both hemispheres. Exposure during sleep reduced waking after sleep onset and affected heart rate variability. Exposure prior to sleep reduced heart rate during waking and stage 1 sleep. The lack of asymmetries in the effects on sleep EEG, independent of bi- or unilateral exposure of the cortex, may indicate involvement of subcortical bilateral projections to the cortex in the generation of brain function changes, especially since the exposure of the thalamus was similar in both experiments (approx. 0.1 W/kg)."

21. Johansen, C. (2004). Electromagnetic fields and health effects--epidemiologic studies of cancer, diseases of the central nervous system and arrhythmia-related heart disease. *Scand.J.Work Environ.Health., 30 Suppl 1:1-30.*, 1–30 ABSTRACT: "This epidemiologic investigation comprised separate studies of the risk of cancer, cause-specific mortality rates, risks for neurodegenerative diseases, and the risk of arrhythmia-related heart disease among employees exposed to extremely low-frequency (50-Hz) electromagnetic fields (EMF) in the Danish utility industry. All the employees in this industry were followed-up in several registers. The risk of disease was analyzed in relation to occupational exposure to EMF, latency, and duration of employment. A specific job-exposure matrix was developed and validated by comparison with direct measurements of EMF during a workday. Linkage with the Danish Cancer Register did not identify increased risks for the cancers suggested a priori to be associated with exposure to EMF, including leukemia, brain tumors, and breast cancer. Significantly increased risks for lung cancer and mesothelioma were identified for workers highly exposed to asbestos. Linkage with the National Mortality Register revealed a significantly increased overall mortality rate from amyotrophic lateral sclerosis (ALS), with an increasing trend with duration of employment and

EMF exposure. In addition, a significantly increased mortality rate from electric accidents was observed. It was hypothesized that the observation of increased mortality from ALS was associated with exposure to EMF or electric shocks. No increased mortality rate from cardiovascular or cerebrovascular disease was observed. Linkage with the National Hospital Register also revealed an increased risk of ALS and, thereby confirmed the finding of an increased mortality rate for this disease in the previous study. Linkage of the cohort with the Multiple Sclerosis Register revealed an increased risk of multiple sclerosis, which was not, however, significant. Linkage with the Pacemaker Register showed no increased risk of severe arrhythmia-related heart disease. The second part of the study included the establishment of a large, nationwide cohort of mobile phone subscribers comprising some 420 000 persons. No increased risk was observed for the cancers considered a priori to be possibly associated with the radiofrequency fields emitted by mobile phones, which were brain tumors, including acoustic neuroma, salivary gland tumors, and leukemia. The data were analyzed by duration of phone use, latency, system used (NMT, GSM or both) and age at first subscription. A study of the incidence of ocular malignant melanoma in comparison with the annual increase among the mobile phone subscribers showed a highly stable incidence rate for this rare cancer in Denmark over close to 50 years of registration. On the basis of these studies and the scientific literature, it is concluded that occupational exposure to 50-Hz EMF is not associated with an increased risk of cancer, but that these fields, electric shocks, or some other unknown factor related to alternating current electricity may be associated with the risk of ALS. There is no clear evidence that 50-Hz EMF is associated with other neurodegenerative or cardiovascular diseases. At present, there is little, if any, evidence that the use of mobile phones is associated with cancer in adults, including brain tumors, acoustic neuroma, cancer of the salivary glands, leukemia, or malignant melanoma of the eye”

22. **Kerimoğlu, G., Mercantepe, T., Erol, H. S., Turgut, A., Kaya, H., Çolakoğlu, S., & Odacı, E. (2016). Effects of long-term exposure to 900 megahertz electromagnetic field on heart morphology and biochemistry of male adolescent rats.** ***Biotechnic & Histochemistry: Official Publication of the Biological Stain Commission*****, 1–10** doi:**10.1080/10520295.2016.1216165**
ABSTRACT: “The pathological effects of exposure to an electromagnetic field (EMF) during adolescence may be greater than those in adulthood. We investigated the effects of exposure to 900 MHz EMF during adolescence on male adult rats. Twenty-four 21-day-old male rats were divided into three equal groups: control (Cont-Gr), sham (Shm-Gr) and EMF-exposed (EMF-Gr). EMF-Gr rats were placed in an EMF exposure cage (Plexiglas cage) for 1 h/day between postnatal days 21 and 59 and exposed to 900 MHz EMF. Shm-Gr rats were placed inside the Plexiglas cage under the same conditions and for the same duration, but were not exposed to EMF. All animals were sacrificed on postnatal day 60 and the hearts were extracted for microscopic and biochemical analyses. Biochemical analysis showed increased levels of malondialdehyde and superoxide dismutase, and reduced glutathione and catalase levels in EMF-Gr compared to Cont-Gr animals. Hematoxylin and eosin stained sections from EMF-Gr animals exhibited structural changes and capillary congestion in the myocardium. The percentage of apoptotic myocardial cells in EMF-Gr was higher than in either Shm-Gr or Cont-Gr animals. Transmission electron microscopy of myocardial cells of EMF-Gr animals showed altered structure of Z bands, decreased myofilaments and pronounced vacuolization. We found that exposure of male rats to 900 MHz EMF for 1 h/day during adolescence caused oxidative stress, which caused structural alteration of male adolescent rat heart tissue.”

23. **Kim, M.-J., & Rhee, S.-J. (2004). Green tea catechins protect rats from microwave-induced oxidative damage to heart tissue.** ***Journal of Medicinal Food, 7*****(3), 299–304** doi:**10.1089/1096620041938551** ABSTRACT: “We investigated the effects of green tea catechin on oxidative damage in microwave-exposed rats. The microwave-exposed rats received

one of three diets: catechin-free (MW-0C), 0.25% catechin (MW-0.25C), or 0.5% catechin (MW-0.5C). Rats were sacrificed 6 days after microwave irradiation (2.45 GHz, 15 minutes). Cytochrome P(450) levels in the MW-0C group was increased by 85% compared with normal, but was 11% and 14% lower in the MW-0.25C and MW-0.5C groups than in the MW-0C group. NADPH-cytochrome P(450) reductase activity in the MW-0C group was increased by 29%, compared with the normal group, but was significantly less in the MW-0.25C and MW-0.5C groups. Superoxide dismutase activity in the MW-0C group was decreased by 34%, compared with the normal group, but in the MW-0.25C and MW-0.5C groups was 19% and 25% higher. The activity of glutathione peroxidase in the MW-0C group was decreased by 28% but remained near normal with catechin supplements. Superoxide radical concentrations in the MW-0C group were increased by 35%, compared with the normal group. However, superoxide radicals in the MW-0.25C and MW-0.5C groups were 11% and 12% lower, respectively, compared with the MW-0C group. Microwave irradiation significantly increased levels of thiobarbituric acid-reactive substances, carbonyl values, and lipofuscin contents, but green tea catechin partially overcame the effects of the microwave irradiation. In conclusion, the mixed function oxidase system was activated, the formation of superoxide radical, lipid peroxide, oxidized protein, and lipofuscin was increased, and the antioxidative defense system was weakened in heart tissue of microwave-exposed rats, but the oxidative damage was significantly reduced by catechin supplementation."

24. Levitina, N. A. (1966). [Non-thermal effect of microwaves on the rhythm of cardiac contractions in the frog]. *Biulleten' Eksperimental'noĭ Biologii I Meditsiny*, *62*(12), 64–66

25. Maioli, M., Rinaldi, S., Santaniello, S., Castagna, A., Pigliaru, G., Gualini, S., … Ventura, C. (2012). Radiofrequency energy loop primes cardiac, neuronal, and skeletal muscle differentiation in mouse embryonic stem cells: a new tool for improving tissue regeneration. *Cell Transplantation*, *21*(6), 1225–1233 doi:**10.3727/096368911X600966** ABSTRACT: "Radiofrequency (RF) waves from Wi-Fi (wireless fidelity) technologies have become ubiquitous, with Internet access spreading into homes, and public areas. The human body harbors multipotent stem cells with various grading of potentiality. Whether stem cells may be affected by Wi-Fi RF energy remains unknown. We exposed mouse embryonic stem (ES) cells to a Radio Electric Asymmetric Conveyer (REAC), an innovative device delivering Wi-Fi RF of 2.4 GHz with its conveyer electrodes immersed into the culture medium. Cell responses were investigated by real-time PCR, Western blot, and confocal microscopy. Single RF burst duration, radiated power, electric and magnetic fields, specific absorption rate, and current density in culture medium were monitored. REAC stimulation primed transcription of genes involved in cardiac (GATA4, Nkx-2.5, and prodynorphin), skeletal muscle (myoD) and neuronal (neurogenin1) commitment, while downregulating the self renewal/pluripotency-associated genes Sox2, Oct4, and Nanog. REAC exposure enhanced the expression of cardiac, skeletal, and neuronal lineage-restricted marker proteins. The number of spontaneously beating ES-derived myocardial cells was also increased. In conclusion, REAC stimulation provided a 'physical milieu' optimizing stem cell expression of pluripotentiality and the attainment of three major target lineages for regenerative medicine, without using chemical agonists or vector-mediated gene delivery."

26. Mann, K., Röschke, J., Connemann, B., & Beta, H. (1998). No effects of pulsed high-frequency electromagnetic fields on heart rate variability during human sleep. *Neuropsychobiology*, *38*(4), 251–256 ABSTRACT: "The influence of pulsed high-frequency electromagnetic fields emitted by digital mobile radio telephones on heart rate during sleep in healthy humans was investigated. Beside mean RR interval and total variability of RR intervals based on calculation of the standard deviation, heart rate variability was assessed in the frequency domain by spectral

power analysis providing information about the balance between the two branches of the autonomic nervous system. For most parameters, significant differences between different sleep stages were found. In particular, slow-wave sleep was characterized by a low ratio of low- and high-frequency components, indicating a predominance of the parasympathetic over the sympathetic tone. In contrast, during REM sleep the autonomic balance was shifted in favor of the sympathetic activity. For all heart rate parameters, no significant effects were detected under exposure to the field compared to placebo condition. Thus, under the given experimental conditions, autonomic control of heart rate was not affected by weak-pulsed high-frequency electromagnetic fields."

27. Parazzini, M., Ravazzani, P., Thuroczy, G., Molnar, F. B., Ardesi, G., Sacchettini, A., & Mainardi, L. T. (2013). Nonlinear heart rate variability measures under electromagnetic fields produced by GSM cellular phones. *Electromagnetic Biology and Medicine, 32*(2), 173–181 doi:**10.3109/15368378.2013.776424** ABSTRACT: "This study was designed to assess the nonlinear dynamics of heart rate variability (HRV) during exposure to low-intensity EMFs. Twenty-six healthy young volunteers were subjected to a rest-to-stand protocol to evaluate autonomic nervous system in quiet condition (rest, vagal prevalence) and after a sympathetic activation (stand). The procedure was conducted twice in a double-blind design: once with a genuine EMFs exposure (GSM cellular phone at 900 MHz, 2 W) and once with a sham exposure (at least 24 h apart). During each session, three-lead electrocardiograms were recorded and RR series extracted off-line. The RR series were analyzed by nonlinear deterministic techniques in every phase of the protocol and during the different exposures. The analysis of the data shows there was no statistically significant effect due to GSM exposure on the nonlinear dynamics of HRV."

28. Parazzini, M., Ravazzani, P., Tognola, G., Thuróczy, G., Molnar, F. B., Sacchettini, A., … Mainardi, L. T. (2007). Electromagnetic fields produced by GSM cellular phones and heart rate variability. *Bioelectromagnetics, 28*(2), 122–129 doi:**10.1002/bem.20275** ABSTRACT: "In this study, 26 healthy young volunteers were submitted to 900 MHz (2 W) GSM cellular phone exposure and to sham exposure in separate sessions. The study was designed to assess cardiac regulatory mechanism in different autonomic nervous system (ANS) states during exposure to low-intensity EMF. Rest-to-stand protocol was applied to evaluate ANS in quiet condition (rest, vagal prevalence) and after a sympathetic activation (stand). The procedure is conducted twice in a double-blind design: once with a genuine EMF exposure and once with a sham exposure (at least 24 h apart). During each session three-leads electrocardiograms were recorded and RR series extracted off-line. Time domain and frequency domain HRV parameters were calculated in every phase of the protocol and during different exposures. The analysis of the data show there was no statistically significant effect due to EMF exposure both on main (i.e., RR mean) and most of the other HRV parameters. A weak interaction between some HRV parameters (i.e., SDNN, TINN, and triangular index in time domain and LF power in frequency domain analysis) and RF exposure was observed and this effect seems to be gathered around the sympathetic response to stand."

29. Powerwatch News. (2010). DECT Cordless Phones (and WiFi) Causes Heart Irregularities. *Powerwatch News*

30. Saili, L., Hanini, A., Smirani, C., Azzouz, I., Azzouz, A., Sakly, M., … Bouslama, Z. (2015). Effects of acute exposure to WIFI signals (2.45GHz) on heart variability and blood pressure in Albinos rabbit. *Environmental Toxicology and Pharmacology, 40*(2), 600–605 doi:**10.1016/j.etap.2015.08.015** ABSTRACT: "Electrocardiogram and arterial pressure measurements were studied under acute exposures to WIFI (2.45GHz) during one hour in adult

male rabbits. Antennas of WIFI were placed at 25cm at the right side near the heart. Acute exposure of rabbits to WIFI increased heart frequency (+22%) and arterial blood pressure (+14%). Moreover, analysis of ECG revealed that WIFI induced a combined increase of PR and QT intervals. By contrast, the same exposure failed to alter maximum amplitude and P waves. After intravenously injection of dopamine (0.50ml/kg) and epinephrine (0.50ml/kg) under acute exposure to RF we found that, WIFI alter catecholamines (dopamine, epinephrine) action on heart variability and blood pressure compared to control. These results suggest for the first time, as far as we know, that exposure to WIFI affect heart rhythm, blood pressure, and catecholamines efficacy on cardiovascular system; indicating that radiofrequency can act directly and/or indirectly on cardiovascular system."

31. Schwartz, J. L., House, D. E., & Mealing, G. A. (1990). Exposure of frog hearts to CW or amplitude-modulated VHF fields: selective efflux of calcium ions at 16 Hz. *Bioelectromagnetics, 11*(4), 349–358 ABSTRACT: "Isolated frog hearts were exposed for 30-min periods in a Crawford cell to a 240-MHz electromagnetic field, either continuous-wave or sinusoidally modulated at 0.5 or 16 Hz. Radiolabeled with calcium (45Ca), the hearts were observed for movement of Ca2+ at calculated SARs of 0.15, 0.24, 0.30, 0.36, 1.50, or 3.00 mW/kg. Neither CW radiation nor radiation at 0.5 Hz, which is close to the beating frequency of the frog's heart, affected movement of calcium ions. When the VHF field was modulated at 16 Hz, a field-intensity-dependent change in the efflux of calcium ions was observed. Relative to control values, ionic effluxes increased by about 18% at 0.3 mW/kg (P less than .01) and by 21% at 0.15 mW/kg (P less than .05), but movement of ions did not change significantly at other rates of energy deposition. These data indicate that the intact myocardium of the frog, akin to brain tissue of neonatal chicken, exhibits movement of calcium ions in response to a weak VHF field that is modulated at 16 Hz."

32. Tahvanainen, K., Niño, J., Halonen, P., Kuusela, T., Laitinen, T., Länsimies, E., … Lindholm, H. (2004). Cellular phone use does not acutely affect blood pressure or heart rate of humans. *Bioelectromagnetics, 25*(2), 73–83 doi:**10.1002/bem.10165** ABSTRACT: "A recent study raised concern about increase of resting blood pressure after a 35 min exposure to the radiofrequency (RF) field emitted by a 900 MHz cellular phone. In this randomized, double blind, placebo controlled crossover trial, 32 healthy subjects were submitted to 900 MHz (2 W), 1800 MHz (1 W) cellular phone exposure, and to sham exposure in separate sessions. Arterial blood pressure (arm cuff method) and heart rate were measured during and after the 35 min RF and sham exposure sessions. We evaluated cardiovascular responses in terms of blood pressure and heart rate during controlled breathing, spontaneous breathing, head-up tilt table test, Valsalva manoeuvre and deep breathing test. Arterial blood pressure and heart rate did not change significantly during or after the 35 min RF exposures at 900 MHz or 1800 MHz, compared to sham exposure. The results of this study indicate that exposure to a cellular phone, using 900 MHz or 1800 MHz with maximal allowed antenna powers, does not acutely change arterial blood pressure and heart rate."

33. Tamer, A., Gündüz, H., & Ozyildirim, S. (2009). The cardiac effects of a mobile phone positioned closest to the heart. *Anadolu Kardiyoloji Dergisi: AKD = the Anatolian Journal of Cardiology, 9*(5), 380–384 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."

34. Trottier, L., & Kofsky, H. (2009). Likely fatal flaw in new Havas heart rate study Retrieved from http://www.emfandhealth.com/EMF&Health%20EHS%20Poor%20Studies%206.html

35. Türedi, S., Hancı, H., Topal, Z., Unal, D., Mercantepe, T., Bozkurt, I., … Odacı, E. (2014). The effects of prenatal exposure to a 900-MHz electromagnetic field on the 21-day-old male rat heart. *Electromagnetic Biology and Medicine*, 1–8 doi:**10.3109/15368378.2014.952742** ABSTRACT: "Abstract The growing spread of mobile phone use is raising concerns about the effect on human health of the electromagnetic field (EMF) these devices emit. The purpose of this study was to investigate the effects on rat pup heart tissue of prenatal exposure to a 900 megahertz (MHz) EMF. For this purpose, pregnant rats were divided into experimental and control groups. Experimental group rats were exposed to a 900 MHz EMF (1 h/d) on days 13-21 of pregnancy. Measurements were performed with rats inside the exposure box in order to determine the distribution of EMF intensity. Our measurements showed that pregnant experimental group rats were exposed to a mean electrical field intensity of 13.77 V/m inside the box (0.50 W/m(2)). This study continued with male rat pups obtained from both groups. Pups were sacrificed on postnatal day 21, and the heart tissues were extracted. Malondialdehyde, superoxide dismutase and catalase values were significantly higher in the experimental group rats, while glutathione values were lower. Light microscopy revealed irregularities in heart muscle fibers and apoptotic changes in the experimental group. Electron microscopy revealed crista loss and swelling in the mitochondria, degeneration in myofibrils and structural impairments in Z bands. Our study results suggest that exposure to EMF in the prenatal period causes oxidative stress and histopathological changes in male rat pup heart tissue."

36. Türker, Y., Nazıroğlu, M., Gümral, N., Celik, O., Saygın, M., Cömlekçi, S., & Flores-Arce, M. (2011). Selenium and L-carnitine reduce oxidative stress in the heart of rat induced by 2.45-GHz radiation from wireless devices. *Biological Trace Element Research*, *143*(3), 1640–1650 doi:**10.1007/s12011-011-8994-0** ABSTRACT: "The aim of this study was to investigate the possible protective role of selenium and L-carnitine on oxidative stress induced by 2.45-GHz radiation in heart of rat. For this purpose, 30 male Wistar Albino rats were equally divided into five groups namely controls, sham controls, radiation-exposed rats, radiation-exposed rats treated with intraperitoneal injections of sodium selenite at a dose of 1.5 mg/kg/day, and radiation-exposed rats treated with intraperitoneal injections of L-carnitine at a dose of 1.5 mg/kg/day. Except for the controls and sham controls, the animals were exposed to 2.45-GHz radiation during 60 min/day for 28 days. The lipid peroxidation (LP) levels were higher in the radiation-exposed groups than in the control and sham control groups. The lipid peroxidation level in the irradiated animals treated with selenium and L-carnitine was lower than in those that were only exposed to 2.45-GHz radiation. The concentrations of vitamins A, C, and E were lower in the irradiated-only group relative to control and sham control groups, but their concentrations

were increased in the groups treated with selenium- and L-carnitine. The activity of glutathione peroxidase was higher in the selenium-treated group than in the animals that were irradiated but received no treatment. The erythrocyte-reduced glutathione and β-carotene concentrations did not change in any of the groups. In conclusion, 2.45-GHz electromagnetic radiation caused oxidative stress in the heart of rats. There is an apparent protective effect of selenium and L-carnitine by inhibition of free radical formation and support of the antioxidant redox system."

37. Wolke, S., Neibig, U., Elsner, R., Gollnick, F., & Meyer, R. (1996). Calcium homeostasis of isolated heart muscle cells exposed to pulsed high-frequency electromagnetic fields. *Bioelectromagnetics*, *17*(2), 144–153 doi:**10.1002/(SICI)1521-186X(1996)17:2<144::AID-BEM9>3.0.CO;2-3** ABSTRACT: "The intracellular calcium concentration ([Ca(2+)]i) of isolated ventricular cardiac myocytes of the guinea pig was measured during the application of pulsed high-frequency electromagnetic fields. The high-frequency fields were applied in a transverse electromagnetic cell designed to allow microscopic observation of the myocytes during the presence of the high-frequency fields. The [Ca(2+)]i was measured as fura-2 fluorescence by means of digital image analysis. Both the carrier frequency and the square-wave pulse-modulation pattern were varied during the experiments (carrier frequencies: 900, 1,300, and 1,800 MHz pulse modulated at 217Hz with 14 percent duty cycle; pulsation pattern at 900 MHz: continuous wave, 16 Hz, and 50 Hz modulation with 50 percent duty cycle and 30 kHz modulation with 80 percent duty cycle). The mean specific absorption rate (SAR) values in the solution were within one order of magnitude of 1 mW/kg. They varied depending on the applied carrier frequency and pulse pattern. The experiments were designed in three phases: 500 s of sham exposure, followed by 500 s of field exposure, then chemical stimulation without field. The chemical stimulation (K+ -depolarization) indicated the viability of the cells. The K+ depolarization yielded a significant increase in [Ca(2+)]i. Significant differences between sham exposure and high-frequency field exposure were not found except when a very small but statistically significant difference was detected in the case of 900 MHz/50 Hz. However, this small difference was not regarded as a relevant effect of the exposure."

38. Yıldız, M., Yılmaz, D., Güler, I., & Akgüllü, C. (2012). [Effects of radiation emitted from mobile phones on short- term heart rate variability parameters]. *Anadolu kardiyoloji dergisi: AKD = the Anatolian journal of cardiology*, *12*(5), 406–412 doi:**10.5152/akd.2012.124** ABSTRACT: "OBJECTIVE: In this study, the effects of radiation emitted from mobile phone (MP) on heart rate variability (HRV) which is accepted a non-invasive indicator of autonomic nervous system (ANS) were investigated with considering the deficiency of previous studies.METHODS: A randomized controlled study has been designed and utilized with 30 young and healthy volunteers. During the experiment that had three periods, the electrocardiogram (ECG) and respiration signals were recorded and MP was attached to subjects' right ear with a bone. Ten subjects selected randomly were exposed to high -level radiation during the second period (Experimental Group 1). Ten of others were exposed during the third period with maximum level radiation (Experimental Group 2). Ten records were also made while MP was closed as a control. Short -term HRV parameters were obtained and repeated measures ANOVA and suitable post-hoc tests applied to the results.RESULTS: According to the results of the repeated measures ANOVA; there were no significant main effects of groups. However, there were some significant differences in measuring time periods and groups*period interactions. The post-hoc tests showed that mean R to R interval and HF power are significantly changed by maximum radiation emitted from MP.CONCLUSION: Due to the radiation emitted from MPs at maximum power, some changes may occur in HRV parameters that are associated with increased parasympathetic activity. But, the level of these changes is similar to daily activities as excitement, and stand up."

39. Yılmaz, D., & Yıldız, M. (2010). Analysis of the mobile phone effect on the heart rate variability by using the largest Lyapunov exponent. *Journal of Medical Systems, 34*(6), 1097–1103 doi:**10.1007/s10916-009-9328-z** ABSTRACT: "In this study, the effects of electromagnetic fields (EMFs) emitted by GSM900 based mobile phones (MPs) on the heart rate variability (HRV) were examined by using nonlinear analysis methods. The largest Lyapunov exponent (LLE) calculation was used to evaluate the effect of MP under various real exposure conditions. Sixteen healthy young volunteers were exposed to EMFs emitted by GSM900 based MP at two levels from a very low EMF (MP at stand-by) to a higher EMF (MP at pre-ring handshaking and ringing). A blind experimental protocol was designed and utilized with consideration to the physiological and psychological factors that may affect HRV. The results showed that the LLE values increased slightly with higher EMF produced by MP ($P < 0.05$). This change indicates that the degree of chaos in the HRV signals increased at higher EMF compared to low level EMF. Consequently, we have concluded that high level EMF changed the complexity of cardiac system behavior, significantly."

40. Zhang, J., Peng, R., Ren, J., Li, J., Wang, S., Gao, Y., … Liu, S. (2011). [The protective effects of Aduola Fuzhenglin on the heart injury induced by microwave exposure in rats]. *Zhonghua Lao Dong Wei Sheng Zhi Ye Bing Za Zhi = Zhonghua Laodong Weisheng Zhiyebing Zazhi = Chinese Journal of Industrial Hygiene and Occupational Diseases, 29*(5), 367–370
ABSTRACT: "OBJECTIVE: To study the protective effects of AduoLa Fuzhenglin(ADL) on the heart injury induced by microwave exposure in rats.METHODS: One hundred forty male Wistar rats were divided randomly into 5 groups: control, microwave radiation, 0.75 g x kg(-1) d(-1) ADL, 1.50 g x kg(-1) d(-1) ADL and 3.00 g x kg(-1) d(-1) ADL pretreatment groups. Rats in three ADL pretreatment groups were administrated by ADL per day for 2w then exposed to 30 mW/cm2 microwaves for 15 min. The left ventricle blood of rats was obtained at 7 d and 14 d after exposure to microwaves, and the blood Ca2+, AST and CK were detected with Coulter automatic biochemical analyzer, then the histological changes and ultrastructure of heart were observed under light and electron microscopes.RESULTS: At 7 d and 14 d after exposure to microwaves, the blood Ca2+, AST and CK concentrations significantly increased ($P<0.05$ or $P<0.01$) as compared with controls; Heart muscle fibers showed wavilness, endotheliocyte karyopyknosis, anachromasis; The mitochondria swelling and cavitation, intercalary dies blurred in radiation groups. The changes in 0.75 g x kg(-1) d(-1) ADL pretreatment group were similar to the radiation group, but in 1.50 g x kg(-1)d(-1) and 3.00 g x kg(-1) d(-1) ADL pretreatment groups, above indexes of rats significantly reduced as compared with microwaves group ($P<0.05$); also the blood Ca2+, AST, CK contents were significantly lower than those in microwave group ($P<0.05$); The heart showed a tendency to improve.CONCLUSION: Microwave radiation (30 mW/cm2) can cause the blood Ca2+, AST and CK turbulence, and heart injury in the histology and ultrastructure; ADL at the dosages of 1.50 g x kg(-1) d(-1) and 3.00 g x kg(-1) d(-1) has a protective effects on the heart injury induced by microwave in rats."

41. Zhu, W., Shen, N., Zhong, X., Hou, J., Lü, S., & Cai, J. (2015). [The cardiac injury effect of microwave radiation on rabbit and its mechanism]. *Wei Sheng Yan Jiu = Journal of Hygiene Research, 44*(5), 818–821 ABSTRACT: "OBJECTIVE: To investigate the cardiac injury effect of different intensities microwave radiation on rabbits and its possible mechanism.METHODS: Rabbits were radiated by intensity of 50, 100, 150 and 200 mW/cm2 2450 MHz microwave for 20 min. 6 h after microwave radiation, the heart tissue was taken. ATP and mitochondria complex IV and V were measured in myocardial cells. The changes of myocardial tissue were observed by light microscopic. The expression of Caspase-3 and HSP 70 were detected by western blotting.RESULTS: The activity of ATP and mitochondria complex IV and V decreased significantly compared with normal control in cardiac tissue. 100, 150 and 200 mW/cm2 microwave radiation group vs. control group ($P <0. 05$). The HE staining result showed that

myocardial cell appears edema, muscle fiber malalignment, cells appeared obvious injury. Results of western blotting showed that the expression of Caspase-3 and HSP 70 protein increased significantly in different dosage radiation group (P <0. 05).CONCLUSION: Microwave radiation has injury effect on rabbit heart. The possible mechanism may be related with inducing cell apoptosis by changing of stress level in myocardial cell."