Effect of electromagnetic interference of digital cellular telephones with different specific absorption rate value on implantable cardioverter defibrillators

Thesis
Submitted for partial fulfillment
Of Master Degree in Cardiology

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2014

سورة النساء (١١٣)

Acknowledgment

First of all, my thanks and all gratitude to ***ALLAH*** *whose help I always seek and without his will this work would not see the light.*

I wish to express my deepest gratitude to ***Prof. Dr. Wagdy Galal*** *Professor of Cardiology, Faculty of Medicine, Ain Shams University, for his great encouragement, support, and kindness. It was a great honor to work under his supervision.*

I am really indebted to ***Prof. Dr. Mervat Abo-Elmaaty****, Professor of Cardiology, Faculty of Medicine, Ain Shams University, who had expressed so much sincere care and devoted much of her time, her kind continuous assistance and her precious remarks which enabled me to go ahead and complete this work.*

My deepest appreciation and profound gratitude to ***Dr. Rania Samir****, Assistant Professor of Cardiology, Faculty of Medicine, Ain Shams University. I appreciated and enjoyed her valuable advice, generous cooperation and great support. Her valuable continuous guidance during this study has made its completion possible.*

Finally, I would like to thank my dear family. And I would like to thank everyone encouraged me even with a little word…even with a little smile.

Amr Salah Kotb Hassan Masaud

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LIST OF ABBREVIATIONS

ACC	**:**	American College of Cardiology.
ACR	**:**	American College of Radiology.
AF	**:**	Atrial fibrillation.
AHA	**:**	American Heart Association.
ARVD	**:**	Arrythmogenic right ventricular dysplasia.
ATP	**:**	Anti-tachycardia pacing.
CABG	**:**	Coronary artery bypass graft.
CEPT	**:**	Conference Europeene des Postes et des Telecommunications
CHD	**:**	Congenital heart disease.
CMOS	**:**	Complementary Metal Oxide Semiconductor.
CRT-D	**:**	Cardiac resynchronization therapy-defibrillator.
CRT-P	**:**	Cardiac resynchronization therapy-pacer.
DC	**:**	Direct current.
DCM	**:**	Dilated cardiomyopathy.
DFT	**:**	Defibrillation threshold.
ECG	**:**	Electrocardiogram.
EMI	**:**	Electro-magnetic interference.
EPS	**:**	Electrophysiological study.
FDA	**:**	Food and Drug Agency.
FVT	**:**	Fast ventricular tachycardia.
GSM	**:**	Global System for Mobile Communication.
Gy	**:**	Grey unit.
HF	**:**	Heart failure.
HOCM	**:**	Hypertrophic obstructive cardiomyopathy.
Hz	**:**	Hertz.
ICD	**:**	Implantable cardioverter defibrillator.
IHD	**:**	Ischemic heart disease.
ILR	**:**	Implantable loop recorder.
IRD	**:**	Implantable rhythm device.
LQTs	**:**	long Q-T syndrome.

LVEF	**:**	Left ventricular ejection fraction.
MI	**:**	Myocardial infarction.
MRI	**:**	Magnetic resonance imaging.
NYHA	**:**	New York Heart Association.
OMT	**:**	Optimal medical therapy.
PCS	**:**	Personal Communication Services.
PPM	**:**	Permanent pacemaker.
PVC	**:**	Premature ventricular complex.
RF	**:**	Radiofrequency.
RR	**:**	Relative risk.
RV	**:**	Right ventricle.
SAECG	**:**	Signal averaged electrocardiogram.
SAR	**:**	Specific absorption rate.
SCD	**:**	Sudden cardiac death.
SVC	**:**	Superior vena cava.
TACS	**:**	Total Access Communication System.
TENS	**:**	Transcutaneous electrical nerve stimulation.
TOF	**:**	Tetralogy of Fallot.
VF	**:**	Ventricular fibrillation.
VT	**:**	Ventricular tachycardia.
VTA	**:**	Ventricular tachyarrythmia.

INTRODUCTION

The development of implantable cardioverter-defibrillators (ICDs) during the past 25 years has revolutionized the approach to prevention of sudden cardiac death (SCD). Multiple clinical trials have defined the indications for ICD therapy in the prevention of primary and secondary SCD. Our current understanding of risk stratification is a victory for evidence-based medicine; perhaps no other area of cardiology has been so rigorously evaluated. ***(Margaret et al., 2007)***

Electromagnetic interference (EMI) is defined as any signal, biological or nonbiological, that is within a frequency spectrum detectable by the sensing circuitry of the ICD. EMI can result in rate alteration, sensing abnormalities, asynchronous pacing, noise reversion, or reprogramming. EMI can also cause failure to deliver antibradycardia pacing, inappropriate delivery of antitachycardia therapy, resetting of programmed parameters, and damage to the pulse generator or myocardial interface. ***(Hayes et al., 1997)***

Mobile phones (also known as cellular or cellphones) allow communication from any location via a network of base stations.

The information is transmitted from the mobile phone to the base station and vice versa via high-frequency electromagnetic fields.

The proportion of the radiation that is absorbed by the body when making a call varies according to the model of mobile phone. It is expressed by the specific absorption rate (SAR). The lower SAR of the device, the lower the radiation that is absorbed by the body. ***(Bit-Babik et al., 2003)***

A SAR value is a measure of the maximum energy absorbed by a unit of mass of exposed tissue of a person using a mobile phone, over a given time or more simply the power absorbed per unit mass. SAR values are usually expressed in units of watts per kilogram (W/kg) in either 1g or 10g of tissue. ***(Bit-Babik et al., 2003)***

AIM OF THE WORK

To investigate whether electromagnetic field generated by mobile phones with different SAR values can interfere with the function of implantable cardioverter defibrillators.

HISTORICAL PERSPECTIVE

The implantable cardioverter-defibrillator (ICD) was the vision of Michel Mirowski, who first implantated a defibrillator in Baltimore in 1980, after more than 10 years of development. The devices were not approved by the US Food and Drug Administration for widespread use until 1985 ***(Kastor et al., 1989).*** The discovery that defibrillation could successfully restore sinus rhythm to fibrillating dog heart was made in the late 1800s in Switzerland and was applied in humans with an external alternating current defibrillator in 1947 by Claude beck at University Hospitals in Cleveland during open heart surgery using paddles applied to the myocardial surface ***(Beck et al,. 1947).*** By the mid 1950s, external closed chest defibrillators had been developed, and by the late1950s alternating current was replaced by direct current power sources. As units became smaller, the 1960s saw the development of smaller, portable units that could be placed in ambulances. The discovery that a biphasic waveform could successfully defibrillate with smaller amounts of energy in greater than 90% of patients has allowed both the external and internal devices become even smaller. ***(Mirowski et al., 1982)***

The earliest implanted devices had limited capabilities with respect to pacemaker function, stored telemetry, and arrhythmia discrimination ability. The only criterion for detection of