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Measurement of Electromagnetic Fields Emitted from Some Medical Devices

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Abstract

New medical devices such as surgery devices, physiotherapy devices, cosmetological devices and Magnetic Resonance Imaging (MRI) systems generate a complex electromagnetic fields, so they consider as a potential hazard for medical personnel during surgical procedures. The aim of this research is to detect the EMFs emitted from medical devices and determine the safety ranges from these devices which emit EMF radiations in order to protect Medical staff from its risks. The research has been performed in two parts, numerical calculation and practical measurement. Practical measurements are done in Dijlah hospital at Tikrit city. Obtaining results shows that the practical measurements are consistent with the mathematical calculation results. Comparison of these results with the safety standard guideline limits shows that they are within the acceptable exposure limits recommended by the International Commission on Non-Ionizing Radiation Protection (ICNIRP) and that means there is no health risk from exposure to these fields if the exposure is for a short and not continued periods and lay within the acceptable limits.

Key words: Medical devices, Health hazard, standard limits for EMF, medical staff

حساب المجالات الكهرومغناطيسية المنبعثة من بعض الاجهزة الطبية

الخلاصة

الأجهزة الطبية الحديثة، كأجهزة التشخيص الطبي وأجهزة العلاج الطبيعي وأجهزة الرنين المغناطيسي تعتبر كمصدراشعاع مجالات مغناطيسية مختلفة والتي بدورها تعتبر كمصدر خطورة على صحة (الكادر الطبي المعالج جراء تعرضه لهذه الإشعاعات أثناء قيامه بمعالجة المرضى عن طريق هذه الأجهزة. إن الهدف من هذا البحث هو تحديد شدة المجالات الكهرومغناطيسية المنبعثة من أجهزة طبية مختلفة وتحديد المديات الآمنة للعمل على هذه الأجهزة لحماية الكادر الطبي من التأثير الصحي السلبي لهذه الأجهزة. تم انجاز البحث بجزأين القياسات العملية و الحسابات النظرية وقد تم اجراء القياسات العملية في مستشفى دجلة للتأهيل الطبي في مدينة تكريت. إن دراسة النتائج أظهرت آن القياسات العملية تتفق مع النتائج النظرية.كما أن مقارنة النتائج الحاصلة مع المعايير الآمنة بينت أن هذه النتائج تقع ضمن الحدود الآمنة المسموح بها دوليا المحددة من قبل ((اللجنة الدولية للحماية من خطر الإشعاع اللاايوني)) وهذا يعني لا خطورة من التعرض لهذه الاشعاعات اذا كانت شدة الاشعاع ضمن الحدود المسموح بها ولفترات قصيرة .
الكلمات الدالة : الاجهزة الطبية ،الاثار الصحية ،المعايير الامنة للإشعاع الكهرومغناطيسي، الكادر الطبي.

List of abbreviations

EMFR: Electromagnetic Field radiation
FCC: Federal Communication Commission
RF : Radio frequency
ICNIRP: International Commission on Non-Ionizing Radiation Protection)
WHO: World Health Organization

Introduction

Electric and magnetic fields are invisible lines of force that surround all electrical devices, home wiring, power lines in the street and high voltage transmission lines. Magnetic fields are not easily shielded by most materials. The intensity of magnetic and electric fields minimizes as you move away from the source [1]. As electricity moves through wires and machines, it produces EMF. Equipments emit magnetic fields all around them, not just in front. Many large devices have very high fields in the back where the motor is located. The magnetic field does not depend on the size of the appliance.[2].

Electromagnetic field radiation (EMFR) in the occupational factor is a health risk factor for some professional groups. One of these professional groups occupationally exposed by EMF is the medical personnel. EMFs of different devices, intensity, and modulation high biological efficiency are used in medicine for diagnostics, preventive maintenance and treatment of different diseases, from the other side they consider a source of different negative health effects for medical personnel group because If patients are exposed by EMF several times only (under diagnostics or treatment) medical personnel are exposed by EMF regularly.[3].

In this research the focus will be on the measurements of magnetic field emitted from some medical devices which work in the frequency of 50Hz.

Previous work

The following paragraphs provide a summary of studies on the biological effects of electric and magnetic fields in various environmental conditions:

- Delaplace and Reilly (1978) placed 122 men subjects directly under overhead transmission lines in various environmental conditions; 90% of them could perceive a 20 kV/m 60 Hz electric field, and perception reached a self reported ‘annoyance’ threshold for 10%. A small percentage reported perception at field strengths below 5 kV/m.[4]
- Schmitt and Tucker (1978) are tested the ability of 200 volunteers to perceive 60 Hz magnetic fields over the range 0.7–1.5 mT and reported little evidence for perception.[5].
- Graham and Cohen (1985) performed a laboratory-based study of the perception of 60 Hz electric fields (0–15 kV/m) and of magnetic fields (0–40 mT) by 10 men and 10 women aged 21–35. The men and women had similar sensitivity. The threshold of 90% of the group was 39kV/m. Perception improved when the field onset was abrupt and when the volunteer changed body position in the field. Perception of initial field onset ceased after about 20 min of continuous exposure but was immediately reestablished by body movements within the field. [6].
- The study of Davanipour et al. (1997) showed an increased risk for workers with the highest exposure, which was significant for those with 20 years’ or more experience [7].

Biological effects

Laboratory studies to date have not answered questions about possible human health effects. These studies are, however, providing clues about how EMFs interact with basic biological processes. The cell membrane may be an important site of interaction with induced currents from EMFs. Damage to tissue may be caused by exposure to high levels of RF energy because the body is not equipped to dissipate the excessive amounts of heat generated. Possible injuries include skin burns, deep burns, heat exhaustion and heat stroke. Eyes are particularly vulnerable to extended exposure to RF energy; the lack of blood flow to cool the cornea can result in cataracts. [8]

Some of these effects are:

-Changes in functions of cells and tissues
-Decrease in the hormone melatonin
-Alterations of immune system
-Accelerated tumor growth
-Changes in biorhythms
-Changes in human brain activity and heart rate [9]

So, there are a number of national and international standards and recommendations dealing with electromagnetic exposure in all frequency ranges. The limits are generally very similar and are usually based on recommendation from the world health organization. In this research the magnetic field levels emitted from some medical devices working in (50 Hz) will be determined , so we will consider (The International Commission on Non-Ionizing Radiation Protection (ICNIRP)), which is applicable in Europe and elsewhere as EMF Exposure Standards as shown in table (2).The exposure level in the Physiotherapy hall consider as a public environment, so we will give (100 µT) as a standard level to be compared with the obtaining results**.**

Methodology

In this research there have been steps of determining the magnetic field levels emitted from some medical devices which operate at frequency of (50Hz) as follows:

- Mathematically calculating the magnetic flux density (B). for some medical devices at three ranges (5cm , 25cm and 75cm).
- Practically measuring the magnetic flux density (B).
  for some medical devices at three ranges (5cm , 25cm and 75cm).
- Practically measuring the magnetic flux density (B) in the Physiotherapy hall which contains ten different physiotherapy devices as shown in figure (1).

Mathematical calculation

The magnetic flux density(B) can mathematically calculating using Amperes law which gives the magnetic flux density (B) when a current (I) flow through the very long conductor.[11]

$$B = \frac{I.\,\mu_0}{2\pi.r} \qquad \dots (1)$$

Where:

B: Magnetic field (magnetic flux density), measured in *Tesla (T)*

I : Electrical current , measured in *ampere (A)*

r : Distance from the source of EMF , measured in *meter (m)*

μ_0: Permeability of free space, measured in *Tesla .meter/ampere* (T . m / A)

$\mu_0 = 4\,\pi \times 10^{-7}$ $(T \,.\, m / A)^{-7}$

Based on Maxwell's equations [12], The magnetic field in any point at work place can be calculated by superimposing the individual contribution of the current of each conductor : as in the following equation:

$$B = \frac{\mu_0}{4\pi} \int_{k_i} \frac{I\mathrm{d}l \times (r)}{|r|} \qquad .(2)$$

Where:

I : Electric current in (Ampere).

r : distance between the observed point and the original conductor [m]

ε – permittivity of space in which the field is calculated′ .

We will apply equation (1) for calculating magnetic field density (B) because we have only one source of magnetic field for each case in determining the magnetic field from medical devices which works individually.

Practical measurements

Practical measurements are carried out by using ENF detector EMF- 824 which provide the user with real able and easy way to measure the electromagnetic field at low frequencies up to (50 HZ) .figure (2).

.The measurements are conducted in micro Tesla at three different ranges:

-At range (0.05 m) from the source .

-At range (0.25 m) from the source .

-At range (0.75 m) from the source .

as shown in table (3).

Results and discussion

Mathematical calculations for magnetic field (B) in a (3) ranges away from medical device for type **(Galva 5**) which work at a frequency of 50 Hz and current flow throw it is (0.3)A is

For a distance: $r = 0.05$ m and current: $I = 0.3 \ A$

$$B = \frac{0.3\ \mu_0}{2\pi\,.\,(0.05)} = \frac{0.3 \times 4\pi \times 10^{-7}}{2\pi\,.\,(0.05)} = \frac{0.6 \times 10^{-7}}{(0.05)}$$

$= 1.2 \times 10^{-6}$ Tesla $= 1.2$ µT < 100 µT micro Tesla .(3)

So, according to (ICINRP), It is a safe range .

This is one example for calculating magnetic field (B) emitted from medical devices.

Calculating and Practical measurements of magnetic field levels Radiated from different medical devices at frequency of 50 Hz at a distance of (`5 cm, 50cm,75cm) from the source are indicated in tables (2) .

Measurements at random point's inside the Physiotherapy hall are carried out to determine the average magnetic exposure level inside the Physiotherapy hall which contain ten deferent Physiotherapy devices and some electrical lighting lamps and some ceiling fans besides of the electrical wiring in the hall . Measurement results are indicated in table (3) and graphical representation illustrated in figure (3).

Figure (4) represent the decreeing of magnetic field strength by increasing the distance from the device type (Microwave R-980) which emits (18 µT) for a range of (5 cm) from the device while it emits , (3.6 µT) for a range of (25 cm) from the device and (1.2 µT) for a range of (75 cm) for the same value of current I = 4.5 A). From the mathematical calculations and the practical results we can see that both measuring results of determining the EMF levels are identical and they are seem to be much lower than the international exposure limits set by the ICINRP (< 100 µT) as shown in tables(2,3) . this meaning that there is no risk from working with these medical devices if the working time is for a short and not continued periods and the exposure level is in the determined safety ranges from the medical devices.

Recommendations

Medical personnel staff recommended using devices that have magnetic radiation at the farthest possible range within which it can still possible to make useful use of these devices and in the same time to guarantee the safety of medical personnel staff. Finally from all previous results and discussion we can conclude that there is no health hazard.

Conclusions

In our everyday life, we are exposed to electromagnetic fields all the time without knowing .Electromagnetic radiation is energy radiated in the form of a wave caused by an electric field interacting with a magnetic field that is produced when electrical charges are accelerated. Normally, electric and magnetic fields occur together and both electric and magnetic field weaken with increasing distance from the source.

Medical devices as any other electrical devices radiate electromagnetic fields. Certain implanted medical devices, such as insulin delivery systems and pacemakers consider a source of electromagnetic field radiations and a wide range of diagnostic medical imaging systems including MRI and Ultra Sound equipment can also be consider as a source of magnetic field. Several medical applications use electromagnetic fields in the RF range. As there is a benefit for the patient, there is a negative health effect for the medical personnel, so exposure of therapists or other medical personnel needs to be periodically controlled to avoid over limit exposure levels. Finally we can conclude that there is no health hazard from working with these medical devices if the work is for a short time and in the indicated safety ranges from the devices.

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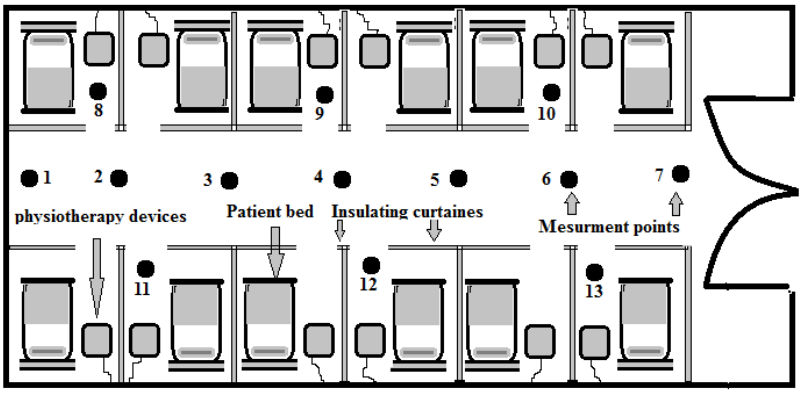

Figure(.1): Physiotherapy hall contains ten different physiotherapy devices

Figure. (2) : EMF tester type EMF- 824 tester

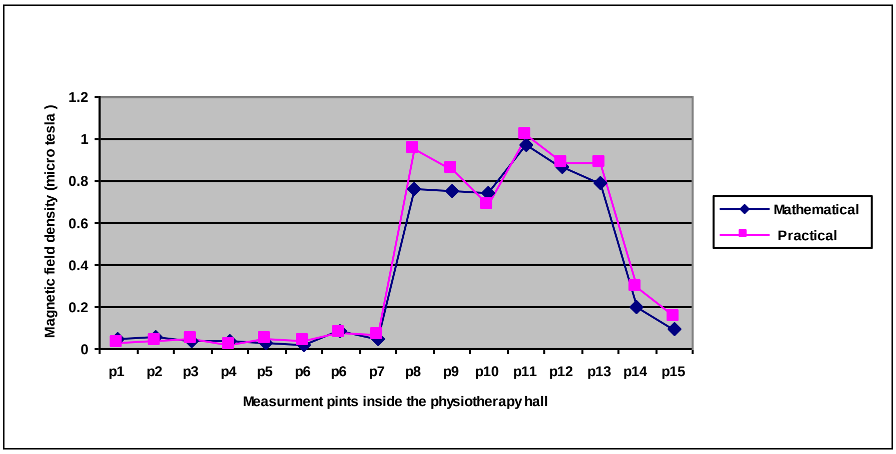

Figure (3):Graphical representation of measurement of magnetic field in random points inside the physiotherapy hall .

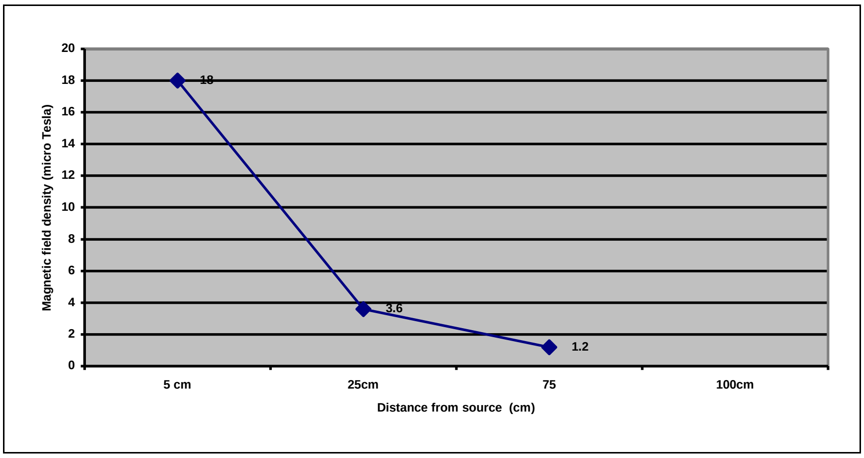

Figure (4):The magnetic field strength reduced by increasing the distance from the source

Table(1): Magnetic field Exposure Standards Applicable in Europe and Elsewhere [10].

Magnetic field Exposure	B(µT)
For occupational	500
For general public	100

Table (2) : Calculating and Practical measurements of magnetic field levels Radiated from different medical devices at distance of (`5 cm) from the source

Medical Device	Current (ampere)	B (µT)at (`5 cm)		B (µT) at(`25cm)		B (µT) at (`75 cm)	
		Practical	Mathematical	Practical	Mathematical	Practical	Mathematical
Galva 5	**0.3**	**1.3**	**1.2**	0.3	0.24	0.09	0.08
Short wave Dx-500	**1.4**	**6**	**5.6**	1.5	1.12	0.5	0.38
Radar med	**1.1**	**5**	**4.4**	1.1	0.88	0.4	0.3
MicrowaveMW300	**1.2**	**4.5**	**4.8**	1.2	0.96	0.4	0.32
Microwave R-980	**4.5**	**19.5**	**18**	4	3.6	1.4	1.2
Carpals (419)	**5.5**	**21**	**22**	4.6	4.4	1.6	1.47
PM-800S	**6**	**23**	**24**	5	4. 8	1.8	1.6
Super freshall-5	**0.1**	**0.4**	**0.3**	0.07	0.08	0.03	0.027
Sono-5	**2**	**7.5**	**8**	1.8	1.6	0.09	0.08
ITO-SW180	**1.3**	**4.6**	**5.2**	1.1	1.04	0.5	0.38

Table (3): Measurements in random points inside the Physiotherapy hall

Area	Measurement points	Magnetic field density (B) in (µT)	
		Mathematical	Practical
Physiotherapy hall	1	0.05	0.03
	2	0.06	0.04
	3	0.04	0.05
	4	0.04	0.02
	5	0.03	0.05
	6	0.02	0.04
	7	0.09	0.08
	8	0.05	0.87
	9	0.76	0.95
	10	0.75	0.86
	11	0.74	0.69
	12	0.97	1.02
	13	0.87	0.98
average		0.47	0.43