

How Much are Anesthesiologists Exposed to Electromagnetic Fields in Operating Rooms?

Jong Hwa Lee¹, Haeng Chul Lee¹, Hoon Do Kim¹, Ji Young Kim¹, Deok Won Kim², Yong Taek Nam¹, and Ki Jun Kim¹

Departments of ¹Anesthesiology and Pain Medicine and ²Biomedical Engineering, Yonsei University College of Medicine, Seoul, Korea

Numerous electronic devices have been introduced into the operating room. Although little is known about the relationship between exposure to electromagnetic fields (EMF) and health hazards, some authors reported its association with cancer or other diseases. We measured the amount of EMF exposure that an anesthesiologist gets in the operating room. The density of the magnetic field was checked by an extremely low frequency (ELF) field strength measurement system in the 19 operating rooms of our hospital. We measured the magnetic field intensity at a distance of 30 cm, 50 cm, and at the place where the anesthesiologist usually stands from the center of the main monitor. The average exposure quantities of magnetic fields in 19 operating rooms were 2.22 ± 1.13 mG at 30 cm, 1.29 ± 0.84 mG at 50 cm and 1.00 ± 0.78 mG at the anesthesiologist's standing points respectively. Because quantities over 2 or 3 mG were accepted to be high radiation levels of EMF by many reports describing the hazards of EMF, we set 2 mG to be the cutoff value. In some of the 19 operating rooms, the measured EMF density exceeded our cutoff value. Although the health hazards related to EMF exposure are still equivocal, anesthesiologists should consider making an effort to improve their environment and reduce their exposure to EMF.

Key Words: Electromagnetic field, operating rooms

INTRODUCTION

Currently, the use of electricity has become one of life's daily necessities. It has brought prosperity and welfare to humanity. As a result, we are constantly exposed to electromagnetic field

(EMF) from electrical appliances. EMF is a form of electromagnetic energy that has a wide range of frequencies from 0 Hz of direct current (DC) to 1015 Hz of ultraviolet radiation. In this report, when we say EMF, we mean the power-frequency of the EMF that is in the extremely low frequency (ELF) range because electricity in operating rooms has a frequency of 50 to 60 Hz. This kind of EMF is produced by power lines, electrical wiring, electrical equipment and many other sources.

The EMF has both thermal and non-thermal effects on living organisms. Microwaves are examples of electromagnetic energy having frequencies ranging from 300 MHz to 300 GHz which produce heat upon tissue absorption. Adey reported occurrences of cataracts in eyes exposed to high frequency EMF.¹ However, an EMF of extremely low frequency (ELF) carries very little energy and has no ionizing effects. It may produce a non-thermal effect such as blood brain barrier permeability change² and cause an occurrence of brain tumor, deranged calcium metabolism and or a neurotransmitter effect.³

At present, there is not enough information to determine if EMF exposure causes adverse health effects. However, the effect of an EMF on the human body has become a much-discussed issue in developed countries. There are some reports discussing the possibility of an increased risk of developing brain cancer, breast cancer and leukemia in EMF exposed populations.^{4,5} Other reports show an association between video display terminals (DVT) with pregnancy outcome.⁶

A very large number of monitors and other electric equipments are used in the modern pra-

Received May 16, 2002

Accepted December 2, 2002

Reprint address: requests to Dr. Ki Jun Kim, Department of Anesthesiology, Yonsei University College of Medicine, 134 Shinchon-dong, Seodaemun-gu, Seoul 120-752, Korea. Tel: 82-2-361-6448, Fax: 82-2-312-7185, E-mail: kkj6063@yumc.yonsei.ac.kr

ctice of anesthesiology. Therefore, anesthesiologists are presumed to be exposed to EMF for a long period of time but there is no data showing how much EMF they receive and what kind of effects of EMF has on them. This study was undertaken to give basic information on EMF by measuring the magnetic field intensity produced by anesthetic equipments and monitors in operating rooms.

MATERIALS AND METHODS

All the electronic equipments (anesthetic machines and monitors) were checked in a vacant operating room. Using the Extremely Low Frequency (ELF) Field Strength Measurement System (Model HI-3604, Holaday Industries, Eden Prairie, MN, USA) (Fig. 1), we measured the intensity of EMF at 30 cm, 50 cm, and at the places where the anesthesiologist usually stands away from the center of the monitors. We measured consecutively EMF three times on three fields (X, Y, Z axis) at 5 minute intervals and averaged. Since magnetic fields are vectors, they were calculated as being the root square of EMFs on three fields. We calculated the average magnetic field intensity

and standard deviation of each point in 19 operating rooms.

RESULTS

All the electronic equipments used in each of 19 operating rooms are listed in Table 1. The ELF intensities were 0.56 - 4.25 mG (2.22 ± 1.13 mG) at 30 cm, 0.47 - 3.19 mG (1.29 ± 0.84 mG) at 50 cm, and 0.41 - 3.02 mG (1.00 ± 0.78 mG) at the anesthesiologist's standing points. The average distance between the monitors and an anesthesiologist was 83.58 ± 11.89 cm. At 30 cm, 50 cm, and the anesthesiologist's standing points from the center of monitor, 8, 4, and 2 operating rooms' intensities were measured to be above 2 mG respectively. The average magnetic field intensity and standard deviation of all 19 operating rooms are listed in Table 2.

DISCUSSION

Since a numerous varieties of electronic equipments are used in operating rooms, it is difficult to point out which is the main source of the EMF described earlier in this study. A visual display terminal produces EMF having several frequencies. Among them, direct current (DC) is not harmful and the radio frequency (RF) is minimal. ELF is the one that is much discussed these days because of its potential harmful effects and that is the reason why only the EMF of the ELF measured. All things in an operating room, especially electric conductors, affect the electric field. Since even the measuring person himself can be a variable for electric field measurements, only the magnetic field is measured. In the 19 operating rooms studied in this report, 4 at 50 cm distance and 2 at a distance from the anesthesiologist's standing point measured to be above 2 mG. In 3 rooms, measurements closer to the anesthesiologist were tenser than at the monitor.

We later discovered that a main power supply unit passed behind the wall of the operating room where the anesthesiologist stood and which could adversely affect the measurement of radiation that anesthesiologist received. 6th and 12th room have



Fig. 1. Extremely low frequency (ELF) field strength measurement system

Table 1. Anesthesia Machines and Monitoring Devices in Operating Rooms

OR Number	Equipment	
	Anesthesia Machines	Monitoring Devices
1st	Dameca MCM 590	Space Labs 90303B
2nd	Ohmeda BBTV 00284	Hewlett Packard M 64S, Datex ULT-SV-28-06
3rd	Dameca MCM 890	Hewlett Packard M 1026A
4th	Dameca MCM 590	Space Labs 90385
5th	Draeger PM 8050	Hewlett Packard M 64S
6th	Dameca 10888	Datex ULT-SV-28-06, Space Labs 90303B
7th	Draeger(Seneca)	Datex ULT-SV-28-06, Space Labs 90622A
8th	Royal Delta-88X	Datex ULT-SV-28-06, Space Labs 90622A
9th	Draeger PM 8050	Datex ULT-SV-28-06, Space Labs 90622A
10th	Dameca MCM 590	Space Labs 90385
11th	Royal Delta-88X	Datex ULT-SV-28-06, Space Labs 90303B
12th	Dameca 10888	Datex ULT-SV-28-06, Space Labs 90303B
13th	Dameca MCM 890	Hewlett Packard M 1026A
14th	Dameca MCM 590	Space Labs 90303B
15th	Dameca MCM 590	Space Labs 90385
16th	Dameca MCM 890	Hewlett Packard M 1026A
17th	Draeger PM 8050	Space Labs 90651A
18th	Draeger(Seneca)	Hewlett Packard 78354C, Datex ULT-SV-28-06
19th	Draeger PM 8050	Space Labs 90651A

OR, operating room.

the same equipments each other. However, the intensities measured on the rooms are quite different. It seemed that this was due to the differences in electric supplies, and the effects of other floors' equipments and electric supplies.

The Sweden Board for Technical Accreditation (SWEDAC) regulation for monitors requires that the intensity is not to exceed 2 mG at 30 cm away from the monitors.⁷ Our data showed that some of our operating rooms did not satisfy the regulation. Although the SWEDAC regulation is accepted as the worldwide standard for EMF exposure, this is only an arbitrarily chosen technical guideline.⁷

The number of 2 mG was derived from other epidemiological studies. EMF exposed group was defined being people who were exposed to 2 or

3 mG of EMF.⁸ The upper level of EMF exposure has not yet been established because there is no data describing their effect on human health. We do not know how variables such as different frequency, exposure time and the quantity of radiation influence our health. Therefore we excluded the exposure time from our data. The effect of EMF on human health was difficult to show definitely since the authors could not distinguish the effect of EMF from other environmental factors. Individual differences of susceptibility to EMF are also confusing.

Several epidemiological studies, clinical trials, and studies at the cellular level are going on to clarify the effects of EMF as posing health hazards. The results of epidemiological studies on the relationship between several disease groups

Table 2. The Density of Magnetic Fields in Operating Rooms (mG)

OR Number	Distance from Monitor		
	30 cm	50 cm	83.5 cm*
1st	1.39	0.76	0.76
2nd	2.7	0.81	0.57
3rd	0.56	0.58	0.81
4th	2.34	2.15	1.09
5th	0.7	0.48	0.69
6th	0.82	0.47	0.41
7th	3.49	2.45	1.67
8th	4.25	1.78	1.36
9th	2.79	1.06	0.47
10th	1.78	0.79	0.7
11th	1.44	0.62	0.5
12th	1.6	1.48	1.28
13th	1.89	3.19	3.02
14th	1.53	1.11	2.92
15th	1.61	1.1	0.91
16th	0.82	0.49	0.44
17th	2.99	2.98	0.41
18th	4.15	1	0.52
19th	3.26	1.21	0.55
Mean \pm SD	2.11 \pm 1.13	1.29 \pm 0.84	1.00 \pm 0.78

The distance from monitor to anesthesiologists stand point was 83.58 ± 11.89 cm (Mean \pm SD).
OR, operating room.

and EMF are much debated recently. Studies on the association between EMF exposure and some cancers such as leukemia and brain cancer that occurred from 1993 to 1995 showed no strong associations and a lack of consistency in the study results.⁹⁻¹¹ According to these results, most developed countries of the world decided that because people must not disregard the health hazard of EMF, more studies must be carried out to confirm the association. Some countries have already accepted the potential health hazards of EMF and set a standard for EMF exposure limit and regulate that limit.

This study measured the amounts of EMF exposure that an anesthesiologist in the operating

rooms get. Some of them were over the exposure limit. We hope our result will serve as the basic reference data for other studies on the health hazards of EMF. Furthermore, we must clearly define the EMF exposure limits, and regulate it in our country just as radiation exposure limits in order to prevent the health hazard of EMF.

REFERENCES

1. Adey WR. Tissue interactions with nonionizing electromagnetic fields. *Physiol Rev* 1981;61:435-514.
2. Oscar KJ, Hawkins TC. Microwave alteration of the blood-brain barrier system of rats. *Brain Res* 1977;126:281-93.

3. Cleary SF. A review of *in vitro* studies: Low-frequency electromagnetic fields. *Am Ind Hyg Assoc J* 1993;54:178-85.
4. Kolmodin-Hedman B, Hansson MK, Hagberg M, Jonsson E, Andersson MC, Eriksson A. Health problems among operators of plastic welding machines and exposure to radiofrequency electromagnetic fields. *Int Arch Occup Environ Health* 1988;60:243-7.
5. Demers PA, Thomas DB, Rosenblatt KA, Jimenez LM, McTiernan A, Stalsberg H, et al. Occupational exposure to electromagnetic fields and breast cancer in men. *Am J Epidemiol* 1991;134:340-7.
6. Roman E, Beral V, Pelerin M, Hermon C. Spontaneous abortion and work with visual display units. *Br J Ind Med* 1992;49:507-12.
7. Computers and office machines: measuring methods for electric and magnetic near fields. Report No. SS 436-14-90. 2nd ed. Stockholm: Svenska Elektriska dommissiones (SEK); 1995 Dec.
8. Feychting M, Ahlbom A. Magnetic fields and cancer in children residing near Swedish high-voltage power lines. *Am J Epidemiol* 1993;138:467-81.
9. Sahl JD, Kelsh MA, Greenland S. Cohort and nested case-control studies of hematopoietic cancers and brain cancer among electric utility workers. *Epidemiology* 1993;4:104-14.
10. Savitz DA, Loomis DP. Magnetic field exposure in relation to leukemia and brain cancer mortality among electric utility workers. *Am J Epidemiol* 1995;141:123-34.
11. Theriault G, Goldberg M, Miller AB, Armstrong B, Guenel P, Deadman J, et al. Cancer risks associated with occupational exposure to magnetic fields among electric utility workers in Ontario and Quebec, Canada, and France:1970-1989. *Am J Epidemiol* 1994;139:550-72.