

## ORIGINAL ARTICLE

# Diurnal variation of extremely low frequency electromagnetic field in an empty operating room

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## ABSTRACT

**Objective:** Extremely low frequency electromagnetic field (ELF-EMF) is harmful to human body and causes various diseases like cancer. ELF-EMF is mainly produced by surgical or anesthetic equipment in operating room. However, it can be made by surrounding electricity without electric device. We measured it in an empty operating room of our hospital over two days and nights.

**Methodology:** The intensity of ELF-EMF was measured as two-second interval for two days in an empty operating room. One day was divided to three groups; night, morning, and afternoon. Each group continued for three hours due to capacity of ELF-EMF instrument. All of electrical devices were off including lamp, computer and air conditioner. Groups were compared using one-way ANOVA.  $P < 0.05$  was considered significant.

**Results:** Mean value of ELF-EMF during 1st and 2nd night was 1.9459 and 1.9486 respectively. It was lower than data of morning and afternoon ( $P < 0.001$ ). All values (100%) were above 2 mG (micro-Gauss) in daytime. In night time, most of ELF-EMF (99.9%) was below 2 mG.

**Conclusion:** The intensity of ELF-EMF is higher in an empty daytime operating room than at night time.

**Keywords:** Extremely low frequency electromagnetic field; Operating room; Diurnal variation; Electricity

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## INTRODUCTION

The invention of electricity brought revolutionary change and convenience in human society. However, many electronic devices are potentially harmful in aspect of electromagnetic wave. The hazard of electromagnetic field was first reported by Wertheimer and Leeper that children near electrical power lines have high prevalence of leukemia compared to control children in Colorado, 1976-1977.<sup>1</sup>

The biologic effect of extremely low frequency electromagnetic field (ELF-EMF) to human body is not completely understood. In vitro study, powerful ELF-EMF can cause seizure, infertility, and DNA damage.<sup>2-5</sup> Furthermore, recent study represented ELF-EMF over 4 mG (micro-Gauss) has a risk of brain tumor and leu-

kemia in pediatric population.<sup>6</sup> ELF-EMF has received a lot of attention after first report of hazard in 1979.<sup>1</sup> Along with the rise of electrical products in modern society, it draws a lot of focus dangerous or not. Laptop computers is widely used in the public, but passed unobserved in impairment of health. Women can be influenced by Laptop computers, especially womb of pregnant.<sup>12</sup> Female reproductive system would be affected by ELF-EMF that reduce the number of flushed blastocysts and augment the height of fallopian tube epithelium.<sup>2</sup> In swine model, ELF-EMF intensity of 1mT corrupted sperm ability and interrupted fertilization.<sup>3</sup> In addition, ELF-EMF exposure deforms synaptic activity and steps up possibility of seizure activity in experimental condition to the rat.<sup>4</sup> Catecholamine like adrenalin and dopamine was released by ELF-EMF on

## ELF-EMF in empty operating room

cultured chromaffin cells.<sup>7</sup> DNA integrity can be also affected by ELF-EMF.<sup>5</sup>

Children are easily influenced by environment and ELF-EMF is no exception. EMF has a possibility of carcinogen in leukemia and brain tumor.<sup>6</sup> In recent study, Children living near power line are made a comparison between 200m and 600m distance.<sup>8</sup> The group of 200m power line represented high risk of acute lymphocytic leukemia in Brazil. Occupational exposure of EMF decreases the level of cortisol in the serum among dentist group.<sup>9</sup> The heart of rat was not influenced by short-term exposure of 1 $\mu$ T EMF.<sup>10</sup>

As advances in medical science and facilities, electric products and consumption are increasing rapidly in operating room. Medical staffs including anesthesiologist, surgeon, and nurse have high potential exposure to ELF-EMF in operating room for long period. A number of equipment makes electromagnetic field that is formed by sum of individual electric product. Furthermore, ELF-EMF may be built by invisible electric wiring system and other unidentified electric instrument.

We hypothesized that ELF-EMF value is different as daytime and night time in empty operating room. TCO guideline by Swedish Confederation of Professional Employees recommends under 2mG in the distance of 30cm from electronic monitor.<sup>11</sup>

## METHODOLOGY

This test was designed as prospective experimental study and conducted in an empty operating room of our university hospital. All the electrical equipment including computer, astral lamp, monitors, surgical and anesthetic devices had been put off in the operating room. The intensity of ELF-EMF was measured as two-second interval for two days by ELF-EMF meter (TM-192D, Tenmars, Taiwan) (Figure 1).



Figure 1: ELF-EMF meter (TM-192D, Tenmars, Taiwan)

Sample size was calculated by MedCalc version 11.6 as following conditions: type I error-alpha 0.05, type II error-beta 0.20, difference 0.01, standard deviation 1 – 0.1, standard deviation 2 – 0.1. Minimal required sample size was computed to be 1570.

A day was divided into three groups; night (midnight to 3 AM), morning (8:30 AM to 11:30 AM), and afternoon (1:30 PM to 4:30 PM). Each group continued for three hours due to limits of capacity of ELF-EMF instrument. The data were measured 5,400 times per each group. ELF-EMF meter was placed between operating table and anesthetic machine at about a height of one meter. Each group was compared by one-way ANOVA using SAS 9.2 (SAS Institute, Cary, NC). Post-hoc test was conducted with Tukey procedure. Total night time data of two days was compared with total non-night time data of two days (day and afternoon) by Wilcoxon's rank sum test.

## RESULTS

The total average of ELF-EMF was 2.0718  $\pm$  0.09059 (mean  $\pm$  SD) (Table 1).

Table 1: The descriptive of ELF-EMF in empty operating room

	Number of count	Mean (mG)	Standard deviation	Minimum	Maximum
1st night	5400	1.9459	0.01477	1.86	2.20
1st morning	5400	2.1115	0.02044	2.05	2.35
1st afternoon	5400	2.1251	0.01435	2.06	2.21
2nd night	5400	1.9486	0.01341	1.91	1.98
2nd morning	5400	2.1404	0.01381	2.09	2.20
2nd afternoon	5400	2.1593	0.01471	2.11	2.21
Total	32400	2.0718	0.09059	1.86	2.35

The mean value of ELF-EMF during 1st and 2nd night was 1.9459 and 1.9486 respectively (Figure 2). Average ELF-EMF of total night time was 1.9472 (Figure 3). 1st and 2nd night readings were significantly different than that of 1st and 2nd mornings and afternoons (Figure 3) ( $p < 0.001$ ).

Table 2: The count of ELF-EMF over 2mG

	ELF-EMF <2mG	ELF-EMF >2mG	Total
1st night	5395	5	5400
1st morning	0	5400	5400
1st afternoon	0	5400	5400
2nd night	5400	0	5400
2nd morning	0	5400	5400
2nd afternoon	0	5400	5400

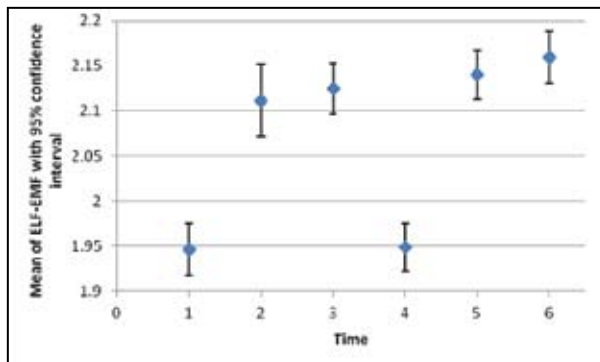


Figure 2: Mean  $\pm$  SD values of ELF-EMF in mG for two days

Time 1: 1st day from midnight to 3AM (5,400 data)  
 Time 2: 1st day from 8:30AM to 11:30AM (5,400 data)  
 Time 3: 1st day from 1:30PM to 4:30PM (5,400 data)  
 Time 4: 2nd day from midnight to 3AM (5,400 data)  
 Time 5: 2nd day from 8:30AM to 11:30AM (5,400 data)  
 Time 6: 2nd day from 1:30PM to 4:30PM (5,400 data)

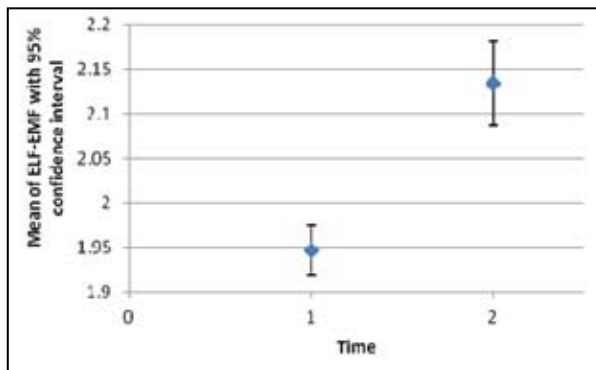


Figure 3: Mean value of ELF-EMF for night time and daytime period

Time 1 : 1st and 2nd day from midnight to 3AM (10,800 data)  
 Time 2 : 1st and 2nd day from 8:30AM to 11:30AM and 1:30PM to 4:30PM (21,600 data)

## DISCUSSION

Intensity of ELF-EMF was investigated during surgery at the position of anesthesiologist in another study,<sup>13</sup> showing a mean of 5.83 mG and ratio over 2 mG was 70.98% in average of 18 operating rooms. Our study showed lower value because of empty operating room with no surgery. All the data of daytime was over 2 mG in our study, but nearly all was below 2 mG in

night time (Table 2).

Accurate determination of ELF-EMF is not easy. A lot of external factors can affect exact value, which may be a possible limitation in this study. The difference of ELF-EMF between 1st and 2nd daytime was considered due to the number of operation cases. There were 39 operation cases on the 1st day and 75 cases on 2nd day in other functional operating rooms. Less number of cases on the first day meant that less electricity was used and less environmental ELF-EMF was formed to be recorded by our ELF-EMF meter. This is verified by the smaller minimum value of ELF-EMF during the daytime of the first day. It seems that even empty operating rooms can be under potential hazard in the face of whole electric mass. Protection equipment or EMF cut-off is necessary to reduce the risk. Expert electrical engineers should be employed to monitor its level and take appropriate measures to contain high levels for the safety of the staff and the patients, as ELF-EMF from electrical devices has been proven for possible harmful effects to the living animals, especially on the rapidly proliferating cells of the reproductive system,<sup>2,3</sup> with possible repercussions to humans as well.<sup>1,4-6,8</sup>

More studies on this subject are required at different centres, taking into account the type and number of electromedical equipment used in the operating rooms, the usage of operating rooms and the type of electric source and cables used there. Microbiological studies are required in the healthcare workers, especially those who are exposed more to this hazard e.g. operating rooms, radiology and intensive care workers.

## CONCLUSION

The intensity of ELF-EMF is higher in an empty operating room at daytime than at night time. Medical personnel and patients can be exposed to high levels of ELF-EMF at daytime, hence it should be routinely monitored with or without electrical equipment in operating rooms.

**Conflict of interest:** None declared.

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