



## Extremely Low Frequency Electromagnetic Field from Convective Air Warming System on Temperature Selection and Distance

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### Abstract

**Background:** Hypothermia generates potentially severe complications in operating or recovery room. Forced air warmer is effective to maintain body temperature. Extremely low frequency electromagnetic field (ELF-EMF) is harmful to human body and mainly produced by electronic equipment including convective air warming system. We investigated ELF-EMF from convective air warming device on various temperature selection and distance for guideline to protect medical personnel and patients.

**Methods:** The intensity of ELF-EMF was measured as two-second interval for five minutes on various distance (0.1, 0.2, 0.3, 0.5 and 1meter) and temperature selection (high, medium, low and ambient). 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 values of ELF-EMF on the distance of 30 cm were 18.63, 18.44, 18.23 and 17.92 milligauss (mG) respectively (high, medium, low and ambient temperature set). ELF-EMF of high temperature set was higher than data of medium, low and ambient set in all the distances.

**Conclusion:** ELF-EMF from convective air warming system is higher in condition of more close location and higher temperature. ELF-EMF within thirty centimeters exceeds 2mG recommended by Swedish TCO guideline.

**Keywords:** ELF-EMF, Operating room, Air warmer

### Introduction

Electromagnetic field exists everywhere electricity flows. The concerns about the hazard of electromagnetic field were first reported by Wertheimer and Leeper (1). They issued high prevalence of leukemia in children near electrical power lines compared to control children. Extremely low frequency electromagnetic fields (ELF-EMF) are produced by electrical currents that have wavelength of 50 or 60 Hz. All the electronic devices are operated with input of electricity that produces electromagnetic waves. After report of

Wertheimer and Leeper, the carcinogenic effect of ELF-EMF was brought up on various kinds of cancer like brain, breast, and leukemia (2-4).

The harmful effect of extremely low frequency electromagnetic field (ELF-EMF) to human body is not entirely understood. However, ELF-EMF can be hazardous to health in animal and in vitro study. Health risk was also documented in human based epidemiology. Exposure to high intensity of ELF-EMF is proved as relatively detrimental. Long-term effect of low intensity is still under the

controversy (5).

Hypothermia is one of most important problem during or after surgery. Perioperative hypothermia results from thermoregulatory impairment or cold operating environment. Inadvertent hypothermia is associated with high mortality rate and complication. Convective air warming system is an effective method to maintain body temperature. ELF-EMF was produced by Convective air warming unit like other electronic devices. Medical workers have a potential risk of exposure to ELF-EMF especially in case of long-time use. Though it is short-time use, repetitive exposure could be also harmful to medical staff. Air warming device (WarmTouch™, Covidien, USA) has various target temperature on demand (Fig. 1).

We investigated ELF-EMF from convective air warming device on various temperature selection and distance for guideline to protect medical personnel and patients.



**Fig. 1:** WarmTouch™ manufactured by Covidien

## Methods

This test was designed as prospective experimental study and conducted in an empty operating room of university hospital. The operating room is rectangular shape and 9.25 X 5.32 square

meters. All the electrical appliances including computer, astral lamp, monitor, surgical and anesthetic devices had been off during measurement. Atmosphere temperature was 21°C. ELF-EMF meter takes a measurement of triple axis (X, Y, Z) from 2.5 times per second sampling rate. The intensity of ELF-EMF was measured as two-second interval for five minutes by ELF-EMF meter (TM-192D, Tenmars, Taiwan). Each group consists of 150 data on four-temperature selection (high, medium, low and ambient) and five different distances (0.1, 0.2, 0.3, 0.5 and 1 meter). All the data were stored in the device that operated by battery.

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. Minimal required sample size was computed to 63. Each group was compared by One-Way ANOVA using SAS 9.2 (SAS Institute, Cary, NC). Post-hoc test was conducted with Tukey procedure.  $P < 0.05$  was considered significant.

## Results

The mean value of ELF-EMF was posted in Table 1 on four-temperature selection (high, medium, low and ambient) and five different distances (0.1, 0.2, 0.3, 0.5 and 1 meter). Average ELF-EMF of high temperature selection was 134.706, 41.518, 18.637, 5.343 and 0.780 mG respectively (0.1, 0.2, 0.3, 0.5 and 1 meter) (Fig. 2).

ELF-EMF from long distance represented lower value in all kinds of temperature. Mean value of 0.3 meter distance was 18.637, 18.447, 18.239 and 17.928 mG respectively (high, medium, low and ambient temperature) over Swedish TCO guideline 2mG (Fig. 3). Measured values from the distance of 1 meter were under Swedish TCO guideline.

The intensity of ELF-EMF was higher in high temperature set than in medium, low and ambient. All the groups were significantly different ( $P < 0.05$ ).

Table 1: ELF-EMF on various temperature and distance

Temperature	High	Medium	Low	Ambient	Average
Distance					
0.1 meter	134.706±0.448	132.061±0.626	131.760±0.927	130.329±0.369	132.214
0.2 meter	41.518±0.544	40.995±0.144	40.705±0.234	39.912±0.126	40.783
0.3 meter	18.637±0.288	18.447±0.055	18.239±0.077	17.928±0.060	18.313
0.5 meter	5.343±0.046	5.249±0.033	5.230±0.045	5.170±0.037	5.248
1 meter	0.780±0.017	0.776±0.016	0.774±0.014	0.762±0.012	0.773
Average	40.070	39.385	39.223	38.820	

Data was presented as mean ± standard deviation.

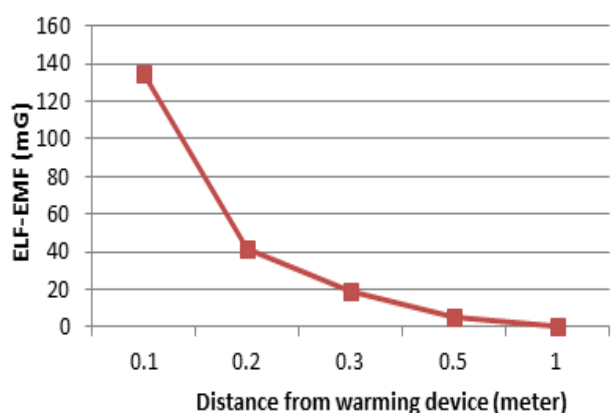


Fig. 2: ELF-EMF of high temperature set

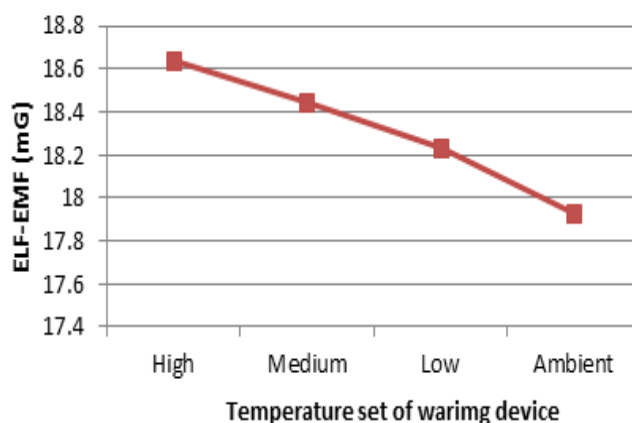


Fig. 3: ELF-EMF on the distance of 30cm

## Discussion

ELF-EMF was classified as group 2B, possibly carcinogenic by international agency for research on cancer (IARC) that ELF-EMF could be some hazardous to human body (6). ELF-EMF may be produced in usual electrical environment like household electrical appliance. Laptop computers induce EMF to human body, especially to fetus in pregnant women (7). Electric products and consumptions are increasing rapidly in operating theatre as medical science advances. This leads to more opportunities of exposure to ELF-EMF in operating room. Various system of human body could be influenced by EMF like hematic, neurologic, reproductive, endocrine and genetic structure.

ELF-EMF is still controversial that critically dangerous to human. However, there was growing

evidence that ELF-EMF is harmful in human and animal research. Animal study can be conducted in high level of EMF, but human study is usually based on epidemiologic data.

Acute non-lymphocytic leukemia was significantly increased in electrical workers of New Zealand (8). Children environmentally exposed to high EMF have a risk of high incidence of leukemia. EMF might be carcinogen in childhood leukemia and brain tumor (9). Unexplained spontaneous abortion is probably related to ELF-EMF in Iranian women population (10). Occupational exposure to EMF can alter the serum cortisol level in dentists and dentistry students (11). ELF-EMF has a biological stress and damage on prostate gland of rat during pregnancy and postnatal period in 80 Gauss condition (12). Long-term exposure of EMF can affect bone metabolism, followed by decrease of calcium, zinc and magnesium in rat (13). ELF-EMF has potential risk of genotoxic

effect (14). DNA strand can be affected by EMF in high level, 1000  $\mu$ T (15). Humans are revealed to several kinds of carcinogen simultaneously, and EMF can promote carcinogenesis with other carcinogen (16).

EMF has not only hazardous effect, but also positive effect. EMF exposure is followed by anti-inflammatory effect in pathologic condition, especially chronic wound healing. Cytokine is modulated due to ELF-EMF, and contributes bioavailability of nitric oxide (17).

Perioperative hypothermia has several detrimental effects as followings: arrhythmia, coagulopathy, decreased metabolism, wound infection and mental change (18). Anesthesiologists make an effort to maintain body temperature using various methods like airway heating, warm intravenous fluid, circulating water mattress and forced air (19). Convective air warming system is effective to prevent hypothermia combined with warming blanket. There are several kinds of blanket offered by a manufacturing company for upper body, lower body and pediatric use.

Forced air warmer (WarmTouch™) generates ELF-EMF like other electronic manufactures.

ELF-EMF is inversely proportional to square distance due to the nature of physics. In this study, intensity of ELF-EMF is almost a quarter in two-fold distances (Fig. 3). Electricity is the factor that primarily affects ELF-EMF value. High temperature set has a possibility of strong ELF-EMF because of more electric consumption. High, medium, low and ambient temperature set demonstrate intensity of ELF-EMF in order (Fig. 2).

ELF-EMF should be considered in occupational health protection. More electromagnetic radiation leads to abnormal value of cardiovascular, liver and hematology system in Chinese workers (20, 21). Safe standard of ELF-EMF was under 2 mG recommended by TCO guideline, Swedish Confederation of Professional Employees in the distance of 30cm (22). To protect workers, it is necessary to put distance from EMF source or physical protectors between them.

## Conclusion

ELF-EMF from convective air warming system is possibly harmful in close distance. Therefore, medical personnel and patients are safe to establish sufficient distance from ELF-EMF source.

## Ethical considerations

Ethical issues (Including plagiarism, informed consent, misconduct, data fabrication and/or falsification, double publication and/or submission, redundancy, etc.) have been completely observed by the authors.

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