Original Article

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Evaluation of the Incubator-Generated Magnetic Field

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ABSTRACT

BACKGROUND AND OBJECTIVE: Some ill or premature neonates require special care nursery and maintenance of environmental conditions through incubator. Incubator electric system exposes the premature infants to electromagnetic radiation. Given the fact that magnetic radiation is one of the causative agents of leukemia in children, in this study, we aimed to evaluate the intensity of the magnetic field generated by incubators.

METHODS: In this cross-sectional study, we measured the intensity of magnetic field produced by 17 incubators utilized in our neonatal intensive care units (NICU), using a teslameter. In each of the incubators, five points were determined to measure the intensity of the magnetic field. Measurements were performed twice (during two weeks between 10 and 12 am), in both horizontal and vertical directions.

FINDINGS: The mean intensity of the magnetic field measured at all points inside the incubators was 0.2±0.03 µT. The intensity of magnetic field at a point inside the incubators (0.27±0.03 µT), measured in both horizontal and vertical directions, was significantly different from a point outside the incubators ($p<0.04$).

CONCLUSION: At some points inside the incubators, the intensity of magnetic field increases by switching the heater on. Hence, minimizing the length of neonatal incubation period is recommended.

KEY WORDS: *Magnetic field, Neonatal, Incubators.*.

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Introduction

Some neonates require special care nursery and maintenance of environmental conditions through incubator, due to premature birth or congenital anomalies. Therefore, to reduce the rate of mortality in pre-term newborns, incubators were used (1). The first incubator was used to care for a premature infant by Denuce in 1857, and then Tarnier invented another incubator in 1878 similar to a heating chamber (1). Stephane Tarnier was a French obstetrician, who after observing the chicks being kept in an incubator in the Paris zoo, built a similar device for taking care of babies. In the first incubator, which was invented to save a number of infants, heat was supplied by an external hot water supply (2). The next model was built to care for a single infant and the required heat was supplied by hot-water bottles which were changed every three hours (2). The necessity for mother-infant proximity led Budin to develop a glass incubator which was placed at mothers' bedside. Tarnier also

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invented a large metal incubator which functioned with a thermostat and a powerful ventilation system (2). After that, in 1914, Hess made an electrically heated incubator, which was surrounded with a water jacket (2).

Thus, the use of electricity in incubators has led to exposure of babies to electromagnetic field. Generally, any incubator requires several parts to maintain temperature, humidity and oxygen including: electric power (AC) for the heating, a fan for circulation of the warm air, a water tank to moisturize the chamber, oxygen control valves and apertures for access to the neonate (3). In some parts of the incubator, low-voltage power supply is required, but to provide proper temperature, the heater should be connected to urban electric power (220 volts). Since the intensity of the electromagnetic field is closely associated with electric current and voltage, incubator heater is one of the main parts generating electromagnetic field. Several studies have been carried out to determine the relationship between childhood leukemia and magnetic field.

Moreover, based on the epidemiological studies, the international agency for research on cancer (IARC) has classified the effect of very low frequency electromagnetic field exposure on childhood leukemia as 'possible' (4). A study conducted on 500 Norwegian children with cancer, who were exposed to the magnetic field of high-voltage cables at least for one year, did not indicate a significant relationship between magnetic fields and the incidence of childhood malignancies (5). Additionally, a study performed on 729 Swedish children with leukemia showed that there is a poor relationship between the incidence of childhood leukemia and exposure to magnetic fields inside the incubator. In that study, the magnetic field intensity inside various types of incubators was 4.36-0.23 µT (mean intensity= 1.04 µT) (6), but some believe that in the setting of magnetic intensities higher than 4.0 µT, the risk of leukemia in children would be doubled (7). Several environmental factors in neonatal intensive care units (NICUs), such as light, sound, magnetic field, radiation and medicines can be considered as the potential sources of deleterious effects on babies (8). Given the increased efficiency of incubators in hospitals during the first days of life, taking into account the intensity of magnetic field produced by incubators seems to be mandatory. In the present study, the intensity of magnetic field produced by infant incubator devices in NICUs of two hospitals affiliated to Semnan University of Medical Sciences were studied and compared with the international standards.

Methods

This cross-sectional study investigated 18 active incubators in the NICUs of the hospitals affiliated to Semnan University of Medical Sciences, Semnan, Iran. The findings of an old incubator were omitted from study due to generating more than 2 µT magnetic field intensity and was excluded due to being outlier. Thus, data of the 17 incubators were used for the statistical analysis. To measure magnetic field we used EMF-827 (Lutron Electronic Enterprise Co., Taiwan) teslameter device (with sensitivity and accuracy of 0.01% and ±0.04%, respectively). Teslameter sensor were placed at five selective points of the incubators (at a distance of 5cm from the incubator floor) (fig 1).

Given the uncertainty about the direction of the magnetic field inside the incubators, magnetic field measurements were performed in both horizontal and vertical directions. Moreover, to promote the accuracy of measurements and to account for the fluctuation in the electrical current and magnetic fields, measurements were repeated twice (within two weeks at 10-12 am). In order to increase the accuracy of the test, measuring the background magnetic field produced by the other electrical devices was performed 50 cm away from the incubator. To analyze the data, Mann-Whitney, Wilcoxon and Friedman tests were performed using SPSS (16.0). $p<0.05$ were considered statistically significant.

Figure 1. The points used inside the incubator to measure the magnetic field intensity

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Results

The results demonstrated that the mean magnetic field intensity of the studied incubators was 0.2 µT (intensity range=0.1-0.8 µT), while the mean intensity of the magnetic field 50 cm away from the incubators was 0.16 µT. Statistical analysis of the results in both horizontal and vertical directions indicated that the magnetic field intensities at various points inside the incubators were significantly different ($p<0.05$).

Comparison of the magnitude of the background magnetic field (outside the incubator) in horizontal and vertical directions showed no significant difference. As indicated in Figure 1, comparison of the measures in the vertical magnetic field inside the incubator showed that the magnetic field strength at point 3 (0.27±0.03 µT) was significantly different from the background magnetic field (0.16±0.02 µT) (P=0.001). In addition, the findings in the horizontal direction disclosed that at points 3 (0.24±0.03 µT) and 4 (0.02±0.23 µT) the generated electromagnetic field was significantly more than the background magnetic field (0.16±0.01 µT) ($p<0.04$) (fig 1).

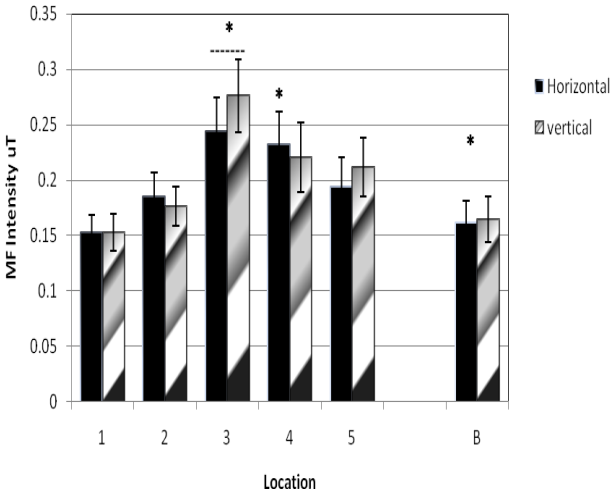

Figure 1. The magnetic field intensity at various points inside the incubator as compared to the background intensity outside the incubator (B), through both vertical and horizontal field measurements. The intensity of the vertical magnetic field at point 3 was significantly different from that of the background magnetic field (P=0.001); moreover, the horizontal magnetic field at points 3 and 4 showed significant differences from the background magnetic field ($p<0.04$) (Mean±SD)

Discussion

Study of the commonly used incubators in the NICUs of the hospitals affiliated to Semnan University of Medical Sciences, indicated that the magnetic field intensity ranged between 0.1 and 0. 8 µT (mean= 0.2 µT). Moreover, there was a significant difference between both sides of the incubators and their center regarding magnetic field intensity. There was no significant difference between vertical and horizontal magnetic field measurements. Our results are in agreement with the findings of the study by Riminesi and colleagues. They demonstrated that the magnetic field magnitude inside NICU was less than 0.2 µT. In addition, they found that the magnetic field intensity was higher on the sides of the medical instruments, which greatly decreases with farther distances, so that within the range of 20-30 cm it appears as background radiation (9). A study conducted on 729 Swedish children with leukemia demonstrated a weak association between the incidence of childhood leukemia and exposure to magnetic fields inside the incubators.

This study showed that the field intensity inside a variety of incubators ranged between 0.23 and 4.36 µT (mean intensity= 1.04 µT) (6). In another study, the incidence of malignancies in children who were exposed to more than 0.2 µT magnetic fields was not statistically different from those who were exposed to magnetic field of less than 0.1 µT (10). Ahlbom believes that despite lack of association between the magnetic field intensity of less than 0.4 µT and the incidence of malignancies, but magnetic field intensities of higher than 0.4 µT doublize the risk of leukemia (7). The sensitivity of the issue came to light when Bellini and colleagues found that even switching the incubators on/off can alter heart rate of the babies, which may be due to the effect of the magnetic field on their autoimmune nervous system. Heart rate variability can be explained with magnetic field strength ranging between 0.7 and 2.2 milli-gauss (0.7-0.22 µT) (11). Cermakov believes the magnitude of the magnetic field inside incubators is less than the European standard, while electrical conductivity of babies is more than adults, thus, at equal magnetic fields, a higher current density passes through infants' body (12). Although some epidemiologic studies suggest a weak relationship between leukemia and exposure to environmental magnetic

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fields, but there are little empirical findings. (5). Two plausible hypotheses can be proposed to explain this association: 1) passing an electrical current of 100 $mv.m^{-1}$ from the bone marrow may lead to triggering some mechanisms in hematopoietic tissue, which increases the risk of leukemic generation; 2) magnetic field exposure in childhood would result in impaired secretion of melatonin, which in turn, promotes the risk of leukemia (13).

Studies of the infants who were kept in incubators for at least 48 hours showed a transient increase of melatonin production, which may be secondary to weak electromagnetic field of incubators (14). However, the current findings cannot illustrate the potential effect of the electromagnetic fields on melatonin or ion resonances (15). A low-birth-weight premature infant may be kept in incubator for few months, while, radiation exposure of the infant should be compared to longer exposure periods of adults. Moreover, the possible effects of melatonin secretion should be taken into consideration. Hence, the manufacturers must place the magnetic field sources away from babies and if possible, reduce the exposure duration for neonates (9). Since the risk of leukemia for children is doubled at the magnetic field intensities higher than 0.4 µT, using the current standard incubators with magnetic field intensities of less than 0.4 µT should not be a concern. Meanwhile, it should be borne in mind that IARC has classified the effect of very low frequency electromagnetic field exposure on development of childhood leukemia as 'possible' (4). The results of the current study showed that the magnetic field intensity in the commonly used incubators in NICUs of the hospitals affiliated to Semnan University of Medical Sciences, ranged between 0.1 and 0.8 µT (mean intensity=0.2 µT). There was also a significant difference between the incubators' sides and center regarding magnetic field intensity.

Therefore, to reduce the possible risk of leukemia, it is recommended to: A) if possible, minimize the length of incubation period; B) change the position of the baby to prevent constant magnetic field radiation to a certain body part (considering the fact that the most intense magnetic field, when the incubator is powered on, appears on the right side [points 3 and 4]). Since the effects of sound and light on neonates have been investigated in the previous studies (8) and this study evaluated the effect of magnetic field, carrying out other studies on the impact of electric field intensity is highly recommended.

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