A Meta-analysis of Epidemiological Studies on the Relationship between Occupational Electromagnetic Field Exposure and the Risk of Adult Leukemia

Hongbing WANG*, Yoshihiro MURA*, Shigehiro NOMURA*, Michikazu SEKINE*, Shigeru SOKEJIMA*, Hideo SAKAI* and Sadanobu KAGAMIMORI*

*1 Department of Welfare Promotion and Epidemiology, Toyama Medical and Pharmaceutical University, Toyama
*2 Department of Pathology, Toyama Medical and Pharmaceutical University, Toyama, *
*3 Department of Earth Sciences, Toyama University, Toyama

Abstract

Since the first paper by Milham et al. suggested that occupational exposure to an electromagnetic field (EMF) could increase the risk of adult leukemia, many epidemiological studies on this problem have been published. In this report the method of meta-analysis was used to summarize the results from these papers quantitatively. The combined relative risk of all leukemia (RR=1.11), as well as acute lymphocytic leukemia (RR=1.38), acute myeloid leukemia (RR=1.07) and chronic lymphocytic leukemia (RR=1.14) increased but not significantly. So far, it is difficult to make a consistent conclusion about the relationship of the occupational exposure to EMF and adult leukemia. Further carefully designed case-control and cohort studies using the more valid means of exposure assessment are required.

Key words: electromagnetic field, leukemia, occupational exposure, meta-analysis

Introduction

The National Institute of Environmental Health Sciences (NIEHS) of America held a scientific conference on the health effects of electromagnetic field exposure from June 16th to 24th, 1998. It was suggested that there was some possible association (GROUP 2Bi) according to the International Agency for Research on Cancer (IARC)) between the residential or occupational exposure to an extremely low frequency electromagnetic field and the risk of leukemia among children and adults according to the results of a number of studies during past two decades, especially of the various epidemiological studies on this issue. Concern about a possible association between cancer and electric and magnetic fields from generation and use of electricity was first suggested in the study of childhood cancer by Wertheimer and Leeper. A weak association was suggested by the first epidemiological paper on occupational electromagnetic exposure and the risk of leukemia among electrical workers. Since then, nearly one hundred epidemiological studies of both occupational and environmental exposure have been published. No, or only weak, correlation was found by most of the studies on the leukemia risk from occupational exposure to an electromagnetic field. Until now it has been difficult to make a consistent conclusion from these studies directly. In this paper we conducted a quantitative meta-analysis of epidemiological studies on the relationship between occupational exposure to electromagnetic field and the risk of adult leukemia.

Method

To prepare this paper, all epidemiological studies published from the first paper by Milham et al. from the period of 1982 through December 1998 that examined occupational electromagnetic field exposure and the risk of adult leukemia were collected through a literature search using MEDLINE. Their references, as well as citations from electric and magnetic field newsletters and any other sources, were cross-checked and additional papers were added to the list. Relative risk was used as a measure of the relationship between occupational exposure to electromagnetic field and the risk of adult leukemia. For case-control studies, the odds ratio was used as a surrogate measure of the corresponding relative risk. The overall log(RR) was estimated as

$$\log(\text{RR}) = \frac{\sum (w_i \times \log(\text{RR}_i))}{\sum w_i}$$

Where $w_i$ is a weight that consists of the reciprocal of the variance of the log(\text{RR}_i). The homogeneity of log(\text{RR}_i) across the k studies was tested by using Woolf's $\chi^2$ statistic:

$$\chi^2 = \sum w_i [\log(\text{RR}_i) - \log(\text{RR})]^2$$

with df=k-1

The variance of the natural logarithm was derived from the confidence interval provided in the study or was calculated by...
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Fig. 1 Epidemiological studies on occupational EMF exposure and adult all leukemia

Fig. 2 Epidemiological studies on occupational EMF exposure and adult acute lymphocytic leukemia

Fig. 3 Epidemiological studies on occupational EMF exposure and adult acute myeloid leukemia

Fig. 4 Epidemiological studies on occupational EMF exposure and adult chronic lymphocytic leukemia

Fig. 5 Epidemiological studies on occupational EMF exposure and adult chronic myeloid leukemia

Means of standard formulas. A two-tailed P value of less than 0.05 was considered to indicate statistical significance. We used both a fixed-effects model and a random-effects model to calculate the pooled relative risk. If all the relative risks of the results were examined to be homogeneous among various studies, the fixed-effects model was used to get the combined effect of the all studies. However, the random-effects model was used as alternative method for estimating the combined effect of heterogeneous studies. The meta-analysis was conducted with EPIMETA software developed by the Center for Disease Control and Prevention (CDC) in America.

Results

Each result of epidemiological studies on occupational electromagnetic field exposure and the risk of adult all leukemia is shown in Fig. 1. Of all 22 studies, 10 showed a significant increase in relative risk. In the paper by Richardson et al., 'electrical workers' were studied and the largest risk (relative risk=3.99) of adult all leukemia was shown, but the range of 95% confidence interval was very large, from 1.06 to 14.69. On the other hand, significantly reduced relative risk was reported by Savitz et al. (relative risk: 0.76, 95% confidence interval: 0.64-0.88).

There were only 4 epidemiological studies on the relationship between occupational electromagnetic field exposure and risk of acute lymphocytic leukemia (ALL) (Fig. 2). An increased tendency was shown, but because of the small samples of the studies and the wide range of 95% confidence interval of the results, it is difficult to make any conclusion from these results.

Fig. 3 shows the results of 12 epidemiological studies of acute myelogenous leukemia (AML). The relative risk of more than 3.0 was reported by Flodin et al., Basuji-Garin et al. and Miller et al. The results of studies on the relationship between chronic lymphocytic leukemia (CLL) or chronic myelogenous leukemia (CML) and occupational electromagnetic exposure are