RESEARCH COMMUNICATION

Acute Childhood Leukemias and Exposure to Magnetic Fields Generated by High Voltage Overhead Power Lines - A Risk Factor in Iran

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Abstract

Many investigators have studied the effects of Extremely Low Frequency-Magnetic Fields generated by ordinary and domestic power lines, as a risk factor in acute leukaemias of children, but there are limited information available regarding very high voltage overhead power lines. Children in developing countries sometimes live very close to such structures and we have registered several patients with acute leukaemias appearing in clusters. In the present study we have analyzed 60 consecutively diagnosed patients with acute leukaemias, and 59 matched controls in a provincial capital city in North-Western Iran. After provision of consent, a detailed form was filled in, and a visit to the present (or previous) residential areas of both groups was arranged. The locations of the very high voltage power lines (123, 230, 400 kilo volts), were noted in each area, if present, and their distances from the houses under study were detected. The expected intensities of the Magnetic Fields (B) were calculated having the mean intensity of the electrical current and other line characteristics, by means ofÅırelevant equations. Fourteen patients in the case group (23.5%) were living near the high voltage power lines in distances ≤ 500 meters. (Mean B = 0.6 microTeslas, μT). In the control group at the same distance, the figure was 2 children (3.3%) (Mean B = 0.35 μT). Statistically, the likelihood of leukaemia was increased considerably in this distance (Odds ratio (OR) = 8.67, 95% Confidence Interval (CI) = 1.74- 58.4, P value= 0.001). On the other hand 15 pts(25 %) in the leukaemia group were experiencing Magnetic fields above 0.45 ¬μT in comparison to 5 in the control group (8.5%)(OR = 3.60, 95% CI = 1.11-12.39, P = 0.01). More children in developing countries like Iran live close to very high voltage lines, and they experience relatively more harmful effects from the Magnetic Fields, in comparison with children in developed countries. Residence near very high voltage overhead power lines, in distances ≤500 meters, and Magnetic Fields > 0.45 μT, should be considered a risk factor for the pathogenesis of acute leukaemias in children.

Key words: Acute leukaemia - children - high voltage power lines - extremely low frequency -magnetic fields

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Introduction

A possible link between childhood cancer and electrical power lines was raised when epidemiologists Nancy Wertheimer and ED Leeper, published a paper on 1979, in which they reported a 2-3 fold increased risk for childhood cancers. Since then other investigators from Scandinavian countries, USA, UK, New Zealand, Canada, and others, have studied the effects of Extremely Low Frequency Magnetic Fields (ELF - MF) (formerly known as Electro-Magnetic Fields), generated by power lines, on childhood malignancies. At least two extensive pooled analyses have also been carried out by Greenland et al, (2000) and Ahlbom et al (2000). Although malignancies like tumors of the central nervous system, lymphomas, leukemia and /or all the childhood cancers, have been investigated, acute lymphoblastic leukemia (ALL), has attracted more interest.

The method of estimating the intensity of ELF- MF, initially used by Scandinavian studies, i.e; Feychting and Ahlbom (1993),Olsen et al (1993), Verkasallo et al (1993), and Tynes and Haldorsen (1997), was based on calculations, but direct measurements or both methods were used later on. Despite earlier findings indicating an increased risk of malignancies (Wertheimer 1979), other studies showed that there was not an increased risk of developing malignant disease in children exposed to MF generated by ordinary domestic power lines (Olsen 1993, Verkasalo 1993, Tynes 1997, Linet 1997, Dockerty 1999, Mcbride 1999, Day 1999, Ahlbom 2000, Greenland 2000), or even decreased risk was reported (Kleinerman 2000). Children living, usually in slums, in industrializing major cities in developing countries, sometimes live very close to very high voltage overhead power lines, by negligence

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on housing safety standards. Since the establishment of Pediatric Oncology Department in 1994 in our centre, we have registered groups of patients with acute leukemias, appearing in clusters and living in such areas as neighbors. In this regard, we have analyzed 60 children with acute leukemia, and 59 matched controls, who were residents in a provincial capital city in North Western Iran. We tried to find out if there was any association between acute childhood leukemia and these lines as a risk factor.

Materials and Methods

In this case –control study, 87 consecutively diagnosed patients with Acute Leukemia, diagnosed between "1998 -2004", who were less than 15 years old at the time of both diagnosis and study, residents in the city itself (excluding cases living in nearby towns or villages), registered with the Hematology/Oncology clinic of Children's Hospital of Tabriz Medical Sciences University, were included. This hospital is the only 3rd level referral centre In East Azerbaijan province (total population = 4 million, and population of the capital = 2 million) and nearby provinces (Ardebil, parts of West Azerbaijan, Nakhjewan enclave of Republic of Azerbaijan), providing both Hematology and Oncology services at subspecialty level, and nearly completely covering all hematology and oncology cases in the capital city itself. For this reasons this study could be regarded as a population based study rather than a sole hospital based one. Sixteen patients excluded, because of incomplete medical records in 6, and non precise or unknown addresses in 10. Of 71 patients eligible, 11 parents (15.7%) refused to enter the study, but 60 patients entered successfully (84.3%). The control group consisted of 59 out of 75 randomly selected, either non-malignant hematological or surgicalpatients, registered with the hematology and surgery outpatient clinics of the Children's Hospital. They were matched for age, sex, race and socio-economic situation, who were living at the same geographic districts of the city as the cases.

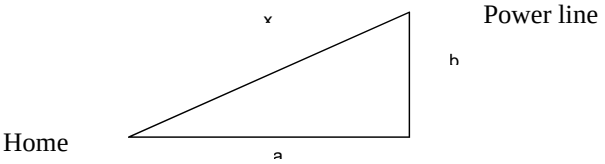
Sixteen cases in the control group were excluded because of non-consenting (21.3%), but 59 controls (78.7%) were included in the study. After getting written consent, and reviewing the hospital notes, an interview with the mothers of both groups was arranged. A detailed form was filled in by one of the authors. A visit to the homes/houses of both groups was made, and for cases with a previous addresses up to one year before diagnosis, the former houses were inspected if the patients lived there for at least 6 months immediately before the time of diagnosis. At the same visit, the locations of the very high voltage overhead transmission power lines and power stations were spotted (if present), and the distances from the house under study were measured as follows:

1) At distances up to 100 meters, and straight, using a builder's tape measure.

2) At distances more than 100 meters, and straight, using a Rolla tape.

3) At any distance, and not straight, by builder's optical device.

The real and more accurate distances of the houses to the wires (x) were calculated, where applicable, taking into account the height of the power towers (average 18meters) , the distances of the wires to earth in the mid-point between two towers (b = average15 meters), and the measured distance from homes under study (a) using the following equation : $x2 = a2 + b2$.



The necessary data regarding power lines and stations, were collected from the Department of Research, Azerbaijan Electrical Power Engineering Academy, Tabriz, Iran.

The parameters obtained included: 1) The voltages of electricity; 2) Average load of electrical current; 3) Electricity Hertz 4) Electricity Phase.The intensity of the MF was calculated, by an Academic researcher, blinded to the cases and controls, using the following equation:

$$B = \frac{\mu 0\_Idx}{2\pi\_x2}$$

Where: B = Intensity of MF (_T), μ0 = magnetic field penetration coefficient in vacuum, I = load of current, in amperes, (mean I = 1ooo), X = the distance in meters, π = 3.14, Hz = 50.

Results

The cases consisted of 58 patients with ALL, 2 with AML, 35 males (58%), 25 females (42%), all under chemotherapy, (some for relapses) , 56 alive (93.5%), and four died while under study (6.5%), with a mean age of 12.5 years at the time of study. The randomly selected controls consisted of 47 benign haematological (40 with thalassemia major, 7 hereditary spherocytosis), and 12 surgical patients, 38 boys and 21 girls, with a mean age of 13.2 years. The voltages on overhead power lines and stations under study were mostly 123 and some 230 kilovolts. The lines with 400 kilovolts were enough far from residential areas, and were considered safe. The actual distances from the power lines varied from 63 to 880 meters in the case group, and in the control group from 100 to 1100. The cases and controls regrouped according to the distances from the lines, and corresponding MF intensities they experienced (Tables I and II). The data, odds ratios (OR), 95% confidence interval (CI), and P values are shown in Tables 1 and 2. The mean intensity of MF experienced by the case group living in a distance of ≤500 meters was 0.6 μT, and that for the control group at the same distance was 0.35μT.

Discussion

The average domestic exposure to 50 HZ magnetic fields has been estimated to be 0.06μT, accordin to a study in Denmark (Olsen et al, 1993). Although the

Table 1. Odds Ratio (OR), 95% Confidence Interval (CI), and P Value According to Distances from Power Lines

Distance (meters)	<500	≤500	Total
Leukaemia Cases	14	46	60
Controls	2	57	59
Total	16	103	119

OR = 8.76, CI = 1.74- 58.4, P = 0.001

Table 2. Odds Ratio, 95% Confidence Interval (CI), and P value according to Mean Magnetic Field Intensity in μTeslas (μT)

Magnetic Field Intensity	≤0.45	<0.45	Total
Leukaemic cases	15	45	60
Controls	5	54	59
Total	20	99	119

OR = 3.60, 95% CI = 1.11-12.39, P = 0.01

majority of the investigators studying the possibility of a relation between MF and childhood ALL, did not find an increased risk in children in the low intensity category; i.e. fields equal or less than 0.2 μT, but looking carefully to their results ,in a very small percentage of their patients living in the higher intensity fields there was indeed an increased risk for malignancy. The size of this small group usually was low even in very large series. For instance it was 2.3% in the UK study (Cheng, Day, et al 1999), 1.5 - 2% in Germany(Schuz et al, 2001, and Michaelis et al, 1998), 11.4% in USA (Linet et al 1997), 15.4% in Canada (MacBride et al 1999), and 2.3% in NewZealand (Dukerty et al 1999).

A pooled analysis carried out by Ahlbom and his colleagues (2000) disclosed that only 0.8% of all cases were living in areas with MF intensities of 0.4μT or more. In our study 25% of the patients and 8.5% of controls were living in high MF areas (>0.45 μT), which are the highest ones reported so far.The OR for the higher risk groups varied from 1.72 to 6.41 in previous international studies. In fact the higher the MF intensity, the higher was the possibility of a malignancy. Linet et al (1997) reported odds ratio of 3.28 for unmatched, and 6.41 for matched case group living in an area with MF intensity of 0.4 - 0.5 μT. Olsen, et al (1993) also reported a risk of 5.6 for malignancies occurring in children exposed to EMF of ≥0.4. Ahlbom et al (2000) reported the doubling of the risk of leukemia in those exposed to MF of ≥ 0.4 μT. Tynes, et al (1997) observed an OR of 3.3 for leukemia in the highest exposure category. Greenland et al (2000) discovered no association between childhood leukemia and MF of 0.2μT intensity, but the OR rose to 1.99 when MF intensity exceeded 0.3μT. MacBride et al (1999), reported increasing in the risk of ALL in cases living near Very High Wiring Configuration facilities with an OR = 1.72. This study is a relatively small population – based, case - control analysis, performed for first time in a developing country. The relative risk of ALL in children living in close (≤ 500 m.) distance in this study was 8. 67, which is the highest one reported. Also, the relative risk of ALL for the group experiencing higher MF intensities,

Figure 1. Very high voltage ;123 kilo-volt, Power Line

was considerably high (OR = 3.60) in this study.

Interestingly our study disclosed that children in a developing country like Iran, do experience more intensive effects from such fields, and in relatively much far distances, i.e.; 500 vs. 100 meters, in comparison with their counterparts in developed countries. Electricity is very important for modern life, and an important factor for development, and no one could think of living without electricity, but potential hazards to human being should be addressed carefully. Children in developing countries sometimes live very close to very high voltage overhead power lines, because there is not any competent laws protecting them (Figures 1 and 2). They live, play, do schooling and grow up there because they have no other options. Occasionally children are admitted to the department of emergency with accidental electrical shock injuries, when playing in the vicinity of a power tower, or even trying to climb them!

The authorities in developing countries should re-assess the hazards and re-define the safe zones near the high voltage power lines. The equipments, towers and stations dealing with very high voltage electricity should be installed enough far from the residential areas. If unavoidable, it is rational to underground them in the densely populated areas. It is reasonable to appreciate a minimum of 500 meters as potentially hazardous area, and no building permits should be issued if the safe distance is not respected. In practice the danger zone observed in the vicinity of these lines, is only 34 meters (17 meters in both side), according to laws appreciated by the Electrical Engineering authorities, at the time of this study, in this region. Could the intensive effects of the fields in a developing country like Iran, be due to differing physical characteristics of hardware used in high voltage electrical equipments? Could the coverage of the bare copper wires with special plastic or other materials, be helpful in prevention of such effects? Researchers hopefully will find out more about these. Expression of oncogens like C-fos Ab1 and C-fos Ab2 has been reported after exposure to low intensity home source MF.(Omura and Losco 1993).It might be the etiology behind the carcinogenic effects of high voltage power lines. Also a prolongation in the life of free radicals have been suggested as an explanation for its carcinogenesis. (Yokus et al 2005) In conclusion, we did find a significantly

Figure 2: Very high voltage, 123 Kilo Volts, Power Line

increased risk of Acute Lymphoblastic Leukemia in children, living In the vicinity of very high voltage (123 & 230 kilo volts) power lines in distances ≤ 500 meters, and in MF intensities > 0.45μT. It also seems that children in a developing country, like Iran, do experience more intensive MF effects than children in developed countries.

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