Report on:

Pseudo-iron deficiency in a French population living near high-voltage transmission lines: a dilemma for clinicians

Professor Eric Hachulla
Service de Medecine interne
Hospital Claude Huriez, CHRU, 59045
Lille cedex, France

March, 2001

Compiled by
Emfacts Consultancy
PO Box 1403, Lindisfrane
Tasmania, 7015
Ph: + 61 3 6243 0195
E-mail: dmaisch@emfacts.com
Web site: http://www.emfacts.com

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Professeur Eric Hachulla
Service de Médecine Interne
Hôpital Claude Huriez, CHRU, 59045 Lille cedex
Tel: 0320444296; Fax:0320444062; Mail: ehachulla@chru-lille.fr

Lille, le 14 Mars 2001

Monsieur Don Maïsch
PO Box 96
North Hobart 7002
Tasmania
AUSTRALIE

mail emfacts@trump.net.au

Dear Don Maisch,

I acquainted with your work with a big interest. It is accidentally that I was brought to work on a population exposed to the EMF. I am naturally very interested to know if this aspect of " pseudo-iron deficiency " is also found at you. CFS's aspects are also found in France, the Professor Pelerin continues in Lille to be worked on this subject, he observed numerous cases of it.

I join you in file the version long my article published in European Journal of Internal Medicine, he can help you you or your colleagues in their research on this subject.

PS : Monsieur le Professeur Paul PELERIN
Hôpital Saint Vincent
Boulevard de Belfort
BP 387
59020Lille cedex
France

Professeur Eric HACHULLA
Service de Médecine Interne
Hôpital Claude Huriez - CHRU
59037 LILLE Cedex

ELSEVIER

European Journal of Internal Medicine 11 (2000) 351–352

EUROPEAN JOURNAL OF INTERNAL MEDICINE

www.elsevier.com/locate/ejim

Letter to the Editor

Pseudo-iron deficiency in a French population living near high-voltage transmission lines: a dilemma for clinicians

Eric Hachulla[a,*], Marie-Thérèse Caulier-Leleu[b], Odile Fontaine[c], Lofti Mehianoui[d], Paul Pelerin[e]

[a]*Service de Médecine Interne, Hôpital Claude Huriez, Lille, France*
[b]*Service des Maladies du Sang, Hôpital Claude Huriez, Lille, France*
[c]*Centre de Transfusion Sanguine, Lille, France*
[d]*Laboratoire d'Hématologie, Hôpital Claude Huriez, Lille, France*
[e]*Hôpital Saint Vincent, Lille, France*

Received 26 June 2000; accepted 29 June 2000

The observation during the years 1993–1994 of an unexplained iron deficiency in a number of patients from the same small, northern French village (Coutiches, 50°31′ latitude north and 3°15′ longitude east, altitude 24–31 m; a dormitory suburb of a large nearby conurbation) [1] prompted us to evaluate the iron profile and iron metabolism in subjects from this village who live in proximity to high-voltage (2×400 kV) 50–60 Hz transmission lines.

A Mag check 50+ and a Metrix MX 52 multimeter were used to measure electromagnetic fields (EMFs) levels at 50 Hz. At 1.50 m overground, EMF levels varied from 4.8 μT under the lines to 0.2 μT at 100 m from the lines. A total of 15/31 men (48.4%) ($P<0.05$ compared with controls), and 13/34 women (38.2%) had a low iron level but none had anemia. While none of the male subjects had a low ferritin level, 7/34 women (20.6%) did. Among the 13/34 women with a low iron level, only three had a low ferritin level (15/31 men (48.4%) and 10/34 women (29.4%) had a low iron level, but no anemia and normal ferritin level; $P<0.05$ compared with control, respectively). These results were much higher than those normally observed in the general population, i.e. the prevalence of iron deficiency is usually less than 25% in women and less than 5% in men [2–4].

Four male inhabitants with typical low iron levels and normal ferritin levels had a myelogram. Cell distribution was normal and the percentage of erythroblasts without iron granules was 56, 68, 73 and 87%, respectively. In two cases, iron in macrophage was absent.

Three of the males described above had isotopic explorations (more details of the method in Ref. [5]). We found a high red cell ^{59}Fe incorporation in all cases (85, 85, and 95% respectively; normal 65–75%) with a fast injected plasma ^{59}Fe epuration in one case ($T_{1/2}$=65 min, normal: 110±20 min). The red cell half-life was normal in all three cases (25, 26.5, and 28 days, respectively). Plasma iron clearance was normal in all cases (65, 80, and 115 min, respectively; normal: 60–140 min). In three cases (surface counting), a fast ^{59}Fe bone marrow incorporation with a fast regression of radioactivity was observed. In one case, no liver radioactivity was found; in the two other cases, only a minute amount of radioactivity was observed in the liver. ^{59}Fe uptake studies were similar to those of 'classic' iron deficiency but with normal ferritin levels, which is normally the first biological marker to decrease. The diminution of iron levels may have been due to the intensity of the EMFs but also to the total cumulative dose and to the number of hours of exposure per day. We also observed individual susceptibility, as a low iron level was not observed in all of the members of the same family, and in the same individuals the iron level varied during this time. This is not unique to the Coutiches population. Since the beginning of this study we have seen other subjects who live in proximity to high-voltage lines (e.g. in Bolezeele, another northern French village) with sometimes the same iron profile in the population near the EMFs.

We speculate that EMFs may modify iron metabolism in populations subjected to 0.2 μT or more with a high bone marrow incorporation of the iron (that would explain the low iron level) and a rapid utilization for the metabolism

*Corresponding author: Service de Médecine Interne, Hôpital Huriez, CHRU, 59037 Lille, France.

0953-6205/00/$ – see front matter
PII: S0953-6205(00)00114-X

of hemoglobin, sometimes with non-incorporation of ^{59}Fe in the liver. There is currently no data about modification of iron metabolism in patients leaving near EMFs. These spurious results plead for a larger study to confirm our observations.

Acknowledgements

We are grateful to J.M. Provincial and the Comité des Riverains SOS Environnement of Coutiches for their technical assistance. We thank Dr. J.J. Huart for providing the control group, Dr. Th. Perez for statistical advice, Dr. J. Kerr-Conte of the Laboratoire de Culture Cellulaire, Faculté de Médecine de Lille and R. Medeiros, English professor from the medical university of Rouen for the English translation and corrections, and M. Tomczak for typing the manuscript.

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Summary of Dr. Hachulla's research by Jean-Pierre Lentin
e-mail: jplentin@club-internet.fr

Coutiches is a village near Lille, in the North of France, situated right under a big HT line (2 x 400 kV). It was a famous case in the early 1990s, with lots of citizen protests, media reports, court cases, some medical studies - all to no avail. No health risk was acknowledged, most inhabitants eventually left, EDF (Electricite de France, the national grid company) bought the houses, many of them are empty now...

In 1991, an agreement was reached with EDF (Electricite de France), the national power company. A regular medical follow-up of residents would be financed by EDF, on 117 residents, having a check-up and blood analysis every 6 months. Pr Paul Pelerin, from Lille General Hospital, headed the medical team.

Initial findings:

The first findings were presented at Assemblee Nationale in 1994. Along with the symptoms below, iron deficiency (ferritinemia) was found from regular blood analysis. (Now the new research, with more precise and thorough analysis, shows it's a "pseudo-deficiency").

Reported symptoms were :

- general tiredness (chronic fatigue)
- headaches
- insomnia, especially in children
- hypernervosity
- hypotension
- iron deficiency (since identified as pseudo iron deficiency)
- 2 cases of severe anxiety /depression
- one resident died from bone marrow cancer in September 1992
- nausea and dizziness
- vision / ocular troubles

It was also noted that insomnia would disappear when the power was lower than usual, and return when the power got back to full level. The children often could not sleep at all, so often they were sent to grandparents' or relatives' homes, where they would sleep normally.

Current findings:

Dr Hachulla originally got involved by "chance" in 1994-95. Working in a big hospital in Lille, he noticed that several patients who came for blood analysis had very unusual parameters - and they were all living in Coutiches under the lines. Eventually a thorough follow up study was financed, on 15 men and 13 women, plus 31 male and 34 female controls (people also living in Coutiches but farther from the HT lines). There was repeated blood analysis, myelograms, isotopic explorations (and of course meausurements of fields levels). The results, despite individual variations, show clearly that most of the people living under the line have a "iron pseudo-deficiency". I.e. they have low iron levels in the blood, but no symptoms of anemia and no decrease of ferritin, which normally goes with iron deficiency.

Conclusion: "We speculate that EMFs may modify iron metabolism in populations subjected to 0.2 microTesla (2 milliGauss) or more, with a high bone marrow incorporation of the iron (that would explain the low iron level) and a rapid utilization for the metabolism of hemoglobin, sometimes with non-incorporation of (39)Fe in the liver."

At the symposium, Dr Hachulla commented that this peculiar syndrome is unknown in medical records, and that one does not know at this point what are the consequences on health and whether this effect could be detrimental or lead to other symptoms linked with EMF. But it is apparently the first time that an "objective", measurable bio-chemical effect is clearly and unmistakably shown in people living under HT lines.

Jean-Pierre Lentin

March 2001

Dr. Hachulla's oral presentation at the conference,"Biological and medical effects of high tension electrical equipment", held at Assemblee Nationale (French Congress), Paris, March 26, 1999.

Transcript by Jean-Pierre Lentin

"Here are some basics in order to understand what we have found. Humans have approximately 30 grams of iron in their body. There are 2 methods for evaluating iron stocks in the organism. The indirect method measures seric iron (iron in blood). Many of you must have had a seric iron control. It is well known that seric iron is often diminished in women with abundant menstruation. This can be a direct sign of iron deficiency, but it's a crude indication, because there are many individual variations. There is another method that is more elegant and interesting for demonstrating an iron deficiency. Here we measure the increase of a protein that transports iron, called siderophilin or transferrin. And another method for measuring iron stocks more precisely is dosing ferritinemia. When you have diminished seric iron and an iron deficiency is suspected, one measures ferritinemia in order to know whether it's a real iron deficiency.

In the blood plasma, iron is transported on a protein called transferrin. The normal destiny of iron is to enter the haeme which will, in the blood marrow, permit the making of haemoglobin, which is a structure in the red cell that carries oxygen towards the tissues. The destiny of the red cells is that they get old and die in the reticulo-endothelial system, notably the macrophage system, and notably in the spleen. We have iron stocks because all our iron is not circulating. These stocks are located in several places, and they are notably evident through ferritinemia. In normal conditions iron is transported by transferrin and this transferrin is saturated by one third. When there is an iron deficiency, the organism increases hepatic production of transferrin, so there will be more transferrin, but there is not enough iron to transport. In the true deficiency transferrin is increased, and also transferrin's transport capacity, with more binding sites, but still we have decreased seric iron.

I am a clinician in internal medicine and I was astonished, in 1996 - 1997, by the arrival to my consultation of several people who had strange seric assays, that were done in other labs in town and confirmed by our own lab, with perturbations that I could not explain. The first one was a little girl. At first I did not take it seriously, I thought it was a lab error or an individual variation. Then there were 4 men, with decreased seric iron, which is rare in men, and they had no anaemia, haemoglobin rate was normal, iron stocks were normal, ferritinemia was normal. But these 4 patients had also increased levels of transferrin, so they appeared to have iron deficiency, but really there was no deficiency, and this corresponded to nothing known.

As I am curious as a clinician, I wondered why they had this biological profile, and I found they were all living in the same village, Coutiches. So I went there. It's close to Douai, not very far from Lille. Since 1991 there are high tension lines, of 2 x 400 000 volts. The village has approximately 2000 inhabitants, altitude varies from 24 to 31 meters. Some houses are right under the lines. Measures of

EM fields have been done repeatedly. Here are the measures taken on 15th of July, 1996, at 11 PM. Right under the line we have 50 mG (milliGauss), at 100 m from the line it goes down to 2 mG. These levels vary very little from day to day, we have 20 % variations - we know that thanks to measures done regularly by the association Environnement-Coutiches.

In order to try to understand, we took biological samples, with their consent, from 31 men, 34 women and 26 children, all living in Coutiches, less than 200 m from the lines. No woman was pregnant, nobody took iron supplementation, no one had an inflammatory syndrome - those are interference causes. Each person was living at least 8 hours in this perimeter. Then we made up a control population, with the help of Lille blood transfusion center, people who were recent blood donors, matched in age and gender.

Here are the first results. People with decreased seric iron : men, 48,4 %, women, 38,2 %, children, 34 %. In the control population, it was 20 % for women and 15 % for men. Nobody had anaemia, according to haemoglobin levels. Seric iron rates in men varied from 33 to 82, where the normal rate is above 90. For women rates were 40 to 63, normal rate being above 70. The normal rate of transferrin in our lab is 350. But here this rate was increased, both in men and women. It was as if the organism sought to compensate a lack by increasing hepatic synthesis of this iron-carrying protein. Ferritinemia was normal for average values, and even for extreme values, no man had a low ferritinemia, so no man had true iron deficiency. 3 women out of 13 had low ferritinemia, and 1 child out of 9. So we found, on a larger scale, what we had found with the first 4 patients. Even if it is a small population sample, we see a distinct tendancy.
I tried to figure if these modifications might be linked to intensity of EM fields. I separated the people living less than 60 m from the line, from those living farther. At less than 60 m, iron level, in the global population, is slightly lower, and so is ferritinemia. Binding capacity of the protein is slightly higher. There is no increase of haemoglobin levels. These variations are not statistically significant, the sample is too small, we need a bigger sample. On haemoglobin levels, there is a trend towards inverse correlation with distance from the line. Nearer to the line, levels appear higher. You will understand why later.

Levels of seric iron, in the adult population of Coutiches, compared to control population, have very significant differences. Average is 85 for Coutiches residents and 107 for control population. Also the proportion : 15 out of 31 men had decreased levels in Coutiches, 5 out of 31 for controls. For women the difference is not significant, but it exists : 13 women out of 34 in Coutiches, 7 out of 34 in controls. For a decreased seric iron level with normal ferritinemia, we have 15 men out of 31 in Coutiches, 2 out of 31 in controls. This is highly significant, and it's also significant for women. We have here a typical profile of people exposed to EM fields. Why does it also appear in a small number of controls? Maybe because they are also exposed to one of the many EM sources in the environment.

In order to explain that, we had to search if there was a modification in iron metabolism. So we had to study bone marrow. We took sternal samples from 4 people, and we did an isotopic exploration of radioactive iron, in order to follow the iron metabolism and the path of iron through the organism. 3 people took this test, which is very long, they had to go daily at the hospital. On myograms, their marrow is normally rich, but, astonishingly, poor in iron. Incorporation of radioactive iron injected through the veins in the marrow is rapid and almost complete - in a normal person, incorporation is rarely more than 60 or 80 %. And we did an external count of radioactivity of Fe59 injected in the organism, we saw that iron is very rapidly incorporated in bone, where haemoglobin synthesis takes place, then very quickly evacuated from the bone. Also, probably, red cells are rapidly ejected by the bone marrow. Iron, which is normally stocked in the liver and spleen, is depleted and rapidly evacuated by normal stocking organs. And after 6 days there is nothing left. This kind of profile is exactly the profile of iron deficiency, But there is no deficiency, since ferritinemia is normal.

Our working hypothesis is that there is probably a displacement of iron from some part of the organism to others, in order to have a rapid synthesis of haeme and haemoglobin, and this may explain that, nearer to the HT line, there is higher haemoglobin levels. This is probably linked to EM fields intensity and cumulative doses. Clearly, there are individual susceptibilities. We also observed that the iron parameters would return to normal when people moved from the exposed residence, and it took several months. And this is not a "Coutiches effect", because we observed the same thing with residents of Bolezeele. "

24/03/2000

Final version

Pseudo-iron deficiency in a French population living near high-voltage transmission lines : a dilemma for clinicians

Eric Hachulla[1], Marie-Thérèse Caulier-Leleu[2], Odile Fontaine[3], Lofti Mehiafxcoui[4], Paul Pelerin[5]

1 Eric Hachulla (MD, PhD), Service de Médecine Interne, Hôpital Claude Huriez, Lille - France

2 Marie-Thérèse Caulier-Leleu (MD), Service des Maladies du Sang, Hôpital Claude Huriez, Lille - France

3 Odile Fontaine, Centre de Transfusion Sanguine, Lille, France

4 Lofti Mehianoui, (MD), Laboratoire d'Hématologie, Hôpital Claude Huriez, Lille , France

5 Paul Pelerin, (MD), Hôpital Saint Vincent, Lille, France

Correspondence to : Eric Hachulla (MD, PhD), Service de Médecine Interne, Hôpital Claude Huriez, 59037 Lille cedex, France - Fax : (33) 320444062

ABSTRACT

Background : In 1994 a high incidence of unexplained iron deficiency was reported in a small northern French village. Some of these patients lived close to high voltage electricity transmission lines (HVTLs) (2 X 400 KV, 50-60Hz). Therefore, the possibility that HVTLs may be associated with abnormalities of iron metabolism was explored.

Methods : The iron profiles and serum ferritin levels of 31 men and 34 women living within 200 m of HVTLs were compared with age and sex matched controls. Examination of all subjects failed to reveal causes of blood loss, dietary insufficiency, concomitant illness, or other known causes of defects in iron metabolism. Four subjects agreed to bone marrow examinations and three male subjects to uptake studies with Fe 59 isotope.

Results : No subjects were anaemic. However, 15 of the 31 men (48%) and 10 of the 34 women (29 %) had low serum iron but normal ferritin levels compared with controls ($p < 0.0002$ and < 0.01, respectively). Bone marrow examinations revealed a high proportion of erythroblasts without iron granules : in two subjects iron was absent from bone marrow macrophages. Fe 59 uptake studies were also similar to those of " classic " iron deficiency, with high incorporation into bone marrow and little or no uptake by the liver and spleen.

Conclusion : Living close to HVTLs may modify iron metabolism in the absence of other causes.

Chronic residential exposure to EMFs (electromagnetic fields) with low frequencies of 50/60 Hz can result from proximity (i.e. < 200 m from habitation) of high-power lines and transformers. Some epidemiological studies have suggested that exposure to ambient, low-level 50/60 Hz EMFs increases the risk of disease. More specifically, the risk of lymphoid or myeloid disorders, brain and breast cancers may increase [1,2,3]. There is little evidence that home exposure increases the risk of lymphoblastic leukaemia when residential magnetic-field levels are less than 0.2 µT[4].

The exposed subjects submitted to low-frequency EMFs of 0.2 µT to 6.6 µT had a significant increase in the frequency of certain neurovegetative disorders and a significant fall in total lymphocytes [5]. The observation during the years 1993-1994 of unexplained iron deficiency in a number of patients from the same small northern French village [6] prompted us to evaluate the iron profile and iron metabolism in subjects from this village who live in proximity to high-voltage (2 x 400 KV) 50-60 Hz transmission lines.

METHOD AND PATIENTS

Measuring of EMFs

The study involved the population of a small northern French village (Coutiches, 50°31' latitude north and 3°15 ' longitude east, altitude 24 to 31 m ; a dormitory suburb of a large nearby conurbation) of 2056 people in July 14^{th} 1998. In August 1991 high-voltage (2 x 400 KV) 50-60 Hz transmission lines were placed throughout the village over the residential areas in the proximity of an older 150 KV. A Mag check 50+ and a Metrix MX 52 multimeter was used to measure EMFs levels at 50

Hz. When transformers were functioning normally, three orthogonal measurements were performed in the three spatial dimensions (i.e., vertical [x] and two [y.z] horizontal at 90°). Each measurement was squared, and EMF levels calculated as

$$\sqrt{x^2 + y^2 + z^2}.$$

Population studied

During 1996 and 1997 at the medical consultation we evaluated 4 men from Coutiches with an apparent iron deficiency (Table 1). None had anaemia and all had normal ferritin level. No inflammatory syndrome, no history of bleeding and no digestive symptoms were observed. We postulated that EMFs may have modified iron metabolism. All investigations were performed with the informed consent of the studied population.

We analysed the iron profile and serum ferritin of 31 men (mean age 35.3 ± 16.4 SD) and 34 women (mean age 39.3 ± 13.5 SD). All lived within 200 m from the 2 x 400 KV transmission lines. No women were pregnant, and no subjects had an iron supplementation at the time of the study, or an inflammatory syndrome. EMFs exposure was at least 8h per day for the entire population studied. Subjects (men and women) were matched for sex and age with a control population living nearby with no history of exposure to EMFs and no past nor present iron supplements [first screening blood donors from the Blood Transfusion Center (CTS, Lille)]. Both the studied and control population had no diet particularity and had the same climatic and environmental factors except for EMFs exposure.

Biological data

Iron and TTC were measured by Atomic Absorption SpectrAA n°200 (Varian, Australia). Normal values for our laboratory were : iron = 90-160 µg/dl in male, 70-140 µg/dl in female ; TTC = 250-350 µg/dl. Haemoglobin (Hb) level was calculated by a STKS Coulter (Coultronics, USA). Normal values were 12.9-18.1 g/dl in male, 11.5-16.5 g/dl in female. Ferritin level was measured using an automate immunochemiluminescence system (ACS 180, Ciba-Corning). Normal values in adults were 20-300 ng/ml.

Sternal bone marrow with Perls staining (potassium ferrocyanure) was studied in 4 subjects who apparently had iron deficiency but a normal ferritin level.

Isotopic exploration with iron 59 (^{59}Fe) and red cells chromium 51 (^{51}Cr) was performed in 3 male subjects who lived in a perimeter of 100 m from the EMFs lines as previously described in [7] because they apparently had iron deficiency but normal ferritin level. Plasma iron clearance was carried out by noting the rate of decrease of radioactivity in the plasma following the intravenous injection of 0.3-0.4 Mbq of ^{59}Fe in the form of ferric citrate labelled autologous plasma. Surface counting after the administration of ^{59}Fe was carried out on liver, spleen and sacrum and heart for circuliting radioactivity correction. The average life span of red cells was estimated using ^{51}Cr labelled autologous red cells. Following a period of watchful waiting, necessary for circulation homogenisation, an EDTA sample was taken. This represented the radioactivity on day zero. Further samples were taken on succeeding days (daily for the first week and twice weekly for the next month, radioactivity was expressed as a percentage of that found on day zero).

Statistical analysis

Descriptive analysis was performed with ANOVA and a paired T test was used to compare biological parameters. The Chi-2 test was used to compare percentages.

RESULTS

At 1.50 meters overground EMFs levels varied from 4.8 μT under the lines to 0.2 μT at 100 meters from the lines (Figure 1). In households within 30 m from the EMFs lines, field measurements performed at 2 meters over ground (4 weekly measures were performed between 7 AM and 8 AM) during the period from March 1996-March 1997 revealed a relative stability of EMF levels (variation from 0.7 μT and 1.05 μT, median 0.8 μT).

The biological values of the studied population and controls are shown in table 2. Paired T test compared the adult population to controls. Iron levels were significantly lower in the adult Coutiches' population when compared with controls. TTC was higher in Coutiches' population but the difference did not reach a significant level versus controls. No statistical difference in Hb, ferritin and mean corpuscular volume was found.

A total of 15/31 (48.4 %) men, and 13/34 (38.2 %) women had a low iron level while none had anaemia (Table 3). No male subjects had a low ferritin level, however 7/34 (20.6 %) women had low ferritin levels. Among the 13/34 women with a low iron level, only 3 had a low ferritin level.

The frequency of low iron levels was statistically significantly higher in the adult Coutiches population when compared with controls :15/31 (48.4 %) vs 5/31 (16.1 %)

in men, p=0.006 ; 13/34 (38.2 %) vs 7/34 (20.6 %) in women, but did not reach a significant level. In the control population, 2 of the 5 men with low iron level had low ferritin level (i.e. an authentic iron deficiency), 2 of the 7 women had low ferritin level (i.e. an authentic iron deficiency). In the Coutiches population, if we consider only those individuals with low iron level and normal ferritin level and compared with controls (15/31 vs 2/31 in men and 10/34 vs 2/34) the differences were found to be significant in both groups (p= 0.0002 and p = 0.01 respectively). None had anaemia nor inflammatory syndrome (Table 4).

A total of 4 male inhabitants with typical low iron levels and normal ferritin levels had a myelogram (patients described in table 1). Cell distribution was normal, the percentage of erythroblasts without iron granules was respectively 56 %, 68 %, 73 % and 87%. In two cases, iron in macrophage was absent.

Three of the males described above had isotopic explorations. We found a high red cell ^{59}Fe incorporation in all cases (85 %, 85 %, 95 % respectively, normal 65 to 75 %) (Figure 2a) with a fast injected plasma ^{59}Fe epuration in 1 case (T1/2 = 65 min, normal : 110 ± 20 min). The red cell half-life was normal in the 3 cases (25 days, 26.5 days, 28 days respectively). Plasma iron clearance was normal in all cases (65 min, 80 min, 115 min respectively, normal : 60-140 min). In 3 cases (surface counting) a fast ^{59}Fe bone marrow incorporation with a fast regression of radioactivity (Figure 2b) was observed. In one case, no liver radioactivity was found, in the two other cases only a minute amount of radioactivity was observed in the liver.

DISCUSSION

Coutiches is a small northern French village which is traversed by high-voltage lines (2 x 400 KV) since 1991 and in the proximity of older 1 x 150 KV 50-60 Hz transmission lines. EMFs levels varied from 4 μT under the lines to 0.2 μT at 100 m from these lines. After examining 4 subjects from this village with an apparent iron deficiency (low iron level, high TTC) but normal ferritin level and without anaemia nor inflammatory syndrome, we postulated that EMFs may interact with iron metabolism. With informed consent of the population we studied 65 subjects who lived for at least 8 h in a 200 m perimeter from the lines. We found an abnormally high frequency of low iron levels : 48.4 % of the men and 38.2 % of the women. These results were much higher than that normally observed in the general population : the prevalence of iron deficiency is usually less than 25 % in women, less than 5 % in men [8, 9, 10]. We found no explication other than the proximity of high voltage lines. In the studied population, none had anaemia, and ferritin levels were not different compared to controls, this confirmed the pseudo-iron deficiency. When a paired comparison was made with controls without any exposure to EMFs, we only found a statistical difference in men. The absence of statistical difference in women was explained by the high frequency of iron deficiency in women. When authentic iron deficiency (i.e. patients with low ferritin level) was excluded, the difference in patients with low iron level was significantly present in men and women (see Table 4). This profile was found in 48.4 % (15/31) in men and in 29.4 % (10/34) in women in the Coutiches population studied who lived near the EMFs, with a highly significant difference when compared with controls (2/31 in men and 2/34 in women, $p = 0.0002$ and $p = 0.01$ respectively). In the population with low iron levels and normal ferritin levels we found no sources of blood loss, malabsorption and or inflammatory syndromes. Nevertheless, when myelogram and ^{59}Fe isotopic exploration were made, both the erythroblast incorporation and the liver and spleen evacuation resembled an authentic iron deficiency. However, the normal ferritin levels and the absence of anaemia confirm the normality of iron stock. Is there more iron on Hb, is iron localised elsewhere ? Could this biological particularity induce some long term pathology ? Further investigations should be performed to answer these questions.

The diminution of iron levels may possibly be due to the intensity of the EMFs but also from the total cumulative dose and from the number of hours exposed per day. We also observed individual susceptibility as a low iron level was not observed in all the members of the same family and in the same individuals the iron level varied during this time. This is not unique to the Coutiches population. Since the beginning of this study we have seen other subjects who live in proximity to high voltage lines (Bolezeele, an other northern French village) with sometimes the same iron profile in the population near the EMFs. We postulate, as Li et al. [11] that populations living in households less than 100 m from high voltage tension lines may be susceptible to organic health modifications.

We speculate that electromagnetic fields may modified iron metabolism in population submitted to 0.2 μT and more with a high bone marrow incorporation of the iron (that explain the low iron level) and a rapid utilisation for the metabolism of hemoglobin with sometimes non incorporation of ^{59}Fe in the liver.

Acknowledgement

We are grateful to JM Provincial and the Comité des Riverains SOS Environnement from Coutiches for technical assistance. We thank Dr JJ Huart for the control group constitution, Dr Th Perez for statistical advice, Dr J Kerr-Conte of the Laboratoire de Culture Cellulaire, Faculté de Médecine de Lille and R Medeiros, English Professor in the Medicine University of Rouen for the English translation and correction, and M Tomczak who carried out the typing of the manuscript.

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Table 1 : Iron profile of the 4 male subjects from Coutiches seen in consultation

Subjects	Iron (µg/dl)	TTC (µg/dl)	Ferritin (ng/ml)	Hb (g/dl)	MCV (µ3)	ESR (mm/h)
1	38	511	66	16.4	93	4
2	76	400	142	15.9	86	12
3	69	362	164	14.5	83	8
4	54	366	246	13.4	88	10

TTC = Total iron binding Transfer Capacity ; Hb = Haemoglobin ; MCV = mean corpuscular volume ; ESR = erythrocyte sedimentation rate

Normal values in our laboratory :

Iron = 90-160 µg/dl in male, 70-140 µg/dl in female ; TTC = 250-350 µg/dl ; Ferritin = 20-300 ng/ml in adult ; Hb = 12.9-18.1 g/dl in male, 11.5-16.5 g/dl in female ; MCV = 85-95 µ3 ; ESR < 15 mm/h

Table 2 : Biological data of the studied population and in controls

	Iron (µg/dl) mean ± SD	TTC (µg/dl) mean ± SD	Ferritin (ng/ml) mean ± SD	Hb (g/dl) mean ± SD	MCV (µ3) mean± SD
Total studies population (n = 65, 31 men and 34 women)	men : *82.34 ± 26.91	men : 368.57 ± 58.55	men : 147.0 ± 131.0	men : 14.60 ± 0.86	men : 88.8 ± 3.0
	women : *87.42 ± 35.37	women : 376.68 ± 71.82	women : 40.77 ± 29.32	women : 13.41 ± 0.67	women : 87,8 ± 3,3
Controls (n = 65, 31 men and 34 women)	men : 111.6 ± 31.2	men : 355.7 ± 45.34	men : 104.32 ± 85.72	men : 14.78 ± 0.63	men : 89.77 ± 3.69
	women : 95.76 ± 3.5	women : 321.25 ± 44.01	women : 43.37 ± 52.73	women : 13.14 ± 1.07	women : 90.26 ± 5.12

. TTC = Total iron binding Transfer Capacity ; Hb = Haemoglobin ; MCV = mean corpuscular volume

. Normal values in our laboratory :

Iron = 90-160 µg/dl in male, 70-140 µg/dl in female ; TTC = 250-350 µg/dl ; Ferritin = 20-300 ng/ml in adult ; Hb = 12.9-18.1 g/dl in male, 11.5-16.5 g/dl in female ; MCV = 83-95 µ3 ;

* $p < 0.01$ when compared with controls

Table 3 : Frequency of low iron levels in the Coutiches population and in controls

	Coutiches population		Controls	
	men	women	men	women
Number of subjects with low iron level	15/31* (48.4 %)	13/34 (38.2 %)	5/31 (16.1 %)	7/34 (20.6 %)
Number of subjects with low iron level and normal ferritin level	15/31* (48.4 %)	10/34* (29.4 %)	2/31 (6.4 %)	2/34 (5.8 %)

* : $p < 0.05$ when compared with controls

Table 4 : Results observed in the Coutiches population with low iron levels

	Men (n=15/31)	Women (n=13/34)
ESR (mm/h) median (extreme)	6 (4-12)	11 (6-15)
Hb (g/dl) median (extreme)	14 (13.3-16.4)	13.3 (12.4-14.4)
MCV (µ3) median (extreme)	89 (84-94)	87 (81-93)
Iron (µg/dl) median (extreme)	67 (33-82)	54 (40-63)
TTC (µg/dl) median (extreme)	365 (263-488)	409 (253-531)
Ferritin (ng/ml) median (extreme)	137 (22-246)	31 (11-80)

ESR = erythrocyte sedimentation rate ; Hb = Hemoglobin ; MCV = mean corpuscular volume ; TTC = Total iron binding Transfer Capacity ;

Normal values in our laboratory :

ESR < 15 mm/h ; MCV = 83-95 µ3 ; Hb = 12.9-18.1 g/dl in male, 11.5-16.5 g/dl in female ; Iron = 90-160 µg/dl in male, 70-140 µg/dl in female ; TTC = 250-350 µg/dl ; Ferritin = 20-300 ng/ml in adult

Legends

Figure 1 : EMFs levels observed at 1.50 meter over ground, underground and near the 2 x 400 KV – 50-60 Hz transmission lines (July 15th 1996 at 11 A.M.)

Figure 2 : Bone marrow incorporation after administration of ^{59}Fe in the peripheral blood (Fig 2a) and ^{59}Fe surface counting using a collimated scintillation counter (Fig 2b) (typical exploration of patient1).

The results were corrected after heart measurement for blood circuliting radioactivity correction

Fig. 1

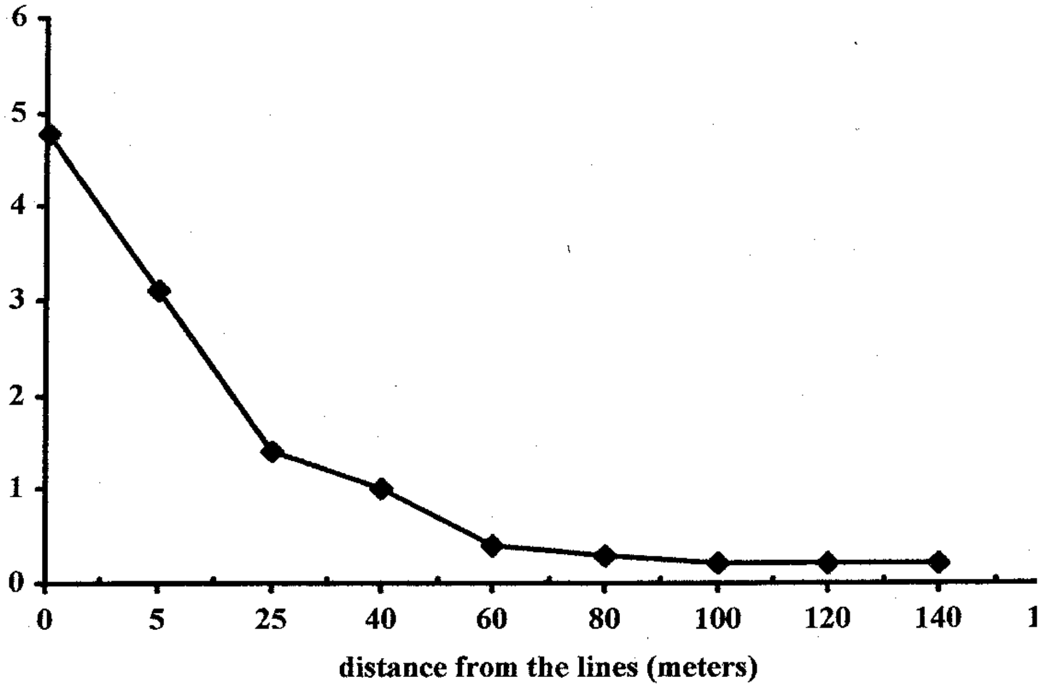

6
5
4
3
2
1
0
0
5
25
40
60
80
100
120
140
1
distance from the lines (meters)

Fig 2 a

% incorporation of ^{59}Fe in erythroblast

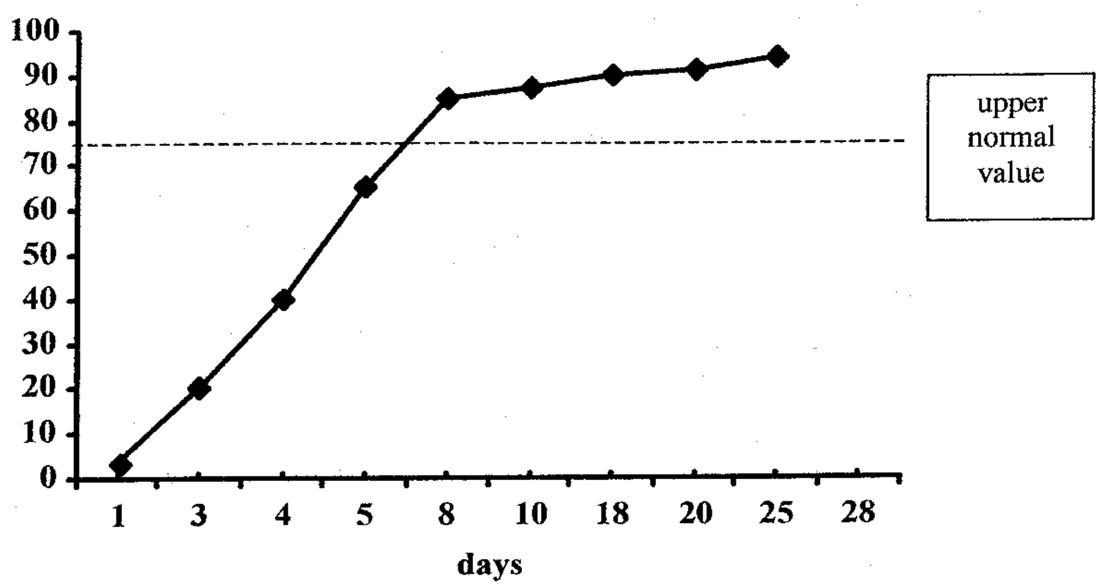
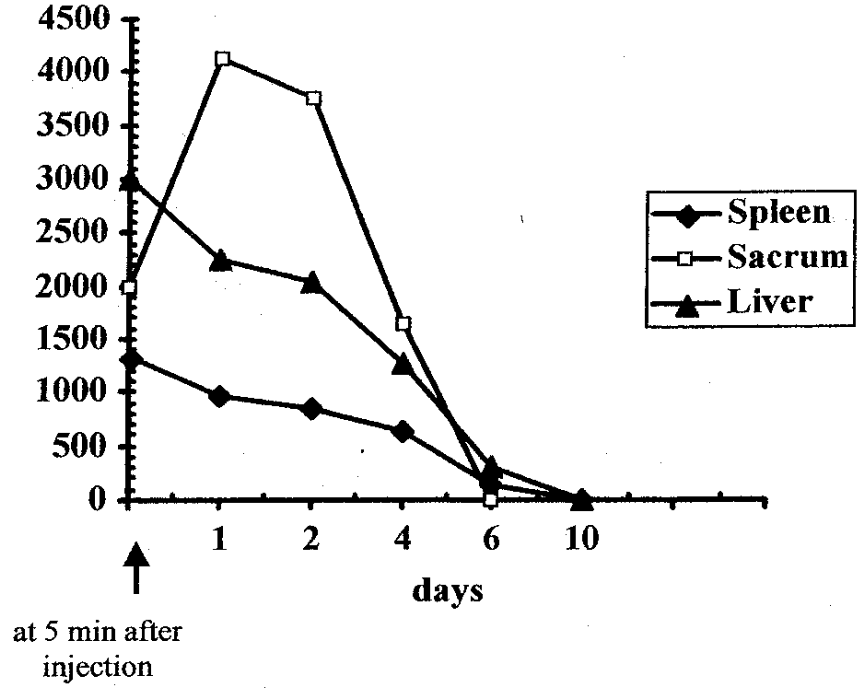


Fig 2 b

% incorporation of ^{59}Fe in erythroblast



QUOTATION – ARL REFERENCE No 14.

25 February 2002.

Don Maisch
EMFacts Consultancy
PO Box 96
North Hobart. 7002.

Dear Don

We have pleasure in submitting our quotation for your consideration.

ANALYSIS : Salivary Melatonin and Iron Studies (ESR,MCV,Hb,Ferritin,TIBC,Iron).

NUMBER OF SAMPLES : 50-200.

SAMPLES - BATCH SIZE : This quotation has been prepared on the basis of analysing batch sizes of 50 samples.

SAMPLE REQUIREMENTS : Saliva (ARL will provide collection tubes) and blood.

TURNAROUND TIME FOR RESULTS : 5-7 working days after receipt of specimens.

QUOTATION : Salivary Melatonin $16.50 per sample (+ 10% GST). Iron Studies $29.90 per sample (+ 10% GST).

TERMS AND CONDITIONS : The work will commence on receipt of an official order. Payment is Nett 30 days from the date of final reports.

Thank you for the opportunity to submit our quotation. We look forward to your favourable response.

Please confirm your acceptance by return fax.

Yours sincerely,

Colm Benson,
Health Services Manager,
ANALYTICAL REFERENCE LABORATORIES PTY. LTD.

PLEASE FAX BACK TO COLM BENSON (03)93265004

ACCEPTANCE OF QUOTATION - ARL REFERENCE No 14.

Quotation and Terms and Conditions dated 25 February 2002 are accepted - Salivary Melatonin and Iron Studies as per Analytical Reference Laboratories Pty. Ltd. written Quotation No 14 - Salivary Melatonin $16.50 per sample (+10% GST). Iron Studies $29.90 per sample (+ 10% GST).

Samples are expected to arrive at ARL on ______________________________

Signed by : ______________________________

Position/Company (if applicable) ______________________________

Account to be sent to(name and address) ______________________________

Dated ______________________________