Do magnetic fields cause increased risk of childhood leukaemia via melatonin disruption?

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Introduction

We present the hypothesis that exposure to power frequency magnetic fields causes increased risk of childhood leukaemia via the disruption of the nocturnal production of melatonin in the pineal gland. Melatonin (N-acetyl-5-methoxytryptamine) has been identified in a wide range of organisms from bacteria to human beings. Its principal source in man is as the chief secretory product of the pineal gland. This follows a marked circadian rhythm, the majority production occurring at night regulated by non-rod, non-cone receptors in the eye sensing the absence of light.

Melatonin is remarkably non-toxic and has been found to be a radical scavenger and antioxidant, more effective than either vitamins C or E. The hormone has been found to protect cells, tissues and organs against oxidative damage induced by a variety of free radical generating agents and processes, e.g. the carcinogen safrole, lipopolysaccharide, kainic acid, Fenton reagents, potassium cyanide, ischemia-reperfusion and ionising radiation (Reiter et al. 1997). Melatonin is an antioxidant effective in protecting nuclear DNA, membrane lipids and possibly cytosolic proteins from oxidative damage. It has been reported to alter the activities of enzymes which improve the total antioxidative defence capacity of the organism.

The melatonin hypothesis.

Stevens (1987) noted that breast cancer was a disease of modern life associated with industrialisation. He proposed that the use of electric power may increase the risk of breast cancer. The risk arose from reduced production of nocturnal melatonin brought about by exposure to two principal agents, namely light-at-night (LAN) from domestic as well as street lighting and magnetic fields associated with the electricity supply. Strong support for LAN affecting breast cancer risk has come from experiments in animals. Support in humans comes from the observation of reduced hormone-related cancer rates in the blind and partially sighted and increased breast cancer rates in nightshift workers (e.g. Hahn 1991, Feychting et al. 1998, Hansen 2001).

Magnetic field suppression of melatonin.

There are now at least 12 studies in human populations examining whether exposure to power frequency magnetic fields reduces or otherwise disrupts the nocturnal production of pineal melatonin. One study does not support this notion, although the study sample was small. For the remaining 11 studies, while some show a weak effect of melatonin disruption, others show clear effects including a dose response relationship for magnetic field exposures as low as 0.2 µT or lower (e.g. Davies et al. 2001, Burch et al. 2002). Of particular interest are those studies reporting melatonin disruption in relation to 3-phase EMF sources (e.g. Burch et al. 2000). Such sources set up elliptically or circularly polarised fields which induce higher currents in the body compared with linearly polarised (plane wave) fields and which have been reported to be more effective in suppressing pineal melatonin in rats (Kato and Shigemitsu 1997). We have noted that some degree of polarisation is the norm for magnetic fields associated with the electricity supply (Ainsbury 2004). The effect of magnetic fields on breast cancer risk, however, is not well established and pooled analyses of studies suggest only a small increase in risk (Erren 2001).

Childhood leukaemia and melatonin

The potential importance of melatonin suppression to leukaemia risk arises from the observation that the hormone is highly protective of oxidative damage to the human haemopoietic system. Vijayalaxmi et al. (1996) administered 300 mg of melatonin to four healthy volunteers. Immediately, and one and two hours later, blood samples were taken and irradiated with 1.5 Gy ¹³⁷Cs gamma
radiation. Compared with blood samples taken immediately, those taken at two hours had significantly decreased (50 – 70%) chromosome aberrations and micronuclei. The authors concluded that the observations may have important implications for the protection of human lymphocytes from genetic damage induced by free radical-producing mutagens and carcinogens. The authors investigated the mechanism of melatonin protectiveness in terms of both direct scavenging in the cell nucleus of radiation-induced free radicals, including the hydroxyl radical and action at the cell membrane and in the cytosol to trigger activation of existing DNA repair enzymes and/or activation of a set of genes that lead to de novo protein synthesis associated with DNA repair (Vijayalaxmi et al. 1998). In a further experiment, Vijayalaxmi et al. (1999) irradiated mice with 8.15 Gy gamma radiation untreated and pre-treated with 125 and 250 mg melatonin. In the untreated mice, 45% were alive after 30 days, but 85% were still alive in those pre-treated with 250 mg melatonin.

Melatonin has also been shown to be highly protective of oxidative damage to the fetus in animals and there is a sizeable literature on this subject (e.g. Wakatsuki et al. 1999, 2001). In women, Okatani et al. (1998) showed the efficient maternal-fetal transfer of melatonin near term. The relevance to childhood leukaemia stems from compelling evidence that the initiating event(s) in acute lymphoblastic leukaemia (ALL) appear to take place in utero (Greaves 2002).

**Epidemiological and experimental tests of this hypothesis.**

The significant increase in childhood leukaemia aged 1-4 last century in England and Wales (ONS 2004) may implicate in its aetiology LAN, and melatonin disruption and therefore magnetic fields. The protectiveness of melatonin to the haemopoietic system could be examined in the presence of magnetic fields.

**References**

Ainsbury E. 2004 University of Bristol, personal communication.