**Brain cancer with induction periods of less than 10 years in young military radar workers**

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CASE REPORTS. Previously, (1) we reported that 6 young patients had cancers (i.e., melanoma of the eye, seminoma, nasopharyngeal cancer, breast cancer, pituitary adenoma, and non-Hodgkin's lymphoma) that occurred following high or prolonged occupational exposures to radar in the military. Given that there were other cases of cancer among young coworkers, we used a linear model of risk to suggest a precautionary threshold for no detectable increase in risk, ranging from--10 [micro]w/[cm.sup.2] to 100 [micro]w/[cm.sup.2] for all cancers, and from 1 [micro]w/[cm.sup.2] to 10 [micro]w/[cm.sup.2] for specific cancers.

In this article, we report on 5 young patients with cancer of the brain with an induction period of less than 10 yr following occupational exposure to radar in military settings. In 4 patients, age of onset was under 30 yr, and in 3 patients the induction periods were less than 5 yr; 1 patient had already died at the time of publication. Exposures were generally unregulated, monitoring was lax, and exposures were based on detection thresholds that exceeded 100 [micro]w/[cm.sup.2]. The patients, listed by year of first exposure, are listed in Table 1. The tumors appeared in the first 4 patients prior to the advent of cell phone use in Israel. The remaining 1 patient did not own a cell phone prior to diagnosis.

Comments

Subsequent to Zaret's (2) first report of 2 individuals with astrocytoma in a group of 18 radar-exposed workers, Goldsmith (3) reanalyzed the Moscow Embassy data and showed increased risks for brain cancer from exposure to radar/microwaves in adult dependents. In addition, there have been suggestions that there are increased risks of brain cancer in subgroups of naval (4) and air force electronic radar technicians. (5,6)

Szmigielski et al. (7) reported increased risks for brain cancer in Polish military personnel who were exposed to radar; this is the only such study that contained reported exposure estimates. It is generally assumed that episodes of brain cancer that appear after latent periods of less than 10 yr are merely coincidental associations, not sentinel indicators of causation. In an authoritative text on brain cancer and occupational exposures, and specifically on exposure to radiofrequency fields from cell phones, it was stated that "in adult humans, all known environmental carcinogens, including radiation, require a latency period usually more than 10 and often more than 20 years." (8) Such a statement ignores the well-established epidemiologic observation that short induction periods following high exposures in certain individuals are a recognized indicator of impending group risk. (9-11) With respect to leukemia and multiple myeloma, latencies between first exposure to benzene and death can be as brief as 2-3.5 yr. (12)

We suggest that the earlier-reported individual cases characterized by short latencies in young persons with high military occupational exposures serve as indicators of impending increased group risk for exposures to radiofrequency fields/microwaves. If the brain tumors we report are causally related to prior exposures, then induction periods can be very brief, and growth of brain tumors can be extremely rapid. This statement applies to brain tumors from other exposures also. We have seen other patients--1 with astrocytoma and another with medulloblastoma (both deceased)--whose brain tumors presented within 5 yr of the first exposures to high levels of solvents. Furthermore, if exposures are high, induction periods may be brief for clusters of patients with several types of tumors.

All of the aforementioned points about risks from military exposures to radar state the case for the reduction of work

exposures of individuals to the lowest achievable levels, and they should guide our evaluations of recent reports on hazards and risks from exposure to radiofrequency fields from cell phones. The use of cell phones represents the first time in history that humans are carrying out a mass "experiment" in which possibly hundreds of millions of individuals are holding a source of radiofrequency fields that produce field strengths that sometimes reach several hundred [micro]w/[cm.sup.2], and the fields are in direct contact with the side of each individual's head.

Frey (13) called attention to the limited power of recent epidemiological studies of brain cancer and prior use of cell phones, inasmuch as the studies were based on small numbers and short latencies for the elimination of increased risks--a point the authors of these studies (14,15) and editorialists (16) themselves make. Lai and Singh (17) reported experimental findings on effects of radiofrequency on deoxyribonucleic acid breaks. Gandhi et al. (18) and Schornborn et al. (19) have presented models on the geometry of the gradient of diffusion of microwave energy into the brain from side of use. Weinberger and Richter (20) have suggested that the frequencies for transmission and reception by cellular telephones (900 MHz and 1,800 MHz) exploit the head as a lossy resonator.

What, then, is to be made of reports of brain cancers following short latencies in persons who use cell phones? Hardell et al. (21) reported that 13 patients developed brain cancer on the same side of their head reportedly used for cell phone activities. Eight of the patients had induction periods of less than 5 yr (5 were under the age of 50 yr), and 2 individuals had induction periods between 5 and 9 yr. In a case-control study conducted subsequently, Hardell et al. (22) suggested that the risk for brain cancer increases on the same side of the head a cell phone is used. We suggest the hypothesis that brief latent periods for brain cancer from radar, as well as from radiofrequency in individual cell phone users, predict the likelihood of impending increased risks for brain cancer from the radiofrequency of cell phones. If, however, latencies for ipsilateral tumors of the brain are briefer than for contralateral tumors, we would have even stronger evidence for a very early indicator of risk.

Epidemiology will enhance its effectiveness as a tool for the early detection and prevention of hazardous exposures to carcinogens when it recognizes that the first signs of increased risks come from cases with brief latency periods following high exposures--before there are detectable increases in group risk. When such cases follow exposures for which there is experimental evidence for a genotoxic effect, precautionary measures are indicated.

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Table 1.--Case Reports for 5 Young Patients with Cancer of the Brain, with an Induction Period < 10 yr Following Occupational Exposure to Radar in Military Settings

| Patient no. | Years of exposure | Age at first exposure (yr) | Job, tasks, exposure | Symptoms when exposed or symptoms leading to diagnosis |
|---|---|---|---|---|
| 1 | 1980-1982 | 19 | Radar technician; supervised direction of firing. | Headache, vision problems, loss of memory. |
| 2 | 1982-1996 | 29 | Senior engineer. | Numbness and |

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| | | | 18-GHz signal generators, power up to 100 W; microwave communication systems with radio-frequencies (10-100 W). Communication systems and large antenna arrays. ELF from mainframe. | tingling, left side of face, left hand |
| 3 | 1987-1992 | 20 | Technician, communi-cation equipment (i.e., radios) with power sources of 0.01-1 W in MHz to GHz range. Radiofrequency fields/ microwaves (30-88 MHz) at very high transmission power--up to 300 W. | Asymptomatic; diagnosis made after concussion was diagnosed in connection with a motor-cycle accident. |
| 4 | 1987-1991 | 20 | Technician-supervisor. Active and passive instruments for trans-mitting and receiving radiofrequency. A co-worker who was the same age committed suicide. | No information on symptoms |
| 5 | 1995-1998 | 18 | Technician. Receiving and transmitting antennas; radar nets and wave guides; electronic equipment and generators. | Gait disturbance, dysmetria, and nystagmus |

| Patient no. | Diagnosis | Year of diagnosis | Induction period (yr) | Age at diagnosis (yr) | Current age in 2002 or age (yr) at death |
|---|---|---|---|---|---|
| 1 | Cystic astrocytoma (surgery). | 1982 | 2 | 21 | 41 |

| | | | | | |
|---|---|---|---|---|---|
| 2 | Invasive pituitary adenoma (surgery). | 1990 | 8 | 37 | 47 |
| 3 | Neurocytoma, left ventricle, on septum pellucidum (surgery) | 1994 | 7 | 27-28 | 35 |
| 4 | Probably glioblastoma brain stem (MRI). | 1991 | 3 | 23-24 | 29 * |
| 5 | Medullo-blastoma right posterior fossa with obstructive hydrocephalus (surgery). | 1998 | 3 | 21 | 25 |

Notes: GHz = gigahertz, W = watts, MHz = megahertz, MRI = magnetic resonance imaging, and ELF = extremely low frequency.

* Age at death.

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* The author has served as witness for 2 plaintiffs for the reported patients.