MANAGEMENT OF RADIO-FREQUENCY

RADIATION OVEREXPOSURES

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Bruce Hocking FAFOM FRACGP
Consultant in Occupational Medicine
9 Tyrone St
Camberwell
Vic Australia 3124
Email: bruhoc@connexus.net.au

ABSTRACT

Objective
To inform the profession of the possible health effects from over-exposure to radiofrequency radiation and the clinical approach to cases.

Data sources
Information on biophysics of RFR and possible health effects was derived from standard texts and the author's clinical experiences.

Results
An introduction to the health effects of overexposure to RFR is given. A clinical approach to integrating the patient's symptoms and the circumstances of the exposure is given. Emergency treatment and ongoing care is outlined, and sources of expert advice given.

Conclusion
Overexposure to RFR is a complex injury. Advice is given for emergency care and planning ongoing care.

Radiofrequency Radiation (RFR) has long been used in industry, for example in RFR welding and medical diathermy, and in the burgeoning radio-communications industry. Overexposures sometime occur in these traditional usages but the proliferation of antennae on places such as roof tops has created new possible overexposure situations, not only for communication workers but for other workers such as window cleaners, painters and air conditioning mechanics. At other times possible overexposure is retrospectively suspected when two or more co-workers develop unusual illnesses.

Inadvertent exposure to RFR is of intense concern to workers. A doctor's scientific and humane skills are fully required to manage these patients. This paper intends to advise general practitioners, emergency department staff, occupational physicians and other practitioners on the basic biophysics and health effects of RFR so as to guide management of cases. It is based on key texts and papers plus the author's 20 years experience of investigating health effects of RFR and updates a previous paper on the subject[1].

An over-exposure occurs by definition when the safety standard for RFR[2] is exceeded. This is nor always easy to determine and advice may be sought from the resources listed below.

BIOPHYSICS OF RFR[3]

Radio-frequency Radiation (RFR) includes electro-magnetic waves ranging from 300 kHz to 300 GHz frequencies. It is different from power line frequency (which is 50 Hz) and has different interactions with the body in that RFR interacts much better and has modulations which may have biological effects. Modulations, for example by frequency (FM) or amplitude (AM) are small time-varying modifications to the carrier wave which allow it to carry information such as sound, or there may be pulsed modulations, for example radar.

Whole body interaction. The different frequencies of RFR have widely differing wavelengths which result in different coupling (uptake) by the body. KHz waves are very long (approximately 300 metres) and have minimal uptake. 30-300 MHz waves are 5-1 metres long (respectively) and have maximal coupling. The higher MHz and GHz waves are centimetres-millimetres in length (respectively) and exposure results in localised deposition in skin, eyes, testis, head or superficial layers of the body. Thus energy deposition into the body is complex and varies across the RFR spectrum.

Mechanism of action. Once RFR is coupled to the body it can interact to cause biological effects. There is general agreement that if sufficient energy is absorbed it can cause heating by the rapidly alternating field agitating dipolar molecules particularly water, and thence cause deleterious effects (similar to warming food in a microwave oven). The present safety standards for RFR[2] are largely based on preventing these effects from heating; the lower frequencies (<10MHz) may cause currents of biological significance. For example, at 400 MHz the safety level is set at 1mW/cm^2 for occupational exposure and for the general public it is set more conservatively at 0.2mW/cm^2. There is dispute as to whether lower levels of energy can cause biological effects (non-thermal or athermal mechanisms.) Modulations may be important in this regard as there is evidence that modulated but not plane waves can effect calcium flux in cells[4].

HEALTH EFFECTS (WHO[3])

This paper only discusses effects from overexposure and not the possible effects from long term low level exposures. The likelihood of health effects is influenced by the frequency (wave length), modulations, duration, and the intensity of the exposure. The possible health effects after RFR overexposure are listed and discussed further below. The list indicates possible effects but does not preclude others.

- Sensation of warmth
- Auditory effects (click sounds)
- Electric shock
- Burns (superficial and deep)
- Microwave sickness/radiofrequency neurasthenia
- Dysaesthesiae
- Ocular effects (irritation, cataract,retina)
- Reproductive (male, female)

It is important to recognise that some effects occur immediately, but others are delayed and can occur in the medium (weeks) to long (years) term. Immediate ones include a sensation of warmth at the time of exposure which indicates an appreciable exposure, but the absence of warmth does not exclude over-exposure. Shock which may be painful, but is not fatal because the high frequencies do not disrupt cardiac rhythm[5]. Burns may be superficial or deep[5]. Deep burns may manifest 1-2 days later and cause thrombosis or compartmental syndromes requiring urgent surgical intervention. Clicking sounds may be heard from exposure to even very low levels of radar and are generally regarded as benign.

Other effects may be delayed by weeks or months. Cataracts, for example, may appear within a few days or not appear until months or years after exposure. The lesion in the lens is often posterior sub-capsular but nuclear cataracts have also been reported in human overexposures. The cornea may be irritated and uveitis occur, and changes in the electro-retinogram have been recorded in animals.

The symptoms of microwave sickness [6,7,8] which include effects on the central nervous system (headaches, fatigue and malaise), peripheral nerves (dysasthesia, impaired sensation), and autonomic nervous system (diarrhoea, raised blood pressure) may only be fully apparent months later. The symptoms have lasted for years in some cases. Dysaesthesia in an exposed area may become persistent and a cause of disability.

The effect of an acute exposure on a pregnancy is unclear and is probably best managed as for accidental hyperthermia. Considerable testicular heating may reduce sperm count, but animal studies indicate this usually reverses within weeks.

Metal components in the body can act as antennae to concentrate the field[9]. They may be medical rods and screws, or metallic jewelry which can be worn in surprising places! The concentration of the field may lead to local effects depending on the adjacent tissue, for example bone is more heat tolerant than nervous tissue.

The relationship of RFR to cancer is debatable[3]. Providing the exposure was limited reassurance can usually be given on this matter.

CLINICAL APPROACH

History taking has three main aims. One is to ascertain symptoms experienced by the worker, the next is to assess the bodily distribution of exposure, and the third is to develop rapport so the fears of the worker may be explored. The history should begin by carefully

noting any symptoms experienced post-exposure and then a full review of systems be conducted to establish a baseline. The physical examination should be directed to the area of symptoms, and then a full physical and neurological examination be conducted to form a baseline. Particular attention should be given to dysaesthesiae which are best tested for with cotton wool.

Investigations should be determined by symptoms. If the eyes have been overexposed it is useful to obtain an ophthalmic record of the eyes as a baseline before any changes are likely (if a pre-employment eye examination has not been done in recent years), and then repeat it in about six months. Dysaesthesiae may be investigated using a Neurometer to determine current perception thresholds. This has been found to identify abnormalities where conventional neurological examination has not[10]. The worker will often have unvoiced concerns about fertility and this issue should be raised by the doctor and the anatomical extent and duration of the exposure considered. An offer of a sperm count may be made to help resolve concerns. There are no blood or urine tests which can be used to determine the extent of RFR overexposure.

Details on the exposure should be sought from the worker with regard to his/her anatomical position in relation to the source (whole body, head, limb) as well as the duration of the exposure. Some workers will also know details of the frequencies (wave length), modulations and power of the radiation. Otherwise these details must be obtained from the company involved (which may also arrange for measurements to fully characterize the exposure) because they are important to assessment and understanding the health effects of RFR.

Information about the exposure details and symptoms experienced should now be integrated noting the above discussion on biophysics and health effects. This enables an overall assessment to be made and advice given including the need for follow up of specific organ effects. Persisting symptoms should not be dismissed as psychosomatic although distinguishing microwave sickness from post traumatic stress disorder may be difficult. Pointers to microwave sickness are the occurrence of dysaesthesiae in an exposed area, more than one worker ill, and failure to meet DSM criteria of post traumatic stress disorder.

Because RFR overexposures can lead to various health consequences it is important good records are made for potential medico-legal purposes. Overexposure accidents should also be notified to Workcover and the appropriate certificate given to the worker.

RESOURCES

Practitioners seeking urgent expert advice in managing these accidents may contact the Radiation Health Branch in their state, or the Australian Radiation Protection and Nuclear Safety Authority (03 9433 2211), or the author can provide emergency consultant advice (03 9809 1096).

REFERENCES

1. Hocking, B. & Joyner, K. Health aspects of radio-frequency radiation accidents. J.Microwave Power & Electromagnetic Energy. 1988:23(2):75-80.

2. Australian Standard (Interim) Radiofrequency fields Part 1: Maximum exposure levels – 3kHz to 300 GHz. Standards Australia. Homebush 1998

3. WHO. Environmental Health Criteria 137. Electromagnetic Fields (300Hz to 300 GHz). Chapter 8: Human Responses. Geneva. 1993.

4. Adey, R. Effects of Weak Amplitude Modulated Microwave Fields on Calcium Efflux from Awake Cat Cerebral Cortex. Bioelectromagnetics, 1982:3:295-307

5. Hocking B, Joyner K, Newman H and Aldred R. Radiofrequency electric shock and burn. Med J Aust 1994:161: 683-685.

6. Forman SA, Holmes CK, McManamon TV, Wedding WR. Psychological symptoms and intermittent hypertension following acute microwave exposure. J Occup Med 1982:24(11):932-4

7. Schilling C Effects of acute exposure to ultra high radio-frequency radiation on three antenna engineers Occup. Environ.Med. 1997:54:281-284).

8. Schilling C Effects of exposure to very high frequency radiofrequency radiation on six antenna engineers in two separate incidents Occup Med 1999 in press.

9. Hocking B Joyner K, Fleming A Implanted medical devices in workers exposed to radio- frequency radiation Scand J work Environ Health 1991:17: 1-6

10. Hocking, B. & Westerman, R. Neurological abnormalities associated with mobile phone use. Occup.Med. in press.