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Report

Magnetic resonance imaging (MRI) scanners are alternative to X-ray medical examination tools. MRI can be used for both, conventional examination or for intraoperative support during surgery treatment (currently app. 1 % of applications). In the contrary to X-ray's examination based on the use of ionising radiation, MRI technique is based on 3 components of non-ionising electromagnetic fields (EMF): the static magnetic field produced constantly by strong magnets (permanent, resistive or superconductive) and pulses of time-varying magnetic gradient field and pulses of radiofrequency (RF) radiation.

The highest exposure of health care staff (nurses, technicians, radiologists) to the static magnetic field occurs when they approaching to the magnet's housing while they are attending to patients before and after examination and also while operating the manual console situated on the housing of the magnet. Exposure to gradient and RF pulses is possible only during the course of examination and affects workers only in special cases, e.g. during dynamic or intraoperative examination, or because of emergency situations (when worker may have to enter into the bore of the magnet). The attendants usually stay during the course of examination in front of the monitor of the computer console controlling the examination, far from magnet and EMF exposure. Cleaners can be also exposed to high level of static magnetic fields inside the MRI room or inside the bore of the magnet. At the beginning of the diagnostic use of MRI scanners (in 1980s), low field magnets (0.2-0.5 Tesla) were used. Magnets of 0.5-3 T are currently the most popular.

Biological and health consequences of RF and gradient fields, associated with thermal effects and electro-sensitive tissues excitations, are well investigated and covered by safety guidelines (eg. ICNIRP, IEEE, Directive 2004/40/EC or national occupational legislations), whereas possible adverse health effects of static magnetic fields are less explored, especially in case of chronic exposure to high fields. Recent World Health Organization (WHO) monograph (WHO, 2006) concluded that there is not sufficient scientific data for establishing health risk of exposure to static magnetic fields.

Physical effects of static magnetic fields (translation and orientation of charged molecules) cause electrodynamic forces on moving electrolytes, and effects on electron spin states of chemical reaction intermediates (WHO, 2006). Translation and orientation of molecular and cellular substances such as retinal rods, and some living cells have been experimentally observed in vitro-studies of static fields of high level (above 1 T), in various materials - dia- and paramagnetic such as hemoglobin, collagen, fibrin, and also on ferromagnetic particles such as magnetite. Water distribution can be also affected by high-gradient magnetic fields of high flux density, producing the force directly proportional to the square of the magnetic field strength and inversely proportional to the radius of the magnet.

Static magnetic fields exert electrodynamic forces on moving ions in blood vessels, generating an electric potential across the blood vessels (Hall effect) and theoretically a reduction of blood flow velocity (Tenforde, 1992) - a 5 and 10% reduction in blood flow in the aorta was predicted to occur in static fields of 10 and 15 T, respectively, due to magneto-hydrodynamic interactions (Kinouchi et al., 1996). Related observations included a change in blood velocity of an order of a 0.2 % to 3 % in the case of exposure to static fields of the level increasing from 1 T to 10 T (Dorfman, 1971; Keltner, 1990). Experimental examination of the scale of biomedical effects associated with electrodynamic and magnetodynamic forces in exposed human body are still under examination, frequently using electrocardiogram (ECG) technique. In addition, vertigo and other sensations, as difficulty with balance, nausea, headaches, numbness and tingling, phosphenes, and unusual taste sensations, were recorded during movement in high field. The other investigated endpoint were: cognitive function, assessed during exposure using standard neuropsychological tests, effects of exposure to fields of up to 8 T on heart rate, respiratory rate, systolic and diastolic blood pressure, finger pulse oxygenation levels, and core body temperature (ICNIRP, 2004).

The exposed volunteers moved very slowly (one or two feet over a few seconds, followed by a 15-30 s pause, taking overall about 3-4 min) into the magnet bore in order to avoid the transient, movement-induced sensations described above. Such movements are very slow in comparison with normal workers activities in the vicinity of magnets. Nevertheless, some number of subjects of 4 T exposure reported sensations of dizziness and a metallic taste, assumed to be due to electrolysis of metallic chemicals in the subjects' teeth fillings (Schenck et al., 1992).

IARC (2002) notes that two somewhat dated studies (Neurath, 1968; Ueno et al., 1984) report that exposure to 1 T fields with high spatial gradients (10-1,000 T/m) can adversely effect the development of frogs and toads, but notes that most studies indicate a lack of effect of static field exposure.

With static magnetic fields, reactions under laboratory conditions include a 17% increase in human cardiac cycle length at 2 T (Jeheson et al., 1988). The authors suggested that the observed effect is probably harmless in healthy subjects, but that its safety in dysrhythmic persons was not certain. Such question is very important in the case of routine health examination of workers, who are going to start or continue MRI scanners operation.

Workers operating MRI scanners are one of the occupational groups with the highest exposure to static magnetic fields. There are still many gaps in our knowledge of the biological effects and mechanisms of MRI-emitted EMF interaction with tissues. Further investigations should provide knowledge and significantly reduce the level of uncertainty in the current scientific literature, and should also help to establish the protection level for exposures to be published by various international and national bodies. In the case of medical staff operating MRI scanners, the occupational risk assessment should consider also the safety of patients from non-error work ability of medical staff and safety requirements preventing hazards such as from "flying metallic objects" (3 mT) and possible destruction of magnetic memories/cards (0.5 mT).

No serious adverse health effects from the whole-body exposure of healthy human subjects up to 8 T have been reported in the literature. However, no epidemiological studies have been carried out until now to assess possible long term health effects in patients, workers, or volunteers. Only few informative studies have been performed using exposures above 2 T. In consequence, no sufficient knowledge concerning safety conditions is available today for static magnetic fields exposure of MRI scanners workers. The level of workers' exposure depends both on the type of the magnet and on the ergonomical design of the particular MRI scanner. Presented gaps in scientific knowledge on health risk for MRI workers should be taken as one of important arguments for the use of any technical and organisational methods for reduction of the worker's exposure leves (eg. the use of infusion pumps instead of manual injection of drugs necessary for contrast examination, which reduce the level of nurse's exposure).

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