Understanding occupational exposure limits and their impact on MR safety practice.

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The formulation of EU Directive 2004/40/EC has focussed attention on the issue of occupational exposure in MRI. MRI staff will typically be exposed to the B_0 fringe field and its spatial gradient dB/dr during the common activities of patient positioning and coil selection. Staff who remain close to the scanner during an acquisition, for example with a child or unconscious patient, will also be exposed to time-varying magnetic fields dB/dt from the imaging gradients and RF B_1 fringe field. Both movement through the fringe field gradient and exposure to the imaging gradients induce electric fields in the body which give rise to induced electric fields (E) in tissues.

Occupational exposure limits or "Basic Restrictions" are expressed in terms of the induced E or SAR. As these cannot be easily measured in-vivo, "Reference Levels" are also defined in magnetic flux density B (μ T). Where a Reference Level is exceeded, demonstration that a Basic Restriction is not exceeded is required. It has been shown both by measurement and calculation that the ICNIRP reference values applicable to the imaging gradients may exceeded very close to the bore opening during scanning. Additionally RF Reference Levels may be exceeded for a person standing within 0.2-0.45m of the bore opening.

MRI workers experience typical peak dB/dt from movement of up to 2 Ts^{-1} for routine clinical activities for 1 Tesla to 3 Tesla MR systems. Corresponding staff dB/dt exposures from the gradient can be in the range 0.5 to 5 Ts^{-1}. Monitoring of the peak and time-averaged static field exposure of workers has also been carried out, giving time-averaged static field exposures in the range 1.5 to 12.5 mT with a peak of around 40% of B_0.

There are a number of practical implications from the statutory enforcement of guideline limits for occupational exposure as in the EU Directive. These include limitations on interventional MR procedures, support for vulnerable patients or children, monitoring of during sedation and general anaesthesia, and the use of manual contrast injections (which may be required for sick or very young patients).

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