

Occupational exposure to electro-magnetic fields in MRI: a survey of working practices from 1 T-7 T

D. W. McRobbie¹, M. Oberle², A. Papadaki¹, R. Quest¹, K. Hansson Mild³, M. Capstick², J. Hand¹, and N. Kuster²

¹Radiological Sciences Unit, Imperial College Healthcare, London, United Kingdom, ²ITIS Foundation, Zurich, Switzerland, ³Radiation Physics, University of Umea, Umea, Sweden

INTRODUCTION: The formulation of EU Directive 2004/40/EC⁽¹⁾ has focussed attention on the issue of occupational exposure in MRI. Whilst the EU's attempts to regulate occupational exposure to electro-magnetic (EM) fields is new, the underlying exposure guidance has been in existence since 1998⁽²⁾. This work represents an attempt to identify specific MR-related work activities which may exceed the Action Values (AV) or ICNIRP Reference Values.

METHODS: Four MR centres with a range of clinical and research practices and MR equipment were nominated for participation. Each centre received a visit by members of the research team to ascertain the procedures most likely to exceed an Action Value and to plan a further visit for the video recording of procedures. A recording system was developed using two MR compatible video cameras linked by optical cables to a PC running Streampix 4 software. The cameras had a maximum resolution of 658x494 operating at 25 frames per second with 8 bit color depth (Bayer filter encoded). The lenses had a focal length of 4.2 mm giving horizontal visible width of 3 m at 3 m distance. MR compatible batteries had a life of 12 hours. For each scanner one camera was positioned with a view along the patient couch into the bore, with the second at 90 degrees looking across the couch. Markers were positioned on a 0.5 m grid on the floor, and at 0.2 m separation along the couch and above the bore entrance. Prior to recording, a calibration procedure was carried out at each point of the floor grid. Procedures observed were as follows:

- 1 T *Open (Philips):* Breast biopsy, Clip placement (breast), General Anaesthesia (GA) child (x4), Parent in room, Simulation of emergency evacuation.
- 1.5 T *(Siemens Avanto):* Monitoring of paediatric GA procedure, Paediatric spectroscopy, Parent/Carer in the bore with child, Simulation of emergency evacuation, Cleaning.
- 3 T *(Philips Achieva):* Clinical fMRI with tactile stimulation (x2), Cardiac Stress Test, Paediatric GA (x2), Evacuating patient in emergency, Cleaning.
- 7 T *(Philips Intera):* Manual contrast injection –perfusion-BOLD (simulation), EEG experiment (positioning only), Simulation of emergency evacuation.

From analysis of the videos, the position, times and velocities of staff were calculated. In a parallel piece of work EM fields were measured throughout a 3D grid⁽³⁾ (B_0 , B_1 , dB_x/dt , dB_y/dt , dB_z/dt) enabling us to determine whether AVs were exceeded. Where they were, further modelling of induced current or SAR was carried out.

RESULTS: Figures 1 and 2 show activities in which a staff member exceeded the action values, in terms of B field and dB/dt⁽⁴⁾.

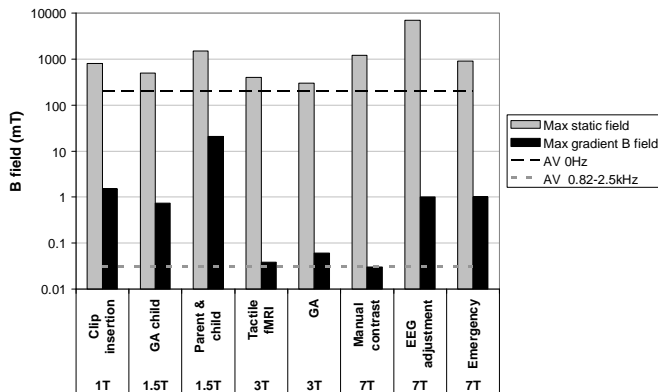


Figure 1

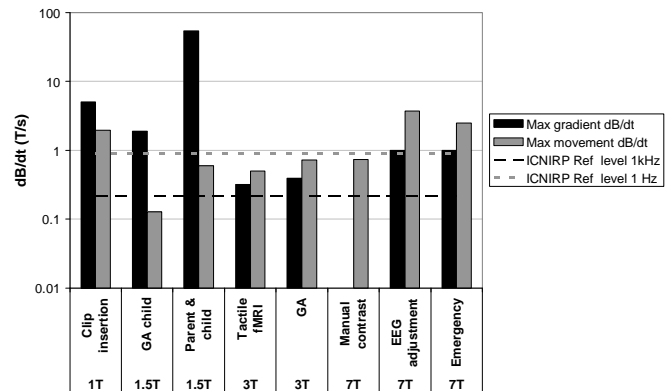


Figure 2

The static field (B_0) Action Values was exceeded for the breast clip insertion, GA monitoring of a child, carer with child in the scanner, tactile fMRI and all the 7T procedures. Gradient field action values were exceeded for breast clip insertion, GA monitoring, carer with child in the scanner and tactile fMRI. Movement in the static field resulted in current densities which exceed the low frequency AV (<1 Hz) for EEG electrode adjustment and emergency evacuation at 7 T and for the clip insertion at 1 T. RF action values were only exceeded for the carer in the scanner with a child.

Further studies⁽³⁾ showed that Exposure Limit Values (ICNIRP Basic Restrictions) were exceeded for the gradient exposure from the breast clip insertion and GA monitoring and parent in the bore with a child. Under enforcement of the current ICNIRP limits these practices would be illegal. The tactile fMRI was just within the limit depending upon the choice of frequency encode gradient.

CONCLUSIONS This study has produced actual numerical values of real work practices in clinical and research MRI. These provide definitive evidence of the problems associated with the regulatory enforcement of current ICNIRP guidance for occupational exposure in MRI.

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REFERENCES

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- 4 ICNIRP (2003) *Health Physics* **84**: 383-7.