Occupational hazard? Working in MRI and the potential impact of EU PAD (EMF)

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**Mag-lag revisited**

More than 15 years ago, a magazine article appeared that claimed to show small changes in memory among MR radiographers, and coined the term ‘mag-lag’ for this effect. The study was conducted via objective surveys and the effect has never been substantiated by any scientific study, but the name stuck. ‘Mag-lag’ has become a joke term, used to tease colleagues in MRI when they have memory lapses. Let’s be honest, when people are working under pressure, who doesn’t occasionally forget something simple?

Although we make light of this, there remains a small body of true scientific evidence for deleterious health effects from electromagnetic fields at all frequencies, including those used in MRI. Much of the evidence is equivocal, conducted in animal models or in extreme conditions, and has not been reproducible.

In 1998, the International Commission for Non-Ionizing Radiation Protection (ICNIRP) conducted a major review of the available evidence and published guidelines for limiting exposure. Some years later, the European Parliament and Council adopted the Physical Agents (Electromagnetic Fields) Directive (2004/40/EC) that incorporates the values proposed by ICNIRP. The EMF directive is designed to harmonise European legislation for work protection and is just one part of a series of measures (others cover acoustic, noise, mechanic vibrations, etc). Implementation was planned for April 2008, meaning that all EU member states should have introduced or revised their national occupational safety legislation.

**Impact on MRI**

In late 2004, a group of concerned MRI workers in the UK came together to discuss the potential impact of the legislation. The group included researchers based in universities and hospitals, professional organisations, including the British Institute of Radiology and the British Association of MR Radiographers, and manufacturers of MR systems.

The most obvious threat was to interventional MRI, a new technique which is still considered ‘research’. Interventional MRI includes image-guided biopsies (for breast and liver), ablation (again for liver) and more complex techniques such as paediatric cardiac interventions where x-ray guidance is used to introduce a catheter but the rest of the procedure is conducted under MR guidance. However, as the discussions progressed, the group looked more closely at the limits set by the directive and noted a more widespread threat, that it would become impossible for any healthcare worker to stay in the magnet room during a scan.

The group began to lobby various government agencies, as well as the wider MRI community, in order to alert people to the potential problems that might be introduced. Due to the paucity of documented evidence about working practices, these discussions tended to rely on anecdotes and personal testimonies which could be easily countered by legislators giving opposing evidence. BAMRR attempted to address this during one of its member surveys, with financial support from Philips Healthcare.

**BAMRR safety survey 2005**

The survey was sent to all 224 BAMRR members (both individual and site memberships), and to a number of MRI units in the private sector. Most questions were supplied with a range of answers and tick boxes, as well as space for free text where appropriate. The first section concerned information about the respondent’s expertise in MRI safety. Eight safety-related publications were listed, including the ICNIRP Guidelines and the EU PAD, and respondents were asked to indicate whether they had read each document, had heard of it but not read it or had not heard of it.

The second section concerned working practices related to MRI scans with sedation or general anaesthetic, the duration of such scans and which staff groups were most likely to remain in the room during scanning. Similar questions were asked about nervous or claustrophobic patients and interventional procedures. Finally a free text area allowed respondents to describe other situations when a staff member stayed with a patient during a scan.

Seventy-five responses were received, a reply rate of 33.5%. All respondents identified themselves and no duplication was found, thus the survey answers represented 23% of all UK MRI centres (326 at the time of the survey). The majority of respondents had a supervisory role for MRI safety (81%). Awareness of national and international safety standards was variable (figure 1), with the MHRA guidelines being the mostly widely read. Only 37% of respondents had heard of the EU Directive.

One quarter of sites had one or more sessions a week for patients under general anaesthetic (GA), with examinations taking on average 30 minutes. Despite these relatively large case loads, only one site had specialist remote monitoring equipment for GA. The majority of sites reported that their normal practice was for anaesthetic staff to remain in the magnet room during the examination. This practice was also common among sites with a smaller GA case load.

As we would expect of a new application, only two sites reported having an interventional practice, and both of these were performing MR guided biopsies taking around 30 minutes. At one site, a radiologist and a radiographer would remain in the room during scanning, but at the other scanning was done with no member of staff in the room. However, a larger number (29% of sites) reported that staff remained in the magnet room to perform a bolus injection of contrast agent (eg for contrast-enhanced MRA).

More than 90% of sites reported that nervous or claustrophobic patients would be accompanied during their examination to help calm them. Respondents estimated that half the time the escort would be a friend or relative of the patient, the other half would have a nurse or radiographer.

**Alternatives to staying in the magnet room**

In total, it was estimated that about 3% of all MR examinations, amounting to 38,103 cases a year, were performed with a member of staff in the room. The majority of these (around 32,000) were patients under sedation or general anaesthetic. It is likely that many of these would be paediatric cases (although these details were not gathered in the survey).

Of course, there are alternatives to having staff in the magnet room during scans. Power injectors replace the need for a human bolus injector, at an estimated total cost of around £1.3m. For anaesthetic cases, remote monitoring equipment may be used at an approximate cost of £35k-40k per installation, amounting to a total for the UK of around £2.7m.

However, remote monitoring is not suitable for all cases or all anaesthetists. Such cases will need an alternative diagnostic method and this will often involve a CT scan with the associated x-ray dose. By making ‘educated assumptions’
about the number of cases and the average dose per case, we estimated that this might increase medical exposures by 224 man-Sv per year. Russell and Webb have established a financial cost related to radiation dose and we used this information to estimate a “cost” to society of £5.32m per year. Taking another educated guess about the number of paediatric cases, the “cost” could be as high as £16m per year.

**Gatso cameras in the scan room?**

One remaining issue in the PAD was ambiguous and caused much discussion, and that was the static main field. The directive explicitly excluded this from its scope. However, there is no difference between currents induced in the body by standing in a temporally-varying magnetic field and those induced by moving around in a spatially-varying, temporally static magnetic field. Since all MRI magnets have a finite fringe field, typically extending for 2-5m around the magnet covers, anyone moving around the system is likely to induce such currents, at low frequencies up to 1Hz. These frequencies were included in the scope of the directive. In a study commissioned by the HSE, Crozier et al. modelled these effects and found that a ‘speed limit’ of 0.7 m s⁻¹ is needed to avoid exceeding the exposure limits in the PAD. Normal walking speed is 1.5-2 m s⁻¹, and, of course, people move much faster in an emergency situation. Solutions were proposed to help staff to monitor their speed around the magnet; however, these were largely dismissed as impractical.

**The future of the directive**

Drawing firm conclusions from this survey should be done with caution as there were several imperfections in the study. Nevertheless, this evidence was important in helping to convince government and EU agencies that the directive could cause real problems for MRI practice.

As a result of intense lobbying by several governments, including the UK, the EU postponed implementation of the directive until April 2012. It also announced its intention to review the scientific evidence again and, if necessary, to re-define the exposure limits. It is important for the MRI community to remain involved in the next 2-3 years in order to avoid a similar problem with any new limits. The directive is designed to improve occupational safety, and that is something the whole MRI community supports. However, occupational safety limits should be measurable and practical, and in the case of MRI should take into account the social and medical benefits of MR, analogous to the legislation for ionising radiation.

**References**


**FIGURE 1**

Awareness of national and international safety guidelines. Figures show the percentage of respondents who had read the reference, those who knew the guidelines existed and those who were unaware of the reference. References are ranked from the most well-known to the least.