Acoustic noise in MRI

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Purpose

Hearing loss, caused by noise, is one of the 10 most common diseases in the European Union. The acoustic noise in magnetic resonance (MR) is associated with activation and deactivation of the electrical current that induces vibrations in the gradient coils. The noise levels of the safety guidelines of the Food and Drug Administration (FDA) according to measurements should be between 65 and 95 dB.

The purpose of this work is to determine radiographer noise daily personal exposure at work per day ($L_{\text{EX},8h}$) and the sound pressure level peak ($L_{\text{Cpeak}}$). With this values, potential harm from exposure to noise in MR could be analyzed and prevented and control noise recommendations will be created.
Methods and materials

This study was conducted in clinical imaging in Portugal. One sound level meter was used, CESVA brand, model SC310 for an initial screening, and a dosimeter CESVA, model DC112, was used to determine the daily personal exposure of workers to noise at work ($L_{EX, 8h}$), and the sound pressure level peak ($L_{Cpeak}$), as well as their exposure to noise of various MRI sequences (the MRI equipment used, belonging to the clinic, was a GE with 1.5 Tesla).

The study was divided in three phases: a screening test of acoustic noise with a sonometer, measurements with a dosimeter DC112 in radiographer shoulder during several sequences and measurements during one day daily practice of radiographer.

A first measurement using a sound level meter served to make a screening test, since the use of non-integrated sound level meters for the determination of the worker’s personal exposure should be avoided when the sound pressure shows fluctuations of the sound level ($L_{pA}$), in a large-scale or for irregular periods of exposure from worker in movement (as in this case).

The microphone was placed on the shoulder of the Radiographer, near the acromion-clavicular joint. The dosimeter was glued securely in a pocket to protect it from damage. Several measurements were made, with the use of the dosimeter, throughout the duration of several sequences programmed for particular examination.

Subsequently throughout the period of work of a radiographer as been evaluated, from the time he actually start to work, until the time of his departure, registering the worker that used the dosimeter and the hearing protection devices, if used by the worker, as well the activity performed during the controlled period, the measurement duration and daily noise exposure duration.

After perform these measurements, obtained data was discharged and analyzed through the "CESVA Capture Studio" program.
Fig. 1: Exemple of obtained data discharged and analyzed through the "CESVA Capture Studio" program.

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Results

For the purposes of the Directive, three physical parameters are defined to be used as indicators of risk: peak acoustic pressure ("Peak sound pressure" in the Portuguese Law Decreto-Lei No. 182/2006), daily sound exposure level and weekly noise exposure level. The peak sound pressure is expressed in dB (C), while the levels of daily and weekly noise exposure are expressed in dB (A). We can say that the sound exposure level allows evaluation of the effects of prolonged exposure to noise while the peak sound pressure allows to evaluate the effects of exposure to very intense and short sounds (impulse noise).

According to the Portuguese Law Decreto-Lei No. 182/2006, the exposure limit values and upper and lower action values, in relation to the daily or weekly personal exposure of a worker and the sound pressure level of peak, are set in:

Exposure limit values: \( L_{EX, 8h} = \text{average } L_{EX, 8h} = 87 \text{ dB (A)} \) and \( L_{Cpeak} = 140 \text{ dB (C)} \) equivalent to 200 Pa;

Upper exposure action values: \( L_{EX, 8h} = \text{average } L_{EX, 8h} = 85 \text{ dB (A)} \) and \( L_{Cpeak} = 137 \text{ dB (C)} \) equivalent to 140 Pa;

Values below action: \( L_{EX, 8h} \) average \( L_{EX, 8h} = 80 \text{ dB (A)} \) dB and \( L_{Cpeak} = 135 \text{ (C)} \) equivalent to 112 Pa;

For each measurement made even withdrew the values of noise over multiple frequencies (in Hz octave bands) preset in the dosimeter (as shown also in Fig.2/Table 1). We can also seen that the sequences that have higher levels of noise exposure (Leq) are the Diffusion, with a value of 76.1 dB (A), and the Flair, with 75.1 dB (A) respectively. Furthermore, sequences that have lower values are SPGR, with 49.9 dB (A), and Merge sequence, with 52.5 dB (A).
Fig. 2: Table 1 - Measurements obtained during magnetic resonance imaging sequences performed.

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<table>
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<tr>
<th>Sequences</th>
<th>Leq. dB (A)</th>
<th>LCpeak dB (C)</th>
<th>63</th>
<th>125</th>
<th>250</th>
<th>500</th>
<th>1000</th>
<th>2000</th>
<th>4000</th>
<th>8000</th>
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<td>41.5</td>
<td>49.2</td>
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<td>65.4</td>
<td>71.9</td>
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<td>84.0</td>
<td>41.3</td>
<td>42.8</td>
<td>46.2</td>
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<td>63.9</td>
<td>69.7</td>
<td>52.9</td>
<td>41.1</td>
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<td>83.6</td>
<td>40.8</td>
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<td>48.0</td>
<td>41.6</td>
<td>41.8</td>
<td>38.4</td>
<td>34.0</td>
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<td>55.4</td>
<td>68.6</td>
<td>68.4</td>
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<td>47.1</td>
<td>46.4</td>
<td>44.0</td>
<td>38.1</td>
</tr>
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</table>

Fig. 3: Table 2 - Representation of the measurements obtained over a working day period of a radiographer A, with an approximate duration of 12 hours.

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<table>
<thead>
<tr>
<th>Work period</th>
<th>Leq. dB (A)</th>
<th>LCPeak dB (C)</th>
<th>63</th>
<th>125</th>
<th>250</th>
<th>500</th>
<th>1000</th>
<th>2000</th>
<th>4000</th>
<th>8000</th>
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<td>09h11 - 21h30</td>
<td>75.8</td>
<td>88.4</td>
<td>41.5</td>
<td>40.7</td>
<td>51.1</td>
<td>59.8</td>
<td>70.4</td>
<td>74.0</td>
<td>55.5</td>
<td>42.5</td>
</tr>
</tbody>
</table>
Conclusion

We conclude that the noisiest sequence was the diffusion and the less noisy was the SPGR sequence. In none of the performed evaluations we found noise levels higher than those imposed by the Directive nº2003/10/EC of the European Parliament and of the Council and Portuguese law 182/2006, not revealing the need to implement a hearing protection program.

It is suggested for further study, the introduction of some important factors, such as a more representative sample; make a further evaluation of the acoustic noise in the patient's perspective, ie the measurements carried out within the MRI room; studying the low frequency noise (infrasound), the 2nd to 15th Hz, in order to evaluate whether there were possible vibro-acoustic disease.

Despite all the limitations and difficulties presented, this study has shown that the radiographer who works daily on magnetic resonance imaging, are exposed to relatively high levels of acoustic noise. However, the results do not demonstrate cause for concern from the point of view of hearing health itself but since several values are close to those stipulated by law, as recommended, for example, radiology technicians undergo the regular audiometric examinations.
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