Hearing loss after noise exposure

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Abstract

The higher field strength magnetic resonance imaging (MRI) such as 3 Tesla (T) and above generates noise that has potential detrimental effects on the hearing. Temporary threshold shifts following MRI examination have been reported for MRI with lower field strength. Such effect, however, have not been reported so far for a 3 T MRI. We report a case that exemplifies the possible detrimental effects of a 3 T MRI generated noise on the auditory system. Our patient underwent investigation of his chronic backache in a 3 T MRI unit and developed hearing loss and tinnitus post-MRI examination. Hearing assessment was done using pure tone audiogram, distortion product otoacoustic emission (DPOAE) and brainstem electrical response audiometry (BERA) which revealed a unilateral sensorineural hearing loss which recovered within 3 days. However the tinnitus persisted. This is possibly a case of temporary threshold shift following noise exposure. However a sudden sensorineural hearing loss remains the other possibility.

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1. Introduction

Acoustic noise generated by the magnetic resonance imaging (MRI) has potentially detrimental effects on the hearing. Temporary thresholds shifts following MRI examination have been reported based on objective findings from pure tone audiometry (PTA) [1].

We describe a man who developed hearing loss and tinnitus post-MRI whose hearing showed improvement after 3 days. We discuss the possible role of acoustic noise, in particular a MRI system with a higher magnetic field of 3 Tesla (T), causing temporary threshold shifts (TTS).

2. Case report

A 39 year-old man underwent MRI of the lumbo-sacral region for investigation of his chronic backache. The imaging was performed with a 3 T MRI (model GE Signa HDx 3 T) utilizing a protocol as outlined in Table 1. Subsequently, sound pressure level (SPL) data collected per NEMA Standards Publication no. MS4 2006 (Acoustic Noise Measurement Procedure for Diagnostic Magnetic Imaging Device) and IEC/CEI 60601-2-33 clause 26 was done for the above protocol (Table 1). Patient wore 3M-foam ear plugs throughout the session which lasted 41 min. Immediately post-MRI examination, the patient noted a blocked sensation in his right ear, and 3 h later, tinnitus in the same ear. He did not complain of a subjective hearing loss. Assuming it was a normal after-effect of being in a noisy environment, the patient only returned to the hospital the next day to seek advice, 17 h after the incident.

The patient denied being exposed to any loud sound or music prior to the MRI examination. There was also no significant history of recent upper respiratory tract infections, symptoms of headache, blurring of vision, limb weakness or head injury. MRI was performed at another centre a few years earlier for similar backache but no abnormality was found and his past medical history otherwise revealed no significant illness. There was also
no evidence of history of hearing loss and related illness among family members. He works as a computer analyst and consumes alcohol and smokes occasionally. There is a history of mobile phone use for more than 15 years on the dominant ear.

ENT consultation was arranged for symptoms of hearing loss and persistent tinnitus. Clinical assessment revealed normal findings including a normal otoscopy. However, tuning fork examination revealed abnormality which was consistent with a sensorineural hearing loss (SNHL) as confirmed by pure tone audiogram (PTA) examination (Fig. 1) (PTA machine model Masen Orbiter 922 was used). PTA on the day of assessment revealed a SNHL at a threshold of 40 dB between the frequencies 250 and 1000 Hz. A tapering pattern was seen over the rest of the tested frequencies (2000–8000 Hz) with a highest threshold at 80 dB on the affected ear. Stapedial reflex showed recruitment at 500 and 1 kHz and absent reflex at 2 and 4 kHz. The left ear had essentially normal hearing.

The patient was subsequently admitted to the ward and received intravenous Dextran 40 bd, Tab Betahistine 24 mg bd, Tab Methylcobalamin 500 mg tds and tapering dose of Tab Prednisolone. The following day the patient had significant improvement in his hearing but the tinnitus persisted. Repeat PTA showed the hearing returned to within normal level between 250 Hz and 4000 Hz (Fig. 2).

3. Discussion

MRI-generated noise is primarily produced by rapidly alternating currents within a gradient coil of a MRI system [2]. Analysis of the gradient coil noise investigated on MRI systems with different magnetic field strengths and during various pulse sequences has shown a trend towards increase in noise with higher magnetic fields. The noise level for a 3 T system was recorded at 118.4 dB (A). There was also a significant increase in noise with reduction of field of view (FOV) and repetition time (TR) than slice width or echo time.

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**Table 1**

<table>
<thead>
<tr>
<th>Orientation</th>
<th>Sequence</th>
<th>TR (ms)</th>
<th>TE (ms)</th>
<th>FOV (cm)</th>
<th>MATRIX</th>
<th>Leq dB (A)</th>
<th>Lpeak dB</th>
</tr>
</thead>
<tbody>
<tr>
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<td>Fast Spin Echo-XL T1</td>
<td>780</td>
<td>12.86</td>
<td>18</td>
<td>320 × 224</td>
<td>112</td>
<td>124</td>
</tr>
<tr>
<td>AXIAL</td>
<td>Fast Relaxation Fast Spin Echo T2</td>
<td>4000</td>
<td>113.9</td>
<td>18</td>
<td>448 × 224</td>
<td>111</td>
<td>122</td>
</tr>
<tr>
<td>SAGITAL</td>
<td>FLAIR T1</td>
<td>3384</td>
<td>32.95</td>
<td>28</td>
<td>448 × 224</td>
<td>101</td>
<td>115</td>
</tr>
<tr>
<td>SAGITAL</td>
<td>FRFSE-XL T2</td>
<td>4000</td>
<td>118</td>
<td>28</td>
<td>512 × 256</td>
<td>101</td>
<td>115</td>
</tr>
</tbody>
</table>

TR = repetition time, TE = echo time, FOV = field of view, Leq = equivalent noise level, Lpeak = peak sound pressure level.

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**Fig. 1.** Pre-treatment pure tone audiogram 17 h post-exposure to 3 T MRI.
(TE) [3]. Hattori found an even higher sound level up to 130.7 dB for a 3 T MRI scanner [4].

Thus MRI-generated noise has prompted routine use of hearing protection but despite using hearing protection there are reports of hearing loss. In one study, 24 patients underwent audiometric testing pre- and post-MRI (0.35 T). Five of the 14 without protective ear plugs and one of the 10 patients with ear plugs had temporary threshold shifts (TTS) of at least 15 dB hearing loss. The duration of noise exposure was on average between 42.1 and 39.1 min and the TTS returned to baseline within 15 min [1].

In a later study otoacoustic emission (OAE) was measured in 16 patients with ear plugs pre- and post-MRI (1.5 T) and compared with 16 controls. The duration of the protocol was about 20–38 min. Measured noise levels peaked between 122 dB and 131 dB, and OAE were significantly decreased post-MRI. However, it was not reported if patients had also subjective hearing loss with PTA documentation and whether the OAE reverted to normal later on [5].

Therefore, ear plugs may not be completely protective. Hattori who studied the subjective sound levels in a 3 T MR unit also showed that noise reduction was not sufficient with the use of either ear plugs or headphones alone, while the use of both devices provided better results [4].

Noise-induced hearing loss can be described in terms of temporary threshold shifts and permanent threshold shifts. TTS is a temporary reduction in auditory acuity following noise exposure and the duration is arbitrary, ranging from hours to days [6].

The aetiology of hearing loss in our patient is not very clear cut. It is unilateral with a tapering pattern over the high frequencies, not typical of the well described features of noise induced hearing loss with a 4 kHz notch on PTA for occupational exposure. However, the limited report of TTS post-MRI recorded unilateral threshold change in 6 of the 7 who demonstrated changes and only one patient had bilateral change post-MRI. The frequencies at which changes were observed was also mainly at 6 and 8 kHz and only one patient had changes at 4 kHz [1]. Assuming noise as aetiology for the hearing loss, the TTS was considerably longer than those observed in Brummett’s study [1]. Ear plugs may not be completely protective but in our case it is unclear if one of the ear plugs was either not worn properly or was defective contributing to a unilateral hearing loss.

A diagnosis of sudden sensorineural hearing loss (SSNHL) was also entertained as he fitted into the criteria of sudden hearing loss occurring more than 30 dB over 3 contiguous frequencies within 3 days and showed an apparent response to the treatment. However investigations of possible causes other than noise-related revealed no positive findings. It is tempting to conclude that a SSNHL occurred coincidently with the MRI examination but the effect of noise should not be ignored.

It is important for the benefit of patients undergoing MRI examination, that the results of the earlier studies showing only mild TTS are interpreted in the light of the advances made in the MRI technology noting that it could bring about a larger effect. An individual’s susceptibility to noise-induced hearing loss varies, creating difficulty in predicting hearing loss in anyone in particular. In the present case noise levels during the procedure with the patient in the gantry was not available and the nature of impulse noise of the MRI itself makes it complicated to define damage risk criteria for this kind of noise exposure.

4. Conclusion

MRI scanner which has a higher magnetic field, with its elevated noise levels, has a potential to affect the auditory system but further studies are required to confirm this to warn patients of its potential impact on hearing. All precautions should be taken to prevent it and adhere to the recommended hearing protection measures such as that recommended by Hattori to use both ear plugs and headphones simultaneously [4].
References