Evaluation and Reduction of Acoustic Noise in PET/MR

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Abstract

OBJECTIVES

Excessive acoustic noise during MR scanning poses a risk of damage to patients. Early experiences with a recently installed PET/MR scanner at our institution led us to an evaluation of acoustic noise levels and mitigation techniques. The objective was to determine the most effective technique or combination of techniques to reduce the noise level for patients while maintaining adequate image quality.

METHODS

A sound level meter was used to measure the noise level for each clinically approved sequence used with the head coil. The microphone was positioned in the head coil in a location meant to approximate ear level, and then positioned in a volunteer. Sequences deemed to be ‘loud’ were modified to reduce sound levels. The modified sequences were then scanned on a volunteer with images reviewed for image quality. In addition, all other aspects of our safety program related to hearing protection were reviewed.

RESULTS

Acoustic noise measurements of our approved sequences demonstrated a range of sound levels from 104 to 122 dBA. Modifications were made to 42 sequences by using the vendor supplied ‘quiet’ option or through manual modifications to sequences. The sound level dropped by an average of 11 dBA with the quiet option. The reduction level was determined to be the expense of decreased residual or increased scan time.

During review of our hearing protection safety program, a number of important points were noted regarding the application of hearing protection and patient communication.

CONCLUSION

Patients may be subject to increased risk of damage to hearing when a combination of conditions exists. It is important to understand the risks associated with acoustic noise in MR imaging and the methods by which those risks may be mitigated. Technology education regarding hearing protection is an important component of an MR safety program.

Table 1: Acoustic Noise Reduction

| Sequence | Original Sound Level (dBA) | Modified Sound Level (dBA) | Reduction (%)
|----------|---------------------------|---------------------------|-------------
| Sequence 1 | 112 | 102 | 9 |
| Sequence 2 | 104 | 98 | 6 |
| Sequence 3 | 120 | 108 | 9 |

Figures

1. Schematic of the modified PET/MR scanner, demonstrating the location of the PET detector ring.
2. Comparison of original and modified sound levels for several sequences.
3. Graph showing the reduction in sound levels for a selected sequence.

Discussion

Our experience with the Signa PET/MR scanner is that it is louder than the other MR scanners at our institution. It has been suggested that the PET detector ring may contribute to increased acoustic noise in the bore of the scanner. It should be noted that measurements by manufacturer service determined that the acoustic noise levels of our PET/MR scanner were within FDA and manufacturer specifications.

Headphones are a preferred method for hearing protection in MRI due to ease and consistency of application. However, the size of the head coils is such that headphones generally will not fit, and there is a concern about the amount of PET attenuation that headphones may cause. To this end we have developed custom 3D-printed headphones that use commercially available foam inserts for use with this scanner. We have tested them to demonstrate that they cause minimal PET attenuation (Fig. 2a). These are used in combination with ear plugs.

Conclusions

• Patients may be subject to increased risk of damage to hearing when a combination of conditions exists, including scans in which ear plugs only are used; when the incorrect size ear plugs are used and/or they are improperly inserted; protocols which use particularly loud pulse sequences; and patient conditions which may exacerbate the problem. Ear plugs plus ear phones should be used when possible. Headphones should be well educated regarding the use of hearing protection and should instruct patients to notify them if they experience uncomfortable levels of acoustic noise.

References