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 injury to patients. Early experience with a recently installed a PET/MR scanner (SIGNA PET/MR, GE Healthcare) at our institution led us to an evaluation of acoustic noise levels and mitigation techniques. Our goal 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 coils. The microphone was positioned in the head coil in a location meant to approximate ear level, and then positioned at isocenter. 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 by Radiologists. 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 104.9 to 122.6 dBA. Modifications were made to 42 sequences by using the vendor supplied 'quiet' option or through manual modifications to the sequences. The sound level dropped by an average of 11 dBA with the modifications. However, the reductions often came at the expense of decreased resolution or increased scan time.

During review of our hearing protection safety program, a number of important points were raised 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. Technologist education regarding hearing protection is an important component of an MR safety program.

Objectives

MR scanning generates acoustic noise at levels capable of inducing injury to patients. Upon learning that patients were experiencing uncomfortably high levels of noise on our new PET/MR scanner, a thorough evaluation was conducted into the levels of noise being generated, patient conditions which might exacerbate the problem, and the methods available to reduce noise levels or mitigate a patient's risk. The objectives were to reduce the noise levels through sequence adjustment while maintaining adequate image quality and to improve our MR safety program through staff education regarding noise levels and methods used to reduce risk to patients undergoing MR imaging.

Figure 1

Methods

A sound level meter with MR Safe microphone and cable (Bruel & Kjaer model 2250L) was used to measure A-weighted sound levels (dBA) for each clinically approved sequence used with the head coils. The microphone was positioned in the head coil adjacent to a spherical phantom in a location approximating ear level, with measurements taken with the microphone at isocenter (Fig. 1). Sequences with measured sound levels above a conservative 105 dBA were identified to be modified to reduce sound levels. Acoustic noise for these sequences was re-measured to determine modified sound level (Table 1). The modified sequences were then scanned on a volunteer with images reviewed by Radiologists to identify any image quality issues that may need to be addressed. In conjunction with the acoustic noise measurements, our safety program related to hearing protection was evaluated.

Results

- Acoustic noise measurements conducted on imaging pulse sequences resulted in a range of sound levels from 104.9 to 122.6 dBA. Modifications were made to 42 sequences in an attempt to reduce sound levels. Initial adjustment was made simply by activating the vendor supplied 'quiet' option for the pulse sequence. However, several sequences required manual modifications to reduce the noise level. The average sound level for un-modified sequences was 112. 4 dBA. After modifications, the average sound level of these sequences was 101 dBA, resulting in an overall average decrease of 11 dBA (Table 1). The reduction in sound level resulted in decreased resolution or increased scan time for many sequences, thus these aspects were carefully considered in the decision to keep the new sequence or revert to the louder sequence.
- During review of our hearing protection safety program, we discovered or were reminded of several important factors: 1. Proper technique must be used when inserting ear plugs. 2. Ear plugs are not 'one-size-fits-all' (Fig. 2a). Patients with small ear canals should be given appropriate sized ear plugs. 3. Improperly inserted or incorrect size ear plugs may shift in position during scanning, and may have reduced effectiveness. (Fig. 2b) 4. Technologists should communicate with patients about acoustic noise, just as they do about other risks. 5. Hearing protection combination of ear plugs plus headphones may be used for non-head coil scans. When headphones may not be used, proper insertion of ear plugs becomes critically important. 6. Some patients (e.g. those with pre-existing conditions, and those undergoing certain types of chemotherapy) may be more sensitive to acoustic noise issues.

Table 1: Acoustic Noise Reduction

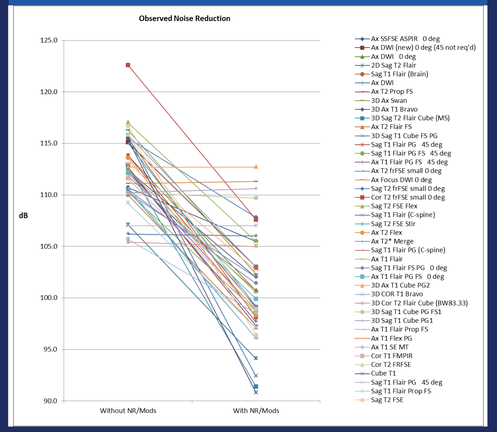
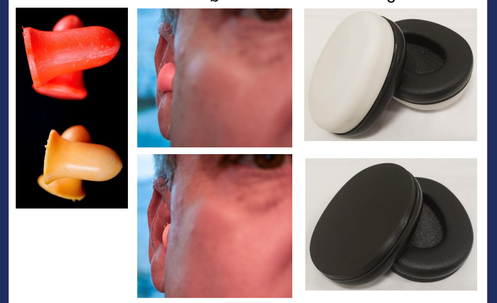


Figure 2



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 scanner design modifications to allow insertion of 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 MR 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 concern about the amount of PET attenuation that headphones may cause. To this end we have developed slim 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. 2c). 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. Technologists 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

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