

Evaluation of Effective Sound Insulation Method for Noise Generated by MRI

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Abstract

Background/Objectives: MRI is a popular method in modern diagnostic medicine. However, MRI equipment produces 65 to 130 kHz noise when operated, which can cause patients to feel anxious or fear enclosed spaces. To lower the level of noise, method such as earplugs and headsets have been used.

Method/Statistical Analysis: In this study, the researchers tried to find out the effective sound insulation method by measuring the degree of noise heard by the patients and evaluating the difference of noise by sound insulation material. A sound meter was placed in a water phantom made outside the magnetic field of the MRI to measure the noise using four sequences (EPI, T1, T2, GRE) and compared it to the sound felt by the patient.

Findings: As a result, the average noise felt by the patient was measured to be 92.5 dB at EPI, 73.1 dB at T1, 87.4 dB at T2, and finally 74.4 dB at GRE. The average noise when the earplug was worn was measured to be 84.4 dB at EPI, 66.3 dB at T1, 79.4 dB at T2, and 67.7 dB at GRE. The average noise value when the headset was worn was measured to be 78.2 dB at EPI, 61.3 dB at T1, 74.4 dB at T2, and 65.3 dB at GRE. Finally, the average noise when both earplug and headset were simultaneously worn was measured to be 77.4 dB at EPI, 60.5 dB at T1, 73.3 dB at T2, and 63.4 dB at GRE respectively. Based on the above result, the most effective sound insulation was made when both earplug and headset were worn at the same time, the next effective sound insulation method was headset wearing, and the least sound insulation method was earplug wearing.

Improvements/Applications: If it is not possible to apply a fundamental management method to eliminate the causes of noise, which is difficult to practice in actual clinical practice, it is suggested that hearing protection gear should be actively used to reduce the degree of noise-exposed to patients.

Keywords: *Magnetic resonance imaging, headset, earplug, noise, Sound insulation.*

Introduction

Nuclear Magnetic Resonance (NMR), initially published in 1946 by Purcell and Block researchers,

was able to provide imaging ability by the development of gradient magnetic fields by Laterbur of New York State University in 1973. Thus, the device was named Nuclear Magnetic Resonance Imaging (NMRI), which combines nuclear magnetic resonance and imaging. It is now commonly referred to as MRI by omitting the initial letter N of Nuclear. MRI uses nuclear magnetic field and non-ionizing radiation to generate nuclear magnetic resonance in the nucleus of the body, imaging the density and physicochemical characteristics of the nucleus ^[1]. Therefore, MRI (Magnetic Resonance Imaging) is harmless to the human body, unlike X-ray

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or CT (Computed Tomography) and is widely used in the modern diagnostic medicine [2]. However, these MRI devices generate the noise of 65 ~ 100 dB for 1.5 Tesla, and close to 120 ~ 130 dB for 3.0 Tesla MRI equipment. In addition to the extremely narrow magnet bore of MRI, patients often complain of anxiety or claustrophobia during MRI because the patient's movement is limited to the maximum. As a result, MRI scanning may be delayed or interrupted. [3-4]. To reduce such anxiety, the current clinical practice uses music therapy that provides the music that the patient likes during MRI scanning [5], communicates with the patient through broadcasting [6], and simultaneously communicates with music therapy [7], which has been reported to reduce the psychological tensions of patients and makes them feel stable and consequently reduces anxiety. However, above method do not remove the real noise generated during MRI. Therefore, the method of managing the cause of the noise should be applied to reduce the amount of sound reaching the patient. However, the method of Hennel F et al (1999), which reduces the noise by smoothing the slope of the electric signal input to the coil, has a limitation in that the resolution of the image is lowered[8].

Since the numerical value of noise generated from MRI may cause an anxiety in patients, it is necessary to take measures to deal with it [9]. In the actual clinic, earplugs and headsets are used to reduce noise reaching patients.

Previous studies have identified the amount of noise generated by MRI, but there is no study that measures the amount of noise that patients experience after wearing sound insulation gear. Through this study, the researchers tried to find an effective sound insulation method that reduces the noise value that reaches the patient by measuring the degree of noise actually heard by the patient and comparing and evaluating the noise of each sound insulation material.

Method

- 1. Materials for Experiment:** As the material of the above experiment, RION's NL-42, an international standard Class 2 (normal) sound measuring instrument, was used. As a phantom, a hand-made water phantom was used. The size was 270 mm × 230 mm × 240 mm, the material was PP, and its purpose was to insert a noise meter [Figure 1].



Figure 1. Experimental material

- 2. Experimental Method:** The experiment was conducted in MRI room (3.0T Intera system Philips MRI), which was generally inspected, and noise was measured and evaluated by placing it at the end of the MRI, which is not affected by the magnetic field. [Figure 2] shows the experiments placing a sound meter in the phantom based on the method of sound insulation to the patient using earplug, headset and both earplug and headset at the same time without

sound insulation material. The noise was measured and compared by 4 method of earplug wearing, headset wearing and both earplug and headset wearing with 4 sequences (EPI, T1, T2, GRE) after measuring the noise that the patients felt. In order to increase the reliability of the experiment, total five measurements were performed, and the values at 5, 15, 25, 35, 45, and 55 seconds were recorded for 60 seconds by each sequence.



Figure 2. Measuring method (a) General MRI noise (b) Earplugs (c) Headset (d) Earplugs + Headset

3. Statistics: The average noise value of sequence by each method was obtained utilizing SPSS software Ver.25.

Result

[Table 1] shows the results of measurement and comparison of noise using sound insulation method. [Figure 3] is a graph showing the results of the comparison. At EPI, the highest noise-sequence, the average noise value of patients was 92.5 dB and the average value of noise when insulated by earplug was 84.4 dB. The one when insulated by headset was 78.2 dB and the one when insulated by both earplug and headset at the same time was 77.4 dB respectively. At T1 sequence, the average noise value of patients was 73.1 dB and the average value of noise when insulated by earplug was 66.3 dB, the one insulated by headset was 61.3 dB, and the one insulated by both earplug and headset at the same time was 60.5 dB. At T2 sequence, the average noise value of patients was 87.4 dB, the average noise value when insulated earplug was 79.4 dB, the average noise value when insulated by headset sound was 74.4 dB and the one when insulated by both earplug and headset at the same time was 73.3 dB. Finally, the average noise of the patients at GRE sequence was 74.4 dB. The average noise value when insulated by earplug was 67.7 dB, the average noise value when insulated by headset was 65.1 dB, and the one when insulated by both earplug and headset was 63.4 dB respectively. This shows that the noise is insulated most when earplugs and headsets are worn at the same time. The headset was then the second, and the earplug was third in sound insulation.

Table 1. Measured Value [Unit : dB(A)]

Sequence	General	Earplug	Headset	Earplug + Headset
EPI	92.5	84.4	78.2	77.4
T1	73.1	66.3	61.3	60.5
T2	87.4	79.4	74.4	73.3
GRE	74.4	67.7	65.1	63.4

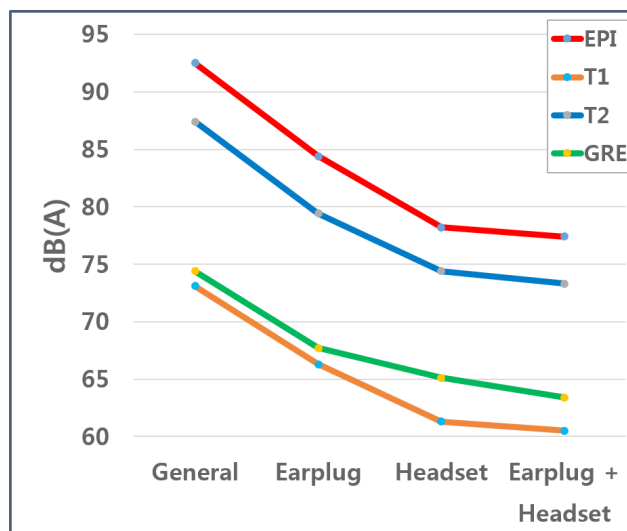


Figure 3. Measurement Value Graph

Discussion

The noise at the EPI sequence was from 92.5 dB to 77.4 dB and decreased up to by -15.1 dB, about 16.3%, and the sound at the T1 sequence was from 60.5 dB to 73.1 dB, and decreased up to by -12.6 dB, about 17.2%. The noise at T2 sequence was from 73.3 dB to 87.4 dB and decreased up to by -14.1 dB, about 16.1%, and the noise at the GRE sequence was 63.4 dB to 74.4 dB and decreased up to by -11 dB, about 14.8%. The MRI test showed the most significant sound insulation effect of -15.1 dB at EPI sequence, and the sound insulation effect about 16% was achieved by simultaneous wearing of both earplugs and headsets. At EPI sequence, the noise was from 77.4 dB to 92.5 dB and decreased up to -15.1 dB, about 16.3%, and the sound at the T1 sequence was from 60.5 dB at 73.1 dB and decreased up to -12.6 dB, about 17.2%. At the T2 sequence, the noise was from 73.3 dB to 87.4 dB and decreased up to by -14.1 dB, about 16.1%, and the noise at the GRE sequence was from 63.4 dB to 74.4 dB and decreased up to -11 dB, about 14.8%. The MRI test showed the most significant sound insulation effect of -15.1 dB at EPI sequence, and the sound insulation effect of about 16% was achieved by the simultaneous wearing of both earplug and headset.

MRI is one of the most important imaging diagnoses in modern medicine. It is possible to diagnose diseases in a way that is harmless to the human body, not to diagnose diseases using radiation such as X-ray or CT and provides anatomical and pathological information of human tissues unlike other diagnosis method, so the perception that MRI is safe unlike other diagnostic method is widespread to modern citizens. Contrary to the advantages of MRI, however, MRI generates quite a large amount of noise. Although the degree of noise varies slightly between manufacturers and equipment, it generates noise of 65 ~ 100 dB in case of 1.5 Tesla MRI and 120 ~ 130 dB in the case of 3.0 Tesla MRI. Besides, 7.0 Tesla MRI equipment under development is expected to generate even higher noise, which may cause various problems [3]. The short-term exposure to such noise not only temporarily reduces hearing but also causes hearing loss difficult to recover when exposed for a long time [10]. The noise of MRI causes an imbalance between the sympathetic and parasympathetic nerves, causing stress, anxiety [11], and also affects breathing or pulse. It brings physiologically, the sympathetic nerves causing excitement and tension, elevation of blood pressure, excessive secretion of gastric acid, increased heart rate, constriction of blood vessels, and hormonal changes [12]. ‘Noise work’ refers to a work that generates noise higher than 85 dB over 8 hours a day. ‘Intense noise work’ refers to a practice that produces the noise higher than 90 dB at the same time as above. This noise does not cause noise-induced hearing loss, but the noise reaching the patient causes various physiological disorders in the human body [13]. In fact, these noises cause many patients to feel anxiety or claustrophobia during MRI, which often causes delayed examination or movement of the patient resulting in poorly diagnosed images. It is reported that the fundamental management method of noise should be applied to improve the noise generation, but if it is difficult, it should be shielded by hearing protection gear [14]. Although these method are not sufficient to prevent noise with a frequency band between 500 and 1000 Hz, which affects the patient much during the MRI scan [15], this reduces the degree of noise-exposed [2]. Claustrophobia and noise sensitivity were reported to be reduced after the MRI examination [16]. In the case of the previous studies, the amount of noise generated during the MRI test can be identified and evaluated. However, no study measured the degree of noise felt by patients wearing the sound insulation materials during the test. Therefore, in this study, the researchers measured the actual noise level that patients

felt using sound insulation method that are widely used in clinical practice, and then compare and evaluate the noise of each sound insulation material to find an effective sound insulation method that reduce the degree of noise reaching the patient.

The limitations of the study were first, the noise measurement with nonmagnetic material was not made in MRI bore, and the noise was measured in an accessible place. Second, the structure of the human body was much more complicated than the phantom implemented, so indirect measurement was made. Further research needs to measure the noise at the center of MRI using a nonmagnetic noise meter to make the measurement close to the sound heard that patients hear.

Conclusion

This study compares and evaluates the method of insulating the noise generated during MRI test. The most effective method to insulate the noise generated from MRI was wearing both earplug and headset at the same time. The second effective way was wearing a headset and the least effective one was wearing an earplug. When comparing and evaluating the noise values heard by patients, the actual sound insulation value was significant, and the sound insulation effect up to by -15.1 dB, about 16.3% was achieved at EPI sequence. These values are thought to be effective for various physiological functions as well as claustrophobia and anxiety for patients. As a result, it is suggested that hearing protection gears should be used to reduce the level of noise exposed to patients if fundamental management method such as the installation of soundproof hoods on MRI are not available.

Ethical Clearance: Not required

Source of Funding: Self

Conflict of Interest: Nil

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