The Noise Pressure Level in Magnetic Stimulation

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Abstract: Magnetic stimulation causes a short auditive pulse. We determined the sound pressure levels of five different commercial stimulation coils. In addition, by using miniature microphone techniques, the acoustic peak level to magnetic stimulation was measured in an occluded ear.

INTRODUCTION

In magnetic stimulation (MS) a time-varying magnetic field is generated by delivering electrical current to an electrically isolated coil ring. The duration of pulse in commercially available magnetic stimulators is about 100 µs and the flux density of the pulse is about 2 T [1]. The magnetic stimulation technique is primarily used to evaluate the function of descending motor pathways from the motor cortex to the muscles in the extremities [2].

The transcranial magnetic stimuli are delivered with the coil positioned over the scalp. The distance of the coil is usually less than 10 cm from the aperture of the external ear canal. The coil ring causes a short audible clicking noise on stimulation [3]. During past five years an intensive discussion has taken place about the intensity of these click sounds and the potential risks which they may introduce for the hearing. A general opinion has been that the noise generated by the stimulating coil may affect the hearing of the patients as well as the examiner. However, the noise level seems to significantly depend on various factors: the geometry of the coil, the shape of the pulse and the distance of the coil from the ears.

To evaluate the potential risk caused by the impulse noise of the stimulating coils, we examined the A-weighted peak sound pressure levels from the five different types of magnetic stimulator coils. In addition, the acoustic peak (I_{peak,la}) in an occluded ear channel was measured from one healthy volunteer by using miniature microphone techniques (MIRE) [4].

METHOD

We performed the tests for three different commercially available stimulators: Dantec Mag2, Magstim Model 200, and Cadwell MES-10. There were altogether five different types of coils. Magstim stimulator was connected to a 40 mm round coil and a 70 mm double coil (Butterfly). With Dantec stimulator we used a Large Round Spiral Coil with an external diameter of about 100 mm, and a Butterfly Shaped Coil (coil diameter 55 mm). Cadwell MES-10 stimulator was supplied with a Focal Point coil that has an external diameter of 90 mm.

The A-weighted peak sound pressure levels from the stimulator coils were measured by using a precision sound level meter (Wärtsilä 7178). A half-inch condenser microphone was located at the distances of 0.1, 0.2, 0.4, 0.8, 1.6 and 3.2 meters from the center of the coil and the coil was in vertical position. The measurements were performed in an acoustically treated semi anechoic chamber at the height of 1.5 m above the floor.

For the measurements the power source of the stimulator was adjusted to full power (100%), and further to 90%, 70% and 30% from the full power. At the distance from the coil and each setting of power, the measurements were repeated 4 times for calculation of the mean value of the peak sound pressure level.

The acoustic linear peak level (I_{peak,la}) in an occluded ear was measured from one healthy volunteer using a miniature microphone (Senheiser KSE4-211-2) mounted to a peace of occlusion. The microphone was connected to a dynamic signal analyzer (Hewlett Packard HP35670), and the system was calibrated using calibrator (Bruel & Kjaer BK4220). During the measurements 20 000 samples were taken using a bandwidth of 25.6 kHz. The sampling was triggered 10 ms before the stimulation pulse. The acoustic pulse was caused by Cadwell Focal Point coil, which was set in ipsilateral tangential position. The stimulation intensities were 80% and 100% of the maximal capacity.

RESULTS

The different coils with Dantec and Magstim stimulators created almost similar peak levels, exceeding 119 dB at the distance of 10 cm with 100% stimulation intensity. Correspondingly, Cadwell MES-10 created maximum peak sound pressure levels of 133 dB, when stimulation intensity of 100% was used. Generally, the higher the stimulation intensity, the higher the A-weighted level. The decrease of the peak levels followed quite closely the distance rule. At a distance of 40 cm the decrease of the peak level was on average 14 dB (from 10.4 dB to 17.8 dB), as the stimulus intensity was decreased from 100% to 50%.

In the occluded ear, the acoustic peak level of noise was 125 dB for the stimulation intensity of 100%, and 116 dB for the intensity of 80%.

DISCUSSION

Based on the threshold levels of impact noise given by the American Conference of Governmental Industrial Hygienists (ACGIH), the allowed maximum daily number of magnetic
stimuli is from 1000 to 10 000 [5]. These numbers of daily stimuli are very rare in clinical practice. Our results lead to the conclusion that the risk is as small for the patients who are being examined as for the operator using the magnetic stimulator. The potential risk can further be reduced by even a very light weighted hearing protectors that will provide a proper attenuation to the coil impulses.

Based on our experiments the noise level in the ear depends not only on the location of the coil and the relative amplitude, but also on the stimulator type. It is evident that the differences of the stimulators are based on differing absolute powers of the stimulation circuits. Also the differences of pulse waveforms probably affect the noise levels. The effect of coil type was quite small, suggesting that the mechanical stability of all coils is at the same level.

REFERENCES