Original Article

The protective effects against noise trauma by sound conditioning in rats

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Abstract

Objective To investigate the protective effects of sound conditioning against subsequent high-level noise trauma in rats. Method Rats were exposed to a 4 kHz octave band noise at 95 dB SPL for 10 hours, then to a traumatic exposure dose (105 dB SPL for 13 hours) delivered 12h later. Control animals were exposed to the traumatic dose only. ABR thresholds were obtained before and after noise exposure. Result Animals that had been sound conditioned demonstrated less ABR threshold shift compared to those that had not. Conclusion Moderate level sound exposure appears to have a toughening effect on the rat cochlea (or "conditioning") leading to decreased hearing loss from subsequent traumatic exposure.

Key words sound conditioning, noise trauma, rat

Introduction

Noise exposure causes acoustic trauma in the form of temporary threshold shift (TTS) and/or persistent threshold shift (PTS). Traditionally, noise trauma is considered to be caused by mechanical and/or metabolic mechanisms. However, for an organ as complex and specialized as cochlea, a clear understanding of mechanism of cochlear noise trauma requires further investigation. In addition, it is not clear if mechanisms of acoustic trauma may be different among different species. In contrast to traditional noise trauma models, using guinea pig, we choose rats to study potential protective effects of sound conditioning against noise trauma. This paper summarizes our findings and offers a discussion on possible mechanism of noise trauma.

1 Materials and Methods

1.1 Animal: Wistar rats of both sexes were raised for one week, to allow a weight gain to between 250 and 300 grams.

1.2 Noise exposure: Octave band noise (OBN) with a central frequency at 4 kHz was delivered through a Sound Tech PL500 amplifier and a Celection RTT 50x microphone mounted above the cage. The sound was calibrated using a B&K 2209 level meter and a B&K 2606 amplifier.

Rats in the test group were exposed to the OBN at 95dB SPL for 10 hours, and to the same OBN at 105dB SPL noise for 13 hours after a 12 hours break. Animals that served as the control were exposed only to the OBN at 105 dB SPL noise for 13 hours (Table 1).

1.3 Auditory function assessment: ABR thresholds to 1, 2, 4 and 8 KHz tone pips were measured under general anesthesia before, immediately after and 3 weeks following noise exposure, using a Madsen 2250. ABR thresholds are summarized in Table 2.

1.4 Statistics analysis: ABR results were compared between the test and control groups using F-tests and variance analysis.

2 Results

2.1 Exposure to the 95dB SPL OBN resulted in an average ABR threshold shift of 8 dB. Less ABR TTS and PTS were noticed in sound treated animals immediately after and at 3 weeks following the traumatic dose exposure when compared to the control animals (p<0.05) (Table 2).

Discussions
Noise trauma research has been conducted in a number of mammalian species, including rats, mice, guinea pig and chinchillas. The reason for selecting rats in this study is because sound conditioning studies in rats are relatively incomplete. Besides, rats are easy to handle, suitable for physiological and biochemical tests in a high-throughput way. Also mature threshold measuring technology is ready for use.

Noise trauma can present as shows TTS and/or PTS. TTS resulting from exposure to the conditioning OBN at 95 dB is about 8 dB in this study. Clark considers such sound conditioning a “toughing” phenomenon. It has been reported that sound conditioning can reduce PTS resulted from subsequent high-level noise exposure (Canlon, 1988; Canlon, 1995). Exposure to OBN at 105 dB SPL following sound conditioning at 95 dB SPL in this study resulted in a 11 dB decrease in TTS (21 vs 32 dB) and almost no PTS at 3 weeks following exposure (in contrast a 15 dB residual PTS in non-conditioned animals), indicating a protective effect.

Utilizing low-level noise as sound conditioning to reduce the noise trauma brought by subsequent high-level noise has been frequently reported. Canlon exposed guinea pig to 1 kHz tone at 81 dB SPL for 24 days. Rayn exposed hamsters to 1/2 octave sound at 81 dB SPL for 21 days. Both showed protective effect in reducing the persistent hearing loss. Sound conditioning with 4kHz OBN at 95dB SPL for 10 hours in this study is shorter in duration than a forementioned reports, but demonstrates similar protective effects against hearing damage from subsequent noise overexposure.

The mechanism of reducing the hearing loss and hair cell injury from high–level noise exposure by sound conditioning is still unclear. There are two possibilities: sound conditioning may change biochemical metabolism in the cochlea, or it may change the intensity of middle ear muscle reflex or olivo–cochlear bundle reflex. Both reflexes can have protective effect after high–level noise exposure. But the protective effects by sound conditioning do not seem to disappear after sectioning the two reflex pathways, suggesting that, the possible reason for the protective effects by sound conditioning may be change inside the inner ear. More research is clearly needed to completely understand related mechanisms.

### References


**Table 1** noise exposure in experimental group and control group

<table>
<thead>
<tr>
<th></th>
<th>Sound conditioning (dB SPL, 10h)</th>
<th>Break (h)</th>
<th>Subsequent high–level noise (dB SPL, 13h)</th>
</tr>
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<tbody>
<tr>
<td>Experimental group</td>
<td>8 95</td>
<td>12</td>
<td>105</td>
</tr>
<tr>
<td>Control group</td>
<td>10</td>
<td></td>
<td>105</td>
</tr>
</tbody>
</table>

**Table 2** Averaged ABR thresholds over 1, 2, 4 and 8 kHz before and after exposure to traumatic dose of OBN

<table>
<thead>
<tr>
<th></th>
<th>before</th>
<th>Right after exposure</th>
<th>3 weeks after exposure</th>
</tr>
</thead>
<tbody>
<tr>
<td>Control Group</td>
<td>39.8±1.4</td>
<td>71.5±1.8*</td>
<td>54.1±1.4*</td>
</tr>
<tr>
<td>Experimental group</td>
<td>40.2±1.2</td>
<td>61.9±1.8*</td>
<td>41.3±0.8*</td>
</tr>
</tbody>
</table>

*P<0.05