Influence of Suction Tube Noise on Hearing in Pediatric Patients Who Received Ventilation Tube Insertion

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Background: Myringotomy with ventilation tube insertion is the most frequently used surgical procedure performed on children to treat otitis media with effusion. The risk of acoustic trauma caused by the suctioning noise during the procedure has not been clearly understood. The objective of this study was to investigate whether the suctioning noise during ventilation tube placement procedure damaged children's hearing.

Methods: The study was conducted in a prospective manner. The ventilation tube placement procedures were performed on a series of 30 consecutive patients (60 ears). The electro-acoustic signals of the suctioning noises during the procedure were analyzed using a high quality digital tape recording system. The hearing threshold was measured using pure tone audiometry before and after the procedures.

Results: The peak intensity of the suctioning noise ranged from 4 kHz to 10 kHz in frequency. The mean intensities of the suctioning noise were 86.4 ± 9.6 dB for serous effusion and 96.4 ± 9.6 dB for mucoid effusion, respectively. No noise-induced sensori-neural hearing loss was observed in this cohort.

Conclusions: Even though the peak intensity of the suctioning noise may reach a level of more than 90 dB, it is not likely that the suctioning noise during the ventilation tube placement procedure causes noise-induced sensori-neural hearing loss.
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Key words: ventilation tube placement, suctioning noise, sensori-neural hearing loss.

Otitis media with effusion (OME) can cause conductive hearing loss in children. Myringotomy with ventilation tube insertion is the standard surgical procedure used to treat children with OME.[1] Aspiration of middle ear fluid following myringotomy is a crucial step to prevent future blockage of the inserted ventilation tube. Continuous suctioning vacuum is highly effective in cleaning effusion but it can also generate significant levels of noise during the procedure. Whether the ventilation tube placement procedure causes collateral damage to hearing is an issue of interest to many otolaryngologists and general pediatric practitioners as well.

Neel et al. speculated about the possibility of acoustic trauma caused by the suctioning noise during a myringotomy procedure.[2] Mason et al.[3] reported three cases of raised auditory brain stem response (ABR) threshold after suctioning aspiration

of glue effusion from the middle ear. Egili and Kiris advocated the ventilation tube insertion without suctioning the middle ear effusion to avoid noise exposure.[4] On the contrary, Spencer concluded that although the sound pressure may at times attain a high level during the suctioning process,[5] it was not sufficient to induce sensori-neural hearing loss. The opinions appeared to be polarized on this matter and there is a lack of quantitative evidence in the reports in the literature. The consequential relationship between the suctioning noise and acoustic trauma remains unclear. The objectives of this study were to measure the intensity of the suctioning noise and to investigate whether suctioning noise during ventilation tube placement procedure damaged children's hearing.

METHODS

Patients and surgical procedure

A series of 30 consecutive patients (60 ears) were prospectively recruited into this study. The patients' ages ranged from 5 to 13 years (mean age, 7 years) with a gender ratio of 1.2:1 (male:female). The inclusion criteria for myringotomy with ventilation tube insertion included the existence of persistent middle ear effusion for longer than 3 months. Surgeries were performed under intravenous hypnotic anesthesia. Laser myringotomy using a 0.2 mm diameter sapphire tip with 8 watt (Nd: YAG, SLT Co, Penn, USA) was routinely performed. A 2 mm hole was made at the anterior-inferior quadrant of the tympanic membrane for each ear. Each middle ear effusion was aspirated using a Bellucci suction tube (6 F.G. in diameter). The continuous vacuum pressure was set at 35 cmHg/cm^2 for every procedure.

Measurement and acoustical analysis of suctioning noise

Informed consent was obtained from the parents in advance of performing the procedure. The measuring instruments used were probe microphone (4182, B&K Co. Denmark), preamplifiers (2633, B&K Co. Denmark), digital audiotape (DAT, PC 216Ax, Sony Co. Japan), multiplexer (2811, B&K Co. Denmark), and real-time analyzer (2133, B&K Co. Denmark). The probe microphone was oriented at a 90° angle to the tympanic membrane. A standard distance of 0.2 mm from the probe microphone to the eardrum was calibrated before every measurement. For each procedure (ear), two measurements were undertaken and the mean intensity was retrieved for statistical analysis; each measurement would take 5 seconds to complete.

Hearing test

Hearing tests were performed immediately before the ventilation tube placement procedure and were performed again when the children fully recovered from hypnotic anesthesia. Paired pure tone audiometry (PTA) data were obtained from all 30 children. Pure tone threshold was determined for each ear at frequencies of 0.25 to 8 kHz for air conduction and 0.5 to 4 kHz for bone conduction.

Statistical analysis

The pre- and post-operative mean hearing threshold levels for each ear were compared using the paired t-test. The level of significance was set at 0.05.

RESULTS

The recorded peak noise levels and noise patterns are shown in Figures 1-4. The peak noise intensity of serous effusion suctioning appeared at the frequency levels ranging from 4 kHz to 10 kHz. The mean intensity was 86.4±9.6 dB (Fig. 1). The pattern of suctioning noise of serous effusion showed fluctuating pattern with rhythmic changes (Fig. 2). The peak noise intensity of mucoid effusion suctioning appeared at frequency levels that ranged from 4 kHz to 10 kHz. The mean intensity was 90.4±9.6 dB (Fig. 3). The suction noise for mucoid effusion showed irregular and greater fluctuating patterns than those of the serous effusion (Fig. 4).

The mean preoperative air conduction threshold was 36.2±1.2 dB and the mean bone conduction threshold was 7.8±1.3 dB. The mean postoperative air conduction threshold was 16.7±1.4 dB; a statistically significant air conduction improvement of 19.4 ±1.8 dB was observed (paired t-test, $p=0.039$). However, the mean bone conduction threshold of 7.2 ±1.7 dB was indistinguishable from the pre-operative data (paired t-test , $p=0.942$), showing no signs of threshold shift following operation.
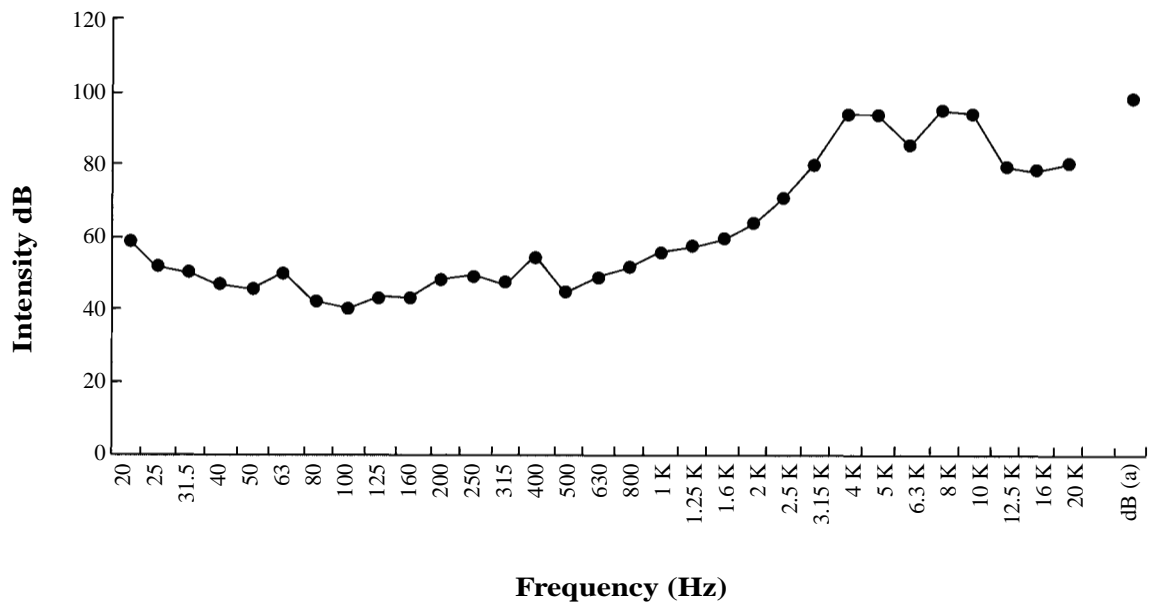
Fig. 1 Suctioning noise during aspiration of serous effusion. Peak intensity of noise appears from 4 to 10 kHz. The mean ± SD intensity is 86.4 ± 9.6 dB.
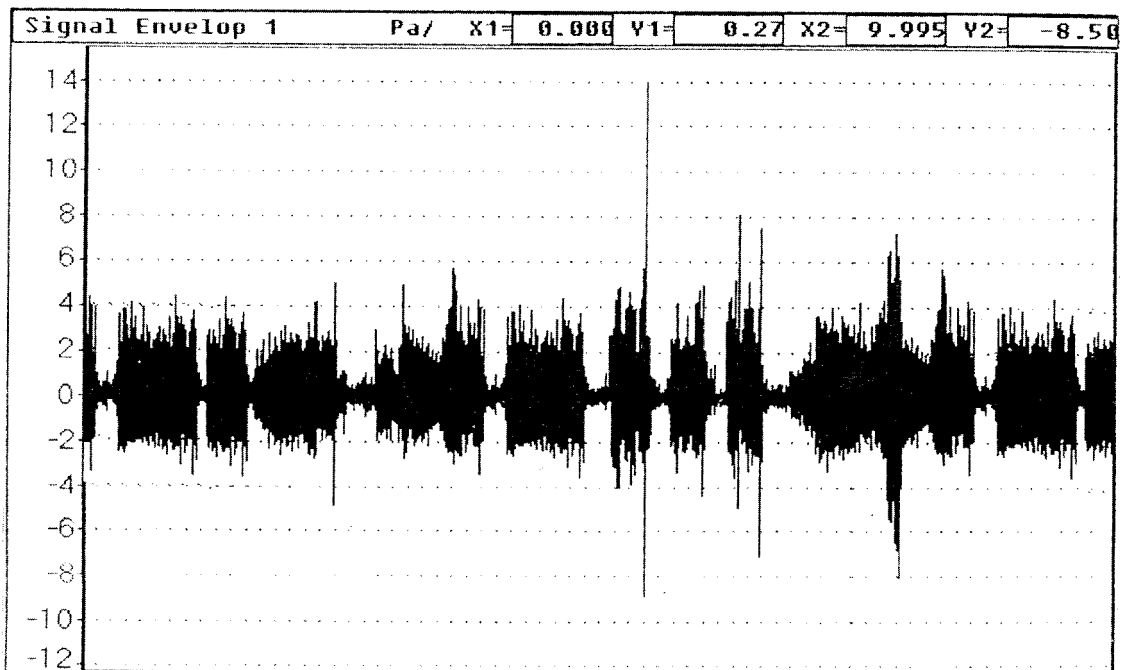

Fig. 2 Analysis of noise characteristics: suctioning noise during aspiration of serous effusion shows a fluctuating pattern. The pattern is irregular and is with rhythmic changes. Duration is 10 seconds.
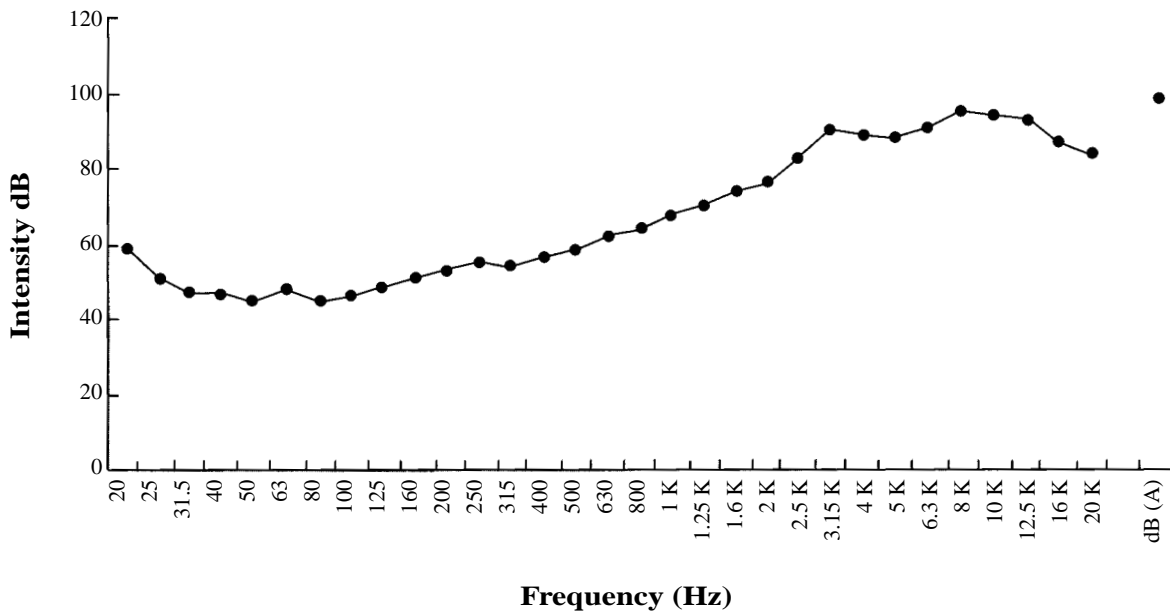
Fig. 3 Suctioning noise during aspiration of mucoid effusion. Peak intensity of noise appears from 4 to 10 kHz. The mean±SD intensity is 90.4±9.6 dB.
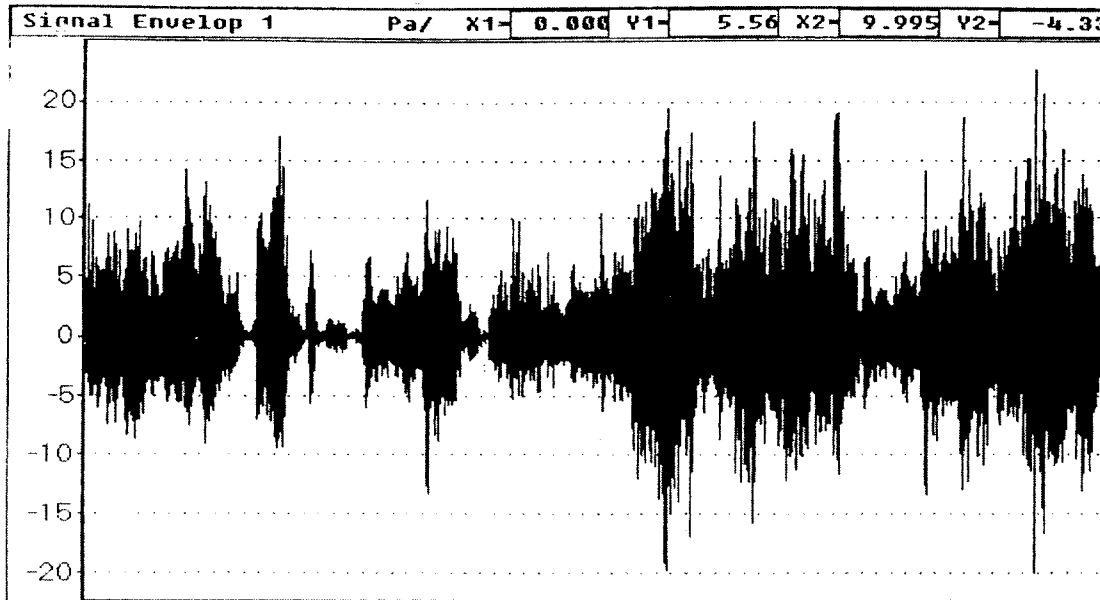

Fig. 4 Analysis of noise characteristics: suctioning noise during aspiration of mucoid effusion shows more irregular and fluctuating pattern than the serous effusion. Duration is 10 seconds.

DISCUSSION

Impulse noise is hazardous to human hearing. A single exposure to an intense short-duration sound can cause permanent hearing loss.[6-8] Impulsive sound energy is able to mechanically damage the organ of Corti. Acoustic trauma can produce a greater degree of hearing loss than that caused by industrial noises.[9-17]

The possibility of a sensori-neural hearing loss caused by high level suctioning noise during ventilation tube placement procedure has long been speculated. The chance is particularly high when the sound intensity and noise exposure duration are overwhelmingly excessive.[17]

In this study, we used digital audiotape recorders and digital sound level meter to measure the suctioning noise. Digital audio tape recording is superior to conventional tape recording in respect of their frequency response, dynamic range, and signal-to-noise ratio.[18] The digital information are also advantageous for computerized analysis. Similar to other reports,[19] our data show that the peak intensity of suctioning noise typically did not sustain for more than 2 seconds. The whole operational procedure typically took less than 15 minutes for each ear. The peak intensity of noise for suctioning mucoid effusion (90.4 ± 9.6dB) was higher than that of serous effusion (86.4 ± 9.6dB). Nevertheless, the short duration of peak noise exposure may explain why none of the tested ears sustained sensori-neural hearing loss following the ventilation tube placement procedure. However, the possible impacts of whole duration of suctioning, influences of anesthesia agent, and length of total operation time were not taken into consideration in this study.

Youngs and Gatland found that the outcomes between aspirated and non-aspirated middle ears were similar at 3 months following surgery.[20] The findings led to their recommendation not to evacuate middle ear effusion to avoid possible acoustic trauma. Ventilation tube occlusion is common, and the tube occlusion rates may range from 7% to 37%, rendering the plugged ventilation tube nonfunctional.[21,22] It is generally agreed that suctioning the middle ear effusion may effectively prolong the tube survival rate to reduce the recurrence of middle ear infection. Even though the relatively small case number and a short follow-up period have restricted the exploration of this study, our findings provide evidence that suctioning the middle ear during the ventilation tube placement procedure, for either serous or mucoid effusion, can be done safely without inducing sensori-neural hearing loss.

According to the results of this study, we concluded that suctioning the middle ear during the ventilation tube placement procedure can be done safely without inducing sensori-neural hearing loss on children with OME.

Acknowledgements

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兒童患者通氣管置入術中抽吸管噪音對聽力之影響

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背 景：鼓膜切開與中耳通氣管置入是治療兒童積液性中耳炎最常施行的手術。通氣管置入過程抽吸中耳積液所引發的噪音是否會造成聽覺傷害至今仍尚未完全明瞭，本研究的目的在探討鼓膜切開手術過程當中抽吸中耳積液所造成的噪音是否會造成兒童的聽覺障礙。

方 法：本研究共收入30名（60耳）患有積液性中耳炎而必須接受耳膜切開及通氣管置入術的兒童；本研究使用高品質數位錄音設備來記錄在鼓膜切開手術當中抽吸中耳積液所造成的噪音，所記錄到的數位化音響數據經過分析以後，用以判別噪音的強度。我們以純音聽力檢查來測定病人在接受鼓膜切開手術前後聽力閾值的變化。

結 果：抽吸噪音的尖峰強度其頻率範圍約在4K赫茲至10K赫茲之間，經測得抽吸漿液性積液平均噪音爲86.35±9.6dB。術前術後聽力檢查顯示鼓膜切開及中耳通氣管置入能有效的去除兒童因積液性中耳炎所引起的傳導性聽力喪失，但是我們並沒有觀察到任何因爲噪音所引起的神經性聽力障礙。

結 論：本研究發現即使抽吸的尖峰強度可達到90dB以上，在鼓膜切開及中耳通氣管植入手術過程當中似乎並不會造成噪音性的神經性聽力障礙。
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關鍵字：通氣管置入手術，抽吸噪音，神經性聽力喪失。