Original Article

Comparing of anteroinferior and posteroinferior tympanostomy tube insertion: a cohort study

Xiaobo Ma[1], Ying Li[1], Mengshuang Lv[1], Jie Li[2], Shouqin Zhao[1]

[1]Department of Otolaryngology – Head and Neck Surgery, Beijing Tongren Hospital, Capital Medical University, Beijing, China; [2]Department of Otolaryngology – Head and Neck Surgery, Fuxing Hospital, Capital Medical University, Beijing, China

Contributions: (I) Conception and design: X Ma; (II) Administrative support: None; (III) Provision of study materials or patients: X Ma, S Zhao; (IV) Collection and assembly of data: Y Li, J Li, M Lv; (V) Data analysis and interpretation: Y Li, J Li, M Lv; (VI) Manuscript writing: All authors; (VII) Final approval of manuscript: All authors.

Correspondence to: Shouqin Zhao, MD. Department of Otolaryngology Head and Neck Surgery, Beijing Tongren Hospital, Capital Medical University, Beijing 100730, China. Email:shouqinzhao@163.com.

Background: Tympanostomy tube insertion (TTI) is one of the primary treatments for Otitis media with effusion (OME) in children, a common condition in children. However, there is still no conclusion on the better choice of tube position, and no relevant research has been found in the literature. This study analyzed the results of the two commonly selected tube insert positions, anteroinferior quadrant (AQ) and posteroinferior quadrant (PQ), in order to determine which is the better choice.

Methods: Children with bilateral OME who received TTI in Beijing Tongren Hospital from May 2020 to January 2021 were selected as subjects. one side on AQ and the other side on PQ randomly. Follow-up visits were arranged at 1 week, 1 month, 6 months and 12 months after surgery. The results of audiology and the tube status of the two positions were recorded and compared statistically.

Results: A total of 90 patients with bilateral OME were selected. There was no difference in preoperative hearing between the 2 groups. The AQ group's average air conduction threshold was significantly higher than that of the PQ group 1 week after surgery. Although there was no significant difference in tube fall-off rate between the two groups within 6 months, it was significantly higher in AQ group than that in PQ group at 12 months after surgery.

Conclusions: Compared to TTI on AQ, TTI on PQ is more stable and better improves hearing, and the operation is also more convenient for surgeons. This study provides reference for a better position of TTI in OME therapy.

Keywords: Otitis media with effusion (OME); tympanostomy tube insertion (TTI); position

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Introduction

Otitis media with effusion (OME) is defined as the presence of fluid in the middle ear without signs or symptoms of acute ear infection (1). OME is a common and frequently occurring disease in children, which not only carries a huge economic burden, but also affects children's speech development, learning process, and daily life. Under normal circumstances, the pressure inside the middle ear basically equals that outside the middle ear and is about the same as the atmospheric pressure. In the physiological state, the air in the middle ear is constantly absorbed and exchanged by the middle ear mucosa. Through the intermittent opening of the eustachian tube, fresh air is continuously supplied to the middle ear to maintain the balance of the air pressure inside and outside the middle ear. Children's eustachian tubes are immature without sufficiently good elasticity; thus, when the eustachian tube is in a negative pressure state, the tube wall of cartilage segment is prone to collapse, resulting in negative pressure in the middle ear, which in turn cause the suck back of part of the secretion of the nasopharynx and the intracellular fluid exudate, which is an important mechanism of acute otitis media (AOM) and OME (2). Tympanostomy tube insertion (TTI) re-establishes the channel to balance the internal and external pressure of the middle ear.

TTI is one of the primary methods to treat OME. The clinical practice guidelines issued by the American Society of Otolaryngology on head and neck surgery recommended that otologists perform TTI on children with bilateral OME who have suffered from hearing loss for ≥3 months. Otologists may choose TTI for children with unilateral or bilateral OME with vestibular problems, ear discomfort, behavioral problems, decreased school performance, or quality of life and other symptoms that may be related to suffering from OME for ≥3 months. Children with recurrent AOM, who have unilateral or bilateral OME, should be offered bilateral TTI by clinicians assessing tube candidacy. In relation to unilateral or bilateral OME, at-risk children may undergo TTI if the tympanometry is a type B tympanogram or the effusion has persisted for ≥3 months; thus, the chance of OME resolving quickly is small.

The position of TTI is usually chosen on the AQ and PQ, but it is puzzling whether the effect of these two positions is consistent. Or which is better? There are no relevant studies and conclusions in the existing literature. In order to solve this confusion and improve the efficacy of TTI, we examined and compared the outcoming of two tube position on AQ and PQ of the pars tensa. We present the following article in accordance with the STROBE reporting checklist (available at https://tp.amegroups.com/article/view/10.21037/tp-22-273/rc).

Methods

Patients

In this cohort study, children with bilateral OME who received TTI in Beijing Tongren Hospital from May 2020 to January 2021 were selected as subjects. The onset time for all patients was ≥3 months. For the patients in this study, any previous drug treatment had been ineffective or not had any obvious effect. Residence in other provinces and cities that cannot guarantee punctual follow-up is excluded. All the children were examined by otoscopy, pure tone audiometry, and acoustic immittance. The study was conducted in accordance with the Declaration of Helsinki (as revised in 2013). Our study was approved by the Ethics Committee of Beijing Tongren Hospital, Capital Medical University (No. TRECKY2020-054). We obtained the informed consent of the children's parents or legal guardians.

Pure tone audiometry was conducted in a standard sound insulation room; the acoustic characteristics of the sound insulation room met the international standards. The pure tone audiometry test was performed using a GSI-61 Type 1 audiometer (Grason-Stadler, Eden Prairie, MN), and the audio devices applied were TDH-39 on-ear headphones and ER-3A insert earphones. The mean values of bone conduction and air conduction thresholds at 500, 1,000, 2,000, and 4,000 Hz were recorded. All patients suffered from conductive hearing loss according to the preoperative pure tone audiometry test.

For the acoustic immittance inspection, a Genemed Synthesis Incorporation–33 (United States) type acoustic immittance instrument was used, and 226 Hz was used for the probe tone frequency. All the children had type B tympanogram preoperative acoustic immittance.

Surgical method

One random ear for each patient was chosen for the placement of the tube (Model Spiggle & Theis 10125SC) on the AQ of the pars tensa, then another tube was placed on the PQ of the pars tensa in the other ear. The patients were generally placed under anesthesia and in the supine position for the TTI. After topical disinfection and laying sterile towels, the tympanic membrane was probed with the microscope. The AQ or PQ of the pars tensa was radially incised with a tympanic membrane surgical knife. After the placement of the tympanic ventilation tube, the effusion in the tympanic cavity was aspirated, and the tympanic cavity was rinsed with 10% dexamethasone solution.

Postoperative follow-up

Outpatient reexaminations were performed at 1 week, 1 month, 6 months, and 12 months after the operation. The patients were reexamined with pure tone audiometry 1 week after the operation, and the mean values of the air conduction hearing threshold at 0.5, 1.0, 2.0, and 4.0 kHz were recorded. In the remaining reexaminations, the state of the tympanostomy tube (i.e., whether it had fallen off or not) was recorded.

Table 1 Comparison of the preoperative hearing of the 2 groups

Groups	Mean value (dB)	Standard deviation	t	P
AQ group	34.26	3.65	1.579	0.118
PQ group	34.12	3.39		

AQ, anteroinferior quadrant; PQ, anteroinferior quadrant.

Table 2 Comparison of the hearing between the 2 groups 1 week after surgery

Groups	Mean value (dB)	Standard deviation	t	P*
AQ group	10.36	2.48	2.105	0.038
PQ group	10.28	2.39		

*, paired *t*-test, P<0.05. AQ, anteroinferior quadrant; PQ, anteroinferior quadrant.

Table 3 Comparison of the tube fall-off rates between the 2 groups 1 month after surgery

Groups	Tube state		Total	Tube fall-off rate (%)	χ^2	P
	Fell off	Normal				
AQ group	3	87	90	3.33	0.206	0.650
PQ group	2	88	90	2.22		
Total	5	175	180	2.78		

AQ, anteroinferior quadrant; PQ, anteroinferior quadrant.

Statistical method

SPSS 17.0 software was used for the statistical analysis. Paired-samples *t*-tests were performed using the mean values of the air-conduction hearing thresholds in the AQ group and the PQ group to examine whether there was any difference between the 2 groups in terms of the pre-operative and post-operative hearing thresholds. The Chi-square test was used to compare the tube fall-off rates between the 2 groups in each time period. P<0.05 was considered as significant difference.

Results

A total of 90 children with bilateral OME were enrolled, including 41 males and 49 females, aged 5–12 years, with an average of 8.2 years. Since it was randomly selected from the same group of children, only differences in preoperative hearing were compared between the two groups. Before the operation, the mean values of the air-conduction hearing threshold in the AQ group and the PQ group were tested for normality, and the results indicated a normal distribution (P=0.082). The results of the paired-samples *t*-test implied no statistical significance (P=0.118). Thus, there was no difference in preoperative hearing between the 2 groups (see *Table 1*).

The mean values of the air-conduction thresholds in the 2 groups were tested by a normality test 1 week after the operation, and the results indicated a normal distribution (P=0.122), and the difference between the groups was statistically significant (paired *t*-test: P=0.038). The mean value of the AQ group was 10.36 dB, and that of the PQ group was 10.28 dB. The average threshold of air conduction in the AQ group was lower than that in the PQ group. The results of the tests are set out in *Table 2*.

A Chi-square test was used to compare the tube fall-off rates between the 2 groups at 1, 6, 12 months after the operation, and there was no statistically significant difference between the 2 groups at 1 month (P=0.650; see *Table 3*) and 6 months (P=0.281; see *Table 4*). The difference between the two groups was significant at 12 months (P=0.038; see *Table 5*).

Table 4 Comparison of the tube fall-off rates between the 2 groups 6 months after surgery

Groups	Tube state		Total	Tube fall-off rate (%)	χ^2	P
	Fell off	Normal				
AQ group	15	75	90	16.67	1.161	0.281
PQ group	10	80	90	11.11		
Total	25	155	180	13.89		

AQ, anteroinferior quadrant; PQ, anteroinferior quadrant.

Table 5 Comparison of the tube fall-off rates between the 2 groups 12 months after surgery

Groups	Tube state		Total	Tube fall-off rate (%)	χ^2	P*
	Fell off	Normal				
AQ group	23	67	90	25.56	4.292	0.038
PQ group	12	78	90	13.33		
Total	35	145	180	19.44		

*, 2 independent sample rate: Pearson 2 test, chi square test, P<0.05. AQ, anteroinferior quadrant; PQ, anteroinferior quadrant.

Discussion

In 1954, Beverley Armstrong first applied the tympanostomy tube in clinical practice. Since then, various types of ventilation tubes have been used. TTI is one of the most frequently performed otology operations in childhood (3). The tympanostomy tube is so small in size that patients experience no discomfort when the tube is placed in the tympanic membrane, and it can provide long-term ventilation to the middle ear cavity. Thus, TTI is used to treat conductive deafness caused by OME, control recurrent AOM, and prevent cholesteatoma caused by tympanic invagination.

An individual analysis is needed to determine whether or not TTI should be used (4,5). In this analysis, the following factors should be considered: (I) the effect of TTI on the control of middle ear diseases. A systematic retrospective study comparing the curative effect of TTI with simplex myringotomy or non-surgical treatment showed that 1 year after surgery or treatment, the time of middle ear effusion of the tympanostomy tube group was 32% less than that of the control group (3); (II) the risks associated with TTI, including the risk of general anesthesia, surgical injury to the tympanic membrane, and the possibility of permanently perforating the tympanic membrane; (III) that recurrent AOM leads to physical discomfort and complications, but TTI can drain middle ear effusion and relieve earache; and (IV) that long-term hearing loss caused by OME may affect the development of speech function in children (6,7).

There are 2 types of tympanostomy tubes; that is, the short-acting tube and the long-acting tube. The short-acting tube can stay in the tympanic membrane for 4–18 months. In relation to these tubes, either the outer end of the tube has an open wing or both ends have open wings, and these wings can be embedded in the tympanic membrane. The long-acting tube, also known as the T-tube, has an open long wing at the inner end, and can be kept for >15 months or even a lifetime. In theory, the long-term tube should provide long-term ventilation and thus should be preferred. However, only 30–40% of the children who first use a short-acting tube later require a second TTI. Additionally, the incidence of otorrhea and the permanent perforation of the tympanic membrane increase after the placement of the long-acting tube (8). Thus, the short-acting tube is recommended for most children.

Most of the tympanostomy tubes are placed in any quadrant but the posterior upper quadrant in the pars tensa. A few permanent tympanostomy tubes have been reported to have been placed between the tympanic anulus and the bony external auditory canal (9). It is generally believed that the AQ of the pars tensa is the safe quadrant for tympanostomy tubes. As the PQ is close to the fenestra area of the cochlea, some doctors choose not to place the tube there, as they do not wish to risk injuring the cochlear fenestra membrane. However, as the cochlear fenestra membrane faces backward, is roughly parallel to the external auditory canal, and is protected by the cochlear fenestra niche, it is very unlikely to be damaged during the TTI process.

The tympanic membrane inclines forward and downward and forms an angle of 45–50° with the bottom of the external auditory canal. During the operation, the front wall of the external auditory canal is often observed to protrude to the rear, which makes it difficult to fully expose the AQ of the tympanic membrane, thus increasing the difficulty of operating in this area. At the same time, the front wall of the backward protruding external auditory canal can also easily be damaged by the surgical instruments. Compared to the AQ, the PQ of the pars tensa is closer to the surgeon and less obstructed in the operation field; thus, it is more convenient for the surgeon to perform the TTI and easier to observe the situation of the tympanostomy tube after the operation. There are few studies on the curative effect of different positions of tympanostomy tubes, and most textbooks do not specify whether there is an optimal position. This study sought to analyze the relationship between the positions of tympanostomy tubes and the postoperative effects by observing the effect of TTI in 2 positions on 2 corresponding ears of patients under the same conditions.

To ensure the effectiveness of the tympanostomy tubes, the following 3 conditions should be met: (I) the tympanostomy tube should straddle the tympanum; (II) the tympanostomy tube lumen should be unobstructed; and (III) there should be no effusion in the tympanum. In this way, the tympanostomy tube can make the air in the tympanum circulate fully to maintain good hearing and reduce the frequency, duration, and severity of recurrent OME (10). In this study, there was no significant difference between the 2 groups before the operation, but the difference after the operation was significant, which indicated that the hearing of patients with a tympanostomy tube located in the PQ of the pars tensa improved more that of patients with a tube located in the AQ.

The cause of conductive hearing loss in OME is due to fluid accumulation in the tympanum. The more thoroughly the effusion is removed, the better the restoration of hearing. In the TTI procedure, the patient is placed in the supine position. Notably, the PQ of the pars tensa is located at the lower point of the tympanum cavity. As more tympanic effusion is aspirated if the incision is conducted at the PQ, the degree of hearing improvement can be greater. There were statistical differences in the mean values of the hearing thresholds between the 2 groups (the AQ group had a mean value of 10.36 dB and the PQ group had a mean value of 10.28 dB); however, as the difference was only 0.08 dB, the patients would not notice this slight difference. Thus, its clinical significance requires further examination.

It has been reported that the position of the tympanostomy tube has nothing to do with the time that it can be maintained in the tympanic membrane (11). One theory is that the expulsion of the short-acting ventilation tube starts with the continuous shedding of the squamous debris in the epithelial layer of tympanic membrane. The falling keratin accumulates between the surface of the tympanic membrane and the lateral wing of the tympanostomy tube and gradually lifts the lateral edge until the tympanic ventilation tube is finally completely discharged (12). The long-acting tube (T-tube) avoids the above drainage mechanism, as it has no lateral wing. Long-term postoperative follow-up examinations showed that keratin accumulated around the T-tube. In a normal follow-up period, a small amount of keratin fragments was observed to be attached to the periphery of the tympanostomy tube. If keratin accumulation does not block the lumen or cause a local inflammatory reaction, it is unnecessary to deal with it. However, the follow-up results of this study showed that when the tympanostomy tube was located in the PQ, it was more difficult to block and discharge the tube than when it was located in the AQ. There was a significant difference in the tube fall-off rate between the 2 groups 12 months after surgery.

In our opinion, keeping the lumen of the tympanostomy tube unobstructed is one of the necessary conditions to ensure the effectiveness of the tympanostomy tube, as when the lumen is blocked, the function of tympanostomy tube will be weakened or lost completely, the incidence of OME will increase again, and the blocked tympanostomy tube may then be pushed out by the effusion in the tympanum. The effusion in the middle-ear cavity cannot be completely sucked out during the tube placement operation. The rest of the effusion can be continuously discharged through the eustachian tube or the tympanostomy tube after the operation, but the discharge of effusion through the tympanostomy tube will increase the chance of blocking the tube, which in turn causes the tube to fall off.

As mentioned above, when the tympanum tympanostomy tube is located at the PQ of the pars tensa, more effusion in the tympanum can be sucked out, and the burden of postoperative discharge can be reduced. In our daily standing position, our heads tend to incline forward slightly, and in this position, the AQ of the tympanic membrane is lower than the PQ, and the remnants of effusion are more likely to gather in the AQ. Thus, the tympanostomy tube located in the AQ of the pars tensa is more likely to be blocked. Additionally, the dirt in the external auditory canal is easy to accumulate in the deep anterior lower part of the external auditory canal, which also increases the chance of retrograde blockages in the tympanostomy tube in the AQ of the pars tensa.

This study also has some limitations. For example, most of the subjects were from Beijing and surrounding areas. Children's individual physical conditions were not taken into account, such as adenoid hypertrophy and chronic sinusitis. There were also not enough children in the study. Multi-center studies with large sample sizes are needed in the future, and subgroup analysis of children's physique is required.

To sum up, compared to the placement of the tympanostomy tube in the AQ of the pars tensa, the placement of the tympanostomy tube in the PQ of the pars tensa led to a more significant improvement in hearing, was more convenient in surgery, and was more stable after surgery.

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Footnote

Reporting Checklist: The authors have completed the STROBE reporting checklist. Available at https://tp.amegroups.com/article/view/10.21037/tp-22-273/rc

Data Sharing Statement: Available at https://tp.amegroups.com/article/view/10.21037/tp-22-273/dss

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Ethical Statement: The authors are accountable for all aspects of the work in ensuring that questions related to the accuracy or integrity of any part of the work are appropriately investigated and resolved. The study was conducted in accordance with the Declaration of Helsinki (as revised in 2013). The study was approved by Ethics Committee of Beijing Tongren Hospital, Capital Medical University (No. TRECKY2020-054). Informed consent was taken from all the patients' parents or legal guardians.

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