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 outcome of two tube positions on AQ and PQ of the pars tensa. We present the following article in accordance with the STROBE reporting checklist (available at https://tp.amergroups.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 (%) | χ²  | P   |
|------------|------------|-------|------------------------|-----|-----|
| 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 preoperative 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).
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
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
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

Conflicts of Interest: All authors have completed the ICMJE uniform disclosure form (available at https://tp.amegroups.com/article/view/10.21037/tp-22-273/coif). The authors have no conflicts of interest to declare.

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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