Water Penetration into Middle Ear Through Ventilation Tubes in Children While Swimming

Mao-Che Wang[1,2], Chia-Yu Liu[3,4], An-Suey Shiao[1,2]*

[1]*Department of Otolaryngology, Taipei Veterans General Hospital,* [2]*National Yang-Ming University School of Medicine,* [3]*Department of Otolaryngology, Taipei Municipal Wan-Fang Hospital, and* [4]*Taipei Medical University School of Medicine, Taipei, Taiwan, R.O.C.*

Background: Ventilation tube insertion is a common treatment for children with persistent otitis media with effusion. Parents are concerned about the morbidity of this procedure and the influence of ventilation tubes on daily activities. Permissibility of swimming is a question that is most often asked. The aim of this study was to investigate the possibility of water penetration through ventilation tubes into the middle ear while swimming in children with ventilation tubes under immediate observation.

Methods: We included 14 patients who had otitis media with effusion who received ventilation tube insertion. They had complete ear, nose and throat physical examination. All 14 patients were taken to enjoy surface swimming for 1 hour without ear protection. Before and after swimming, we checked the tympanic membrane and external ear canal using a videotelescope and monitor immediately at the poolside to discover if there was fluid in the external ear canal and middle ear. Patients were followed-up 2 weeks later to check if otorrhea had occurred.

Results: The 14 patients were from 5 to 14 years old. Nine were male and 5 were female. Nine patients had bilateral ventilation tubes and 5 had unilateral ones. One ear was excluded due to the tube nearly dropping out. A total of 22 ears were included. Eight ears were noted to be dry after swimming. Five ears were noted to have water over the outer 1 third of the external ear canal. Two ears were noted to have water over the inner 2 thirds of the external ear canal. Water on the tube or tympanic membrane was found in 6 ears. Only 1 ear with water penetration into the middle ear was found. No otorrhea had occurred in any ears after 2 weeks.

Conclusion: Water penetration into the middle ear through ventilation tubes and middle ear infection are not likely when surface swimming. Children with ventilation tubes can enjoy swimming without protection in clean chlorinated swimming pools. [*J Chin Med Assoc* 2009;72(2):72–75]

Key Words: middle ear, otitis media with effusion, swimming, ventilation tube

Introduction

"Can children with ventilation tubes be permitted to swim without any protection?" This is a question that otolaryngologists are often asked by the parents of their pediatric patients. It is also a controversial issue that has been debated over the last few decades. As with any debate, there are otolaryngologists who argue for it and those who argue against it.[1] Some believe that it is safe for children with ventilation tubes (VTs) to enjoy swimming without protection. Others consider that such children can swim if they wear earplugs, and quite a few others believe that such children should avoid swimming altogether. However, several studies including prospective clinical trials and retrospective reviews have not been able to show that swimming without water protection increases the risk of otorrhea.[2–10]

Our study is the first to observe water penetration into the middle ear through VTs directly without

*Correspondence to: Dr An-Suey Shiao, Department of Otolaryngology, Taipei Veterans General Hospital, 201, Section 2, Shih-Pai Road, Taipei 112, Taiwan, R.O.C.
E-mail: asshiao@vghtpe.gov.tw • Received: October 20, 2008 • Accepted: February 10, 2009

using animal or mechanical models. We had the following aims: (1) to investigate the possibility of water penetration into the middle ear in children with VTs while swimming; (2) to investigate the possibility of middle ear infection in children with VTs after swimming.

Methods

We included 14 patients who had otitis media with effusion who had received VT insertion. Informed consent was obtained from the parents of all patients. All patients received pure tone audiometry and a complete ear, nose and throat physical examination. None of the patients had upper respiratory tract infection or otorrhea 1 week prior to the start of the study.

We took the patients to enjoy surface swimming in a clean, chlorinated, outdoor swimming pool without earplugs or other ear protection. The patients spent about 1 hour swimming in the pool, and diving was prohibited during swimming.

Before swimming, we checked all the patients' ears with a videotelescope to record external ear and tympanic membrane condition and VT position. Videotelescopy is an accurate tool to diagnose otitis media with effusion. We can accurately evaluate if there is fluid in the middle ear using videotelescopy. In our previous study, the sensitivity and specificity of videotelescopy to diagnose otitis media with effusion were 97.8% and 100%, respectively, with an accuracy of 98%.[11] Videotelescopy is composed of a high-quality CCD (Karl Storz telecam ntsc 20210101), video monitor (Sony HR Trinitron), light source (Karl Storz Xenon light source 615), and narrow-diameter (2.7 mm) rigid telescope (Karl Storz Teleotoscope straight 1218A) (Figure 1). During the videotelescopic examination, the pinna was retracted backward, and the telescope was advanced medially to the tympanic membrane, thereby achieving a clear view on the video monitor.

We checked all the ears again immediately after swimming to record if there was any water in the external ear canal or in the middle ear. The videotelescopy images were assessed by a senior otologist (18 years board-certified) and a junior otologist (1 year board-certified). The results reported were agreed on by both otologists. The ear checking was performed at poolside. Toilet of the ears was done by using a hairdryer to dry the external ear canal right after ear checking. The hairdryer was applied until the hair around the ear was also dried, which took a few minutes. All patients were followed-up 2 weeks later to determine if otorrhea had occurred.

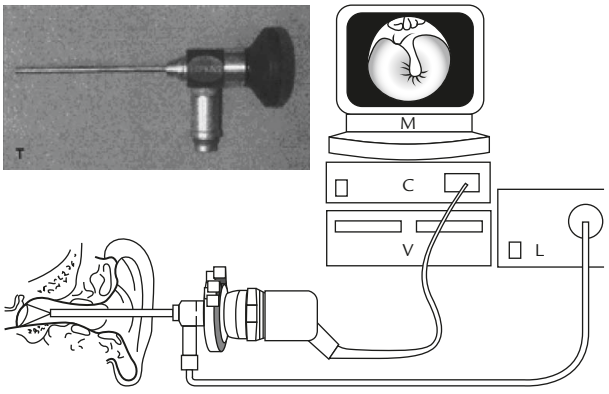

Figure 1. High-quality video camera (C), video recorder (V), monitor (M), light source (L), and narrow-diameter rigid telescope (T) for videotelescopy. During videotelescopic examination, the telescope is advanced across the isthmus of the external ear canal towards the eardrum until a clear view is produced on the monitor.

Table 1. Location of water discovered and infection rate ($n = 22$)

	Ears, *n* (%)
Dry ear canal	8 (36.4)
Wet on outer 1/3 of ear canal	5 (22.7)
Wet on inner 2/3 of ear canal	2 (9.1)
Wet on tympanic membrane or tube	6 (27.3)
Water in middle ear	1 (4.5)
Otorrhea within 2 wk	0 (0)

Results

Fourteen patients were included in this study. Nine patients had bilateral VT insertion and 5 had unilateral VT insertion. One ear was excluded due to near dropping out of the VT. A total of 22 ears were included (Table 1). Of the 14 patients, 9 were male and 5 were female; age ranged from 5 to 14 years. Twelve patients had single VT insertion. One patient had this procedure twice, and another had experienced the procedure 3 times. Seven patients had adenoidectomy and 7 did not. The time between last VT insertion date and swimming ranged from 1 month to 28 months.

On telescope examination before swimming, all the ear canals were dry, and no fluid was noted in any of the middle ear cavities. On telescope examination right after swimming, 8 ears were noted to be dry over the external ear canal. Five ears were found to have water over the outer 1 third of the external ear canal, and 2 ears had water over the inner 2 thirds of the external ear canal. Water on the external flange of the tube or tympanic membrane was found in 6 ears,

and 1 ear with water penetration into the middle ear was discovered. Water penetration into the middle ear was defined as water medial to the tympanic membrane as shown by videotelescopy. No otorrhea had occurred in any of the ears after 2 weeks.

Discussion

A controversial issue

Some doctors believe that it is safe for children with VTs to enjoy swimming without protection. Others consider that these children can swim if they wear earplugs, while others would say that these children should be strictly forbidden from swimming. Should antibiotic otic drops be used after swimming? Should diving be allowed? Would swimming in different waters (chlorinated swimming pools, rivers, lakes, sea) make any difference? These questions are all matters for debate.[12] Derkay et al surveyed 1,266 otolaryngologists practicing in the southern and eastern United States by questionnaire.[13] Of all the respondents, 14.1% strictly forbade swimming and 3.1% had no water precautions; 68% limited their patients with regard to the depth of swimming and the most common recommended form of protection was earplugs. Of note, 94% said that they would be willing to alter their current practice based on new information generated from a clinical trial. This indicated that most otolaryngologists were not confident with their current practice.

How much pressure is needed for water to enter the middle ear?

Pashley and Scholl conducted an *in vitro* study which showed that it took 11.45–22.57 cmH_2O to force water through a tympanostomy tube.[14] Length and position of the tube did not have any effect, while soapy water or any liquids with decreased surface tension could enter the middle ear more readily. They described 3 necessary parameters for water to enter the middle ear: Eustachian tube opening; fixation of the tympanic membrane; increase in external canal pressure. Hebert et al designed a model of the human ear with pinna, external ear canal, tympanic membrane with VT, middle ear cleft, and mastoid cavity and put the model into the following conditions:[15] showering, hair rinsing, and head submersion in clean tap water. None of these conditions promoted water entry into the middle ear. However, head submersion in soapy water and swimming at a depth greater than 60 cm produced a significant number of positive test results (water into middle ear). Morgan used fluorescent powder to show the extent of water penetration into the external ear canal and tympanic membrane.[16] He reported that water on the tympanic membrane was found in 13.5% of those washing hair and 52% of those whose head was submersed in water for 4 minutes.

Swimming and otorrhea

Several prospective studies and meta-analyses showed no difference in otorrhea rate between swimming and non-swimming groups of children with VTs. They all concluded that swimming should not be prohibited in children with VTs.[2–10]

Should diving be allowed?

Generally speaking, diving is not advised for children with VTs. Lounsbury studied patients with VTs who swam unprotected.[10] Divers showed a significant increase in the rate of infection: they had 1 infection per 100 days of swimming, while non-divers had 1 infection per 600 days of swimming.

Must earplugs be worn?

Whether ear plugs are worn or not when swimming does not seem to make any difference in the rate of ear infection in children with VTs. Becker et al found a 16% infection rate in swimming without earplugs and a 30% infection rate in swimming with earplugs.[3] Salata and Derkay found no difference in the rate of otorrhea between swimming unprotected and swimming with earplugs.[6] In this study, none of the ears were protected by earplugs.

The effects of different waters

Smelt and Monkhouse irrigated guinea pig middle ears with normal saline, bath water, sea water and swimming pool water.[17] They then sacrificed the guinea pigs and sent the middle ears for histologic examination to evaluate any middle ear mucosal changes. Swimming pool water and sea water led to no greater reactive changes than did normal saline. However, more inflammation was demonstrated in the ears that were irrigated with bath water. It may be that bath water is easier to be contaminated with enteral bacteria.

Middle ear fluid detected by videotelescopy

Videotelescopy is an accurate tool to diagnose otitis media with effusion. We can tell accurately if there is fluid in the middle ear by videotelescopy. In our previous study, the sensitivity and specificity for videotelescopy to diagnose otitis media with effusion were 97.8% and 100%, respectively, with an accuracy of 98%.[11] However, videotelescopy may not detect very small amounts of fluid in the middle ear. In this study,

fluid was found in only 1 middle ear. There might have been more ears with water penetration into the middle ear through VTs, but they were not detected due to 2 possible reasons. One is a very small amount of fluid in the middle ear, and the other is the fluid in the middle ear leaking into the nasopharynx through the Eustachian tube on swallowing.

Conclusion

For children with VTs, it is not easy for water to penetrate into the middle ear through the VTs while surface swimming. Earplugs are not necessary. If middle ear infection and otorrhea do occur, it is not a difficult problem for otolaryngologists to manage. It is safe for children with VTs to enjoy surface swimming in a clean, chlorinated swimming pool.

References

1. Giannoni C. Swimming with tympanostomy tubes. *Arch Otolaryngol Head Neck Surg* 2000;126:1507–8.
2. Smelt GJC, Yeoh LH. Swimming and grommets. *J Laryngl Otol* 1984;18:243–5.
3. Becker GD, Eckberg TJ, Goldware RR. Swimming and tympanostomy tubes: a prospective study. *Laryngoscope* 1987;97:740–1.
4. Cohen HA, Kauschansky A, Ashkenasi A, Bahir A, Frydman M, Horev Z. Swimming and grommets. *J Fam Pract* 1994;38:30–2.
5. Parker GS, Tami TA, Maddox MR, Wilson JF. The effect of water exposure after tympanostomy tube insertion. *Am J Otolaryngol* 1994;15:193–6.
6. Salata JA, Derkay CS. Water precautions in children with tympanostomy tubes. *Arch Otolaryngol Head Neck Surg* 1996;122: 276–80.
7. Pringle MB. Grommets, swimming and otorrhea: a review. *J laryngol Otol* 1993;107:190–4.
8. Lee D, Youk A, Goldstein NA. A meta-analysis of swimming and water precautions. *Laryngoscope* 1999;109:536–40.
9. Carbonell R, Ruiz-Garcia V. Ventilation tubes after surgery for otitis media with effusion of acute otitis media and swimming: systemic review and meta-analysis. *Int J Pediatr Otorhinolaryngol* 2002;66:281–9.
10. Lounsbury BF. Swimming unprotected with long-shafted middle ear ventilation tubes. *Laryngoscope* 1985;95:340–3.
11. Shiao AS, Guo YC. A comparison assessment of videotelescopy for diagnosis of pediatric otitis media with effusion. *Int J Pediatr Otorhinolaryngol* 2005;69:1497–502.
12. Wang MC, Liu CY, Shiao AS, Wang T. Ear problems in swimmers. *J Chin Med Assoc* 2005;68:347–52.
13. Derkay CS, Shroyer MN, Ashby J. Water precautions in children with tympanostomy tubes. *Am J Otolaryngol* 1992;13:301–5.
14. Pashley NRT, Scholl PD. Tympanostomy tubes and liquids: an *in vitro* study. *J Otolaryngol* 1984;13:296–8.
15. Hebert RL II, King GE, Bent JP III. Tympanostomy tubes and water exposure: a practical model. *Arch Otolaryngol Head Neck Surg* 1998;124:1118–21.
16. Morgan NJ. Penetration of water down the external auditory meatus to the tympanic membrane. *J Laryngol Otol* 1987;101: 536–7.
17. Smelt GJC, Monkhouse WS. The effect of bath water, sea water and swimming pool water on the guinea pig middle ear. *J Laryngol Otol* 1985;99:1209–16.