Objective: To determine whether water exposure causes middle ear contamination in patients with collar button tympanostomy tubes (TTs).

Method and Design: An in vitro model of a human head that contained an auricle, external auditory canal, tympanic membrane with TT, middle ear, eustachian tube, and mastoid cavity was developed. Two electrodes connected to an external ohmmeter resided in the middle ear to detect water entry. The model was tested with 4 types of water exposure: showering, bathing, hair rinsing, and swimming. Statistical analysis was performed by the Fisher exact test.

Main Outcome Measures: A positive test result corresponded to water entering the middle ear via the TT, confirmed by a resistance reading of zero on the ohmmeter. A negative test result indicated no change in the initial high resistance reading.

Results: No positive test results were obtained for showering (0 of 60 tests), hair rinsing (0 of 60 tests), or head submersion (12.7 cm) in clean tap water (0 of 60 tests). Ten positive test results were obtained for head submersion in soapy water (10 of 97 tests), which was statistically different from clean water (P ≤ .007). Swimming pool depths of 30, 45, 60, and 75 cm elicited positive test results in 2 of 16, 3 of 18, 2 of 20, and 11 of 20 tests, respectively. A higher incidence of water entry into the middle ear occurred at depths of more than 60 cm (P ≤ .001). No statistical difference between depths of 60 cm or less occurred (P = .88).

Conclusions: Showering, hair rinsing, and head submersion in clean tap water do not promote water entry into the middle ear. Submersion in soapy water increases the probability of water contamination. Pool water infrequently enters the middle ear with head submersion, but the incidence increases with deeper swimming (>60 cm). These data provide further evidence that many water precautions frequently advised in patients with TTs are unnecessary.


From the Division of Otolaryngology (Drs Hebert and Bent) and the Department of Biomechanics, Section of Biomedical Engineering, Research Support Services (Dr King), Medical College of Georgia, Augusta.
METHODS

MODEL

An in vitro model of a human head with an auricle, EAC, tympanic membrane (TM) with TT, middle ear, ET, and mastoid cavity was developed (Figure 1 and Figure 2). An ear irrigating model by Adam Rouilly Inc (Sittingbourne, Kent, England) served as the basis for our model. The model comprised a hollow, watertight replica of an adult human head, auricle, and EAC.

The model was modified by attaching the auricle and EAC to the head in a watertight fashion with epoxy and silicone putty. The EAC (3.0 cm long, 0.8 cm in diameter, and 1.5 mL in volume) was formed with epoxy to create an anterior slant from lateral to medial that correlates with the angled EAC in humans. The lateral 1 cm consisted of rubber, with the medial 2 cm being part of the acrylic apparatus attached within the hollow portion of the head. This apparatus was attached to the inside of the right lateral skull in a watertight fashion. The left lateral skull was formed by a removable molded fiberglass plate and seal.

Machined acrylic blocks (Figure 3 and Figure 4), cylinders, and a hypodermic 5-mL syringe plunger created a middle ear cavity with a variable volume by length (0.0-4.5 mL). A 35-mL hypodermic syringe barrel trimmed to 10 mL and attached to the middle ear cavity served as the mastoid cavity with a variable volume (0-10 mL). A Sylastic sheet (Dow Corning, Midland, Mich) measuring 0.01-cm thick and 8 mm in diameter with a 0.3-cm² surface area represented the mobile area of the TM. A Sheehy-style collar button TT (ActiveVent, XOMED, Jacksonville, Fla) with a 1.27-mm inner diameter resided in the anterior and inferior quadrant of the TM. An 18-gauge hypodermic needle tip and a 28-gauge surgical wire were secured in the middle ear 1 mm apart and 2 mm medial to the TM. Both served as electrodes to detect the presence of water in the middle ear cavity. The electrodes connected to electrical wire extending out of the model base and supporting pole, where they made contact with positive and negative plugs in the watertight cap. An ohmmeter (model 630, Triplett, Bluffton, Ohio) connected to the cap registered a high resistance when the middle ear was dry (200 000 Ω) and zero resistance when the middle ear was contaminated with moisture. The 18-gauge needle served as a functioning ET. The needle was connected by small bore plastic tubing to a glass tube, the end of which was placed below the surface of water in a vertical cylinder. By setting the position of the glass tube, the pressure required to overcome hydrostatic pressure, which would allow air escape, was adjustable. This was set to correlate with ET opening pressure (12-15 cm H₂O).

TESTING

The overall volume of the mastoid air cell system was determined to average 8.7 mL by Zwislocki14 in 1962 using impedance measurements in live patients. We, therefore, chose a mastoid volume of 7 mL and middle ear space volume of 2 mL to test our model. Four types of practical water exposure were evaluated: showering, bathing, hair rinsing, and swimming. A positive test result corresponded to water entering the middle ear cavity via the patent TT and was confirmed by a zero resistance reading on the ohmmeter. A negative test result indicated no change in the initial high resistance reading. Statistical analysis was done by the Fisher exact test.

Clean bathtub tap water was tested in the settings of head submersion (supine with the EAC 12.7 cm below the water level), hair rinsing (supine and prone), showering (supine and prone), and filling of the EAC. Soapy bathtub water was evaluated using head submersion (supine) and filling of the EAC. On-site chlorinated swimming pool water was first tested as the control at varying depths (30-90 cm) with an intact TM but no TT. The model, with an intact TM and a patent TT, was then evaluated at increasing depths (30, 45, 60, and 75 cm).

The 1990s followed, with clinical prospective studies confirming earlier retrospective findings and increasing the interest in limited water precautions and prophylactic use of antibiotic otic suspensions after water contamination. Even with the current literature, Derkay et al15 found that practicing otolaryngologists differ widely with regard to water precautions after M/T. Of 1266 board-certified otolaryngologists surveyed, 13% forbade all swimming, 53% recommended using ear plugs during swimming, and only 3% allowed unrestricted swimming. These water precautions deter a parent or pediatrician from proceeding with M/T or even seeking otolaryngology consultation. This study sought to determine whether and under what conditions water exposure causes middle ear contamination via a patent TT.

RESULTS

Exposing the model to daily practical activities involving clean tap water resulted in no positive test results (0 of 200 tests). These activities included submersion into bathtub water (0 of 60 tests), placement under a stream of running water (0 of 60 tests), showering (0 of 60 tests), and filling of the EAC (0 of 20 tests). Soapy water exposure increased the incidence of middle ear contamination via the TT to 14.6% (20 of 137 tests). Positive test results arose when the model was submersed in bathtub water (10 of 97 tests) and with filling of the EAC (10 of 40 tests). The increased incidence was statistically significant when comparing the EAC filled with soapy vs clean tap water (P<.007). When evaluating chlorinated swimming pool water, a control model with an intact TM was tested at varying depths (30-90 cm) and elicited no positive results (0 of 20 tests). Head dunking at depths of 30, 45, 60, and 75 cm yielded positive results in 2 of 16, 3 of 18, 2 of 20, and 11 of 20 tests, respectively. Comparing depths of 60 cm and less (7 of 54 tests) with depths greater than 60 cm (11 of 20 tests), a statistically significant difference arose (P=.001), but no significant difference was detected between depths of 60 cm and less (P = .88).

COMMENT

Most parents ask, “Can he get water in his ears?” when confronted with the recommendation for TTs. For gen-
erations, strict water precautions have been recommended, forcing parents to struggle with avoiding water exposure and assumed contamination of the middle ear. In turn, children have been restricted from swimming or have been forced to wear ear plugs during everyday activities involving water exposure.

Only recently has the otolaryngology literature, using prospective clinical studies, focused on disproving this myth (Table). No statistically significant differences in postoperative otorrhea were found in trials with swimming vs nonswimming,8,10,12 water exposure with protection vs prophylactic use of otic drops only,7 no water restrictions plus the use of otic drops,9,11 and swimming without ear plugs vs with ear plugs vs no swimming.6 In addition, other studies focused on depth of water exposure and diving. Lunusbury8 concluded that unrestricted surface swimming was less likely to cause postoperative otorrhea compared with deep swimming and diving (1 of 600 and 1 of 100 tests, respectively). Using an in vitro model, Pashley and Scholl1 found that increased depths led to increased EAC pressure, resulting in contamination of the middle ear via the TT. Salata and Derkay2 and Arcand et al7 also noted that the incidence of postoperative otorrhea was higher in children 2 years of age and younger secondary to the higher incidence of upper respiratory tract infections in this group. Children using ear protection actually had a higher incidence of otorrhea than children swimming without protection8,7 (Table). Brook and Coolbaugh15 described the use of EAC occlusive devices leading to increased bacterial colonization, which may be the source of increased otorrhea in these patients.

Our model dispelled the myth that all types of water exposure cause middle ear contamination. Exposure to clean tap water via head submersion, showering, and hair rinsing did not cause middle ear contamination. Exposure to clean tap water via head submersion, showering, and hair rinsing did not cause middle ear contamination. Exposure to clean tap water even at the greatest depth (600 cm) did not lead to increased EAC pressure, resulting in contamination of the middle ear via the TT. Soapy water decreased the surface tension of the TT, allowing infrequent middle ear contamination.
CONCLUSIONS

Our recommendations for water exposure in children with tympanostomy are as follows:

1. Showering, hair rinsing, and head submersion in clean tap water do not require EAC protection.

2. Protection of the EAC during bathing in soapy water is not necessary, although head submersion does increase the incidence of middle ear contamination and is not advised.

3. Surface swimming (≤60 cm) in chlorinated pool water without EAC protection is allowable. Because deeper swimming or diving significantly increases the likelihood of middle ear contamination, restrictions may be considered. Given the lack of evidence that water contamination actually leads to otitis, we do not advise restrictions unless a patient clearly develops suppurrative otitis media after water exposure.

4. Occlusive devices for the EAC have not been shown to reduce postoperative otitis media in prospective clinical trials but have been found to increase bacterial counts of the EAC. Their only potential use is in children who have developed otitis media after deep swimming or diving and wish to continue this practice.

5. Prophylactic use of otic antibiotic suspensions after water exposure is theoretically helpful in preventing otitis media but has not been proven statistically significant in prospective clinical trials; therefore, it is not recommended on a routine basis.

These recommendations apply to patients with TT and do not necessarily apply to patients with TM perforations.

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REFERENCES


Incidence of Tympanostomy Tubes and Postoperative Otorrhea After Water Exposure*

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*Values are percentages unless otherwise indicated. Ellipses indicate data not applicable.