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MAIN ARTICLE

Bacterial strain changes during chronic otitis media surgery

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Abstract

Objective: Cultures obtained from pre-operative middle-ear swabs from patients with chronic otitis media have traditionally been used to guide antibiotic selection. This study investigated changes in the bacterial strains of the middle ear during chronic otitis media surgery.

Methods: Pre-operative bacterial cultures of otorrhoea, and peri-operative cultures of the granulation tissue in either the middle ear or mastoid cavity, were obtained. Post-operative cultures were selectively obtained when otorrhoea developed after surgery.

Results: Bacterial growth was observed in 45.5 per cent of pre-operative cultures, 13.5 per cent of peri-operative cultures and 4.5 per cent of post-operative cultures. Methicillin-resistant *Staphylococcus aureus* was identified as the most common bacteria in all pre-operative (32.4 per cent), peri-operative (52.4 per cent) and post-operative (71.4 per cent) tests, and the percentage of Methicillin-resistant *S aureus* increased from the pre- to the post-operative period.

Conclusion: The bacterial culture results for post-operative otorrhoea showed low agreement with those for pre-operative or peri-operative culture, and strain re-identification was required.

Key words: Otitis Media; Bacteriology; Methicillin-Resistant Staphylococcus Aureus

Introduction

Chronic otitis media is an inflammatory disorder that causes irreversible changes in the mucosa of the middle ear and mastoid cavity. Chronic middle-ear inflammation can lead to changes in middle-ear structures, including tympanic perforation, granulation, and deformities of the ossicles and ossicular chain, resulting in conductive or sensorineural hearing loss.[1] The general management of chronic otitis media includes surgery to remove the middle-ear and mastoid lesions, and reconstruction of the tympanic membrane and ossicular chain. In addition, antibiotics are used for the complete eradication of bacteria.

Prior to the selection of appropriate antibiotics, it is important to cure chronic otitis media, and bacteriological testing must be performed to determine antibiotic sensitivities.[2] Because of the increase in methicillin-resistant *Staphylococcus aureus* (MRSA) and quinolone-resistant *Pseudomonas aeruginosa*, broad-spectrum antibiotics may be required. In previous studies, the reported prevalence of *S aureus* in ear discharge ranged from 9.9 to 54.1 per cent, while that of MRSA isolates ranged from 0.3 to 24.8 per cent.[3]

We conducted a retrospective analysis to: (1) determine the bacteriological profile during the pre-, peri- and post-operative periods of surgery for chronic otitis media; (2) assess the bacterial flora of patients with post-operative otorrhoea; and (3) facilitate the pre-operative antibiotic selection process to avoid otorrhoea after chronic otitis media surgery.

Materials and methods

We analysed the medical records of 156 patients (65 males and 91 females; 156 ears) who underwent chronic otitis media surgery at Daejeon St Mary's Hospital, Korea, from March 2012 to September 2015. Mean patient age (± standard deviation (SD)) was 51.2 ± 15.7 years (range, 6–79 years). The results of culture and antibiotic sensitivity tests performed on otorrhoea in out-patient clinics were analysed retrospectively. All patients were diagnosed with chronic otitis media, with or without cholesteatoma, based on otoscopic findings, temporal bone computed tomography, and the presence or absence of cholesteatoma for surgery. Of the 156 patients, 111 had chronic otitis media without cholesteatoma and 45 had chronic otitis media with cholesteatoma. All

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patients underwent surgery: 60 underwent tympanoplasty only, and 96 underwent mastoidectomy with tympanoplasty. The mean follow-up period (± SD) was 2.01 ± 1.0 years (Table I).

At each patient's initial visit, a pre-operative bacterial culture was prepared using otorrhoea. The external auditory canal was well cleaned and the aural discharge was collected with cotton swabs, while preventing contact with the external auditory canal, using a sterilised otoscope. If a patient did not show otorrhoea, we swabbed the mucosa of the middle-ear cavity for bacterial culture.

If the culture results revealed MRSA, the patient underwent peri-operative prophylactic antibiotic treatment with vancomycin. If the culture result was quinolone-resistant *P aeruginosa*, then a peri-operative prophylactic antibiotic was selected based on susceptibility testing of the pre-operative bacterial culture. If the culture result revealed other susceptible strains, then ceftizoxime (a third-generation cephalosporin) was selected as the peri-operative prophylactic antibiotic.

Chronic otitis media surgery was performed after otorrhoea had stopped for at least two weeks. A peri-operative culture was prepared with granulation tissue from either the middle ear or mastoid cavity. If the peri-operative culture result showed MRSA or quinolone-resistant *P aeruginosa* which was not identified in the pre-operative culture, the post-operative antibiotic was changed in accordance with the antibiotic sensitivity of the bacteria. For example, if the peri-operative culture results revealed MRSA, the post-operative antibiotic selected was trimethoprim/sulfamethoxazole. Finally, a post-operative culture was performed when otorrhoea developed after surgery.

Statistical analysis

The chi-square test or Fisher's exact test was used to compare categorical variables, and the Mann–Whitney U test was used for continuous variables. For all statistical analyses, we used SPSS® software (version 20.0); *p*-values of less than 0.05 were considered statistically significant.

Ethical considerations

The study protocol was reviewed and approved by the institutional review board of the Catholic University Hospital, Korea, (institutional review board number: DC16RISI0017). Informed consent was exempted by the board.

TABLE I
PATIENT DEMOGRAPHICS

Parameter	Value
Age at surgery (mean ± SD; years)	51.2 ± 15.7
Sex ratio (male : female)	65:91
Diagnosis (COM without cholesteatoma : COM with cholesteatoma)	111:45
Operation (tympanoplasty : M&T)	60:96
Follow-up period (mean ± SD; years)	2.01 ± 1.0

SD = standard deviation; COM = chronic otitis media; M&T = mastoidectomy with tympanoplasty

Results

Among the 156 ears, positive results from the pre-operative cultures were confirmed in 71 patients (45.5 per cent) and negative results were confirmed in 85 patients (54.5 per cent). Overall, MRSA (32.4 per cent) was the most common species, followed by methicillin-sensitive *S aureus* (29.6 per cent), quinolone-resistant *P aeruginosa* (7.0 per cent), fungus (5.6 per cent), quinolone-sensitive pseudomonas species (1.4 per cent) and other bacteria (24.0 per cent). Among the peri-operative cultures, positive results were confirmed in 21 patients (13.5 per cent); in comparison, the post-operative cultures were positive in 7 patients (4.5 per cent). Methicillin-resistant *S aureus* was the most common bacteria identified in all pre-, peri- and post-operative tests – it was identified in 23 of 71 cases (32.4 per cent), 11 of 21 cases (52.4 per cent), and 5 of 7 cases (71.4 per cent), respectively. Additionally, the percentage of MRSA increased from the peri- to the post-operative period (Table II).

Among 23 cases of MRSA revealed in pre-operative tests, 6 cases showed MRSA in peri-operative tests and 3 cases showed MRSA in post-operative tests; however, 2 cases of MRSA in post-operative tests did not show MRSA in either pre- or peri-operative tests. Two cases of MRSA in post-operative tests showed graft failure (Figure 1).

For the chronic otitis media without cholesteatoma patients, culture results were positive in: 46 cases (41.4 per cent) in pre-operative tests, 10 cases (9.0 per cent) in peri-operative tests and 5 cases (4.5 per cent) in post-operative tests. For the chronic otitis media with cholesteatoma patients, culture results were positive in: 25 cases (55.6 per cent) in pre-operative tests, 11 cases (24.4 per cent) in peri-operative tests and 2 cases (4.4 per cent) in post-operative tests. Rates of positive peri-operative culture were higher in chronic

TABLE II
ORGANISMS CULTURED DURING PRE-, PERI- AND POST-OPERATIVE PERIODS

Pathogen	Pre-operative	Peri-operative	Post-operative
MSSA	21 (29.6)	6 (28.5)	1 (14.3)
MRSA	23 (32.4)	11 (52.4)	5 (71.4)
QSP	1 (1.4)	1 (0)	0 (0)
QRP	5 (7.0)	1 (4.8)	1 (14.3)
Fungus	4 (5.6)	1 (4.8)	0 (0)
Other	17 (24.0)	2 (9.5)	0 (0)
Total	71 (100)	21 (100)	7 (100)

Data represent numbers of cases (and percentages of bacterial pathogens divided by the total number of positive culture cases). MSSA = methicillin-sensitive *Staphylococcus aureus*; MRSA = methicillin-resistant *S aureus*; QSP = quinolone-sensitive *Pseudomonas aeruginosa*; QRP = quinolone-resistant *Pseudomonas aeruginosa*

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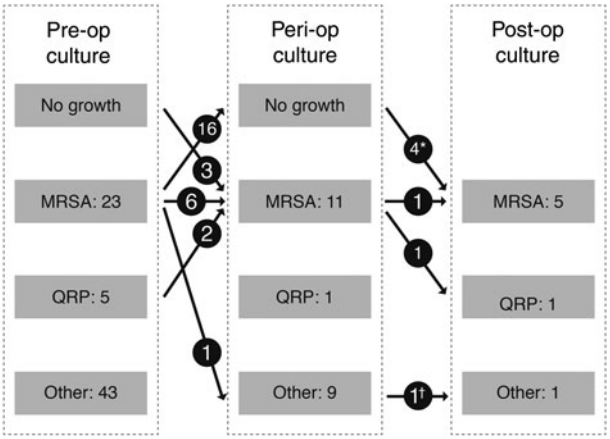

FIG. 1

Flow chart of organisms cultured during the pre-operative (Pre-op), peri-operative (Peri-op) and post-operative (Post-op) periods. *Two cases were positive for methicillin-resistant *Staphylococcus aureus* (MRSA) pre-operatively. †Case positive for methicillin-sensitive *S aureus*. QRP = quinolone-resistant *Pseudomonas aeruginosa*

otitis media with cholesteatoma patients than in chronic otitis media without cholesteatoma patients ($p = 0.018$), but the pre- and post-operative culture results did not show a positive relationship according to diagnosis.

Comparing tympanoplasty-only cases and mastoidectomy with tympanoplasty cases, the positive culture rates for all pre-, peri- and post-operative tests were significantly higher in the mastoidectomy with tympanoplasty cases (Table III).

The mean air–bone gap was greater in those with positive peri-operative culture results than in those with negative results (29.0 ± 10.2 *vs* 24.4 ± 8.5 dBHL, $p = 0.014$) (Table IV).

Discussion

Although there have been many bacteriological studies of chronic otitis media, continuous and periodic evaluations are important because of: changes in the bacteria and antibiotic sensitivity, the emergence of antibiotic-resistant strains of bacteria due to the misuse of antibiotics, and nosocomial infections.[4] In addition, the bacteriological analysis of post-operative otorrhoea is important; failure to appropriately treat post-operative otorrhoea prevents the cure of chronic otitis media.[5]

TABLE IV
RELATIONSHIP OF CULTURE RESULT WITH POST-OPERATIVE ABG

Parameter	Cases (*n*)	Post-op ABG (dBHL)	*p*
Pre-op culture			
– Positive	71	25.5 ± 9.3	0.249*
– Negative	85	23.8 ± 7.9	
Peri-op culture			
– Positive	21	29.0 ± 10.2	0.014*†
– Negative	135	24.4 ± 8.5	
Post-op culture			
– Positive	7	27.9 ± 9.5	0.340‡
– Negative	149	23.9 ± 8.1	

*t-test; ‡Mann–Whitney U test. †$p < 0.05$. ABG = air–bone gap; post-op = post-operative; pre-op = pre-operative; peri-op = peri-operative

Pre-operative cultures of 71 (45.5 per cent) of 156 ears were positive for bacterial species; this rate is higher than the 8.3–20 per cent reported previously.[6–9] Among the cultured pathogens, the most common pre-operative pathogenic bacterial species identified was MRSA (32.4 per cent), followed by methicillin-sensitive *S aureus* (19 per cent) and *P aeruginosa* (including both quinolone-sensitive and quinolone-resistant pseudomonas species; 8.4 per cent). In contrast, previous studies in Korea showed that *P aeruginosa* was the most common pathogen identified (31.8 per cent).[9]

Methicillin-resistant *S aureus* has become particularly prevalent in Europe and the USA. The proportion of cultures containing nosocomial MRSA increased worldwide from 2 per cent in 1974 to 50 per cent in 1997.[10] Methicillin-resistant *S aureus* was first reported in England, two years after methicillin began to be used in clinics, and it subsequently became more prevalent in Europe and the USA. In Korea, the MRSA culture rate in the otorrhoea of patients with chronic otitis media increased continuously from the late 1970s to the 1990s, rising to 18.8 per cent in 1997. The prevalence of MRSA was 24.2 per cent in 2005, representing a further increase since 1997.[11]

Methicillin-resistant *S aureus* was the most common bacteria identified in all pre-, peri- and post-operative tests, and the proportion of MRSA cases increased from the pre- to the post-operative period (Table II). Of 23 cases of MRSA identified in pre-operative

TABLE III
RELATIONSHIP OF POSITIVE CULTURE RESULT WITH DIAGNOSIS AND OPERATION

Operative period	Diagnosis			Operation		
	COM without cholesteatoma*	COM with cholesteatoma†	*p*	Tympanoplasty‡	M&T**	*p*
Pre	46 (41.4)	25 (55.6)	0.115	18 (30.0)	53 (55.2)	0.003§
Peri	10 (9.0)	11 (24.4)	0.018§	2 (3.3)	19 (19.8)	0.003§
Post	5 (4.5)	2 (4.4)	1.000	0 (0)	7 (7.3)	0.044§

Data represent numbers of (and percentages) of positive culture results, unless indicated otherwise. *$n = 111$; †$n = 45$; ‡$n = 60$; **$n = 96$. §$p < 0.05$. COM = chronic otitis media; M&T = mastoidectomy with tympanoplasty

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tests, 6 cases showed MRSA in peri-operative tests and 3 cases showed MRSA in post-operative tests. The other two cases of post-operative MRSA showed no growth in either pre-operative or peri-operative tests. Only about half of the cases that showed antibiotic-resistant bacteria in post-operative otorrhoea had produced the same result in pre-operative and peri-operative tests; the other cases showed 'no growth' in pre-operative and/or peri-operative tests (Figure 1).

A lack of bacteria was evident in 54.5 per cent of patients pre-operatively and 86.5 per cent peri-operatively. 'No growth' does not mean the absence of bacteria. The failure to culture organisms from patients with chronic otitis media may have been because of the use of antibiotics prior to bacteriological testing;[12] in this bacteriostatic state, the amplification and/or proliferation of pathogens is reduced. Alternatively, in these patients, infection may have been caused by slowly proliferating pathogens. Therefore, culture and antibiotic sensitivity testing should be performed before the empirical use of antibiotics to decrease the frequency of post-operative otorrhoea.[5]

- **Distribution of bacterial strains in the middle ear changed during chronic otitis media surgery**
- **The percentage of resistant strains (especially methicillin-resistant *Staphylococcus aureus*) increased**
- **Post-operative otorrhoea bacterial culture results showed low agreement with pre- or peri-operative results**
- **Re-identification of bacterial strains is required if post-operative otorrhoea develops**

Furthermore, if post-operative otorrhoea does occur, culture retesting should be considered, even if the cases showed negative results in pre- and peri-operative tests, and antibiotics should be selected following consideration of antibiotic-resistant bacteria.

Conclusion

According to the results of peri- and post-operative bacterial cultures, the distribution of bacterial strains in the middle ear changed during chronic otitis media surgery. The positive ratio of culture results decreased from the pre- to post-operative tests, but the percentage of resistant strains (especially MRSA) increased. As the bacterial culture results for post-operative otorrhoea showed low agreement with those for the pre- or peri-operative tests, re-identification of bacterial strains is required if post-operative otorrhoea develops.

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