Int J Clin Exp Med 2015;8(6):9985-9990
www.ijcem.com /ISSN:1940-5901/IJCEM0006780

Original Article

Surgical approaches to treating otitis media in the only hearing ear of patients with contralateral hearing loss

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Received February 6, 2015; Accepted April 5, 2015; Epub June 15, 2015; Published June 30, 2015

Abstract: The aim of this study was to retrospectively analyze the surgical procedures used to treat the only hearing ears of two patient cohorts diagnosed with otitis media in the last twenty years. Clinical, surgical, and follow-up data of 15 patients with otitis media in the only hearing ear who underwent middle ear surgery prior to 2000 (Cohort A) and 13 patients with a similar condition (Cohort B) who underwent middle ear surgery between 2000 and 2013 were retrospectively collected, analyzed, and compared. Mean preoperative air conduction (AC) and bone conduction of the patients in Cohort B was 61 ± 18.7 and 20 ± 15.7 dBHL, respectively. Mean preoperative and postoperative air bone gap was 43.21 ± 13.2 dBHL and 12.66 ± 3.93 dBHL, respectively. The success rate of the surgical procedures in this patient cohort was 85%. Surgery of the only hearing ear in patients with otitis media is safe and effective if performed carefully.

Keywords: Hearing loss, middle ear cholesteatoma, otitis media, tympanoplasty

Introduction

Otitis media is an infection of the middle ear that can result in perforation of the tympanic membrane [1]. Cholesteatoma occurs when the tympanic membrane is drawn into the middle ear forming a cyst that may become infected [2]. Otitis media can occur with or without cholesteatoma. Prompt diagnosis and treatment improve outcome [3], and tympanoplasty is recommended. The least invasive technique is often used in surgical management of chronic otitis media with cholesteatoma. Management goals are to obtain a small self-cleaning mastoid cavity and good hearing results [4]. Performing middle ear surgery on the only hearing ear of otitis media patients with contralateral hearing loss is particularly challenging, and the merits of these surgical procedures on the only hearing ear have been debated [5-7]. Surgery can cause permanent sensory damage [8], and the risks and benefits of operating must be considered.

Very few reports have investigated the different surgical strategies employed to treat otitis media in the only hearing ear of patients with contralateral hearing loss [9]. In China, this treatment approach has rarely been attempted. In a previous retrospective study, we reported that we performed tympanoplasty on 15 otitis media patients with contralateral hearing loss prior to 2000 (Cohort A) [10]. From May 2000 to January 2013, tympanoplasty was performed on more than 2500 ears at our hospital; 13 of these were the only hearing ears in patients with otitis media (Cohort B). Radical operation and auditory rehabilitation approaches were used to treat these patients. In the present study, the surgical and follow-up data of these patients (Cohort B) were retrospectively analyzed and compared with the results from Cohort A. The safety and effectiveness of treating the only hearing ear with surgery were analyzed. Prognoses, success rates, and failure rates between the two cohorts were compared.

Materials and methods

Patient information

This retrospective study was performed on the clinical data of thirteen patients that presented

Table 1. Ear surgeries performed on patients in Cohort A and B

Procedure	Cohort A	Cohort B
Tympanoplasty I	5	2
Partial ossicular replacement prosthesis	6	8
Total ossicular replacement prosthesis		1
Radical mastoidectomy + Partial ossicular replacement prosthesis	3	
Radical mastoidectomy	1	
Cholesteatoma resection plus tympanic scute repair		1
Laser ablation of the stapedial tendon ossification and tympanoplasty I		1

with otitis media from May 2000 to January 2013 (Cohort B). The patients (six males and seven females) had a mean age of 45 years (range, 17-62 years). All patients in Cohort B were absent bone conduction (BC) or island BC in the contralateral ear. The air conduction of the contralateral ear was 71-79 dB for three patients, 80 dB for one patient, and > 100 dB for nine patients. Five of the patients had acquired contralateral hearing loss; three had congenital contralateral hearing loss; four had contralateral hearing loss caused by otitis media; and one had contralateral hearing loss following puncture of the tympanic membrane during treatment of otitis media with effusion at another hospital. Cohort B patients underwent surgery for the following reasons: five had cholesteatoma otitis, five had chronic otitis media with tympanic membrane perforation, two had chronic infection of the radical cavity, and one had adhesive otitis media. This study was conducted in accordance with the declaration of Helsinki. The patients provided informed written consent prior to surgery, and the study was approved by the hospital's ethics committee.

Surgical procedures

The surgical procedures performed on the patients in this study cohort are summarized in **Table 1**. These included tympanoplasty I; partial ossicular replacement prosthesis (PORP); total ossicular replacement prosthesis (TORP) [11-13]; cholesteatoma resection and tympanic scute repair [14]; and laser ablation of the stapedial tendon ossification and tympanoplasty [15].

Hearing assessments

Hearing levels at 0.5, 1, and 2 kHz were measured before and after undergoing middle ear surgery. A post-operative GAP improvement < 20 dBHL was considered successful, and GAP that had improved (compared with pre-operative GAP) more than 15 dB was considered effective. GAP < 10 dBHL, or that had improved more than 30 dBHL, was considered excellent.

Statistical analyses

Hearing levels were compared using the U-test. $P < 0.05$ was considered statistically significant.

Results

Medical history and surgery in Cohort A

All patients in this study cohort had contralateral hearing loss that was congenital or caused by otitis media. The surgical procedures performed on the only hearing ear of these patients are listed in **Table 1**. Seven of these patients had never undergone any prior middle ear surgery.

Three patients in this study cohort had undergone two previous middle ear surgeries. One of these patients was diagnosed with contralateral hearing loss several years prior, and the only hearing ear was radically treated at another hospital. The patient was admitted to our hospital because of infection and poor hearing in 2002. Scute repair, tamping, PORP, and grommet insertion were performed. In addition, a titanium nickel alloy stent was implanted as stenosis at the pharyngeal opening and cartilage segment of the eustaqin tube was implanted after the tympsnoplasty. The second patient in this subgroup had acquired contralateral hearing loss because of chronic otitis media. The first procedure comprised calcification removal and PORP on the only hearing ear in 2006. The second operation was performed in 2008 to treat perforation of the tympanic membrane.

Table 2. Pre-operative and post-operative hearing assessments in the only hearing ear

Assessment	Pre-operative GAP (dB HL)	Post-operative GAP (dB HL) (obtain)	Pre-operative AC (dB HL)	Post-operative AC (dB HL)	Pre-operative BC (dB HL)	Post-operative BC (dB HL)
Cohort B	43.21 ± 13.2	12.66 ± 3.93	61 ± 18.7	35.55 ± 17.91	20 ± 15.7	23.66 ± 17.43
Patients with no prior ear surgeries (n = 7)	35	17 (18)	63	45	28	22
	58	10 (48)	68	23	10	13
	42	7 (35)	85	50	43	43
	36	16 (20)	98	78	62	62
	32	10 (22)	55	33	23	23
	50	19 (31)	58	27	8	12
	15	10 (5)	27	22	12	12
Patients with two prior surgeries (n = 3)	45	11 (34)	65	31	20	20
	40	16 (24)	45	28	5	13
	44	15 (29)	57	28	13	15
Patients with three prior surgeries (n = 3)	40	35 (5)	50	45	10	12
	40	19 (21)	70	49	30	37
	38	22 (16)	73	57	35	18

The third patient in this subgroup had acquired contralateral hearing loss because of otitis media, and the patient's condition was complicated by cholesteatoma. The first procedure in 2007 was performed to remove the cholesteatoma, and the epitympanum was resected. We also found that the auditory ossicle chain was closely connected, and air passages surrounding the ossicle were detected. We performed a scute repair and fixed the flaccid part of the tympanic membrane. The patient underwent a second procedure in 2013 because of hearing loss and tympanic fluid. During the operation, we found that the tympanic membrane had returned to a flaccid state. Grommet insertion and autologous perichondrium graft were performed.

Medical history and surgery in Cohort B

Three patients in Cohort B had undergone previous middle ear surgeries. Complete hearing loss in the contralateral ear was reported in one patient who had undergone the previous surgeries at another hospital. The remaining hearing ear was also radically treated prior to the patient's admission to our hospital. Infection and perforation was detected in the only hearing ear of the patient upon admission. Under our care, the patient underwent PORP in 2000, 2004, and 2009.

The second patient in this group had congenital contralateral hearing loss. The remaining hearing ear was previously treated at another hospital, but no improvement in hearing was reported. Upon admission to our hospital, suppuration and hearing loss was obvious. PORP was performed in 2004, and iliac bone filling was performed in 2008 to treat an infected mastoid cavity. In 2012, an infection and a retracting mastoid cavity were detected. An autologous bone graft was used to reconstruct the mastoid canal wall.

The third patient in this group had acquired complete contralateral hearing loss by otitis media several years prior. In 2005, the patient was admitted to our hospital for hearing loss in the only hearing ear after treatment at another hospital. Auditory ossicle calcification, epithelization of the tympanum inner wall, and absence of the outer wall epitympanum were found during PORP. Hearing loss was again reported one year later, and a bulging tympanic membrane and cholesteatoma were detected under the epithelial layer. A cholesteatoma resection was performed. However, no substantial improvement in hearing was reported after the operation. An examination performed one month after the procedure revealed residual cholesteatoma in the posterior tympanum and it was resected.

Hearing assessments and follow-up

Hearing in the only hearing ear of all patients in Cohort B was assessed. The average pre-oper-

ative AC and BC was 61 ± 18.7 and 20 ± 15.7 dBHL, respectively. The average pre-operative GAP was 43.21 ± 13.2 dBHL.

The mean follow-up period was 84.55 ± 56.84 months (range, 6-156 months). All 13 patients had dry ears at the follow-up visit. The average post-operative GAP was 12.66 ± 3.93 dBHL and this was significantly different ($U = 7.1$, $P < 0.01$) from the pre-operative GAP (43.21 ± 13.2 dBHL). Eleven (85%) of the 13 patients were treated successfully. Four patients had a post-operative GAP < 10 dBHL, seven patients had a postoperative GAP of 11-20 dBHL. The other two had a postoperative GAP of 22 dB. One of them considered effectively treated as the postoperative GAP had improved at least 15 dBHL when compared with pre-operative results. Therefore, improved conditions in 12 of the 13 patients (92.3%) were observed; while no substantial changes in hearing levels were detected in the remaining patient but who also achieved dry ear which significantly decreased the risk of infection induced hearing loss.

GAP assessments in the patients with prior ear surgeries are summarized in **Table 2**. All patients that had undergone two previous surgeries were considered successfully treated. One of the three patients that had undergone three prior ear surgeries were successfully treated.

Post-operative AC and BC were also assessed (**Table 2**). The mean post-operative AC assessment of the patient in cohort B was 35.55 ± 17.91 dBHL. This was significantly different ($U = 3.43$, $P < 0.01$) from the mean pre-operative AC assessment (61 ± 18.7 dBHL). In contrast, there was no significant difference ($U = 0.03$, $P > 0.05$) when pre-operative and post-operative BC assessments were compared (20 ± 15.7 vs. 23.66 ± 17.43 dBHL).

Discussion

We analyzed the surgical management of the only hearing ear in a small patient cohort with contralateral deafness and otitis media. We reviewed the clinical data detailing causes of hearing loss, previous middle ear surgeries, as well as pre-operative and post-operative hearing assessments.

Advanced middle ear surgical techniques that greatly decrease the risk of operation-induced hearing loss are now applicable to the only hearing ear of patients with contralateral deafness [16]. As hearing loss for patients with contralateral deafness can profoundly impact the patient's quality of life, preventing this complication is of utmost importance [17]. We have retrospectively analyzed the surgical treatment of the only hearing ear in patients with contralateral deafness and otitis media for over 20 years, and we have found that treating lesions around the stirrups (stapes bone) can introduce a greater risk of hearing loss. Six of 15 patients (40%) in our previous study (Cohort A (10)) and nine of the 13 patients (69%) in this study (Cohort B) had lesions surrounding the stirrups and were treated with PORP. Stapedial tendon ossification was also detected in several Cohort B patients. However, surgery was performed without hearing loss, and no post-operative BC deterioration was observed in either cohort.

Interestingly, GAP improved by > 20 dBHL in eight (53%) and by > 30 dBHL in two (13.3%) patients within Cohort A, while 10 (77%) patients improved by > 20 dBHL and four (31%) patients by > 30 dBHL in Cohort B. Although six patients in Cohort B had undergone several previous middle ear surgeries, no BC deterioration was found. Post-operative hearing levels of the patients were significantly better in Cohort B than in Cohort A, suggesting that recent technical advances in middle ear surgeries have greatly improved prognoses.

Strategies for preventing hearing loss differ according to surgical procedure [18]. Type I tympanoplasty is considered a low risk procedure [19]. The absence of the tympanic membrane, or part of the tympanic membrane, is commonly accompanied by ossicular exposure, particularly in the manubrium of malleus. This increases the risk of incurring permanent damage in the inner ear [20]. In our opinion, there are several factors that can improve outcomes: Firstly, the otologists must be cautious when using an electric drill, and they should be aware of patient responses that could signal when too much noise is generated under local anesthesia. Drilling should be stopped or slowed when patients cannot tolerate the process. Secondly, a sharp hook should be used to divide the epithelial cells on the surface of the ossicle to minimize contact with the manubrium of malleus. Moving the ossicle could transfer pressure

to the stapedial footplate and inner ear, and the effects are similar to those of an explosion near the tympanic membrane. Thirdly, glucocorticoids should be post-operatively administered to reduce patients' dizziness, nausea, and/or vomiting due to incurred inner ear damage. Finally, all precautions must be taken to ensure minimal contact with the ossicle during graft implant procedures.

A number of other factors should be considered when treating stapes lesions. For instance, rupture may occur if the stapes is pressed inward in some patients that have a stapedial footplate covering the oval window. This is comparable to the effects of a nearby exploding bomb in the inner ear. Under normal conditions, the front end of the stapedial footplate has a greater range of motion than the back end. As such, contact with the stapes should be minimized. We also recommend that the front-stapes arch be treated before the back-stapes arch. The epithelia of the back-stapes arch of the stapedial footplate could help fix the stapes and attenuate vibrations while the front-stapes arch is treated. Moreover, the epithelia on the front stapes arch will have already been divided when the back stapes arch is treated and will not influence the process. For patients with an epithelia covering stapedial footplate and the stapes arch, the process should be started with the stapes arch. The epithelia on the oval window could help fix the stapes arch while treating the stapes arch. Secondly, delicate and sharp hooks should be used in the process. Any change in the stapes position must be taken seriously, and the operation should be stopped or start from another direction or location when any obvious positional change occurs. For example, a hook could be used to fix the neck of the stapes, and another hook could be used to divide the epithelia if necessary.

In patients with stapedial tendon ossifications or calcifications, the procedure is not as challenging as when the stapes is well fixed. In treating such patients, lesions should be treated at the front end of the stapes before the back end is treated. However, when the procedure is near completion, precise treatment of the remaining lesions can greatly affect outcome. Fortunately, mucosa is often found in lesions comprised of calcifications and ossifications between the lesions and the stapes. In these cases, a very fine hook might facilitate the operation.

Contralateral hearing loss was induced by operation in four patients in Cohort A while they were under our care, and no patients suffered from hearing loss in Cohort B. We hypothesize that too much contact was made with the stapes or the stapedial footplate in the four patients in Cohort A, and this resulted in poor outcomes.

Several pharmacotherapies, including glucocorticoids, are widely used to treat sudden sensorineural hearing loss. As glucocorticoids are indicated for sudden and explosive deafness, we recommend that glucocorticoids be post-operatively administered (within three days) to reduce edema caused by serous labyrinthitis of the inner ear, and to prevent hearing loss. Other drugs including mouse nerve growth factor and ganglion anhydride ester that have proven effective in treating sudden deafness could also be used.

Our findings suggest that surgeries performed on the only hearing ear of otitis media patients (with or without cholesteatoma) are safe and effective, and prognoses for these patients has improved in the last decade. Prior ear surgeries do not necessarily affect outcomes, but a complete history of these surgeries is important. We conclude that recent technical advances in middle ear surgeries have improved success rates, decreased the risk of hearing loss, and improved hearing levels as measured by GAP, AC, and BC assessments. Retrospective meta-analyses of larger patient cohorts are required to support our findings.

In conclusion, surgery of the only hearing ear in patients with otitis media is safe. Surgery improved sound conduction in these patients. Success rate of the surgery was 85%.

Disclosure of conflict of interest

None.

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