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Original Article

Re-evaluation of CO_2 laser myringotomy for managing children with persistent acute otitis media

Yen-Ling Kuo [a,b,c], Mao-Che Wang [a,b], Chia-Huei Chu [a,b], An-Suey Shiao [a,b,c,*]

[a] *Department of Otolaryngology and Taipei Veterans General Hospital, Taipei, Taiwan, ROC*
[b] *National Yang-Ming University School of Medicine, Taipei, Taiwan, ROC*
[c] *National Defense Medical Center, Taipei, Taiwan, ROC*

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Abstract

Background: This study aimed to re-evaluate the utility of CO_2 laser myringotomy in children with persistent acute otitis media (PAOM).
Methods: From September 2002 to April 2008, 40 children with PAOM received CO_2 laser myringotomy. PAOM was defined as continuing symptoms and signs after systemic antibiotic treatment. Before laser myringotomy, the eardrums were checked under videotelescopy, pure tone audiometry or behavior audiometry and tympanometry. Middle ear effusions were collected using our own designed bottle culture device after laser myringotomy. The patients were followed up at outpatient clinics for 3 months. Cultured middle ear pathogens, healing time of the eardrums, hospital course (for admitted patients), and the development of middle ear effusions were recorded.
Results: Forty children with 53 ears with PAOM were enrolled. Eight patients (20%) had bilateral disease and underwent bilateral laser myringotomy. The overall culture rate was 28.3%, and *Streptococcus pneumoniae* was the most common pathogen. Eight patients (20%) were admitted for intravenous antibiotics. The average eardrum healing time was 22 days in those with positive cultures, and 16.4 days in those with negative cultures ($p = 0.125$). All eardrums healed in 1 month. The resolution rate was 62.5% at 1 month. Patients with bilateral PAOM were prone to have positive middle ear culture (5/8) compared with those with unilateral PAOM (8/32) ($p = 0.086$).
Conclusion: CO_2 laser myringotomy is an applicable means of treating PAOM. *S pneumoniae* is the most common pathogen in PAOM. CO_2 laser myringotomy allows for the drainage and culture sampling of middle ear effusion, relieving the need of taking prolonged medication.

Keywords: children; laser myringotomy; persistent acute otitis media

1. Introduction

Diagnosis of acute otitis media (AOM) requires a history of acute onset of signs and symptoms, middle ear effusion, and signs and symptoms of middle ear inflammation.[1] From pneumatic otoscopy or otoendoscopy, middle ear inflammation and middle ear effusion can be observed, including bulging of the tympanic membrane, limited or absent mobility of the tympanic membrane, air fluid level behind the tympanic membrane, and otorrhea from the perforated eardrums. A high diagnostic accuracy of 98% was obtained by otoendoscopy in a previous study.[2]

Streptococcus pneumoniae, *Haemophilus influenzae*, and *Moraxella catarrhalis* are the most common pathogens detected in AOM,[3,4] whereas *Staphylococcus aureus* is the primary bacterial pathogen cultured from patients treated with preadmission antibiotics.[5] For persistent acute otitis media (PAOM), tympanocentesis has been suggested for middle ear pressure alleviation, pain relief, and microbiologic sampling for pathogen identification. However, this procedure can only be performed on children when they are sedated.[6] Advantages of CO_2 laser myringotomy for otitis media include medium-term

* Corresponding author. Dr. An-Suey Shiao, Department of Otolaryngology, Taipei Veterans General Hospital, 201, Sec 2, Shih-Pai Road, Taipei 112, Taiwan, ROC.
E-mail address: asshiao@vghtpe.gov.tw (A.-S. Shiao).

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middle ear ventilation, easy manipulation in an office-based service, adequate middle ear sampling, and serving as a temporary alternative to ventilation tube insertion.[7,22–29]

The incidence of AOM complicated with acute mastoiditis has fallen in recent years; however, cases of children with PAOM are still found during clinical practice. Diseased children usually manifest as being irritable or toxic, with otalgia and spiking fever. Herein, we focus on CO_2 laser myringotomy in treating children with PAOM. Our aim was to discover whether laser myringotomy healing is influenced by the presence of pathogens, the microorganisms of PAOM, and re-evaluation of the utility of laser myringotomy. Most patients were treated at an outpatient clinic; this approach and its implications have not been fully discussed previously.

2. Methods

From September 2002 to April 2008, 40 children with 53 affected ears presented with PAOM and received CO_2 laser myringotomy at the outpatient clinic of a tertiary referral center. The data were collected by retrospective chart review, and no syndromic patients were included. Referencing a large study proposed by Loundon et al,[8] "PAOM" was defined as continuing symptoms of high fever (more than 38.5 °C), severe otalgia, and signs such as injection and bulginess of the eardrums plus middle ear effusion after primary medical management. The duration of antibiotic prescriptions prior to laser myringotomy was documented. Pure tone audiometry when possible or behavior audiometry and tympanometry were performed prior to CO_2 laser myringotomy and at post-operative follow-up. The study was conducted in accordance with the principles stated in the Declaration of Helsinki (1964), and its design was approved by the Institutional Review Board.

Prior to the performance of CO_2 laser myringotomy, the external auditory canals and eardrums were prepared with 5% xylocaine application for 20 minutes, and then local infiltration of ear canals with alcohol (70%) was done for 1 minute. CO_2 laser myringotomy (model 1041; Sharplan Lasers Inc., Allendale, NJ, USA) with a micromanipulator (AcuSpot 1041s; Lumenis, Inc., Santa Clara, CA, USA) was conducted by a single shot of 15 watts lasting 0.2 seconds in the anterior-inferior quadrant. The average myringotomy was 1.5–1.9 mm in diameter. After creating the myringotomy, middle ear effusions were collected by our own designed sterilized bottle culture set, which comprises a sterilized glass bottle connected to the negative pressure suction system of an ENT unit, and a metallic ear suction tip (Fig. 1). In general, the whole procedure can be done in 30 minutes.

The cultured pathogens of the middle ear effusions, clinical courses of the patients, and healing of the eardrums were documented. All patients were followed-up at 1, 2, 3, 4, 8, and 12 weeks post-laser myringotomy, and some ($n = 25$) were followed-up until 1 year.

In this study, we used paired t tests for the comparisons of healing rate and time course of the eardrums using SPSS version 16 software (SPSS, Inc., Chicago, IL, USA). A p value of ≤ 0.05 or less was considered statistically significant.

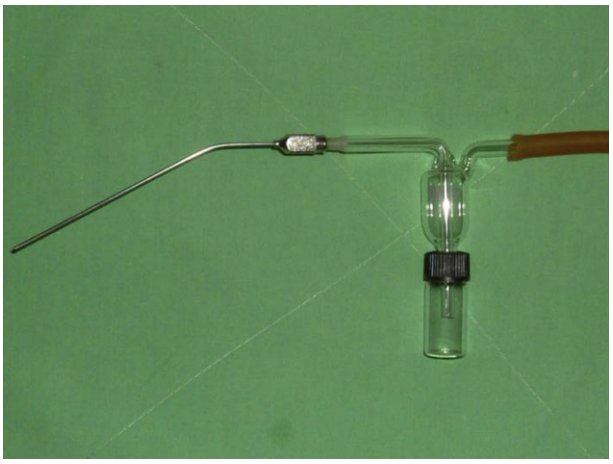

Fig. 1. The sterilized bottle culture set.

3. Results

Of the 40 children enrolled, 25 were boys and 15 were girls, and were from 1 to 12 years old, with an average age of 5.52 years (SD ± 2.85). All patients had received oral antibiotics from 7 to 28 days (mean = 9.3 days) prior to referral to our clinic. Fifteen ears of 13 patients had positive middle ear cultures for an overall positive culture rate of 28.3% (Table 1). *S pneumoniae* was the most commonly cultured pathogen (8/15, 53.3%). Six of the eight isolated *S pneumoniae* cases showed resistance to erythromycin, trimethoprim/sulfamethoxazole (TMP/SMX), and clindamycin. Three patients also revealed resistance to oxacillin. Two Gram-negative pathogens, *Enterococcus* and *Klebsiella pneumoniae* revealed multidrug resistance, and were only sensitive to vancomycin and imipenem, respectively. No pan-resistance microorganism and only one oxacillin-resistant *S aureus* (ORSA) was isolated. Table 2 shows the antimicrobial susceptibilities of the Gram-positive pathogens.

Meanwhile, eight patients (20.0%) were admitted, including three patients with concurrent pneumonia and one with acute pan sinusitis. Laser myringotomy was performed owing to persistent disease after 48 hours of intravenous antibiotics. The average hospitalization length was 5.67 days.

Table 1
Bottle cultures of 53 middle ear effusions

Pathogens	Positive ear(s)
Gram-positive (13/15)	
Streptococcus pneumoniae	8
Staphylococcus aureus	2
Coagulase-negative *Staphylococcus*	1
Streptococcus viridans	1
ORSA	1
Gram-negative (2/15)	
Klebsiella pneumoniae	1
Enterococcus	1
Total	15

ORSA = oxacillin-resistant *Staphylococcus aureus*.

Table 2
Susceptibilities of Gram-positive organisms

Organisms	Ampicillin	Oxacillin	Cefazolin	EM	TMP/SMX	CM	Van	Levo
Streptococcus pneumonia								
#1	S	S	S	S	S	S	S	S
#2	S	S	S	S	S	S	S	S
#3	S	S	S	R	R	R	S	S
#4	S	R	S	R	R	R	S	S
#5	S	R	S	R	R	R	S	S
#6	S	R	S	R	R	R	S	S
#7	S	S	S	R	R	R	S	S
#8	S	S	S	R	R	R	S	S
Resistance (%)	0	37.5	1	75	75	75	0	0
Staphylococcus aureus/coagulase negative *S aureus*								
#1	R	S	S	S	S	S	S	S
#2	R	S	S	S	S	S	S	S
#3	R	R	R	R	R	R	R	R
#4	R	S	S	S	S	S	S	S
Resistance (%)	100	25	25	25	25	25	25	25
Overall resistance (%)	33	33	8.3	58.3	58.3	58.3	8.3	8.3

CM = clindamycin; EM = erythromycin; Levo = levofloxacin; TMP/SMX = trimethoprim/sulfamethoxazole; Van = vancomycin.

No intracranial or intratemporal complications, such as periosteal abscess, meningitis, petrositis, or sigmoid thrombophlebitis, were noted in this cohort.

There were no perforated eardrums at presentation. The mean healing period in those with positive middle ear cultures (15 ears) was 22 days, and 16.4 days for those with negative cultures (three patients were lost to follow-up after laser myringotomy, $p = 0.1249$). The overall healing period in this study was 17.7 days. All tympanic membranes closed in 1 month.

Eight patients (20%) had bilateral PAOM and underwent bilateral laser myringotomy during the study cohort. Slightly more patients with bilateral PAOM had positive middle ear cultures (5/8) than those with unilateral PAOM (8/32) ($p = 0.086$).

All patients had pure conductive hearing loss at presentation. Tympanometry was performed at time of first visit in 23 children, and the results varied. Most of them presented with bilateral type B, except for two patients with type C in one ear and type B in the other ear, two patients with type B on one side and type A on the other side, and two patients with bilateral type C on tympanograms.

During follow-up, all eardrums healed well within 2 months without tympanosclerosis or persistent perforations. Their hearing levels also returned to an average of 15–25 decibel hearing level (dBHL) in 12 weeks. Fifteen patients (37.5%) developed middle ear effusions after healing of the tympanic membranes at 1 month. The expected resolution rate at 1 month after laser myringotomy was 62.5%. Six patients had ventilation tube insertion (with or without adenoidectomy) after laser myringotomy in the subsequent 2–14 months owing to persistent middle ear effusion in one patient and recurrent otitis media in the other five patients. One patient had repeated ventilation tube insertion during the study period.

Fig. 2A–C presents a serial telescopic view of a 4-year-old boy who failed from a 2-week course of oral antibiotics for left PAOM and the follow-up endoscopic pictures after laser

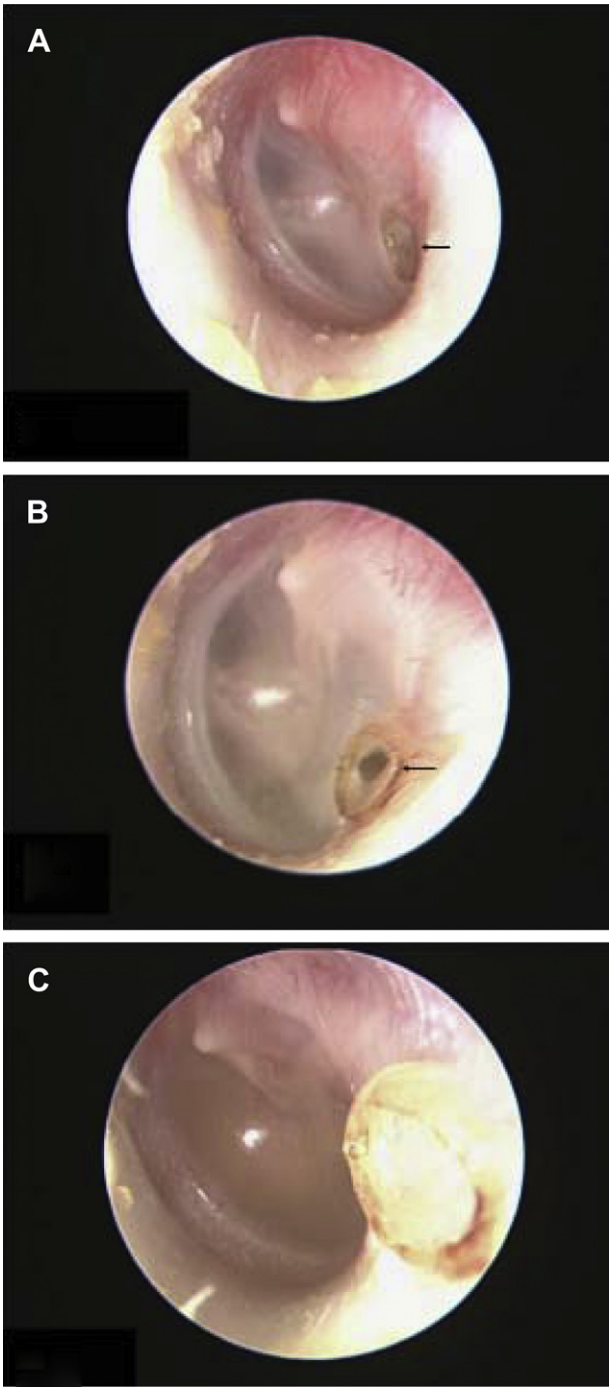

Fig. 2. A–C. Telescopic view of a 4-year-old boy with left persistent acute otitis media. (A) Immediately after CO_2 laser myringotomy. (B) One week later, smaller laser hole was noted. (C) Six weeks later, migration of scar out of the eardrum without middle ear effusion.

myringotomy (Fig. 2A: immediately after laser myringotomy; Fig. 2B: at 1 week; Fig. 2C: 6 weeks later). Migration and lateralization of the "tympanic scar" can be observed post-laser myringotomy with resolution of the disease. No subsequent middle ear effusion was noted in this patient.

4. Discussion

Different procedures have been used to treat PAOM, including tympanocentesis and incisional myringotomy. Comparisons of incisional myringotomy and CO_2 laser myringotomy have been conducted on rats,[9] with the latter providing latency for a longer period of time (3 vs. 15 days). In a previous study, incision myringotomy was indicated for AOM patients who appeared toxic or with severe otalgia, had failed appropriate antibiotic therapy, or had other risk factors of severe disease, such as immunocompromised status.[10] The immediate advantages of CO_2 laser myringotomy include a short procedure time of 0.2 seconds, which is better for irritable children than incisional myringotomy, which needs to be performed under heavy sedation most of the time, and easy collection of middle ear effusions by our culture device (Fig. 1). If any pathogen is found by culture, oral antibiotics can be adjusted. However, the issues of a slightly longer eardrum healing course than with needle aspiration or incisional myringotomy, and the transient noise when doing the laser myringotomy should be thoroughly discussed with the parents (and older children) prior to doing the procedure, and a regular follow-up is necessary.

Treatment of AOM has been discussed for decades. Oral antibiotics should be applied for younger patients (<2 years old) with Eustachian tube dysfunction[11] and those with severe illness (moderate-to-severe otalgia or a fever of 39 °C or higher).[12] Amoxicillin is the first choice for most patients owing to its general effectiveness when used in sufficient doses against susceptible and intermediate-resistance pneumococci. A high dose of amoxicillin, amoxicillin-clavulanate, or ceftriaxone is suggested when initial treatment fails.[1] According to the literature, the term "refractory" AOM is used for describing AOM with resistant species. Thus, this study focused on the clinical management of clinical "persistent" disease. Failure to respond to empirical antibiotics is a clinical issue, and an indication that a more aggressive treatment should be taken. In addition, these children should be regarded as more susceptible to severe comorbidities.

According to the literature, only *S pneumoniae* is highly resistant to penicillin and will not respond to conventional doses of amoxicillin.[13] In this study, the most cultured middle ear pathogen in PAOM children was *S pneumoniae*, which was compatible with a 15-year study.[8] *H influenzae* was not detected, possibly owing to the eradication of this pathogen by previous antibiotics. Although patients presented with persistent disease, few multidrug-resistant pathogens were isolated in this study. Thus, persistent pathogens may not be the only cause of persistent disease. The culture result also reflected that *H influenzae* and particularly *M. catarrhalis* infection seem to be not detected as much as other pathogens. Therefore, both microorganisms might be less correlated with children having PAOM or complicated AOM in Taiwan than in the Western world.[14] Although the overall culture rate was not high, the four middle ears infected by *S aureus* showed resistance to ampicillin, which may have been the cause of the failure of primary medication in these children. By reviewing the isolated pathogens (Table 1), it is encouraging that only one case with coagulase-negative *S aureus*, and no *Pseudomonas* species was found, which suggests that our culture device is effective in avoiding contamination of the normal flora of external auditory canals.[15,16]

CO_2 laser myringotomy provided a method for pressure relief of the middle ear in children with PAOM. Resolution of acute symptoms and signs can be observed soon after the purulent middle ear is drained. Slovik et al[6] reported that closure of the eardrums after tympanocentesis occurred early in most cases (90%, 4–6 days after the procedure) and was independent of disease etiology and history, age and bacterial eradication. In this study, closure of the tympanic membranes occurred slightly earlier in the culture-negative ears (16.4 days) than the culture-positive ears (22 days), however, without significance ($p = 0.1249$). Thus, the healing process of the eardrums was not influenced by the presence or not of microorganisms. In contrast to the larger laser myringotomy done in a previous study (one case with persistent perforation),[30] we found that it was safe to perform laser myringotomy with a smaller size of 1.5–1.9 mm (power = 15 watts, duration = 0.2 seconds) in oriental children, even for the two 1-year-old patients. No persisting perforation of eardrums was noted during the cohort.

Culture rates of middle ear effusion have been recorded to be as high as 86% in untreated AOM children, with symptoms and signs within 7 days.[6] Sterilized cultures were noted in 71.7% of samples in the cohort, which demonstrated that many of the microorganisms were eliminated by the previous antibiotics, and that prolonged empiric medication may be of little help. Other studies have also contributed to the decline of repeated cultures in persistent disease,[8] and the direct relationships include: (1) antibiotics used prior to culture; (2) nonbacterial pathogens; and (3) pathogens that do not proliferate in classic culture conditions (e.g., mycobacteria and anaerobic pathogens). Another issue may be that it is difficult to assess clinical success in patients because inflammatory signs and symptoms often persist after bacterial eradication when the middle ear effusions become sterile.[17] In addition, concomitant viral infections that aggravate the disease course may account for the higher percentage of sterile middle ear cultures.[18]

The application of laser-assisted myringotomy has been an effective option for otitis media with effusion after preliminary studies since the 1990s.[19–31] Atypical usage, such as for middle ear dysfunction or hyperbaric oxygen therapy, mastoiditis with post-auricular cellulites, and canal exostosis prohibiting tympanostomy, have also been proposed as additional options.[25] However, most studies have addressed the treatment of chronic serous otitis media. For children with PAOM or AOM, the studies have been limited in number and the follow-up periods have been relatively short.[29,30] Table 3[24,28,30] shows

Table 3
Comparison with serial studies

Author, y	Conditions	Affected ears (*n*)	Resolution rate (%)	Follow-up period
Cohen et al, 1997[34]	OME	21	47	2 mo
Silverstein et al,[24] 2001	OME	23	46	4.7 wk
Sedlmaier et al,[28] 2002	OME	159	73.7	6 mo
Duetsch et al, 2003[29]	OME & AOM	430	68.8	12 wk
Cotter & Kosko,[30] 2004	OME & AOM	79	42.6	>3 mo
Lin et al, 2006[31]	OME	73	73.0	5 wk
Kuo et al, 2010	AOM	53	62.5	3 mo

AOM = acute otitis media; OME = otitis media with effusions.

a comparison with other studies. One of the studies on laser myringotomy for refractory AOM patients reported a failure rate of 53.6% for patients followed-up on average for 2.2 weeks after the procedure. The authors thus concluded a high failure rate for laser myringotomy and the possible subsequent requirement of ventilation tube insertion.[30] However, our study showed a different picture. The expected resolution rate at 1 month reached 62.5%, and fewer patients underwent ventilation tube insertion during follow-up. It is not surprising that with a higher success rate, there would be less ventilation tube insertion. In addition, lower direct and indirect costs would be required.

Approximately 24 articles in the English-language medical literature discuss CO_2 laser myringotomy in clinical use, and some of these were basic studies about the healing process of laser myringotomy. According to the American Academy of Otolaryngology–Head and Neck Surgery guideline for treatment of otitis media with effusions, laser myringotomy is an option for treatment.[32] However, in the United States, the CO_2 laser device is not a common device used in the clinic, especially for myringotomy. Most clinicians abandoned this procedure owing to it being an expensive device and the belief that there was no difference in treatment result between cold instruments and laser myringotomy.[30] In fact, there are several advantages for laser myringotomy. First, it may provide mid-term ventilation. According to our previous study, laser myringotomy will heal in 3 weeks[31] and incisional myringotomy will close within 3 days. In addition, the function of the Eustachian tube is worse in the 3- to 6-year-old group than the 7- to 12-year-old group.[33] Decreased incidence of otitis media has been observed from infancy to adolescence. In our study, most of the patients were 5 to 6 years old, which fell into the age group in which the Eustachian tube function has become more mature. Mid-term ventilation of the middle ear after laser myringotomy can help these children to go through the disease period. Second, it may be performed under local anesthesia; most of the children in our study sustained this procedure without much anxiety. Third, according to data (unpublished) from our institute, from 2002 to 2006, the number of ventilation tube insertions declined after we introduced the CO_2 laser myringotomy procedure.

The main limitation of this study is that the data were collected retrospectively. Further study should be designed to compare cold instrument myringotomy and laser myringotomy for the treatment of PAOM. For clinical utility, studies should also combine laser myringotomy with the impact of pneumococcal vaccinations on the pathogens of the middle ear and in the primary care of complicated children.

In conclusion, CO_2 laser myringotomy is a feasible way to treat PAOM. No chronic sequelae, neither chronic otitis media nor tympanosclerosis, were noted during follow-up. Purulent middle ear effusions can be drained and cultured after laser myringotomy. *S pneumoniae* is the most common pathogen in PAOM. Oral medication, if needed, can be adjusted according to the culture results. Most important of all, children with PAOM can be relieved from acute symptoms and the need for prolonged medication.

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