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Cost–utility Analysis of Tympanomastoidectomy for Adults with Chronic Suppurative Otitis Media

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OBJECTIVE: To undertake cost–utility analysis for tympanomastoid surgery to analyze its cost-effectiveness in treating adult chronic suppurative otitis media (CSOM).

METHODS: Seventy-seven patients with CSOM were evaluated with the Chronic Ear Survey (CES) before and 1 year after tympanomastoid surgery. Direct health care cost data during the 1st year after operation were retrieved. The utility gain was defined as change in the CES total score. The cost–utility ratio (CUR) was defined as cost per utility gain. Patients were stratified by disease type into wet-ear and dry-ear groups.

RESULTS: The average total direct cost attributable to tympanomastoid surgery is (in New Taiwan dollars [NT\$]) 45,716.3 in the 1st postoperative year, and the average CUR is NT\$ 1850.9. The lower CUR of NT\$ 1280.9 for the wet-ear group is due to the greater utility gain (37.6 ± 3.4 versus 24.4 ± 6.8 , $P < 0.05$) despite its higher cost (NT\$ 48,163.2 versus NT\$ 38,419.7, $P < 0.05$).

CONCLUSIONS: Treating continuously or intermittently draining ears is more cost-effective, as compared with managing a quiescent infection, because of its favorable utility gain.

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Cost–utility analysis has emerged as a basic tool to assess the cost-effectiveness of health care practice. The cost, outcomes, and clinical process are incorporated into a decision-analytical model, and the expected cost–

utility ratio (CUR) can be calculated. CUR provides a quantified assessment of medical interventions; unit of clinical effects from a particular medical intervention can be described in terms of benefit and cost. There has been heightened awareness in recent years of the necessity for health care sectors to live within budgets. The climate in the shifting health care system toward a more managed environment has placed health care providers in a position to streamline resources and to provide quality care in the most cost-effective way. In terms of cost and health improvement trade-offs, it is essential to understand the relative values for medical and surgical interventions.^{1–3}

Adult chronic suppurative otitis media (CSOM) is a major disease entity in otolaryngology practice. Thus, it is our intent to gather more scientific evidence for the establishment of practice guidelines in surgical treatment of adult CSOM. The aims of this study are to evaluate the cost structure of tympanomastoid surgery, and to analyze the CURs for different CSOM disease groups.

MATERIAL AND METHODS

Study Design

The study was conducted in a prospective, nonrandomized manner. Seventy-seven consecutive adult patients with

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CSOM undergoing tympanomastoid surgery at the Cathay General Hospital were enrolled during a period from January 2000 to December 2000. Informed consent to participate and institutional review board approval were obtained in advance. Patients were administered the validated Chinese-version Chronic Ear Survey (CES)^{4,5} before and 1 year after surgery. Direct health care costs generated by tympanomastoid surgery during the 1st year after operation were retrieved from the hospital claim database.

Disease Classification

On the basis of clinical findings and otorrhea history, patients were further stratified by disease type (wet-ear and dry-ear groups) using the classification system proposed by Nadol.⁶ The wet-ear group was composed of patients with (1) chronic active otitis media without cholesteatoma (with granulation), (2) chronic active otitis media with cholesteatoma, and (3) chronic inactive otitis media with frequent reactivation. The dry-ear group was composed of patients with chronic inactive otitis media.

Surgery

Standard tympanoplasty with (n = 58) or without mastoidectomy (n = 19) were performed under general anesthesia on all patients. The tympanomastoid surgery is an inpatient service in our institute.

Medical Resource Utilization and Cost Calculation

Medical resource utilization information, including the length of stay, frequency of postoperative office visits, and duration of medication were retrospectively obtained from medical records. Records of revision operation within 1 year after the initial tympanomastoid surgery were also identified.

Cost data were retrieved from the hospital claim database. The up-front admission cost for each hospitalization was composed of physician fee, ward fee, nursing fee, laboratory fee, operation fee, anesthesia fee, inpatient dispensary service fee, and other miscellaneous fees (Table 1). Costs associated with the postoperative outpatient service, including antibiotics, physician fee, registration fee, ENT local treatment fee, and dispensary, also are listed in Table 1.

The cumulative cost for tympanomastoid surgery is defined as a summation of admission cost, postoperative 1-year outpatient services cost, and readmission cost. The admission cost is adjusted with reoperation and inflation (5%) rates. The monetary unit is in 2000 New Taiwan dollars (NT\$); the average exchange rate with US dollars was around 33.5:1 within that year. The formula for calculating 1-year cumulative cost is as follows:

$$\begin{aligned} \text{Cumulative cost} = & \text{admission cost} \\ & + \text{postoperative 1-year outpatient services cost} \\ & + \text{readmission cost (reoperative rate} \\ & \quad \times \text{admission cost} \times 1.05) \end{aligned}$$

Table 1
Unit cost for the surgical treatment of CSOM

Cost structure	Unit cost (NTD\$)
Admission service item	
Physician fee	243/day
Ward fee	512/day
Nursing fee	613/day
Lab fee	1,218/admission
Pathology exam fee	1,714/specimen
Image fee	200/admission
Tympanoplasty	12,000/admission
Tympanomastoidectomy	15,000/admission
Anesthesia (<2 h) fee	3850/operation
Anesthesia (2–4 h) fee	880/30 min
Anesthesia (>4 h) fee	1100/30 min
Inpatient dispensary fee	84/day
Intravenous fluid fee	75/day
Local treatment fee	280/day
Material fee	85/admission
Outpatient service item	
Antibiotics	50/wk
Ear drop	150/bottle
Physician fee	213/visit
Registration fee	150/visit
ENT local treatment fee	120/visit

Utility Measure

Developed by the Massachusetts Eye and Ear Infirmary, the CES is a statistically validated chronic ear-specific outcomes measure.⁴ It is a 13-item Likert scale survey that uses 3 subscales. The activity restriction (AR) subscale examines the impact of chronic otitis media on a patient's daily life. The symptom subscale (SY) examines the presence of symptoms such as hearing impairment and drainage, whereas the medical resource utilization subscale (MR) reviews the use of medications and office visits. The Chinese version CES (CCES) used in this study was previously validated, and its performance characteristics proved to be equivalent to the CES.⁵

Cost–Utility Ratio

The CUR is defined as the 1-year cumulative cost divided by the change in the CES total score. The formula for CUR is as follows:

$$\text{Cost–utility ratio} = \frac{\text{1-year cumulative cost}}{\div \text{change in the CES total score.}}$$

Statistical Analysis

Fisher's exact test was used to compare recurrence rates between disease groups. Mann-Whitney U tests were used to compare the medical resource utilization, costs, utility gains, and CURs between different CSOM groups. All data were stored in an Access 7.0 database (Microsoft, Seattle, WA). Analyses were conducted by using the SAS software package (SAS Institute, Cary, NC). Continuous data are presented as mean \pm standard deviation.

Table 2
1-year medical resource utilization

Variable	Whole group (n = 77)	Wet-ear group (n = 58)	Dry-ear group (n = 19)
Operation time (min)	158 ± 51.9	164.59 ± 52.74*	139.23 ± 46.22
Length of stay (d)	4.32 ± 0.98	4.49 ± 0.93*	3.85 ± 0.99
Reoperation, n (%)	4 (5.2)	3 (5.2)	1 (5.3)
Visit	7.84 ± 3.28	7.61 ± 3.56	8.45 ± 2.47
Antibiotics (no. wk)	3.50 ± 1.98	3.53 ± 2.22	3.38 ± 1.15
Ear drop (no. bottles)	1.20 ± 1.24	1.32 ± 1.35	0.84 ± 0.85

*Mann-Whitney U test, comparison between wet-ear and dry-ear group, $P < 0.05$. Continuous data are presented as mean ± standard deviation.

RESULTS

Patient Characteristics

The study population comprises 77 patients (male-female ratio, 20:57; mean age, 43.2 ± 12.6 years). The distributions of systemic comorbid diseases are as follows: 2 with hypertension (2.6%), 2 with diabetes (2.6%), and 10 with nasal allergy (13.0%). The distribution of disease category is as follows: wet-ear group, 58 (75.3%, including 7 with cholesteatoma, 8 with granulation, and 43 with frequent reactivation), and dry-ear group, 19 (24.7%, including 3 with retraction pocket, 11 with perforation, 2 with ossicular resorption, and 3 with adhesive otitis media).⁶

Medical Resource Utilization

The surgeries all went smoothly; no adverse events were reported in this group of patients.

The mean operation time (including the induction and resuscitation time) is 158.0 ± 51.9 minutes. There is a significant difference in operation time between the 2 disease groups ($P < 0.05$). Patients in the wet-ear group tend to have longer operation times.

The average length of stay for this population is 4.32 ± 0.97 days. The medical resources utilization within the 1-year period after tympanomastoid surgery is as follows: number of visits, 7.84 ± 3.28 ; antibiotics use, 3.50 ± 1.98 weeks; ear drops, 1.20 ± 1.24 bottles. Except for length of stay ($P < 0.05$), there is no significant difference in medical utilization within 1 year after tympanomastoid surgery between different disease groups ($P > 0.05$; Table 2). Patients in the wet-ear group tend to stay longer in the hospital (4.48 ± 0.93 versus 3.84 ± 0.98 , $P < 0.05$); but the postoperative visit number and medication use (both antibiotics and ear drop) are similar in both groups.

The recurrence rate within 1 year after tympanomastoid surgery is 5.2%. A total of 4 revision surgeries are identified. The reoperation rates are 3 (5.2%) for the wet-ear group and 1 (5.3%) for the dry-ear group. There is no significant difference in recurrence rates between the disease groups ($P > 0.05$).

One-Year Cumulative Cost

The operation (NT\$ 19,447.1) and anesthesia (NT\$ 6906.1) fees comprise 55% and 19% of the up-front admission cost (NT\$ 35,691.94), respectively. The inpatient medication, laboratory, and physician fees comprise 5%, 4%, and 3% of the up-front admission cost, respectively. The ward fee is 9% of the up-front admission cost, based on an average of 4.3 days' stay in the hospital. The admission cost structure analysis is shown in Figure 1.

The average cumulative cost within a 1-year period after tympanomastoid surgery is NT\$ 45,716.3. The components of tympanomastoid surgery cost structure are as follows: admission cost, NT\$ 35,691.9 (78.07%); outpatient services cost, NT\$ 8112.7 (17.75%); and readmission cost, NT\$ 1911.7 (4.18%). The cumulative costs for different disease groups are listed in Figure 2.

Utility Gain

The average utility gain is 24.7 ± 3.0 in the change of the CES total scores. The utility gains for different disease groups are as follows: wet-ear group, 37.6 ± 3.4 ; and dry-ear group, 24.4 ± 2.2 (Fig 3). There are significant differences in the changes of the CES total scores between disease groups ($P < 0.05$).

Cost–Utility Ratio

The average CUR (\$NT/utility gain) is 1850.9 New Taiwan dollars per utility gain, and the CURs for different disease groups are as follows: wet-ear group, NT\$ 1280.9; and

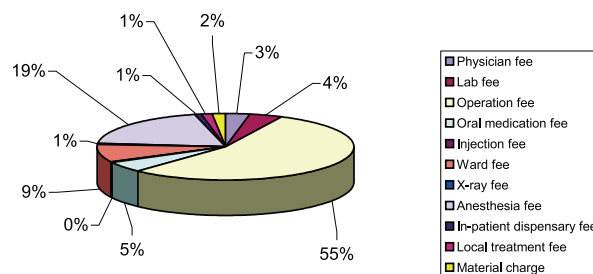


Figure 1 Cost structure for the surgical treatment of CSOM.

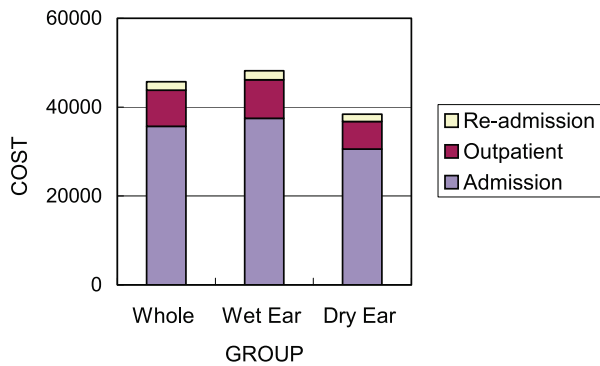


Figure 2 One-year cumulative cost for surgical treatment of CSOM.

dry-ear group, NT\$ 1574.6 (Fig 4). There is a significant difference in the CUR between disease groups ($P = 0.0001$).

Sensitivity Test

In general, shortening length of stay by 1 day (discounting the sum of NT\$ 1807 from daily physician, ward, nursing, dispensary, intravenous fluid, and local treatment charges; Table 1) will reduce average CUR by NT\$ 73.1 for the whole group. Improving the reoperation rate by 1% (discounting readmission cost by NT\$ 374.7) will reduce average CUR by NT\$ 15.1.

DISCUSSION

Cost-effectiveness analysis (CEA) is a method for evaluating the outcomes and costs of interventions designed to improve health. The results are usually summarized in CURs that demonstrate the cost of achieving a unit of health effect for diverse types of patients or for variations of intervention. In a CUR, changes in health caused by an intervention can be captured in the denominator; and changes in resource use, valued in monetary terms, are captured in the numerator. The central function of CEA is to

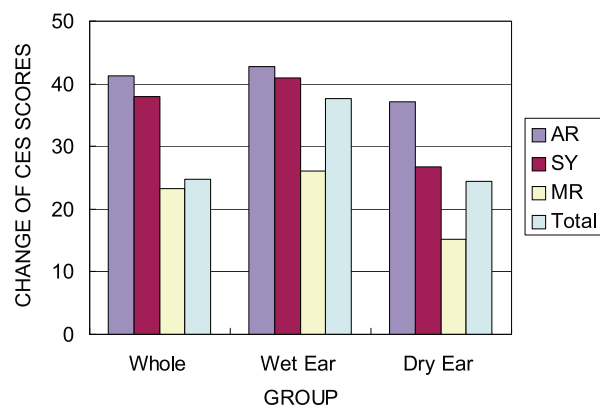


Figure 3 One-year utility gain after tympanomastoid surgery.

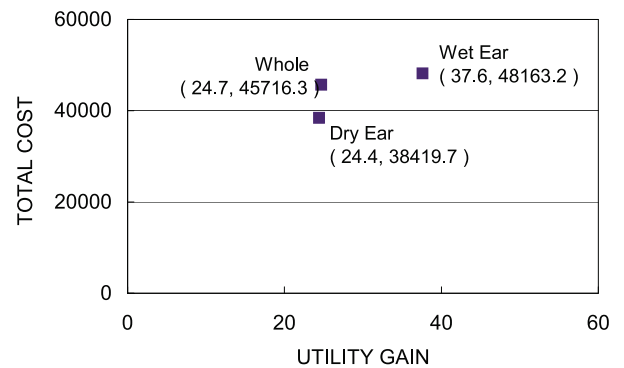


Figure 4 Cost-utility ratio for surgical treatment of CSOM.

show the relative values of alternative interventions for improving health. Information provided by CEA can help decision makers in a variety of settings to prioritize their constrained medical resources.¹⁻³

The average total direct cost attributable to CSOM in the 1-year period after tympanomastoid surgery is NT \$45,716.3, or US\$ 1364.6 (2000~2001 average exchange rate, 33.5 NT\$ to 1 US\$); the majority of that cost stems from the up-front operation-related fees (operation, 43.0%; anesthesia, 15.1%). Treating wet-ear group patients is more expensive; the 1-time admission cost is 23% higher in the wet-ear group (NT\$ 37,490.0) than that of NT\$ 30,574.4 in the dry-ear group. Our data demonstrate that the upfront cost is sensitive to the change of operation cost, anesthesia time, and length of stay in the hospital. For example, the variance in cost-effectiveness regarding length of stay for the whole group shows that the reduction of hospitalization by 1 day will reduce the CUR value by 3.9% accordingly.

The aftercare expenses during the 1st year after tympanomastoid surgery comprise 17.7% (16.07% for the dry-ear group and 17.9% for the wet-ear group) of the total 1-year cumulative cost. The 1-year postoperative outpatient services cost is nearly 40% higher in the wet-ear group (NT\$ 8665.2 versus NT\$ 6176.2); the difference of NT\$ 2489 may partly attribute to the significant difference in cumulative cost between 2 disease groups. Data from previous CEA research on the endoscopic sinus surgery demonstrated that the after-care expenses were case sensitive and might amount to one fourth of the total cumulative cost.⁷ Our data in this study prove that outpatient medical resource utilization during the 1st postoperative year is also a major determinant of cumulative costs after chronic ear surgery.

A conservative, short-term estimation on rate of recurrence or failure for the chronic ear surgery is around 5% in this study. Merchant et al⁸ reported a 95% so-called dry-ear rate with a minimum of 12 months' follow-up after chronic ear surgery. A review of the otologic literature indicates that the incidence of dry ears in various large clinical series ranges between 70% and 95%⁹⁻¹⁵; greater differences between wet-ear and dry-ear groups in recurrence rates might be observed over time. However, the readmission cost plays a relatively minor role by comprising only 4.18% of the total cumulative cost. Sensitivity simulation shows that the

reduction of revision rate by 1% will barely reduce the CUR value by 0.8% accordingly.

Theoretically, healthcare effectiveness can be measured in terms of quality-of-life-years (QALYs); use of interval-scaled, patient-perceived health status to serve as a utility measure also is an acceptable alternative. As an adjunct to objective clinical findings, the CES we used in this study is a well-established subjective outcome measure in reporting tympanomastoid surgery results.¹⁶⁻¹⁸ The change in the CES total score of 24.7 ± 3.0 points for the whole population is suggestive of a meaningful enhancement in their ear-related quality of life. We found that the effects of surgery are particularly remarkable for patients with draining ears. The significantly superior improvements of all CES subscores (AR, SY, MR) are observed in the wet-ear group.

The average CUR indicates that the average cost is around \$1850 New Taiwan dollars, or \$55.2 US dollars to gain 1 unit of ear-specific quality-of-life. The CUR is a product of sophisticated multifactorial effect; even though the 1-year cumulative cost for the wet-ear group of NT\$ 48,163.2 is 25% higher than that of the dry-ear group (NT\$ 38,419.7), the favorable CUR for wet-ear group is caused by its preferred utility gain (54% greater than that of dry-ear group). Our data support that treating continuous or intermittent chronic draining ear is most cost-effective because of their favorable utility gain and relatively reasonable cost. However, the efficacy of surgery for dry chronic otitis media should not be discouraged by these cost utility data; patients in the dry-ear group still proved to benefit from surgery by showing significant improvement in their quality of life (Fig 3).

This study has followed the consensus in reporting CEA results.¹⁻³ However, because the actual direct costs of tympanomastoid surgery are difficult to obtain, readers are reminded that the cost calculations in this study are based on hospital bills (claim data); the price variation and intangible opportunity costs are not taken into consideration. Also, the cost–utility methodology can be limited by the assumptions underlying its model, and the exploration of this study might be restricted by the relatively small cohort data from a single institution.

CONCLUSION

CSOM is one of the most common surgical disease entities in otolaryngology practice. The cost–utility data generated from this study provide more scientific evidence for the establishment of tympanomastoid surgery practice guidelines. We find that treating continuous or intermittent drain-

ing ear is more cost-effective, as compared with managing a quiescent infection, because of its favorable utility gain. Disease subclassification and outcomes data are key information needed for a cost-effective approach to tympanomastoid surgery.

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