Objective: To determine the costs and effectiveness of treatment with ventilation tubes as compared with watchful waiting in children with persistent otitis media with effusion.

Design: Randomized controlled trial.

Setting: Institutional practice.

Patients: A total of 187 young children (19 months old) with persistent bilateral otitis media with effusion.

Interventions: Treatment with ventilation tubes or watchful waiting.

Main Outcome Measures: The time without effusion, language development, and the costs from a societal perspective during 1-year follow-up.

Results: The mean duration of effusion was 9.2 months in the watchful waiting group and 4.7 months in the ventilation tube group. The language development was comparable in both groups (0.7 month of improvement difference [95% confidence interval, −0.3 to 1.7 months] after correction for confounding variables). Because no statistically significant differences were found in the language development between the treatment groups, we performed a cost minimization analysis. The mean costs per child during 1 year of follow-up were US $454 in the ventilation tube group and US $120 in the watchful waiting group. On average, an additional investment of US $334 per patient was needed for ventilation tube treatment.

Conclusion: In the absence of differences in language development and in view of higher costs, treatment with ventilation tubes is not recommended as standard treatment in all young children with persistent otitis media with effusion traced by a population-based screening program.


Otitis media with effusion (OME) is one of the most common diseases in childhood. The term OME refers to an accumulation of fluid in the middle ear cavity behind an intact membrane without the signs and symptoms of an acute infection. By 2 years of age, 70% of children have had OME at least once; at 4 years of age, this percentage is 80%. The most common surgical intervention for OME is the insertion of ventilation tubes (VTs), a technique introduced by Armstrong in 1954. The aim of treatment with VTs is to resolve the effusion, to restore the hearing level, and to prevent potential language developmental problems. Ventilation tubes may also prevent irreversible changes to the middle ear structure, like tympanosclerosis.

The reported estimated costs of tube insertion range from US $937 to $2174 per treatment. The annual costs of chronic OME are approximately US $2 billion for the United States. These cost studies are based on theoretical models that estimate, rather than directly measure, the different components of OME-related costs.

Moreover, the costs of OME have never been related to clinical outcomes other than time without effusion, while the magnitude and duration of time without effusion due to the insertion of tubes were limited. The question of whether treatment with VTs is justifiable, however, also depends on other effects such as a possible prevention of delayed language development. This effect needs to be studied before conclusions can be drawn about the effectiveness of treatment with VTs in infants with persistent OME.

We conducted a large multicenter randomized trial of the effect of treatment with VTs on time without effusion, hearing level, language development, and quality of life.
PATIENTS AND METHODS

PATIENTS

The randomized controlled trial was described in detail by Rovers et al. The trial was embedded in a cohort that included children born in the eastern part of the Netherlands between January 1, 1996, and April 1, 1997. These children were invited for routine hearing screening at the age of 9 months. For the purpose of the trial, those who failed 3 successive tests were referred to 1 of the 13 participating ear, nose, and throat (ENT) outpatient clinics for diagnosis and follow-up. Children for whom informed consent was obtained were randomly allocated (by means of a balanced allocation method) to 1 of 2 groups: the VT group, who received treatment with VTs (Bevel Bobbins; Entemed BV, Woerden, the Netherlands), or the WW group, who underwent a period of observation. The follow-up period was 1 year. We obtained approval from the ethical committees of all 13 participating hospitals.

OUTCOME MEASURES

Two outcome measures were used in the cost-effectiveness analysis: time without effusion and language development. Language development was considered the most important outcome measure. Time without effusion was used as a disease-specific outcome measure. In all hospitals, OME was defined according to the Maastricht Otitis Media With Effusion Study (MOMES) protocol, which is primarily based on tympanometry. The tympanograms were classified according to Jerger. If tympanometry could not be performed, or if the tympanograms were doubtful (type C2), otoscopy was used to reach a diagnosis. Both otoscopy and tympanometry were performed every 3 months. The mean time spent with OME was calculated on the basis of these 3 monthly measurements. If a child had OME at 2 successive measurements, the days between these measurements were counted as days with effusion. If, on the other hand, a child had OME at the first measurement but not at the second, only half of the days were counted as days with effusion. The Reynell test and the Schlichting test were used to measure comprehensive language development and expressive language development, respectively. Scores were obtained as age standardized and equivalent age. Both language tests were performed at baseline and every 6 months.

RESULTS

The patient flow is presented in Figure 1. Between January 1, 1996, and April 1, 1997, 30,099 children were born. A total of 1,081 children failed 3 successive screening tests and was referred to an ENT clinic. Parents of 386 children were invited to enter their child in the trial. A total of 187 children were randomized: 93 children to the VT group and 94 to the WW group. Of these 187 children, less than 30% of all diaries were completed for 13 and less than 50% of all diaries were completed for 13 and 275 = 139 days = 4.5 months (Table 2).

No relevant differences were found in expressive or comprehensive language between the 2 groups. At 12 months of follow-up, the children in the WW group had improved by 0.8 month (95% confidence interval, –0.1 to 1.6 months), while the children in the VT group had improved by 1.8 months (95% confidence interval, 1.0–2.6 months). After adjustment for educational level of the mother, IQ of the child, and language development at baseline, the children in the VT group improved 0.7 month (95% confidence interval, –0.3 to 1.7 months) more than the children in the WW group.

OUTCOME MEASURES

Differences in the mean duration of effusion during 1-year follow-up between the VT and WW groups were (398 – 140) – (394 – 275) = 139 days = 4.5 months (Table 2).

Both medical and nonmedical costs were determined. Costs were calculated on the basis of real costs rather than charges. Costs per patient were calculated by multiplying prospectively measured quantities per patient with a fixed cost price and converted to US dollars ($1 = NLG 1.98).

Cost prices were calculated according to guidelines for economic evaluations in health care research. All prices were based on the price level of 1998. Older prices were
adjusted to the price level of 1998 with price index numbers. Real cost prices were calculated for the following items: insertion of tubes, hospital stay (day care), and outpatient visit to an ENT surgeon. These prices were calculated in both a teaching hospital and a general hospital. In- tegral cost prices were calculated, which included employee costs, costs for materials, depreciation costs for inventory, and overhead costs. Costs of the ENT surgeon in the teaching hospital were based on the wage classification. Costs of the ENT surgeon in the general hospital were based on guidelines. Overhead costs included housing, cleaning, and the costs of nonproductive departments in a hospital. In the general hospital, no overhead costs could be calculated. Prices were adjusted by means of the percentage overhead costs of each price in the teaching hospital. A weighted mean of the 2 prices was calculated with the ratio of the national number of outpatient visits in general hospitals and teaching hospitals. For the medication, the costs of a standard dose in each week were calculated. If more than 1 cost price was available, the lowest price was chosen. The price of adenoidectomy was based on charges. The costs of visits to a general practitioner and the cost price per kilometer were valued according to guidelines. The distance to a general practitioner or the hospital was noted in the diaries. Other nonmedical costs were directly noted in monetary units in the diaries.

The medical costs were classified as costs of tube insertion, adenoidectomy, ENT outpatient visits, visits to the general practitioner, medication on prescription, and other medical costs related to OME. The costs of tube insertion consisted of costs for surgery (tube insertion), hospital stay (day care), and 3 visits to the ENT surgeon. Nonmedical costs were divided into traveling costs, costs of medication not on prescription, costs of extra help (babysitter and family), and other expenses related to OME.

Diaries were corrected for missing periods by means of the patient-year approach. For each patient, the missing periods were filled with the mean quantities and expenses the patient had before he or she dropped out. Patients with more than 50% of the diaries missing were not included in the cost-effectiveness analysis. After correction, the mean, median, and interquartile range of the costs were calculated.

ANALYSIS

Time without effusion, language development, and costs were compared between the VT and WW groups. Differences in time without effusion were tested with the $t$ test. Differences in language development at 0, 6, and 12 months of follow-up as well as differences between 12 and 0 months of follow-up between the groups were tested with the $t$ test for independent groups. To adjust for potential confounders and to study possible effect modifiers, a regression analysis was performed (more detailed information in Rovers et al11). The Wilcoxon test was used to test the difference in the mean total costs between the VT and WW groups.

In the incremental cost-effectiveness ratio (ICER), differences in the mean total costs between the treatment groups were compared with differences in language development. A bootstrapping technique was used to provide a confidence interval for the ICER. In this analysis, 1000 samples were made from the clinical data. For each sample, an ICER was calculated and plotted in a figure.

A sensitivity analysis was performed to examine the robustness of the findings. The prices of the surgery (VTs), hospital stay (day care), and visits to an ENT surgeon were varied. In addition to the baseline estimate, for each of these prices, 3 values were available: the charge, the calculation in a teaching hospital, and the calculation in a general hospital. The lowest and the highest values of these 3 prices were included in the sensitivity analyses.

In this trial, a difference between the VT and WW groups was found in mean time without effusion. However, the estimate of the number of days without OME might not be very precise. If a child had OME at the first measurement but not at the second, only half of the days were counted. Thus, there is a potential for measurement error. A solution might be to measure OME more frequently, but this is difficult in practice.

No differences in language development were found between the treatment groups. The results do not correspond to the findings by Maw et al, who reported a marginal effect on language development. An explanation might be that the children in our trial were younger (19 months in this study vs 3 years in the study by Maw et al). Also, the children in the trial by Maw et al were included because of complaints, whereas the children in our trial were traced by a population-based screening program. The confidence interval around the difference in language development (−0.3 to 1.7 months) might introduce questions about the possible type II error. The upper limit of the confidence interval, 1.7 months' difference in language development, might reach signifi-
cance. However, the trial was designed to detect a difference of 3 months. The question is raised whether the follow-up period was long enough to measure the effect of VT on language development. Because of the short duration of the effect of VTs (recurrent effusion) and spontaneous recovery in the WW group, it is not to be expected that an effect would have appeared after a longer follow-up period. Furthermore, the critical age for language development is between 1 and 2 years. In our study, the mean age at randomization was 19 months. After 12 months of follow-up (mean age, >2 years), no differences in the age-standardized scores for language development were found between the treatment groups.

The mean total cost per patient was US $454 in the VT group. Several other studies have presented the costs of treatment of otitis media.7-9,24,25 The costs in our VT group were low compared with costs presented in the literature. Berman et al,7 for instance, estimated the costs related to tube insertion to be on the order of US $957 to $1800. A first explanation might be that, in our study, differences in costs between the 2 groups were calculated. This means that costs of outpatient visits before the surgery and costs of diagnostic tests (audiometry and tympanometry) were not included because these activities were also performed in the WW group. Second, the costs were based on real prices. These prices were partly based on the prices in a teaching hospital. In this hospital, many activities were performed by registrars instead of registered ENT surgeons. This means that the costs of employees were relatively low. Third, treatment with antibiotics for OME is rare in the Netherlands, whereas these antibiotics form a substantial part of the total medical costs in some of the studies reported in the literature.9 Finally, the nonmedical costs were low. In this study, the parental time was not included in the cost analysis because the data on this aspect were deficient. However, it was often the mother who attended the child during visits to the hospital, mostly not during paid work.

### Table 1. Baseline Characteristics of 187 Patients*

<table>
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<tr>
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<th>VT Group (n = 93)</th>
<th>WW Group (n = 94)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sex, No. (%) F</td>
<td>38 (41)</td>
<td>39 (41)</td>
</tr>
<tr>
<td>Age, mean (SE), mo</td>
<td>19.5 (1.7)</td>
<td>19.4 (1.9)</td>
</tr>
<tr>
<td>Hearing threshold level, mean (SE), dB</td>
<td>46.4 (1.1)</td>
<td>43.4 (1.2)</td>
</tr>
</tbody>
</table>

*VT indicates ventilation tube; WW, watchful waiting.

### Table 2. Days With Effusion for 174 Children Included in the Cost-effectiveness Analysis*

<table>
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<tr>
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<th>VT Group (n = 88)</th>
<th>WW Group (n = 86)</th>
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<tbody>
<tr>
<td>No. of days with OME, mean (% of total)</td>
<td>140 (35)</td>
<td>275 (70)</td>
</tr>
<tr>
<td>Total days of follow-up, mean</td>
<td>398</td>
<td>394</td>
</tr>
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</table>

*VT indicates ventilation tube; WW, watchful waiting.
About 50% of the parents eligible for the trial refused randomization. This might decrease the generalizability of the trial results. In a separate article, the results for the children in this trial were compared with results for the children of 133 parents who refused randomization but gave informed consent to follow up. No differences were found between these 2 groups of children. Furthermore, patients were included on duration-based criteria in this study. Some other criterion might be relevant in the decision to perform surgery. Another part of this trial attempted to define subgroups that might benefit from VTs. However, the power of the study was too low to detect relevant effects in a subgroup analysis.

In the absence of differences between the VT and WW groups in language development and in view of higher costs in the VT group, the trial results suggest that there is no need for treatment with VTs for all young children with persistent OME who are traced by a population-based screening program.

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REFERENCES