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EFFECT OF EARLY OR DELAYED INSERTION OF TYMPANOSTOMY TUBES FOR PERSISTENT OTITIS MEDIA ON DEVELOPMENTAL OUTCOMES AT THE AGE OF THREE YEARS

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ABSTRACT

Background A main indication for the insertion of tympanostomy tubes in infants and young children is persistent otitis media with effusion, reflecting concern that this condition may cause lasting impairments of speech, language, cognitive, and psychosocial development. However, evidence of such relations is inconclusive, and evidence is lacking that the insertion of tympanostomy tubes prevents developmental impairment.

Methods We enrolled 6350 healthy infants from 2 to 61 days of age and evaluated them regularly for middle-ear effusion. Before the age of three years 429 children with persistent effusion were randomly assigned to have tympanostomy tubes inserted either as soon as possible or up to nine months later if effusion persisted. In 402 of these children we assessed speech, language, cognition, and psychosocial development at the age of three years.

Results By the age of three years, 169 children in the early-treatment group (82 percent) and 66 children in the late-treatment group (34 percent) had received tympanostomy tubes. There were no significant differences between the early-treatment group and the late-treatment group at the age of three years in the mean (\pm SD) scores on the Number of Different Words test, a measure of word diversity (124 ± 32 and 126 ± 30 , respectively); the Percentage of Consonants Correct-Revised test, a measure of speech-sound production (85 ± 7 vs. 86 ± 7); the General Cognitive Index of McCarthy Scales of Children's Abilities (99 ± 14 vs. 101 ± 13); or on measures of receptive language, sentence length, grammatical complexity, parent-child stress, and behavior.

Conclusions In children younger than three years of age who have persistent otitis media, prompt insertion of tympanostomy tubes does not measurably improve developmental outcomes at the age of three years. (N Engl J Med 2001;344:1179-87.)

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MYRINGOTOMY with the insertion of tympanostomy tubes is the most common operation among children beyond the newborn period in the United States; an estimated 280,000 children younger than three years of age underwent the operation in 1996 (Kozak LJ: personal communication). A main indication for the procedure in young children is persistent otitis media with effusion,^{1,2} which because of its commonly associated conductive hearing loss,³ has been thought to result in lasting impairments of speech, language, cognitive, and psychosocial development.⁴ Current guidelines of the American Academy of Otolaryngology-Head and Neck Surgery list otitis media with effusion of more than three months' duration as an appropriate indication for the insertion of tympanostomy tubes,² and guidelines issued by the Agency for Health Care Policy and Research for children one through three years of age list this procedure as optional when otitis media with effusion has been present for three months and as recommended when the condition has been present for four to six months, provided in each circumstance that the effusion is accompanied by bilateral hearing loss characterized by a hearing-level threshold of 20 dB or more (higher values reflect poorer hearing).¹

Studies addressing possible relations between otitis media in young children and subsequent developmen-

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tal outcomes have had important limitations, and the results have been inconsistent.⁵ Moreover, all the studies have been associational in nature and accordingly unable to address the issue of causality. The present trial was part of a larger study⁵ designed to address two interrelated questions: whether, in young children, the presence of middle-ear effusion for a period sufficient to be considered developmentally threatening by many investigators actually results in developmental impairments, and whether prompt insertion of tympanostomy tubes protects against or minimizes subsequent impairment.

METHODS

General Procedures

Between May 1991 and December 1995, we enrolled a total of 6350 healthy infants who were 2 to 61 days of age at eight sites in the greater Pittsburgh area: Children's Hospital of Pittsburgh, Mercy Hospital of Pittsburgh, and two small-town and rural and four suburban private pediatric group practices. The study was approved by the institutional review boards of the two hospitals. Written informed consent was obtained from one or both parents of each enrolled infant. The study procedures have been described previously.⁶⁻⁸ In brief, we excluded infants who met any of the following criteria: a birth weight of less than 2270 g (5 lb), a small size for gestational age, a history of neonatal asphyxia or other serious illness, a major congenital malformation or chronic illness, or the product of a multiple birth. Infants were also excluded if they had a sibling enrolled in the study; they were in foster care or adopted; their mother was dead, seriously ill, a known drug or alcohol abuser, or (in the judgment of study personnel) too limited socially or intellectually to give informed consent or adhere to the study protocol; their mother was younger than 18 years of age; or English was not the only language spoken in the household.

We used pneumatic otoscopy, supplemented by tympanometry, to evaluate the middle-ear status of the children at least monthly until they were three years old. We continually monitored the validity of the study clinicians' otoscopic observations and found satisfactory levels of interobserver agreement. Antimicrobial drugs were routinely prescribed for episodes of acute otitis media; they were also routinely prescribed for episodes of otitis media with effusion until 1995 but were prescribed selectively thereafter.

Audiometric Testing

Audiometric testing was carried out whenever possible in all children who had unilateral or bilateral middle-ear effusion continuously for eight weeks, every four weeks thereafter as long as effusion remained present, and once effusion had resolved. Audiometric testing was also conducted in a sample of children to serve as a presumably normative comparison group. These children either had never had middle-ear effusion or had not had middle-ear effusion for at least 60 days and were selected so as to represent a range of age groups. Audiometric testing was also conducted in all children about to undergo developmental testing and in any child in whom hearing loss was suspected by a parent or a clinician.

Hearing levels were defined with the use of data on auditory brain-stem responses in infants younger than six months of age and pure-tone data in children six months of age or older. For behavioral testing, stimuli were presented in the sound field to children up to 2½ to 3 years of age and by means of earphones to older children. For each behavioral test the reliability of the results was rated by the audiologist performing the test as good, fair, or poor. On the basis of the data obtained in children who had no effusion, abnormal results were defined as an auditory brain-stem-response threshold more-than-20-dB above the normal hearing level or a pure-tone average more-than-25-dB hearing level up to the age of

10 months, more-than-20-dB hearing level from 10 to 23 months, and more-than-15-dB hearing level from the age of 2 years onward.

Estimation of Cumulative Proportions of Days with Middle-Ear Effusion

We used the term "middle-ear effusion" to encompass all types of otitis media in which effusion is present: acute otitis media with or without otorrhea, otitis media with effusion, and otorrhea through a tympanostomy tube. To determine eligibility for the randomized trial, we estimated the cumulative proportions of days each child had unilateral effusion and bilateral effusion on the basis of diagnoses made at individual visits and interpolations for intervals between visits. The rules we used to determine eligibility were more restrictive⁹ than the ones we used to assess the outcomes after randomization.⁶⁻⁸

The Randomized Clinical Trial

Children became eligible for the randomized clinical trial if, beginning at the age of 2 months and within the first 3 years of life, they had middle-ear effusion that appeared substantial in degree and that persisted, despite treatment with antimicrobial drugs, for 90 days in the case of bilateral effusion or 135 days in the case of unilateral effusion. Children with intermittent bilateral or unilateral middle-ear effusion for specified proportions of longer periods were also eligible (the criteria are listed in Appendix 2, available with the full text of the article at <http://www.nejm.org>). For example, a child would be eligible if he or she had had bilateral effusion for 67 percent of the preceding 180-day period or unilateral effusion for 67 percent of the preceding 270-day period. Children who met one of these criteria and whose parents or guardians gave written informed consent were stratified according to practice site, age (in six-month categories), and whether the eligibility criteria were met on the basis of bilateral or unilateral effusion. They were then assigned randomly, within these strata and in balanced blocks of four, to undergo either early or late insertion of tympanostomy tubes. Assignments were made by designated nonclinical staff members using separate, computer-generated lists of random numbers. Children assigned to the early-treatment group were scheduled to have tympanostomy tubes inserted as soon as practicable. Those assigned to the late-treatment group were to undergo the operation six months later if bilateral effusion persisted or nine months later if unilateral effusion persisted, but children in this group could receive tubes earlier if their parents requested the operation. Children for whom consent for randomization was withheld were offered tube insertion electively. In all children the tubes were inserted according to conventional methods¹⁰ and allowed to remain in place until they were extruded spontaneously.

Developmental Tests and Procedures

We attempted to conduct developmental testing of children as soon as possible after their third birthday, and in any case within two months afterward. Whenever possible, developmental testing was conducted only if on the same day the child's hearing level met specified criteria. For children whose hearing was tested by means of earphones, the criteria consisted of a hearing-level threshold of 15 dB or less in each ear at 1000, 2000, and 4000 Hz. For children tested in the sound field, the criteria consisted of a hearing-level threshold of 20 dB or less at 500, 1000, 2000, and 4000 Hz. Children who failed the hearing test were scheduled to be retested when feasible. When retesting was not feasible or when children failed the hearing test at or near the end of the two-month period of developmental testing, developmental testing was undertaken without further delay. We used three methods of developmental assessment: formal, norm-referenced tests; samples of conversation; and parent-reported inventories (Table 1). Details concerning test conditions, examiners, and procedures and the recording, transcription, and analysis of conversational samples have been described previously.^{7,8,14} The examiners and transcriptionists were unaware of the children's histories and health insurance status and their mothers' level of education.

Statistical Analysis

All analyses excluded findings concerning middle-ear status within the first two months of life. We assumed a priori that a difference of 0.33 SD or more between groups on any outcome measure could be clinically important. On the basis of an assumption that only poorer outcomes in the late-treatment group would be clinically important, we calculated that 182 children would be needed in each group for the study to have the ability to detect a difference of 0.33 SD at a power of 0.80. Results of the clinical trial were based on the intention-to-treat principle. We used two-tailed tests for all analyses. We used chi-square tests to evaluate differences in proportions among children in different groups. We used analysis of variance to test for differences between mean values, and a modification²⁰ to test for differences involving trends. We used linear regression analysis to adjust for potentially confounding variables.

RESULTS

Study Sample and Treatment Groups

Of 6350 children enrolled in the larger study, 588 eventually met the eligibility criteria for the clinical trial. A total of 429 of these children (73 percent) underwent randomization after their parents or guard-

ians gave consent, and 402 of the 429 children (94 percent) received developmental testing at the age of three years (Fig. 1). Selected demographic and clinical characteristics of the 402 children who were tested are shown in Table 2. Their mean age when they met the randomization criteria was 15 months, and their median age was 14 months; 57 percent were boys, and 60 percent were white. In 73 percent of the children who met the criteria on the basis of having unilateral middle-ear effusion, bilateral effusion had been present for more than 25 percent of the preceding six-month period. In 380 of the children (95 percent), developmental testing was completed within two months after their third birthday. In comparison with the 429 children who underwent randomization, a higher proportion of the 159 children whose parents declined to consent to randomization were seen at urban study sites (62 percent vs. 50 percent, $P=0.02$) and a lower proportion were seen at facilities in small towns or rural areas (23 percent vs. 35 per-

TABLE 1. DEVELOPMENTAL TESTS PERFORMED IN THE CHILDREN AT THE AGE OF THREE YEARS.

| TYPE OF TEST | FOCUS OF TEST | TEST | SCORING METHOD* |
|---|--|---|--|
| Formal, norm-referenced | Cognition† | McCarthy Scales of Children's Abilities, including General Cognitive Index and Verbal, Perceptual Performance, and Quantitative Subscales ¹¹ | The number of correct responses is calculated. The normative mean score is 100 ± 15 on the General Cognitive Index and 50 ± 10 on each subscale. |
| | Receptive language† | Peabody Picture Vocabulary Test—Revised ¹² | The number of correct responses is calculated. The normative mean score is 100 ± 15 . |
| Assesses a sample of approximately 15 minutes of spontaneous conversation | Expressive language† | | |
| | Word diversity | Number of Different Words ¹³ | With use of a computer-assisted analysis of the transcribed sample, all first-occurrence word roots, ignoring inflectional morphemes, are counted in all utterances. ¹⁴ |
| | Sentence length and grammatical complexity | Mean Length of Utterance in Morphemes ^{15,16} | With use of a computer-assisted analysis of the transcribed sample, the mean length of all utterances that were both complete and intelligible is calculated. ¹⁴ |
| Parental report, norm-referenced | Speech-sound production | | |
| | Percentage of intended consonants that are articulated correctly | Percentage of Consonants Correct—Revised ¹⁷ | With use of a computer-assisted analysis of the phonetically transcribed sample, the first 100 first-occurrence words in the transcript are analyzed. ¹⁴ |
| | Parental distress‡ | Parenting Stress Index, Short Form ¹⁸ | Parent rates the parent-child dyad on 36 items in 3 subscales in terms of the degree of agreement with each statement (“strongly agree,” “agree,” “not sure,” “disagree,” or “strongly disagree”). The total of the subscale scores is the Total Stress score. The normative mean scores are 26 ± 7 for the Parental Stress subscale, 19 ± 5 for the Parent-Child Dysfunctional Interaction subscale, 26 ± 7 for the Difficult Child subscale, and 71 ± 15 for the Total Stress score. |
| | Behavior‡ | Child Behavior Checklist ¹⁹ | Parent rates the child's overall behavioral and emotional health by responding to 99 items and scoring each statement as “not true,” “somewhat or sometimes true,” or “very or often true.” The results are organized into 6 specific scales and a miscellaneous scale. Scores of the 6 specific scales and a Total Problem score are calculated and converted to T scores. ¹⁹ The normative mean T score on each scale and for Total Problems is 50 ± 10 . |

*Plus-minus values are means \pm SD.

†Higher test scores reflect more favorable results.

‡Higher test scores reflect less favorable results.

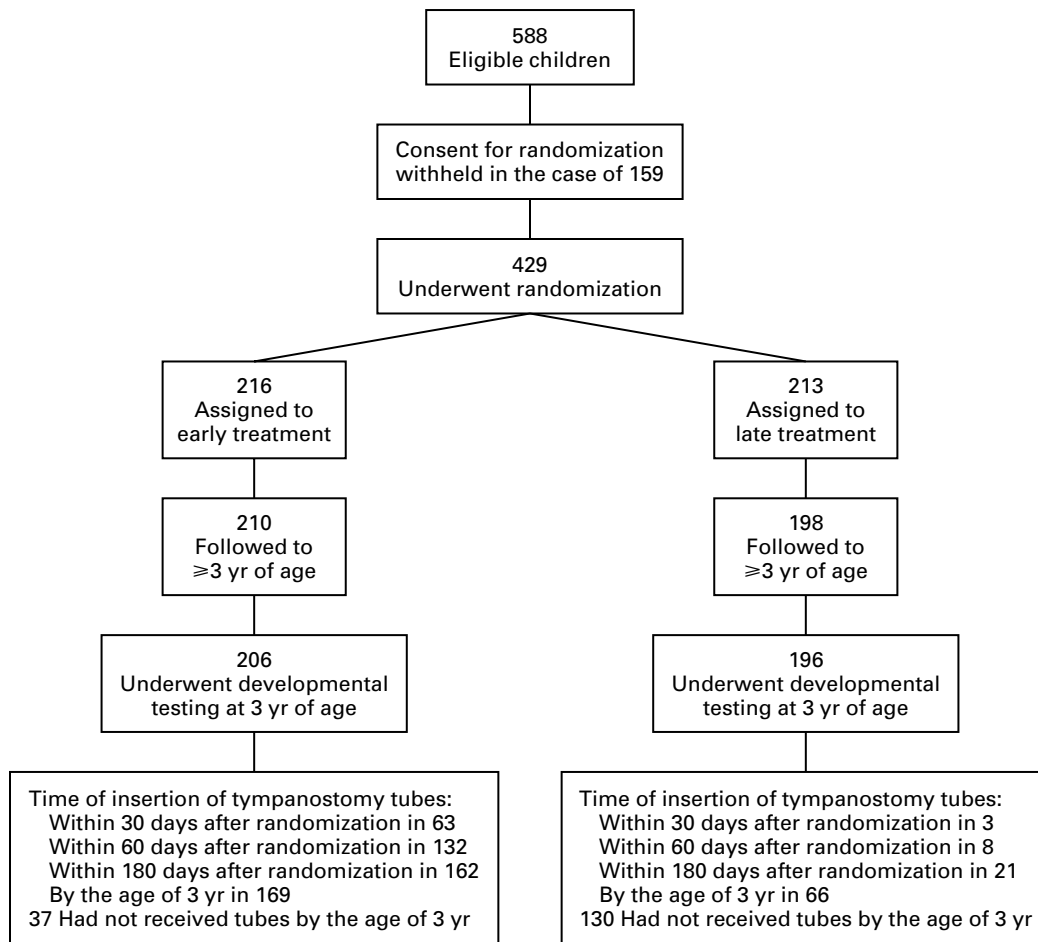


Figure 1. Enrollment and Randomization of the Children and the Time of Insertion of Tympanostomy Tubes.

cent, $P=0.005$); there were no other significant differences in demographic or clinical characteristics. Also, there were no significant differences in characteristics between the 402 children who received developmental testing and the 27 randomized children who were not tested, or between the 206 children who were tested in the early-treatment group and the 196 children who were tested in the late-treatment group.

Among the 402 children who were tested, the number who had tympanostomy tubes inserted and the intervals from randomization to insertion are summarized in Figure 1. In the children in the early-treatment group, delays resulted mainly from requirements to obtain third-party authorization; in other children, surgery was initially withheld because the middle-ear effusion cleared or improved markedly soon after randomization, but surgery was subsequently performed because the effusion recurred. In the children in the late-treatment group, tubes were sometimes inserted

before the scheduled time because of supervening episodes of acute otitis media, parental request, or both.

Duration of Middle-Ear Effusion after Randomization

During the first 12 months after randomization, the percentage of children in the late-treatment group who had effusion more than 50 percent of the time was approximately three times the percentage in the early-treatment group. During the first 24 months, the percentage in the late-treatment group was approximately twice that in the early-treatment group (Table 3).

Hearing in Relation to Middle-Ear Effusion

The 402 children underwent 765 audiometric examinations before randomization and 952 examinations after randomization. Of the total, 50 were tests of auditory brain-stem responses and 1667 were behavioral tests. A total of 1522 behavioral tests (91 percent) were conducted in the sound field, and 145

TABLE 2. CHARACTERISTICS OF THE TESTED CHILDREN ACCORDING TO TREATMENT GROUP.*

| CHARACTERISTIC | EARLY-TREATMENT GROUP | LATE-TREATMENT GROUP | ALL CHILDREN (N=402) |
|--|-----------------------|----------------------|----------------------|
| | (N=206) | (N=196) | |
| | no. of children (%) | | |
| Location of study site | | | |
| Urban | 104 (50) | 95 (48) | 199 (50) |
| Small town or rural area | 70 (34) | 73 (37) | 143 (36) |
| Suburban | 32 (16) | 28 (14) | 60 (15) |
| Maternal level of education | | | |
| Less than high school | 25 (12) | 27 (14) | 52 (13) |
| High-school graduate | 80 (39) | 67 (34) | 147 (37) |
| Technical or other training | 83 (40) | 87 (44) | 170 (42) |
| College graduate | 18 (9) | 15 (8) | 33 (8) |
| Health insurance status | | | |
| Medicaid | 132 (64) | 127 (65) | 259 (64) |
| Private | 72 (35) | 68 (35) | 140 (35) |
| None | 2 (1) | 1 (0.5) | 3 (1) |
| Year of life during which randomization criteria were met | | | |
| First | 82 (40) | 80 (41) | 162 (40) |
| Second | 96 (47) | 94 (48) | 190 (47) |
| Third | 28 (14) | 22 (11) | 50 (12) |
| Laterality and sequence of middle-ear effusion serving as basis for meeting randomization criteria | | | |
| Bilateral, continuous | 40 (19) | 33 (17) | 73 (18) |
| Bilateral, discontinuous | 40 (19) | 35 (18) | 75 (19) |
| Unilateral, continuous | 34 (17) | 31 (16) | 65 (16) |
| Unilateral, discontinuous | 92 (45) | 97 (49) | 189 (47) |
| Hearing thresholds at time of developmental testing | | | |
| Protocol-specified criteria met† | 156 (76) | 152 (78) | 308 (77) |
| Protocol-specified criteria not met | 44 (21) | 32 (16) | 76 (19) |
| Audiometric results incomplete or child's hearing not tested | 6 (3) | 12 (6) | 18 (4) |

*Because of rounding, percentages may not equal 100.

†For children tested by means of earphones, the criteria consisted of a hearing-level threshold of 15 dB or less in each ear at 1000, 2000, and 4000 Hz. For children tested in the sound field, the criteria consisted of a hearing-level threshold of 20 dB or less at 500, 1000, 2000, and 4000 Hz.

(9 percent) were conducted with the use of earphones. Both before and after randomization among the children in the two groups, hearing was normal in approximately two thirds of instances in which children were tested when they did not have effusion and abnormal in approximately one half of instances in which they had unilateral effusion during testing and in approximately three quarters of instances in which they had bilateral effusion during testing.

Scores on Developmental Measures

In the study group as a whole, mean scores on all outcome measures were significantly most favorable among the most socioeconomically advantaged children and least favorable among the least advantaged children. On measures of cognition, receptive language, expressive language, and speech-sound production, mean scores were also significantly more favorable in girls than in boys.

The mean scores on measures of cognition, recep-

tive language, expressive language, and speech-sound production are shown in Table 4 (higher scores reflect more favorable results), and the mean scores on parent-rated measures of parent-child stress and children's behavior are shown in Table 5 (higher scores reflect less favorable results). There were no significant differences between the two treatment groups on any measure, either before or after adjustment for age (in months) at the time of testing. Similarly, there were no such differences within subgroups constituted respectively according to the age at which the randomization criteria were met and according to whether the criteria were met on the basis of the presence of unilateral or bilateral effusion.

Among the 159 children whose parents declined permission for randomization, we obtained test results at the age of three years regarding cognition, language, and speech in 105 and regarding parent-child stress and behavior in 79. With the exception of a slightly lower mean score for the Percentage of Consonants

TABLE 3. ESTIMATED PERCENTAGES OF TOTAL DAYS WITH BILATERAL OR UNILATERAL MIDDLE-EAR EFFUSION AFTER RANDOMIZATION.

| FOLLOW-UP PERIOD AFTER RANDOMIZATION | NO. OF CHILDREN* | PERCENTAGE OF DAYS WITH MIDDLE-EAR EFFUSION | | | | | MEAN PERCENTAGE OF DAYS WITH MIDDLE-EAR EFFUSION |
|--------------------------------------|------------------|---|---------|---------|---------|---------|--|
| | | 0-25% | 26-50% | 51-75% | 76-99% | 100% | |
| no. of children (%) | | | | | | | |
| First 6 months | | | | | | | |
| Early treatment | 183 | 74 (40) | 71 (39) | 27 (15) | 10 (5) | 1 (1) | 35† |
| Late treatment | 183 | 24 (13) | 42 (23) | 52 (28) | 34 (19) | 31 (17) | 61 |
| First 12 months | | | | | | | |
| Early treatment | 159 | 89 (56) | 47 (30) | 18 (11) | 5 (3) | 0 | 29† |
| Late treatment‡ | 157 | 27 (17) | 60 (38) | 51 (32) | 17 (11) | 2 (1) | 48 |
| First 18 months | | | | | | | |
| Early treatment | 121 | 71 (59) | 34 (28) | 12 (10) | 4 (3) | 0 | 28† |
| Late treatment | 118 | 26 (22) | 57 (48) | 29 (25) | 6 (5) | 0 | 41 |
| First 24 months | | | | | | | |
| Early treatment | 57 | 29 (51) | 20 (35) | 7 (12) | 1 (2) | 0 | 30† |
| Late treatment | 62 | 15 (24) | 30 (48) | 16 (26) | 1 (2) | 0 | 40 |

*The analysis was limited to children who had no gaps in information concerning middle-ear status during the specified period.

†P<0.001 for the comparison with the late-treatment group after adjustment for laterality of middle-ear effusion that served as the basis for meeting randomization criteria.

‡Because of rounding the percentage does not total 100.

TABLE 4. SCORES ON MEASURES OF COGNITION, LANGUAGE, AND SPEECH AT THE AGE OF THREE YEARS.*

| TREATMENT GROUP | COGNITION | | | | RECEPTIVE LANGUAGE (PPVT-R) | EXPRESSIVE LANGUAGE | | |
|--|----------------------------------|--------------------------|--|--------------------------------|-----------------------------|---------------------|-------------|-------------|
| | McCARTHY GENERAL COGNITIVE INDEX | McCARTHY VERBAL SUBSCALE | McCARTHY PERCEPTUAL PERFORMANCE SUBSCALE | McCARTHY QUANTITATIVE SUBSCALE | | NDW | MLUm | PCC-R |
| Early treatment | | | | | | | | |
| Score | 99±14 | 49±9 | 50±7 | 51±8 | 92±13 | 124±32 | 2.7±0.7 | 85±7 |
| No. of children for whom data were missing | 4 | 4 | 0 | 4 | 3 | 1 | 1 | 1 |
| Late treatment | | | | | | | | |
| Score | 101±13 | 50±9 | 51±8 | 52±8 | 92±15 | 126±30 | 2.8±0.7 | 86±7 |
| No. of children for whom data were missing | 5 | 5 | 3 | 5 | 4 | 3 | 3 | 3 |
| 95% Confidence interval for the difference in mean scores (early treatment minus late treatment) | -4.1 to 1.1 | -2.7 to 0.9 | -2.2 to 0.8 | -2.3 to 0.9 | -2.8 to 2.8 | -7.6 to 4.8 | -0.2 to 0.0 | -2.1 to 0.7 |

*Plus-minus values are means ±SD. The tests and the meaning of the scores are explained in Table 1. Higher scores reflect more favorable results. PPVT-R denotes Peabody Picture Vocabulary Test-Revised; NDW Number of Different Words; MLUm Mean Length of Utterance in Morphemes; and PCC-R Percentage of Consonants Correct-Revised.

Correct-Revised test (84 vs. 86, P=0.04), mean scores for these children did not differ significantly from the mean scores for the children in the randomized study.

DISCUSSION

The rationale of our study hinged on an expectation, based on earlier experience,^{21,22} that children assigned to receive tympanostomy tubes as soon as

possible after randomization would thereafter remain relatively free of middle-ear effusion, whereas in most children in the group assigned to receive tubes up to nine months after randomization, effusion would persist for varying periods. That expectation was borne out. Nonetheless, despite the difference in the duration of effusion, we found no significant differences between the two groups in the range of developmental outcomes that we measured. The associated confi-

TABLE 5. SCORES ON MEASURES OF PARENT-CHILD STRESS AND CHILDREN'S BEHAVIOR AT THE AGE OF THREE YEARS. *

| TREATMENT GROUP | PARENTING STRESS INDEX, SHORT FORM | | | | CHILD BEHAVIOR CHECKLIST | | | | | | |
|---|------------------------------------|---|--------------------------|--------------|--------------------------|-----------------|----------------------|------------------------|---------------------------|----------------------------|----------------|
| | PARENTAL DISTRESS SUBSCALE | PARENT-CHILD DYSFUNCTIONAL INTERACTION SUBSCALE | DIFFICULT CHILD SUBSCALE | TOTAL STRESS | ANXIOUS/DEPRESSED SCALE | WITHDRAWN SCALE | SLEEP PROBLEMS SCALE | SOMATIC PROBLEMS SCALE | AGGRESSIVE BEHAVIOR SCALE | DESTRUCTIVE BEHAVIOR SCALE | TOTAL PROBLEMS |
| Early treatment | 23 ± 8 | 18 ± 6 | 25 ± 8 | 66 ± 18 | 53 ± 5 | 55 ± 7 | 54 ± 7 | 54 ± 6† | 55 ± 7 | 54 ± 6 | 50 ± 10 |
| Late treatment | 24 ± 9 | 18 ± 6 | 26 ± 9 | 68 ± 21 | 53 ± 4 | 54 ± 6 | 54 ± 5 | 53 ± 5 | 54 ± 7 | 53 ± 5 | 49 ± 10 |
| 95% Confidence interval of the difference in mean scores (early treatment minus late treatment) | -2.6 to 0.6 | -1.5 to 0.9 | -1.7 to 1.5 | -5.3 to 2.3 | -0.3 to 1.5 | -0.4 to 2.0 | -0.8 to 1.6 | 0.0 to 2.2 | -1.0 to 1.8 | -0.2 to 2.0 | -0.6 to 3.4 |

*The tests and the meaning of the scores are explained in Table 1. Higher scores reflect less favorable results. Scores for the Parenting Stress Index, Short Form, were available for 206 children in the early-treatment group and 193 children in the late-treatment group; T scores for the Child Behavior Checklist were available for 202 children in the early-treatment group and 193 children in the late-treatment group. A score on every scale was not available for every child. Three children in the early-treatment group and 2 children in the late-treatment group were not among the 402 children who had other developmental assessments at the age of three years.

†P=0.05 for the comparison with the late-treatment group.

dence intervals afforded assurance that differences as small as 0.33 SD favoring the early-treatment group, if present, would have been detected.

One might question whether the absence of any differences reflects the possibility that, even in the children in the early-treatment group, middle-ear effusion had been present long enough before the tubes were inserted to impair development. In that regard, it is instructive to compare developmental outcomes in the children in the late-treatment group with outcomes reported previously in the larger study among three-year-old children in whom effusion was less prevalent. One such subgroup comprised 241 children who were randomly selected and selected within sociodemographic strata and who ranged from having no effusion to having effusion just short of meeting the criteria for the present trial.⁸ The other subgroup was an unselected sample of 2278 children.⁷ Because the sociodemographic compositions of those subgroups differed from that of the present sample and because health insurance status was our most objective indicator of socioeconomic status, we compared developmental outcomes within categories on the basis of health insurance status (Medicaid vs. private insurance). Within these categories, the mean scores on measures of language, speech-sound production, and cognition in the children in the late-treatment group differed little and in no consistent direction from the mean scores in the 241 randomly selected children.⁸ Similarly, the mean scores on measures of parent-child stress and children's behavior in the children in the late-treatment group did not differ significantly from the mean scores in the 2278 unselected children.⁷ These findings argue against the likelihood that antecedent middle-ear effusion poses any developmental risk at the age of three years within the duration of effusion that we studied. The findings also suggest that the weak negative associations we had found in the group of 241 randomly selected children between the cumulative duration of antecedent middle-ear effusion and scores at the age of three years on measures of receptive vocabulary and verbal aspects of cognition⁸ were not causal but rather were the result of confounding.

Certain important caveats apply to our findings. No conclusions are justified concerning children with periods of effusion longer than those that we studied or concerning children whose effusion is accompanied by moderately severe (rather than the usual mild-to-moderate) hearing loss. Longer periods of effusion or more severe degrees of hearing loss may well have adverse developmental effects. Also, relations that were not consistently apparent at the age of three years might become apparent at later ages, either because children's responses when they are older may be more representative of their actual abilities or because certain impairments may emerge only at later ages.²³⁻²⁵

Recently, Maw and colleagues undertook a ran-

domized clinical trial of the effect of the insertion of tympanostomy tubes on language development.²⁶ In that trial, children in the early-treatment group had slightly better scores for receptive and expressive language than children in the watchful-waiting group 9 months but not 18 months after randomization. The design of the trial differed from ours in important ways. First, at enrollment, all children had “disruptions to speech, language, learning, or behavior.” Second, the mean age of the children at randomization was 3 years, whereas in our trial all children were assigned to a treatment group within the first 3 years of life, and most within the first 18 months, during which periods many crucial aspects of language development are taking place. Third, in that trial, many of the children may have had effusion before enrollment for periods much longer than those specified in our trial. Fourth, only language development was assessed and only by means of a single formal test.

How may our results contribute to clinical decision making with respect to young children who have persistent otitis media with effusion? Our results are particularly applicable to the commonly encountered child of less than three years who is otherwise healthy and who has had effusion for the intervals that we studied, with its usual, attendant mild-to-moderate hearing loss, but who has no other, less debatable indications for the insertion of tympanostomy tubes, such as a severe retraction pocket of the tympanic membrane or a recent history of frequent episodes of acute otitis media. For such a child our results indicate that the insertion of tympanostomy tubes cannot be expected to result in improved developmental outcome at the age of three years. This finding may help clinicians and parents weigh the hypothetical risk of developmental impairment at older ages against the established cost and risks of the insertion of tympanostomy tubes.^{1,27-30}

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APPENDIX

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