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Language development in children with recurrent acute otitis media during the first three years of life. Follow-up study from birth to seven years of age

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Abstract
From a cohort of 113 children, followed prospectively from birth during the first three years of life regarding different aspects of acute otitis media (AOM), two study groups were selected for the present investigation: 13 children with recurrent AOM (rAOM, i.e. at least six episodes of AOM during a 12-month period), and 29 children without any AOM episode. The purpose of this study was to analyse the possible effects of early onset rAOM on language development as assessed at four and seven years of age at phoniatric and linguistic examinations performed blindly. There were no differences between the two groups on any of the linguistic analyses performed, although the rAOM group manifested a somewhat better performance on auditory discrimination tests at four years of age. The results of the present study show that rAOM during the first three years of life, in otherwise healthy children, does not cause a detectable delay of language development at four and seven years of age.

Key words: Otitis media; Language development.

Introduction

Acute otitis media (AOM) occurs most frequently in early childhood (Pukander *et al.*, 1982; Ingvarsson *et al.*, 1982; Teele *et al.*, 1989), a period generally considered to be important for language acquisition. Conductive hearing loss, a major complication of middle ear effusion (Paradise, 1981), may impair auditive perception of speech. Hence, children with recurrent bouts of middle ear disease during the first years of life may be considered to be at risk of delayed language development.

During the last decade results have been published of some prospective studies of language development in children, followed from birth with respect to diagnosis of middle ear disease. These results are, however, a matter of controversy. Some of the researchers report having found evidence of a relationship between early otitis media with effusion (OME) and impaired language development (Friel-Patti *et al.*, 1982, 1990; Teele *et al.*, 1984, 1990; Wallace *et al.*, 1988), whereas others have been unable to confirm the existence of any such relationship (Fischler *et al.*, 1985; Roberts *et al.*, 1986, 1988, 1989; Wright *et al.*, 1988). Moreover, studies of the impact on verbal communication by treatment of OME with ventilating tubes have differed in the results obtained (Watanabe *et al.*, 1985; Rach *et al.*, 1991).

This discrepancy in the results obtained by different investigators may be due to the fact that a distinction between AOM and OME is not always clear. Moreover, the ages at which language skills are evaluated differ widely (from 10 months to above school age). However, in order to estimate enduring language sequelae, the follow-up period should be long enough to cover the age of school entry, i.e. about 6–7 years.

The purpose of the present prospective, longitudinal study was to evaluate whether a relationship exists between recurrent AOM during the first three years of life and language development at four and seven years of age.

Materials and methods

Study population and follow-up procedures during the first three years of life

One-hundred and thirteen healthy monolingual Swedish children, born at University Hospital of Lund, were enrolled at birth with the informed consent of the parents (Harsten *et al.*, 1989). The children were observed for three years. Six or more episodes of AOM during a 12-month period were defined as recurrent AOM (rAOM). During the observation period, 13 children developed rAOM (rAOM group), 71 children contracted occasional episodes of AOM and/or more than five episodes of other acute respiratory tract infections, and 29 children had no AOM episodes and less than six other acute respiratory tract infections (healthy group). The present study comprises the rAOM group (n = 13) and the healthy group (n = 29).

By questionnaire and repeated personal interviews with every family involved, data were obtained regarding the ages of any siblings, type of day-care and the level of parental education.

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A special service was provided for all children included whereby a paediatrician or an otolaryngologist could be consulted without delay, and all infections referred to in this study were diagnosed by a physician at such unscheduled consultations. AOM was diagnosed by otomicroscopy, performed by an otolaryngologist, and defined as an acute episode of earache in a child, with red bulging eardrum(s) or purulent discharge, occasionally febrile and with signs of upper respiratory tract infection. The treatment of AOM consisted of oral antibiotics, the drug of choice being phenoxymethyl penicillin, given for five days in isolated, uncomplicated episodes, otherwise for ten days. Tympanostomy tubes were inserted in cases of persistent middle ear effusion.

Examination procedures at four and seven years of age

All children participated in evaluations at the age of four years, whereas at the age of seven, one child from each group was missing. The children were first examined with otomicroscopy and tympanometry by an otolaryngologist, and tone-audiograms were recorded (at frequencies from 125 to 8000 Hz). Subsequently, the children were examined by a phoniatrician and a clinical linguist, neither of whom was informed whether the children belonged to the rAOM or the healthy group. The examinations were performed in the presence of one of the parents; depending on the degree of co-operation of the child, the examination lasted altogether about 1.5 hour, including 45–60 minutes of language assessment procedures.

Oral, postural and hand motor examinations at four and seven years of age

All findings were noted on a standardized form, listing signs of reduced nasal passage, tonsillar or adenoids hypertrophy, abnormal configuration or motility of the palate, abnormalities of occlusion or exfoliation of the teeth. Postural motor control was assessed by testing ability to jump on one leg at a time (i.e. correctly jumping on one leg *vs.* using the other leg for support). Hand motor control was checked in executing pronation/supination (i.e., correct sequence of movements with both hands *vs.* clumsy movements). Voluntary oral and facial motor skills were tested by asking the child to close the eyes, bare the teeth, blow out a match, blow up his/her cheeks, and to stick out the tongue (correct performance *vs.* inability to perform or inability to understand the instructions being noted).

Procedures for obtaining the linguistic material

Different procedures were used in order to obtain material allowing analysis of a broad range of language functions within a single session. Introductory tasks were performed before each testing procedure, to assess the child's level of co-operation.

The so-called *phoneme test* (Hellquist, 1984) is used to produce utterances for *phonological analysis*. The child is required to name objects and activities illustrated on pictures. The target words cover the Swedish consonant (n = 18) and vowel (n = 9) phonemes, main types of consonant clusters (n = 40) and prosodic contrasts, i.e. word stress where a distinction is made between initial *vs.* non-initial stress, and word accent, accent 1 and 2 (Nettelbladt, 1983).

The *Ringsted material* (Ege, 1974) consists of 28 pictures illustrating model sentences uttered by the examiner. The child is required to produce phrases of increasing complexity, corresponding to the model sentences. The material demands production of basic syntactic and morphological constructions of Swedish and is used for *grammatical analysis*.

Sequential pictures consist of a series of related pictures telling a short story. The child is asked to organize the story and subsequently to describe it. The speech material is used for *grammatical and interactional analysis*.

Material for checking *auditory discrimination* consisted of 24 pictures of single objects demanding the production of six minimal pairs: four segmental contrasts, i.e. t/k, t/s, s/sch, s/tj, and two prosodic contrasts, i.e. vowel length (short *vs.* long vowels) and word stress (i.e. initial *vs.* non-initial stress). The choice of minimal pairs was based on those contrasts which are late to be mastered, and on the acoustic properties (high frequencies) of some of the consonants (viz. non-labial fricatives). The child was first asked to name each member of the pairs, to establish whether the child actually knew the words involved. This part was tape-recorded. Two pictures were shown at the same time, representing each of the words in a segmental or prosodic minimal pair. One of the objects was named by the examiner and the child was asked to point it out. Each pair was presented six times to preclude random guessing.

At the age of seven years, the children were also asked to describe *thematic pictures* (Holmberg and Sahlén, 1986) consisting of a main event and associated and unassociated events. The purpose was to enable the child to expand in narrative speech, providing material for *grammatical and interactional analyses*.

Linguistic analyses

The entire session, except for parts of the auditory discrimination task, was audiotaped (Revox A 77, Sennheizer microphone) and transcribed phonetically (*phoneme test*, naming the pictures of the *auditory discrimination task*) and orthographically (*the Ringsted material*, *sequential pictures*, *thematic pictures*) by the clinical linguist. In the auditory discrimination task, where the children did not answer verbally but pointed or made other appropriate gestures indicating their comprehension with the task, the answer was coded.

1. Phonological analysis (Nettelbladt, 1983) was based on material obtained from the *phoneme test* and producing the word pairs of the *auditory discrimination task*. The analysis focuses on systematic simplications of phonological processes (Ingram, 1976), of consonants, vowels and prosodic contrasts, e.g. dentalization of velar consonants, derounding of rounded front vowels and substitution of accent 1 to accent 2. The degree of pervasiveness of each substitution was evaluated, and the results of the phonological analysis scored as follows: 0 = normal phonology without any deviance; 1 = traces of processes only in isolated words or phrases; and 2 = three or more systematic processes in all possible instances.

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2. Grammatical analysis (Hansson and Nettelbladt, 1990) focuses on deviances in syntax and morphology, e.g. erroneous word order patterns in negated utterances and omissions or over-generalizations of morphological markers. The transcribed material obtained for each child from *the Ringsted material, sequential pictures* and *thematic pictures* was scored as follows: 0 = normal grammar without any deviance; 1 = traces of deviance, only in isolated words or phrases; and 2 = three or more systematic deviances in all possible instances.

3. Interactional analysis, and analysis of word mobilization ability, aim to evaluate the child's level of co-operation with the examiner, to estimate the coherence of the dialogue (Linell *et al.*, 1988; Hansson and Nettelbladt, 1990), and to discover possible difficulties in the mobilization of words (Holmberg and Sahlén, 1986). *Thematic pictures* were used for this analysis and the following score system: 0 = normal (without any deviance); 1 = slight deviances (i.e., the child is taciturn and needs repeated prompts, the answers are very limited and/or the child has occasional difficulties in word mobilization); and 2 = gross deviance (i.e., the child is unco-operative, the dialogue lacks coherence and/or the child has apparent difficulties in word mobilization (McTear and Conti-Ramsden, 1992).

4. Responses on *the auditory discrimination task* were coded for each pair of pictures illustrating the minimal pairs as follows: 0 = all responses correct; 1 = the child points first to a wrong picture but then corrects him/herself; and 2 = wrong pointing without self-correction. The aggregate score for the whole performance was calculated for every child, the range being 0–144 (six minimal pairs × 24 pictures).

Statistical methods

The Mann–Whitney U-test (two-tailed) and the chi-squared test were used to analyse the data.

Results

Characteristics of the study population

As shown in Table I, there were no differences between the rAOM children and the healthy children regarding sex distribution, the proportion of first-borns, or the level of parental education. The healthy children spent more time in family day-care homes ($P<0.05$) and less time in day-care centres ($P<0.02$) than did the rAOM children. However, there was no difference between the two groups with regard to total time spent in home-care or age at enrolment in either category of day-care.

TABLE I

CHARACTERISTICS OF THE STUDY POPULATION; RAOM CHILDREN (N = 13) AND HEALTHY CHILDREN (N = 29)

	rAOM	Healthy
No. of girls/boys	5/8	14/15
No. of first-borns	6	13
No. of mothers educated at		
comprehensive school	1	1
upper secondary school	2	8
university/college	10	20
No. of fathers educated at		
comprehensive school	2	1
upper secondary school	2	5
university/college	9	23
Mean time (months) spent in		
home-care	19.3	19.5
family day-care homes	3.8[a]	10.6[b]
day-care centres	12.9[c]	5.9[d]
Mean age (months) at enrolment in		
family day-care homes	15.2	13.5
day-care centres	19.7	20.5

[a,b] $P<0.05$; [c,d] $P<0.02$.

Otological and audiological findings at four and seven years of age

Tympanostomy tubes were only used in the rAOM children: 11 tubes in six children at four years of age, and five tubes in three children at seven years of age. Abnormal middle ear status was found in five ears (in five children) at four years of age, and in four ears (in four children) at seven years of age (Table II).

Abnormal tone-audiometry (i.e. ≥25 dB at any frequency), in all cases due to conductive hearing-loss, was found in seven ears (bilaterally in one rAOM child) at four years of age, and in five ears (bilaterally in one healthy child) at seven years of age (Table II). The thresholds did not exceed 30 dB at any frequency.

Apart from tympanostomy tubes being exclusively used in rAOM children, there were no differences between the two groups of children regarding otomicroscopical findings or the results of tympanometry and audiometry at four and seven years of age.

Findings at oral, postural and hand motor examinations at four and seven years of age

The findings in this part of the investigation are summarized in Table III.

At the age of four, several children acted up at testing, e.g. made inappropriate movements or refused to perform some oral movements. Thus, in cases of doubtful co-operation the performance was judged to be incorrect. The majority of four-years-old children had difficulties in postural and oral motor tasks, particularly blowing up the cheeks, whereas hand diadochokinesis was correctly performed by the majority of the children.

At the age of seven years, co-operation was satisfactory. Tonsillar hypertrophy and open bite were found more often than at four years. In two healthy children, palatal anomalies were not discovered until the age of seven: uvula bifida and constitutionally short soft palate. However, in

TABLE II

OTOLOGICAL AND AUDIOLOGICAL FINDINGS AT FOUR AND SEVEN YEARS OF AGE

	Nos. of ears with indicated findings			
	4 Years		7 Years	
	rAOM	Healthy	rAOM	Healthy
No. of ears tested	26	58	24	56
Otomicroscopy and tympanometry				
normal	13	55	17	54
patent tubes	11	0	5	0
hypomobile tymp.membrane	1	3	2	2
effusion	1	0	0	0
Tone-audiometry				
normal	23	54	22	53
abnormal[a]	3	4	2	3

[a] ≥25 dB threshold at any frequency.

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TABLE III
FINDINGS AT ORAL, POSTURAL AND HAND MOTOR EXAMINATIONS AT FOUR AND SEVEN YEARS OF AGE

	4 years		7 years	
	rAOM	Healthy	rAOM	Healthy
No. of children	13	29	12	28
Tonsils/adenoid				
normal	13	24	9	21
hypertrophy	0	5	3	7
Palate				
normal	13	29	12	26
anomaly	0	0	0	2
Occlusion				
normal	11	23	10	20
open	2	6	2	8
Exfoliation of teeth				
no	12	28	9	16
yes	1	1	3	12
Jumping (one foot)				
correct	5	10	12	26
incorrect	8	19	0	2
Oral motor				
correct	4[a]	6[a]	12	28
incorrect	1[a]	3[a]	0	0
Hand motor				
correct	12	24	11	27
incorrect	1	5	1	1

[a]Only a limited number of children co-operated at examination (five rAOM and nine healthy children).

none of the children was hypernasality or any other sign of palatal dysfunction present. At this age, clumsiness was noted in two children (both in the healthy group) in jumping, and in two other children (one from each group) in hand motor control.

There were no statistically significant differences between the rAOM and healthy groups at any of the examinations either at the age of four or at seven years.

Findings on linguistic analyses of phonology, grammar, interaction and auditory discrimination at four and seven years of age

The results of analyses of phonology, grammar and interaction are summarized in Table IV.

Traces of systematic simplifications in *phonology* (score = 1) were common both at four and seven years of age. Systematic simplifications in phonological processes (score = 2), considered to be phonological delay, were found in 8/42 children at four years and in one healthy child at seven.

TABLE IV
ANALYSES OF PHONOLOGY, GRAMMAR AND INTERACTION AT FOUR AND SEVEN YEARS OF AGE

	4 years		7 years	
	rAOM	Healthy	rAOM	Healthy
No. of children	13	29	12	28
Phonology				
normal	4	7	2	13
traces of deviance	8	15	10	14
deviant	1	7	0	1
Grammar				
normal	13	29	12	28
Interaction				
normal	9	23	10	17
traces of deviance	4	6	2	11

TABLE V
RESPONSES ON THE AUDITORY DISCRIMINATION TASK. MEAN VALUES AND RANGE OF INDIVIDUAL AGGREGATE SCORES AT FOUR AND SEVEN YEARS OF AGE

	4 years		7 years	
	rAOM	Healthy	rAOM	Healthy
No. of children	13	28[a]	12	28
Discrimination				
mean value	9.5	15.5	1.1	1.8
range	2–25	2–58	0–5	0–7

[a]One child did not co-operate at examination.

Interdentalization or other substitutions of /s/, the most common phonological process found, seemed to be related to the presence of open bite (in seven children at four years and in four children at seven years of age), or exfoliation of teeth (in two children at four years and in six children at seven years of age). Guttural articulation was noticed in one of the children with tonsillar hypertrophy. There were no statistically significant differences in phonology between the rAOM and healthy children at any age.

On the *grammatical* tasks, twelve of the four-year-old children (seven rAOM and five healthy children) occasionally used the regular past tense inflection for irregular verbs ('gådde' for 'gick'; English equivalent 'goed' for 'went') which is a normal grammatical characteristic of four-year-old Swedish children. At the age of seven no grammatical errors were found.

Interaction during the discourse was adequate in the majority of the children on both testing occasions, and none of the children exhibited deviant interaction (i.e., a score of 2) at any age. There were no statistically significant differences between the groups of children.

At four years of age, one child refused to co-operate and seven children acted up and gave dubious answers on the *auditory discrimination* task. The range of individual variations was large, especially in four-year-olds (Table V). At this age, the healthy children made more errors than the rAOM children, though the difference was not statistically significant ($P<0.10$). At the age of seven, the children in both groups only occasionally made errors or self-corrections.

Discussion

The results of the present, prospective study suggest that, in otherwise healthy children, recurrent acute otitis media (rAOM) during the first three years of life will not have an impact on language development which is detectable at the ages of four or seven years. The slightly deviant auditory discrimination observed in the healthy group at four years of age was no longer present at the age of seven.

Methodological considerations on study design

Although the present study population comprised a relatively small number of children, the disadvantages of a small series were offset by the satisfactory compliance (due to the limited number of examiners), the low drop-out rate (only two children missing at seven years of age), and the reliability of AOM diagnosis (every episode of AOM being diagnosed by an otolaryngologist). More-

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over, the socio-linguistic homogeneity of the population was high, since the children were recruited from a small university community, the educational level of the parents being high and comparable in both study groups. Studying larger groups would allow the statistical procedures to be adjusted to a relatively low frequency of developmental language disorder, though the clinical value of findings so rare as to be demonstrable only in very large populations has been questioned (Paradise, 1981).

According to clinical experience, silent episodes of middle ear disease may be responsible for temporary hearing loss of such a magnitude that the child's verbal communication becomes impaired (viz. the children cease to babble or talk). In order to detect such a subclinical disorder, symptomless children are sometimes checked at short intervals (e.g., Wright *et al.*, 1988). As no such procedure was used in the present study, it can not be excluded that some episodes of symptomless middle ear disease might have gone undetected.

In several previous studies, especially retrospective studies, a strong relationship was concluded to exist between language delay and middle ear disease. Today it is generally accepted that the aetiology of language development disorders is multifactorial (Bishop, 1992), *viz.* genetic predisposition, disorders of the central nervous system, perceptual deficits and social factors. When studying the possible effects of mild transitory conductive hearing impairment on language development, all the other factors mentioned above should be excluded. In the present study, as revealed by repeated examinations, all children were otherwise healthy, the minor postural, oral motor and hand motor difficulties being within the wide range of normal variations (Stott *et al.*, 1984). The only boy who at the age of seven showed traces of phonological deviance, belonged to the healthy group.

The results of all examinations in children are dependent on their co-operation. Especially at four years of age, many of the children did not co-operate optimally on the oral motor and the auditory discrimination tasks. This may explain our failure to discover the two asymptomatic minor palatal anomalies at the age of four years.

Methodological considerations on linguistic analysis

No internationally accepted standards for testing language abilities in children have yet been established. In most of the comparable studies (longitudinal follow-up from birth), language tests based on American English were used. Some tests have been translated—for example to Dutch (Rach *et al.*, 1988). From a linguistic point of view it is necessary, however, to study language-specific characteristics of the particular language under consideration. For the present study of Swedish children, we have chosen analytical procedures based on Swedish. Hitherto there have been no commonly accepted standardized procedures suitable for clinical testing of linguistic abilities in Swedish children. Instead, reliable procedures have been developed for different age groups, designed to elicit the child's verbal communicative behaviour, an approach which not only allows evaluation of the individual child's progress, e.g. in therapy, but also comparison of selected aspects of language in different groups. Our approach enabled both quantitative and qualitative evaluations to be made of different aspects of language for the purpose of comparing the two groups. This procedure is consistent with the suggestion by Stephens and Montgomery (1985) that not only standardized tests but also other types of observations should be included in the evaluation of language.

In order to sustain the child's level of motivation throughout the examination, the test procedures must be limited. We were able to obtain materials suitable for the analysis of language production (phonology and grammar), comprehension (auditory discrimination) and interaction during discourse with an adult. Thus, we believe the language measures used in our study to have been appropriate, although we did not perform such analyses as vocabulary or comprehension of syntactic construction.

Short vs. *long term effects of rAOM on language development*

We found no evidence of delayed language development, due to rAOM during the first three years of life, to be detectable in children followed up at the ages of four and seven years. However, it can not be excluded that transitory language or communicative deficits may have passed undetected in the rAOM before the first language development assessments were made at four years of age. Deteriorated scores on some language tests, related to the frequency and/or duration of OME or AOM, have been found in children aged 10–36 months (Friel-Patti *et al.*, 1982, 1990; Teele *et al.*, 1984; Wallace *et al.*, 1988). However, there seems to be a general tendency for the results of language tests to improve with increasing age (Paden *et al.*, 1989).

Few studies of children followed prospectively from birth until school age have been published, and their results are somewhat contradictory. Thus, when the tests were applied at both preschool and school ages, either no impact of early middle ear disease on language test results could be demonstrated (Roberts *et al.*, 1988), or the impact was only discernible on parts of the tests, *viz.* articulation and morphological markers (seven other parts of the tests yielding no difference between groups) at seven years of age (Teele *et al.*, 1990).

The active treatment given to our children, *viz.* antibiotics or tympanostomy tubes, might also have eliminated short-term adverse effects of rAOM on hearing, and thus on subsequent language development. Moreover, the study design ensured ready access to a physician by participants, perhaps more ready access than is usually available at the clinic. Thus, our results might not necessarily be reproducible in less favoured populations.

The social aspect of interactive language learning should not be overlooked. The cognitive development of infants with otitis media has been shown to be improved due to their exposure to an enriched linguistic environment (Black *et al.*, 1988). In this context, it is noteworthy that we found a tendency for auditory discrimination scores to be better in the rAOM group than in the healthy children at four years of age. This remarkable finding may be explained by the fact that the rAOM children in the present study spent significantly more time in organized day-care centres than did their healthy peers. Presumably, the four-year-old children at such day-care centres had better experience of co-operating with adults in organized social activities, which might have resulted in their perfor-

ming on auditory discrimination tests with greater confidence than children attending other less formal types of day-care (e.g., family day-care homes), where less pedagogically stimulating conditions might prevail.

Conclusion

The results of the present study suggest that recurrent acute otitis media (rAOM) during the first three years of life does not cause any relevant language disorder detectable at four and seven years of age. However, the population studied represents a rather selected group of children in a welfare state, benefitting from active medical treatment and exposed to a linguistically stimulating environment. Language acquisition, being a result of several covariant factors, may be less optimal in children brought up in other conditions. Adverse effects of early rAOM or enduring bilateral OME may also augment an already manifest delay of language development. It is therefore urgent to define and detect such risk groups.

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