Otitis Media and Learning Disabilities: The Case for a Causal Relationship

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Despite an extensive literature suggesting a relationship between otitis media in early childhood and later learning disabilities, controversy still exists as to whether this link is causal. The hallmarks of otitis media, including decreased hearing and delayed language acquisition, and the characteristics of learning disabilities are reviewed. Further analysis of the studies that support a relationship between otitis media and learning disabilities strongly suggests that the relationship is causal in spite of methodologic limitations of some individual studies. If a causal relationship is accepted, then otitis media in early childhood is a disease with significant long-term morbidity that deserves careful follow-up and, when indicated, preventive interventions.

Otitis media is a frequent acute problem in family practice.[1] Since treatment generally involves the use of antibiotics, its importance as an episodic disease has been well recognized in the medical literature.[2-5] Less widely recognized, however, is the fact that severe or recurrent infections in the middle ear, especially in young children, may have permanent disabling effects on the neurological maturation of the central nervous system, thus contributing to the conditions termed "learning disabilities." Since learning disabilities affect 2 to 10 percent of school-aged children and require costly remedial educational intervention if serious lifelong educational handicap is to be avoided, any medical measures that may reduce its prevalence deserve careful consideration. This paper reviews the literature that supports or refutes a correlation between early otitis media and later learning disabilities and outlines suggested options for therapeutic intervention.

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Epidemiology and Clinical Characteristics of Otitis Media

Otitis media is a disease of young children with a peak incidence at 2 to 3 years.[5] Male-to-female case ratios of 2 to 1 are reported from several sources.[6,7] Race (Amerindian),[8] allergies,[9] bottle feeding,[10] recumbent position with feeding,[11] cleft palate,[12] prematurity,[13] and recurrent adenotonsillitis[14] have all been cited as predisposing factors.

Although precise details of the pathogenesis are still being investigated, a general theory has been suggested by Bluestone and Shurin[14] and others[4] as follows: Eustachian tube blockage, due to

edema, adenoiditis, or structurally "floppy" tubes, leads to gas reabsorption in the middle ear. The resulting partial vacuum causes a transudate to form. (The possible role of secretory cells has been posited as well.) A conductive hearing loss is thus created. In the absence of drainage, such fluid then functions as a breeding medium for oropharyngeal bacteria, with the final product being an abscess—otitis media. Normally such an abscess will resolve either spontaneously or with rupture through the tympanic membrane. However, Nilson et al[15] and Mandel et al[16] have demonstrated a more rapid resolution and fewer recurrences with antibiotic treatment. Although the efficacy of antimicrobial treatment is challenged by European data,[17,18] methodological difficulties and lack of diagnostic criteria in these studies have contributed to their lack of acceptance in the United States. Significantly, 15 percent of children with one episode of otitis media will continue to have a hearing loss six months after the original episode.[19]

Learning Disabilities

The term "learning disabilities" came into wide use in the 1960s and early 1970s to describe the finding among educators that some children suffered from educational achievement handicaps unrelated to motivational and psychological factors or intellect. The concept has been further defined[20] to apply to children with normal intelligence but low school achievement with the characteristics shown in Appendix 1.

A typical child with learning disabilities will have a normal or high intelligence quotient (IQ). School failure or problems are common and are often the first manifestation of the problem. Frustration may lead to acting out, especially in older children, and a perceived difference by teachers or parents between potential and performance will often lead to negative labeling, eg, "dumb," "lazy," poorly motivated, or behavioral problem.

It is possible to test for learning disabilities with considerable precision. Unfortunately, there is a great deal of variation in the aggressiveness with which school districts approach the diagnostic task. As a result, physicians are sometimes asked to become involved in helping the family locate competent independent resources for testing and advocacy. Specific testing should include an accurate assessment of IQ as well as achievement testing for a comparison of the child's levels with established norms. Additional testing should be done to reveal whether a processing problem exists in translating auditory or visual signals or both into meaningful symbolic activity.

Children with auditory deficits will display such symptoms as inability to discriminate similar sounds and words, difficulty with short-term recall of instructions, mispronunciations, or language delay. Although it is possible to help children with learning disabilities through specific education techniques that circumvent the impairment in processing information, progress is often slow. Teachers must be specially trained and capable of devoting extra time to these students.

It would be far preferable, of course, to prevent such problems. As more evidence shows that hearing loss may have a role in causing the type of learning disabilities specifically concerned with the processing of auditory stimuli, increasing focus has been given to otitis media as a preventable cause of learning disabilities. This association, however, may not be so well proven as lay sources[21] imply, and in turn, an academic backlash of sorts has occurred.[22,23]

Since otitis media is extremely common in childhood, the consequences of either neglecting adequate treatment if it is a cause of learning disabilities, or overtreating if it is not causally related are enormous. In the first case, if there are no long-term effects from recurrent infections, the use of polyethylene grommets (PE tubes), a widely employed preventive measure, may rarely be indicated. In the second, antibiotic use, with its known attendant side effects and risks, may be dramatically increased.

Recurrent Otitis Media and Auditory Processing Learning Disability

Acute Otitis Media and Impaired Hearing

Authors citing a relationship between otitis media and learning disabilities have focused on several lines of evidence. First, there is a persistent

hearing deficit with acute episodes of otitis media. Olmstead et al[19] followed 82 children with otitis media for six months following the initial episode. Twenty-five percent had losses of 15 dB or greater persisting for more than two months. Twelve percent had hearing loss for more than six months following a single episode of otitis media. In two other long-term follow-up studies from private practice, Lowe et al[24] and Fry et al[25] reported hearing losses in 55 percent of the children at 6 months of age and 17 percent (control 4.5 percent) after 5 and 10 years, respectively. Although the mechanism for hearing impairment following otitis media is not proven, it is correlated with a persistence of effusions in the middle ear.[26-28] Bennett et al[29] also reported a hearing loss with unsuspected otitis media in school children.

Since Merluzzi and Henchcliffe[30] have determined that auditory thresholds for handicapping hearing loss are age dependent and thus lower in younger children, it seems reasonable to assume that a significant number of children with otitis media will suffer impaired hearing to a degree that interferes with the ability to correctly receive speech.

Evidence for a Critical Period

The case that otitis media may be causally related to later learning disabilities is based on the argument that hearing deficits associated with acute middle-ear infections interfere with the acquisition of auditory learning skills during a critical period in a child's development, permanently impairing these skills and leading to lifelong learning disabilities. It is posited that a "critical period" for language acquisition exists in humans and that interruption or diminution of hearing during this time will irreversibly damage a child's abilities to receive and process auditory input.[31] From animal studies it is well known that brain function in many anatomic areas is dependent on the exposure to appropriate environmental stimuli during a limited "critical period" of development. After this critical period has passed, the ability to respond to these stimuli and acquire the behavior in question is severely diminished or absent. Specifically, such a critical period has been shown to be in effect for auditory learning development in animal models.[32] In addition to behavioral deficits, animals deprived of auditory stimulation in infancy also exhibit irreversible morphologic changes in the auditory nuclei of the brainstem.

Evidence for a critical auditory period in humans is strengthened by studies of hereditary deafness in children. Children with congenital conductive deafness not treated with sound amplification typically suffer lifelong language acquisition deficits. Indeed, the case that unremediated deafness in the first two years of life leads to irreversible damage in auditory and language capacity is so overwhelming that it has been termed by Downs[33] as irreversible auditory learning disaster. However, two studies indicate that if congenital hearing loss is treated with amplification in the first year of life, psychological and intellectual deficits may be minimized. Beratis et al[34] reported a case study of an infant with severe congenital hearing loss whose developmental deficits were reversed with a hearing aid. Griffiths[35] studied 42 similar infants. All were fitted with hearing aids and regained normal hearing and language. Although the exact length of the critical period for language acquisition remains to be precisely delineated, it appears that its outer boundary is approximately age 2 years.

Similar evidence favoring a critical period for global sensory deprivation is also available in the literature. A long-term study by Dennis[36] of orphans adopted before and after 2 years of age showed a marked reduction in IQ for the latter reared in orphanages in an atmosphere of reduced stimulation. Conversely, when compared with control infants, Herber and Garber[37] reported a significant increase in IQ when ghetto infants of mothers with low IQs were given one-to-one stimulation. Although these studies are, of course, not directly relevant to the question addressed here, they do support the thesis that sensory deprivation in early childhood can lead to permanent later impairment of intellectual functioning.

Learning Disabilities and Otitis Media

Numerous studies of school-age children with learning disabilities show a correlation between

modest to severe otitis media in early childhood and learning disabilities.

Several early studies showed decreases in school achievement correlating with a history of otitis media. In 1935 Bond (according to Mustain[38]) reported that compared with normal children, a history of draining ear was 15 times more common in children with delayed reading achievement. Kaplan et al[8] reported a large group of Eskimo children with a history of extensive middle ear disease. All had school achievement deficits. Significantly, severity and age of onset of otitis media correlated with the degree of later deficiencies. Children with early and extensive disease and continued hearing loss of more than 25 dB (16 percent of the group) had the most profound drop in achievement scores, especially in those measuring verbal ability. Children with a history of severe otitis media but normal hearing also showed lower scores on achievement tests. Although the achievement scores in controls were also low compared with test norms, it should be emphasized that the lowered achievement noted in the otitis media groups was in addition to the overall "cultural" deficit noted in this group. This gap in achievement showed a tendency to widen with grade level, suggesting to the authors that the effect may be permanent.

Lewis[39] reported similar findings in testing 14 aboriginal Australian children with chronic middle ear disease. In addition to school achievement, a wide range of tests for auditory discrimination, speech, and intelligence were done. Control groups of aboriginal children without a history of otitis media and a similar group of white children were similarly tested. Socioeconomic status was controlled by the setting, a remote site in Australia. On almost every parameter tested, the children who had a history of otitis media performed poorly whether or not they had an existing hearing loss at the time of testing.

In a study controlling for age, sex, and race, Holms and Kunze[40] compared 16 children with a history of otitis media before the age of 2 years with 16 controls. Testing for language skills with the Illinois Test of Psycholinguistics Ability, the Peabody Picture Vocabulary Test, the Tempkin Dorley Picture Articulation Screening Test, and the Mechan Verbal Language Development Scale showed a consistent deficit in auditory language skills including reception, processing, and production of verbal responses. Significantly, visual learning abilities were unaffected in the experimental group.

In a retrospective study comparing 18 children with severe early otitis media (requiring myringotomy) with 22 children having mild otitis media (less than one episode per year in the first three years of life), Zinkus et al[41] found a broad range of auditory-related learning deficits in the experimental group. In addition, the reported first onset of speech was delayed in the severe otitis media group, with the use of first words occurring five months late and speaking in sentences 14 months late. Although both groups were of similar age, sex, IQ, and socioeconomic status, the experimental group had significantly greater hearing impairment at the time of testing. As in the Holm and Kunze study, the severe otitis media group was not significantly handicapped in respect to visual learning skills.

An additional study by Hersher[42] compared the frequency of otitis media in two groups of school-aged children, one with learning disabilities associated with hyperactivity and another large group of normal controls. All patients were from the author's practice, and thus severity of middle-ear disease was documented in the medical record and not reported retrospectively from parental memory as in the previously reviewed studies. Age and social class were matched. In addition, the learning disabled-hyperactive groups had nearly four times the incidence (54 percent) of severe otitis media (more than six episodes) that "normal" children had (15 percent). No relationship was noted between learning disabilities and hyperactivity and the frequency of other common childhood diseases.

Bennett and co-workers[29] also reported a series of school-aged learning disabled children compared with controls matched for age, sex, and race. Socioeconomic status was relatively controlled in that all students were from a homogenous upper-middle-class suburban school district. An early history of severe otitis media (more than six episodes in first six years of life) was found in 23 percent of children with learning disabilities and 9 percent of controls. Undetected, current middle-ear dysfunction was also detected in 49 percent of children with learning disabilities compared with 21 percent of controls. Although this study does not support (or reject) the hypothesis that early

otitis media may play a role in the development of learning disabilities, it does suggest that at least for children with chronic middle ear disease, learning disabilities are a frequent and significant concomitant.

Evidence for Causal Relationship Between Otitis Media and Learning Disabilities

In several recent articles, Paradise and Rogers[22,23] have challenged the common belief that the relationship between otitis media and learning disabilities is causal. He cites the small number of subjects in most studies, the lack of controls in any individual study for such variables as socioeconomic status and cultural bias, and the lack of any study that, controlling for all variables, follows subjects longitudinally. Thus, he argues that the possibility exists that other underlying factors, common to both otitis media and learning disabilities, may be responsible for the correlation. More important, perhaps, as Rapin[31] has pointed out, no study has convincingly demonstrated a relationship between preschool middle ear effusion and delayed or impaired language acquisition.

Although it is true that the single definitive study linking otitis media and learning disabilities has not been performed, it does not follow that a causal relationship is therefore unproven. Mausner and Bahn[43] have established criteria for causality based on epidemiologic principles. According to their paradigm, causality is implied if the following exist: (1) there is a strong relationship among the associated variables, (2) the relationship is consistent when tested for under varying conditions, (3) temporal correctness is maintained, (4) the effect has specificity sufficient to rule out other competing variables, and (5) coherence with existing information is maintained (eg, biological plausibility is present).

The relationships between otitis media and learning disabilities meet the above criteria. All studies reviewed show a strong correlation between otitis media and learning disabilities, with children with learning disabilities having several times the incidence of otitis media of controls. Although populations as diverse as aboriginals in Australia, Eskimos, and suburban Americans have been tested, the relationship does not seem to vary, implying a high degree of consistency. All studies except that by Bennett et al[29] showed a temporal relationship between preschool otitis media and later learning disabilities. This one study by Bennett et al did not report the incidence of otitis media in early childhood, but did reveal a high rate of persistent middle ear disease in school-aged children with learning disabilities. This study in no way refutes the temporal relationship reported in other studies; it simply does not address the question.

The effect of otitis media on learning disabilities has striking specificity in those studies that analyzed the degree to which the learning deficit is selective to auditory and auditory processing skills. Both Zinkus et al[41] and Holms and Kunze[40] reported that the learning disabilities seen in children with early otitis media affected primarily these skills and spared both general intelligence and visual learning parameters.

Finally, as has been outlined above, the relationship between conductive hearing loss associated with otitis media in early childhood and later learning disabilities is consistent with a wide variety of known information from other syndromes of hearing loss in early childhood. Remediation effects seen in children with congenital conductive deafness, critical period studies on animals with hearing impairment, and a known association of otitis media with secretory accumulations in the middle ear with relative conductive deafness are all compatible with a causal theory relating otitis media and learning disabilities.

This is not to say that there is no need for further studies to delineate the relationship more precisely. As suggested by Rapin,[31] the degree to which otitis media interferes with language acquisition in the first two years of life is not well characterized and indeed critical to the theory. A well-controlled longitudinal study, including socioeconomic status, race, and home environment as well as clinically precise descriptions of the severity of otitis media and the degree and length of hearing impairment, is a much needed priority in the field. Moreover, it is not clear that all children with otitis media develop learning disabilities. Since all otitis media is not associated with persistent hearing impairment, it is plausible and consistent with the theory that some children, perhaps those with minimal or unilateral hearing

impairment, would escape the deleterious effect of the disease on later learning skills. Furthermore, there are no data suggesting that either primary prevention of episodes of otitis media or special enrichment of the aural environment while such episodes are occurring may prevent later undesirable sequelae.

An Approach to Treatment and Prevention

Until such time as the question of how to intervene in the course of severe early otitis media is answered definitively, the practicing physician is faced with determining what course of action is most consistent with known findings. Otitis media can be either prevented[43] or treated episodically and then followed. Children at risk for hearing impairment, especially those with known learning disabilities, can be audiologically screened.[29] When identified, such high-risk children can then be treated or their environment manipulated to minimize the effects of learning disabilities.

Management of Acute Otitis Media

Howie et al[7] have identified risk factors associated with what they call the "otitis-prone" condition, in which recurrent episodes of severe otitis media persist through early childhood. The factors are early onset (91 percent at less than 12 months), a preponderance of pneumococci on culture, and the number of episodes, especially when multiple episodes (more than two) occur in the first year of life. Antibiotic treatment of otitis media, however, has not been shown to significantly lower secretory complications or abnormal tympanograms on follow-up. Although treatment of acute infections probably has intrinsic merit, as reviewed earlier, preventive measures would seem to be more important, especially in the "otitis-prone" group. Follow-up of children after acute episodes is also indicated, since a high proportion will have tympanographic abnormalities, although the efficacy of specific therapy is not conclusive, as will be outlined below. Classes of children with otitis media at high risk for developing learning disabilities are summarized in Appendix 2.

Antibiotic choice and usage in this disease is a broad topic, adequately reviewed elsewhere.[3] The clinician must be aware of the predominant organisms (in particular Diplococcus pneumonae and Hemophilus influenzae) and the high rate of persistent effusions and hearing loss following acute episodes. Decongestants in the treatment of acute infections do not seem to be effective.[44] If, after the disease has been followed with otoscopy and tympanometry for 6 to 12 weeks, effusion and poor tympanic membrane compliance are still present, many authors recommend the use of polyethylene tubes following myringotomy and aspiration of the fluid from the middle ear. A recent report[45] notes that short-term treatment with prednisone can be used to clear persistent middle ear effusion. This treatment may offer an alternative to surgery. The study deserves replication as well as the attention of physicians who commonly deal with otitis media.

Preventive Strategies

Two major approaches, medical and surgical, have been commonly employed to prevent recurrent otitis. A summary of these regimens is shown in Table 1. Surgical treatment is probably the most commonly used approach, although precise data comparing the rates at which the two approaches are used are not available. Paradise[3] and others have suggested, however, that medical prophylaxis be used as the treatments of first choice. Controlled comparisons of the effectiveness of the two methods have not been reported in the literature, although a theoretical risk-benefit analysis can be done using existing data. Both methods reduce the incidence of recurrence of otitis media by approximately 90 percent and thus can be judged equally effective. The most commonly used antibiotic regimen, sulfisoxazole in a twice-a-day dosage, seems to be relatively free of frequent side effects.[46] Occasional idiosyncratic allergic reactions, some potentially life threatening, have been reported. The major impediment to success with treatment by sulfisoxazole is compliance, since the administration of medication twice a day for

Table 1. Primary Prevention of Otitis Media

Treatment Modality	Regimen	Special Problems	Side Effects and Complications
Prophylactic antibiotics (treatment of choice)			Allergic reactions; severe reactions unusual
Sulfisoxazole	Twice a day for one year	Compliance with daily medication	Rare but reported; cultural biases against "drugs"; used long term
Amoxacillin	Daily for one year	Compliance	Allergy, diarrhea, yeast overgrowth
Polyethylene grommets (back-up therapy)	Placed surgically, remain for six months to a year	Special precautions for swimming and bathing	Anesthetic risks; long-term changes in tympanic membrane—25%, permanent atrophy; conductive deafness; long-term risks of polyethylene in human tissue undocumented; higher cost

the suggested year requires dedication on the part of the parents. An alternative, administering sulfa at the onset of upper respiratory symptoms, has been suggested[47] as having nearly equal prophylactic results. In the experience of the author (CRK), however, this method increases compliance problems, and without intense follow-up, far less success may be obtained.

The surgical alternative is the use of polyethylene grommets inserted through the tympanic membrane, allowing ventilation of the middle ear and drainage of effusions. This method is strikingly successful at clearing acute effusions.[48] Compliance problems are minimal, since the tubes commonly remain in place for six months to two years. It is necessary, however, for parents to monitor conditions where water could enter the ear canal (bathing and swimming, principally) and to ensure their children wear ear plugs or other mechanical barriers to prevent reinfection. The major serious complication of this method is related to anesthetic risk, since it is virtually impossible to place the devices in young children without anesthesia. Since many of these procedures could be expected to be performed in community hospitals, where staff experienced in the special problems of anesthetized young children are less likely to be present, this risk is not insignificant, and such operations result in as many as 1 death in 5,000 to 10,000 procedures. Tos and Poulsen[49] also reported disturbing long-term results of the effects of tubes on the tympanic membrane. Fifty percent of such children had abnormalities of the tympanic membrane after five years, the most serious being atrophy of the drum in 25 percent of cases. Atrophy as such can be associated with hearing deficits. Finally, since the long-term consequences of polyethylene implants in human tissue are unknown, some concern should remain that other serious side effects may yet be discovered.

A final group presenting management problems are those children of school age with known learn-

ing disabilities. Since Bennett et al[29] have shown a high rate of undetected intercurrent effusions in these children, screening them periodically for middle ear disease seems to be a reasonable minimum intervention. Since a small but significant rate of positive cultures is found with asymptomatic effusions,[50] it may also be prudent to place such children on antibiotics and to consider prophylaxis, especially if effusions are recurrent.

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Appendix 1
Definition of Learning Disabilities*

A severe discrepancy between achievement and intellectual ability should be present in one or more of the following areas:

- Oral expression
- Listening comprehension
- Written expression
- Basic reading skills
- Reading comprehension
- Mathematics calculation
- Mathematics reasoning

The discrepancy must not primarily be the result of any of the following:

- Visual, hearing, or motor handicaps
- Mental retardation
- Emotional disturbance
- Environmental, cultural, or economic disadvantage

Included in the definition are such conditions as the following:

- Perceptual handicaps
- Brain injury
- Minimal brain dysfunction
- Dyslexia
- Developmental aphasia

*From *Education for All Handicapped Children Act of 1975,* United States Congress, Statues at Large, PL 94/142

Appendix 2
Classes of Children at Risk for Learning Disabilities as a Complication of Otitis Media

1. Children with recurrent otitis media
   The "otitis-prone" child—more than two episodes of otitis media in the first or second year of life
   Recurrent otitis media—more than six episodes during the preschool years
2. Children with acute otitis media that fails to resolve: persistent effusion or learning impairment and abnormal tympanogram persist six weeks to two months following an episode of otitis media
3. Children under the age of 3 years
4. Other groups with known high risk for otitis media, eg, cleft palate (see text)