

Role of Adenoidectomy in Otitis Media and Respiratory Function

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Abstract Adenoidectomy is among the most frequent surgical procedures performed on children. The rationale for adenoidectomy is to remove a chronically infected or enlarged and obstructing adenoid. Adenoidectomies are performed on children who have recurrent or chronic otitis media with effusion, on children with chronic rhinosinusitis, and on children with nasopharyngeal obstruction causing sleep disturbances and continuous mouth breathing. Various underlying factors that lead to adenoidectomy are also associated with asthma. Asthma is associated with recurrent respiratory tract infections predisposing individuals to recurrent or chronic otitis media and chronic rhinosinusitis. Children with asthma also have an increased risk of sleep-disordered breathing that is treated with adenoidectomy in the presence of nasopharyngeal obstruction. In nonasthmatic children, adenoidectomy does not influence the development of IgE-mediated allergy, bronchial hyperreactivity, or exhaled nitric oxide concentrations, all of which are surrogate asthma markers. Adenoidectomy in selected asthmatic children may relieve comorbidities associated with asthma.

Keywords Adenoidectomy · Otitis media · Asthma

Introduction

The rationale for adenoidectomy is to remove the adenoid only when it is diseased by chronic infection or by

abnormal hyperplasia and is causing nasopharyngeal obstruction. However, in clinical practice, the distinction between a healthy adenoid and a chronically diseased adenoid is often made by clinical symptoms and signs exhibited by the child.

Chronic adenoidal infection is thought to be associated with otitis media by transmission of the adenoidal infection through the eustachian tubes into the middle ears [1]. In addition, an enlarged adenoid may obstruct the orifices of eustachian tubes and contribute to the pathogenesis of chronic otitis media with effusion [2]. Thus, the adenoid has a critical location in the nasopharynx in close proximity to the eustachian tubes, which serve as the entry of pathogenic microbes into the middle ear. Removal of an enlarged or chronically infected adenoid by adenoidectomy has been reported to be effective in the resolution of chronic otitis media with effusion in children older than 4 years of age [2–4]. Adenoidectomy also has been reported to be effective in the treatment of children with recurrent otitis media who previously received tympanostomy tubes [5].

The above reports have encouraged the use of adenoidectomy to prevent otitis media in children younger than 4 years of age [6]. This has been tempting, as this is the age range in which the highest prevalence of acute otitis media is observed. It has been suspected that the adenoid could be chronically infected even in very young children, predisposing them to otitis media. Disappointingly, however, randomized studies have failed to prove any efficacy of adenoidectomy in preventing acute otitis media in children younger than 4 years of age [7–9] as well as in older children when used as the first surgical treatment [10]. Currently, adenoidectomy is not recommended as the primary treatment for otitis media unless an evident adenoidal pathology exists, such as an enlarged adenoid causing nasopharyngeal obstruction [11, 12••].

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An enlarged adenoid can cause nasopharyngeal obstruction. This results in continuous mouth breathing, sleep disturbances, and long-term effects on the growth of the facial skeleton and teeth [13]. Thereby, adenoidectomies are also performed in cases of nasopharyngeal obstruction without any evident history of recurrent or persistent otitis media [14]. In addition, adenoidectomies are performed on children with chronic sinusitis [15], although they are most frequently performed to treat chronic otitis media with effusion (Fig. 1) or nasopharyngeal obstruction associated with sleep disturbances.

Natural Function of the Adenoids: Role in Immunity of Young Children?

The nasopharyngeal location of the adenoid allows it to confront inhaled antigens, suggesting that it may have evolved to aid in the maturation of immune responses to inhaled antigens. It is composed mainly of lymphatic tissue and covered by an epithelium that forms specialized invaginated crypts that are thought to convey nasopharyngeal antigens inside the adenoid tissue [16]. The characteristic feature of the adenoid is that it is present at birth and is largest at 7–10 years of age; thereafter, it gradually decreases in size and is usually rudimentary in adults [17].

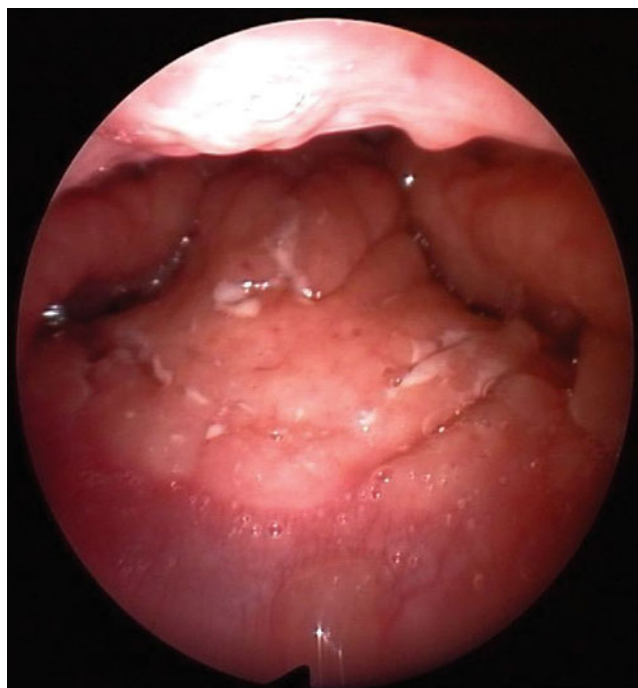


Fig. 1 An adenoid of a 7-year-old child with chronic otitis media with effusion. The image shows an inferior view through a rigid 70° endoscope. Inflammatory exudate is seen on top of the adenoid. Some lymphatic tissue in the mucosa at the orifices of the eustachian tubes is also present

As the adenoid has persisted through human evolution, its function is probably not insignificant. One may presume that a healthy adenoid is beneficial for the child. Despite this, children who have undergone adenoidectomy are apparently healthy, and adenoidectomy is not known to yield any severe long-term side effects.

The nasopharynx has a special role in pneumococcal colonization in children, as it is the primary reservoir of pneumococci [18]. This is contrary to what is seen in adults, in whom oropharyngeal swabs yield higher carriage rates of pneumococci than nasopharyngeal swabs [19, 20]. Currently, there is no explanation as to why the nasopharynx of a child yields more pneumococci than the nasopharynx of an adult. However, the possibility exists that the nasopharyngeal adenoid of the child has a role in this, as adenoids are rudimentary in adults.

In a recent study in which children 1–4 years of age were randomly allocated to undergo or not to undergo adenoidectomy, adenoidectomy was associated with an increased rate of nasopharyngeal carriage of pneumococci 1 year after randomization [21•]. The effect on pneumococcal carriage was less marked on the 2- and 3-year follow-up visits. Adenoidectomy seemed not to influence nasopharyngeal carriage of *Haemophilus influenzae* or *Moraxella catarrhalis*. As the risk of pneumococcal infections (e.g., otitis media, pneumonia, and sepsis) is highest among children younger than 5 years of age, the adenoid may have evolved to augment immune responses to *Streptococcus pneumoniae*. In this respect, the adenoid resembles the spleen, a lymphoid organ that has a role in immune defenses against pneumococcal infections [22].

It should be noted that in the above study, adenoidectomy seemed to increase pneumococcal carriage significantly in children 1–4 years of age only during the first year after adenoidectomy [21•]. Thus, adenoidectomy at an early age may not result in any long-term effects, as the adenoid may promote and boost pneumococcal immunity only in very young children, who are the most vulnerable to pneumococcal infections [23]. At an older age, other mechanisms may be more important in immunity, and the relative importance of the adenoid may decrease, which may be the reason for its natural involution as the child grows older.

Epidemiologic Surveys on the Association of Childhood Asthma and Adenoidectomy

Reports support an epidemiologic association between childhood asthma and adenoidectomy. A cohort study of 8,806 children examined at ages 7, 11, and 16 years showed that adenotonsillar surgery predicted asthma risk [24]. A questionnaire study of 483 individuals who were on average

18 years old showed that adenoidectomy was performed more frequently on asthmatic children [25]. In a survey of hospital discharge records of 1,606 children who had undergone adenoidectomy, the frequency of asthma diagnosis was significantly higher compared with 161 control children who had not undergone adenoidectomy [25]. This survey showed that the frequency of asthma diagnosis increased even before adenoidectomy was actually performed. This indicated that adenoidectomy per se may not increase the risk of asthma but that underlying factors associated with the development of early-childhood asthma also predispose children to adenoidectomy. Of note is that in contrast to adenoidectomy, childhood tonsillectomy is not associated with childhood asthma or atopic disease [25]. Also, an association between childhood adenotonsillar surgery and asthma has not been found in all populations [26]. Despite this, underlying factors can contribute to an epidemiologic association between childhood asthma and adenoidectomy.

Sleep-Disordered Breathing in Asthmatic Children and Adenoidectomy

Asthma has been identified as a risk factor for childhood obstructive sleep apnea (OSA), which is more common in overweight children [27]. Overweight without sleep-disordered breathing is not associated with increased airway inflammation [28]. Thus, there seems to be an association among OSA, airway inflammation, and asthma.

Children with OSA frequently have adenotonsillar hyperplasia, which causes nasopharyngeal obstruction. Therefore, children with OSA frequently undergo adenoidectomy. Children with severe OSA who undergo adenotonsillectomy show a significant improvement in respiratory distress and quality of life over a period of several months after surgery. However, OSA does not resolve in all these children, and some may require additional therapy [14]. Of note is that in children with obstructed breathing during sleep, the presence of asthma is associated with an increased risk of respiratory complications after adenotonsillectomy [29]. Taken together, the coincidence of OSA, asthma, and adenoidectomy can contribute to the epidemiologic association between adenoidectomy and asthma.

Respiratory Tract Infections: A Common Feature Associated With Asthma and Otitis Media

According to the hygiene hypothesis, exposure to a farming environment early in life [30] and repeated viral infections other than lower respiratory tract infections early in life [31] may protect an individual from asthma. This has been

attributed to exposure to endotoxin and other microbial compounds that may have a beneficial effect [32, 33].

However, certain viral infections early in life have been associated with the development of asthma later in life. Severe lower respiratory tract infections caused by respiratory syncytial virus at a young age have been found to be associated with the development of asthma [34], as are symptomatic infections with rhinovirus early in life. Rhinovirus infections are also major causes of asthma exacerbations, accounting for more than half of all such attacks, and rhinovirus persistence in the lower respiratory tract may contribute to asthma persistence and severity [35•].

Thus, a clear connection exists between childhood asthma and infections, as respiratory tract infections are associated with childhood asthma [36–38], and asthma symptoms are exacerbated by respiratory infections [39–41]. Although moderate exposure to pathogens or exposure to certain kinds of microbial products during early childhood may protect an individual from subsequent development of atopic symptoms and asthma [42], evidence indicates that excessive respiratory tract infections, especially in the lower respiratory tract, early in life are associated with childhood asthma [43]. As exposure to respiratory tract infections is associated with recurrent or chronic otitis media with effusion, which is often treated with adenoidectomy, the coincidence of respiratory tract infections in both asthma and otitis media may contribute to the epidemiologic association between adenoidectomy and childhood asthma.

Immune Abnormalities in Asthmatic Children and Respiratory Infections

The association of excessive respiratory infections and childhood asthma may imply that excessive exposure to certain microbes directly predisposes an individual to asthma. On the other hand, some evidence indicates that children who are vulnerable to asthma have an underlying immune abnormality that may predispose them to recurrent infections and asthma. This may suggest that excessive respiratory infections and asthma occur by coincidence and that excessive respiratory infections may not have a significant role in directly causing childhood asthma. It has been reported that asymptomatic 1-month-old neonates who are colonized with respiratory pathogens are at increased risk of developing childhood asthma [44]. Also, patients with asthma may have impaired innate antiviral responses that could predispose them to respiratory tract infections [35•]. Thus, respiratory infections may be more frequent in asthmatic children due to an underlying immune abnormality predisposing them to asthma and respiratory infections. Nevertheless, children who are prone to asthma are also susceptible to respiratory infections, which can

contribute to the epidemiologic association between adenoidectomy and childhood asthma.

Effect of Adenoidectomy on Respiratory Function in Nonasthmatic Children

Although asthmatic children often undergo adenoidectomy, it is not known whether adenoidectomy would have any effect on lower airway inflammation or on the development of asthma. As the adenoid is a prominent lymphoid organ in the upper respiratory airway that readily confronts particles inhaled through the nose, the adenoids could be involved in the control of airway inflammation. Also, as adenoidectomy is among the most common surgical procedures in children, its possible harmful effects on lung function or on the development of atopy, which have not been assessed previously, need to be investigated.

We recently conducted a randomized study on the effect of adenoidectomy [45•]. The study children had suffered from recurrent or persistent otitis media, had no history of insertion of tympanostomy tubes, had no evident adenoid enlargement causing obstruction of the nasopharynx, were 1–4 years of age at the start of the trial, and did not have asthma. The children were randomly assigned to undergo or not to undergo adenoidectomy. All the children received tympanostomy tubes. The children had scheduled visits 1, 2, and 3 years after the surgery.

Lung function was evaluated at the 3-year follow-up visit [45•]. Exercise-induced bronchoconstriction was chosen as a measure of bronchial hyperreactivity, as it is a sign suggesting asthma [46]. This was assessed by a previously validated protocol of impulse oscillometry [47]. The mean value of baseline respiratory resistance (Rrs) was first measured at the 5-Hz oscillating pressure. The child then took part in an outdoor running exercise test for 6–7 min, and Rrs was measured again. Exercise-induced bronchoconstriction was estimated as the percentage of maximum change in Rrs after the exercise test (Δ Rrs). An increase greater than 35% in Δ Rrs was defined as an abnormal response. This corresponds to the 95th percentile in healthy, nonatopic children and has been found to

distinguish children with probable asthma from asymptomatic children [47].

Exhaled nitric oxide fractional concentration was also measured, as it is considered a surrogate for eosinophilic airway inflammation [48], and it is usually increased in young children with probable asthma [49]. We previously determined the normal value for exhaled nitric oxide fractional concentration, which depends on the child's height. It was considered abnormal when it was more than two SDs higher than predicted. In addition, the development of allergy was assessed by skin prick tests against common allergens.

After the 3-year follow-up, adenoidectomy did not seem to promote exercise-induced bronchoconstriction as evaluated by oscillometry, bronchial inflammation as measured by exhaled nitric oxide, or the development of allergy or clinically diagnosed asthma (Table 1). Collectively, our results indicated that adenoidectomy does not increase the risk of asthma or the development of allergy to respiratory allergens [45•]. This is conceptually important, as the adenoids are located in the nasopharynx confronting inhaled antigens and potentially have a role not only in the development of immunity to microbes but in the development of tolerance to inhaled particles.

During the annual follow-up visits, acute otitis media episodes were prospectively documented in patient diaries. Information in the diaries was gathered during the scheduled follow-up visits 1, 2, and 3 years after the randomization. Analysis of otitis media episodes showed that in the study population, adenoidectomy was inefficient in preventing acute otitis media. However, analysis of the number of otitis media episodes showed that children who had recurrent episodes of otitis media during the first follow-up year tended to perform worse on lung functions tests [45•]. This may explain why the risk of asthma is increased in children with recurrent otitis media who had undergone adenoidectomy [25].

Adenoidectomy in Asthmatic Children

Our study did not include children with asthma or adenoid hyperplasia. It is not known whether adenoidectomy has

Table 1 Lung function, allergy, and asthma in children 3 years after randomization to undergo or not to undergo adenoidectomy

	Adenoidectomy, % (n)	No adenoidectomy, % (n)	Odds ratio (95% CI)	P value
Children with increased Δ Rrs	4 (82)	10 (72)	0.35 (0.09–1.42)	0.19
Children with increased FE_{NO}	21 (67)	11 (57)	2.16 (0.77–6.06)	0.15
Children with positive RAST	15 (87)	22 (72)	0.61 (0.27–1.38)	0.30
Children with asthma diagnosis	0 (89)	4 (77)	–	0.10

Δ Rrs percentage of maximum change in respiratory resistance, FE_{NO} exhaled nitric oxide fractional concentration, RAST radioallergosorbent test

any effect on lung function and airway inflammation in asthmatic children. In some series, adenotonsillar surgery has even been reported to result in improvements in asthma [50], but the topic has not been investigated thoroughly, and the possible influence of adenoidectomy on lung function and airway inflammation in asthmatic children remains controversial. Nevertheless, adenoidectomy in asthmatic children with evident adenoid enlargement or chronic adenoid infection relieves these asthma-associated comorbidities and likely increases the quality of life of the children.

Conclusions

Underlying disorders associated with asthma and adenoidectomy lead to an epidemiologic association between adenoidectomy and childhood asthma. Adenoidectomy per se does not seem to predispose individuals to childhood asthma. In clinical practice, it is not uncommon to encounter a child with asthma and a history of respiratory infections. Some such children may benefit from adenoidectomy. Although adenoidectomy has not been shown to influence the outcome of asthma, in selected asthmatic children, it may relieve comorbidities associated with asthma.

Disclosure No potential conflict of interest relevant to this article was reported.

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- Of major importance

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