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Prevalence and risk factors of otitis media with effusion in children with obstructive sleep apnea

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Abstract. – OBJECTIVE: The aim of this study was to investigate the correlation between obstructive sleep apnea (OSA) and otitis media with effusion (OME) in Chinese children and identify risk factors for OME to support the development of standardized diagnostic and treatment methods.

PATIENTS AND METHODS: Clinical data of 1,021 children with OSA admitted to our hospital between January 2019 and December 2020 were collected. The prevalence of OME was assessed based on age groups and different grades of adenoid hypertrophy (AH). Multivariate logistic regression was performed to determine risk factors for OME in this population.

RESULTS: Among the patients, only 73 (6.15%) reported hearing loss as the main complaint, while 178 (17.43%) were diagnosed with OME after the examination. Acoustic immittance showed higher detection rates for OME compared to those of otoscopy and pure tone audiometry. In addition, the incidence of OME did not increase with AH grade but was higher in children with OSA with AH grade IV. Multivariate regression analysis showed that the younger age group (2-5 years), AH grade IV, nasal inflammatory disease, and passive smoking were significant risk factors for OSA and OME. However, sex, age of 6-12 years, and presence of chronic tonsillitis/tonsillar hypertrophy had no significant impact on the prevalence of OME.

CONCLUSIONS: OME is highly prevalent in children with OSA. Clinicians should be vigilant in diagnosing OME, should conduct routine audiological examinations, and actively screen for middle ear fluid in all children with OSA, especially in younger children (2-5 years) with nasal mucosa inflammation and a history of passive smoking. This will help improve the detection rate of OME, as early intervention is paramount for preventing complications.

Key Words:
Children, Obstructive sleep apnea, Otitis media with effusion, Risk factors.

Introduction

Obstructive sleep apnea (OSA) is one of the most common sleep disorders encountered in pediatric otorhinolaryngology[1]. It is characterized by recurrent partial or complete upper airway obstruction during sleep, leading to abnormal patterns of ventilation[2]. Its high prevalence and possible secondary systemic complications have led to an increase in the number of children and families who are adversely affected. Therefore, early diagnosis and timely intervention for children with this disease are extremely important for improving the prognosis[3]. Although the pathophysiology of OSA in children is multifactorial, the most common etiology is enlarged tonsils and adenoids, leading to constraints of the upper respiratory tract during sleep. The swollen adenoids mechanically block the pharyngeal orifice of the Eustachian tube in the nasopharynx; given that the adenoids serve as bacterial reservoirs for biofilm formation, this blockage leads to retrograde infection of the Eustachian tube and middle ear[4-6]. Therefore, adenoid hypertrophy (AH) can be an early sign of fluid accumulation within the middle ear cavity[7].

Otitis media with effusion (OME) is a non-suppurative inflammatory disease of the middle ear characterized by tympanic effusion and conductive hearing loss[8]. Epidemiological investigations[9] show that preschool children have a high incidence of OME, which is one of the main causes of infant hearing loss. Since children are still developing their speech ability, and some cases of OME are unilateral, many parents find it hard to ascertain if there is a medical problem. However, it is often the caregivers' concern about the child's speech retardation or unintentional behaviors that prompt medical evaluation[10]. In addition, not only hearing but also the vestibular system is

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affected, resulting in a decline in balance ability[11]. All of these conditions may lead to learning difficulties or other serious consequences[12,13]. There is sufficient evidence[14] to indicate that OSA is related to the development of OME in children, and that AH increases the prevalence of OME.

Therefore, given the correlation between AH and OSA in children, it is necessary to identify OME in children with AH and administer appropriate treatment. The prevalence of OME in children with OSA varies depending on the regions where the studies have been conducted. In India, the reported[15] prevalence is 36.0%, while a study[16] conducted in Cameroon on children aged 2-3 years showed a prevalence rate of 7.2%. The prevalence of OME among school-aged children in Pakistan[17] is approximately 27%. The proportion reported by studies[18] conducted in Croatia is about 46.15-49.23%. However, data on OME and OSA in northern China are limited.

This study aimed to further explore the correlation between OSA and OME in Chinese children and evaluate the risk factors related to the development of OME, to provide evidence for the design of more standardized diagnostic and treatment methods for these diseases.

Patients and Methods

Study Design

The clinical data of 1,021 children with OSA admitted to our hospital from January 2019 to December 2020 were collected. The study population included 536 males and 485 females aged 2-12 years, with an average age of 5.76 ± 2.35 years and a history of 3 months to 10 years. Most children were admitted due to sleep snoring and were diagnosed with AH by complete ear, nose, throat (ENT) examination, including nasal endoscopy, nasopharyngeal computed tomography (CT), or X-ray soft tissue nasopharynx lateral view. The patients and their parents were informed about the need for further investigation to ascertain the reason for hospitalization.

Audition-Related Examination and Evaluation

All children were routinely examined using a HEINE Otoscope (HEINE Optotechnik GmbH & Co., Gilching, Germany) and pure tone audiometry (MELISON Corp., Guangzhou, China). The tympanograms of the acoustic immittance examination showed types B or C, and pure tone audiometry and behavioral audiometry usually indicated mild or moderate conductive hearing loss. We determine the classification of hearing loss according to the guidelines[19] for the diagnosis and treatment of OME in children (2021) in China. Middle ear effusion was found on otoscopy, and pneumatic otoscopy was not used as a routine examination because of the lack of patient cooperation.

Grading of Adenoid Hypertrophy

The gold standard was used to diagnose and quantify AH. The results were classified according to the method described by Cassano et al[20]. The grades were determined according to the percentage of choanal opening obstruction by the adenoids as follows: grade I, adenoid obstructs < 25% of the choanal opening; grade II, adenoid occupying 25-50% of the choanal opening; grade III, 50-75% obstruction; and grade IV, 75-100% obstruction. The grading of AH is shown in Figure 1.

Treatment Method

The clinical characteristics of the children included age, sex, course of disease, combined diseases, and hearing loss. All children with adenoid and/or tonsillar hypertrophy who met the diagnosis of OSA underwent adenoidectomy or adenoidectomy and tonsillectomy simultaneously. Children ≥ 4 years old who did not meet the OSA criteria also underwent adenoidectomy. Patients with severe and mild hearing loss and a course of disease < 3 months were treated conservatively with drugs; patients with mild hearing loss with a course of ≥ 3 months and moderate or severe hearing loss with a course of < 3 months underwent simple myringotomy or myringotomy, and tube insertion was selected according to the characteristics of tympanic effusion (serous or mucus type); patients with moderate or severe hearing loss and a course of disease ≥ 3 months were treated with myringotomy and tube insertion.

Statistical Analysis

The various measurement data were recorded on a spreadsheet. Statistical analyses of the data were performed using SPSS 20 (IBM Corp., Armonk, NY, USA).

Descriptive statistics were performed, and the study hypothesis was subjected to analytic (comparative) statistical tests. Categorical variables were compared using the Chi-square test, while continuous variables were compared using the

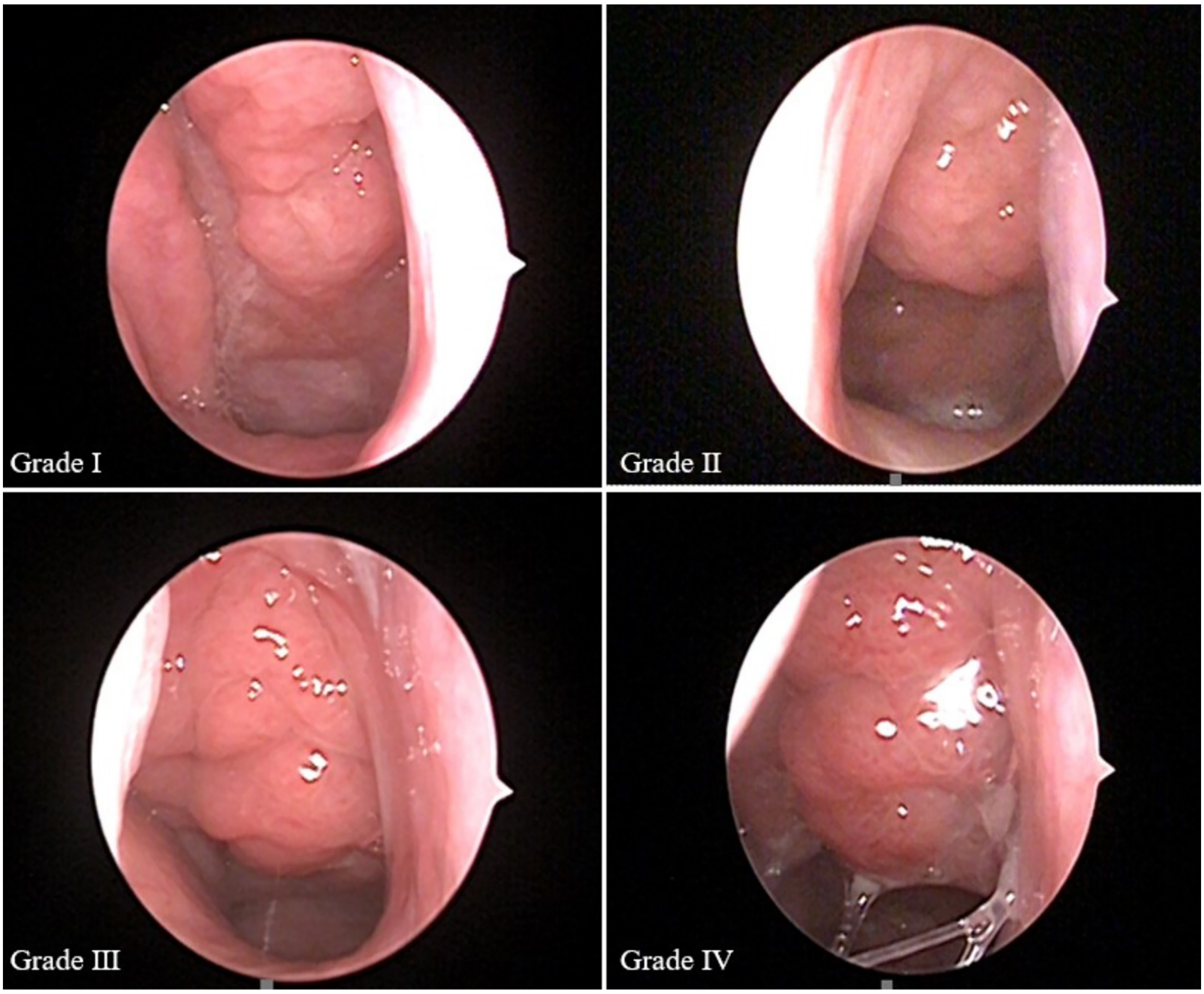

Figure 1. Original images of adenoid hypertrophy grading I-IV in study patients. Adenoid hypertrophy was graded according to the method proposed by Cassano et al[20].

Student's *t*-test. The results are presented in a tabular format. Multivariate logistic regression was used to analyze the risk factors of AH with OME. A p-value < 0.05 was considered statistically significant.

Results

Distribution of Symptoms in Children with OSA

According to the medical history data, the most common symptoms of AH were snoring (73.75%), mouth breathing (68.76%), and nasal congestion (64.83%), while only 6.15% of patients reported hearing loss as the main complaint. The other symptoms included sleep disorders, voice changes, headache, and epistaxis (Table I).

Audiological and Endoscopic Findings in Children with OSA

Ultimately, 178 cases (17.43%) of OME were diagnosed after performing the relevant examinations in this study. The audiological examination was of high value in determining

Table I. Presenting symptoms in children with obstructive sleep apnea.

Presenting symptom	N	%
Snoring	753	73.75
Mouth Breathing	702	68.76
Nasal obstruction	662	64.83
Nasal discharge	117	11.46
Hearing loss	73	6.15
Others	52	5.09

Table II. Audiological and endoscopic findings in children with obstructive sleep apnea.

Parameter	N	%
Tympanometry	966	
Normal	828	85.71
Unilateral/Bilateral Type B or C Tympanogram	150	15.52
Others	8	0.82
PTA/BTA	752	
Normal hearing	647	86.43
Conductive hearing loss	91	12.50
Sensorineural hearing loss	3	0.39
Mixed hearing loss	11	1.46
Endoscopy	231	
Normal	199	86.15
Abnormal	21	9.09
Others	11	4.77

PTA: pure tone audiometry; BTA: behavioral tone audiometry.

OME. Among them, 150/966 (15.52%) children with type B or C tympanograms and children with type C tympanograms had a significantly increased risk of developing OME. A total of 102/752 (13.96%) children had pure tone threshold or behavioral audiometry abnormalities, including 91 cases of conductive deafness and 11 cases of mixed deafness. We performed simple otoscopy in some patients, but the detection of OME was very poor. Only 9.09% of affected ears showed signs of tympanic membrane effusion (Table II).

Correlation Between Adenoid Hypertrophy and the Prevalence of OME

Table III shows the distribution of AH grading in this group of cases. There were 28 patients with AH grade I, of which the proportion of children with OME was 2/28 (2.74%). The prevalence of OME was 77/396 (19.44%) and 82/532 (15.41%) in grade II and III, respectively, and 17/65 (26.15%) in grade IV. The prevalence of OME did not increase with the increase of AH grade but was significantly higher in grade IV.

Comparison of Clinical Data of OSA Children with and Without OME

Among the included patients, there were 536 male children and 485 female children, and there was no significant difference in age. The children were divided into two age groups: 603 cases in the 2-5 age group and 418 cases in the 6-12 age group. The number of males was the same as that of females in each group. However, the incidence of AH combined with OME was higher in the 2-5 age group, accounting for 64.4% of cases. There was no significant difference between children with and without tonsillar hypertrophy/chronic tonsillitis. However, the proportion of children with OSA complicated by nasal inflammatory diseases, including sinusitis or allergic rhinitis, and a history of passive smoking, was significantly higher (Table IV).

Risk Factors of OME in Children with OSA

Table V shows the results of the multivariate logistic regression analysis of factors related to the occurrence of OME in children with OSA. Among them, the youngest age (2-5 years), AH grade IV, and nasal inflammatory disease had a significant impact on children with OSA and OME. Passive smoking was also a risk factor. However, sex, age of 6-12 years, and whether OSA was complicated with chronic tonsillitis/tonsillar hypertrophy had no significant impact on the presence of OME.

Discussion

This study demonstrated that approximately 17.43% of children with OSA have OME, and about 11.28% of them have asymptomatic hearing loss. However, hearing loss is detected during audiological and otoscopic examinations. If children's OME is not treated effectively in a timely manner, it may cause permanent hearing loss and speech development disorders. Therefore, it

Table III. Number of patients in each adenoid hypertrophy grading category.

Grade	Total number	Combined with OME	%
I	28	2	7.14
II	396	77	19.44
III	532	82	15.41
IV	65	17	26.15

OME: otitis media with effusion.

Table IV. Clinical characteristics of children with obstructive sleep apnea with and without otitis media with effusion (OME).

Parameter	Without OME (n = 843)	%	Complicated with OME (n = 178)	%
Sex				
Male	429	50.88	107	60.11
Female	404	49.12	81	45.50
Age range				
2-5	489	58.01	114	64.04
6-12	354	41.99	64	35.96
Adenoid hypertrophy grade				
I	26	3.08	2	1.12
II	319	37.84	77	43.26
III	450	54.38	82	46.07
IV	48	5.69	17	9.55
Combined with chronic tonsillitis/tonsil hypertrophy				
Yes	379	44.96	81	45.51
No	464	55.04	97	54.49
Combined with sinusitis/allergic rhinitis				
Yes	97	11.51	73	35.39
No	746	88.49	105	64.61
Passive smoking				
Yes	181	21.47	92	57.30
No	662	78.53	66	42.70

is important to diagnose OME early in children with OSA and develop appropriate treatment strategies.

The most reliable method for diagnosis of OME is fluid extraction or myringotomy; however, these invasive procedures are not harmless. One minimally invasive technique for evaluating middle ear effusion is otoscopy. Nevertheless, we found that the signs of tympanic effusion were noted in only 9.09% of cases during otoscopy, and in some children, no typically positive signs of OME were found. This could be attributed to the different pathological stages of OME. The latest clinical practice guidelines[21] suggest that children diagnosed with suspected OME should be tested for tympanic pressure after the implementation of pneumatic otoscopy. Kumar et al[15] and Egeli et al[22] noted the high sensitivity of pneumatic otoscopy in the diagnosis of OME. However, children's ear canals are generally narrow, and tympanic membrane examination is difficult. The lack of cooperation among children remains a significant problem in clinical otoscopy. In addition, we did not perform pneumatic otoscopy in patients when the relevant instruments were not available. In this study, we mainly used acoustic immittance to perform a noninvasive evaluation of OME. This method

Table V. Relationships between pediatric obstructive sleep apnea with otitis media with effusion and risk factors.

Variable	β	OR	95% CI	*p*-value
Sex	0.77	1.02	0.49-3.43	0.69
Age range				
2-5	0.60	0.47	0.17-0.79	**0.021**
6-12	0.16	1.73	0.53-2.70	0.71
AH grade				
I-II	0.22	0.83	0.20-1.99	0.83
III-IV	1.20	7.81	1.87-31.22	**0.019**
Chronic tonsillitis/tonsil hypertrophy	2.87	7.87	3.16-22.04	**< 0.0001**
Sinusitis/allergic rhinitis	2.42	11.16	2.67-35.12	**< 0.0001**
Passive smoking	1.03	2.89	2.14-3.89	**< 0.001**

AH: adenoid hypertrophy, OR: odds ratio, CI: confidence interval.

monitors and graphically records the pressure changes and acoustic reflections in the middle ear cavity. Type B or C tympanograms usually represent OME. The sensitivity and specificity of the type B tympanogram, which indicates fluid in the middle ear, were 91.7% and 92.2%, respectively. A Type C tympanogram peak pressure < 200 daPa indicates negative middle ear pressure secondary to Eustachian tube dysfunction[10,23]. In addition, cerumen in the external auditory canal affects otoscopy and acoustic immittance examination, and attention should be paid to cleaning the external auditory canal. The results of tympanometry, pure tone audiometry, and behavioral audiometry in younger ears were consistent with the results of acoustic immittance testing, which can reflect the specific situation of OME well before surgery.

This study also indicated that the incidence of OME was not significantly correlated with an increase in AH grade; however, in children with AH grade IV, the prevalence of OME was higher. Similar results have been reported by Nwosu et al[24]. Conversely, another study[25] reported the opposite conclusion, which was that there was no significant correlation between OME and AH. The reason for this phenomenon may not be the mechanical obstruction of the Eustachian tube orifice directly caused by the adenoid tissue, but the joint action of adenoid and bacterial biofilm, adenoid local immune regulation, IgE-mediated allergic reaction, and other factors[5,26].

The treatment for OSA combined with OME in children is mainly adenoidectomy and myringotomy, or myringotomy alone. Compared to myringotomy alone, myringotomy and adenoidectomy can maintain long-term pressure balance, reduce the proliferation of goblet cells and glands, prevent excessive fluid production, and indirectly promote the recovery of ciliary movement, which provides time for the improvement of Eustachian tube function[27]. However, tympanic membrane tube insertion may cause multiple complications, including middle ear infection, tympanic membrane perforation, and vent tube prolapse[28]. Vlastos et al[29] believe that tympanic membrane puncture and tympanic membrane tube insertion have the same effect on OME under the premise of adenoidectomy. Therefore, in our clinical practice, the treatment of OME should be selected by comprehensively considering the main complaint of the patient, the duration of the disease, and the effect of auxiliary examination results on the severity of the disease. For those with moderate hearing loss and those with a chronic history of mild hearing loss, tympanic membrane incision should be performed, tube placement should be determined according to the characteristics of middle ear effusion, and patients with an acute history of critical hearing loss or mild hearing loss can be treated conservatively. Simultaneously, it is necessary to actively manage allergic rhinitis or other nasal inflammatory diseases.

It is important to elucidate the factors related to OME in children with AH. In this study, we found that age, nasal inflammatory disease, and history of passive smoking were significantly correlated with OME, while sex, adenoid size, and effusion were not[30]. However, no significant difference was observed in the development of OME in patients with AH with and without tonsillar hypertrophy. According to Restuti et al[31], the extra burden of tonsils should exacerbate OME, but this was not found in our research.

Limitations

Some limitations must be considered while interpreting this study's results. Firstly, only part of the children underwent relevant audiological testing and evaluation, such as pure tone audiometry and acoustic immittance, which limits the effectiveness of these results. Pure tone audiometry is a subjective measurement method, and its sensitivity depends heavily on children's cooperation. In future studies, objective hearing assessments, such as otoacoustic emissions, can be used for younger children's hearing tests.

Conclusions

OME is highly prevalent in children with OSA. Clinicians must be alert to the potential diagnosis of OME, conduct routine audiological examinations, and actively screen for fluid within the middle ear cavity for all children with OSA, especially in younger (2-5 years) children with nasal mucosa inflammation and a history of passive smoking. This will help improve the detection rate of OME, as early intervention is paramount for circumventing complications.

Conflict of Interest
The Authors declare that they have no conflict of interests.

Acknowledgements
None.

Ethics Approval

Approval was obtained from the Ethics Committee of Hebei Eye Hospital (Approval Number: 2023LW01). The study was conducted in accordance with the principles of the Declaration of Helsinki.

Informed Consent

Informed consent was obtained from all guardians of individual participants included in the study.

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Authors' Contribution

All authors contributed to study conception and design. Data collection and analysis were performed by Yanhong Shi and Xiaoyan Li. The first draft of the manuscript was written by Chaobing Liu. Chaobing Liu and Zhitao Fan reviewed and edited previous versions of the manuscript. All authors read and approved the final version of the manuscript.

Data Availability

The datasets generated during and/or analyzed during the current study are available from the corresponding author on reasonable request.

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