A Systematic Review and Meta-Analysis: Correlation between Nasal Obstruction and Middle Ear Infection

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Систематический обзор и мета-анализ: корреляция между назальной обструкцией и инфекционными заболеваниями среднего уха

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系统评价和荟萃分析：鼻腔阻塞与中耳感染的相关性

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Introduction. Nasal obstruction is a symptom that manifests itself in reduced airflow through the nose. The nasal cavity is linked to the middle ear, so that pathological processes in the nose may also affect the condition of the middle ear.

Objective: This systematic review and meta-analysis were conducted to assess the relationship between nasal obstruction and middle ear infection.

Materials and Methods. This study involves a systematic review and a meta-analysis. Our literature search included the following five databases: Pubmed, CENTRAL, DOAJ, TRIP, and BMC; we aimed to find clinical trials and observational studies related to this topic. The risk ratio (RR) and standardized mean difference (SMD) with 95% confidence intervals (CI) were calculated to evaluate the relationship between nasal obstruction and middle ear infections through meta-analysis. Data were analyzed using the Review Manager (RevMan) version 5.4.0.

Results. A total of 13 studies were included in this systematic review, and we conducted a meta-analysis of 9 of them. The cumulative RR showed a tendency to develop otitis media in the population with nasal obstruction (RR = 1.30; 95% CI, 0.41–4.10, p = 0.65). Subgroup analysis showed no significant difference (p = 0.78) between these indicators in relation to the occurrence of middle ear infection (SMD = 0.04; 95% CI, -0.26–0.35). An association with allergy was found in the nasal obstruction with the occurrence of middle ear infections (RR = 1.17; 95% CI, 0.08–17.64), but this result was not statistically significant (p = 0.91).

Conclusions. There was no significant relationship between nasal obstruction and middle ear infection, which is affected by various factors.

Keywords: A meta-analysis, middle ear infection, nasal obstruction, otitis media, systematic review

Conflict of interests. All authors have no conflict of interests

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The authors are responsible for the originality of the data presented and the possibility of publishing illustrative material – tables, drawings, photographs of patients.

Актуальность. Назальная обструкция - симптом, проявляющийся в снижении потока воздуха через нос. Носовая полость соединяется со средним ухом, поэтому патологические процессы в носу могут влиять на состояние среднего уха.

Цель: Данный систематический обзор и мета-анализ были проведены для оценки взаимосвязи между назальной обструкцией и инфекционными заболеваниями среднего уха.
Материалы и методы. В рамках данного исследования выполнены систематический обзор и мета-анализ. Поиск литературы проводили в следующих пяти базах данных: Pubmed, CENTRAL, DOAJ, TRIP и BMC; авторы стремились найти клинические испытания и наблюдательные исследования по данной теме. Для оценки взаимосвязи между назальной обструкцией и инфекциями среднего уха с помощью мета-анализа были рассчитаны отношение рисков (ОР) и стандартизованная разница средних (SMD) с 95% доверительными интервалами (ДИ). Анализ данных проводили с помощью программы Review Manager (RevMan) версии 5.4.0.
Результаты. Всего в данный систематический обзор было включено 13 исследований, по результатам 9 из них авторы провели мета-анализ. Суммарное ОР показало тенденцию к развитию среднего отита в популяции с назальной обструкцией (ОР = 1,30; 95% ДИ, 0,41–4,10, p = 0,65). Анализ подгрупп не выявил значимых различий (p = 0,78) между этими показателями в отношении возникновения инфекционных заболеваний среднего уха (SMD = 0,04; 95% ДИ, -0,26–0,35). Была выявлена ассоциация между аллергической обструкцией носа и возникновением инфекций среднего уха (ОР = 1,17; 95% ДИ, 0,08–17,64), однако этот результат не был статистически значимым (p = 0,91).
Выводы. Не было выявлено значимой связи между назальной обструкцией и инфекционными заболеваниями среднего уха, которые могут быть вызваны различными факторами.
Ключевые слова: мета-анализ, инфекции среднего уха, назальная обструкция, средний отит, систематический обзор

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介绍：鼻腔阻塞是一种症状，表现为通过鼻子的气流减少。鼻腔与中耳相连，因此鼻子的病理过程也可能影响中耳的状况。目的：本系统综述和荟萃分析旨在评估鼻阻塞与中耳感染之间的关系。
材料和方法：本研究包括系统综述和荟萃分析。我们的文献检索包括以下五个数据库：Pubmed、CENTRAL、DOAJ、TRIP和BMC；我们旨在寻找与该主题相关的临床试验和观察性研究。通过荟萃分析计算风险比（RR）和95%置信区间（CI）的标准化平均差（SMD），以评估鼻阻塞与中耳感染之间的关系。使用Review Manager（RevMan）5.4.0版对数据进行分析。
结果：本系统综述共纳入13项研究，我们对其中9项进行了荟萃分析。累积RR在鼻阻塞人群中显示出发展为中耳炎的趋势（RR=1.30；95%CI，0.41—4.10，p=0.65）。亚组分析显示，这些指标与中耳感染的发生率之间没有显著差异（p=0.78）（SMD=0.04；95%CI，—0.26—0.35）。鼻腔阻塞与中耳感染的发生与过敏有关（RR=1.17；95%CI，0.08—17.64），但这一结果没有统计学意义（p=0.91）。
结论：鼻阻塞与中耳感染之间没有显著关系，中耳感染受到多种因素的影响。
关键词：荟萃分析：中耳感染、鼻梗阻、中耳炎，系统综述

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Introduction

Nasal obstruction is a symptom that manifests itself as reduced airflow through the nose. Anatomical changes in nasal structures and inflammatory processes such as allergies, toxins, infections, and foreign particles can cause nasal obstruction, which then disrupts nasal physiology such as nasal cycle and nasal airflow resistance [1]. It is more likely that most patients experience a severe degree of obstruction and

have more than one anatomic cause for their nasal obstruction; however, the prevalence of such anatomic causes has not been reported [2].

Nasal obstruction can cause additional issues, such as in the ears. If there are disturbances in the nasal tract, ears will be affected; a middle ear infection (otitis media, OM) may occur. OM often begins when viral or bacterial infections that cause sore throat, colds, or other respiratory or breathing problems spread to the middle ear. As the infection worsens, too much fluid in the ear can pressure the eardrum and eventually tear it [3].

A nasal obstruction such as septal deviation also causes a decrease in ipsilateral nasal airflow and otherwise increase on contralateral, resulting in changes in the airflow patterns. This may affect the Eustachian tube function and mucociliary clearance time (MCT) itself. The MCT is the key defense mechanism in the upper airways to remove debris-laden mucus in the sinuses via wave actions of cilias[4], and it can be affected by environmental heat, moisture, trauma, smoking, viral and bacterial infections such as OM, chronic rhinosinusitis, allergic rhinitis (AR), adenoid hypertrophia, septum deviation, surgery, cystic fibrosis, chronic bronchitis, and asthma [5]. Furthermore, changes may also be experienced on the side not affected by septal deviation due to other nasal obstructions such as turbinate hypertrophy [6]. Therefore, clinicians suggest an intervention to deal with the nasal obstruction before conducting middle ear surgeries [7].

However, the clinical significance of the relationship between nasal obstruction and middle ear infection is still generally debatable. A preliminary search found that several previous systematic reviews were focused more on the effectiveness of surgery or medication specifically for several causes of nasal obstruction [7]. Therefore, a more in-depth systematic review of the relationship between them is required.

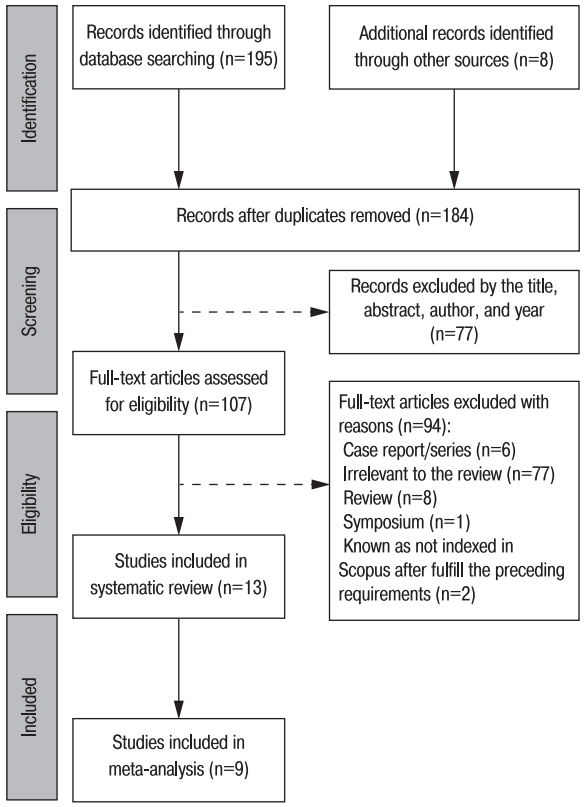

Fig. 1: PRISMA flow diagram

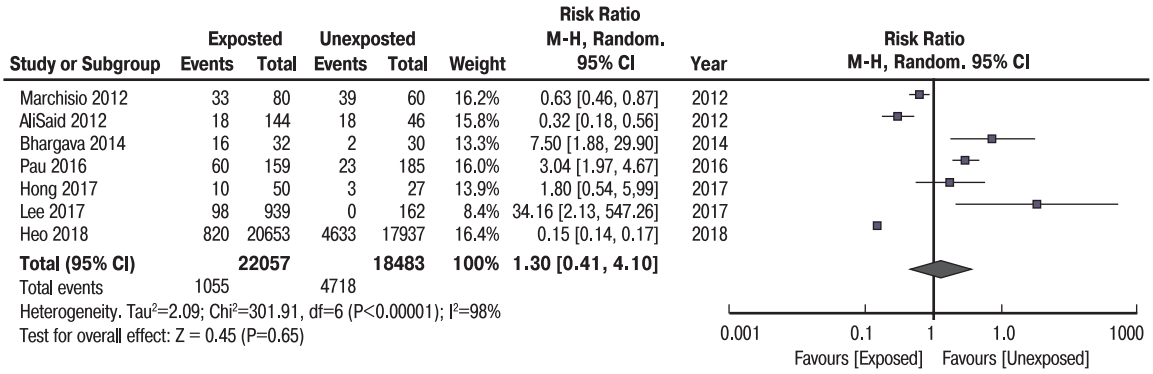

Fig. 2: Forest plot of the risk in developing middle ear infection due to nasal obstruction

Table 1: Initial search through the included database

Databases	Number after Initial Search	Filters				Number after Filtering
		Study Type	Publication Year	Species	Language	
Pubmed	242	-	✓	✓	✓	55
DOAJ	54	-	✓	-	-	45
BMC	120	✓	✓	-	-	52
CENTRAL	50	✓	✓	-	-	21
TRIP	270	✓	✓	-	-	22
Total	736					195

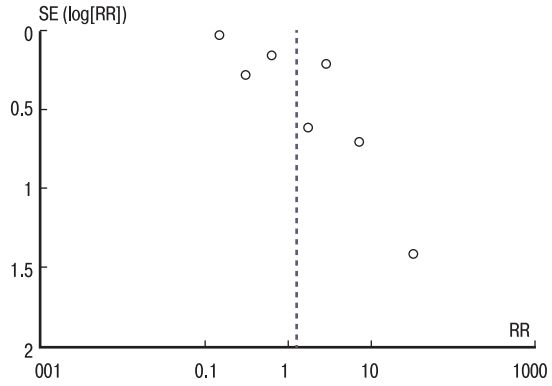

Fig. 3: Funnel plot of the risk in developing middle ear infection due to nasal obstruction

Materials and Methods

Study Design

This study included a systematic review and meta-analysis evaluating the relationship between nasal obstruction and middle ear infection.

Searching Strategies

Research articles were collected from the following five databases. The articles were then filtered using filters in each database according to eligibility criteria.

Data Collection Process

Included studies were extracted to obtain required data, following a matrix table based on the PEO framework

Data Analysis

All OM types were considered as the primary outcomes, and its complaints were considered as the secondary ones. The risk ratio (RR) and standardized mean difference (SMD) with 95% confidence intervals (CI) were calculated to evaluate the relationship between nasal obstruction and middle ear infections through meta-analysis. Effect assessments were conducted using relative effect measurement in the form of RR and SMD with random-effects model and 95% CI, considering the heterogeneity (I2) between studies. Data were analyzed using the Review Manager (RevMan) version 5.4.0.

Results

Study Characteristics

A total of 13 articles that met the eligibility criteria were included in this review. The total number of participants from studies included in this review was 41,620. Their age ranged from 5 months to 59 years. Most of the participants were aged ≥18 years old. However, the exact number is uncertain due to the unmentioned frequency of participants per age range.

Risk of Bias Within Studies

A total of five studies presented high quality, while another observational study and RCTs got the scores <7 and <3, respectively

Result of Individual Studies

There were 10 out of 13 studies that explained a positive relationship between nasal obstruction and middle ear infections. All studies with the RCT design, cross-sectional, and case-control generally showed a positive relationship. Meanwhile, all three cohort studies showed a negative relationship between the two variables [10-12]. These positive relationships were found in studies with participants ranging from pre-school children to adolescents. Participants aged 18 years, and another one was in a group of children. In addition, a partial negative association that was found in one study [20], other than the previous three studies, also occurred in the pediatric age group.

Insignificant relationships obtained from four studies were derived from the results of the examination of nasal flow resistance and mucociliary transport time in subjects with chronic OM, mobility of tympanic membrane in subjects with nasal obstruction, the results of acoustic rhinometry in subjects with chronic OM, and the results

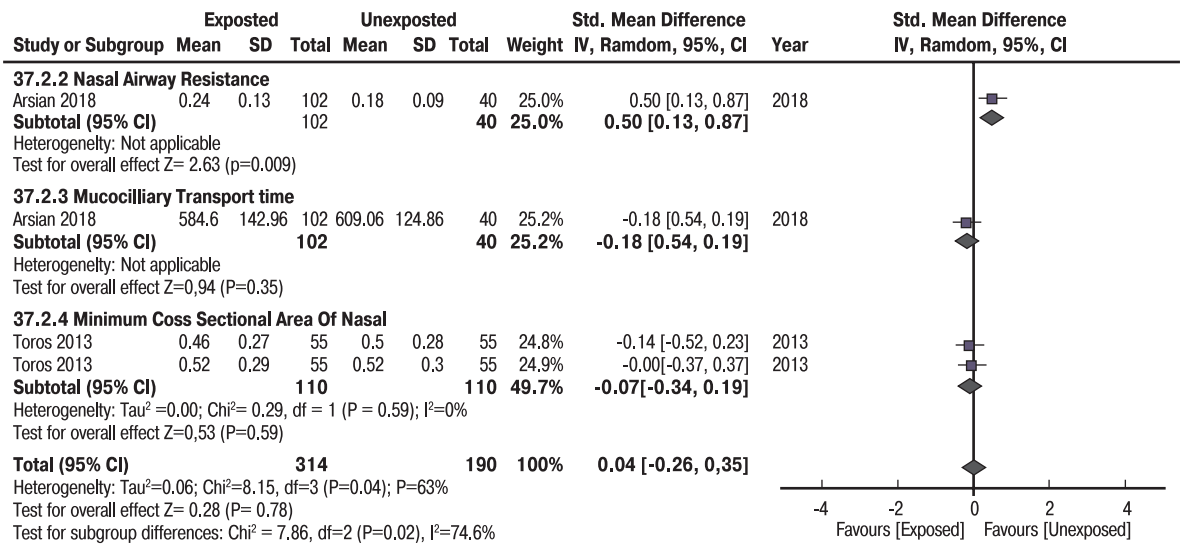

Fig. 4: Forest plot of nasal obstruction indicator toward middle ear infection

Table 2: Characteristics of included studies

Study	Patients(n); (M/F); Age; Mean of Age	Nasal Obstruction	Middle Ear Infection	Intervention; Outcome
Bhargava et al., India [8]	62; (38/24); 2–12 years; 7.4 years	Adenoid hypertrophy Grades 3 and 4 according to Cassano classification	Average conductive hearing loss associated with bilateral otitis media effusion (OME) assessed by tympanometry and pure tone audiometry (PTA)	Mometasone furoate 6 months vs placebo Decreased in adenoid size, change in OME, and a decrease of average conductive hearing loss
Said et al., Tanzania [9]	190; (95/95); 5 months–56 years; 8.5 years	Allergic rhinitis (AR)	Ear discharge	The six most common comorbidities are tonsillitis, adenoid hypertrophy, inferior turbinate hypertrophy, nasal polyps, ear discharge, and sinusitis
Arslan et al., Turkey [10]	102; (84/18); >18 years; 22.04 – 3.67 years	Nasal airway resistance assessed by rhinomanometry	Unilateral chronic non-suppurative otitis media (OM) and unilateral chronic OM with cholesteatoma	No difference in nasal airway resistance on the side of the ear with chronic OM and the side of the healthy ear. No difference in nasal airway resistance in ears with non-suppurative chronic OM and ears with chronic OM + cholesteatoma
Lee et al., South Korea [13]	939; (577/362); -; AR (7.5 – 3.4 years), nonallergic rhinitis (NAR) (5.5 – 2.9 years)	AR and NAR confirmed using allergen sensitization tests and ARIA (Allergic Rhinitis and Its Impact on Asthma)	OM	OM is one of the most common comorbidities, both in AR and NAR
Pau et al., China [16]	344 (AR:159, NAR:185); AR (96/63), NAR (113/72); 4–12 years; AR (8.4 – 2.4 years); NAR (7.6–2.4 years)	AR confirmed through symptoms, interviews, and questionnaires, as well as atopy status assessed from skin prick test (SPT), serum IgE, and blood eosinophils	OM with effusion that assessed by pneumatic otoscopy and tympanometry	More patients with AR had OME compared to patients with NAR. More tympanogram results were abnormal in patients with AR compared to patients with NAR. More abnormal otoscopy results in patients with AR compared to patients with NAR
Walker et al., New Zealand [18]	387; -; 3–4 years; cases (47.8 months), control (49.3 months)	Nasal obstruction symptoms	Chronic OM with effusion	Frequent nasal obstruction in last 12 months in the case group
Marchisio et al., Italy [19]	220; -; 5–9 years; 80 months	AR with turbinate hypertrophy and Grade 1–4 adenoid hypertrophy assessed by rhinoscopy	OM with effusion that assessed to evaluate opacification, tympanic membrane retraction, association with a flat tympanogram, and absence of signs or symptoms of acute infection	Hypertonic vs. normal saline; Changes in the adenoid size and bilateral effusion OM
Alexandrino et al., Portugal [20]	75; -; <3 years; control (20.3 – 5.92 months), intervention (22.6 – 7.49 months)	Acute respiratory infections (ARI) with the common cold, acute rhinosinusitis, pharyngitis, and tonsillitis on the first day of onset	Changes in the state of middle ear indicators of acute otitis media that assessed from peak pressure and mobility of tympanic membrane	The frequency of patients with nasal obstruction decreased. Peak pressure in both sides of the ear increased. Mobility of tympanic membrane was not significantly affected
Toros et al., Turkey [11]	55; (19/36); 18–59 years; 32.56 – 12.60 years	Nasal obstruction symptoms assessed by the NOSE score and nasal airway obstruction assessed by acoustic rhinometry	Unilateral chronic OM with dry tympanic membrane perforation	NOSE score was inversely correlated to MCA2 and V2 values on the side of the affected ear
Heo et al., South Korea [14]	38,626; -;-;-	Nasal pathology: nasal septal deviation, nasal polyps, inferior turbinate hypertrophy, chronic hypertrophic rhinitis, and postnasal drip (PND)	Chronic suppurative otitis media (CSOM) with or without cholesteatoma	Chronic PND, chronic hypertrophic rhinitis, nasal polyps, and allergic rhinitis were associated with middle ear abnormalities (CSOM and cholesteatoma) No significant relationship between nasal septal deviation and CSOM or cholesteatoma
Park MS et al., South Korea [15]	432; (165/267); -; 45 – 18 years	Nasal obstruction symptom	Ear fullness regarding OM with effusion	Nasal obstruction was associated with bilateral ear fullness
Hong et al., China [17]	92; (46/46); 6–8 years; responder (83 – 5, 80 months); nonresponder (83.74 – 5.56 months); control (83.16 –5.97 months)	Adenoid hypertrophy with an adenoid-to-nasopharyngeal ratio >5	OM with effusion assessed by tympanometry and audiometry	12-week transnasal nebulization with budesonide compared with placebo (saline solution); OME frequency decreased over 12 weeks
Durgut et al., Turkey [12]	50; (25/25); 5–14 years; 8.32 – 2.66 years	Adenoid hypertrophy based on the adenoid location and size	OM with effusion and suspect of hearing loss that assessed by otoscopy, tympanometry, and PTA	No significant relationship between the effusion duration and adenoid size, adenoid location, and hearing threshold

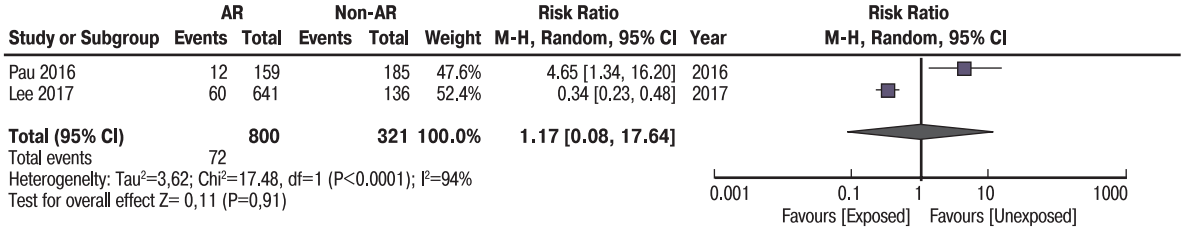

Fig. 5: Forest plot of risk in developing middle ear infection due to nasal obstruction with allergy

of hearing threshold and duration of OME in subjects with adenoid hypertrophy.

Synthesis of Results

Meta-analysis of nine studies was performed if the studies had similar comparisons and outcomes. Effect measurements were done using relative effect measurement, namely the RR, and absolute effect measurement, namely, the SDM with random-effects model and CI95%, considering the presence of heterogeneity between studies. Data were analyzed using the Review Manager (RevMan) version 5.4.0. Seven studies were assessed to obtain an association between two variables based on their prevalence [8,9,13,14,16,17,19]. The cumulative RR indicated a tendency to develop OM in the population with nasal obstruction (RR = 1.30; 95% CI, 0.41–4.10). However, this relationship was not statistically significant (p = 0.65). The heterogeneity test showed the presence of heterogeneity in these studies (–2 = 301.91; df = 6; I2 = 98%). A visual funnel plot analysis showed asymmetry, which indicates publication bias.. Two studies [10,11] were analyzed in a subgroup analysis for several indicators regarding nasal obstruction and its association with the incidence of middle ear infection. Fig. 4 showed no significant difference (p = 0.78) between these indicators in relation to incidence of middle ear infection (SMD = 0.04; 95% CI, –0.26–0.35). Heterogeneity test showed heterogeneity in these studies (–2= 7.86; df = 2; I2 = 74.6%). Concerning allergy and atopy, two studies [13,16] were analyzed to compare AR and NAR to the occurrence of middle ear infection based on allergy test and family history of diseases. Fig. 5 indicates that there was a relationship in nasal obstruction between allergy with the emergence of middle ear infections (RR = 1.17; 95% CI, 0.08–17.64), but this result was not statistically significant (p = 0.91). The heterogeneity test showed heterogeneity in these studies (–2 = 17.48; df = 1; I2 = 94%).

Discussion

Summary of Evidence The option to treat nasal obstruction before middle ear infection is widely practiced by clinicians considering a connection between nose and ear anatomically and physiologically [7]. This review and meta-analysis showed a 1.3 times greater likelihood of subjects with nasal obstruction to develop middle ear infections (OM). However, this value did not reach statistical significance. Several factors might play a role in the relationship between these two variables.

Although several studies revealed that nasal obstruction had important roles in the pathological condition of the middle ear, three studies [10-12] were unable to show a clear association between nasal obstruction and middle ear infections. Another consideration is that those studies with negative results were cohort studies intended to assess disease course over a longer time. Another study that found an insignificant relationship between two variables showed that changes in one of the indicators of middle ear condition, which is tympanic membrane mobility, were not affected by acute nasal obstruction. However, it is believed that removing nasopharyngeal secretions can restore normal pressure to the middle ear and normalize Eustachian tube function acutely [20]. This is in line with the consideration that inflammatory and infectious conditions causing edema of the nasal mucosa, compared to structural disorders such as septal deviation [14], are considered to play a greater role in nasal obstruction and etiopathogenesis of chronic OM[11].

The distribution of study countries of origin in this review was quite even, with the predominance of studies from the Asian continent. Most of the studies were conducted in subtropical countries with various seasons, including winter. Certain seasons are considered to contribute to allergens' presence that triggers the emergence of nasal obstruction such as rhinitis, which then affects the middle ear condition. Middle ear infections such as OME were twice more frequent in winter than summer, as indicated by the number of children diagnosed with OME in that season [21]. Other studies also reported the need to analyze factors of the season at the birthplace of study subjects [18,22]. winter was considered to increase the frequency of the ear and upper respiratory system infections, including seasonal influenza. Having close contact with household members during winter increases the chance of spreading the infection to children [21]. Allergies are considered to play a role in nasal obstruction with middle ear infections outcome through several theories that explain that the Eustachian tube dysfunction caused by allergic inflammation occurs due to retrograde spread of edema, decreased mucociliary function, excessive venous dilation, and mucus hypersecretion [22]. An onset of nasal obstruction symptoms, such as in AR, is associated with the development of comorbidities, including OM and accompanying complaints [9]. Studies on children with a history of OME showed that 89% of these children had a history of AR, and some of them were accompanied by asthma and eczema through history, physical examination, and supporting examinations such as nasal smears, skin prick tests, number of eosinophils, and total IgE [23]. This could be related to allergy or atopy march, a course of allergy events that begins with atopic eczema and is followed by AR and/or asthma in early childhood and remains until several years later [24]. In children with a family having an allergies history, rhinovirus was found in their tympanic cavity [25]. In contrast, other studies have shown that allergies have very little effect on the pathogenesis of chronic OM disease in the age group 6–7 years. There was no difference in the prevalence of allergy complaints in children with OME inserted with ventilation tubes compared to the control group. The high prevalence of nasal obstruction symptoms in children with OME came from other accompanying nasal obstructions such as

Table 3: Quality assessment of RCT

Reference	Randomization is Mentioned	Appropriateness of Randomization	Blinding is Mentioned	Appropriateness of Blinding	An Account of All Patients or Description of Withdrawal or Drop Out	Total
Alexandrino et al.[20]	1	1	1	1	1	5
Hong et al.[17]	1	1	1	1	1	5
Marchisio et al.[19]	1	0	1	0	1	3
Bhargava et al.[8]	1	0	1	0	0	2

Table 4: Quality assessment of case-control studies

Study	Selection				Comparability		Outcome			Total Score
	Case Definition Adequate	Representativeness of the Case	Selection of Control	Definition of Controls	Main Factor	Additional Factor	Ascertainment of Exposure	Same Method of Ascertainment for Cases and Reports	Non-Response Rate	
Walker et al.[18]	*	*	*	/	*	*	*	*	/	7/9

Table 5: Quality assessment of cross-sectional studies

Study	Selection				Comparability	Outcome		Total Score
	Representativeness of the Sample	Sample Size	Ascertainment of Exposure	Non-Respondents	Comparability of Subjects based on the Design or Analysis (max 2 stars)	Assessment of Outcome	Statistical Test	
Said et al.[9]	*	*	*	/	**	*	*	7/9
Lee et al.[13]	*	*	*	/	**	/	*	6/9
Pau et al.[16]	*	*	*	/	**	/	*	6/9
Heo et al.[14]	*	*	*	/	*	*	*	6/9

adenoid hyperplasia, resulting from allergic rhinitis [26]. This is in line with the results of a meta-analysis conducted from two studies with children who found allergies affected only 1.17 times to middle ear infections compared to nasal obstruction without allergies. However, the role of allergy or atopy in the pathogenesis of middle ear infections, especially OME, is still generally debatable. There are several possible mechanisms in which OM is triggered by nasal obstruction. Eustachian tube dysfunction is suspected to be associated with OM due to nasal obstruction. Abnormal values of the Eustachian tube function assessed by tympanometry were higher in patients with AR than in healthy individuals. Abnormal mucociliary activity due to nasal obstruction facilitated the aspiration of nasopharyngeal secretions containing pathogenic bacteria into the Eustachian tube [27,28]. Studies in this review reported a large number of study subjects from the pediatric age group. This may be due to differences in anatomy and physiology of structures associated between children and adults, such as the Eustachian tube and host immune factors [21]. Eustachian tube or auditory tube/pharyngotympanic tube is a canal connecting the nasopharynx to the anterior wall of the middle ear so that the air pressure in the tympanic cavity and nasopharynx or air pressure on both sides of the tympanic membrane remains balanced [29,30]. The eustachian tube is formed by cartilages in the anterior two-thirds (medial) and by bone in the posterior (lateral) third. The Eustachian tube is tilted downward by 45 degrees. The diameter of the Eustachian tube is different for each part. For the bony part, tubal diameter reaches 3–6 mm. When it reaches a point of transition to cartilage (isthmus), the diameter becomes narrower (about 1–2 mm) [29]. The Eustachian tube in children is more horizontal and shorter with a narrower lumen than in adults. The length of the Eustachian tube in infants is only 21 mm compared to the length of the tube in adults, which reaches 31–38 mm. Mucosal folds in the Eustachian tube lumen are found to be more numerous than in adult lumen tubes. These anatomical immaturities make it easy for infection to spread to the middle ear in children compared to adults due to poor mucociliary transport function, presence of pathogenic reflux, and inflammatory or allergic mediators from the nasopharynx, even nasogastric reflux to the middle ear [28,30,31]. Nasal obstruction

Table 6: Quality assessment of cohort studies

Study	Selection				Comparability	Outcome			Total Score
	Representativeness of Exposed Cohort	Selection of Non-Exposed Cohort	Ascertainment of Exposure	Demonstration that Outcome of Interest Was Not Present at the Start of Study	Comparability of Cohort Based on the Design or Analysis (max 2 stars)	Assessment of Outcome	Was the Follow-up Long Enough for Outcomes to Occur	Adequacy of Cohorts Follow-up	
Park et al.[15]	*	/	*	/	**	/	*	/	5/9
Arslan et al.[10]	*	*	*	/	/	/	/	/	3/9
Toros et al.[11]	*	/	*	/	/	/	/	/	2/9
Durgut et al.[12]	*	/	*	/	/	/	/	/	2/9

is generally associated with chronic OM through allergic and upper respiratory tract infection mechanisms [32]. However, biofilms in the nose and nasopharynx independently can be the influencing factors for chronic nasal obstruction or chronic OM. Nasal biofilms cause an increase in nasal resistance, leading to Eustachian tube dysfunction as well[33,34]. Biofilm is a community of bacterial sessile in extracellular polymer matrix from its synthesis. This community is resistant to cell membrane disruption and has a low metabolic rate. Adhesion of biofilms on mucosal surfaces will cause host immunity disorders [21]. Increased biofilm represents a chronic inflammatory condition, such as middle ear infection and nasal obstruction caused by chronic rhinosinusitis and chronic tonsilloadenoiditis. However, the contribution of biofilms found in the middle ear accompanied by nasal obstruction to the pathogenesis of middle ear infections such as OME is still uncertain. The formation of biofilms may be a secondary effect of viral respiratory tract infection, which then triggers inflammation and mucus production, which then causes nasal obstruction [21,35]. Bacteriological culture examination on the aspiration of middle ear fluid showed the most common positive results of respiratory tract bacteria: Streptococcus pneumoniae, Haemophilus influenza, and Moraxella catarrhalis [36,37]. The culture found the most positive bacteria forming biofilms were Staphylococcus epidermidis which is commonly found in the normal nasal cavity, followed by Staphylococcus aureus, Klebsiella spp, and Proteus mirabilis in low frequency by tube method examination in patients with acute rhinosinusitis [38,39]. Approximately 66% of simple culture techniques yield negative findings for bacteria compared to polymerase chain reaction techniques, for which 36% showed positive results of S. pneumoniae intracellularly [37]. This evidence supports the existence of a defense mechanism for persistent bacteria through the formation of biofilms [21]. Two of three studies [10,11] with negative associations were included in the review to assess the unilateral middle ear infection incidence. Risk factors for middle ear infection, both unilateral and bilateral, were considered the same. Therefore, a study should focus more on patients as an analysis unit than the ear because the ear is not an independent variable [21]. Other factors were assessed in several studies, including sex and exposure to cigarettes/smoking. The difference in the risk of middle ear infection incidence in men and women is relatively small in epidemiology. However, women are considered more at risk because of changes in hormone levels, especially progesterone, that occur during pregnancy, oral contraceptive drug use, and other conditions that induce mucosal hypertrophy [21,31]. Smoking is a risk factor because it causes mucosal inflammation and continues to develop mucosal hypertrophy. A decrease in function of mucociliary transport occurs through an increase in viscosity of secretions and damage to cilia[31].

Conclusions

This review revealed that there was no significant relationship between nasal obstruction and middle ear infection. Both variables can be considered when deciding whether to perform a nasal obstruction intervention before the middle ear infection intervention.

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