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Original Article

Correlation of Rhinomanometry Measurement and True Lateral Radiography towards the Degree of Upper Airway Obstruction in Patients with Adenoid Hypertrophy

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ABSTRACT

Background: *Adenoid hypertrophy is one of the most common disorders in children which may lead to upper airway obstruction. Various modalities to measure airway obstruction in patients with adenoid hypertrophy, including true lateral radiographs, nasoendoscopy, and rhinomanometry are available; however, the results from different studies are still controversial. This study aimed to determine the relationship between the results of rhinomanometry and the true lateral radiographs to the degree of upper airway obstruction in patients with adenoid hypertrophy.* ***Methods:*** *This cross-sectional study included a total of 33 patients with adenoid hypertrophy aged 5-18 years using a purposive sampling technique. Patients diagnosed with adenoid hypertrophy were subjected to a true lateral examination using lateral neck radiographs to measure the degree of airway obstruction. Subsequently, an active anterior rhinomanometry was performed by measuring resistance and nasal airflow and then measuring the degree of airway obstruction. Data analysis was done using Chi-Square test.* ***Results:*** *The rhinomanometric nasal resistance in*

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the inspiratory phase was 0.4159 ± 0.15201 Pa/cm3/s and 0.3694 ± 0.13717 Pa/cm3/s in the expiration phase. The results showed a significant relationship between the true lateral radiographs and both nasal inspiratory (p=0.005) and expiratory resistance (p=0.004). Similarly, the relationship between the true lateral radiographs and nasal airflow on both inspiratory and expiratory rhinomanometry was significant (p<0.05). ***Conclusion:*** *Rhinomanometric measurements can be used as an additional objective examination in assessing the degree of upper airway obstruction in patients with adenoid hypertrophy prior to surgery.*

1. INTRODUCTION

Adenoids or pharyngeal tonsils are triangular-shaped lymphoepithelial tissue located on the posterior wall of the nasopharynx. Physiologically the size of the adenoid changes according to age. Adenoid size increases rapidly after birth and reaches its maximum size at 3-7 years of age and persists until 8-9 years of age.[1] After the age of 14 years, adenoids gradually experience involution/regression. When adenoid hypertrophy occurs, especially in children, it appears as a response to various antigens such as viruses, bacteria, allergens, food, and environmental irritants.[2]

Adenoid hypertrophy is one of the most common disorders in children. Based on its location, enlarged adenoid tissue can cause adverse effects on physiological development, such as hyponasal speech, open mouth breathing, snoring, middle ear infections, changes in facial development, behavioral problems, and decreased intelligence. In addition, it can also cause upper airway obstruction, especially during sleep, known as Obstructive Sleep Apnea (OSA).

The diagnosis of adenoid hypertrophy can be made based on clinical signs and symptoms, physical examination, and investigations. Clinically, signs such as mouth breathing, sleep apnea, adenoid facies, snoring, and middle ear disorders can be found. The main supporting examination is radiological examination by taking a true lateral plain photo. This examination can objectively determine the adenoid size and measure the relationship between adenoid size and upper airway obstruction.[3]

Upper airway obstruction is often a problem, especially in pediatric patients. Therefore, the duration and severity of airway obstruction need to be evaluated for further management. The degree of airway obstruction can be examined by several examinations, such as acoustic rhinomanometry, rhinomanometry, and radiography.[4] Out of these modalities, rhinomanometry is a simple test that objectively evaluates airway patency. This tool is commonly used to diagnose airway obstruction and follow-up patients who receive medical therapy or who have undergone operative therapy to improve respiratory patency.

Several studies have been conducted to find out the best examination to diagnose adenoid hypertrophy in children. Although many objective modalities have been described, such as posterior rhinoscopy, endoscopy, and true lateral radiographs, the results are still controversial. A study by Soldatova reported a significant relationship between intraoperative adenoid enlargement measurements and the degree of airway obstruction using lateral neck radiography ($p<0.001$).[5] Another study by Sharifkashani found a low correlation ($p>0.05$) between endoscopic findings and lateral radiographs.[6] In contrast, a study by Zicari et al. who compared the degree of obstruction in patients with adenoid hypertrophy grade 1 to 5 using nasoendoscopy to rhinomanometry found a specificity of 84.3% and sensitivity 81%.[4]

This study aimed to determine the relationship between the results of rhinomanometric measurements and true lateral radiographs to the degree of upper airway obstruction in patients with adenoid hypertrophy.

2. METHODS

Study Setting and Design

This cross-sectional study was conducted at the otorhinolaryngology outpatient clinic from May 2020 to February 2021.

Study Participants

This study involved 33 samples of adenoid hypertrophy patients who met the inclusion criteria to validate the anterior active rhinomanometry. The inclusion criteria were children aged 5-18 years. Subjects were excluded if there is tumor in the nasal cavity and paranasal sinuses, septal deviation, history of allergies, and if subjects were uncooperative.

Data Collection

True lateral radiographs were plain lateral neck radiographs measured by lateral neck soft tissue radiographs (LNXR). It was used to assess and measure the degree of obstruction in adenoid hypertrophy patients with blockage/obstruction. Those obstruction degree categories were:

a. Grade I : Adenoid size less than 25% of the nasopharyngeal airway

b. Grade II : Adenoids in 25% to 50% of the nasopharyngeal airway

c. Grade III : Adenoids in 50% to 75% of the nasopharyngeal airway

d. Grade IV : Adenoid size greater than 75% of the nasopharyngeal airway

The normal value of resistance in the nasal cavity based on ISCR (International Standardization Committee of Rhinomanometry) was 0.15–0.5 Pa/(cm^3/sec) after decongestant administration. If it exceeded 0.5 Pa/(cm^3/second), the nasal resistance was increased due to obstruction/blockage in the nasal cavity. Airflow (nasal airflow) measured the amount of air per unit time that flows through the nasal cavity measured at one time and was classified according to the following criteria:

a. > 800 cm^3/s : No obstruction

b. 500 – 800 cm^3/s : Light obstruction

c. 300 – 500 cm^3/s : Medium obstruction

d. 100 – 300 cm^3/s : Severed obstruction

e. < 100 cm^3/s : Closed airway

Statement of Ethical Approval

This research had obtained ethical approval from the local ethical board committee with recommendation number 425/UN4.6.4.5.31/PP36/2020.

Statistical Analysis

Data analysis was conducted using SPSS version 25 and by using Chi-Square test with a significance level of 0.05.

3. RESULTS

Demographic Data

Data analysis was carried out on 33 patients aged between 5-18 years. Table 1 shows that 54.5% of all participants were female and the 5-9 years age group was the most affected age group (42.4%). In addition, 45.5% participants had grade III obstruction followed by grade II (27.3%), grade I (21.2%), and grade IV (6.1%). No significant between age and nasal inspiration and expiration resistance was found in this study (Table 2).

Table 1. Patient Characteristics

Characteristic	**n**	**%**
Sex		
Male	15	45,5
Female	18	54,5
Age		
5-9 Years	14	42,2
10-14 Years	10	30,3
15-18 Years	9	27,3
Airway Obstruction Grade		
I	7	21.2
II	9	27.3
III	15	45.5
IV	2	6.1
Total	33	100

Table 2. Relationship between inspiratory and expiratory nasal resistance and age at a pressure of 150 Pa in patients with adenoid hypertrophy

Age	Inspiratory nasal resistance				Total		r	P-value
	0,15-0,5		>0,5					
	n	%	n	%	n	%		
5-9 years	4	12.2	10	30.3	14	42.5	0.265	0.136
10-14 years	1	3.0	9	27.2	10	30.2		
15-18 years	3	9.1	6	18.2	9	27.3		
Total	8	24.3	25	75.7	33	100		

Age	Expiratory nasal resistance				Total		r	P-value
	0,15-0,5		>0,5					
	n	%	n	%	n	%		
5-9 years	3	9.1	11	33.3	14	42.5	0.244	0.172
10-14 years	1	3.0	9	27.2	10	30.2		
15-18 years	3	9.1	6	18.2	9	27.3		
Total	7	21.3	26	78.7	33	100		

Average nasal resistance in the inspiratory and expiratory phases

Figure 1 presents the percentage of the average nasal resistance in the inspiratory and expiratory phases. At a pressure of 75Pa in the inspiratory phase of 0.3534±0.13817 Pa/cm^3/s, while the value of nasal resistance in the expiratory phase of 0.3299±0.12655 Pa/cm^3/s. At a pressure of 100Pa, the value of nasal resistance in the inspiratory phase was 0.3595±0.131158 Pa/cm^3/s, while the resistance value in the expiratory phase was 0.3403±0.12685 Pa/cm^3/s. Then, at a pressure of 150Pa, the value of nasal resistance at the inspiratory phase was 0.4159±0.15201 Pa/cm^3/s, while the value of nasal resistance at the expiratory phase was 0.3694±0.13717 Pa/cm^3/s.

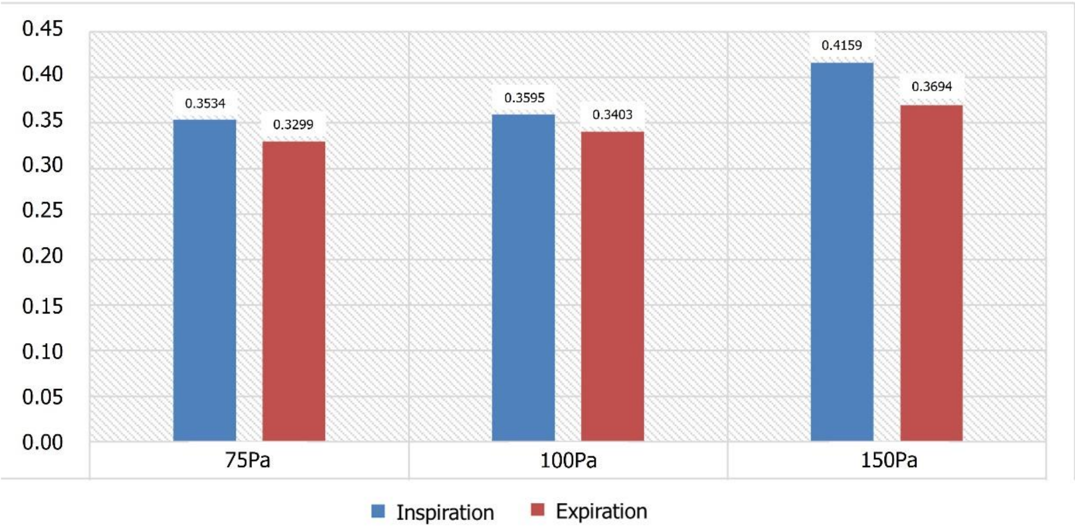

Figure 1. Values of Nasal Resistance at pressures of 75 Pa, 100 Pa and 150 Pa in the inspiratory and expiratory phases

Association between nasal inspiration and expiration resistance and true lateral photos

A significant association between nasal inspiration and expiration resistance and true lateral photos was shown in table 3, respectively ($p<0.05$) which is supported by the positive correlation of the scattered diagram (Figure 2). This suggests that higher degree of obstruction on the true lateral photo is associated with higher nasal inspiratory resistance on rhinomanometry.

Table 3. Relationship between nasal inspiratory and expiratory nasal resistance and true lateral photographs in adenoid hypertrophy patients

Grade	Nasal resistance				Total		P-value
	0,15-0,5		>0,5				
	n	%	n	%	n	%	
I	7	21,2	0	0	7	21,2	0,005
II	9	27,3	0	0	9	27,3	
III	10	30,3	5	15,2	15	45,5	
IV	0	0	2	6,1	2	6,1	
Total	26	78,8	7	21,2	33	100	

Grade	Nasal resistance				Total		P-value
	0,15-0,5		>0,5				
	n	%	n	%	n	%	
I	7	21,2	0	0	7	21,2	0,004
II	9	27,3	0	0	9	27,3	
III	11	33,3	4	12,1	15	45,4	
IV	0	0	2	6,1	2	6,1	
Total	27	81,8	6	18,2	33	100	

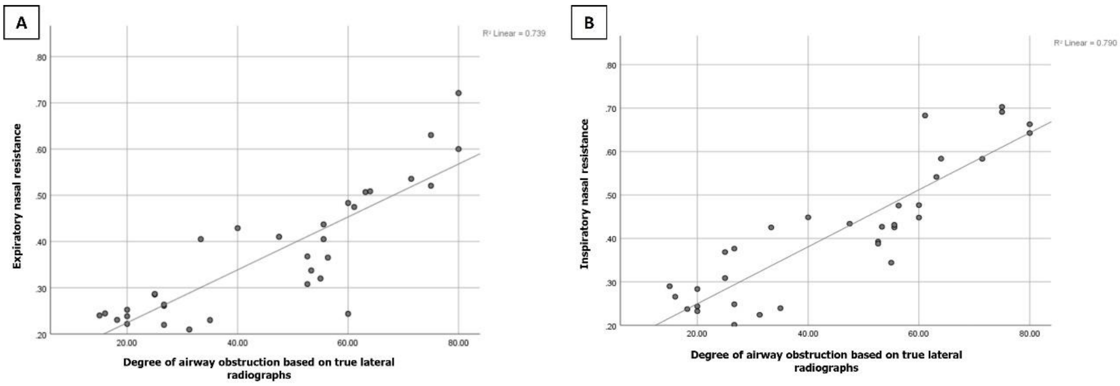

Figure 2. Relationship between inspiratory and expiratory nasal resistance and true lateral radiographs in adenoid hypertrophy patients

Association between nasal inspiration and expiration airflow and true lateral photos

Figure 3 showed a significant negative correlation between inspiratory and expiratory airflow with true lateral photographs (r^2 values of 0.714 and 0.795, respectively). Data presented on table 4 also supported this notion ($p<0.05$). This suggests that higher of obstruction on the true lateral photo, the lower the inspired airflow on rhinomanometry is.

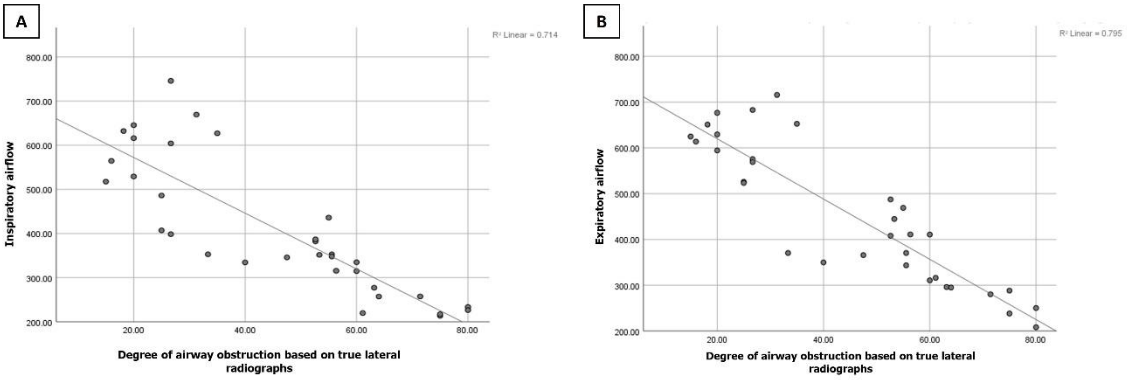

Figure 3. Relationship between inspiratory and expiratory airflow and true lateral radiographs in adenoid hypertrophy patients

Table 4. Relationship between inspiratory and expiratory airflow and true lateral photographs in adenoid hypertrophy patients

Grade	**Inspiratory Airflow**						**Total**		**P-value**
	Light (500-800)		Moderate (300-500)		Severe (100-300)				
	n	%	n	%	n	%	n	%	
I	6	18,2	1	3,0	0	0	7	21,2	0,000
II	4	12,1	5	15,2	0	0	9	27,3	
III	0	0	9	27,3	6	18,2	15	45,5	
IV	0	0	0	0	2	6,1	2	6,1	
Total	10	30,3	15	45,5	8	24,2	33	100	

Grade	**Expiratory Airflow**						**Total**		**P-value**
	Light (500-800)		Moderate (300-500)		Severe (100-300)				
	n	%	n	%	n	%	n	%	
I	7	21,2	0	0	0	0	7	21,2	0,000
II	6	18,2	3	9,1	0	0	9	27,3	
III	0	0	10	30,2	5	15,2	15	45,5	
IV	0	0	0	0	2	6,1	2	6,1	
Total	13	39,4	13	39,4	7	21,2	33	100	

4. DISCUSSION

This study shows that adenoid hypertrophy was more commonly found in female (54.5%) and in the 5–9-year age group. To date, the association between gender and the development adenoid hypertrophy is still unclear. However, the role of age is already well known. The study by Sharifkhasani obtained slightly more males (56.6%) than females (43.4%), mostly aged 5-9 years (42.4%).[6] The study of Aydin et al. separated their patients into the age groups of 5-7 years, 8-10 years, and 11-14 years, with the highest prevalence in the age range of 8-10 years (95%).[7] Children aged 8-14 years have a higher prevalence of adenoid hypertrophy than those with younger ages. Physiologically the size of the adenoid can change according to age. According to Havas, adenoid enlarges rapidly after birth and reaches its maximum size at 3-7 years of age, persists at 8-9 years of age, then regresses gradually after 14 years of age.[1]

Table 1 presents the distribution of adenoid enlargement based on true lateral radiographs. True lateral radiographs have been extensively studied in assessing adenoid enlargement and measuring airway obstruction. However, no studies have reported the prevalence of enlarged adenoid hypertrophy based on true lateral photos measured by LNXR. Our data shows that 15 subjects (45.5%) had Grade III obstruction.

Figure 1 shows the total resistance values in the inspiratory and expiratory phases with 75Pa, 100Pa, and 150Pa pressure. The results of this study were higher than the research conducted by Ren L et al., which stated that the total resistance value after administration of decongestants at a pressure of 75 Pa averaged 0.160±0.05 Pa/cm^3/s and at a pressure of 150 Pa 0.236±0.067 Pa/cm^3/s.[8] A research by Kobayashi et al. found that the value of nasal resistance in normal children was 0.35±0.16 Pa/cm^3/s and for children with respiratory disorders was 0.57±1.05 Pa/cm^3/s.[9] The study also found younger children had higher nasal resistance which decreased with increasing age. On the contrary, our study did not find significant relationship between age and nasal resistance, both inspiration and expiration ($p>0.05$). This difference might be attributed to the fact that the aforementioned study only examined normal children while in this study, all subjects experienced respiratory obstruction although with different degrees of obstruction.[10] It can also be caused by the small sample of our study (n=33). In a previous study by Kobayashi factors such as body posture, temperature, and other physiological conditions for instance the nasal cycle also play a factor in affecting nasal patency.[10] Nasal cycle is influenced by vascular activity, which causes congestion and decongestion in the nasal cavity. Thus, in normal people or those with mild abnormalities, resistance value fluctuates continuously.[11] However, in this study, no measurements of weight and height, temperature, or size of the nasal dorsum were carried out before rhinomanometry examination, which could impact the results.

Table 4 and 5 show a significant relationship between inspiratory and expiratory nasal resistance and true lateral radiographs. The greater the degree of airway obstruction based on the true lateral photo, the higher the nasal resistance is. However, as previously described, the value of nasal resistance is also influenced by several factors that were not measured in our study. Measurement error can also be a factor that causes differences in measurement results. This can occur in the setting of uncooperative patient, loose mask, air leak in the nasal cavity or if the patient breathes too fast or does not close his mouth tightly.

Based on the recommendations of the European Rhinomanometry Standardization Committee, all airflow measurements should be examined at 150Pa.[12] The range of airflow values has been associated with varying degrees of difficulty breathing and the general population.[13] In line with the result stated above, resistance is inversely proportional to nasal airflow which implies that an increase in nasal resistance will cause a decrease in airflow and vice versa.

To our knowledge, this is the first study to examine the association between rhinomanometric measurements and true lateral radiographs to assess the degree of upper airway obstruction. In this study, there was a significant relationship (p=0.000) between true lateral photographs and the results of rhinomanometric airflow measurements, both in inspiratory and expiratory phases, to the degree of obstruction of the upper airway. This revealed that the higher the degree of upper airway obstruction based on true lateral photos, the lower the airflow based on rhinomanometric measurements is. As is well known, true lateral radiograph is an additional objective examination in diagnosing adenoid hypertrophy. Many studies have investigated the use of true lateral radiographs in evaluating the presence of enlarged adenoids by various methods. A previous study on 61 subjects by Lertsburapa et al. showed that adenoid/nasopharyngeal ratio assessed by true lateral radiographs was significantly associated with enlarged adenoid in intraoperative mirror exam ($p<0.0001$).[14] Soldatova's study reported the relationship between intraoperative adenoid enlargement and the degree of airway obstruction using lateral neck radiography ($p<0.001$).[5] Based on the results of this study, true lateral radiographs could provide useful information to determine the degree of upper airway obstruction. However, the radiation effect of true lateral photo radiation needs to be considered prior to conducting this examination.

5. CONCLUSION

Rhinomanometric measurements could be used as an additional objective examination in assessing the degree of upper airway obstruction in patients with adenoid hypertrophy. In addition, it could serve as an additional tool to assist surgery in patients with adenoid hypertrophy. We suggest that future studies should be carried out to compare the values of airflow and nasal resistance on rhinomanometry before and after surgery in patients with adenoid hypertrophy.

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Conflict of Interest Statement:

The authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.