Correlation between the Level of Maximum Airway Obstruction by Flexible Naso-pharyngo-laryngoscopy Examination and Severity of Obstructive Sleep Apnea Syndrome Using Polysomnography

Original Article

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ABSTRACT

Purpose: To assess the correlation between the level and grade of maximum airway obstruction by flexible naso-pharyngo-laryngoscopy examination (FNPL) and the severity of obstructive sleep apnea syndrome (OSAS) using polysomnography.
Methods: A cross-sectional study was conducted on 33 patients diagnosed with OSAS with polysomnography. A FNPL using Müller's maneuver was performed for every patient with its findings evaluated according to the Nose Oropharynx Hypopharynx and Larynx (NOHL) classification. The study assessed the correlation between the grades of obstruction at different levels and the apnea-hypopnea index (AHI) and the significance of the effect of the grade of obstruction at each level on the AHI.
Results: The grades of nasal obstruction, retrolingual obstruction, and tonsillar hypertrophy had a significant positive correlation with the AHI ($p = 0.0052$, 0.0012, and 0.00169, respectively). Moreover, BMI and the grade of retropalatal obstruction had a highly substantial positive correlation with AHI ($p = 0.00004$ and 0,00003, respectively). Multiple regression analysis revealed that retropalatal obstruction was the only factor having a significant individual effect on the grade of sleep apnea ($p = 0.04$).
Conclusion: Flexible Naso-Pharyngo-Laryngoscopy examination is an essential assessment step for OSAS patients with Müller's maneuver being the most available and safest method. In the present study, this assessment showed that OSAS had a multilevel obstructive etiology with a positive correlation between the grade of obstruction at each level and AHI indicating the severity of OSAS. Regression analysis showed that retropalatal obstruction was the significant individual factor affecting AHI.

Key Words: Apnea-hypopnea index, awake endoscopy, flexible naso-pharyngo-laryngoscopy, müller's maneuver, obstructive sleep apnea syndrome

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INTRODUCTION

Obstructive sleep apnea syndrome (OSAS) has gained much interest due to its high morbidity, necessitating the assessment of all individuals who snore for OSAS. Polysomnograms are essential for diagnosing OSA with a need for basic clinical techniques to assess patients with OSA in an outpatient setting. In addition to the recent assessment tools for OSAS, including drug-induced sleep endoscopy (DISE) and cone beam CT, routine assessment of the patients with OSA encompasses body mass index, tonsillar grading, thyromental distance, modified Mallampati grading, lateral cephalometry, and flexible naso-pharyngo-laryngoscopy[1,2].

Müller's maneuver (awake endoscopy) using flexible naso-pharyngo-laryngoscopy provides a three-dimensional soft tissue evaluation of the airway in an outpatient setting. Patients with OSAS exhibit a collapsing airway with a challenging accurate identification of the collapse point during sleep. Awake endoscopy serves as an initial screening procedure to rule out any soft tissue or bone compromise of the airway. It reduces radiation exposure and the patient's financial burden when compared with cone beam CT and DISE, which represent the next steps in the assessment protocol for patients with OSAS[3-6]. Although most cases of OSAS have multilevel obstruction at different levels whether nasal, retropalatal or retrolingual, determination of the level of obstruction needing attention

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remains a matter of investigation. This study aimed to assess the correlation between the level and grade of maximum airway obstruction by FNPL examination and the severity of OSAS using polysomnography.

PATIENTS AND METHODS

The current study was a cross-sectional study on patients diagnosed with OSAS. The study was conducted in the Otorhinolaryngology Department and its phoniatric unit, Menoufia Faculty of Medicine, after approval of the institutional review board with an approval number of "9/2023 ENT-7", and informed written consent was taken from every patient before participation in the study.

The study included patients diagnosed with OSAS by a sleep study, with an apnea-hypopnea index (AHI) of 5 or more. Patients less than 18 years old who underwent upper airway surgeries with syndromic anomalies and craniofacial abnormalities, like retrognathia, prognathism, and mandibular hypoplasia, were excluded from the study.

The sample size of the study was calculated based on a previous study by Narayanan and Faizal[7] showing that the rate of patients with severe AHI with retroglossal collapse was 74.07% in patients with more than 50% obstruction. The sample size with a significant $P < 0.05$ was calculated to be 33 participants:

Assessment protocol

The study participants underwent polysomnography, during which AHI, oxygen saturation, and respiratory disturbance index (RDI) were recorded. According to the American Academy of Sleep Medicine, OSAS is categorized as mild (AHI <5–15), moderate (AHI <15–30), and severe (AHI <30) based on the AHI[8]. Following a standard ENT examination, patients had a flexible naso-pharyngo-laryngoscopy using Müller's maneuver after nasal preparation with topical lignocaine 4% and 0.1% oxymetazoline nasal drops. End expiratory collapse was assessed in five regions: the supraglottic, glottic, lateral pharyngeal walls, retropalatal, and retrolingual regions.

The evaluation of the results of Müller's maneuver for every patient was done by the three authors of the study preventing an inter-rater variability. The authors used the Nose Oropharynx Hypopharynx and Larynx (NOHL) classification described by Vicini *et al.*[9] in which the nasal cavity (nose), retropalatal space (oropharynx), and base of the tongue space (retrolingual) were assessed for the degree and patterns of upper airway collapse. Pharyngeal wall collapses during the Müller maneuver were graded as follows: grade 4 for complete collapse, grade 3 for collapses less than 75%, grade 2 for collapses less than 50%, and grade 0 for no collapse during Müller maneuver. Nasal obstruction by inferior turbinate hypertrophy, obstructive nasal septum deviation, or other nasal obstructive diseases were evaluated using the same categorization ranging from 4 to 0. The various patterns of pharyngeal collapse were defined as follows: anterior-posterior (AP), indicating a collapse caused by anterior pharyngeal collapse against the posterior pharyngeal wall; concentric (C), suggesting a combination of lateral and anterior-posterior pharyngeal wall collapse pattern; and transversal (T), meaning a lateral pharyngeal collapse with movement of the lateral pharyngeal walls toward the center of the airway. At the supraglottic or glottis level, we ultimately documented the presence of laryngeal blockage (larynx), which is represented as follows: (p) meaning positive or (n) referring to negative. When grading, palatine tonsillar hypertrophy was noted if a considerable grade (grade 3 or 4) was detected.

Outcomes

The study's primary outcomes encompassed a correlation between different levels and the grade of OSAS and the significance of the effect of the grade of obstruction at each level on the severity of OSAS. The secondary outcomes of the study included an assessment of the relationship between the body mass index and pattern of pharyngeal closure, as well as the relationship between the pattern of pharyngeal closure and the severity of OSAS.

Statistical analysis

The data of the study was collected, tabulated, and analyzed using Statistical Package for Social Sciences (SPSS) software version 25 (Armonk, NY, USA). Qualitative variables were presented as numbers and percentages. Quantitative variables were presented as range, mean, and standard deviation. The Kolmogorov–Smirnov test indicated that the data were non-normally distributed. Qualitative variables were compared using the chi-square test. Quantitative variables were compared using the Mann–Whitney U test for two groups and the Kruskal–Wallis test for more than two groups. The Spearman correlation test was used to assess the correlation between two variables. Multiple regression was used to determine the impact of individual levels of obstruction on the severity of OSAS. A p value less than 0.05 was considered statistically significant, while *p value* less than 0.001 was considered highly significant.

RESULTS

The current study included 33 patients consisting of 21 (63.3%) males and 12 females (36.7%) with an age range of 34–58 years and a mean of 46.45 ± 6.41 years. The AHI ranged from 21.7 to 79.8 with a mean of 41.04 ± 18.51. The patients were distributed as 16 (48.5%) patients with moderate OSA and 17 (51.5%) patients with severe OSA (Table 1).

Table 1: Baseline demographic and clinical criteria of studied patients

Parameter		Value
Age		34–58 46.45 ± 6.41
Gender	Male	21 (63.3%)
	Female	12 (36.7%)
BMI		32.97 ± 3.16
AHI		21.7–79.8 41.04 ± 18.51
OSAS severity	Moderate	16 (48.5%)
	Severe	17 (51.5%)

BMI: body mass index; AHI: apnea-hypopnea index; OSAS: obstructive sleep apnea syndrome

An evaluation of the obstruction grade demonstrated that grade 2 was the most common grade in nasal obstruction, affecting 14 (42.4%) patients. In contrast, grade 4 was the most prevalent grade in retropalatal level obstruction (Figures 1, 2A-2D, 3A, 3B, 4A, 4B), impacting 21 (63.6%) patients. On the other hand, grade 3 was the most frequent grade in retrolingual obstruction (Figures 2E, 2F, 3C, 3D, 4C, 4D), affecting 13 (39.4%) patients, and grade 2 predominated in the tonsillar hypertrophy level, influencing 17 (51.5%) patients. Five (15.2%) patients showed glottic obstruction, while 4 (12.1%) patients showed supraglottic obstruction (Table 2).

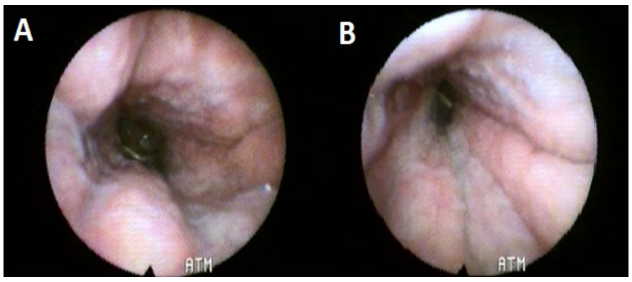

Fig. 1: Endoscopic views using Müller maneuver with flexible naso-pharyngo-laryngoscopy for a 54-year-old male patient showing (A) retropalatal level at rest and (B) grade 4 retropalatal obstruction demonstrating hypertrophied lateral pharyngeal walls, velum, and posterior pharyngeal wall (circular pattern).

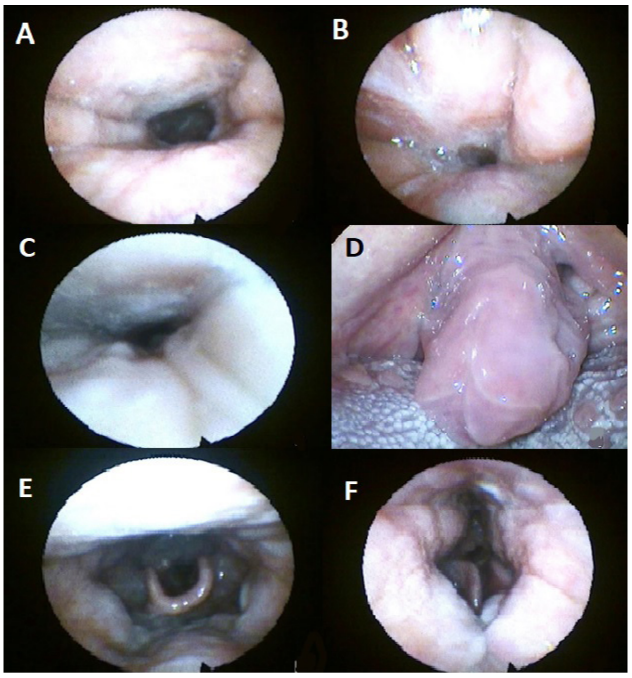

Fig. 2: Endoscopic views using Müller maneuver with flexible naso-pharyngo-laryngoscopy for a 42-year-old male patient showing (A) retropalatal level at rest, (B) grade 4 retropalatal obstruction (circular pattern), (C) lower retropalatal level with grade 4 obstruction, and (D) oral view showing markedly hypertrophied uvula. (E) Retrolingual level at rest, and (F) grade 3 retrolingual level obstruction (transverse pattern)

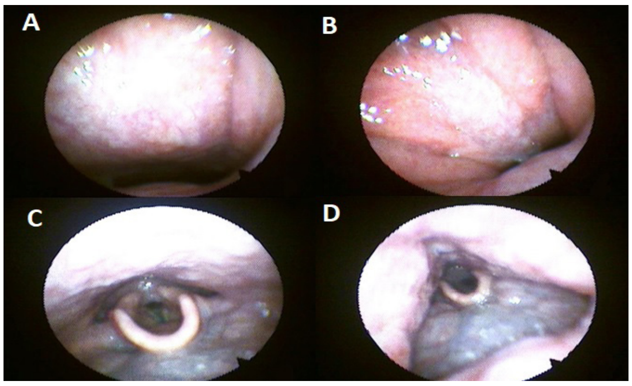

Fig. 3: Endoscopic views using Müller maneuver with flexible naso-pharyngo-laryngoscopy for a 48-year-old male patient showing (A) retropalatal level at rest, (B) grade 4 retropalatal level obstruction (mainly anteroposterior pattern), (C) retrolingual level at rest, and (D) grade 2 retrolingual obstruction (mainly transverse)

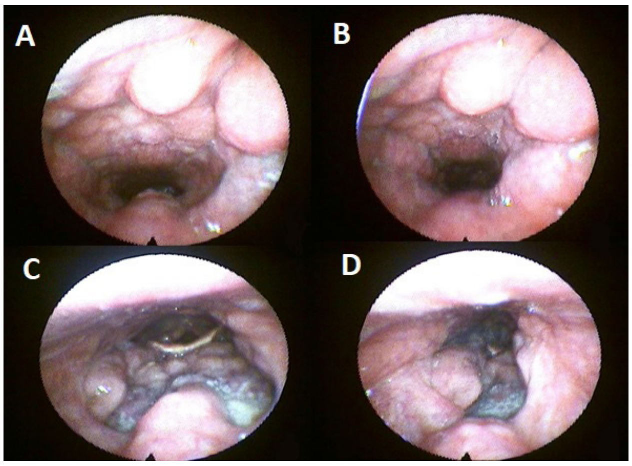

Fig. 4: Endoscopic views using Müller maneuver with flexible naso-pharyngo-laryngoscopy for a 46-year-old male patient showing (A) retropalatal level at rest, (B) grade 3 retropalatal level obstruction (circular pattern), (C) retrolingual level at rest with hypertrophied elongated uvula, and (D) grade 3 retrolingual level (mainly transverse)

Table 2: Levels and grades of obstruction in the study patients

Level of obstruction	Grade of obstruction	No. (%)
Nasal obstruction	3	10 (30.3%)
	2	14 (42.4%)
	0	9 (27.3%)
Retropalatal obstruction	4	21 (63.6%)
	3	12 (36.4%)
Retrolingual obstruction	4	10 (30.3%)
	3	13 (39.4%)
	2	10 (30.3%)
Tonsillar hypertrophy	4	2 (6.1%)
	3	12 (42.4%)
	2	17 (51.5%)
Laryngeal obstruction	Glottic	5 (15.2%)
	Supraglottic	4 (12.1%)

BMI: Body mass index

Spearman's correlation indicated that grades of nasal obstruction, retrolingual obstruction, and tonsillar hypertrophy had a significant positive correlation with the AHI (p = 0.0052, 0.0012, and 0.00169, respectively). In contrast, BMI and grade of retropalatal obstruction had a highly significant positive correlation with AHI (p= 0.00004 and 0,00003, respectively) (Table 3). Multiple regression analysis revealed that retropalatal obstruction was the only factor having a significant individual effect on the grade of sleep apnea (p = 0.04) (Table 4). Assessment of the relationship between BMI and the patterns of retropalatal and retrolingual closure suggested that BMI was significantly higher in the circular pattern of closure compared to the other patterns in both sites (p= 0.032 and 0.0014, respectively) (Table 5). Evaluation of the relationship between the pattern of closure and grade of sleep apnea displayed that a circular pattern of retropalatal obstruction is significantly correlated with severe sleep apnea compared to the transverse type (p = 0.024). However, no significant difference was observed between the transverse and anteroposterior patterns of retrolingual closure regarding the grade of sleep apnea (p = 0.874) (Table 6).

Table 3: Correlation between the BMI and grades of obstruction at different levels on the one hand and AHI on the other hand

Parameter	Correlation coefficient	*P value*
BMI	rs = 0.65299,	0.00004
Nasal obstruction	rs = 0.4752	0.0052
Retropalatal obstruction	rs = 0.80712	0.00003
Tonsillar hypertrophy	rs = 0.53924	0.0012
Retrolingual obstruction	rs = 0.52545	0.00169

BMI: body mass index; AHI: apnea-hypopnea index

Table 4: Regression analysis of the effect of individual levels of obstruction on the AHI

Level of obstruction	Coefficients	Standard error	t Stat	*P-value*
Nasal obstruction	1.791002	2.432027	0.736423	0.467599
Retropalatal obstruction	14.83925	6.900897	2.150336	0.040309
Tonsillar hypertrophy	7.14728	4.581589	1.56	0.129992
Retrolingual obstruction	4.257448	5.038954	0.844907	0.405325

AHI: apnea-hypopnea index

Table 5: Assessment of the relationship between BMI and the pattern of pharyngeal closure

Pharyngeal pattern of closure		BMI range Mean ± SD	Statistical test	*p value*
Retropalatal pattern of closure	Circular	30–41 34.35 ± 3.39	Mann–Whitney U test z = 2.1433.	0.03236
	Transverse	27–38 31.69 ± 2.91		
Retrolingual pattern of closure	Circular	31–41 36.43 ± 3.82	Kruskal-Wallis Test H = 13.1209	0.00142
	Anteroposterior	30–38 33.91 ± 2.26		
	Transverse	27–36 30.87 ± 2.26		

BMI: body mass index; AHI: apnea-hypopnea index

Table 6: Assessment of the relationship between the pattern of pharyngeal closure and the grade of OSAS

Pattern of closure		Moderate	Severe	Statistical test	*P value*
Retropalatal closure	Transverse	11	5	5.1067.	0.024
	Circular	5	12		
Retrolingual closure	Transverse	7	8	0.2704.	0.874
	Anteroposterior	5	6		
	Circular	4	3		

OSAS: obstructive sleep apnea syndrome

DISCUSSION

The apneic collapse of the upper airways (UA) is the primary pathogenic event in obstructive sleep apnea hypopnea syndrome (OSAHS). UA collapse frequently occurs simultaneously at several section levels. When selecting the best surgical procedure for individuals with OSA, it may be helpful to identify the locations of UA obstruction. Many techniques, such as nasopharyngoscopy, fluoroscopy, pressure measures, CT scanning, and MRI, were used to localize the sites of UA blockage during sleep precisely. The vast range of reported findings may be explained by the distinct benefits and drawbacks of each technique[10].

The initial assessment procedure for patients with OSAS is awake fiberoptic nasopharyngeal endoscopy, which is simple for both the patient and the examiner, economical, time-effective, and anesthesia-free. Drug-induced sleep endoscopy (DISE) was developed to address the dependability issues with awake nasopharyngeal endoscopy[11]. In their research, Askar *et al*[12] reported the role of positional awake endoscopy in providing essential information for surgical management of OSAS patients including level, pattern, and degree of severity in OSA. Their results showed that the data gained by this technique were comparable to those gained from DISE with less morbidity and financial burden. The standardization of the description of the sites and dynamic patterns of UA collapses has been one of the primary issues, irrespective of the diagnostic method employed. Vicini *et al*.[9] indicated that the NOHL classification can be used during both awake and sleep endoscopy. It enables a quick, easy, and efficient assessment of all upper airway sites involved in apneic obstruction, together with dynamic patterns of pharyngolaryngeal wall collapse, thereby defining the collapse grading. Due to its short learning curve, it might be coupled with other diagnostic instruments like teleradiography or Panorex. The current study sought to assess the correlation between the level of maximum obstruction, as evaluated by Müller's maneuver, the most available technique in our institution, using NOHL classification, and the severity of obstructive sleep apnea as indicated by the apnea/hypopnea index.

This study revealed that there were no cases of single-level obstruction. All the study cases had multiple levels of obstruction with varying grades of obstruction at these levels. This finding was previously reported by Rama *et al*., who stated that OSA is characterized by multilevel obstruction in the upper airway, with the oropharynx and laryngopharynx being the most common sites. Phua *et al*.[13] described that multilevel obstruction is more prevalent than single-level obstruction and is associated with increased OSA severity, with the number of obstruction sites positively correlated with OSA severity. Specifically, palatal, tongue, and lateral pharyngeal wall obstructions significantly contribute to severe OSA.

In the current study, a significant correlation was observed between the body mass index and AHI. This finding matches the outcomes of Wahbi Abdalhakim *et al*.[14], who reported a significant association between BMI and AHI in both sexes and the combined data of both sexes. Fattal *et al*.[15] provided a simple mathematical relationship between BMI and AHI and found that for every 1-point drop in BMI, AHI decreases by 6.2%. However, Ciavarella *et al*.[16] reported no correlation between BMI and AHI and between BMI and SaO2. These conflicting findings suggest that while BMI may play a role in OSA severity, other factors likely contribute to disease progression and severity, emphasizing the need for comprehensive assessment beyond BMI alone.

In the present study, the circular pattern of retropalatal obstruction was significantly correlated with severe sleep apnea compared to the transverse type and the circular pattern of retropalatal closure was significantly associated with a higher BMI compared with the transverse pattern of closure. Askar *et al*.[12] found that the most prevalent pattern of collapse at the retro-palatal level was the concentric/circular pattern, while the predominant pattern at the hypopharyngeal level was the lateral wall collapse. Guo *et al*.[17] reported that the velopharyngeal sectional regions' shapes were influenced by body mass and that they tend to be more round as body mass increases. The distance between fat pads and ascending rami is closely correlated with body mass and BMI in older guys without apnea. Minor correlations exist between BMI and the volume of the tongue, soft palate, fat pads, and velopharyngeal walls. This finding could explain the detected significant association between severe grades of obstructive sleep apnea and the circular pattern of closure of the oropharynx. However, the pattern of closure of the hypopharynx had a nonsignificant relationship with the grade of OSA.

In the current study, a significant correlation was noted between the grades of obstruction at each individual level of obstruction with the grade of severe apnea. This matches the finding of Phua *et al*.[13], who reported that the grade of palatal, tongue, and lateral pharyngeal wall obstructions were considerably associated with the severity of obstructive sleep apnea. However, regression analysis performed to evaluate the multilevel nature of obstruction in our study revealed that retropalatal obstruction was the most significant individual factor impacting the severity of OSA. This matches the outcomes of Li *et al*.[18], who displayed that upper airway obstruction involved more than one specific site of the upper airway, and the oropharynx was the most common collapse site. Obstructive sites were likely to extend to lower levels during REM sleep. Boudewyns *et al*.[19] employed UA pressure measurements during polysomnography using solid-state pressure sensors at the nasopharynx, oropharynx, tongue base, hypopharynx, and esophagus to determine the lower limit of UA obstruction based on the observed pressure pattern. The site of UA obstruction varied among consecutive apneas in all but two patients. The lower limit of UA obstruction was predominantly located at the naso and oropharynx. Aref *et al*.[20] reported a positive correlation between the extent of retropalatal airway collapse and AHI.

The limitations of our study included the dependence on awake endoscopy alone for assessment of the level of obstruction with its restrictions regarding its proposed limited accuracy compared with DISE due to its evaluation of the patient while awake, not during sleep, with some difference in the underlying pathophysiology in the two conditions. However, the authors used this technique because it is the most available, cost-effective, and anesthesia-free with previous studies showing comparable results between the two techniques.

CONCLUSION

Flexible Naso-Pharyngo-Laryngoscopy examination is an essential assessment tool for OSAS patients with Müller's maneuver being the most available and safest method. In the present study, this assessment showed that OSAS had a multilevel obstructive etiology with a positive correlation between the grade of obstruction at each level and AHI indicating the severity of OSAS. Regression analysis showed that retropalatal obstruction was the significant individual factor affecting AHI. These findings should be considered for better tailoring of the surgical intervention plan.

CONFLICT OF INTERESTS

There are no conflicts of interest.

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