Factors associated with multilevel collapse in patients with OSA

Original Article

Authors

Constança Oom
Hospital Beatriz Ângelo, Unidade Local de Saúde Loures/Odivelas

Bárbara Roque
Hospital Beatriz Ângelo, Unidade Local de Saúde Loures/Odivelas

João Fernandes
Hospital Beatriz Ângelo, Unidade Local de Saúde Loures/Odivelas

João Barbosa
Hospital Beatriz Ângelo, Unidade Local de Saúde Loures/Odivelas

Inês Delgado
Hospital Beatriz Ângelo, Unidade Local de Saúde Loures/Odivelas

Alberto Santos
Hospital Beatriz Ângelo, Unidade Local de Saúde Loures/Odivelas

Carlos Macor
Hospital Beatriz Ângelo, Unidade Local de Saúde Loures/Odivelas

Correspondence:
Constança Oom
constanca.sc.oom@gmail.com

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Abstract

Objective: To identify factors associated with multilevel collapse during Drug-Induced Sleep Endoscopy (DISE) in patients with obstructive sleep apnea (OSAHS).
Materials and Methods: Retrospective study of OSAHS patients who underwent DISE, using the VOTE classification. Multilevel collapse was defined as grade 2 obstruction in at least two levels. Sociodemographic, clinical, and anatomical variables were analyzed for their impact on multilevel collapse occurrence.
Results: A total of 91 patients were included, with a mean age of 50.7 years. Multilevel collapse was identified in 42.9% of cases and was significantly associated with a BMI ≥ 30 kg/m². Patients with retrognathia and/or nasal septum deviation had a lower prevalence of multilevel collapse, although this difference was not statistically significant.
Conclusion: This study confirms the high prevalence of multilevel collapse in OSAHS, identifying obesity as an independent predictor of its occurrence, highlighting the importance of weight loss in the therapeutic management of these patients.

Keywords: Obstructive sleep apnea syndrome; OSAHS, sleep; endoscopy

Introduction

Obstructive sleep apnea (OSA) is a disorder characterized by recurrent episodes of upper airway obstruction during sleep, resulting in intermittent hypoxemia, sleep fragmentation, and excessive activation of the sympathetic nervous system. These changes may lead to increased cardiovascular risk, metabolic disorders, and neurocognitive dysfunction[1].

OSA is associated with several risk factors, including obesity, older age, male sex, and craniofacial abnormalities[2]. The risk of OSA has been directly correlated with the body mass index (BMI), as its prevalence increases proportionally with higher BMI values[3]. This may be because of the narrowing of the upper airway by excess adipose tissue deposition

in critical pharyngeal regions[4]. Obesity also contributes to reduced vital capacity, ventilation-perfusion mismatch, and limited mobility of the lungs and thoracic wall[5].

To date, treatment strategies for OSA have primarily focused on the use of positive airway pressure devices. However, with increased understanding of the disease pathophysiology, it has become evident that a personalized approach is essential and beneficial[6,7]. Surgical treatment encompasses a set of techniques aimed at widening and stabilizing the upper airway. The careful selection of patients and procedures, particularly after considering the anatomical and functional characteristics of the airway, is crucial during preoperative planning[8]. This approach has demonstrated good efficacy in recent years, with drug-induced sleep endoscopy (DISE) emerging as an essential tool for characterizing dynamic upper airway collapse and guiding surgical decision-making, thereby contributing to improved therapeutic outcomes[9].

The presence of multilevel collapse identified during DISE has been linked to various anatomical and clinical factors. Patients exhibiting this condition are considered to have severe OSA, as indicated by higher apnea-hypopnea index (AHI) values[4,10].

Given the significant impact of multilevel collapse on OSA and the treatment response, this study aimed to identify the clinical and anatomical factors associated with multilevel upper airway collapse during DISE in patients with OSA.

Materials and methods

This retrospective longitudinal study evaluated patients diagnosed with OSA by outpatient polygraphy who underwent DISE at Hospital Beatriz Ângelo between January 2019 and December 2024. Data were collected by reviewing the electronic medical records and DISE video recordings. Patients under 18 years of age and those with incomplete medical records were excluded.

Sociodemographic, biometric, anatomical, polysomnographic, and clinical data were recorded. The analyzed variables included sex, age, BMI, AHI, retrognathism identified on physical examination, and nasal septal deviation or tonsillar hypertrophy, the latter categorized according to Friedman classification[11]. This classification grades the size of palatine tonsils from zero to IV according to their extension in relation to the tonsillar pillars.

All DISE procedures were conducted in the operating room on an outpatient basis, in a dark and quiet environment, with the patient in the supine position. The level of sedation was monitored using the bispectral index (BIS), and the examination was commenced when BIS values were between 50 and 70. Propofol was administered via target-controlled infusion (TCI) for sedation. A flexible nasal endoscope was used for examination and video recording. The recordings were evaluated by an otorhinolaryngology specialist and resident physician (not necessarily the same evaluators for all cases), who classified the findings according to the Velum, Oropharynx, Tongue base, and Epiglottis (VOTE) classification system. This system assesses the degree of obstruction and collapse pattern at the velum, oropharynx, tongue base, and epiglottis. Each site was graded as 0 (no obstruction), 1 (partial obstruction), 2 (complete obstruction), or X (not visualized). Multilevel collapse was defined as a grade 2 obstruction involving more than one site.

Statistical analysis was conducted using SPSS® software version 25 (IBM Corp., Armonk, NY; released in 2017). The chi-square test was used for analyzing categorical variables, and the Student's t-test or Mann–Whitney U test were used for continuous variables. Multivariate binary logistic regression analysis was subsequently conducted to analyze the association between independent variables and presence of multilevel collapse.

Results

A total of 91 patients were included in the study, with a mean age of 50.7 ± 13.3 years; 79.1% were men and 20.9% women. The median BMI was

28.1 ± 5.1 kg/m² (Table 1), and the median AHI was 16.3 ± 16.59 events/hour. The distribution of patients according to the severity of OSA is shown in Figure 1 . Regarding the anatomical variables, 75.8% of the patients presented with inferior turbinate hypertrophy, 65.9% with nasal septal deviation, and 18.7% with retrognathism. The distribution of patients by the degree of tonsillar hypertrophy is displayed in Table 2, with most patients (52.75%) exhibiting grade II palatine tonsils. Regarding the DISE findings, 42.9% of patients demonstrated multilevel collapse (Figure 2) with various obstruction patterns. Complete obstruction at the level of the palate and oropharynx was the most commonly observed multilevel collapse pattern (47.5%). Embedded text: with multilevel collapse/ without multilevel collapse

Univariate analysis was conducted to assess the association between each independent variable and the presence of multilevel collapse (Table 3).

Variables showing a trend toward association ($p < 0.20$), including BMI, retrognathism, and nasal septal deviation, were subsequently included in multivariate binary logistic regression analysis to identify potential independent predictors of multilevel collapse (Table 4).

The analysis revealed that BMI was the only independent predictor of multilevel collapse ($p < 0.05$). Although retrognathism and nasal septal deviation showed a trend toward association in the univariate analysis, they were not confirmed as independent predictors in multivariate analysis ($p > 0.05$).

Table 1
Distribution of patients by the body mass index (BMI)

BMI	Classification	N (total = 91)	Percentage (%)
< 18,5	Underweight	0	0
18,5 – 24,9	Normal weight	12	13,19
25 – 29,9	Excess weight	43	47,25
> 30	Obesity	36	39,56

Gráfico 1
Dados demográficos da amostra em estudo

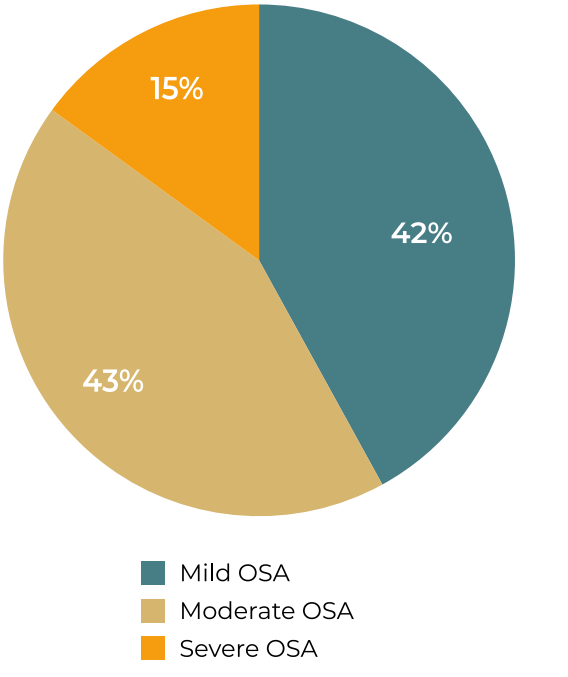

Gráfico 2
Distribuição da amostra por presença/ausência de colapso multinível

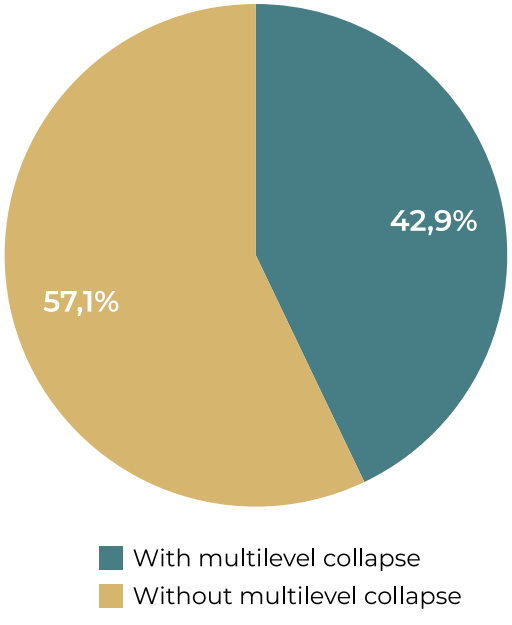

Table 2
Distribution of patients by the degree of tonsillar hypertrophy (according to Friedman classification)

Degree of tonsillar hypertrophy	N (total = 91)	Percentage (%)
0	14	15,38
I	48	52,75
II	23	25,27
III	5	5,49
IV	1	1,1

Table 3
Association between the analyzed variables and presence of multilevel collapse

Variable	Test used	p-value
Age	Student's T	p = 0,883
BMI	Mann–Whitney U	p = 0,014
AHI	Mann–Whitney U	p = 0,434
Sex	Chi-square	p = 0,219
Inferior turbinate hypertrophy	Chi-square	p = 0,596
Nasal septal deviation	Chi-square	p = 0,151
Tonsillar hypertrophy	Chi-square	p = 0,604
Retrognathism	Chi-square	p = 0,130

Table 4
Multivariate binary logistic regression analysis for the association between the variables and multilevel collapse

Variable	OR	95% CI	p-value
IMC	1,15	1,042 – 1,239	p = 0,037
Desvio do septo nasal	0,431	0,146 – 1,243	p = 0,120
Retrognatismo	0,356	0,088 – 1,216	p = 0,116

Collapse pattern analysis

To determine whether patients with obstruction at the level of the palate and oropharynx (the most frequent multilevel collapse pattern) exhibited a significantly higher BMI compared with those with other collapse patterns, patients with multilevel collapse were divided into two groups: Group 1, with obstruction at the level of the palate and oropharynx; and Group 2, with other obstruction patterns. The mean BMI in Group 1 was 30.1 ± 3.87 kg/m^2 and 29.9 ± 3.89 kg/m^2 in Group 2. The independent samples t-test revealed a p-value of 0.270, indicating no statistically significant difference in the mean BMI between the groups.

Discussion

This study found that multilevel collapse is highly prevalent in OSA, observed in 42.9% of patients. Similar findings were reported by Vroegop et al.[10], who evaluated 1,249 patients undergoing DISE and identified multilevel collapse in 68.2% of the cases.

This study also examined the association between specific sociodemographic, anatomical, and clinical variables and the presence of multilevel collapse. BMI was identified as the only independent and statistically significant predictor of multilevel collapse ($p < 0.05$). Our results demonstrate that each 1-unit increase in BMI is associated with approximately a 15%

increase in the likelihood of multilevel collapse (odds ratio = 1.15). This finding supports previous data linking obesity to a higher probability of complete and multilevel upper airway collapse[12,13]. The underlying pathophysiological mechanisms appear to involve increased deposition of parapharyngeal fat[14], reduced upper airway muscle tone, and greater negative inspiratory pressure secondary to decreased pulmonary compliance[15]. Clinically, recognition that obesity is a key anatomical factor contributing to pharyngeal collapse has direct implications for the management of patients with OSA. Obese patients tend to exhibit more complex and refractory obstruction patterns, which may influence both the choice and effectiveness of treatment. Although positive airway pressure devices are effective regardless of the BMI, obese patients show lower adherence and suboptimal response due to the anatomical complexity of their collapse[16]. Weight loss should always be recommended, as it reduces pharyngeal fat, improves the AHI, and optimizes the airway anatomy[17]. Surgical approaches may be considered as alternatives to continuous positive airway pressure, but their effectiveness is reduced in obese patients due to the high prevalence of multilevel collapse[16]. Therefore, dynamic upper airway assessment using DISE is essential for individualized therapeutic planning in these cases. Regarding the other variables analyzed, retrognathism and nasal septal deviation demonstrated a trend toward an inverse association with multilevel collapse but it did not reach statistical significance. Contrary to previously published findings, the present study did not find a higher prevalence of multilevel collapse in patients with higher AHI values[10,18]. This may be explained by the observation that AHI is not a direct marker of upper airway collapse patterns but rather a reflection of the interaction between anatomical, functional, and neurophysiological factors. Recent studies have shown that the correlation between AHI and objective measures of pharyngeal collapsibility, such as the critical closing pressure (Pcrit), is only moderate ($r \approx 0.46$), suggesting that multiple mechanisms contribute to the severity of sleep apnea[19,20]. Moreover, OSA severity can be influenced by factors such as elevated loop gain, low arousal threshold, and variable muscular compensation, which do not necessarily correlate with the anatomical pattern of collapse.

Similar to the results of reported by Wong et al.[12], the most prevalent obstruction was at the level of the palate and oropharynx, occurring in 47.5% of patients with multilevel collapse. However, these findings vary considerably across the literature. In a study by Vroegop et al.[10], the most common combination was collapse at the level of the palate and tongue base, which occurred in 25.5% of cases. Bacak et al.[18] analyzed 263 DISE in patients with OSA and reported that the most frequent multilevel collapse pattern involved the tongue base and epiglottis (33.5%), which was attributed to their close anatomical relationship.

To better understand these findings, we examined whether the most common collapse pattern observed in our study (palate + oropharynx) was associated with higher BMI values. Although patients with this pattern had slightly higher BMI values, the difference was not statistically significant. Future studies with larger and more representative samples are necessary to investigate this potential association and physiological basis of this obstruction pattern, possibly by measuring the pharyngeal muscle tone in the region.

This study has some limitations. The relatively small sample size (91 patients) may have reduced the statistical power and increased the risk of bias. As this was a retrospective study, the results may be limited by the quality of clinical records and potential selection bias. Despite the well-documented validity and reliability of DISE[21], the interpretation of findings remains subjective. In this study, DISE recordings were evaluated by different otorhinolaryngologists, and interobserver reliability testing was not performed, as it was beyond the study's primary objectives, potentially introducing observational bias.

Furthermore, assessment of the upper airway using the VOTE classification has some limitations, as it involves a degree of subjectivity and does not include nasal evaluation or assessment of tonsillar hypertrophy, which may introduce bias. Finally, potential confounding bias cannot be excluded, as some relevant variables such as neck circumference were not included in the analysis.

Conclusion

This study confirmed that multilevel collapse is highly prevalent in patients with OSA and identified BMI as an independent predictor of this obstruction pattern. From a clinical standpoint, these findings reinforce the importance of dynamic upper airway assessment and recognition of obesity as a key determinant of obstruction complexity, with direct implications for therapeutic decision-making.

Conflict of Interests

The authors declare that they have no conflict of interest regarding this article.

Data Confidentiality

The authors declare that they followed the protocols of their work in publishing patient data.

Human and animal protection

The authors declare that the procedures followed are in accordance with the regulations established by the directors of the Commission for Clinical Research and Ethics and in accordance with the Declaration of Helsinki of the World Medical Association.

Privacy policy, informed consent and Ethics committee authorization

The authors declare that they have obtained signed consent from the participants and that they have local ethical approval to carry out this work.

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Scientific data availability

There are no publicly available datasets related to this work.

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