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REVIEW ARTICLE

Drug-induced sleep endoscopy in the obstructive sleep apnea: comparison between NOHL and VOTE classifications

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Abstract Obstructive sleep apnea (OSA) is characterized by recurrent episodes of partial or complete collapse of the pharynx that result in a decrease in oxyhemoglobin saturation. Nasofibrolaryngoscopy under induced sleep is a promising alternative for identifying sites of upper airway obstruction in patients with OSA. This study aimed to compare the obstruction sites screened by drug-induced sleep endoscopy (DISE) using the Nose oropharynx hypopharynx and larynx (NOHL) and Velum oropharynx tongue base epiglottis (VOTE) classifications. We also determined the relationship between OSA severity and the number of obstruction sites and compared the minimum SaO_2 levels between DISE and polysomnography (PSG). This was a prospective study in 45 patients with moderate and severe OSA using DISE with target-controlled infusion of propofol bispectral index (BIS) monitoring. The retropalatal region was the most frequent obstruction site, followed by the retrolingual region. Forty-two percent of patients had obstruction in the epiglottis. Concentrically shaped obstructions were more prevalent in both ratings. The relationship between OSA severity and number of obstruction sites was significant for the VOTE classification. Similar minimum SaO_2 values were observed in DISE and PSG. The VOTE classification was more comprehensive in the analysis of the epiglottis and pharynx by DISE and the relationship between OSA severity and number of affected sites was also established by VOTE. The use of BIS associated with DISE is a reliable tool for the assessment of OSA patients.

Keywords Obstructive sleep apnea · Endoscopy · Pharynx · Propofol · Sleep · BIS

Abbreviations

AHI	Apnea-hypopnea index
BIS	Bispectral index
BMI	Body mass index
DISE	Drug-induced sleep endoscopy
MM	Muller maneuver
NFL	Nasofibrolaryngoscopy
NOHL	Nose oropharynx hypopharynx and larynx
OSA	Obstructive sleep apnea
PSG	Polysomnography
$SatO_2$	Oxygen saturation
TCI	Target-controlled infusion
UA	Upper airway
VOTE	Velum oropharynx tongue base epiglottis

The institution at which the work was performed: Marcílio Dias Naval Hospital.

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Introduction

Obstructive sleep apnea (OSA) is characterized by recurrent episodes of partial or complete collapse of the pharynx that results in snoring, apnea or hypopnea, a decrease in oxygen saturation (SaO_2) and frequent awakenings during the night [1, 2].

The location of upper airway (UA) obstruction in OSA patients has been evaluated using different methods. Among these, we highlight the general physical and ENT examination, nasofibrolaryngoscopy (NFL) using the Muller Maneuver (MM), and imaging tests such as cephalometry and magnetic resonance imaging [3, 4]. All these methods carry questionable predictive values in defining the levels of collapsibility and snoring [5, 6]. NFL under induced sleep, also known as sonoendoscopy or DISE (drug-induced sleep endoscopy), is a promising alternative to identifying obstruction sites of the UA in patients with OSA [7].

Different sedative agents and infusion techniques have been used, but a more standardized state of sedation has been achieved using target-controlled infusion (TCI) of sedative agents, which allows for direct control of sedative concentration in the brain rather than in the blood [8]. Moreover, the association of the bispectral index (BIS) with DISE has enabled the maintenance of respiratory parameters in patients with OSA [9].

However, there is a need to standardize the DISE technique and the way of describing obstruction sites. The following classifications currently exist: the DISE parameter, the Fujita classification, the Velum Oropharynx Tongue base Epiglottis (VOTE) classification, and the Nose Oropharynx Hypopharynx Larynx (NOHL) classification [7, 10–12].

In this study, we compared the obstruction sites in the pharynx and larynx screened by DISE using the NOHL and VOTE classifications. We also determined the relationship between OSA severity and the number of obstruction sites and compared the minimum SaO_2 levels between DISE and polysomnography (PSG).

Methods

Patients

This was a cross-sectional, prospective study in patients with OSA moderate and severe, between July 2013 and July 2014 at Marcílio Dias Naval Hospital, that included men (ages 18–65) and women (ages 50–65). All patients had a detailed medical history, and had undergone a physical examination, NFL with MM followed by PSG, computed tomography of the face and laboratory tests. All patients had received an indication for oropharyngeal surgery with or without nasal corrections (septoplasty, turbinectomy, and/or sinusotomies). The study was approved by the Ethics Committee under protocol number 28113514.9.0000.5256.

The following were considered exclusion criteria for the current study: previous surgical treatment for OSA, a contraindication for sedation due to neurological disease, a history of liver disease, chronic obstructive pulmonary disease or heart failure, UA diseases due to infection or tumors, craniofacial deformity upon clinical examination, allergies or hypersensitivity to propofol or eggs, chronic use of sedatives, narcotics, alcohol or illegal drugs, body mass index (BMI) >35, intolerance to flexible endoscope.

Procedure

Patients underwent NFL in the supine position and under induced sleep. We used the multiparameter monitoring system Drager Infinity Delta® coupled to the Drager Fabius GS® anesthetic cart, and conducted the following procedures: placement of the cuff and blood pressure monitoring, positioning of the oximeter on the index finger contralateral to the cuff, fixation of the cardiac electrodes and the BIS, and peripheral venous puncture.

Using the Diprifusor™ infusion pump system, 1 % propofol was administered in flash mode with an initial target concentration of 1.5 mcg/ml. The target concentration was gradually increased or decreased until the patient had a level of sedation between 70 and 50, as well as snoring and apnea associated with hyporesponsiveness to verbal and tactile stimuli with the device in the nasal vestibule. All SaO_2, blood pressure, BIS, heart rate, and electrocardiographic tracing recordings were performed by filming with the monitor using a mobile phone, and starting when a BIS level below 70 was reached.

To perform the DISE, we used a nasofibroscope of 4 mm, a Storz® xenon light source and camera. All exams were recorded on DVD. The flexible endoscope was introduced into the nasal cavity and placed sequentially in the distal third of the nasopharynx, providing a detailed visualization of the retropalatal region and oropharynx, just below the palatine veil and above the free edge of the epiglottis to visualize the retrolingual region.

Study group characteristics and PSG

We measured the following study group characteristics: BMI, waist circumference, neck circumference, Epworth sleepiness scale, minimum nocturnal SaO_2, and apnea-hypopnea index (AHI). Limits were set according to the literature [1, 2, 13–15].

Obstruction sites screened by DISE

The degrees and types of collapsibility of each site were based on the NOHL[11] and VOTE[12] classifications. We defined obstruction as any site with a lumen reduction greater than 50 %. Because the nose is a static structure, it was not included in the comparison of the two classifications. Two DISE-experimented otorhinolaryngologists blind-reviewed, and randomly assessed exams.

The NOHL classification evaluates the following sites: nose (N), retropalatal region (O-oropharynx), retrolingual region (H-hypopharynx), and larynx (L). In the first three levels the degree of obstruction can be: 1 (0–25 %), 2 (25–50 %), 3 (50–75 %)) and 4 (75–100 %). As to the type of collapsibility, oropharynx and hypopharynx can be: transversal (Tr), anteroposterior form (AP) or concentric (C). In the case of larynx, the classification identifies the presence (p—positive) or the absence (n—negative) of obstructions.

The VOTE classification evaluates the following sites: velum (V), oropharynx lateral walls (O), tongue base (T) and epiglottis (E). As to the degree of obstruction, the four sites can be: 0 (up to 50 % of obstruction), 1 (50–75 %), 2 (75–100 %) or X (not visualized). As to the type of collapsibility, the velum can be anteroposterior (AP), lateral (Lat) or concentric (C); the oropharynx lateral walls (O), but only the lateral pattern; the tongue base (T), only the anteroposterior pattern. The epiglottis (E) can follow a pattern of AP or L (Table 1).

Statistical analysis

All analyses were performed using SPSS 17.0 software (Statistical Package for Social Science, Chicago, IL, 2008). The significance level was set at 95 % ($p < 0.05$).

Results

Forty-five patients were evaluated. There were more men (38/84.4 %) than women (7/15.5 %) in the sample. Patient age ranged between 21 and 65 years, with an average of 42.8 years [standard deviation (SD): ±11.2] and a median of 43 years. Table 2 shows the patient characteristics. For instance, 71.9 and 53.8 % of patients with moderate and severe OSA, respectively, had a BMI >30. However, there was no relationship between OSA severity and BMI >30 in the sample evaluated. The maximum target dose of propofol used for the examination was 3.5 mcg/ml with a procedure time of 37 min, whereas the minimum target dose was 1.3 mcg/ml with a procedure time of 12 min. The average procedure time was 25.3 min (SD: ±6.1).

Thirty-nine (86.6 %), according to observer 1 (O1), and 38 (84.4 %), according to observer 2 (O2), patients had obstruction in the hypopharynx according to the NOHL classification and 35 (O1: 77.7 %) and 33 (O2: 73.3 %) patients had obstruction in the base of the tongue according to the VOTE classification. In both ratings, 19 patients (42 %) had obstruction in the epiglottis according to the

Table 1 Classification NOHL and VOTE

CLASSIFICATION NOHL				
Obstruction sites	**Degree** [a]	**Pattern** [b]		
		AP	**Tr**	**C**
N – Nose	1/2/3/4			
O – Oropharynx	1/2/3/4			
H – Hypopharynx	1/2/3/4			
L - Larynx [c]	-/+			
Palatine tonsillar hypertrophy grade [d]	III/IV			

[a]Degree of obstruction: 1: 0–25% / 2: 25–50% / 3: 50–75% / 4: 75-100%
[b]Configuration: anteroposterior (AP); transversal (Tr); concentric (C)
[c]Absent (-) or Present (+)
[d] Palatine tonsillar hypertrophy grade: III e IV

CLASSIFICATION VOTE				
Obstruction sites	**Degree** [a]	**Patterns** [b]		
		AP	**Lat**	**C**
V – Velum	0/1/2/X			
O - Oropharynx lateral walls [c] **(-/+)**	0/1/2/X			
T - Tongue Base	0/1/2/X			
E – Epiglottis	0/1/2/X			

[a]Degree of obstruction: 0 (0–50%), 1 (50–75%), 2 (75-100%), X (not visualized)
[b]Configuration: ântero-posterior (AP); lateral (Lat); concentric (C)
[c]Tonsillar component: absente (-) or presente (+)

Table 2 Sample characteristics

Variable	*n* (%)	CI 95 %
BMI[a]		
Healthy (18.5 to <25)	5 (11.2)	4.8–23.5
Overweight (25 to <30)	25 (55.6)	41.1–69.1
Class 1 obesity (30 to <35)	15 (33.2)	21.4–47.9
WC[b] (cm)		
Normal	7 (15.6)	7.7–28.8
Higher	38 (84.4)	71.2–92.2
NC [c](cm)		
Normal	17 (37.8)	25.1–52.4
Higher	28 (62.2)	47.6–79.9
ESS[d]		
Normal (<10)	14 (31.1)	19.5–45.6
Higher ($\geq$10)	31 (68.9)	54.3–80.5
AHI[e]		
Light (5 $\leq$ IAH $\geq$ 15)	0 (0.0)	0.0–7.86
Moderate (15 < IAH $\geq$ 30)	32 (71.1)	56.6–82.3
Severe (>30)	13 (28.9)	17.7–43.4
SatO$_2$[f] minimum nocturnal level		
Normal ($\geq$90 %)	7 (15.6)	7.7–28.8
Lower (<90 %)	38 (84.4)	71.2–92.2

[a] *BMI* body mass index (weight/kg and height/m)

[b] *WC* waist circumference (with values altered for men >94 cm and women >80 cm)

[c] *NC* neck circumference (with values altered >40 cm)

[d] *ESS* Epworth Sleepiness Scale

[e] *AHI* Apnea-Hypopnea Index (events/h)

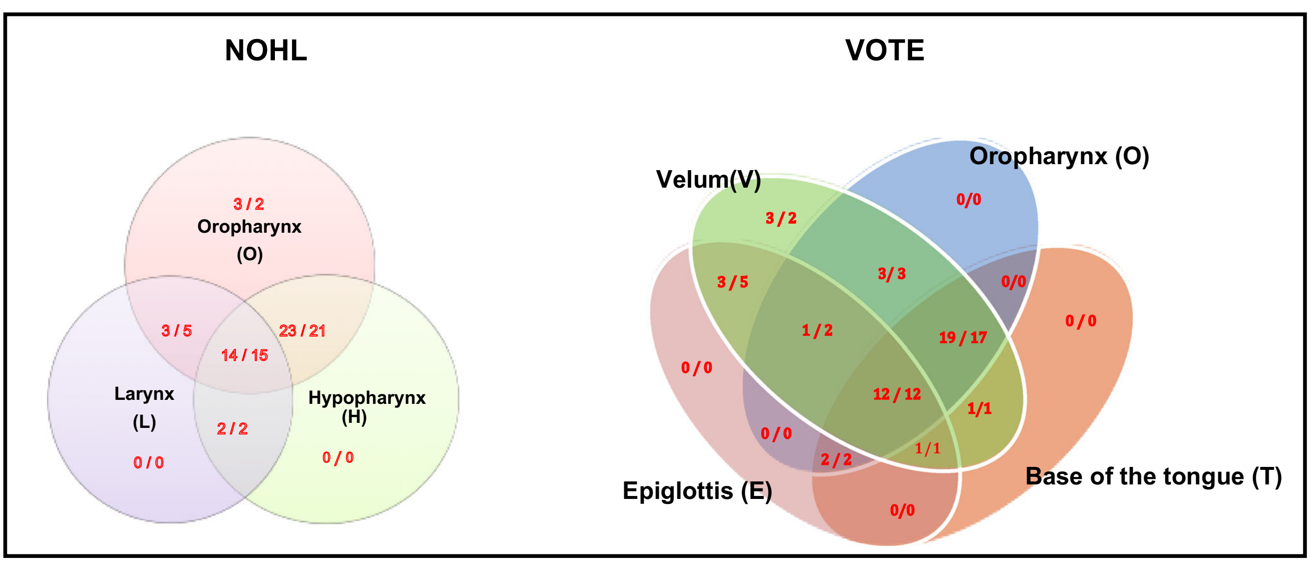
[f] *SatO$_2$* oxygen saturation (%)

VOTE classification whereas 9 patients (20 %) had obstructions above 75 %. The distribution of obstruction sites and concurrent events are shown in Venn diagrams (Fig. 1).

Both ratings similarly identified mono and multilevel obstruction between patients with moderate and severe apnea. When we stratified the group with multilevel obstructions, we observed that in cases with three or more affected levels, the VOTE rating [O1 and O2: 35 (77.8 %)] yielded a higher percentage of obstructed sites than NOHL [O1:14(31.1 %)/O2:15(33.4)] (Table 3).

We identified a higher prevalence of concentrically shaped obstructions with both ratings (NOHL and VOTE) for all sites involving the retropalatal region (Oropharynx-NOHL and Velum-VOTE: O1 = 95.4 % and O2 = 93.2 %). Only VOTE describes epiglottis obstruction formats, indicating greater prevalence of its antero-posterior format (Table 4).

More than two obstructions were observed in 96.9 and 84.6 %, respectively, according to observers 1 and 2, of moderate OSA patients and in 84.6 % of severe patients, by the two observers (Table 5). However, when we grouped them into patients with two, three or more affected sites, the number of patients with three or more levels of obstruction were significantly higher in the severe group, according to the VOTE classification (Table 6), compared to both observers with a Kappa 0.928 and 0.876, respectively, to the group with moderate and severe OSA, according to the NOHL classification, and 0.937 and 0.923, respectively, to the group with moderate and severe OSA, according to VOTE classification.



Observe 1/Observe 2

Fig. 1 Obstruction sites in NOHL and VOTE classifications (observer 1/observer 2)

Table 3 Type of obstruction level identified by DISE according to NOHL and VOTE classifications

Classification	Obstruction	DISE *n* (%)	
		Observer 1	Observer 2
NOHL (*n*)			
45	Monolevel	3 (6.6)	2 (4.4)
	Multilevel (2 levels)	28 (62.2)	28 (62.2)
	Multilevel (3 levels)	14 (31.1)	15 (33.4)
VOTE (*n*)			
45	Monolevel	3 (6.6)	2 (4.4)
	Multilevel (2 levels)	7 (15.5)	8 (17.8)
	Multilevel (≥3 levels)	35 (77.8)	35 (77.8)

DISE drug-induced sleep endoscopy, *NOHL* nose oropharynx hypopharynx larynx, *VOTE* velum oropharynx tongue base epiglottis

Table 4 Form of site obstruction according to NOHL and VOTE classifications

Obstruction site[a]	Form	DISE	
		Observer 1	Observer 2
NOHL *n* (%)			
Oropharynx	AP	0 (0)	0 (0)
	L	2 (4.6)	3 (6.8)
	C	41 (95.4)	41 (93.2)
Hypopharynx	AP	2 (5.1)	5 (13.2)
	L	4 (10.3)	2 (5.2)
	C	33 (84.6)	31 (81.6)
VOTE *n* (%)			
Velum	AP	0 (0)	0 (0)
	L	2 (4.6)	2 (4.6)
	C	41 (95.4)	41 (95.4)
Oropharynx	L	37 (100)	33 (100)
Tongue base	AP	35 (100)	36 (100)
Epiglottis	AP	18 (94.7)	18 (94.7)
	L	1 (5.3)	1 (5.3)

NOHL nose oropharynx hypopharynx larynx, *DISE* drug-induced sleep endoscopy, *AP* anteroposterior form, *L* lateral (=transverse), *C* concentric, *VOTE* velum oropharynx tongue base epiglottis

[a] Sites were considered unique or in association with each other

Similar minimum SaO_2 values (mean and median) were observed during PSG and DISE in patients with AHI >15 (Table 7).

Variability in minimum SaO_2 values was greater in DISE, but median SaO_2 values were higher in DISE than in PSG. One outlier patient had lower SaO_2 values than the rest of the sample in both PSG and DISE (Fig. 2).

Discussion

Propofol has a very short half-life and is considered a very safe drug for sedation [16, 17]. However, there are still questions about the effects of this drug on sleep, especially whether sleep induction may cause changes in breathing pattern. The propofol concentrations used in this study required to induce sedation and that were well tolerated by patients for introduction of the flexible endoscope are within the minimum (1.5 mcg/ml) and mean (2.33 mcg/ml) plasma concentrations reported elsewhere [9, 18]. Previously described side effects such as respiratory depression or excessive muscle relaxation (16) were not observed with the target dose used in our study. The total examination time ranged from 12 to 37 min (mean: 25.3/DP: 6.1/median: 25), consistent with other studies [19, 20].

The BIS values recorded during the examinations ranged between 53 and 70 (mean: 63.1/SD: 2.8/median: 63). Babar-Craig et al. [21] reported mean BIS values between 50.7 and 63.1 at the appearance of snoring in DISE.

The palatal collapse was the most affected obstruction site by the two observers, which agree with other studies [7, 22–25]. Ravesloot and Vries et al. [24] presented obstruction frequency in the following order: palatal collapse (83 %), followed by the base of the tongue (56 %), epiglottis (38 %), and oropharyngeal collapse (7 %). Vroegop et al. [25], in the largest sample reported to date, identified the same sequence with similar values (81, 46.6, and 38.7 %, respectively).

In our study, the hypopharynx (NOHL rating) and the base of the tongue (VOTE rating) were important obstruction sites of the UA of patients with OSA during DISE. Similar results were reported elsewhere [26, 27]. Moreover, 42 % of patients screened by DISE had obstruction in the epiglottis. However, the VOTE classification identified that there was a higher prevalence of the anteroposterior form among the 19 (42 %) patients with obstruction in the epiglottis, and nine of these patients had greater than 75 % obstruction. Testing a group of 100 patients with OSA (mild to severe), Ravesloot and Vries [24] identified 38 % obstruction in the epiglottis, while Salamanca et al. [28] reported a prevalence of 22.5 % obstruction in the epiglottis in patients with AHI >15. Other studies reported significantly greater numbers among DISE when compared to NFL with MM [27, 29, 30]. These different results may be explained by the association between the epiglottis and the anteroposterior force vectors of the tongue base. Nonetheless, in this study both observers have presented the same value. In many instances, the difficulty of decoupling these vectors can hide the role played by the epiglottis in the UA obstruction of OSA patients.

Table 5 Affected sites in the pharynx (1 and ≥2) in patients with moderate or severe apnea (NOHL and VOTE)

NOHL Obstruction levels		AHI $n = 45$					
		Observer 1			Observer 2		
		Moderate n (%)	Severe n (%)	p value	Moderate n (%)	Severe n (%)	p value
Monolevel	1	1 (3.1)	2 (15.4)	0.17	1 (3.1)	2 (15.4)	0.14
Multilevel	≥2	31 (96.9)	11 (84.6)		31 (96.2)	11 (84.6)	
VOTE Obstruction levels		AHI $n = 45$					
		Observador 1			Observador 2		
		Moderate n (%)	Severe n (%)	p value	Moderate n (%)	Severe n (%)	p value
Monolevel	1	1 (3.1)	2 (15.4)	0.17	0 (0.0)	1 (7.7)	0.14
Multilevel	≥2	31 (96.9)	11 (84.6)		32 (100)	12 (92.3)	

NOHL nose oropharynx hypopharynx larynx, *AHI* apnea-hypopnea index, *VOTE* velum oropharynx tongue base epiglottis

$p < 0.05$—estatisticamente significativo (Chi square test)

Table 6 Affected sites in the pharynx (1, 2 and ≥3) in patients with moderate or severe apnea (NOHL and VOTE)

Obstruction levels		AHI $n = 45$					
		Observer 1			Observer 2		
		Moderate n (%)	Severe n (%)	p value	Moderate n (%)	Severe n (%)	p value
NOHL							
Monolevel	1	1 (3.1)	2 (15.4)	0.21	1 (3.1)	2 (15.4)	0.14
Multilevel	2	22 (68.8)	6 (46.2)		21 (65.6)	5 (38.4)	
	3	9 (28.1)	5 (38.4)		10 (31.2)	6 (46.2)	
VOTE							
Monolevel	1	1 (3.2)	2 (15.4)	0.05	0 (0.0)	1 (7.7)	0.04
Multilevel	2	7 (21.8)	0 (0.0)		9 (28.2)	0 (0.0)	
	≥3	24 (75.0)	11 (84.6)		23 (71.8)	12 (92.3)	

NOHL nose oropharynx hypopharynx larynx, *AHI* apnea-hypopnea index, *VOTE* velum oropharynx tongue base epiglottis

$p < 0.05$—estatisticamente significativo (Chi square test)

Table 7 Minimal oxygen saturation during apnea episodes, registered by PSG and DISE

Variables	PSG		DISE	
$SatO_2$Min.	Moderate[a]	Severe[b]	Moderate[a]	Severe[b]
Minimum	70	50	64	55
Maximum	95	93	98	93
Median	81.5	75	85	76
Mean (SD)	80.6 (7.3)	76.2 (11.8)	82.5 (8.3)	77.2 (11.2)

PSG polysomnography, *DISE* drug-induced sleep endoscopy, *$SatO_2$ Min* minimal oxygen saturation (%), *SD* standard deviation

[a] Moderate: apnea and hypopnea index (15 < AHI ≤ 30)

[b] Severe: apnea and hypopnea index (AHI < 30)

Most patients [O1: 23(51.1 %)/O2: 21(46,6 %)] with multiple affected sites had concomitant obstruction in the oropharynx and hypopharynx according to the NOHL classification. In addition using the NOHL classification, Campanini et al. [29] found a 77.5 % frequency for the same combination of obstruction sites. Moreover, other studies have shown this combination to be the most frequent [9, 22, 24, 26, 29, 31]. The palatine veil, oropharynx, and base of the tongue [O1: 19 (42.2 %)/O2: 17 (37.8 %)] was the most frequent combination of obstruction sites using the VOTE classification, to both observers. Vroegop et al. [25] identified the palatine veil and tongue base as the most frequent combination (25.5 %), but that study evaluated patients with mild to severe OSA.

Interestingly, a considerable number of patients had obstruction in all sites concurrently, according to either rating (NOHL—O1: 31.1 %/O2: 33.3 %/VOTE—O1 and O2: 26.6 %). There are different results regarding the percentage of patients with all sites affected. Salamanca

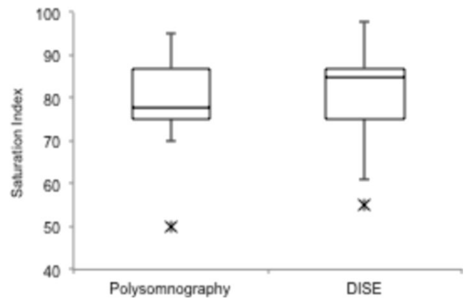


Fig. 2 Minimal oxygen saturation index during apnea episodes, as registered by polysomnography and DISE

et al. [28] found a rate of 8.5 % in patients with AHI >15 in a sample of 614 individuals.

Despite some differences between ratings, we identified a higher prevalence of concentrically-shaped obstructions in DISE using both classifications at all sites involving the pharynx (except the tongue base). However, the literature reports a variety of obstruction patterns [29]. Using the NOHL classification, Salamanca et al. [28] found a higher prevalence of the circular shape in the oropharynx and of the anteroposterior shape in the hypopharynx for patients with moderate or severe apnea. In their study, Vroegop et al. [25] showed that the highest BMI and AHI values were associated with a greater likelihood of complete concentric palatal collapse.

The concentric shape of the hypopharynx in the NOHL classification is composed of the lateral movement of the pharynx and the anteroposterior tongue base. In the VOTE classification these two sites are evaluated separately. The tongue base site (T) does not present a concentric shape description, and the lateral movement of the pharynx is dealt with in oropharynx site (O). A limitation of the VOTE classification is that it may overlook the interactions between UA structures, but it is a foundation for further study of these structures and for assessment of their response to directed interventions [12]. However, this same feature can also be considered a positive and relevant aspect of VOTE, since it allows us to dissociate different strength vectors that take part in the movement of pharynx collapse during apnea, thus making it easier for the observer to identify collapse(s). The transversal format of the hypopharynx (NOHL) was similar to the transversal format of the oropharynx (VOTE), by both observers.

In a prospective evaluation using a low dose of midazolam with propofol, De Corso et al. [32] suggested that the collapse caused by multilevel obstruction greater than 50 % was significantly associated with higher AHI values. We also observed this relationship in the present study, and most participants with AHI >15 presented more than two obstruction sites. When we divided multilevels into two and three or more affected sites, we observed significant differences only with the VOTE rating between the number of sites and the severity of OSA according to the two observers. The dissociation of the hypopharynx site (NOHL classification) into oropharynx and tongue base (VOTE classification) allowed for the establishment of a relationship between the number of sites affected (VOTE classification) and the severity of OSA (O1: $p = 0.05$/O2: $p = 0.04$). Therefore, a larger sample may be needed to reach a significant level with the NOHL classification.

NOHL and VOTE classification share similarities in the majority of their parameters, aiming to identify obstruction sites of UA, the degree and the pattern of obstructions. The decoupling of the strength vectors that are part of the collapse movement in the hypopharynx (H) (anteroposterior, transverse and concentric), within NOHL, yields the tongue base (AP) and oropharynx lateral wall (Lat) sites of obstruction, within VOTE. Therefore, this means that the NOHL site of the hypopharynx can be: (a) Hypopharynx = the presence of the collapse of the oropharynx (O-Lat) + tongue base (T-AP) = the association of these strength vectors (Lat + AP) generates a third strength vector (C—concentric); (b) Hypopharynx = the presence of collapse of the oropharynx (Lat) + the absence of fall of the base of the tongue (AP) = standard lateral (Lat), also called transverse (Tr); (c) Hypopharynx = no collapse of the oropharynx (Lat) + the presence of the fall of the tongue base (AP) = standard anteroposterior (AP). This study does not claim that the VOTE classification shows more multilevel obstructions. It claims that only based on the VOTE classification it has been possible to correlate the multilevel obstructions to the severity of OSA, in the analyzed sample. Furthermore, the study considers not only the existence of an extra site of obstruction in the VOTE classification, but also seeks to justify the correlation between the number of sites and the severity of OSA by the fact that there is one more level (originating from the dissociation of the site of the hypopharynx). Thus, this study shows that the VOTE classification demonstrates more adequately the findings in DISE regarding the severity of OSA once we take the division of the hypopharynx site into consideration.

Minimum SaO_2 values in DISE were similar to those in PSG, when patients were under physiological sleep conditions. It should be noted that SaO_2 is used to assess the severity of OSA. Conversely, Rabelo et al. [9] found a significant reduction in minimum SaO_2 levels using the TCI without BIS monitoring. The median of minimum SaO_2 values was higher in DISE (85 %) than in PSG (78 %). Despite the differences in BIS recorded at the onset of apnea (mean: 69.2/DP: 4.5/median: 69) and during the examination (mean: 63.1/DP: 2.8/median: 63), increasing the target dose of propofol to deepen sedation and improve patient tolerance to the flexible endoscope had no effect on ventilatory patterns. The outlier patient, who had a lower minimum SaO_2 value than the rest of the sample, had no history of pulmonary disease or activities in apnea, and only reported hypertension with regular use of atenolol. This is a very relevant information because It demonstrates the quality of the technique that is used, associating Propofol/TCI and BIS, in DISE. This finding allows us to infer and consider that the obstruction sites found during DISE were similar to those identified during sleep, with similar degree and pattern.

Surgery may not be successful if the identified obstruction sites are not addressed when using DISE. Nevertheless, the use of DISE offers no guarantee that the surgical treatment will be successful. Thus, DISE may actually be more useful for contraindication of surgical treatment of OSA than for its surgical indication.

Conclusion

In our study, the VOTE classification was more comprehensive in the analysis of the pharynx and e piglottis by DISE. Patients with moderate and severe OSA had multilevel obstructions more often. The relationship between the severity of OSA and the number of sites affected was significant according to the VOTE classification. Because it does not affect minimum SaO2 levels, BIS monitoring with DISE is a reliable tool for the assessment of OSA patients.

Compliance with ethical standards

Conflict of interest The authors declare that they have no conflict of interest.

Ethical approval All procedures performed in studies involving human participants were in accordance with the ethical standards of the institutional and national research committee and with the 1964 Helsinki declaration and its later amendments or comparable ethical standards.

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

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