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Comparison of Muller's maneuver simulated snoring and sleep endoscopy according to VOTE classification in sleep apnea patients

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ABSTRACT

Objective: In patients with obstructive sleep apnea syndrome (OSAS), it is important to determine the obstructive pathology in the upper respiratory tract (URT). Drug-induced sleep endoscopy (DISE) has been accepted as the most valuable technique for determining the obstruction site associated with sleep-disordered breathing. Simulated snoring (SimS), one of the techniques developed for this purpose, is practical; however, it is important to determine its reliability according to the standard grading methods. In this study, we aimed to compare the effectiveness of the SimS method in detecting obstructive pathology in URT with Muller maneuver (MM) and DISE according to the velum, oropharynx lateral wall, tongue base and epiglottis (VOTE) classification.

Methods: Forty patients older than 18 years with OSAS diagnosis (apnea-hypopnea index [AHI] > 5) were included in the study. Obstructive findings in URT were evaluated according to VOTE classification with MM, SimS, and DISE. The patients were evaluated with MM and SimS in the polyclinic and with DISE in the operating room on different days. The obstructive pathologies in URT were evaluated and images recorded. Obstructive findings were evaluated using all three methods according to the VOTE classification. The extent of agreement of findings between the methods was evaluated using the weighted κ value Cohen.

Results: The patients' data were evaluated independently of AHI, and it was seen that SimS had a better agreement with DISE than MM. Patient grouping by AHI revealed a high level of agreement between SimS and DISE in all four regions in the group with AHI < 30. SimS and DISE findings were consistent, except lateral pharyngeal collapse was detected at the level of tongue base in patients with AHI > 30.

Conclusion: The results showed that SimS was more effective than MM and provided similar findings to DISE. SimS is a more feasible alternative in the planning phase of surgical treatment of OSAS.

Keywords: Drug induced sleep endoscopy, muller maneuver, obstructive sleep apnea, simulated snoring, UARS

Introduction

Obstructive sleep apnea syndrome (OSAS) can be defined as recurrent obstruction episodes in the upper airway characterized by reduced arterial oxygen saturation during sleep and sleep interruption (1). Although the gold standard for the diagnosis and determination of severity of OSAS, polysomnography does not provide information on the physiopathology of apnea (2). Detection at areas of collapse in these patients is extremely important for the prognosis and planning of appropriate treatment. In practice under polyclinic conditions, the most frequently used and easiest evaluation method is Muller's maneuver (MM), which aims to identify the areas of obstruction in the upper respiratory tract (URT) of patients when they are awake and in a sitting position (3). Today, another increasingly adopted method is drug-induced sleep endoscopy (DISE), which provides visualization of URT during drug-induced sleep (4). DISE is the most effective evaluation method in the planning of surgical intervention, particularly in patients with snoring and OSAS. There are various classification methods used in the evaluation of the URT by DISE, and the most commonly used one is the velum, oropharynx lateral wall, tongue base and epiglottis (VOTE) classification (5, 6). Simulated snoring (SimS) is a newly defined method that overcomes the disadvantages of sleep endoscopy in detection of pathologies causing obstruction (7). In SimS, a non-invasive and easy method, the patient is asked to snore with forced inspiration through an open mouth, and the upper airway is examined with a flexible endoscope to

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evaluate obstructive pathologies (7, 8). It has been suggested that SimS has a similar efficacy to DISE in the identification of the obstruction site and may be used as an alternative for this purpose. However, this method has not been confirmed with sufficient studies yet, and a standard classification has not been used. In addition, there are no studies evaluating these three methods according to the VOTE classification, which is frequently used till now. This will be useful in demonstrating the validity and reliability of this method, which is relatively practical in terms of application.

In this study, we compared the effectiveness of SimS in determining the areas of obstruction in the URT of patients with OSAS with MM and DISE according to the VOTE classification.

Methods

This was a prospective clinical study. The research protocol was submitted to and approved by the Sakarya University ethics committee Approval No: 16214662/050.01.04/153). The patients aged between 18 and 65 years, who were admitted to the Sakarya University medical faculty otolaryngology clinic with a complaint of snoring and interruption of breathing in sleep were evaluated. Detailed physical examination, detailed laboratory tests, and otorhinolaryngological examinations were performed on all the patients who agreed to participate in the study. Furthermore, body mass index (BMI) and the Epworth sleepiness scale (ESS) were calculated for each patient. Tonsil size was described using the Brodsky classification from 0 to 5; 0 tonsils entirely within the tonsillar pillar or previously removed by surgery, 1+ tonsils occupy less than 25% of the lateral dimension of the oropharynx as measured between the anterior tonsillar pillars (solid yellow arrow), 2+ tonsils occupy 26% to 50% of the lateral dimension of the oropharynx, 3+ tonsils occupy 51% to 75% of the lateral dimension of the oropharynx, and 4+ tonsils occupy more than 75% of the lateral dimension of the oropharynx. The Friedman Tongue Position scale was used to classify the position of the palate with the tongue in a neutral position inside the mouth. According to the visibility of the uvula and palate, I visualized the uvula and tonsils/pillar, IIa visualized most of the uvula but not the tonsils/pillar, IIb visualized the entire soft palate to the uvular base, III showed some of the soft palate with the distal end absent, and IV visualized only the hard palate. All the patients were informed about all the procedures and provided written informed consent.

Main Points:

- The main goal of the surgery for the treatment of obstructive sleep apnea syndrome is to remove the obstruction-causing site.
- The search for a practical and effective assessment method for the detection of obstructive pathology continues.
- Although simulated snoring (SimS) is a newly defined method, it has not been evaluated with a classification method, such as velum, oropharynx lateral wall, tongue base and epiglottis (VOTE) until now.
- Our findings reveal that SimS and drug-induced sleep endoscopy are highly compatible according to the VOTE classification. In this respect, it is considered to be more effective than MM, as it has higher compatibility.
- Our data will be the guide for future studies on this subject. In addition, our results suggest that SimS may also be a useful method for evaluating patients with sleep apnea.

The patients were evaluated overnight at the clinic using ambulant polysomnography (Embletta MPR PG sleep system; Natus®) or PSG reports made at an outside center. The apnea-hypopnea index (AHI) values were calculated using a software program. As a result of the test, the patients with an AHI > 5 were included in the study with a diagnosis of OSAS. The patients were excluded from the study if they were < 18 years old, had a BMI > 40, had a history of surgery on the upper respiratory system, were American Society of Anesthesiologists grade 3-4, and had refused surgical therapy.

All the procedures were performed by same doctor (MOK). These patients first underwent MM in the polyclinic. The nasal mucosa was topically anesthetized and shrunk with gauze soaked with 4% lidocaine and 0.1% epinephrine. To visualize the whole URT, a zero degree 3.4 mm flexible nasopharyngoscope (Storz®) examination was undertaken for each patient, who was awake and in a supine position and examined by tilting the examination chair backwards. At the same time, MM was applied to evaluate the susceptibility of the upper airway to collapse during negative intraluminal pressure. URT was visualized and recorded during forced inspiration made with the mouth and nose closed. The SimS procedure was performed in the same position as described in the original study. The patients were asked to perform forced inspiration through slightly open mouths without moving their jaws too much and make a sound similar to snoring during visualizing and recording URT with the flexible nasopharyngoscope.

DISE were performed in the presence of general anesthesia equipment under operating room conditions accompanied by an anesthesiologist. During the procedures, special attention was paid to ensure that the environment was dark and quiet. The nasal mucosa was topically anesthetized and shrunk with gauze soaked with 4% lidocaine and 0.1% epinephrine. The patients were monitored with ECG, noninvasive blood pressure, and oxygen saturation. The patients were then administered bolus midazolam (0.03 mg/kg) to initiate sedation. Deep sedation was induced by administering propofol (Propofol-Lipuro 1%; B. Braun®) (1 mg/kg IV dose) in divided doses to trigger snoring. When the patients began to sleep and snore, the obstruction levels that caused snoring and apnea development were evaluated and recorded with the help of a flexible endoscope.

The degree and types of upper airway collapse in each region of URT were evaluated using the VOTE classification in all three methods (MM, SimS, and DISE). The obstruction sites of the upper airway in the VOTE classification are as follows: velum (V), oropharynx lateral walls (O), tongue base (T), and epiglottis (E). The degree of obstruction is graded as follows: 0 (no obstruction, no vibration), 1 (partial obstruction, vibration), 2 (complete obstruction, collapse), and X (not visualized). The type of collapse is classified as anteroposterior, lateral, or concentric in the velum, although the type of collapse can show only a lateral pattern in the oropharynx lateral wall and only an anteroposterior pattern at the tongue base. The pattern in the epiglottis can be classified as anteroposterior or lateral (9).

The patients were divided into three groups according to AHI values (mild = 5–15/h, moderate = 15–30/h, and severe = > 30/h). The data obtained by all the three methods were compared independently in AHI values and compared in three groups according to AHI values, and reliability was evaluated. To compare reliability between the methods, patients with obstruction at the level of velum (V), oropharynx lateral walls (O), tongue base (T), and epiglottis (grade 1, 2) and those without obstruction were compared. In terms of obstruction pattern, only that at the level of the velum, anteroposterior, lateral, and concentric were evaluated separately.

Statistical analysis

As DISE and MM are the accepted examination methods, the correlation of SimS with these two methods was evaluated. The Statistical Package for Social Sciences version 24.0 software (IBM Corp.; Armonk, NY, USA) used to analyze the data. The student's t-test was performed to determine the averages of basic data (age, ESS, BMI, and AHI). Cohen's kappa test was used to evaluate the results between the dependent groups for the comparison of examination findings. The adaptation levels proposed by Landis and Koch were used to interpret the weighted Cohen's kappa coefficients (10). In this assessment, inter-group agreement was considered to be non-existent if the kappa value (K) was ≤ 0.00, slight if it was 0. 01–0.20, fair if 0.21–0.40, moderate if 0.41–0.60, substantial if 0.61–0.80, and almost perfect if 0.81–1.00.

Table 1. General data of the patients

Patient characteristics	Mean	Max–min
Age (year±SD)	42.37 ± 2.3	28–69
Sex (n, %)		
Male	35 (87.5)	
Female	5 (12.5)	
BMI (mean±SD)	29.58 ±12.1	18–40
AHI (apnea+hypopnea/hour±SD)	19.29 ± 1.6	5–47.9
ESS (mean±SD)	10.44 ± 33.2	1–20
Mallampati grade 3–4 (n, %)	21 (52.5)	
Brodsky tonsil size grade 3–4 (n, %)	13 (32.5)	

SD: Standard deviation, BMI: Body mass index, AHI: Apnea-hypopnea index, ESS: Epworth sleepiness scale

Results

General data

The patients' distribution and examination data are shown in Table 1. The comparison of the grade of upper airway obstruction and rates of patients (independent of AHI and grouped according to AHI values), the degree and pattern of obstruction detected by three evaluation methods at four levels are presented in Table 2.

MM, SimS, and DISE inter-test agreement

Independent of AHI, SimS, and MM showed fair agreement at all four levels for grading of obstruction (K values were between 0.21–0.40). However, there was a better correlation between SimS and DISE findings for detection of grading (K values were between 0.4–0.689). The obstruction pattern was evaluated at only the velum and epiglottis levels. The level of the oropharynx and tongue base was evaluated only in terms of the anteroposterior closure pattern according to the VOTE classification. Therefore, the evaluation of the compatibility of all the three methods in detecting different closure patterns was made in only two regions. When the patients were evaluated according to the AHI values, there were differences in the inter-test agreement between the three methods by levels of obstruction grade and pattern.

Velum: When the obstruction grading was compared in the three methods, there was fair agreement between MM and SimS (K = 0.316) and substantial agreement between SimS

Table 2. The number of patients with grade 3–4 collapse at four different levels in different AHI groups

		V (n)			O (n)			T (n)			E (n)		Grade
Patient groups	Method	0	1	2	0	1	2	0	1	2	0	1	2
Independent of AHI (n = 40)	MM	9	18	13	4	25	11	17	16	7	23	12	5
	SimS	3	15	22	0	17	23	11	14	15	18	14	8
	DISE	0	17	23	0	12	28	7	13	20	12	17	11
Groups Mild (n = 13)	MM	5	5	3	3	10	0	9	4	0	9	4	0
	SimS	2	6	5	0	9	4	7	4	2	7	5	1
	DISE	0	8	5	0	6	7	5	5	3	5	6	2
Moderate (n = 14)	MM	4	6	4	1	8	5	6	4	4	9	4	1
	SimS	1	5	8	0	5	9	3	6	5	7	4	3
	DISE	0	6	8	0	4	10	2	4	8	4	6	4
Severe (n = 13)	MM	0	7	6	0	7	6	2	8	3	5	4	4
	SimS	0	4	9	0	3	10	1	4	8	4	5	4
	DISE	0	3	10	0	2	11	0	4	9	3	5	5

AHI: Apnea-hypopnea index, MM: Muller's maneuver, SimS: Simulated snoring, DISE: Drug-induced sleep endoscopy, V: Level of velum, O: Oropharynx lateral wall, T: Tongue base, E: Epiglottis

Table 3. Comparison of obstruction pattern at two levels (velum and epiglottis) by all the three methods of patients grouped according to their AHI degrees

		V (n)			E (n)			
Patient groups	**Method**	**AP**	**L**	**C**	**AP**	**L**	**C**	**Pattern**
Independent of AHI	MM	16	4	11	16	1	0	
	SimS	20	5	12	18	4	0	
	DISE	20	6	14	22	6	0	-
Agreement % (Cohen value)	MM-SimS	0.776			0.612			-
	SimS-DISE	0.889			0.889			
Groups Mild	MM	4	1	2	3	0	0	
	SimS	5	1	3	4	0	0	
	DISE	6	1	3	4	1	0	0
Moderate	MM	6	1	4	5	0	0	
	SimS	6	1	4	6	2	0	
	DISE	6	2	5	8	2	0	-
Severe	MM	7	3	6	8	1	0	
	SimS	7	3	5	8	2	0	
	DISE	8	3	6	10	3	0	-

AHI: Apnea-hypopnea index, MM: Muller's maneuver, SimS: Simulated snoring, DISE: Drug-induced sleep endoscopy, V: Velum, E: Epiglottis, AP: Anteroposterior, L: Lateral, C: Concentric

and DISE findings (K = 0.649) in the mild group. In the moderate group, slight agreement was observed between MM and SimS (K = 0.049), whereas there was substantial agreement between SimS and DISE (K = 0.759). In the severe group, the MM-SimS agreement was moderate (K = 0.435) and the SimS-DISE agreement was fair (K = 0.235) (Table 2).

When a comparison was made in terms of obstruction patterns, there was an almost perfect agreement (K = 0.889) between SimS and DISE and substantial agreement between MM-DISE (K=0.776) in all the groups. Collapse in the anteroposterior direction was the most common in all the three groups (Table 3).

Oropharynx lateral walls: There was a fair agreement between MM and SimS (K= 0.235) but almost perfect agreement between SimS and DISE findings (K = 0.832) in the mild group. In the moderate group, slight agreement was identified between MM and SimS (K = 0.204) but substantial agreement between SimS and DISE (K= 0.649). In the severe group, the level of agreement was substantial between MM and SimS (K = 0.649) but moderate between SimS and DISE (K = 0.435) (Tables 2 and 3).

Tongue base: At this level, the results of the mild group showed fair (close to moderate) agreement in the detection of obstruction by MM and SimS (K = 0.409) and substantial agreement between SimS and DISE (K = 0.683). For the severe group, there was slight agreement between MM and SimS (K = 0.204), but the agreement between SimS and DISE was substantial (K = 0.652). In the severe group, there was no agreement between MM and SimS data (K = 0.071); however, the SimS and DISE findings were found to be significantly compatible, indicating values close to almost perfect (K = 0.806) (Tables 2 and 3).

Epiglottis: The mild group was found to have moderate agreement (K = 0.451) for MM-SimS and fair agreement (K = 0.283) for SimS-DISE. In the moderate group, MM and SimS had substantial and statistically significant agreement (K = 0.629), whereas SimS had fair agreement with DISE (K = 0.235) in detecting obstruction at this level. For the severe group, the findings at this level indicated moderate agreement both between MM-SimS (K = 0.519) and SimS-DISE (K = 0.552) (Tables 2 and 3).

In terms of obstruction pattern, a statistically significant agreement was observed between SimS and DISE (K = 0.889) than between MM and DISE (K = 0.612). The most common obstruction pattern was in the anteroposterior direction in all the three groups.

Discussion

In this study, we compared the detection of collapse grading and collapse patterns of URT during MM, SimS, and DISE in patients with OSAS. Studies on simulated snoring are limited, and this is the first study to compare these three methods according to the VOTE classification. We found that SimS showed higher compatibility with DISE in determining the degree and pattern of obstruction in general, and this level of compatibility decreased as the AHI value increased.

It is important to define the location and pattern of the upper airway collapse to correctly plan the treatment approach for patients with OSAS. In addition, different airway obstruction features of patients have an impact on determining the severity of disease so that defining an accurate surgical treatment for these patients will reduce unnecessary costs. One of the first examination methods to provide findings to aid such an

assessment was MM (3). However, MM may not always provide data consistent with collapse during sleep because it is applied when the patient is awake and often in a sitting position (11, 12). Terris et al. (13) suggested that evaluation with MM differed from one clinician to another, and the patients were not always able to provide sufficient negative pressure to trigger obstruction. It is, therefore, believed that DISE, another technique developed to eliminate these deficits, is superior to MM (14, 15). However, there are also researchers who argue that endoscopic assessment under sedation does not accurately reflect the state of the patient during normal sleep. Hill et al. (16) reported that the localization causing snoring and the degree of snoring vary depending on the changes in position during sleep; however, DISE is not able to evaluate these changes as it is performed in a single position. In a similar vein, Agrawal et al. (17) suggested that sedative agents administered caused excessive muscle relaxation and might produce false positive results. However, the results of the study comparing natural sleep endoscopy and DISE support that drug use and subjective assessments do not affect DISE reliability (18) Ordones et al. (19) compared the site and configuration of pharyngeal collapse during zolpidem-induced sleep and DISE with propofol and found similar results. In another study, it was observed that the snoring sound during stimulated sleep and natural sleep did not differ in terms of spectrogram and formant frequency (20). Furthermore, DISE requires significant time and equipment support. The possible side effects of the anesthetics administered for DISE present another disadvantage for patients.

In the literature, SimS was first defined as a technique by Herzog et al. (6) in a study of 622 patients, although it had already been in practical use by some otolaryngologists. The primary advantage of SimS is its application when the patient is awake, providing time, equipment, and cost efficiency. Furthermore, the absence of anesthetics reduces the possibility of side effects. Therefore, pre-surgical planning can be performed in office conditions, even during the first examination. The grading system used to evaluate obstruction in URT during the application of SimS has been described in studies conducted by the same authors mentioned above (4, 7). According to this evaluation, the degree of obstruction is determined based on percentages at four different levels. However, in the literature, there are studies conducted with a large number of classification systems to compare the advantages and results associated with DISE (21). In addition, there is no standard method used and defined to compare different methods such as DISE, MM, and SimS. The VOTE classification developed by Keziran et al. (6) is one of the most frequently used classifications for this purpose. In our study, we compared the compatibility of the three methods in all four regions in terms of degree and pattern of obstruction using VOTE classification.

In a study comparing SimS and DISE by Herzog et al. (7) the authors obtained similar results from the two methods in the detection of collapse at the level of the velum. They noted that DISE was more effective than SimS in identifying obstruction only at the level of the tongue base. In this study, when the patients were evaluated independently of AHI, SimS was found to be superior to MM in detecting collapse level at all the four levels. Similarly, a comparison of the findings revealed that SimS and DISE had moderate or substantial agreement in the evaluation of the four levels. When we divided the patients according to the AHI values, we observed that SimS was correlated with DISE at the first three levels in patients with AHI < 30. Fair agreement was only identified for the evaluation of lateral pharyngeal collapse at the level of the tongue base. In patients with AHI > 30, SimS and DISE provided reasonably compatible findings at all the levels, except the level of the velum for which the agreement was only fair. The disagreement between the two methods particularly concerning the evaluation of the lateral pharyngeal region was interpreted as the muscle tone in that region preventing collapse in the awake state. Another reason for this situation was considered as the negative intraluminal pressure created by forced inspiration being able to provide collapse at the palatine uvula but was not sufficient at the inferior level.

In our study, it has been observed that there is a moderate to good agreement between SimS and DISE in terms of detecting obstruction patterns. SimS was superior to MM in detecting an anteroposterior occlusion at the epiglottic level. Although this situation may be related to the position, the collapse created by MM may be insufficient to evaluate the epiglottis level. In a study comparing MM and DISE efficiency using the VOTE classification, a significant agreement was found at the level of the velum and epiglottis in terms of obstruction pattern, and similar to our study, no consistency at the tongue base level was found.[22] In the literature, there is no study on simulated snoring based on VOTE classification. Our study is also the first in this respect.

Bachar et al. (23) who investigated laryngeal and hypopharyngeal obstruction in patients with OSAS, observed that the most frequent area of obstruction was the palatine uvula (89% of the patients), followed by the tongue base and hypopharynx. Another area for which MM does not provide sufficient results in detecting obstruction is the anteroposterior position of the tongue base (24). In this study, SimS and DISE data were found to be compatible in the evaluation of obstruction at the tongue base level. Therefore, it is considered that SimS can offer more advantages than MM in evaluating tongue base obstructions. In the study by Huo et al. (25) that compared SimS and MM in terms of their effectiveness for evaluating obstruction only in the retropalatal and retroglossal regions, they stated that SimS is more effective in the evaluation of retroglossal region.

In general, the most important advantage of obtaining similar results from SimS and DISE is the time and cost advantages offered by the former. SimS can be used in the surgical planning stage without the need for additional medication or equipment in normal clinical conditions. Patients with OSAS and with a high AHI index are associated with high lateral wall collapse (26). Therefore, according to the results obtained from our study, SimS may be an alternative to DISE in patients with mild to moderate OSAS, although this may not be true in individuals with severe OSAS. Therefore, comparative studies presenting the results of surgical success and cost will be useful in terms of providing more detailed data.

One limitation of our study was that the agreement between the three methods in revealing the luminal diameter chang-

es was only evaluated subjectively based on observation. We were not able to determine whether there were similar luminal pressure changes during SimS and sleep. We hope that future comprehensive studies will elucidate this issue with the use of objective methods. Therefore, it will be important for future studies to demonstrate the reliability of these three methods considering the VOTE classification.

In conclusion, sleep apnea occurs because of multi-segmental and dynamic problems involving different regions of the URT. Hence, it is important to accurately determine the region that is causing the obstruction to plan an accurate surgical approach in these patients. Although DISE remains a superior technique on the basis of the imaging of URT during drug-induced sleep, the difficulty to arrange conditions for its application places serious restrictions on both the patient and the clinician. Therefore, SimS, a recently developed method, has been suggested as a cheaper, safer, and easily applicable alternative to DISE. This study conducted according to the VOTE classification is important in terms of demonstrating the reliability and efficiency of the method. However, further studies with larger patient series are required to provide more detailed information on the efficacy of SimS.

Ethics Committee Approval: This study was approved by Ethics committee of Sakarya University, (Approval No: 16214662/050.01.04/153).

Informed Consent: Written informed consent was obtained from the patients who agreed to take part in the study.

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