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Drug-Induced Sleep Endoscopy vs Awake Müller's Maneuver in the Diagnosis of Severe Upper Airway Obstruction

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Abstract

Objective—To compare fiber-optic nasal endoscopy with Müller's maneuver (FNMM) against drug-induced sleep endoscopy (DISE) in diagnosing the presence of severe level-specific upper airway collapse in patients with obstructive sleep apnea/hypopnea syndrome (OSAHS).

Study Design—Case series with chart review.

Setting—Tertiary care academic center.

Subjects and Methods—Medical records of all adult patients undergoing diagnostic DISE as part of their surgical evaluation were reviewed. Patients were included if they had undergone FNMM and had documented Friedman tongue position and tonsillar grade prior to DISE. Airway obstruction on both endoscopic procedures was described according to airway level and severity. Severe airway obstruction was defined as >75% collapse on endoscopy.

Results—Fifty-three patients were included in this study. Fiber-optic nasal endoscopy with Müller's maneuver and DISE did not differ significantly regarding the presence of severe retropalatal airway collapse. There was a statistically significant difference in the incidence of severe retrolingual collapse identified via DISE (84.9% [45/53]) compared with FNMM (35.8% [19/53]; $P < .0001$). This discrepancy between FNMM and DISE findings was statistically significant in individuals with Friedman I and II tongue positions (FNMM = 16.7%, DISE = 88.9%, $P < .0001$) and individuals with Friedman III tongue position (FNMM = 31.8%, DISE = 81.8%, $P = .002$). Patients with Friedman IV showed no significant difference ($P = .65$) between FNMM (69.2%) and DISE (84.6%).

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Conclusion—This study shows a significant difference between FNMM and DISE in the identification of severe retrolingual collapse. Since the effectiveness of surgical interventions depends largely on the accurate preoperative identification of the site of obstruction, further scrutiny of each diagnostic endoscopic technique is warranted.

Keywords

sleep endoscopy; Müller's maneuver; retrolingual collapse; obstructive sleep apnea

The impact of untreated obstructive sleep apnea/hypopnea syndrome (OSAHS) in adults is estimated to approximate \$16 billion yearly in the United States.¹ Adequate surgical management of OSAHS strongly depends on the identification of the level and the pattern of airway collapse demonstrated by each individual patient. The specific contribution of each airway level to increased airway obstruction and resistance needs to be thoroughly assessed prior to determining the ideal surgical intervention. For instance, individuals with Fujita type I collapse (retropalatal only) respond to a uvulopalatopharyngoplasty (UPPP) with an 83% success rate, whereas those with significant base of tongue collapse (types II and III) respond with a success rate of only 19%.² With such disparity in the degree of surgical response, the accurate identification of key sites of airway collapse becomes essential.

Traditionally, airway evaluation relied on lateral cephalometry and/or awake fiber-optic nasal endoscopic evaluation with Müller's maneuver (FNMM), which requires forced inspiration against a closed nasal and oral airway, to determine the most likely sites of airway collapse. However, although no diagnostic gold standard exists, the ability of the FNMM technique to predict the site and severity of airway collapse has been questioned as studies demonstrate disparity against objective measurements such as flextube reflectometry and nasopharyngeal pressure measurements.^{3,4} In addition, because FNMM is performed during wakefulness, there are limitations to its ability to accurately detect and predict the severity of airway collapse that occurs during sleep.⁵ Furthermore, FNMM has been shown to be poorly predictive of surgical success after UPPP, which is thought to be due to a potential underestimation of the degree of collapse at the level of the retrolingual airway.⁶⁻⁹

The introduction of drug-induced sleep endoscopy (DISE) has allowed for an objective form of dynamic airway size evaluation in a state that closely mimics natural sleep.¹⁰ Airway evaluation findings via sleep endoscopy have been shown to have good interuser and test-retest reliability as well as good correlation with the respiratory disturbance index (RDI).¹¹⁻¹⁴ However, concerns over the possible over-estimation of severe airway collapse exist because of the sedative use that characterizes this relatively new diagnostic procedure.¹⁵⁻¹⁷ In the present study, we compare the severity of airway collapse findings diagnosed preoperatively on FNMM against those obtained by DISE in the same patient population with the aim of determining whether significant differences exist between these 2 methods of airway evaluation in terms of site and severity of collapse.

Methods

Approval was obtained from the Wayne State University institutional review board for a retrospective chart review of all patients having undergone DISE at our institution from January 2006 through December 2010. This period coincided with the implementation of routine DISE for preoperative evaluation of patients with OSAHS at our institution. All study patients had a full airway examination via awake FNMM in the clinic, followed by DISE in the operating room. Patients were included in this study if they had documented OSAHS based on a diagnostic polysomnography, comprehensive physical examination including FNMM evaluation, and a preoperative DISE evaluation.

Patient Information

Detailed patient information was obtained as part of a standard obstructive sleep apnea (OSA) evaluation for all patients. Demographic information and physical examination records were obtained, including body mass index (BMI), relative tongue size, and tonsillar grade. Measurements of relative tongue and pharyngeal tonsillar sizes were graded according to criteria described by Friedman et al.⁹ Finally, diagnostic testing, including polysomnographic variables, and DISE and FNMM findings were carefully documented.

Polysomnography

Standard polysomnography was performed on all patients as part of a standard OSAHS evaluation. All studies were conducted and scored according to the standards of the American Academy of Sleep Medicine.¹⁸ The apneahypopnea index (AHI) was the major sleep parameter used in this study as a measure of OSAHS severity. Apneas were defined as a complete cessation of airflow at the nose and mouth for at least 10 seconds, whereas hypopneas were defined as partial obstructive events with diminution of airflow by more than 30% for at least 10 seconds with an associated oxygen desaturation of 4% or more.

Fiber-optic Nasal Endoscopy with Müller's Maneuver

Awake FNMM was performed by a single surgeon on all study patients for investigation of retropalatal and retrolingual collapse. All patients were taught how to perform Müller's maneuver and given the opportunity to practice before nasal endoscopy. All individuals underwent topical nasal administration of aerosolized 4% lidocaine and 0.25% phenylephrine solutions for adequate preprocedure decongestion and topical anesthesia. Subsequently, patients were placed in a sitting position while a flexible fiber-optic nasal endoscope (Olympus, Center Valley, Pennsylvania) was passed through 1 nostril into the nasopharynx. Müller's maneuver was then performed by maintaining maximal inspiration with an open glottis against closed oral and nasal airways. The same maneuver and assessment were then performed with the nasal endoscope placed past the velopharynx into the oropharynx for a measurement of retrolingual collapse. The estimated degree of airway collapse was described qualitatively as a percentage change in cross-sectional airway area and divided into quartile groups of <25%, 25% to 50%, 50% to 75%, and >75% at each level. For this study, the degree of collapse was simplified into severe (> 75 %) and nonsevere (<75%). This cutoff of 75% was used since most authors consider an obstruction of >75% to be significant enough to warrant surgical alteration at that particular level of airway, which is supported by recent studies.^{19,20}

Drug-Induced Sleep Endoscopy

Sleep endoscopy was performed in the operating room by a single evaluating surgeon as part of a standard preoperative assessment. Sleep induction was achieved in the operating room according to a standard propofol titration protocol beginning at a rate of 50 to 75 mcg/kg/min intravenous infusion. The use of benzodiazepines and other sedating medications was strictly prohibited. The target level of sedation was that of light sleep with arousal to tactile but not vocal stimulation. Once sedation was achieved, a flexible fiberoptic nasal endoscope was passed through the nose for inspection of the entire upper airway. Dynamic collapse was evaluated at the level of the retropalatal and retrolingual airway segments and roughly described in terms of a percentage cross-sectional area change based on anteroposterior and lateral axes of collapse. The estimated degree of airway collapse at each level was recorded as >25%, 25% to 50%, 50% to 75%, and >75% and then simplified to the dichotomous groups of severe (>75%) and nonsevere (<75%) for the purpose of this study.

Statistical Analysis

Data analysis was carried out using XLSTAT software (Addinsoft, New York, New York). Numerical data sets were compared using the Mann-Whitney-Wilcoxon test and the Student *t* test as dictated by normality testing. Proportion testing for categorical variables was carried out using Fisher's exact test and the χ^2 test.

Results

A total of 53 patients were included in this study, all of whom underwent DISE and FNMM evaluations, as well as polysomnography testing. The patient population was characterized by a 75.5% (40/53) male predominance, an average age of 46 ± 9.9 years, and an average BMI of 32.6 ± 6.5 kg/m². The average AHI was 42.4 ± 32.4 events/h, with 27 (51.0%) patients having severe OSAHS, 13 (24.5%) patients having moderate OSAHS, and 13 (24.5%) patients having mild OSAHS.

Table 1 shows the incidence of severe vs nonsevere airway collapse for DISE and FNMM according to airway level. At the retropalatal level, there was an incidence of severe collapse in 90.6% (48/53) of patients examined via FNMM compared with 98.1% (52/53) of patients evaluated via DISE ($P = .113$). In contrast, there was a significant difference in the incidence of severe retrolingual collapse identified via DISE (84.9% [45/53]) compared with FNMM (35.8% [19/53]) ($P < .0001$). Individuals undergoing DISE were more than twice as likely to be diagnosed with severe retrolingual collapse as those undergoing FNMM evaluation. Figure 1 provides an illustrative example of such discrepancy between the 2 diagnostic methods in the same patient. Awake fiber-optic endoscopy with Müller's maneuver (MM-A through MM-D) is not characterized by the same severity of anterior-posterior (AP) and lateral retrolingual collapse that is evident on DISE (DISE-A through DISE-D).

An analysis was performed regarding the impact of Friedman tongue position, pharyngeal tonsillar grade, and overall Friedman stage on the likelihood of a discrepancy in the ability to diagnose severe retrolingual collapse between DISE and FNMM. Figure 2 shows the incidence of severe retrolingual collapse on DISE vs FNMM according to Friedman tongue position (I through IV). Individuals with smaller tongue sizes were more likely to display a less severe degree of retrolingual collapse on FNMM than subsequent DISE when compared with those with high Friedman tongue stages. Specifically, 72.2% of individuals with Friedman tongue positions I and II were found to have severe retrolingual collapse that was not identified on FNMM ($P < .0001$). In contrast, 50% of patients with Friedman tongue position III ($P = .002$) and only 14.3% of patients with Friedman tongue position IV ($P = .65$) were found to have severe retrolingual collapse on DISE that was not present during FNMM. Such a pattern was not observed with increasing tonsillar grade, where DISE was more likely to identify severe retro-lingual collapse not otherwise identified on FNMM regardless of tonsillar size (Figure 3).

The overall Friedman stage was also evaluated against the respective incidence of severe retrolingual collapse identified via FNMM and DISE (Table 2). The absence of any significant number of stage I ($n = 1$) subjects, however, limited this type of analysis. Nevertheless, DISE identified severe retro-lingual collapse in 88.2% and 83.0% of Friedman overall stage II and III patients compared with FNMM, which identified severe retrolingual collapse in only 17.6% and 45.7% of Friedman overall stage II and III patients, respectively ($P < .0001$ and $P = .002$, correspondingly).

Discussion

The ability to correctly identify severe collapse at each of the different levels of the upper airway has become essential in guiding the correct surgical management of patients with OSHAS. The presence of severe retrolingual collapse has been implicated as a major risk factor predisposing to surgical failure in patients undergoing single-level surgery (eg, uvulopalatopharyngoplasty).² Furthermore, new multilevel surgical approaches to OSAHS surgery have now resulted in improved outcomes compared with single-level procedures.²¹ It therefore becomes critical that the preoperative airway evaluation of patients with OSAHS reflects the true severity of collapse present during sleep, lest such underestimation of severe collapse precludes the recommendation of necessary surgical interventions or, worse, results in an increased exposure to unnecessary surgical procedures. Classically, airway evaluation in patients with OSAHS relied on awake endoscopic procedures or examination of static physical attributes that fail to account for upper airway muscle relaxation known to occur during sleep. Such airway relaxation is known to predispose to significant airway collapse beyond that which can be predicted by awake endoscopy.³

In the current study, the retrospective review of 53 patients with OSAHS examined via FNMM and DISE revealed a statistically significant difference in the diagnostic incidence of severe retrolingual collapse diagnosed between the 2 methods. Specifically, FNMM did not confirm the presence of severe retrolingual collapse that was seen in 57.8% of patients with severe collapse identified with DISE. Patients were more than twice as likely to demonstrate severe retrolingual collapse on DISE as they were during FNMM. The tendency for FNMM to differ from DISE in demonstrating the presence of severe retrolingual collapse appeared to be dependent on the relative tongue size identified on standard physical examination (ie, Friedman tongue position) but independent of tonsillar size. Individuals with smaller tongue sizes (Friedman I and II) were more likely to show a much lesser degree of retrolingual collapse on FNMM compared with DISE than individuals with larger tongue sizes (Friedman III and IV) (Figure 2). In fact, individuals with Friedman IV tongue size displayed no statistically significant difference in the incidence of severe retrolingual collapse on FNMM vs DISE. Furthermore, DISE demonstrated the presence of severe retrolingual collapse in greater than 80% of patients regardless of their tongue size. Altogether, these findings agree with prior studies²² and suggest that the severity of retrolingual upper airway collapse does not necessarily correlate with tongue size but preferentially upon the extent of pharyngeal and extrinsic lingual muscular relaxation that leads to dynamic fluctuations in airway size during sleep. Such decreases in pharyngeal and extrinsic lingual muscular tone have been well documented to occur to a greater extent during sleep in individuals with OSAHS compared with healthy subjects but are also affected by the use of sedatives.^{15-17,23,24}

The overall Friedman staging system was employed as a comparative standard measure of the likelihood of the presence of significant retrolingual collapse. The Friedman staging system classifies patients into stage I (mostly retropalatal obstruction highly amenable to UPPP), stage II (multilevel obstruction, variably responsive to UPPP), and stage III (large tongue base, not responsive to UPPP). Individuals belonging to Friedman stage II and III categories are classically insufficiently responsive to UPPP because of the presence of extra-palatal collapse and would thus be expected to display a greater incidence of retrolingual obstruction on endoscopy compared with stage I patients. In this study, individuals belonging to Friedman stages II and III demonstrated a much higher incidence of retrolingual collapse on DISE than on FNMM (84.9% vs 35.8%, respectively). The DISE findings therefore show greater correlation with Friedman staging than FNMM. This finding reinforces previous studies demonstrating improved success rate of UPPP when DISE is employed as part of the preoperative airway evaluation. Hessel and de Vries²⁵ demonstrated

a success rate of 81% after UPPP when using DISE for preoperative planning, which sharply contrasts with a predictive rate of success of 33% following UPPP in individuals evaluated via FNMM.⁶

Nevertheless, the possibility of overestimating the degree of retrolingual collapse occurring with DISE as a theoretical contributor to such a large diagnostic difference between the 2 techniques is still possible. Although the use of sedatives is a known contributor to enhanced airway muscle relaxation and increased severity of collapse, the use of sedating medications, such as propofol, has not been found to significantly alter the AHI.¹⁰ However, the lack of an impact on AHI does not equate with a lack of an impact on the severity of visible airway collapse, and the possibility of airway collapse exaggeration still exists.

In the present study, several intrinsic weaknesses are identified by the authors, such as a limited patient sample size, the lack of an objective quantitative airway evaluation during endoscopy, and the lack of a supine FNMM evaluation with quantification of effort-related airway pressure measurements during Müller's maneuver. Although a low-powered study, and therefore unable to determine the existence of a statistically significant difference in the incidence of retropalatal collapse between DISE and FNMM, this study does demonstrate a significant difference between the 2 techniques in their tendency to diagnose the presence of retrolingual collapse. This finding is important within the field of sleep medicine because the precise localization of the site of airway obstruction, including the retrolingual region, is essential in the proper selection of surgical procedures to achieve the most optimal outcome.^{2,26} Second, although quantitative in nature, the DISE evaluation technique has been shown to have good interuser and test-retest reliability and therefore is similar to FNMM.^{13,14} Finally, in this study, the awake endoscopic airway evaluation via FNMM was carried out in a sitting position. Although it can be argued that patient position (supine vs upright) can affect the degree of retrolingual collapse identified during FNMM, this has not been shown to be the case. Ritter et al²⁷ demonstrated that patient positioning during FNMM did not significantly affect airway dimensions in their review of 18 diagnostic endoscopies but that patient effort significantly affected the severity of collapse. In the present study, although no pressure measurements were obtained during FNMM, all patients attempted maximal inspiration during examination.

This study demonstrates the existence of a significant discrepancy in the incidence of severe retrolingual airway collapse in patients with OSAHS evaluated with FNMM and DISE. Although both procedures show similar findings regarding the incidence of retropalatal obstruction, DISE demonstrates a much greater incidence of severe retrolingual collapse compared with FNMM. This difference is possibly due to the presence of additional relaxation of the lingual musculature during sleep but also may result, in part, from the use of sedating agents. Neither endoscopic technique is currently established as a gold standard in the evaluation of the apneic airway, nor do the findings in this study provide evidence of a clear diagnostic superiority of one technique vs the other. Further investigation into which procedure provides the most predictive representation of airway collapse occurring during natural sleep is necessary before such conclusions can be drawn. Such study will benefit from a prospective design with an enhanced sample size as well as simultaneous airway pressure recordings during FNMM and DISE. The establishment of more specific pre-and postoperative parameter correlates associated with severe apnea for each of the 2 techniques will be critical to the standardization of endoscopic findings during preoperative airway endoscopy in the future. Until then, the elaboration of surgical recommendations in the treatment of OSAHS, as well as the comparative reviewing of postsurgical results, especially when using different preoperative diagnostic techniques, must be approached with caution.

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Figure 1.

An example of the endoscopic disparity in apparent degree of severity of retrolingual collapse occurring during inspiration on FNMM (MM-A through MM-D) and DISE (DISE-A through DISE-D) same patient. MM-A and DISE-A = beginning inspiration; MM-D and DISE-D = end inspiration. DISE, drug-induced sleep endoscopy; FNMM, fiber-optic nasal endoscopy with Müller's maneuver.

Figure 2.

Incidence of severe retrolingual collapse diagnosed via fiber-optic nasal endoscopy with Müller's maneuver (FNMM) or drug-induced sleep endoscopy (DISE) according to tongue size (Friedman tongue position). *Fisher's exact test.

Figure 3.

Incidence of severe retrolingual collapse diagnosed via fiber-optic nasal endoscopy with Müller's maneuver (FNMM) or drug-induced sleep endoscopy (DISE) according to tonsillar grade. *Fisher's exact test.

Table 1
Comparison of the Incidence of Severe Airway Level-Specific Collapse^a during Sleep Endoscopy vs Awake Müller's Maneuver

Airway Subsite	Diagnostic Technique, No. (%)		P Value
	FNMM	DISE	
Retropalatal	48/53 (90.6)	52/53 (98.1)	.113
Retrolingual	19/53 (35.8)	45/53 (84.9)	<.0001

Abbreviations: DISE, drug-induced sleep endoscopy; FNMM, fiber-optic nasal endoscopy with Müller's maneuver.

^a Severe collapse defined as >75% airway collapse.

Table 2
Incidence of Severe Retrolingual Pharyngeal Airway Collapse Diagnosed via FNMM vs DISE, Grouped by Friedman Stage

Friedman Stage	Number of Patients	Incidence of Severe Retrolingual Pharyngeal Airway Collapse, No. (%)		<i>P</i> Value
		DISE	FNMM	
I	1	1 (100.0)	0	
II	17	15 (88.2)	3 (17.6)	<.0001
III	35	29 (83.0)	16 (45.7)	.002

Abbreviations: DISE, drug-induced sleep endoscopy; FNMM, fiber-optic nasal endoscopy with Müller's maneuver.