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Evaluation of Polysomnography, Sleep Depth and Sleep Endoscopy Findings in Patients with Obstructive Sleep Apnea Syndrome

Obstrüktif Uyku Apne Sendromlu Hastalarda Polisomnografi, Uyku Derinliği ve Uyku Endoskopisi Bulgularının Değerlendirilmesi

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ABSTRACT Objective: The aim of the study was to evaluate the sleep depth of patients at the minimum oxygen saturation (minSO2) level and the level of airway obstruction during drug-induced sleep endoscopy (DISE). To also evaluate the effects of polysomnography (PSG) and DISE findings on surgical planning and patient outcome. **Material and Methods:** Analysis of patients who presented with Obstructive Sleep Apnea Syndrome between July 2017-and-December 2019 was performed in a tertiary referral hospital. With a Bispectral Index (BIS) monitoring, the sleep depth of the patients at the level of airway obstruction detected during DISE and at minimum oxygen saturation (minSO2) was recorded by Bispectral Index (BIS) monitoring. Clinical characteristics, PSG results, physical examination, and DISE findings were assessed. **Results:** Obstruction was most common in the retropalatal region in patients who underwent DISE. The BIS values during the minSO2 of all patients during DISE ranged from 41-80, with an average of 59.76±7.21. The BIS values during snoring were between 38-85, with an average of 70.94±8.00. The BIS value during obstruction ranged from 38-85, with an average of 61.58±7.00. **Conclusion:** DISE is a valuable diagnostic tool for examining the upper airway during sedation mimicking sleeping, to identify structures that contribute to airway obstruction. Our study showed that as the sleep depth of the patients changes, the level and degree of obstruction detected in DISE will change. Therefore, it is important to evaluate the patients in the sleep depth closest to physiological sleep during DISE.

Keywords: Obstructive sleep apnea syndrome; drug-induced sleep endoscopy; polysomnography

ÖZET Amaç: Çalışmanın amacı, ilaçla indüklenen uyku endoskopisi [drug-induced sleep endoscopy (DISE)] sırasında hastaların minimum oksijen satürasyon düzeyindeki ve hava yolunda obstrüksiyon saptanan seviyedeki uyku derinliğini değerlendirmektir. Polisomnografi (PSG) ve DISE bulgularının cerrahi planlama ve hastanın sonucu üzerindeki etkilerini de değerlendirmektir. **Gereç ve Yöntemler:** Temmuz 2017-Aralık 2019 arasında obstrüktif uyku apne sendromu ile başvuran hastaların analizi üçüncü basamak bir sevk hastanesinde yapıldı. Hastaların DISE sırasında hava yolunda obstrüksiyon saptanan seviyede ve minimum oksijen satürasyonu [minimum oxygen saturation (minSO2)] sırasındaki uyku derinliği Bispektral İndeks [Bispectral Index (BIS)] monitörizasyonu yapılarak kaydedildi. Hastaların klinik özellikleri, PSG sonuçları, fizik muayene bulguları ve DISE bulguları değerlendirildi. **Bulgular:** DISE sırasında hastalarda en çok saptanan obstrüksiyon seviyesi, retropalatal bölge olarak izlendi. DISE sırasında hastaların minimum oksijen satürasyon seviyesindeki BIS değerleri, ortalama 59,76±7,21 ve 41-80 arasında değiştiği izlendi. Horlama sırasındaki BIS değerleri 38-85 arasında değişmekte ve ortalama 70,94±8,00 idi. Obstrüksiyon sırasında BIS değerleri 38-85 arasında değişmekte olup ortalama 61,58±7,00 idi. **Sonuç:** DISE, uykuyu taklit eden sedasyon sırasında üst solunum yolunu muayene etmeyi sağlayan ve hava yolu obstrüksiyonu izlenen seviyeyi saptamaya yarayan bir tanı yöntemidir. Çalışmamız hastaların uyku derinliği değiştikçe DISE'de saptanan obstrüksiyon düzeyi ve derecesinin değişeceğini göstermiştir. Bu nedenle DISE sırasında fizyolojik uykuya en yakın uyku derinliğinde değerlendirilmesi önemlidir.

Anahtar Kelimeler: Obstrüktif uyku apne sendromu; ilaçla indüklenen uyku endoskopisi; polisomnografi

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Obstructive sleep apnea syndrome (OSAS) is a disease characterized by repeated episodes of upper airway obstruction during sleep.[1] Polysomnography (PSG) is the gold standard diagnostic test for OSAS.[2] DISE is a diagnostic method that contributes to identifying structures causing airway obstruction.[3] During DISE, cardiac rhythm, blood pressure, and SO2 are monitored and the patients can be sedated with several drugs (midazolam (Roche, Switzerland) and propofol (AstraZeneca, United). To control the depth and stability of sedation can be evaluated with bispectral index systems (BIS).[4] The BIS translates a patient's' electroencephalogram (EEG) signals into scaled numbers from 0 (EEG silence) to 100 (fully awake) to reflect the levels of consciousness and sedation depth.[5] The BIS can be used in cases where there are individual differences in the depth of sedation.[6]

Sleep depth affects the level and degree of obstruction in the upper airway of the patients. Therefore, in our study, we aimed to determine the sleep depth intervals in which DISE should be performed by evaluating the sleep depth of the patients at the minimum SO2 (minSO2) level and the level of airway obstruction during DISE. Furthermore, we assessed effects of polysomnography and DISE findings on surgical planning and patient's outcome.

MATERIAL AND METHODS

STUDY DESIGN

The analysis of patients who presented with OSAS between July 2017-December 2019 was carried out in a tertiary referral hospital. Clinical characteristics, PSG results, physical examination, and DISE findings were assessed. In the physical examination, the Muller maneuver findings and configuration at the level of obstruction were evaluated as annular, anterior-posterior, and lateral. DISE was performed on the patients before surgery. The DISE results were evaluated according to the velopharynx, oropharynx, tongue base and epiglottis (assessment of VOTE) classification.[7] With BIS monitoring, the sleep depth of the patients at the time of minSO2 during DISE and PSG was measured. These data about the patients with OSAS are recorded in the patient's files in our clinic, and this study was conducted retrospectively by scanning the files.

PARTICIPANTS AND ELIGIBILITY CRITERIA

The study comprised 100 patients who were over 18 years of age and had undergone surgery for OSAS. Patients with incomplete or inaccessible medical records were excluded.

POLYSOMNOGRAPHY

All patients underwent 1-night polysomnographic evaluations in the same settings before and after surgery (with SOMNOlab 2, Wienmann Henstedt-Ulzburg, Germany). EEG, submental and bilateral anterior tibial electromyogram, electrooculogram, nasal flow, thoracic and abdominal respiratory effort, SO2 with pulse oximetry, and body position were recorded during PSG.

DRUG-INDUCED SLEEP ENDOSCOPY

DISE was routinely conducted on each patient in the supine position within an operating room, under the supervision of an experienced ear, nose, and throat specialist. The procedure involved the continuous monitoring of electrocardiography and pulse oximetry. Sleep induction was achieved through the gradual intravenous administration of small propofol boluses, starting with 0.01 mg/kg. Additional propofol was administered at 5- to10-minute intervals until the patient reached a sufficient level of deep sleep, as determined by BIS monitoring. The patients were evaluated in the supine position and were examined with flexible endoscopy in the desired sedation range. VOTE classification was assessed.

STATISTICALLY ANALYSES

The statistical analyses were performed with IBM SPSS software for Mac version 23.0 (IBM SPSS Corp.; Armonk, NY, USA). Chi-square test (Pearson and Fisher's exact test) was used to compare categorical variables. The conformity of the continuous variables to the normal distribution was evaluated with the Shapiro-Wilk and Kolmogorov test, and the Mann-Whitney U and Kruskal-Wallis test were applied to compare the numerical data that did not conform to the normal distribution. Pairwise comparisons were made with the Mann-Whitney U test, and the significance was

checked according to the new p value depending on the number groups with the Benferroni correction.[8] The comparison of the variables with normal distribution was evaluated with one-way analysis of variance and t-test. To test the agreement between the continuous variables, Pearson or Spearmen correlation analysis was performed after their conformity to the normal distribution was evaluated. According to Cohen's classification, "0.10-0.29=low, 0.30-0.49=moderate and 0.50-1.0=high" correlation; According to Büyüköztürk's classification, "0.0-0.29=low, 0.30-0.69=moderate, 0.70-1.00=high" correlation.[9,10]

ETHICS COMMITTEE APPROVAL

Ethics committee approval was received for this study from the Institutional Review Board of Ankara University School of Medicine (date: May 13, 2019; no: 09-694-19). The authors have obtained all appropriate patient consent forms. Our study was conducted in accordance with the principles of the declaration of Helsinki.

RESULTS

The study comprised 100 participants, consisting of 73 men (73%) and 27 women (27%). Patient ages ranged from 25-71 years, with an average age of 47,65 years. Body mass index (BMI) values ranged from 19.95-39.84, with a mean of 29.68. Among the participants, 43% were classified as overweight (25≤BMI<30), 28% as 1st-degree obese (30≤BMI<34.99), 16% as second-degree obese (35≤BMI<40), and 13% as having a normal BMI (BMI<25) (Table 1). When assessing patient complaints, the most common issue was "snoring and apnea together" (36.0%), followed by "snoring"'' (23%), "nasal congestion and snoring", (19%) and "nasal congestion, snoring, and apnea" (19%). During the Muller maneuver, the most prevalent obstruction configurations were annular (63.0%), lateral (25.0%), and anterior-posterior (12.0%). Obstruction levels and grades during DISE were evaluated using the VOTE classification system, focusing on the velopharynx, oropharynx, tongue base, and epiglottis. Velum obstruction was most commonly grade 2 (42%) in the anterior-posterior direction. Oropharynx obstruction was observed in 25% of the participants, predominantly grade 2 (15.0%) and grade 1 (10.0%) in the lateral sites.

TABLE 1: Demographic characteristics of the patients

	Minimum-maximum	X̄±SD
Age	**n**	**%**
Female	34-71	52.74±9.60
Male	25-70	45.77±10.56
Total	25-71	47.65±10.72
Gender	**n**	**%**
Female	27	27
Male	73	73
Total	100	100
	Minimum-maximum	**X̄±SD**
Weight (kg)	55-135	87.40±14.31
Height (cm)	150-195	171.37±9.74
BMI	19.95-39.84	29.68±4.45
AHI	0.90-91.50	25.61±19.91

SD: Standard deviation; BMI: Body mass index; AHI: Apnea-Hypopnea Index

TABLE 2: Evaluation of the level and degrees of obstruction detected during DISE

Velum	**n**	**%**
No obstruction	12	12.0
Anterior posterior grade 1	14	14.0
Anterior posterior grade 2	14	14.0
Anterior posterior grade 3	42	42.0
Lateral grade 2	5	5.0
Annular grade 2	5	5.0
Annular grade 3	8	8.0
Oropharynx	**n**	**%**
No obstruction	75	75.0
Lateral grade 1	4	4.0
Lateral grade 2	10	10.0
Lateral grade 3	11	11.0
Larynx	**n**	**%**
No obstruction	88	88.0
Obstruction	12	12.0
Tongue root	n	%
No obstruction	79	79.0
Obstruction	21	21.0

Epiglottis obstruction was detected in 12% of the patients (Table 2). Although 41% exhibited tongue base hypertrophy, only 21% experienced obstruction at this level. Additionally, 15% of the patients exhibited mandibular posterior movement, causing upper airway obstruction in the supine position.

In the patients with simple snoring, the mean BIS value at the time of obstruction was 60.89, and

the standard deviation was 4.98. In the patients with mild OSAS, the mean BIS value at the time of obstruction was 61.35, and the standard deviation was 6.12. In the patients with moderate OSAS, the mean BIS value at the time of obstruction was 62.20, and the standard deviation was 7.06. In the patients with severe OSAS, the mean BIS value at the time of obstruction was 61.15, and the standard deviation was 9.00. There was no statistically significant difference between the Apnea-Hypopnea Index (AHI) of all patients and BIS values at the time of obstruction compared to the groups ($p>0.05$) (Table 3).

The minSO2 values during DISE ranged from 65-92 for the female participants (average 84.48±5.82) and from 58-93 for the male participants (average 80.47±9.44). BIS values during minSO2 for females ranged from 41-80 (average 61.81±7.56), during snoring from 60-82 (average 70.89±6.12), and during obstruction from 41-75 (average 61.56±6.78).

TABLE 3: The BIS values detected in DISE during MinSO2, obstruction and snoring

BIS values during minimum oxygen saturation	Minimum-maximum	X̄±SD
Female	41-80	61.81±7.56
Male	42-75	59.00 ±6.97
Total	41-80	59.76±7.21
BIS values during snoring	**Minimum-maximum**	**X̄±SD**
Female	60-82	70.89±6.12
Male	38-85	70.96±8.63
Total	38-85	70.94±8.00
BIS values during obstruction	**Minimum-maximum**	**X̄±SD**
Female	41-75	61.56±6.78
Male	40-82	61.59±7.13
Total	40-82	61.58±7.00

SD: Standard deviation; BIS: Bispectral index systems

For males, BIS values during minSO2 ranged from 42-75 (average 59.00±6.97), during snoring from 38-85 (average 70.96±8.63), and during obstruction from 38-85 (average 61.59±7.13). When evaluating minSO2 in female participants based on AHI, there were no statistically significant differences between the groups ($p>0.05$). In contrast, among male participants, there was a statistically significant difference between the AHI groups ($p<0.05$). However, there were no significant differences in BIS values at the time of obstruction between the AHI groups ($p>0.05$) (Table 4).

During DISE in female patients, the mean±SD minSO2 value was 84.48±5.82. During DISE in male patients, the mean±SD minSO2 value was 80.47±9.44. A statistically significant difference was observed between the minSO2 values between the genders ($p<0.05$) (Figures 1, Figure 2).

DISCUSSION

When evaluating the treatment of patients with OSAS, patient preference should be combined with characteristics such as awake upper airway evaluation, BMI, AHI, and medical comorbidities. We think that the treatment of patients should be guided by combining the DISE findings with these data.

DISE is an important part of the diagnostic and therapeutic process. Croft and Pringle 1st described DISE as an outpatient technique for evaluating dynamic changes during sleep.[11] The technique was described as a personalized examination with fiberoptic endoscopy during drug-induced sleep to identify upper airway obstruction.[12] Studies suggested it may be useful in deciding for surgical treatment and in the selection of treatment.[13,14] Hewitt et al. reported that

TABLE 4: Evaluation of BIS values during MinSO2 determined in DISE according to AHI

	AHI					
	Simple snoring (AHI<5)	Mild OSAS (5≤AHI<15)	Modarate OSAS (15≤AHI<30)	Severe OSAS (AHI≥30)		
MinSO2 BIS	X̄±SD	X̄± SD	X̄± SD	X̄± SD	Total	p value
Female	65.83±2.04	60.60±5.59	66.20±9.31	55.00±9.59	61.77±8.25	0.057
Male	60.00±4.35	59.40±6.50	56.33±9.05	58.48±6.30	58.22±7.08	0.64
Total	63.89±3.98	59.70±6.16	58.80±9.89	57.70±7.10	59.25±7.56	0.19

MinSO2: Minimum oxygen saturation; AHI: Apnea-Hypopnea Index; BIS: Bispectral Index systems; SD: Standard deviation; OSAS: Obstructive sleep apnea syndrome

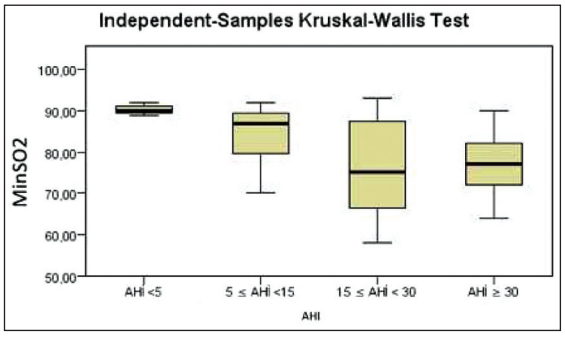

FIGURE 1: MinSO2 of male patients according to AHI
MinSO2: Minimum oxygen saturation; AHI: Apnea-Hypopnea Index

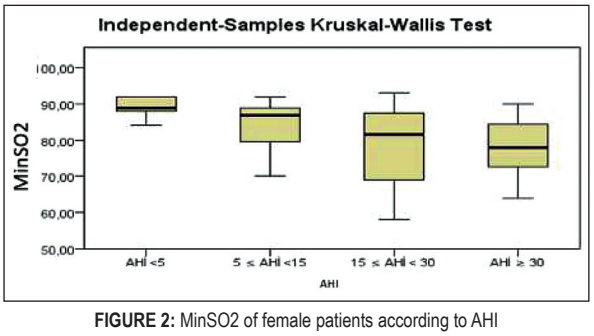

FIGURE 2: MinSO2 of female patients according to AHI
MinSO2: Minimum oxygen saturation; AHI: Apnea-Hypopnea Index

the rate of palatal intervention in patients decreased by 20% when evaluated with sleep endoscopy.[15]

Wang et al. evaluated surgical failure factors with DISE findings and found that complete circumferential collapse at the velum and complete anteroposterior collapse at the base of the tongue were associated with treatment failure.[16] Huntley et al. reported that performing DISE in the preoperative period reduces the rate of multilevel surgery and increases the rate of surgical success.[17] Due to the studies we have given as examples above, we think that DISE should be used in determining the modalities of surgical treatment and guiding the treatment. Because we use DISE in our clinic to guide the treatment of patients with simple snoring detected on PSG, we also included patients with simple snoring in our study.

The negative aspects of DISE have also been emphasized. It is an invasive procedure, and some pharmacological agents with side effects are used to put patients asleep. In addition, compared to physiological sleep, some changes are observed by drug-induced sleep. In diazepam-induced sleep, REM (Rapid Eye Movement) sleep occurs for a much shorter time than normal sleep. However, it has been reported that no difference was observed in NREM (Nonrem Rapid Eye Movement) sleep.[18] At low doses of propofol, the airway-built resistance to collapse, but a dose-proportional decrease in genioglossus muscle activity was observed after loss of consciousness. In some people, an increase in genioglossus muscle activity can be observed in conscious sedation compared with that in wakefulness.[19,20] For this reason , the fact that the effects of the drugs may differ in patients and if the drug dose is not fully adjusted, excessive muscle relaxation may lead to different upper airway muscle dynamics than normal sleep, which may lead to false positive or negative results.

In our study, patients were sedated using propofol during DISE, and propofol dose titration was performed by considering the BIS values of the patients. During the sleep endoscopy of the patients, the obstruction levels and the sleep depths at this time, as well as the minSO2 and the sleep depths at this time were also evaluated and the relationship between the OSAS degrees of the patients and these conditions were examined. When the AHI is compared with the sleep depth during the minSO2 during DISE, it is seen that as the AHI increases, the sleep depth during the minSO2 decreases in the total patient group. As the OSAS severity of the patients increased, it was observed that SO2 decreased at a more superficial sleep depth. When the AHI and the sleep depth at the level of obstruction observed during sleep endoscopy of the patients were compared, it was seen that the AHI and the sleep depth level of the patients did not change and were similar. According to the AHI, when the patients with OSAS and the patients with simple snoring were compared in the total patient group, the minSO2 was observed to be lower in the group with OSAS. However, there was no statistically difference in the total patient group. In female patients, although the minimum SO2 level was lower in the patients with OSAS compared to the patients with simple snoring, this difference was also statistically significant. In addition, when the minSO2 value was compared according to gender in our study, it was observed that the minSO2 values were lower in the male gender, and this difference was also statistically significant. When the sleep depth at the level of

obstruction was compared according to gender, it was observed that there was a similar BIS value between the genders and it was not statistically significant.

Therefore, we attach importance to the correct evaluation of the upper airway with DISE. In order to accurately determine the configuration and degree of upper airway obstruction in patients during DISE, patients should be evaluated at the appropriate depth of sleep.

CONCLUSION

Assessing the extent and nature of airway obstruction through DISE is pivotal in determining the optimal treatment approach for patients with OSAS. Our findings underscore the dynamic nature of the obstruction, which varies with changes in sleep depth. Thus, it is imperative to assess patients at sleep depths that closely approximate natural sleep during DISE. Further research involving a larger patient cohort is warranted to corroborate our results and enhance clinical insights.

Main Points:

- When directing the treatment of patients with OSAS, clinicians must combine patient preference and characteristics such as awake upper airway evaluation, BMI, AHI, and medical comorbidities.
- The treatment of patients should be guided by combining the DISE findings with the characteristics of the patients.
- DISE in the preoperative period reduces the rate of multilevel surgery and increases the rate of surgical success.
- In order to accurately determine the configuration and degree of upper airway obstruction in patients during DISE, patients should be evaluated at the appropriate depth of sleep.

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Conflict of Interest

No conflicts of interest between the authors and / or family members of the scientific and medical committee members or members of the potential conflicts of interest, counseling, expertise, working conditions, share holding and similar situations in any firm.

Authorship Contributions

Idea/Concept: *Hatice Seçil Akyıldız, Rauf Yücel Anadolu;* ***Design:*** *Hatice Seçil Akyıldız;* ***Control/Supervision:*** *Hatice Seçil Akyıldız, Rauf Yücel Anadolu;* ***Data Collection and/or Processing:*** *Hatice Seçil Akyıldız;* ***Analysis and/or Interpretation:*** *Hatice Seçil Akyıldız, Rauf Yücel Anadolu;* ***Literature Review:*** *Hatice Seçil Akyıldız;* ***Writing the Article:*** *Hatice Seçil Akyıldız;* ***Critical Review:*** *Rauf Yücel Anadolu;* ***References and Fundings:*** *Hatice Seçil Akyıldız, Rauf Yücel Anadolu;* ***Materials:*** *Rauf Yücel Anadolu.*

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