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MISCELLANEOUS

Inter-rater reliability between experienced and inexperienced otolaryngologists using Koo's drug-induced sleep endoscopy classification system

Soo Kweon Koo[1] · Sang Hoon Lee[1] · Tae Kyung Koh[1] · Young Jun Kim[1] · Ji Seung Moon[1] · Ho Byung Lee[1] · Geun Hyung Park[1]

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Abstract

Purpose An ideal, drug-induced sleep endoscopy (DISE) classification system should cover all the upper airways, be simple and practical, and quantify the severity of any obstruction. Excellent validity and reliability are essential. We explored the inter-rater reliability of Koo's DISE classification system in the hands of experienced and inexperienced otolaryngologists.

Methods We retrospectively analyzed video images of 100 patients who underwent DISE examination in our hospital between 2015 and 2018. Three experienced and three inexperienced otolaryngologists reviewed and scored all images. We calculated the inter-rater reliabilities of the two groups of otolaryngologists.

Results Independent of the extent of experience with DISE, detection of retropalatal obstructions (overall agreement: 0.87; kappa value: 0.60), and the degree of such obstructions (overall agreement: 0.67; kappa value: 0.52) were more consistent than were the detection of retrolingual obstructions (overall agreement: 0.61, kappa value: 0.37) and the degree of retrolingual obstructions (overall agreement: 0.20, kappa value: 0.35). Inexperienced observers were in good agreement for palatal obstructions and experienced observers were in good agreement for tongue-base obstructions. All of the otolaryngologists found it difficult to detect a lateral pharyngeal wall obstruction at the retrolingual level.

Conclusion Koo's DISE classification system focuses on surgical treatment, especially by otolaryngologists, and the degree of agreement between the experienced and inexperienced observers was relatively high. The participants' level of experience had a strong impact on scoring. The less-experienced otolaryngologists tended to overlook tongue-base obstructions, focusing instead on relatively simple retropalatal obstructions. In the future, development of a DISE classification system that can be accepted globally will be necessary.

Keywords Drug-induced sleep endoscopy · Sleep apnea, obstructive · Observer variation · Reliability

Introduction

In the treatment of snoring and obstructive sleep apnea (OSA), the primary goal of surgical evaluation is to determine the type and degree of obstruction of the upper airway [1]. Many upper airway anatomic assessments are performed in a static and awake state, often failing to reflect the dynamic upper airway during sleep [2]. Drug-induced sleep endoscopy (DISE), proposed by Pringle and Croft, assesses the pattern and severity of upper airway obstruction during drug-induced sleep, and determines the optimal surgical treatment for adults and children with OSA [3]. DISE requires a scoring system to evaluate the results. The initial scoring system was a simple one that assessed obstructions only at the velopharyngeal and oropharyngeal levels [4]. Although several subsequent studies have proposed various scoring systems, there is no comprehensive and accurate classification that reflects the endoscopic findings of OSA patients. Ideally, a DISE scoring system should cover all of the upper airway, be simple and practical, and provide a means of quantifying the severity of an obstruction. Based on such a system, a physician should also be able to establish clinical diagnoses and standardized therapies [5]. Kezirian

✉ Soo Kweon Koo
koosookweon@naver.com

[1] Department Otorhinolaryngology-Head and Neck Surgery, Busan Saint Mary's Hospital, 538-41 Yongho-dong, Nam-gu, Busan, South Korea

proposed VOTE classification, a scoring system focused on specific structures that contribute to obstruction. VOTE classification is widely employed because it is easy to use and can demonstrate the degree and pattern of upper airway obstruction relatively well [1, 6]. However, surgical treatment of OSA is site-specific, and includes tonsillectomy, uvulopalatopharyngoplasty (UPPP), lateral pharyngoplasty, and other techniques. It is difficult to plan the surgical procedure using only the VOTE classification system, because it oversimplifies the upper airway structure, particularly the lateral pharyngeal wall. In fact, in the VOTE classification, the oropharyngeal lateral wall includes the palatine tonsil and pharyngeal sidewall tissue, and it is difficult to determine their relative roles [1]. Fujita et al. functionally divided the upper airway into two parts, which is not an official anatomic classification, but is meaningful in terms of function and surgical treatment [7]. We created Koo's DISE classification system based on Fujita's scoring system as the mainstay of surgical treatment of OSA patients and have published several related papers [4, 5, 8–11]. The validity and reliability of a scoring system are very important, and although some studies have been published on our (Koo's) DISE classification system, much more research is needed. Indeed, the proposed DISE classification systems to date, including ours, are subjective to a degree and may vary depending on clinical experience [2, 12]. To determine differences in inter-observer agreement caused by differences in ear, nose, and throat (ENT) surgeons' experience, Vroegop et al. compared the inter-observer agreement in seven experienced-ENT-surgeon groups and 90 inexperienced-ENT-surgeon groups using six DISE video images [13]. Inter-observer agreement was higher among the experienced-ENT surgeons than in the inexperienced group. Vroegop's study was meaningful in that it evaluated the degree of agreement among many participants, but only six DISE video images were used, which lacked various relevant scenarios. To determine inter-observer agreement, it is important to judge the degree of agreement in a variety of cases. Therefore, we used 100 DISE video images to investigate the degree of inter-rater agreement among experienced and inexperienced otolaryngologists when using our DISE classification system. We focused on how experience affected the detection of obstruction and assessment of the degree of obstruction at specific sites in OSA patients.

Materials and methods

Patient selection and scoring for DISE

We retrospectively analyzed the video images of 100 patients who underwent DISE examination at our hospital between 2015 and 2018. All patients had thorough ENT examinations and had their medical history recorded prior to DISE, and adult male OSA patients over 18 years of age with an apnea–hypopnea index (AHI) > 5 per hour during full-night polysomnography (WEE-1000K; Nihon Kohden, Japan) were selected for this study. Patients who had undergone surgery on the soft palate or tongue before the DISE procedure were excluded [5]. In addition, patients who were ASA class 4, allergic to midazolam or other DISE drugs, or morbidly obese were excluded because of safety concerns regarding DISE [2]. The six observers who participated in this study were all otolaryngologists; three were faculty members with experience in DISE and three were residents who were relatively inexperienced in the DISE procedure. Scoring was performed using our DISE classification system, and the results were analyzed statistically (Table 1) [5]. The study was approved by the institutional review board of our hospital (approval no. BSM-2018-13), and we obtained written informed consent from all participants.

DISE procedure

All DISE procedures were performed by the same otolaryngologist in a quiet semi-dark operating theater with the patient in the supine position. Sleep was induced by intravenous administration of midazolam with respiratory monitoring and with the help of an anesthesiologist. The drug was slowly titrated to 0.07 mg/kg per patient. A 1–2.5-mg bolus of midazolam (up to 7.5 mg per patient) was provided using a target-controlled infusion system. Extremely stressed patients often needed additional injections. Once a patient was snoring and sleep had been induced to a degree that still allowed the patient to respond slowly-to-mild auditory or auditory stimuli (Ramsay's degree of sedation of 5), a flexible video laryngoscope 4 mm in diameter was gently

Table 1 Classification of DISE findings

Level	Degree of obstruction[a]	Configuration[b]		
		AP diameter	Lateral diameter	Contributing structure
Retropalatal	0/1/2	Palate	LPW	Tonsil
		±	±	±
Retrolingual	0/1/2	Tongue base	LPW	Epiglottis
		±	±	±

DISE: Drug-induced sleep endoscopy, AP: antero-posterior, LPW: lateral pharyngeal wall

[a]One number for each structure: 0 = no obstruction (no vibration), 1 = partial obstruction (vibration, 50–75%), and 2 = complete obstruction (collapse > 75%)

[b]Dichotomous configuration noted for structures with a degree of obstruction greater than 0

inserted through the nose to observe obstruction of the upper airway [14].

Classification system

Based on Fujita's scoring system, we divided the upper airway into two parts: the retropalatal level (the region from the posterior to the soft palate) and the retrolingual level (the region from the posterior pharynx to the vertical portion of the tongue) [7]. To aid surgical treatment, our DISE classification system is designed to show the site of an obstruction, the degree of obstruction, and the anatomic structures that have the greatest impact on the obstruction. The retropalatal level is subdivided into the palate (antero-posterior diameter), lateral pharyngeal wall (lateral diameter), and tonsil. The retrolingual level is divided into the tongue base (antero-posterior diameter), the lateral pharyngeal wall (lateral diameter), and the epiglottis. The degree of airway obstruction is categorized as no obstruction (0), partial obstruction (1, 50–75%), or complete obstruction (2, > 75%) (Table 1) [4, 5].

Statistical analyses

We conducted statistical analyses using the "irr" package of the R version 3.4.3 (R Foundation for Statistical Computing, Vienna, Austria), and the confidence interval was estimated using the bootstrap method. Overall agreement (OA) among the raters was calculated to determine the percentage of identical ratings among the raters. The Fleiss kappa value (κ value) was also used to assess the inter-rater reliability of the six raters. The κ value was interpreted as proposed by Landis and Koch [15].

Results

In total, 100 subjects were enrolled in the study and underwent DISE examination. All subjects were male (42.2 ± 15.6 years), their mean BMI was 26.6 ± 3.7 kg/m^2, their mean AHI was 33.8 ± 25.1, and their mean score on the Epworth Sleepiness Scale was 9.9 ± 5.6 .

DISE examination scores of all observers, regardless of experience (Table 2)

Detection of obstruction sites

Detection of an obstruction site, OA, and kappa values were higher at the retropalatal level than at the retrolingual level (OA: 0.87, κ value: 0.60 vs. OA: 0.61, κ value: 0.37).

Scoring of degree of obstruction

OA and kappa values were higher at the retropalatal level than at the retrolingual level (OA: 0.67, κ value: 0.52 vs. OA: 0.20, κ value: 0.35).

Detection of obstruction by specific anatomic structures

OA and kappa values at the retropalatal level were 0.13 and 0.39, respectively. Among the subdivisions of the retropalatal level, the palate showed the highest OA and kappa values, followed by the tonsil and lateral pharyngeal wall. The values were lower at the retrolingual than at the retropalatal level. The OA and kappa values of the epiglottis were higher than those of the tongue and lateral pharyngeal wall.

Comparison of the inter-rater reliability of DISE scoring in the experienced and inexperienced groups (Fig. 1)

Detection of obstruction sites

In the experienced group, OA was higher at the retropalatal level than at the retrolingual level (OA: 0.90 and 0.76, respectively), but kappa values showed a fair degree of agreement between the two levels (0.46 and 0.46, respectively). In the inexperienced group, the mean kappa value was higher at the retropalatal level than at the retrolingual level (OA: 0.93, κ value: 0.66 vs. OA: 0.73, κ value: 0.29).

Scoring of degree of obstruction

In the experienced group, OA was higher at the retropalatal level than at the retrolingual level (OA: 0.75 and 0.51, respectively), and the kappa values of the two levels showed fair agreement (0.41 and 0.44, respectively). In the inexperienced group, both values were higher at the retropalatal level than at the retrolingual level (OA: 0.82, κ value: 0.58 vs. OA: 0.37, κ value: 0.28).

Detection of obstruction by specific anatomic structures

In the experienced group, OA and kappa values were higher at the retropalatal level than at the retrolingual level. The highest values were for the palate, followed by the epiglottis and tonsil, and the lowest were for the lateral pharyngeal wall at the retrolingual level. In the inexperienced group, both values were higher at the retropalatal level than at the retrolingual level. Values were highest for the palate, followed by the tonsil and epiglottis, and the lowest value was that for the lateral pharyngeal wall at the retrolingual level.

Table 2 Summary of DISE examination scores of all observers, regardless of experience

	Experienced group			Inexperienced group			κ value (95% C.I.)	OA(95% C.I.)
	Rev. 1 ($n=100$)	Rev. 2 ($n=100$)	Rev. 3 ($n=100$)	Rev. 4 ($n=100$)	Rev. 5 ($n=100$)	Rev. 6 ($n=100$)		
Presence of obstruction								
Retropalatal level	96	93	91	96	92	90	0.60 (0.42–0.71)	0.87 (0.80–0.93)
Retrolingual level	82	97	79	92	89	74	0.37 (0.22–0.55)	0.61 (0.51–0.70)
Degree of obstruction								
Retropalatal level							0.52 (0.40–0.59)	0.67 (0.57–0.75)
Grade 0	4	7	9	4	8	10		
Grade 1	10	13	9	15	8	7		
Grade 2	86	80	82	81	84	83		
Retrolingual level							0.35 (0.27–0.42)	0.20 (0.12–0.28)
Grade 0	18	13	21	8	11	26		
Grade 1	34	34	25	48	39	23		
Grade 2	48	53	54	44	50	51		
Configuration of obstruction								
Retropalatal level							0.39 (0.32–0.44)	0.13 (0.07–0.20)
Palate	88	88	84	87	88	76	0.55 (0.39–0.66)	0.71 (0.61–0.80)
LPW	29	36	37	39	39	52	0.48 (0.35–0.60)	0.44 (0.34–0.53)
Tonsil	24	22	16	21	39	27	0.48 (0.38–0.57)	0.55 (0.45–0.65)
Retrolingual level							0.25 (0.20–0.30)	0.05 (0.01–0.09)
Tongue	53	65	46	69	65	58	0.33 (0.24–0.41)	0.28 (0.20–0.36)
LPW	62	47	29	57	68	20	0.27 (0.19–0.36)	0.22 (0.15–0.30)
Epiglottis	35	42	42	42	50	46	0.62 (0.52–0.70)	0.57 (0.47–0.66)

DISE drug-induced sleep endoscopy, *κ value* kappa value, *OA* overall agreement, *LPW* lateral pharyngeal wall, *95% CI* 95% confidence interval

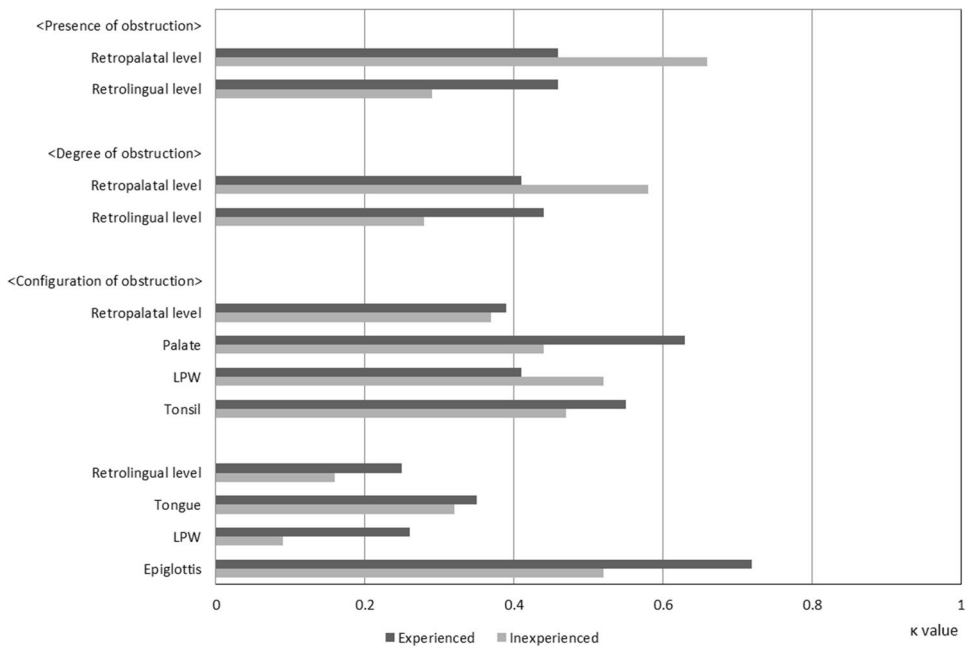

Fig. 1 Comparison of kappa values between the experienced and inexperienced groups

Statistically, there was a high tendency toward inter-rater reliability for the detection of an obstruction site and scoring of the degree of obstruction at the retropalatal level in the inexperienced group, but there were no significant differences between the two groups. The degree of inter-rater reliability was higher in the experienced group than in the

inexperienced group for detection of obstruction, degree of obstruction, and detection of specific anatomic structures causing obstruction in the evaluation at the retrolingual level.

Discussion

Scoring differences among observers is closely related to the reliability and accuracy of a scoring system. Ideally, a scoring system that can produce the same results, regardless of experience, is more attractive.

In this study, there was a low incidence of agreement between the inexperienced and experienced groups in the detection of retrolingual obstruction sites and scoring of their degree of obstruction, especially in obstruction of the lateral pharyngeal wall at the retrolingual level, implying that lateral pharyngeal wall obstruction at the retrolingual level is unfamiliar and technically difficult to observe. It is difficult to advance an endoscope to the hypopharynx during the DISE procedure, and if the obstruction is severe, observation may be interrupted by obstruction of the nasopharynx or tongue root. In our study, as in other studies, OA and inter-rater reliability were higher at the retropalatal level than at the retrolingual level among both experienced and inexperienced observers.

As regards detection of obstruction sites, the results of this study were similar to those of other studies. Rodriguez-Bruno et al. reported good agreement between observers who evaluated tonsillar and epiglottal obstructions [12]. Similarly, we found that the extent of inter-rater agreement was higher for such obstructions than for other obstructions (except palatal obstructions) among both experienced and inexperienced otolaryngologists.

The palate is the most common obstruction site in patients who snore. In one study, less-experienced observers reported more obstruction sites to be a single obstruction site. This means that the less-experienced observers are, the more likely they are to focus on a particular site [2]. In our study, when judging the site and degree of obstruction at the retropalatal and retrolingual levels, the experienced group produced almost identical results, whereas the inexperienced group focused exclusively on obstruction at the retropalatal level (Fig. 1). This indicates that inexperienced observers tend to overlook tongue-base obstruction, with a focus instead on palatal-level obstruction.

To sum up, inexperienced observers showed a high degree of agreement for palatal-level obstruction, whereas experienced observers showed a higher degree of agreement for obstruction of the tongue base. Considering these results, inexperienced observers seem to focus on palatal-level obstruction, overlooking tongue-base obstruction. To date, many scoring systems have been proposed for DISE [4]. The ideal scoring system should include all anatomic sites considered contributors to upper airway obstruction and should also provide a way to quantify the degree of obstruction. It should also have a high degree of inter-rater reliability, and be simple and practical [16, 17]. In addition, a scoring system should allow results to be comparable between centers, so that standardized treatments can be established. In 1991, when Pringle and Croft first introduced DISE, UPPP was the most common surgical treatment for adult OSA patients, so their scoring system was suitable for the success of that operation [3, 18]. In fact, most studies conducted before 2007 were primarily based on this scoring system. Pringle and Croft classified obstruction sites into five grades (grade 1 = simple palatal-level snoring; grade 2 = single palatal-level obstruction; grade 3 = palatal level obstruction with intermittent orohyphopharyngeal involvement; grade 4 = sustained multi-segment involvement; grade 5 = tongue-base-level obstruction) [3]. This grading system helped surgeons to determine which patients were most suited for the most commonly used UPPP at the time, and therefore, they thought they could avoid unnecessary surgery and make more logical decisions about appropriate treatment methods. Since then, however, many additional surgical treatments have been developed, and various scoring systems have been developed [4]. In the case of palatal obstruction at the retropalatal level, palatal surgery such as UPPP, uvulopalatal flap (UPF), limited palatal muscle resection (LPMR), etc., may be considered, and lateral pharyngoplasty, expansion sphincter palatoplasty, etc., may be considered when lateral pharyngeal wall obstruction is present [19–22]. Tonsillectomy can also be performed if the upper airway obstruction is caused by enlargement of the tonsils, which is the mainstay treatment in pediatric OSA. When tongue-base obstruction is observed at the retrolingual level, tongue-base surgery such as tongue-base reduction or lingual tonsillectomy is performed to widen the airway by reducing the size of the anatomic region, or hypopharyngeal surgery such as genioglossus advancement, hyoid myotomy, or hyoid suspension to indirectly move the tongue forward or, recently, hypoglossal nerve stimulation has been performed [19, 23–26]. OSA is also often the result of multilevel obstruction of the upper airway, and thus, multilevel treatment of all obstruction sites may lead to better surgical outcomes. Therefore, an ideal DISE scoring system should be able to demonstrate all obstruction sites and degrees of obstruction and, thus, be suitable for establishing an appropriate surgical plan [27]. Furthermore, there should be a high degree of reliability among observers and it should be standardized globally.

Of the scoring systems proposed to date, the VOTE classification (38.6%), Pringle and Croft (15.9%), NOHL (9.1%), and Bachar (4.5%) systems are widely used [4]. Among them, the VOTE system is the most common, and it is fairly

comprehensive and easy to use. However, the oropharyngeal lateral wall assessment included in that system tends to be too simple and does not actually include the tonsil, which is important for surgical treatment, and there is no standard for laryngeal obstruction [15, 28]. In other words, an anatomical-region-based approach cannot adequately indicate the surgical procedures required. Therefore, a new scoring system should include specific anatomical structures involved in obstruction (tonsils, palate, epiglottis, and so forth) [1]. Indeed, for many years, surgery in patients with OSA has been classified using the Fujita classification system, which includes the palatal/velopharyngeal and hypopharyngeal/retroglossal/retrolingual regions, two major areas of upper airway obstruction [7]. Hence, for our DISE classification system, we divided the pharynx into two parts (the retropalatal and retrolingual levels) based on Fujita's system and included the various sites and degree of obstruction, together with the anatomic structures that most often contribute to obstruction. The retropalatal levels were subdivided into the palate (lateral diameter), lateral pharyngeal wall (lateral diameter), and tonsil (specific structure that contributes to obstruction). The retrolingual levels were divided into tongue base (posterior diameter), lateral pharyngeal wall (lateral diameter), and epiglottis (specific structure that contributes to obstruction) [5].

This study focused on how experience affects the detection of obstruction sites when using a specific DISE classification system (Koo's). However, a major limitation of our study is that it was retrospective and used a DISE classification system designed previously. New treatment modalities such as hypoglossal nerve stimulation, etc., new surgical techniques, and newly emerging specific obstruction sites such as lingual tonsil were not considered. Hypoglossal nerve stimulation is a new therapeutic modality for OSA patients, in which it is important to avoid complete circumferential collapse at the retropalatal level, but this is difficult to detect by the DISE classification used in our study. In some OSA patients, obstruction by the tongue base or epiglottis is observed, which is important for surgical treatment, and some cases were detected in this study. However, agreement on some of the obstruction sites (especially at the retrolingual level) was relatively low, and recent studies have reported that the hypopharynx has a limited role in obstruction of the upper airway [6]. Therefore, the DISE classification system used in this study should be upgraded. Another limitation is that, to exclude the possibility of sex-based bias, the research population has been limited to men, so it is necessary to study sex differences.

Our classification has some disadvantages, but it also has advantages, especially for otolaryngologists and surgeons, as a classification system that focuses on surgical treatment.

Despite these limitations, our study has the strength of having used 100 DISE video images, far more than in the previous studies. The authors hope that this research will provide sufficient implications for future investigations to compare variation among observers depending on their experience. Vroegop et al. reported that the experience of the observer had a great effect on the detection of an obstruction site, as in this study [13]. To compensate for differences in experience, a standardized DISE classification system needs to be developed and education should be carried out.

Conclusion

Our DISE classification system focuses on surgical treatment, especially by otolaryngologists, and the degree of agreement between experienced and inexperienced observers was relatively high. However, there are still some disadvantages, such as limited detection of obstruction by the lateral pharyngeal wall. Therefore, our DISE classification system needs to be further developed to include new treatment methods. Observers' experience had a strong impact on scoring, with less-experienced observers tending to overlook tongue-base obstruction as a result of focusing on relatively simple retropalatal obstructions. In the future, development of a DISE classification system that can be accepted globally is needed.

Compliance with ethical standards

Conflict of interest We have no potential conflict of interest.

Research involving human participants and/or animals All procedures performed in studies involving human participants were in accordance with the ethical standards of the institutional and/or 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. The study was approved by the Institutional Review Board of Busan Saint Mary's Medical Center (Approval no. BSM-2018-13).

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