



HAL
open science

Guidelines of the French Society of ENT (SFORL): Drug-induced sleep endoscopy in adult obstructive sleep apnea syndrome

P.-L. Bastier, O. Gallet de Santerre, S. Bartier, Audrey de Jong, W. Trzepizur, K. Nouette-Gaulain, V. Bironneau, M. Blumen, F. Chabolle, G. de Bonnecaze, et al.

► To cite this version:

P.-L. Bastier, O. Gallet de Santerre, S. Bartier, Audrey de Jong, W. Trzepizur, et al.. Guidelines of the French Society of ENT (SFORL): Drug-induced sleep endoscopy in adult obstructive sleep apnea syndrome. *European Annals of Otorhinolaryngology, Head and Neck Diseases*, 2022, 10.1016/j.anorl.2022.05.003 . hal-03738587

HAL Id: hal-03738587

<https://hal.science/hal-03738587v1>

Submitted on 26 Jul 2022

HAL is a multi-disciplinary open access archive for the deposit and dissemination of scientific research documents, whether they are published or not. The documents may come from teaching and research institutions in France or abroad, or from public or private research centers.

L'archive ouverte pluridisciplinaire **HAL**, est destinée au dépôt et à la diffusion de documents scientifiques de niveau recherche, publiés ou non, émanant des établissements d'enseignement et de recherche français ou étrangers, des laboratoires publics ou privés.

Guidelines of the French Society of ENT (SFORL): Drug-induced sleep endoscopy in adult obstructive sleep apnea syndrome

P.-L. Bastier^a, O. Gallet de Santerre^b, S. Bartier^c, A. De Jong^d, W. Trzepizur^e, K. Nouette-Gaulain^f, V. Bironneau^g, M. Blumen^{h,i}, F. Chabolle^j, G. de Bonnecaze^k, X. Dufour^l, E. Ameline^m, M. Kérimianⁿ, V. Latournerie^o, P.-J. Monteyrol^p, A. Thiery^o, S. Tronche^q, S. Vergez^k, E. Bequignon^{o,*}

^a Pôle Tête et Cou, Maison de Santé Protestante de Bordeaux-Bagatelle, 203, route de Toulouse, 33401 Talence, France

^b Clinique Beausoleil, 119, avenue de Lodeve, 34070 Montpellier, France

^c Service d'ORL et de Chirurgie Cervico-Faciale, Hôpital Henri-Mondor, 1, rue Gustave-Eiffel, 94000 Créteil, France

^d Département d'Anesthésie-Réanimation Saint-Éloi, Hôpital Saint-Éloi, 80, avenue Augustin-Fliche, 34090 Montpellier, France

^e Département de Pneumologie et de Médecine du Sommeil, CHU d'Angers, 4, rue Larrey, 49100 Angers, France

^f Service d'Anesthésie-Réanimation, Hôpital Pellegrin, CHU Bordeaux, place Amélie-Raba-Léon, 33700 Bordeaux, France

^g Service de Pneumologie, CHU de Poitiers, 2, rue de la Milétrie, 86021 Poitiers, France

^h Centre Médical Veille Sommeil, 59, avenue de Villiers, 75017 Paris, France

ⁱ Service d'ORL, Hôpital Foch, 40, rue Worth, 92140 Suresnes, France

^j Cabinet d'ORL, 20, rue Parmentier, 92200 Neuilly-sur-Seine, France

^k Service d'ORL et Chirurgie Cervico-Faciale, Hôpital Larrey, 24, chemin de Pouvoirville, 31059 Toulouse, France

^l Service d'ORL et Chirurgie Cervico-faciale, CHU de Poitiers, 2, rue de la Milétrie, 86000 Poitiers, France

^m Cabinet d'ORL, 1, rue des Iris, 41260 La Chaussée-Saint-Victor, France

ⁿ Service d'ORL et de Chirurgie Cervico-Faciale, Hôpital Pellegrin, CHU Bordeaux, place Amélie-Raba-Léon, 33700 Bordeaux, France

^o Service d'ORL, Centre Hospitalier Intercommunal de Créteil, 40, avenue de Verdun, 94000 Créteil, France

^p Nouvelle Clinique Bordeaux Tondou, avenue Jean-Alfonséa, 33270 Floirac, France

^q SFORL, 26, rue Lalo, 75016 Paris, France

ARTICLE INFO

Keywords:

Obstructive sleep apnea syndrome

Drug-induced sleep endoscopy

Palatal collapse

Propofol

DISE

Mandibular Advancement Device

OSAS

Obstructive phenotypes

Airway surgery

ABSTRACT

Objectives: To determine the indications, anesthesiological and surgical procedure and interest of drug-induced sleep endoscopy in the treatment of adult obstructive sleep apnea syndrome.

Design: A redactional committee of 17 experts was set up. Conflicts of interest were disclosed and followed up throughout the process of drawing up the guidelines. The work received no funding from any firm dealing in health products (drugs or devices). The GRADE (Grading of Recommendations Assessment, Development and Evaluation) method was applied to assess the quality of the data on which the guidelines were founded. It was stressed that strong recommendations should not be made on the basis of poor-quality or insufficient data.

Methods: The committee studied 29 questions on 5 topics: indications and contraindications, anesthetic technique, surgical technique, interpretation and reporting of results, and management guided by results.

Results: Expert review and application of the GRADE method led to 30 guidelines: 10 with high level of evidence (Grade 1+ or 1-), 19 with low level (GRADE 2+ or 2-) and 1 expert opinion.

Conclusion: Experts fully agreed on the strong guidelines formalizing the indications and modalities of drug-induced sleep endoscopy for adult obstructive sleep apnea syndrome.

Abbreviations: OSAS, Obstructive sleep apnea syndrome; CPAP, Continuous positive airway pressure treatment; DISE, Drug-induced sleep endoscopy; MAD, Mandibular advancement device; CCC, Complete concentric collapse; VOTE, Velum Oropharyngeal Tongue Base Epiglottitis; BIS, bispectral index.

* Corresponding author.

E-mail address: emilie.bequignon@chicreteil.fr (E. Bequignon).

1. Introduction

Obstructive sleep apnea syndrome (OSAS) is a heterogeneous entity, with non-anatomic factors (pharyngeal dilator abnormality, low awakening threshold, high loop-gain, etc.) in 70–80% of cases and systematic anatomic factors (obesity, craniofacial bone dimensions, lymphoid and muscular hypertrophy, etc.) to variable degrees [1]. Understanding the role of anatomic factors, the

obstruction site and muscle collapse guides treatment decision-making [2,3]. Precise identification of obstruction sites is hindered by differences between awake and sleeping exploration and by the frequent multiplicity of sites [4]. Drug-induced sleep endoscopy (DISE), first described by Croft and Pringle in 1991 [5], is the dynamic approach best approximating normal sleep. In head and neck surgery, DISE specifies the location, size and type of obstruction, helping reduce resort to surgery, extent of resection and number of sites operated on [6]. It enables anatomic and functional phenotyping and personalization of the surgical plan, optimizing outcome [7]. The aim of the present guidelines is to determine the role of DISE in the management of adult OSAS.

2. Methodology

The guidelines were drawn up on request from the French Association of Otorhinolaryngology and Sleep Disorders (AFSORL) and the French Society of ENT (SFORL, the sponsor) in collaboration with the French Society of Anesthesia and Intensive Care Medicine (SFAR) and French Society for Sleep Research and Sleep Medicine (SFRMS). The coordinators drew up the questions for the working group, using the PICO format (Patients, Intervention, Comparison, Outcome).

The guidelines were based on a literature review using MedLine, PubMed and Embase, with the combined search-terms: Sleep Apnea, Obstructive/surgery, Sleep Apnea, Obstructive/therapy, endoscopy, sleep endoscopy, DISE, sleep disordered breathing. In total, 224 articles published between 1991 and 2021 in French or English were selected.

The working group adopted the GRADE system for critical analysis of the literature presented in the rationale. Levels of evidence per article are shown in the text according to GRADE classification: level 1 (very low) to level 4 (high). Recommendation strength is thus presented according to level of evidence as Strong (GRADE 1+ or 1-), Weak (GRADE 2+ or 2-), or Expert Opinion when literature data were lacking.

The guidelines were submitted to a multidisciplinary reading group of DISE experts, and revised according to their comments.

The strength of expert agreement on recommendations was determined by an on-line survey, in which each expert reported that they “rather agreed”, “rather disagreed” or had “no opinion”. To be validated, at least 50% of the experts had to have an opinion and less than 20% had to prefer the contrary proposal. For a recommendation to be “strong”, at least 70% of the experts had to “agree”. In some cases, no recommendation could be made.

3. Role of DISE in adult OSAS

3.1. Indications for DISE

R1: When upper airway surgery (other than skeletal surgery) is considered in OSAS, DISE is probably recommended to avoid surgery in obstruction sites where success rates are low.

GRADE 2+, Strong agreement

Many studies reported positive predictive value for preoperative DISE, identifying phenotypes associated with failure of surgery, thus enabling contraindication. In a cohort of OSAS patients with failure of continuous positive airway pressure treatment (CPAP) in whom surgery was performed with prior DISE, Soares et al. found a significant association between failure of surgery and severe > 75% laterolateral oropharyngeal or epiglottic obstruction on DISE [8]

(level of evidence 1). Complete concentric collapse (CCC) of the velum has also frequently been reported to be significantly associated with poorer surgical efficacy [9] (level of evidence 2).

In a multicenter retrospective cohort of 275 patients with moderate to severe OSAS, Green et al. found a significant association between surgical failure and laterolateral oropharyngeal collapse or complete retrobasilingual obstruction [10].

Likewise, Huntley et al., in a comparative observational study, reported that preoperative DISE reduced the number of operated sites and increased overall success/cure rates: 86% with versus 51% without DISE [7] (level of evidence 2).

In contrast, 2 studies reported no real benefit of systematic preoperative DISE in terms of success [11,12] (level of evidence 3 and 2). These results were, however, vitiated by numerous methodological biases: imprecise protocol, absence of randomization, and practices varying between centers [13].

Data are lacking to assess the contribution of DISE in skeletal surgery [14,15].

R2: It is probably not recommended to perform DISE to validate indications for tonsillar surgery in case of bilateral grade 3 or 4 hypertrophy without retrobasilingual obstruction on awake examination.

GRADE 2-, Strong agreement

In case of bilateral grade 3 or 4 tonsillar hypertrophy without retrobasilingual obstruction on awake examination, preoperative DISE would not change the treatment guided by awake examination.

The level of tonsillar hypertrophy (Friedman class) is easy to determine on awake examination. It has been clearly demonstrated that palatine tonsil size influences outcome in OSAS treated by palatal surgery [16–19] (level of evidence 3). These prospective studies reported considerable reduction in apnea-hypopnea index (AHI) and good success rates for hypertrophic tonsils without visible retrobasilingual obstacle on awake examination (Friedman class 1), especially in patients who are not overweight (BMI < 25 kg/m²) [20]. A prospective blinded study in 162 patients found a significant association between indications for isolated tonsillar surgery established on awake examination and on DISE regarding the tonsillar obstacle ($P < 0.0001$) [21] (level of evidence 3).

R3: It is probably not recommended to perform DISE systematically ahead of application of a mandibular advancement device (MAD) when MAD is the only option for treatment.

GRADE 2-, Strong agreement

R4: In case of hesitation between MAD and surgery (except nasal surgery) for OSAS, DISE is probably recommended to diagnose obstructive phenotypes (site, degree, collapse direction) liable to contraindicate one or other option.

GRADE 2+, Strong agreement

MAD, like CPAP, is one of the prime treatments for moderate to severe OSAS. DISE has been advocated to predict failure of MAD, thus avoiding production of the device and promptly proposing alternatives. Several studies, with varying methodologies, examined the efficacy of DISE in assessing the impact of simulated mandibular advancement on airway obstruction to predict the final efficacy of custom-made MAD; most reported satisfactory efficacy [22–26] (level of evidence 2). Others focused on the association

between obstructive phenotype (site, degree, collapse pattern) on DISE and response to MAD. Bilingual collapse seemed predictive of good response, and complete laterolateral oropharyngeal collapse of poor response [22] (level of evidence 3).

Although DISE does not seem to reduce the rate of MAD failure, efficacy has not been assessed on randomized trials. Various strategies, less invasive than DISE, have been described to predict MAD efficacy, based for instance on clinical and polysomnographic data, with temporary thermoformed MADs [27] (level of evidence 2). However, no dedicated studies have directly compared these strategies, and it is not at present possible to recommend any one in particular for predicting the outcome of MAD as the sole option proposed to the patient.

On the other hand, when MAD or surgery can be envisaged, DISE is indicated (Recommendation 1) to rule out phenotypes associated with poor response to soft-tissue surgery, and in such cases to support or contraindicate MAD.

R5: DISE is recommended ahead of the decision to implant a hypoglossal nerve stimulator.

GRADE 1+, Strong agreement

Van de Heyning et al., studying the first patients implanted with a unilateral hypoglossal nerve stimulator synchronized to breathing, found that 100% of non-responders had soft-palate CCC, which was not seen in any of the responders; when patients with complete circular collapse on preoperative DISE were excluded, the success rate increased from 43% to 89% [28] (level of evidence 2). These findings were subsequently confirmed in other studies [29,30] (level of evidence 2).

Although palatal CCC correlates with BMI and AHI, the correlation is not strong enough to forgo preoperative DISE [31] (level of evidence 2). DISE is thus mandatory before implanting a hypoglossal nerve stimulator, improving results by eliminating predicted non-responders.

R6: It is probably not recommended to perform DISE under propofol in OSAS predominating in paradoxical sleep.

GRADE 2–, Strong agreement

The question of the contribution of DISE arises for patients in whom respiratory events predominate during paradoxical sleep. Paradoxical sleep was not reproduced in most studies analyzing sleep stages during DISE, whatever the duration or the drug [32–36]. A single study of 15 patients reported paradoxical sleep during a mean 138 minutes' midazolam sedation [37] (level of evidence 1). The present work group recommends target-controlled intravenous propofol sedation for DISE (Recommendation 10). In the light of the above findings, propofol DISE would tend to be non-informative or biased in OSAS predominating during paradoxical sleep, and DISE should presently not be performed in these patients.

The risk/benefit ratio of DISE as a diagnostic examination needs assessing upstream in an anesthesiology consultation [38]. It induces sedation and airway obstruction. The risk of respiratory distress and apnea seen in OSAS is increased by sedation, which may require manual ventilation to correct hypoxemia, or emergency intubation in case of desaturation and prolonged airway collapse [38] (level of evidence 4). However, most authors report few if any side effects or complications relating to general anesthesia in DISE. The sedation induces loss of consciousness and of airway control;

R7: DISE is not recommended in patients with a full stomach at sedation, to avoid inhalation complications.

GRADE 1–, Strong agreement

R8: DISE is not recommended in patients with risk of ventilation being impossible during sedation or with severe chronic respiratory failure.

GRADE 1–, Strong agreement

R9: DISE is probably not recommended if it would not provide extra information or modify treatment (relative contraindications):

- Severe obesity (BMI > 40).
- Contraindications to surgery (hematologic disease, pregnancy, impaired general health, refusal, etc.) associated with contraindications to MAD (dental malocclusion, periodontal pathology, etc.).

GRADE 2–, Strong agreement

the major risk is thus inhalation of gastric fluid. Patients at risk of inhalation are therefore ineligible: history of sleeve gastrectomy, ongoing pregnancy, gastroparesis, esophageal achalasia, etc. The usual preoperative fast instructions apply also to DISE: 6 h for solids, 2 h for liquids (level of evidence 4).

The usual anesthesiological contraindications also apply: allergy to agents, American Society of Anesthesiologists (ASA) category 4 (level of evidence 4).

CPAP is the usual treatment for obese patients with severe OSA. As the aim of DISE is to assess the efficacy of alternative treatments, it is not useful if such treatments are not indicated or are contraindicated [39] (level of evidence 4). The examination is based on visualization of obstructive sites on flexible endoscopy [40], and obstacles or contraindications to passing an endoscope in the nasal cavities render it unfeasible (level of evidence 4).

3.2. Anesthesia technique

R10: For DISE, target-controlled intravenous propofol sedation is probably recommended in first line, beginning with a target site effect concentration of 2–2.5 µg/mL, to optimally reproduce respiratory events occurring during natural sleep.

GRADE 2+, Strong agreement

Many studies with very low to moderate levels of evidence compared propofol and dexmedetomidine. Dexmedetomidine seems to induce more physiological sleep, but propofol seems to provide more faithful reproduction of airway obstructions arising in natural sleep [41–43], and thus of apnea and respiratory events [36,43,44] (level of evidence 3). Moreover, induction time is often longer with dexmedetomidine, making the examination more difficult. The literature is contradictory regarding the rates of adverse events induced by propofol and dexmedetomidine, which greatly depend on injection protocol and dose; dexmedetomidine may sometimes induce severe bradycardia [41,45–47]. Data are likewise contradictory regarding awakening time, although this seems longer with dexmedetomidine [45] (level of evidence 2). Also, in France dexmedetomidine is not authorized for use in the operating room.

Midazolam and propofol showed very little difference on direct comparison [33], with similar results in DISE. However, the probability of adverse events associated with midazolam in OSAS is high,

and gold standard administration is as a bolus; thus, the risk/benefit ratio is not in its favor [48,49] (level of evidence 4).

Target-controlled intravenous propofol sedation induced fewer adverse events (hypotension, desaturation) than bolus administration [50], with finer control of depth of sleep [34,40]. Hillman et al. [51] used increasing doses of propofol to assess impact on pharyngeal muscle tonus and critical closing pressure. Effect site concentrations < 1.5 µg/mL did not increase critical closing pressure or reduce genioglossal muscle activity; above this threshold, propofol began to affect pharyngeal muscle tonus and thus critical closing pressure. Muscle activity increased up to the target effect site concentration of 2 µg/mL [52], then suddenly dropped thereafter, with increased critical closing pressure [51]. This corresponds to loss of consciousness as monitored on bispectral index (BIS). A comparable decrease in genioglossal muscle activity occurs in physiological sleep [53], suggesting that propofol is effective in mimicking changes in pharyngeal muscle tonus in the transition from waking to sleeping state. Kellner et al. [54] also showed a dose-dependent effect of propofol on airway collapse, with maximal effect in deep sleep according to BIS monitoring. European guidelines therefore recommend a dose of 2 µg/mL target-controlled intravenous propofol 2.5 µg/mL to begin sedation [40] (level of evidence 3).

R11: During anesthesia for DISE, the patient should be monitored by pulse oximetry, intermittent blood pressure measurement and cardioscopy, to detect onset of respiratory and cardiac events.

GRADE 1+, Strong agreement

In France, surveillance of anesthesia and sedation is regulated by Decree n° 94-1050 of December 5, 1994, and in Europe by the ESA/EBA taskforce (European Society of Anaesthesiology/European Board of Anaesthesiology) [55]. The importance of monitoring ECG, heart rate, blood pressure and pulse oximetry is due to the risk of onset of severe hypoxemia and cardiac arrhythmia during DISE. These events are often related to patient age and history, procedure time and team expertise (level of evidence 4). For pulse oximetry, SpO₂ should be measured before start of procedure, when the patient is breathing ambient air, and at the nadir of the polysomnography curve. These baseline values for the patient awake and sleeping help the practitioner set target values for intraoperative SpO₂ (level of evidence 4).

No recommendations could be made regarding systematic oxygen supply to prevent complications during DISE. More or less severe desaturation is frequent during DISE and is part of the pathophysiology of OSAS. One option is to administer oxygen preventively against severe desaturation, but this could alter OSAS pathophysiology and the obstructive phenotype. Several studies showed that nocturnal oxygen therapy reduced onset of central apnea in some patients, but also reduced obstructive apnea in certain phenotypes: unstable respiratory command, low pharyngeal collapsibility, and elevated pharyngeal dilator response [56,57]. In case of onset of severe desaturation demonstrated on the polygraph, the first-line attitude is to restore effective breathing by jaw thrust maneuvers associated to reduction in sedation; if this is insufficient, a ventilation mask should be used. Oxygen should be supplied only as a last resort, to avoid biasing the examination.

Likewise, it was not possible to make any recommendations regarding capnography during DISE. In DISE, onset of airway obstruction is studied directly, reducing the interest of capnography. Analyzing the amplitude and rhythm of hypercapnia episodes, more than absolute capnographic values, may, however, be useful in post-procedural surveillance.

R12: During anesthesia for DISE, it is probably recommended to implement EEG monitoring (BIS or equivalent) to titrate propofol sedation.

GRADE 2+, Strong agreement

Any drug-induced sedation leads to airway collapse, and severity is proportional to the brain concentration and depth of anesthesia [54] (level of evidence 2). Surveillance of sedation depth is therefore mandatory. This should be clinical (motor and circulatory reactions), ideally using a sedation score such as Ramsay score or the Richmond Agitation-Sedation Scale, possibly supplemented by EEG.

During drug-induced sedation for DISE, anesthesia depth can be assessed on EEG or bispectral index. Analysis of BIS level, however, has to take account of interindividual variations and the time lag between the displayed measurement and the real-time sedation value.

Lo et al. compared BIS monitoring in DISE for mild (BIS 65–75) and deep sedation (BIS 50–60) in 90 patients. In OSAS patients, obstruction was observed in the velopharynx in 77.8% of cases and in the oropharynx in 63.3% under mild sedation; moreover, airway obstruction was reproducible at both levels of sedation [58] (level of evidence 1).

There are, however, no studies comparing results and safety in DISE with and without BIS. A recent study by Skinner et al. assessed BIS in bronchoscopy under sedation; BIS < 40 at any point in the examination was associated with a higher complications rate (mainly hypotension) [59] (level of evidence 4).

These results support EEG monitoring like BIS or perhaps entropy to ensure a minimal level of sedation and limit the risk of complications associated with excessive sedation.

3.3. Procedural technique

R13: It is probably recommended to use a flexible endoscope with the smallest diameter possible.

GRADE 2+, Strong agreement

There are no studies focusing on comparison of endoscope diameter in DISE. A review of the literature on the techniques employed suggests that the endoscope should be as fine as possible, notably to avoid it awakening the patient when passing through the nasal cavity, and that it is preferable to pass through the less permeable cavity so as to disturb air dynamics as little as possible [40,48]. On the other hand, the smaller the diameter, the poorer the image quality.

Examination quality may be impaired in case of hypersalivation during sedation, making DISE difficult if not impossible to interpret. Some authors advocate using atropine, which has an anticholinergic effect that reduces salivary secretion. According to European guidelines for DISE, however, atropine should be avoided as its impact on sleep physiology is too poorly understood [40]. Studies are contradictory on this point [60,61] (level of evidence 3 and 4). Finally, there are no studies comparing examination quality using an endoscope alone, an endoscope with an operator channel for aspiration, and an endoscope with atropine.

Local anesthesia is not presently recommended in European guidelines [40], although a pilot study suggested that intranasal lidocaine is harmless [62]. Local anesthesia might act on the upper airways and respiratory control, modifying examination results [40] (level of evidence 2).

R14: It is probably recommended to make a video recording of the DISE for later analysis of results or for a second opinion, as well as for teaching or research.
GRADE 2+, Strong agreement

In the literature, flexible endoscopy is usually coupled to a video system to visualize and record images and in some cases sound. The video enables subsequent reinterpretation of the diagnosis by the same or a different operator, thus allowing treatment decisions to be revised.

Several studies analyzed intra- and interobserver agreement for experienced operators and those in training. Agreement is generally good for experienced operators regarding obstruction site location and pattern and degree of collapse, but only moderate for less experienced operators [63–65] (level of evidence 2). There is thus a learning curve, for which digital recording can be useful, enabling reinterpretation by a more experienced colleague. Subsequently, digital recordings can be useful in multidisciplinary sleep team meetings.

R15: It is recommended to perform DISE with the patient supine in case of non-positional OSAS.
GRADE 1+, Strong agreement
R16: In positional OSAS, it is probably recommended to implement lateral rotation of the head associated to positioning in lateral decubitus, to assess the obstructive phenotype and the effect of positional treatment.
GRADE 2+, Strong agreement

The supine position is principally used in reports, although some patients say that they rarely sleep on their backs [48]. In non-positional OSAS diagnosed on respiratory polygraphy or polysomnography, body position (lateral or dorsal decubitus) was shown not to affect collapse seen in DISE [66] (level of evidence 2).

In positional OSAS, positional maneuvers were shown to modify the obstructive phenotype seen in DISE [66–70] (level of evidence 3). They enable assessment of collapse affected by position: improvement or non-response to positional treatment.

Some authors reported that results of DISE in full lateral decubitus (trunk and head) were comparable to those obtained by simple rotation of the head in supine position [67–69] (level of evidence 2). Others reported that lateral decubitus with downward head rotation was preferable for assessing obstacles affected by position [66,70] (level of evidence 2).

R17: It is probably recommended to perform mandibular protraction in DISE, to a degree lower than the prior value of maximum active protraction, to assess the possible impact of a MAD on obstructive sites.
GRADE 2+, Strong agreement

Mandibular advancement during DISE can simulate use of a MAD, observing its effects on variations in airway obstruction and thus predict the efficacy of using a MAD.

Some studies performed non-systematic maximal mandibular advancement during DISE [23] (level of evidence 1). Others determine maximum comfortable protrusion in advance, with the patient awake, and reproduce this by means of a calibrated traction device [24,71] (level of evidence 1 to 2). There is a significant association between positive impact on pharyngeal lumen opening

under simulation of maximum comfortable active protraction and response to MAD treatment [23,24,71,72] (level of evidence 1 to 2).

According to a European position paper, positioning the mandible in maximum advancement is not recommended during DISE, as it does not correctly predict MAD treatment response [40] (level of evidence 1).

According to Vonk et al. [73] (level of evidence 1), advancement by 50–75% of maximal active protrusion is necessary, while for other authors, such as Ravesloot et al., 5 mm is enough [22,74] (level of evidence 1). According to the European expert group, advancement should not exceed 75% of active protrusion, as the release of the obstruction does not correspond to the results expected with MAD [40] (level of evidence 1). According to Vroegop et al. [24] (level of evidence 2) and Cavaliere et al. [72] (level of evidence 2), bite simulation optimally reflects MAD results (level of evidence 2). To optimize titration in DISE, some authors use remotely controlled positioning of the oral appliance, which is currently under evaluation [71,75].

R18: Expert opinion: In DISE, it is probably recommended to use a nasopharyngeal tube to predict the effect of palatal surgery in patients with multi-level palatal plus underlying obstruction.
GRADE: Expert opinion, Strong agreement

During DISE, a nasopharyngeal tube can reveal release of obstruction sites in some cases [76] (level of evidence 2). A prospective study by Victores et al. comparing DISE without then with nasopharyngeal tube in 41 patients showed that introducing the tube down to the soft palate induced complete resolution of obstruction in patients with isolated retropalatal obstruction [76] (level of evidence 2). For patients with multi-level obstruction, a nasopharyngeal tube partially improved 74% of obstruction sites and fully improved 35%. It can simulate the outcome of isolated palatal surgery. According to Li et al., polysomnography during DISE with a nasopharyngeal tube can select patients for isolated palatal surgery versus multi-level surgery [77] (level of evidence 2); in their non-randomized non-controlled prospective study of 73 patients, $AHI < 15/h$ with the tube in place favored isolated palatal surgery [77].

3.4. Interpreting and reporting results

R19: In case of airway surgery (except nasal and skeletal surgery) for OSAS, prior DISE is probably recommended (in comparison to awake examination), to screen for:

- risk factors for failure of surgery: multi-site collapse, complete concentric palatal collapse, complete basilingual collapse, complete lateral oropharyngeal collapse;
- sites not visible on awake examination: epiglottic obstacle.

GRADE 2+, Strong agreement

Awake examination may not reflect the real situation of obstruction during sleep, as muscle tonus is greater in the awake state, notably in the genioglossal muscle. Comparison between awake examination and DISE shows satisfactory agreement for exploration of the retropalatal and oropharyngeal region [78–80]. On

the other hand, a recent meta-analysis of the interest of DISE for diagnosis of obstruction sites reported different findings for the retrobasal and epiglottic region [78–80] (level of evidence 3). Epiglottic tilt cannot be visualized on standard awake examination.

Certain DISE findings seem to be associated with increased probability of failure or of success for certain treatments. Palatal CCC is predictive of failure of palatopharyngeal surgery [9,81], MAD treatment [82] and hypoglossal nerve (CN XII) stimulation [29]. Complete basilingual collapse is predictive of failure of palatopharyngeal surgery [81]. DISE is usually performed to screen for indications or contraindications for a surgical procedure, and findings of more multisite or epiglottic obstructions on DISE than on awake examination helps target treatment and improve surgical outcome [11,21,78–80].

R20: In DISE, it is probably recommended to use the VOTE classification to standardize the description of obstacles.

GRADE 2+, Strong agreement

A large number of classifications for DISE data have been proposed since the early 1990s (Croft and Pringle) [83,84] (level of evidence 2). Certain collapse configurations can guide treatment, but no single classification system has been shown to improve success in OSAS, and there is presently no consensus regarding scoring systems [83,84].

In 2011, Kezirian et al. described the VOTE classification, with 4 sites (velum, oropharynx, tongue and epiglottis) and degrees and patterns of collapse (anteroposterior, lateral, concentric) [85]. It is the most widely used classification of DISE data in the international literature [83] (level of evidence 2). For some authors, it enables complete description of the various observable forms of collapse, with reproducible interobserver findings, and is therefore the system to be preferred [40,86] (level of evidence 1).

R21: After DISE, it is recommended to write up a report specifying the complete obstructive phenotype (sites, patterns and degrees) and changes observed under dynamic maneuvers.

GRADE 1+, Strong agreement

R22: It is recommended that the report should specify examination time, anesthetic agent and mode of administration, maximum concentration and total dose, sedation level at onset of snoring and apnea, effect of the various maneuvers on obstruction sites, and any notable events occurring during DISE.

GRADE 1+, Strong agreement

A detailed surgery report and/or medical observation must be included in the patient's file after DISE, like for any act performed in an operating room according to the regulations contained in article R. 1112-2 of the French Public Health Code (Decree n° 2003-462, May 21, 2003).

As mentioned above, description of the anatomic regions and structures and of the collapse configurations (pattern and degree) help target treatment indications. Simulation of MAD treatment by simple external maneuvers, oral appliances or controlled titration systems helps selection for MAD [22,24] (level of evidence 2).

So as not to overestimate obstruction, the degree of sedation must be specified, for example in terms of the bispectral index at onset of snoring and apnea [54,87] (level of evidence 1). The type of anesthetic agent, mode of administration, maximum concentration and total dose should be specified. It seems that the longer

the examination, the greater the number of obstacles and collapse configurations observed [32] (level of evidence 2).

Finally, if positional maneuvers are performed, the observed changes in collapse must be specified according to position (dorsal decubitus, lateral decubitus, cervical rotation) [68] (level of evidence 1). These data can guide the association of positional therapy to surgery or MAD.

A good quality examination report provides all elements necessary for subsequent interpretation of results, treatment decision-making, data sharing and reproducibility of the examination.

3.5. Treatment according to DISE findings

R23: In case of complete concentric palatal collapse seen on DISE, airway surgery (except nasal and skeletal surgery) is probably not recommended.

GRADE 2–, Strong agreement

Palatal CCC was identified as a factor for poor surgical response in several studies, including a systematic review [9,11] (level of evidence 2). Koutsourelakis et al. retrospectively analyzed polysomnography results in 19 patients receiving DISE and surgery; on multivariate analysis, palatal CCC and/or complete anteroposterior tongue base collapse were the only independent predictive factors for failure of surgery [81] (level of evidence 2).

Two studies reported that palatal CCC was not a factor for failure of maxillomandibular advancement surgery, which could treat palatal CCC by restoring lateral pharyngeal wall tension [14,15] (level of evidence 2). Other than in maxillomandibular advancement surgery, data seem sufficient to contraindicate airway surgery in case of palatal CCC on DISE.

Other obstacles associated with poor prognosis comprise complete anteroposterior tongue base collapse [10,81], lateral pharyngeal wall collapse [8,10], and epiglottic and/or arytenoid collapse [8,81] (level of evidence 2). The surgical procedures assessed in these studies were too varied for any conclusion to be drawn as to the influence of these obstacles on the success of each technique.

R24: It is recommended not to use MAD in OSAS patients with an obstructive phenotype that is not improved by manual or instrumental mandibular advancement maneuvers under DISE, taking account of active mandibular protraction (cf. Recommendation 3.2.3).

GRADE 1+, Strong agreement

Response to mandibular advancement seems to be a reliable means of predicting individual response to MAD. Complete resolution of collapse during mandibular advancement during DISE is the most frequently studied parameter for whatever advancement method: manual protraction (chin-lift or jaw-thrust), protraction simulator, or thermoformed MAD.

The maneuvers release the obstacles found on DISE, even when multisite [24,72,73,88] (level of evidence 2). They are not, however, entirely equivalent. Vroegop et al. reported that improvement under manual protraction (chin-lift) was not associated with MAD response, in contrast to findings for simulation bite [24] (level of evidence 3). Vonk et al., comparing manual protraction (jaw-thrust) versus a thermoformed oral appliance, found a very weak to moderate correlation in efficacy in relieving collapse seen on

DISE. Manual protraction was more effective than the oral appliance in the hypopharynx but less for palatal obstacles [89] (level of evidence 1).

Methods of mandibular advancement directly predict response to MAD, but seem to suggest better response rates than seen in studies based exclusively on obstructive phenotype. De Corso et al. selected patients according to response to manual protraction under DISE and found a MAD response rate of 71.4% [22] (level of evidence 1). Vroegop et al., studying 200 patients, reported 83.3% success for MAD in patients selected on simulation bite [24] (level of evidence 3). Huntley et al. reported that use of a thermoformed MAD during diagnostic DISE provided a 75% response rate for the final MAD [23] (level of evidence 2).

Indications for MAD in OSAS patients should therefore take account of the obstacles observed on DISE and the effect of mandibular advancement on other known negative predictive factors for MAD: i.e., high AHI and BMI [90]. Even with an unfavorable phenotype, MAD may be implemented if mandibular advancement provides improvement.

R25: It is not recommended to implant a unilateral breathing-synchronized hypoglossal nerve stimulator in case of complete concentric palatal obstacle.

GRADE 1–, Strong agreement

DISE and screening for palatal CCC were therefore recommended for patient selection for hypoglossal nerve stimulator implantation [29]. Several studies reported palatal CCC to be a factor of poor prognosis in hypoglossal stimulation [28,29,91] (level of evidence 2 to 4). In a phase II clinical trial of unilateral breathing-synchronized hypoglossal nerve stimulation (Inspire Medical System), patients with AHI ≥ 50 /h, BMI ≥ 32 kg/m² or palatal CCC on DISE showed poor treatment response [28] (level of evidence 2). Taking these factors into account improved the response rate in a subsequent study using the same stimulator [91] (level of evidence 4). In the light of these findings, unilateral breathing-synchronized hypoglossal nerve stimulation is not recommended in case of palatal CCC.

R26: In case of multisite obstacles on DISE in severe OSAS, CPAP is recommended in first line, especially in case of association with other factors for poor response to surgery or MAD.

GRADE 1+, Strong agreement

R27: In case of multisite obstacles on DISE in mild to moderate OSAS, it is probably recommended to present the various treatment options and choose according to the risk/benefit ratios and the patient's preferences.

GRADE 2+, Strong agreement

R28: When DISE reveals several obstacles and surgery is indicated, it is probably recommended to begin with single-site surgery (although nasal surgery may be associated), with gradual multisite treatment in case of primary failure, rather than performing primary one-step multisite surgery.

GRADE 2+, Strong agreement

Involvement seen on DISE is most frequently multisite [4,74,92,93]. Given the association between multisite collapse and elevated AHI [74] (level of evidence 2), patients should be informed of the various treatment options, and firstly CPAP, which offers the best chance of success in case of high AHI [73,94] (level of evidence 4). For overweight patients, high BMI correlates significantly with

obstruction seen on DISE at all levels of the airway [95] (level of evidence 2). In conclusion, in severe OSAS with multisite obstruction, the literature shows CPAP to be the gold standard, especially in case of high BMI [74,93,96,97].

In mild to moderate OSAS, CPAP may not be indicated and DISE serves to assess alternatives such as positional therapy, possible surgeries or MAD [73,93,98,99] (level of evidence 4). DISE can also be performed in severe OSAS in case of failure or refusal of CPAP (around 35% of cases [100]) or on demand for alternatives [73].

In multisite involvement, the multisite surgeries described in the literature usually associated palatal (uvulopalatopharyngoplasty or radiofrequency) or nasal surgery (septoplasty or turbinoplasty) to a procedure such as tongue-base reduction, tonsillectomy, hyoid suspension or genial tubercle advancement. In a meta-analysis of multisite surgery in the velum and tongue base, with 11 studies for 1806 patients, Mulholland et al. found AHI decreased by a mean 23 points, with therapeutic success in 58.5% of cases [101] (level of evidence 3).

Even so, one-step multisite surgery is controversial, as data show that single-site surgery provides improvement not only in the site operated on but also in underlying sites not involved in the surgery as such [76] (level of evidence 3). In a retrospective study of 38 patients undergoing DISE followed by palatopharyngoplasty, Hsu et al. reported identical success rates in the 11 patients with multisite obstruction and the 27 single-site cases; their results tended to show that, in patients with multisite involvement on DISE, treating a single obstacle could be sufficient for treatment success [9] (level of evidence 2). This was confirmed by Blumen et al., who found no correlation between treatment success and the number of sites operated on and concluded that DISE reveals extra obstruction sites that do not require treatment and that conversely treating all sites does not necessarily guarantee treatment success [102] (level of evidence 2).

An expert opinion by Ofer Jacobowitz advocated stepwise treatment rather than simultaneous multisite surgery, which is more painful and at greater risk of complications [92] (level of evidence 1). Jacobowitz recommended beginning with tonsil and soft-palate surgery, as this concerns the narrowest site and palatal surgery can provide reduction of hypopharyngeal collapse [92] (level of evidence 1).

R29: In case of epiglottic obstruction associated with multisite obstruction on DISE, it is probably not recommended to perform epiglottic surgery in first line.

GRADE 2–, Strong agreement

R30: In case of isolated epiglottic obstruction on DISE, it is probably recommended to perform epiglottic surgery in second line after MAD, CPAP or positional treatment.

GRADE 2+, Strong agreement

There are only sparse reliable data on the role of surgery in epiglottic collapse seen on DISE in OSAS patients. Some small studies reported epiglottic surgery to be effective in terms of epiglottic collapse and AHI, without serious side effects [103–105] (level of evidence 1).

Kwon et al., in 54 patients, reported no difference in success of multisite surgery not involving the epiglottis whether or not an epiglottic obstacle had been seen on DISE [106] (level of evidence 1). Thus, in multisite obstruction with epiglottic involvement, the authors advocated reserving epiglottic surgery to a subsequent step, as upstream treatment may reduce the downstream obstruction, making epiglottic surgery unnecessary [106].

Data for other types of treatment are just as sparse. Epiglottic collapse can be treated by CPAP, although Torre et al. showed that the pressure had to be higher than for palatal obstacles (up to 15 cmH₂O) [96] (level of evidence 1). Efficacy of MAD in epiglottic collapse was assessed indirectly by mandibular protraction maneuvers under DISE: Park et al. reported improvement in 4 out of 6 patients with epiglottic collapse in a series of 40 patients [88] (level of evidence 1). Sung et al. reported efficacy of mandibular protraction in 9 patients out of 11 [107] (level of evidence 2). Some studies also found improvement in epiglottic collapse after positional maneuvers [68,107] (level of evidence 1 and 2).

Surgery, CPAP, MAD and positional treatment may be considered for epiglottic obstruction seen on DISE, but large-scale studies are lacking to determine long-term efficacy.

3.6. Guideline limitations

Due to lack of data in the literature, no recommendations could be made on several points, listed below, which could be the focus of future clinical research:

- role of DISE in CPAP treatment for OSAS patients showing difficult adaptation, persistent events or high treatment pressure levels;
- contribution of capnography to safety during DISE;
- contribution of systematic oxygen therapy during DISE to prevent procedure-related complications;
- contributions of aspiration systems, atropine, and intraoperative polygraphy/polysomnography;
- validity of preoperative DISE ahead of nasal surgery in terms of obstacles seen postoperatively;
- contribution of CPAP testing during DISE to determine the effective pressure level.

Disclosure of interest

The authors declare that they have no competing interest.

Validation by the SFAR Clinical Reference Committee, November 10, 2021 (Pr. Marc Garnier) and by the Administrative Board on January 12, 2022.

Funding

None.

Acknowledgments

The organizers and coordinators thank all the experts involved in revising the present guidelines: Mohamed Akkari, André Coste, Valentin Favier, Kelly Guichard, Joelle Huth, Pascal Lestang, Joachim Maurer, Jean-Claude Meurice, Jean-Arthur Micoulaud-Franchi, Julien Nodimar, Charles Paoli, Boris Petelle, Laurie Saloner, Laurent Yona.

They also thank Ms. Sophie Guiquerro, guidelines librarian.

References

- [1] Eckert DJ. Phenotypic approaches to obstructive sleep apnoea – New pathways for targeted therapy. *Sleep Med Rev* 2018;37:45–59.
- [2] Bosi M, De Vito A, Eckert D, et al. Qualitative phenotyping of obstructive sleep apnea and its clinical usefulness for the sleep specialist. *Int J Environ Res Public Health* 2020;17(6):E2058.
- [3] Sundaram S, Bridgman SA, Lim J, et al. Surgery for obstructive sleep apnoea. *Cochrane Database Syst Rev* 2005;(4):CD001004.
- [4] Lee EJ, Cho JH. Meta-analysis of obstruction site observed with drug-induced sleep endoscopy in patients with obstructive sleep apnea. *Laryngoscope* 2019;129(5):1235–43.
- [5] Croft CB, Pringle M. Sleep nasendoscopy: a technique of assessment in snoring and obstructive sleep apnoea. *Clin Otolaryngol Allied Sci* 1991;16(5):504–9.

- [6] Vroegop AV, Vanderveken OM, Verbraecken JA. Drug-induced sleep endoscopy: evaluation of a selection tool for treatment modalities for obstructive sleep apnea. *Respiration* 2020;99(5):451–7.
- [7] Huntley C, Chou D, Doghramji K, et al. Preoperative drug induced sleep endoscopy improves the surgical approach to treatment of obstructive sleep apnea. *Ann Otol Rhinol Laryngol* 2017;126(6):478–82.
- [8] Soares D, Sinawe H, Folbe AJ, et al. Lateral oropharyngeal wall and supraglottic airway collapse associated with failure in sleep apnea surgery. *Laryngoscope* 2012;122(2):473–9.
- [9] Hsu Y-S, Jacobowitz O. Does sleep endoscopy staging pattern correlate with outcome of advanced palatopharyngoplasty for moderate to severe obstructive sleep apnea? *J Clin Sleep Med* 2017;13(10):1137–44.
- [10] Green KK, Kent DT, D'Agostino MA, et al. Drug-induced sleep endoscopy and surgical outcomes: a multicenter cohort study: DISE and Surgical Outcomes Cohort Study. *Laryngoscope* 2019;129(3):761–70.
- [11] Cerial VF, Pratas R, Guimarães L, et al. Awake examination versus DISE for surgical decision making in patients with OSA: a systematic review. *Laryngoscope* 2016;126(3):768–74.
- [12] Pang KP, Baptista PM, Olszewska E, et al. Does drug-induced sleep endoscopy affect surgical outcome? A multicenter study of 326 obstructive sleep apnea patients. *Laryngoscope* 2020;130(2):551–5.
- [13] Kezirian EJ. In reference to does drug-induced sleep endoscopy affect surgical outcomes? A multicenter study of 326 obstructive sleep apnea patients. *Laryngoscope* 2020;130(12):E950.
- [14] Kastoer C, Op de Beeck S, Dom M, et al. Drug-induced sleep endoscopy upper airway collapse patterns and maxillomandibular advancement. *Laryngoscope* 2020;130(4):E268–74.
- [15] Liu SY-C, Huon L-K, Powell NB, et al. Lateral pharyngeal wall tension after maxillomandibular advancement for obstructive sleep apnea is a marker for surgical success: observations from drug-induced sleep endoscopy. *J Oral Maxillofac Surg* 2015;73(8):1575–82.
- [16] Smith MM, Peterson E, Yaremchuk KL. The role of tonsillectomy in adults with tonsillar hypertrophy and obstructive sleep apnea. *Otolaryngol Head Neck Surg* 2017;157(2):331–5.
- [17] Tan LTH, Tan AKL, Hsu PP, et al. Effects of tonsillectomy on sleep study parameters in adult patients with obstructive sleep apnea – a prospective study. *Sleep Breath* 2014;18(2):265–8.
- [18] Senchak AJ, McKinlay AJ, Acevedo J, et al. The effect of tonsillectomy alone in adult obstructive sleep apnea. *Otolaryngol Head Neck Surg* 2015;152(5):969–73.
- [19] Holmlund T, Franklin KA, Levring Jäghagen E, et al. Tonsillectomy in adults with obstructive sleep apnea. *Laryngoscope* 2016;126(12):2859–62.
- [20] Nakata S, Noda A, Yanagi E, et al. Tonsil size and body MADs index are important factors for efficacy of simple tonsillectomy in obstructive sleep apnoea syndrome. *Clin Otolaryngol* 2006;31(1):41–5.
- [21] Fernández-Julián E, García-Pérez MÁ, García-Callejo J, et al. Surgical planning after sleep versus awake techniques in patients with obstructive sleep apnea. *Laryngoscope* 2014;124(8):1970–4.
- [22] De Corso E, Bastanza G, Della Marca G, et al. Drug-induced sleep endoscopy as a selection tool for mandibular advancement therapy by oral device in patients with mild to moderate obstructive sleep apnoea. *Acta Otorhinolaryngol Ital* 2015;35(6):426–32.
- [23] Huntley C, Cooper J, Stiles M, et al. Predicting success of oral appliance therapy in treating obstructive sleep apnea using drug-induced sleep endoscopy. *J Clin Sleep Med* 2018;14(8):1333–7.
- [24] Vroegop AVMT, Vanderveken OM, Deltjens M, et al. Sleep endoscopy with simulation bite for prediction of oral appliance treatment outcome. *J Sleep Res* 2013;22(3):348–55.
- [25] Johal A, Hector MP, Battagel JM, et al. Impact of sleep nasendoscopy on the outcome of mandibular advancement splint therapy in subjects with sleep-related breathing disorders. *J Laryngol Otol* 2007;121(7):668–75.
- [26] Battagel JM, Johal A, Kotecha BT. Sleep nasendoscopy as a predictor of treatment success in snorers using mandibular advancement splints. *J Laryngol Otol* 2005;119(2):106–12.
- [27] Okuno K, Pliska BT, Hamoda M, et al. Prediction of oral appliance treatment outcomes in obstructive sleep apnea: a systematic review. *Sleep Med Rev* 2016;30:25–33.
- [28] Van de Heyning PH, Badr MS, Baskin JZ, et al. Implanted upper airway stimulation device for obstructive sleep apnea. *Laryngoscope* 2012;122(7):1626–33.
- [29] Vanderveken OM, Maurer JT, Hohenhorst W, et al. Evaluation of drug-induced sleep endoscopy as a patient selection tool for implanted upper airway stimulation for obstructive sleep apnea. *J Clin Sleep Med* 2013;9(5):433–8.
- [30] Ong AA, Murphey AW, Nguyen SA, et al. Efficacy of upper airway stimulation on collapse patterns observed during drug-induced sedation endoscopy. *Otolaryngol Head Neck Surg* 2016;154(5):970–7.
- [31] Steffen A, Frenzel H, Wollenberg B, et al. Patient selection for upper airway stimulation: is concentric collapse in sleep endoscopy predictable? *Sleep Breath* 2015;19(4):1373–6.
- [32] Heo SJ, Park CM, Kim JS. Time-dependent changes in the obstruction pattern during drug-induced sleep endoscopy. *Am J Otolaryngol* 2014;35(1):42–7.
- [33] Carrasco Llatas M, Agostini Porras G, Cuesta González MT, et al. Drug-induced sleep endoscopy: a two drug comparison and simultaneous polysomnography. *Eur Arch Otorhinolaryngol* 2014;271(1):181–7.
- [34] Abdullah VJ, Lee DLY, Ha SCN, et al. Sleep endoscopy with midazolam: sedation level evaluation with bispectral analysis. *Otolaryngol Head Neck Surg* 2013;148(2):331–7.

- [35] Ghorbani J, Adimi Naghan P, Safavi Naeini A, et al. Can be compared obstructive respiratory events during drug induced sleep endoscopy (DISE) and nocturnal polysomnography. *Eur Arch Otorhinolaryngol* 2020;277(5):1379–84.
- [36] Rabelo FAW, Küpper DS, Sander HH, et al. Polysomnographic evaluation of propofol-induced sleep in patients with respiratory sleep disorders and controls. *Laryngoscope* 2013;123(9):2300–5.
- [37] Genta PR, Eckert DJ, Gregorio MG, et al. Critical closing pressure during midazolam-induced sleep. *J Appl Physiol* 2011;111(5):1315–22.
- [38] Leeds Teaching Hospitals NHS Trust. Conscious sedation in adults; 2020.
- [39] Vanderveken OM. Drug-induced sleep endoscopy (DISE) for non-CPAP treatment selection in patients with sleep-disordered breathing. *Sleep Breath* 2013;17(1):13–4.
- [40] De Vito A, Carrasco Llatas M, Ravesloot MJ, et al. European position paper on drug-induced sleep endoscopy: 2017 update. *Clin Otolaryngol* 2018;43(6):1541–52.
- [41] Yoon B-W, Hong J-M, Hong S-L, et al. A comparison of dexmedetomidine versus propofol during drug-induced sleep endoscopy in sleep apnea patients. *Laryngoscope* 2016;126(3):763–7.
- [42] Chang ET, Certal V, Song SA, et al. Dexmedetomidine versus propofol during drug-induced sleep endoscopy and sedation: a systematic review. *Sleep Breath* 2017;21(3):727–35.
- [43] Padiyara TV, Bansal S, Jain D, et al. Dexmedetomidine versus propofol at different sedation depths during drug-induced sleep endoscopy: a randomized trial. *Laryngoscope* 2020;130(1):257–62.
- [44] Cho JS, Soh S, Kim EJ, et al. Comparison of three sedation regimens for drug-induced sleep endoscopy. *Sleep Breath* 2015;19(2):711–7.
- [45] Zhao LL, Liu H, Zhang YY, et al. A comparative study on efficacy and safety of propofol versus dexmedetomidine in sleep apnea patients undergoing drug-induced sleep endoscopy: a CONSORT-Prospective, Randomized, Controlled Clinical Trial. *Biomed Res Int* 2018;2018:8696510.
- [46] Kuyruklyildiz U, Binici O, Onk D, et al. Comparison of dexmedetomidine and propofol used for drug-induced sleep endoscopy in patients with obstructive sleep apnea syndrome. *Int J Clin Exp Med* 2015;8(4):5691–8.
- [47] Capasso R, Rosa T, Tsou DY-A, et al. Variable findings for drug-induced sleep endoscopy in obstructive sleep apnea with propofol versus dexmedetomidine. *Otolaryngol Head Neck Surg* 2016;154(4):765–70.
- [48] Blumen M, Bequignon E, Chabolle F. Drug-induced sleep endoscopy: a new gold standard for evaluating OSAS? Part I: technique. *Eur Ann Otorhinolaryngol Head Neck Dis* 2017;134(2):101–7.
- [49] Ravesloot MJL, van Maanen JP, Dun L, et al. The undervalued potential of positional therapy in position-dependent snoring and obstructive sleep apnea – a review of the literature. *Sleep Breath* 2013;17(1):39–49.
- [50] De Vito A, Agnoletti V, Zani G, et al. The importance of drug-induced sedation endoscopy (D.I.S.E.) techniques in surgical decision making: conventional versus target controlled infusion techniques – a prospective randomized controlled study and a retrospective surgical outcomes analysis. *Eur Arch Otorhinolaryngol* 2017;274(5):2307–17.
- [51] Hillman DR, Walsh JH, Maddison KJ, et al. Evolution of changes in upper airway collapsibility during slow induction of anesthesia with propofol. *Anesthesiology* 2009;111(1):63–71.
- [52] Hoshino Y, Ayuse T, Kurata S, et al. The compensatory responses to upper airway obstruction in normal subjects under propofol anesthesia. *Respir Physiol Neurobiol* 2009;166(1):24–31.
- [53] Wilkinson V, Malhotra A, Nicholas CL, et al. Discharge patterns of human genioglossus motor units during sleep onset. *Sleep* 2008;31(4):525–33.
- [54] Kellner P, Herzog B, Plöchl S, et al. Depth-dependent changes of obstruction patterns under increasing sedation during drug-induced sedation endoscopy: results of a German monocentric clinical trial. *Sleep Breath* 2016;20(3):1035–43.
- [55] Hinkelbein J, Lamperti M, Akeson J, et al. European Society of Anaesthesiology and European Board of Anaesthesiology guidelines for procedural sedation and analgesia in adults. *Eur J Anaesthesiol* 2018;35(1):6–24.
- [56] Bordier P, Lataste A, Hofmann P, et al. Nocturnal oxygen therapy in patients with chronic heart failure and sleep apnea: a systematic review. *Sleep Med* 2016;17:149–57.
- [57] Sands SA, Edwards BA, Terrill PI, et al. Identifying obstructive sleep apnoea patients responsive to supplemental oxygen therapy. *Eur Respir J* 2018;52(3):1800674.
- [58] Lo Y-L, Ni Y-L, Wang T-Y, et al. Bispectral Index in evaluating effects of sedation depth on drug-induced sleep endoscopy. *J Clin Sleep Med* 2015;11(9):1011–20.
- [59] Skinner TR, Churton J, Edwards TP, et al. A randomised study of comfort during bronchoscopy comparing conscious sedation and anaesthetist-controlled general anaesthesia, including the utility of bispectral index monitoring. *ERJ Open Res* 2021;7(2):00895–2020.
- [60] Rauniar GP, Gitanjali B, Shashindran C. Comparative effects of hyoscine butylbromide and atropine sulphate on sleep architecture in healthy human volunteers. *Indian J Physiol Pharmacol* 1998;42(3):395–400.
- [61] Kim EJ, Jeong DU. Transdermal scopolamine alters phasic REM activity in normal young adults. *Sleep* 1999;22(4):515–20.
- [62] Pendolino AL, Kwame I, Poirrier A-L, et al. A pilot study to determine the effects of nasal co-phenylcaine on drug-induced sleep endoscopy. *Eur Arch Otorhinolaryngol* 2019;276(9):2603–9.
- [63] Carrasco-Llatas M, Zerpa-Zerpa V, Dalmau-Galofre J. Reliability of drug-induced sedation endoscopy: interobserver agreement. *Sleep Breath* 2017;21(1):173–9.
- [64] Koo SK, Lee SH, Koh TK, et al. Inter-rater reliability between experienced and inexperienced otolaryngologists using Koo's drug-induced sleep endoscopy classification system. *Eur Arch Otorhinolaryngol* 2019;276(5):1525–31.
- [65] Vroegop AVMT, Vanderveken OM, Wouters K, et al. Observer variation in drug-induced sleep endoscopy: experienced versus nonexperienced ear, nose, and throat surgeons. *Sleep* 2013;36(6):947–53.
- [66] Victores AJ, Hamblin J, Gilbert J, et al. Usefulness of sleep endoscopy in predicting positional obstructive sleep apnea. *Otolaryngol Head Neck Surg* 2014;150(3):487–93.
- [67] Safiruddin F, Koutsourelakis I, de Vries N. Analysis of the influence of head rotation during drug-induced sleep endoscopy in obstructive sleep apnea. *Laryngoscope* 2014;124(9):2195–9.
- [68] Lee CH, Kim DK, Kim SY, et al. Changes in site of obstruction in obstructive sleep apnea patients according to sleep position: a DISE study. *Laryngoscope* 2015;125(1):248–54.
- [69] Safiruddin F, Koutsourelakis I, de Vries N. Upper airway collapse during drug induced sleep endoscopy: head rotation in supine position compared with lateral head and trunk position. *Eur Arch Otorhinolaryngol* 2015;272(2):485–8.
- [70] Vonk PE, van de Beek MJ, Ravesloot MJL, et al. Drug-induced sleep endoscopy: new insights in lateral head rotation compared to lateral head and trunk rotation in (non)positional obstructive sleep apnea patients. *Laryngoscope* 2019;129(10):2430–5.
- [71] Kastoer C, Dieltjens M, Op de Beeck S, et al. Remotely controlled mandibular positioning during drug-induced sleep endoscopy toward mandibular advancement device therapy: feasibility and protocol. *J Clin Sleep Med* 2018;14(8):1409–13.
- [72] Cavaliere M, De Luca P, De Santis C, et al. Drug-induced sleep endoscopy (DISE) with simulation bite to predict the success of oral appliance therapy in treating obstructive sleep apnea/hypopnea syndrome (OSAHS). *Transl Med UniSa* 2020;23:58–62.
- [73] Vonk PE, Beelen AMEH, de Vries N. Towards a prediction model for drug-induced sleep endoscopy as selection tool for oral appliance treatment and positional therapy in obstructive sleep apnea. *Sleep Breath* 2018;22(4):901–7.
- [74] Ravesloot MJL, de Vries N. One hundred consecutive patients undergoing drug-induced sleep endoscopy: results and evaluation: association between DISE and PSG outcomes. *Laryngoscope* 2011;121(12):2710–6.
- [75] Dieltjens M, Braem MJ, Op de Beeck S, et al. Remotely controlled mandibular positioning of oral appliance therapy during polysomnography and drug-induced sleep endoscopy compared with conventional subjective titration in patients with obstructive sleep apnea: protocol for a randomized crossover trial. *Trials* 2019;20(1):615.
- [76] Victores AJ, Olson K, Takashima M. Interventional drug-induced sleep endoscopy: a novel technique to guide surgical planning for obstructive sleep apnea. *J Clin Sleep Med* 2017;13(2):169–74.
- [77] Li S, Wu D, Bao J, et al. Nasopharyngeal tube: a simple and effective tool to screen patients indicated for glossopharyngeal surgery. *J Clin Sleep Med* 2014;10(4):385–9.
- [78] Viana A, da C, Thuler LCS, Araújo-Melo MH. de. Drug-induced sleep endoscopy in the identification of obstruction sites in patients with obstructive sleep apnea: a systematic review. *Braz J Otorhinolaryngol* 2015;81(4):439–46.
- [79] Yegün Y, Çelik M, Kaya KH, et al. Comparison of drug-induced sleep endoscopy and Müller's maneuver in diagnosing obstructive sleep apnea using the VOTE classification system. *Braz J Otorhinolaryngol* 2017;83(4):445–50.
- [80] Jung AR, Koh TK, Kim SJ, et al. Comparison of level and degree of upper airway obstruction by Müller's maneuver and drug-induced sleep endoscopy in obstructive sleep apnea patients. *Auris Nasus Larynx* 2017;44(5):571–5.
- [81] Koutsourelakis I, Safiruddin F, Ravesloot M, et al. Surgery for obstructive sleep apnea: sleep endoscopy determinants of outcome. *Laryngoscope* 2012;122(11):2587–91.
- [82] Op de Beeck S, Dieltjens M, Verbruggen AE, et al. Phenotypic labelling using drug-induced sleep endoscopy improves patient selection for mandibular advancement device outcome: a prospective study. *J Clin Sleep Med* 2019;15(8):1089–99.
- [83] Amos JM, Durr ML, Nardone HC, et al. Systematic review of drug-induced sleep endoscopy scoring systems. *Otolaryngol Head Neck Surg* 2018;158(2):240–8.
- [84] Dijemeni E, D'Amone G, Gbati I. Drug-induced sedation endoscopy (DISE) classification systems: a systematic review and meta-analysis. *Sleep Breath* 2017;21(4):983–94.
- [85] Kezirian EJ, Hohenhorst W, de Vries N. Drug-induced sleep endoscopy: the VOTE classification. *Eur Arch Otorhinolaryngol* 2011;268(8):1233–6.
- [86] Altıntaş A, Yegin Y, Çelik M, et al. Interobserver consistency of drug-induced sleep endoscopy in diagnosing obstructive sleep apnea using a VOTE Classification System. *J Craniofac Surg* 2018;29(2):e140–3.
- [87] Hong SD, Dhong H-J, Kim HY, et al. Change of obstruction level during drug-induced sleep endoscopy according to sedation depth in obstructive sleep apnea. *Laryngoscope* 2013;123(11):2896–9.
- [88] Park D, Kim J-S, Heo SJ. The effect of the modified Jaw-Thrust Maneuver on the depth of sedation during drug-induced sleep endoscopy. *J Clin Sleep Med* 2019;15(10):1503–8.
- [89] Vonk PE, Uniken Venema JAM, Hoekema A, et al. Jaw thrust versus the use of a boil-and-bite mandibular advancement device as a screening tool during drug-induced sleep endoscopy. *J Clin Sleep Med* 2020;16(7):1021–7.
- [90] Koutsourelakis I, Kontovazianitis G, Lamprou K, et al. The role of sleep endoscopy in oral appliance therapy for obstructive sleep apnea. *Auris Nasus Larynx* 2021;48(2):255–60.

- [91] Strollo PJ, Soose RJ, Maurer JT, et al. Upper-airway stimulation for obstructive sleep apnea. *N Engl J Med* 2014;370(2):139–49.
- [92] Jacobowitz O. Surgical reconstruction of the upper airway for obstructive sleep apnea. *Dent Clin North Am* 2012;56(2):453–74.
- [93] Vroegop AV, Vanderveken OM, Boudewyns AN, et al. Drug-induced sleep endoscopy in sleep-disordered breathing: report on 1249 cases. *Laryngoscope* 2014;124(3):797–802.
- [94] Giles TL, Lasserson TJ, Smith BJ, et al. Continuous positive airways pressure for obstructive sleep apnoea in adults. *Cochrane Database Syst Rev* 2006;(1):CD001106.
- [95] Wong SJ, Luitje ME, Karelsky S. Patterns of obstruction on DISE in adults with obstructive sleep apnea change with BMI. *Laryngoscope* 2021;131(1):224–9.
- [96] Torre C, Liu SY, Kushida CA, et al. Impact of continuous positive airway pressure in patients with obstructive sleep apnea during drug-induced sleep endoscopy. *Clin Otolaryngol* 2017;42(6):1218–23.
- [97] Civelek S, Emre IE, Dizdar D, et al. Comparison of conventional continuous positive airway pressure to continuous positive airway pressure titration performed with sleep endoscopy. *Laryngoscope* 2012;122(3):691–5.
- [98] Pilaete K, De Medts J, Delsupehe KG. Drug-induced sleep endoscopy changes snoring management plan very significantly compared to standard clinical evaluation. *Eur Arch Otorhinolaryngol* 2014;271(5):1311–9.
- [99] Lim J, Lasserson TJ, Fleetham J, et al. Oral appliances for obstructive sleep apnoea. *Cochrane Database Syst Rev* 2006;(1):CD004435.
- [100] Rotenberg BW, Murariu D, Pang KP. Trends in CPAP adherence over twenty years of data collection: a flattened curve. *J Otolaryngol Head Neck Surg* 2016;45(1):43.
- [101] Mulholland GB, Jeffery CC, Ziai H, et al. Multilevel palate and tongue base surgical treatment of obstructive sleep apnea: a systematic review and meta-analysis. *Laryngoscope* 2019;129(7):1712–21.
- [102] Blumen MB, Latournerie V, Bequignon E, et al. Are the obstruction sites visualized on drug-induced sleep endoscopy reliable? *Sleep Breath* 2015;19(3):1021–6.
- [103] Catalfumo FJ, Golz A, Westerman ST, et al. The epiglottis and obstructive sleep apnoea syndrome. *J Laryngol Otol* 1998;112(10):940–3.
- [104] Oluwasanmi AF, Mal RK. Diathermy epiglottectomy: endoscopic technique. *J Laryngol Otol* 2001;115(4):289–92.
- [105] Salamanca F, Leone F, Bianchi A, et al. Surgical treatment of epiglottis collapse in obstructive sleep apnoea syndrome: epiglottis stiffening operation. *Acta Otorhinolaryngol Ital* 2019;39(6):404–8.
- [106] Kwon OE, Jung SY, Al-Dilaijan K, et al. Is epiglottis surgery necessary for obstructive sleep apnea patients with epiglottis obstruction? *Laryngoscope* 2019;129(11):2658–62.
- [107] Sung CM, Kim HC, Yang HC. The clinical characteristics of patients with an isolate epiglottic collapse. *Auris Nasus Larynx* 2020;47(3):450–7.