

SLEEP DISORDERS

Identification of obstructive sites and patterns in obstructive sleep apnoea syndrome by sleep endoscopy in 614 patients

Identificazione dei siti di ostruzione e dei pattern di chiusura mediante "Sleep endoscopy" in 614 pazienti affetti da sindrome delle apnee ostruttive durante il sonno

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SUMMARY

The aim of this study was to analyze and report sites and patterns of obstruction observed during sleep endoscopy in a large group of patients and suggest consequent therapeutic prescriptions. 614 consecutive patients who approached the Centre for Diagnosis and Treatment of Respiratory Sleep Disorders underwent sleep endoscopy. We used propofol to induce sleep, monitoring the value of bispectral index to evaluate the depth of sedation. For each patient, we recorded obstruction sites, obstruction patterns and the effects of the mandibular pull-up manoeuvre on both obstruction and snoring. We ascertained that, in almost all patients, the noise of snoring was generated at the oropharyngeal level. The obstruction at the oropharyngeal level, either in isolation or in combination with other structures, is far more common. The mandibular pull-up manoeuvre was effective in reducing or resolving the obstruction in a large number of patients, even though their AHI values were high. For those patients having an AHI over 15, we point out the various therapeutic indications gained from the sleep endoscopy examinations. Drug-induced (propofol) sleep endoscopy can be considered to be a safe procedure, easily practicable, valid and reliable; we therefore consider it a fundamental clinical investigation that can be essential when choosing treatment.

KEY WORDS: Sleep endoscopy • Obstructive sleep apnoea syndrome • Mandibular pull-up manoeuvre • Oral device

RIASSUNTO

Abbiamo sottoposto a Sleep Endoscopy 614 pazienti consecutivi che si sono rivolti al nostro Centro per la Diagnosi e Cura dei Disturbi Respiratori del Sonno, allo scopo di rilevare e riportare i siti ed i pattern di ostruzione osservati nel corso di questo esame in un ampio gruppo di pazienti e di riferire le relative prescrizioni terapeutiche. È stato utilizzato il propofol per indurre il sonno, controllando il valore di BIS (Bispectral Index) per valutare la profondità della sedazione; per ogni paziente sono stati riportati i siti ed i pattern di ostruzione, oltre ai risultati della manovra di avanzamento mandibolare, sia sull'ostruzione che sul russamento. Abbiamo rilevato che in quasi tutti i pazienti il rumore del russamento era generato a livello orofaringeo. Anche l'ostruzione a livello orofaringeo, sia isolata che associata ad altre strutture è risultata di gran lunga la più comune. La manovra di avanzamento mandibolare è risultata efficace e quindi in grado di ridurre o risolvere l'ostruzione in un gran numero di pazienti, anche tra quelli con valori di AHI elevati. Per i soggetti con indice di AHI superiore a 15 vengono anche riportate le varie indicazioni terapeutiche ricavate dall'esame di Sleep Endoscopy. La Sleep Endoscopy eseguita con propofol si è dimostrata una procedura sicura, di facile realizzazione, in grado di fornire risultati validi ed affidabili; nella nostra opinione al momento si tratta di un elemento essenziale nella scelta del trattamento.

PAROLE CHIAVE: Sleep endoscopy • Sindrome delle apnee ostruttive del sonno • Manovra di avanzamento mandibolare • Oral device

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Introduction

At present, diagnosis of obstructive sleep apnoea syndrome (OSAS) is codified and fundamentally based on the results of polysomnography in conjunction with a set of other data: anamnesis, objective examination of upper airways and utilization of Epworth's sleep scale to evaluate daytime sleepiness. The breathing obstruction that oc-

curs while sleeping is the consequence of dynamic phenomena inside the upper airways, which are presumable but not foreseeable on the basis of the above-mentioned data. Muller's manoeuvre, which was introduced by Sher et al.¹ in 1985, as an attempt to simulate the obstruction events during wakefulness, has been for a long time the sole resource for the specialists who wanted to challenge the surgical approach to this pathology.

When dealing with a patient subjected to nasal continuous positive airway pressure (nCPAP), it is not important to precisely distinguish the level and the characteristic of the obstruction, since the prosthesis, if used correctly, will be effective. Knowledge of site and pattern of the obstruction (i.e. level and dynamic of obstruction) can be decisive when choosing treatments: surgical, orthodontic or a combination of the two.

As far as the site of origin of snoring is concerned, it is now almost certain that the noise is generated at the level of the palate and contiguous oropharyngeal anatomical structures; however, even in the case of simple snorers, the observation of snoring can contribute to planning treatment.

In 1991, Croft and Pringle² introduced sleep endoscopy in their practice, an endoscopic examination performed during a short term hypnotic (midazolam) induced sleep; they also proposed a grading system based on the results of the test³, which is still in use. Later, Guerin et al.⁴ reported on sleep endoscopy cases carried out by employing intravenous anaesthetic (propofol), which proved to be particularly suitable due to its pharmacokinetic characteristics. Notwithstanding a few initial doubts, mainly due to the fact that the pharmacologically-induced sleep is different from natural sleep, the validity of drug-induced sleep endoscopy (DISE) is commonly agreed upon. The main discrepancy between the two conditions consists in a different degree of oropharynx and tongue muscle relaxation and in a possible central action of the drug.

Berry et al.⁵ demonstrated the validity of this method by comparing the effects of propofol on several different types of subjects: normal, simple and apnoeic snorers, finding that none of the normal individuals became symptomatic after the injection of propofol. Furthermore, Rabelo et al.⁶ compared the polysomnography results of natural sleep to those induced by propofol in the same 15 patients. They concluded that the drug does not significantly interfere with sleep breathing aspects, although the neurological structure of sleep is partially altered (i.e. the REM phase is not reached).

We performed this examination on a large number of patients suffering from respiratory sleep troubles to determine the utility of sleep endoscopy in identifying the sites and patterns of obstruction in view of appropriate therapy.

Materials and methods

614 consecutive patients suffering from sleep breathing disorders were subjected to sleep endoscopy from 2005 to July 2011; the cohort was composed of 497 males (80.9%) and 117 females (19%) with an average age of 50.7 years (range 18 to 80) and an average body mass index (BMI) of 27.3 (range 17.8 to 47)

Before the examination, each patient was subjected to complete anaesthesiological evaluation.

During the examination, oxygen saturation, heart rate and blood pressure were monitored.

We utilized a Pentax flexible video endoscopy system with a CMOS distal sensor and a one-directional microphone positioned close to the mouth of the patient to record snoring.

All video and audio data were recorded and stored on a HHD video recorder as AVI files.

Pharmacological sleep was obtained through propofol. The choice of the drug was determined on the basis of its pharmacokinetic characteristics: short half-life, reduced accumulation in adipose tissue, absence of respiratory depression and negligible effects on muscular tone.

Our process in executing DISE consists in a first phase of induction using an infusion pump at incremental speed, and in a second phase of maintenance with possible dosage adjustments.

The process demanded continuous neurophysiological monitoring achieved through the adoption of the bispectral index (BIS), a non-invasive method which indicates sleep depth. BIS utilises sensors applied on the forehead of the patient recording an EEG tracing. The tracing is processed to give a direct measurement of the degree of sedation expressed by a whole number between 0 and 100. We noticed that BIS optimal value, when executing DISE, was between 45 and 60. As soon as an adequate degree of sedation was reached, the respiratory phenomena was observed.

During the examination, (usually in its initial phase), probable central apnoeas might be noticed; they were characterized by the absence of respiratory chest-abdominal movements that could be revealed by laying a hand on the patient's abdomen.

When snoring or obstructive apnoeas appeared, the observation could usefully be started. In most cases, at the end of each apnoeic episode, an *arousal* phase occurred; this is a rapid solution of the obstruction associated with the restart of snoring and the much slower increment of oxygen values. During sleep endoscopy it is important to be able to achieve the minimum oxygen saturation values reported in polysomnography in order to confirm the validity of the observation so as to reflect the spontaneous sleep condition.

During the examination, while the respiratory space was at its minimum, we performed the *mandibular pull-up* (MPU) manoeuvre, which is capable of predicting the effectiveness of a jaw propulsion oral device (OD). The manoeuvre consists of moving the jaw forward by 6-8 mm, pulling-up the lower dental arch, but avoiding to reach the articular unblock. By doing so, it was possible to evaluate the increase in the air space of the areas under examination while breathing improved or snoring disappeared. Through a continuous EEG recording in the 10 first patients under examination, we noticed that such a manoeuvre did not cause changes of the graph indicating

the rise of an arousal consequent to the manoeuvre itself. The examination results, which were agreed upon with a second specialist who witnessed the procedure were analytically described in the operating minutes and in the discharge letter, then classified on the basis of the *nose, oropharynx, hypopharynx, larynx* (s.e.NOHL) formula proposed by Vicini ⁸.

When presenting the results, we thought it appropriate to only take into account the complete obstruction. This choice was based on the consideration that a partial obstruction was not relevant enough to influence the choice of therapy.

Results

The 614 patients subjected to DISE were divided into 2 groups based on the severity of their disease:

The first group with patients having AHI values <15 (mean AHI = 7.7 range 0.4 to 14.1) was made up of 199 patients (32.4% of the total); 140 patients were males (70.4%) while 59 were females (29.6%); the mean age of this group was 48 years and the mean BMI was 26.

The second group with patients having AHI values > 15 (mean AHI = 38.6 range 15 to 99) was composed of 415 patients (67.6% of the total); 357 patients were males (86%) while 58 were females (14%). The mean age of this group was 52 years and the mean BMI was 28.

Table I reports obstruction levels and patterns, both for

isolated and multiple levels, observed in patients with an AHI <15. In this group, the MPU manoeuvre was effective on the obstruction in 170 of 178 (95.5%) patients, excluding the 21 cases without any localized obstruction (snorers).

Table II reports the obstruction levels and patterns in patients with an AHI >15. Among these patients, the mandibular pull-up manoeuvre was successful at least at one obstruction level in 316 patients (76.1%).

In the first group of patients (AHI < 15), the main problem was represented by snoring, rather than breathing problems, and therefore the choice of the treatment was dictated by the need to solve this problem. We mostly practiced oropharyngeal surgery and/or O.D. excluding nCPAP and major surgery.

For 415 patients of the second group, comprising those with an AHI > 15, the following treatments were given (Table III). In the choice of treatment in this group of patients we usually considered the following guidelines:

- In serious cases with very high AHI values and/or high BMI nCPAP was confirmed except when MPU manoeuvre was really effective at each level; in these cases we prescribed an oral device.
- Multiple obstruction cases with MPU manoeuvre ineffective at the hypopharyngeal level were addressed to nCPAP.
- When MPU manoeuvre was effective at both levels we usually preferred an O.D.

Table I. Levels and patterns of obstruction in patients with an AHI < 15.

	Obstruction	Sites of obstruction
		No Obstruction 21 (10.5 %)
199 PATIENTS 32.4%	Monolevel 122 (61.3%)	O 113 (92.6%) H 5 (4.1%) L 4 (3.3%)
	Multilevel 56 (28.2%)	O + H 49 (87.5%) O + L 7 (12.5%)

O = oropharynx; H = hypopharynx; L = larynx

Table II. Levels and patterns of obstruction in patients with an AHI > 15.

	Obstruction	Sites of obstruction
		Monolevel 193 (46.5%)
415 Patients 67.6%	Multilevel 222 (53.5%)	2 levels 203 (91.5%) O + H 172 (77.5%) O + L 27 (12.2%) H + L 4 (1.8%)
		3 levels 19 (8.5%) O + H + L 19 (8.5%)

O = Oropharynx; H = Hypopharynx; L = Larynx

Site of obstruction (alone or in association)	Pattern of obstruction
Oropharynx 169 Patients 94.9%	Antero-posterior 43.4%
	Latero-lateral 2.6%
	Circular 54%
Hypopharynx 54 Patients 30.3%	Antero-posterior 76%
	Latero-lateral 12%
	Circular 12%

Site of obstruction (alone or in association)	Pattern of obstruction
Oropharynx 401 Patients 96.6%	Antero-posterior 37.2%
	Latero-lateral 7.2%
	Circular 55.6%
Hypopharynx 203 Patients 48,6%	Antero-posterior 45.7%
	Latero-lateral 32.6%
	Circular 21.7%

Table III. Therapies administered in patients with an AHI >15.

147 nCPAP (35.5%)
109 Oral Device (O.D.) (26.4%)
104 Oropharyngeal surgery (with or without tonsillectomy)+ O.D. (25%)
30 Oropharyngeal surgery (with or without tonsillectomy) (7%)
3 Tonsillectomy (0.7%)
1 Epiglottoplasty(0.35%)
4 Epiglottoplasty + O.D. (1%)
4 Epiglottoplasty + UP3 (0.35%)
12 Weight loss (2.7%)
1 TORS (0.35%)

- The combination of oropharyngeal surgery (with or without tonsillectomy) and O.D. was the choice when the MPU manoeuvre was effective only at the hypopharyngeal level
- In young patients with a large tonsillar mass (grade 3-4), we performed only tonsillectomy
- When reduction of snoring noise was fundamental for the patient, we preferred oropharyngeal surgery even when the MPU manoeuvre was effective on obstruction
- In the presence of oropharyngeal and laryngeal obstruction, the treatment was surgery for both levels when nCPAP was refused.

In the choice of treatment, we had to consider also that in Italy, an oral device is not refused by National Health Care Service, while nCPAP and surgery are.

Discussion

On the basis of our experience, a close look at BIS data and clinical observation of the sedation progress permits achieving a stable sleep state, to best obtain reliable data, without necessarily applying target controlled infusion. (TCI) ⁷. We believe that the s.e.NOHL formula as modified by Vicini ⁸ can be considered a valid solution for the synthetic survey of the results, inasmuch as it contains all fundamental data. In our practice, we add information about the effectiveness of the MPU manoeuvre.

We accepted, for further simplification, the hypothesis suggested by some authors to consider the hypopharyngeal level as the lower (retro-lingual) segment of the oropharynx. Particular attention was given to the distinction

between primary obstruction due to epiglottis collapse, from laryngeal obstruction consequent to the fall of the tongue base, in consideration of several therapeutic implications.

The most significant finding our research led to is that oropharyngeal obstruction widely prevails on the other areas; in fact, it is present in 96% of all cases, alone (50% of cases) or in association with other obstruction areas when facing with multiple obstructions. Isolated hypopharyngeal obstruction seems to be rare (2.2%), while specific single obstruction due to the epiglottis is exceptional. These data are only partially in accordance with those published by other authors (Table IV); the disagreements are mainly due to the fact that the cases considered in the different studies were not homogeneous, especially considering severity of disease.

The obstruction pattern is an important component of each single level and provides fundamental information when choosing treatment, especially when surgical. DISE has earned substantial importance since this is the only technique that is able to characterize the obstruction dynamics; Muller's manoeuvre has not proven to be as reliable. Campanini et al. ¹³, in their 2010 publication, ascertained a disagreement in 76% of cases between the Muller's manoeuvre and sleep endoscopy data as far as the obstruction is concerned, especially at the hypopharyngeal level; another 49% disagreement of the kind of the obstruction, and a tendency to overestimate the antero-posterior pattern were noticed. Moreover, this manoeuvre does not permit to observe possible obstruction at the laryngeal level, which occurred in 7.4% of our cases. At the oropharyngeal level, the circular pattern was present in more than half of patients (54% of subjects with mild pathology and in 55.6 % of patients with moderate to serious pathology). We must remember that, at this level, the obstruction pattern is notably influenced by the presence, especially when voluminous, of the palatine tonsils. In fact, a latero-lateral pattern can be observed almost exclusively in patients affected by grade 2-3 tonsillar hypertrophy. In addition, at both levels, but mostly at the hypopharyngeal level, when the intensity grew worse, the antero-posterior pattern frequency was reduced in favour of the circular pattern.

At the hypopharyngeal level, if the indication was OD, the pattern was irrelevant since it was verified that MPU was

Table IV. Comparison of sites of obstruction in literature.

	No obstruction	Monolevel obstruction		Total	Multilevel obstruction
		Palate	Tongue/hypopharyngeal		
Present study (n = 614)	23 (3.7%)	296 (48.2%)	15 (2.9%)	311 (51.1%)	278 (45.2%)
Hamans study ⁹ (n = 70)	4 (5.5%)	23 (31.9%)	20 (27.8%)	43 (59.7%)	23 (31.9%)
Hessel study ¹⁰ (n = 340)		74 (21.7%)	8 (2.4%)	82 (24.1%)	205 (60.3%)
Quinn study ¹¹ (n = 50)		35 (70%)	4 (8%)	369 (78%)	11 (22%)
Pringle study ³ (n = 70)		33 (47.1%)	9 (13%)	42 (60%)	28 (40%)
Carrasco study ¹¹ (n = 51)		33.20%	7.80%	41%	59%

effective in all types of obstruction. Moreover, the MPU manoeuvre was particularly effective to solve obstruction in patients with an AHI index < 15 (95.5%).

As already described by Battagel et al.¹⁴, the MPU manoeuvre was often effective even in those obstructions at the oropharyngeal level, not only in those at the tongue base. This was probably due to an indirect traction mechanism on front pillars, in the absence of a true anatomical obstruction such as that represented by a large tonsillar mass. Even in those cases in which the manoeuvre was effective on “simple” snorers (28.5%), the mechanism probably was the same.

In addition, we observed that in the second group of seriously-affected patients the effectiveness of the MPU manoeuvre decreased, although in many cases it could be considered successful, at least at the hypopharyngeal level (76%). This result is predictable if we take into consideration that the mandibular pull-up manoeuvre is effective in enlarging the antero-posterior diameter of the upper airways. It should be kept in mind that, even if rarely, MPU can worsen breathing because of the appearance of an obstruction at the epiglottal level.

Conclusions

We confirm that DISE is a safe procedure, easily practicable, and is valid and reliable, as already reported in other publications. Although we are aware that the conditions of the examination do not fully correspond to those that occur during physiological sleep, we believe that it is presently the most rational method to observe the phenomenon of snoring and the obstruction in its dynamism while sleeping. Though this procedure is well accepted by patients who easily understand its usefulness, we feel that this examination, when dealing with simple snoring, can be avoided, at least initially. In fact, we ascertained that in all patients the noise of snoring as such, in that it disturbs his/her partner, is generated at oropharyngeal level (soft palate, tonsils, lateral pharyngeal walls). Other kinds of noises, possibly originating by other structures like hypopharyngeal walls or epiglottis, when present, only achieve modest levels of sound poignancy and do not seem strong enough to disturb his/her partner.

Certainly there is a clear indication for DISE when expecting significant surgical intervention and in the analyses of therapeutic failures. The information that can be obtained during sleep endoscopy from the MPU manoeuvre is invaluable for its ability to predict the efficacy of treatment, and only through this manoeuvre is it possible to identify those individuals for whom the application of an OD might be ineffective or worsen the condition.

One limit of the method is represented by the difficulty to gain a valid systematization of the parameters observed. To overcome the inevitable subjectivity of the examiner, it would be desirable to command either numeric values

or graphics to better specify the sites of obstruction and especially its pattern.

The identification of such elements would undoubtedly be useful in understanding this diagnostic technique and, furthermore, would produce a better standardization of the data, which is fundamental when evaluating therapeutic outcomes.

The results of our study confirm that DISE is a basic clinical element and can be an important test for the choice of the treatment; it is likely to become increasingly relevant over time as OSAS surgery continues to evolve. Our intention at present is to verify the appropriateness of our therapeutic indication on the basis of the results of the treatment.

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