Tongue peak pressure: a tool to aid in the identification of obstruction sites in patients with obstructive sleep apnea/hypopnea syndrome

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Abstract

Purpose of this study was to evaluate whether tongue peak pressure measured using the Iowa Oral Performance Instrument is correlated with the topographic site of obstruction in patients with obstructive sleep apnea/hypopnea syndrome observed during drug-induced sleep endoscopy. Thirty-five consecutive adult patients (29 men, 6 women) were prospectively enrolled after having been diagnosed with severe obstructive sleep apnea/hypopnea syndrome by polysomnography. An apnea−hypopnea index > 30 was confirmed, and age, gender, and body mass index were recorded by Epworth Sleepiness Scale questionnaire, and a thorough evaluation of the upper airway by video-flexible endoscopy. Twenty healthy controls according to age and sex were chosen for IOPI measurements. After drug-induced sleep endoscopy, a topographic diagnosis was done using the VOTE classification. Tongue and lip peak pressures were both measured using the Iowa Oral Performance Instrument in all patients and in 20 healthy controls. Main outcomes and measures: the correlations between office findings, Iowa Oral Performance Instrument measures, and the VOTE tongue classification during drug-induced sleep endoscopy (T0, T1, T2) were then investigated.

Results

The average Iowa Oral Performance Instrument tongue and lip pressure were 44.02 ± 12.29 and 15.03 ± 3.71 kPa, respectively. The Iowa Oral Performance Instrument scores were both significantly lower than values in healthy controls ($P < 0.001$). The VOTE classification referring to the tongue position was T0 in 13 cases (37.1%), T1 in 12 cases (34.3%), and T2 in 10 cases (28.6%). A significant correlation was found between the Iowa Oral Performance Instrument tongue pressure and the T size during drug-induced sleep endoscopy (Kruskal−Wallis χ^2 25.82; $P \leq 0.001$).

Conclusions

In our experience, the Iowa Oral Performance Instrument is a useful tool for evaluating tongue collapse for the topographic diagnosis of patients with obstructive sleep apnea/hypopnea syndrome.

Keywords Tongue peak pressure · Sleep apnea · Drug-induced sleep endoscopy

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Introduction

Clinical otolaryngological examination of awake patients with obstructive sleep apnea/hypopnea syndrome (OSAHS) helps to evaluate the site of the obstruction in the upper airway (UA). However, the clinical findings do not always correlate with the anatomical sites of the obstruction [1, 2]. An obstruction located in the hypopharynx and in the tongue is difficult to examine in the office and impedes the prediction of the results of a potential tongue surgery in up to 40% of patients [2].

Drug-induced sleep endoscopy (DISE) has become a very useful tool for the evaluation of obstruction sites in patients with OSAHS [3]. DISE is a UA evaluation technique that uses pharmacological agents for sedation to obtain a target depth of sedation similar to natural sleep, allowing a careful endoscopic evaluation of the UA [4]. Once DISE is performed, the results are recorded, collected, and classified [5]. However, no consensus has been reached regarding how to report DISE findings. Currently, the most widely accepted method is the VOTE classification, which evaluates and scores the degree of collapse during DISE at the level of the velum, the oropharyngeal lateral walls, the tongue, and the epiglottis. The degree of obstruction is expressed as a number for each structure as follows: 0, no obstruction (no vibration); 1, partial obstruction (vibration); 2, complete obstruction (collapse); and X, not visualized [5].

DISE is an expensive procedure as it requires anesthetic facilities and constant monitoring. DISE reports typically include multilevel collapse that may overdiagnose sites of obstruction and induce unnecessary surgical techniques [6].

Eckert [7] reported different phenotypes in patients with OSAHS, among which, poor UA muscle effectiveness is an important phenotype that may result from poor coordination of the neural drive to the various UA muscles during sleep [8, 9], mechanically inefficient muscle fiber orientation (due to excess fat or muscle hypertrophy) [10, 11], or muscle fiber type changes resulting in greater propensity for fatigue [10].

Recently, Villa et al. [11] reported that increasing the tongue tone using myofunctional therapy can be a useful tool to treat sleep-disordered breathing (SDB). In their study, they used the Iowa Oral Performance Instrument (IOPI) to measure tongue tone in children with SDB during an office examination. They concluded that IOPI scores were significantly lower in children with SDB than in healthy controls.

We hypothesized that tongue strength as measured by the IOPI in adult patients with OSAHS during an awake examination would be correlated with the anatomical findings obtained by DISE. We also aimed to investigate whether tongue and lip strength were correlated in patients with OSAHS and to compare the results with healthy controls.

Materials and methods

This multicenter prospective study was approved by the Ethics Committee of the Consejería de Salud de la Junta de Andalucía (code AWGAPN-2019-01). The inclusion criteria were adult patients diagnosed with severe OSAHS by polysomnography showing an apnea−hypopnea index (AHI) > 30. The exclusion criteria were patients with previous surgery in the UA, contraindications to perform DISE (American Society of Anesthesiologists Physical Status Classification IV, allergy to propofol or midazolam, pregnancy), Tonsils grade 4, and UA malformation (i.e., significant tongue tie). All patients gave informed consent.

Thirty-five consecutive patients with OSAHS (29 men and 6 women) were recruited. Age, sex, and body mass index (BMI) were recorded. The study protocol included an extensive medical history with an Epworth Sleepiness Scale (ESS) questionnaire and a thorough evaluation of the UA with video-flexible endoscopy that was performed at the ENT office and included tonsil size grading using the Friedman staging system for OSAHS and the Friedman tonsil position [12]. The frenulum function was assessed using the Marchesan protocol [13].

DISE was performed following the European position paper protocol [14]. The videos of the procedure were recorded and then evaluated by three experienced surgeons blinded to the procedure. The results are reported as means when evaluations were in accord. When the three results were not in accord, the worst classification was reported using the VOTE [5] classification system. The tongue position was evaluated as follows: T0, no obstruction (no vibration); T1, partial obstruction (vibration); T2, complete obstruction (collapse); and X, not visualized.

The IOPI (model 2.1; IOPI Medical LLC, Carnation, WA) was used to measure the variables related to tongue function. The IOPI is a portable tool that measures the amount of pressure exerted on a small air-filled bulb. The pressure (kPa) obtained is digitally displayed on an LCD panel on the instrument. A series of LED lights representing percentages in 10% increments of a manually set pressure baseline acts in combination with a build-in timer to measure endurance. As an instrument that measures tongue function, the IOPI has been utilized in a several published experiments [15] and has high inter- and intra-judge reliability [16].

To ensure accurate measurement, calibration was checked and adjusted, if necessary, prior to obtaining measurements from each participant. A new bulb was used for every participant because of hygienic concerns and to minimize measurement errors due to possible compliance variations of the bulb after extended use. The IOPI objectively measures maximum tongue and lip strength. Tongue strength was assessed by measuring the maximum pressure exerted when an individual pressed a disposable, standard-sized tongue bulb against the

Table 1 Summary of variables analyzed

Sex	6 women 29 men
Age	40.6 ± 14.25 years
BMI	26.5 ± 3 kg/m^2
Epworth	15.6 ± 4.1
IAH	37.9 ± 12
O_{2min}	79.9 ± 8.3
IOPI tongue	44.01 ± 12.2 kPa
IOPI lip	15.05 ± 3.71 kPa
Friedman stage	I 4 (11.4%) II 11(31.4%) III 14(40%) IV 6(17.1%)
VOTE classification	0.13(37.1%) 1.12(34.3%) 2.10(28.6%)

BMI body mass index, *IAH* apnea-hypopnea index, *O_{2min}* minimum saturation oxygen, *IOPI* tongue (maximal tongue strength), *IOPI* lip (maximal lip strength), *kPa* kilopascal

roof of the mouth. Lip strength was assessed by measuring the maximum pressure when the bulb was located between the cheek and closed teeth, and the patient contracted the buccinator without biting the bulb. Reference values had been obtained from measurements in the population [17, 18] and were provided by the manufacturer [19].

Tongue and lip peak pressure were both measured using the IOPI in the patients with OSAHS and in 20 healthy controls. We did not use controls for DISE as it has been well demonstrated that this technique only shows sites of obstruction when an SDB is present [20].

Physicians who performed the DISE had no evidence of the results obtained from the IOPI tests.

Normal IOPI values can be found in https://iopimedical.com/normal-values .

Statistical analysis

Quantitative variables were assessed by calculating the arithmetic mean and standard deviation using a two-sample *t* test or by using a Mann–Whitney rank sum test if the variables were not normally distributed. To evaluate the correlation between IOPI and VOTE, a Kruskal–Wallis test for independent samples was used. $P < .05$ was considered significant. IBM SPSS Statistics for Windows (version 23; IBM Corp, Armonk, NY) was used for the statistical analysis.

Table 3 Lip values compared with control values

IOPI lips	Male	Female
	18.2 ± 3.2 (32 ± 3) kPa	14.2 ± 4.1 (23 ± 4) kPa

IOPI lip (maximal lip strength)

Results

The mean age and BMI of the 29 men and 6 women were 40.65 ± 14.25 years and 26.5 ± 3.4 kg/m^2, respectively. The average ESS score was 15.63 ± 4.1, the average AHI was 37.97 ± 12.8, and O_{2min} was 79.3 ± 8.3. The Friedman staging was stage I in four patients (11.4%), stage II in 11 (31.4%), stage III in 14 (40%), and stage IV in six (17.1%).

The VOTE classification referring to the tongue position was T0 in 13 cases (37.1%), T1 in 12 (34.3%), and T2 in 10 (28.6%). The average IOPI tongue and lip pressures were 44.02 ± 12.29 and 15.03 ± 3.71 kPa, respectively (Table 1). No significant differences were observed between groups when analyzed by age and sex (Tables 2 and 3).

IOPI tongue and lip pressures were significantly lower compared with standard values from healthy controls ($P <$ .00001).

A significant association was found between IOPI tongue pressure and T size during DISE (Kruskal–Wallis χ^2 25.82; $P \leq .000001$). No significant association was found between the Friedman stage, the AHI, or IOPI lip pressure when assessed by VOTE tongue classification (Figs. 1 and 2). A significant correlation was found between IOPI tongue pressure and T size during DISE ($P \leq .000001$).

A photograph of one patient using IOPI is showed in Photo 1.

Discussion

To our knowledge, this is the first study to report a correlation between tongue strength and anatomical findings during DISE in patients with OSAHS. As recently reported [11], tongue strength tone plays a significant role in the development of

Table 2 Tongue values compared with control values

IOPI tongue	20–39 years	40–60 years	> 60 years
	47.1 ± 10.2 kPa (62.4 ± 13.2)	43.2 ± 14.6 kPa (60.3 ± 11.1)	39.3 ± 6.2 kPa (55.32 ± 11.8)

IOPI tongue (maximal tongue strength), *kPa* kilopascal

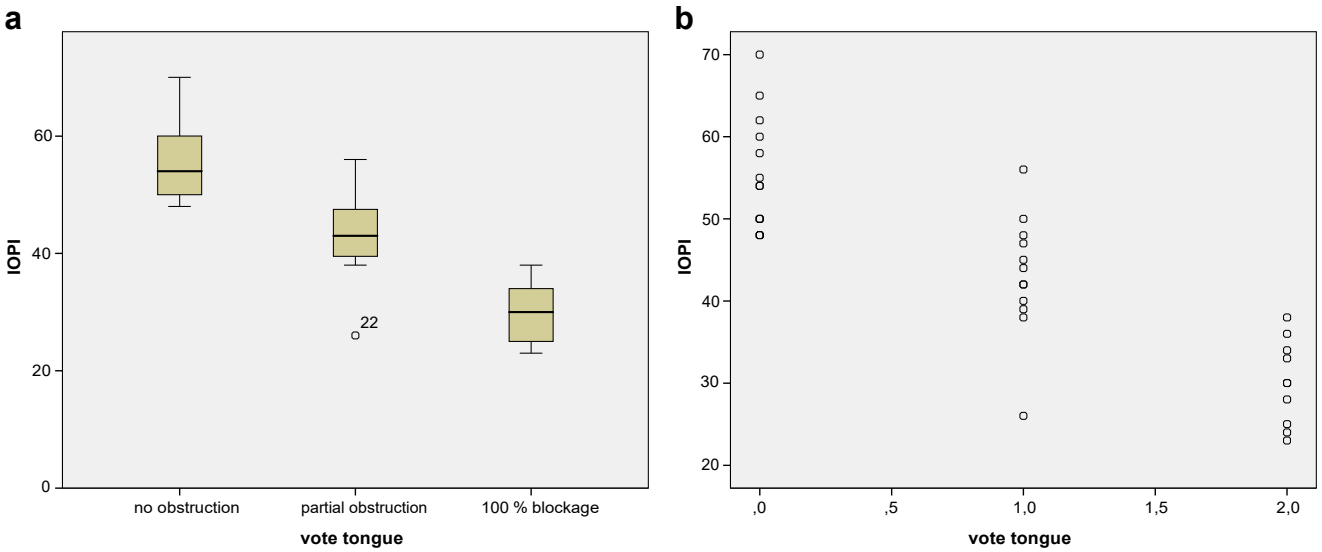

Fig. 1 Relationship between IOPI tongue strength scores and tongue VOTE classification during DISE. pa Kilo Pascals. Individual point data reflect relationship between vote tongue and IOPI

OSAHS because it is typically related to a malfunction of the dilators muscle of the UA [21].

However, most guidelines on the clinical examination [22] of patients with OSAHS do not request an evaluation of the tone of this muscle. IOPI evaluation provides great information for the examiner, who will be able to anticipate the possible site of obstruction, as demonstrated in the present study.

Additionally, as have been suggested in the phenotypic classification of these patients [23], we can provide therapeutic treatment to correct this lack of tone and also provide feedback to our patients explaining the reason of their disease and giving them a way to improve with myofunctional therapy [24]. This may develop "adherence to treatment" habits, the main pearl for therapy in OSAHS. Our investigation demonstrates that most of our patients present IOPI values significantly lower than those in the general population. We suggested that "low tone" osa phenotypic patients could be identified using this tool and should be the target to be treated with MT. [24]

Therefore, we have been using IOPI in our practice for the last 3 years, and we consider it an essential tool for the diagnosis and treatment of patients with OSAHS. It can be performed for each patient in 5 min, and accuracy of the scores remained for long time as have been previously reported [16].

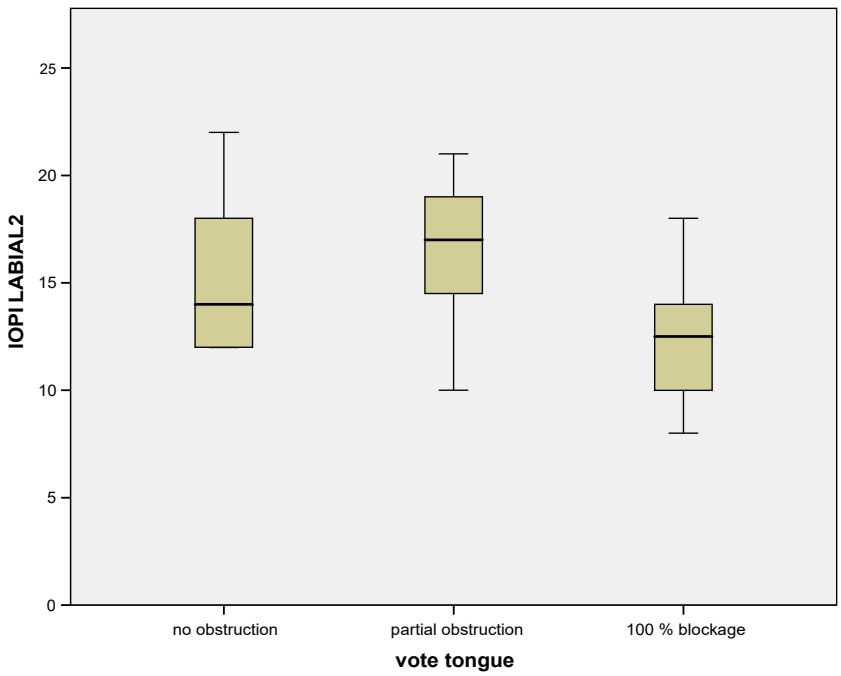

Fig. 2 Relationship between IOPI lip strength scores and vote tongue classification with DISE

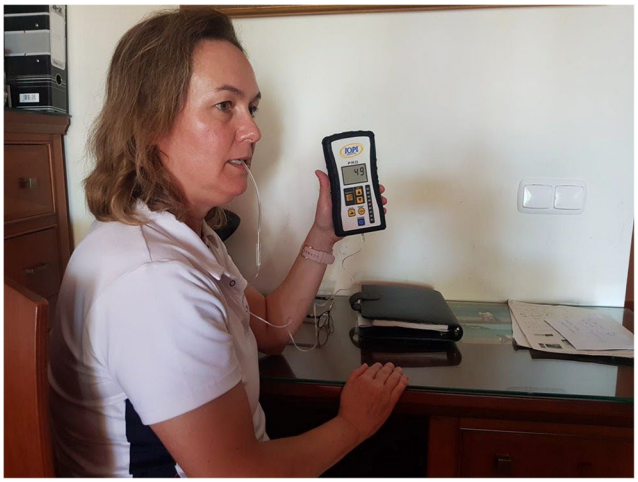

Photo 1 Patient measuring tongue strength with IOPI (permission given)

A significant finding of our investigation is that there was no correlation between the results derived from clinical examination using the Friedman stage and DISE, as has been suggested previously [12]. So, we understand all the tools that we can use to help in our diagnosis will be welcomed.

To simplify our investigation, we used only the T score in the VOTE classification. Based in our experience, we advised our patients that a high tongue peak pressure score should exclude the tongue as the site of obstruction. Low tongue peak pressure as demonstrated in this manuscript is related with the UA obstruction and can be improved using myofunctional therapy. We are performing a multicentric randomized clinical trial about this matter with results in 2020. We are studying a correlation between lip peak pressure and velum classification but due to the character concentric or anteroposterior is not so easy to show. We have identified an epiglottis collapse with a trap door epiglottis in only one case that had a T0 classification and a high tongue peak pressure score. This case had a Friedman I classification, and we anticipated that the epiglottis was the reason for OSAHS because tongue and lip peak pressure were both normal. In that case, DISE was an invaluable tool to diagnose the obstruction and IOPI could be an interesting tool to orientate the diagnosis when this test is not available.

A limitation of our study is the lack of healthy controls for whom DISE can be used to compare IOPI measurements. Nevertheless, there are several examples of UA collapse in the literature showing that it does not affect healthy people [25, 26]. Further investigations using control subjects could support our conclusions. Another limitation of our investigation is the use of DISE to diagnose tongue obstruction in our patients. As has been reported [6], DISE sometimes overdiagnoses tongue and hypopharyngeal collapses. Other publications have suggested that DISE is not such a reliable tool for obtaining predicting success of surgeries [27].

We have chosen DISE instead other diagnostic tools (CT, MRI.) because it provides a dynamic view of the obstruction site in a patient with OSAHS. We have reported recently a case [28] where DISE showed that the anatomical changes happened in a patient after treatment with a Mhealth Application Based on Myofunctional Therapy. DISE reflects the target muscles to be treated and provides a clear information to patients to start with this therapy increasing their adherence under our experience.

In the future, we plan to evaluate not only the anatomical degree of collapse of the UA in patients with OSAHS, but also the function of the tongue muscles. This information could be useful to diagnose and treat OSAHS patients.

Conclusion

In our experience, when measuring tongue peak pressure, the IOPI is a useful tool for evaluating tongue collapse for the topographic diagnosis of patients with OSAHS. The results of the present study suggest that tongue and lip peak pressure are both lower in patients with OSAHS than in healthy controls, and that tongue peak pressure is correlated with the severity of tongue collapse during DISE in patients with OSAHS.

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Dra Garcia Iriarte, Dr. De Vicente, and Dr. Casado special contribution in data collection and writing and editing assistance.

Dr. Ignacio-Garcia assisted in the translation and statistics.

Compliance with ethical standards

Conflict of interest The authors declare that they have no conflict of interest.

Ethical approval 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.

Ethical approval This work was approved by the ethical committee of the Consejería de Salud de la Junta de Andalucía, code AWGAPN-2019-01.

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