# Proposal of a Presurgical Algorithm for Patients Affected by Obstructive Sleep Apnea Syndrome

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**Purpose:** To propose an algorithm for the preoperative management of patients with obstructive sleep apnea syndrome (OSAS) and review the surgical outcomes in such patients.

**Materials and Methods:** This prospective cohort study involved 71 patients with OSAS who underwent presurgical upper airway endoscopy and cephalometry before being assigned to treatment categories based on the site(s) of obstruction, the pattern of collapse, the characteristics of the soft tissue, the air space between the base of the tongue and the posterior wall of the pharynx, and the severity of OSAS. Six months after surgery, they were followed up using polysomnography and the Epworth Sleepiness Scale. The pre- and postsurgical data were compared using a paired Student *t* test.

**Results:** The mean preoperative apnea/hypopnea index of the 71 patients (61 male and 10 female) was 40.98 events/hour (range, 14.7 to 87.6 events/hr), and the mean postoperative apnea/hypopnea index was 13.96 events/hour (range, 0 to 20 events/hr). The difference was statistically significant ($P < .001$).

**Conclusions:** This algorithm was developed on the principle that every patient with OSAS should be considered individually. In the authors' opinion, taking into account the number, site(s), pattern, and degree of the collapse/obstruction is a reasonable means of ensuring the correct diagnosis and treatment.

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Obstructive sleep apnea syndrome (OSAS) is characterized by repetitive episodes of apnea/hypopnea during sleep, which are responsible for abrupt awakenings and a disrupted sleep microarchitecture. The obstructive episodes can also lead to major systemic complications over time, such as pulmonary and systemic hypertension, right heart failure, acute cerebrovascular accidents, ischemic heart disease, and arrhythmias. Furthermore, fragmented sleep can have major repercussions on daytime activities owing to sleepiness, fatigue, and mental disturbances and increase the risk of traffic and working accidents.[1,2]

During sleep, patients with OSAS develop a negative pharyngeal transmural pressure that causes upper airway collapse. The caliber of the upper airway is smaller in patients with OSAS because of the effects of chronic snoring on the pharyngeal soft tissue (swelling and chronic inflammation), the deposition of adipose tissue in the throat area, and skeletal abnormalities (micrognathia and mandibular hypoplasia). The obstruction can occur at any level: the most frequently affected sites are the retropalatal and retrolingual regions (isolated nasal narrowing is not responsible for the genesis of the disorder), and there is frequently more than 1 site of collapse.[3-6]

The treatment of choice is continuous positive airway pressure during sleep, which expands the

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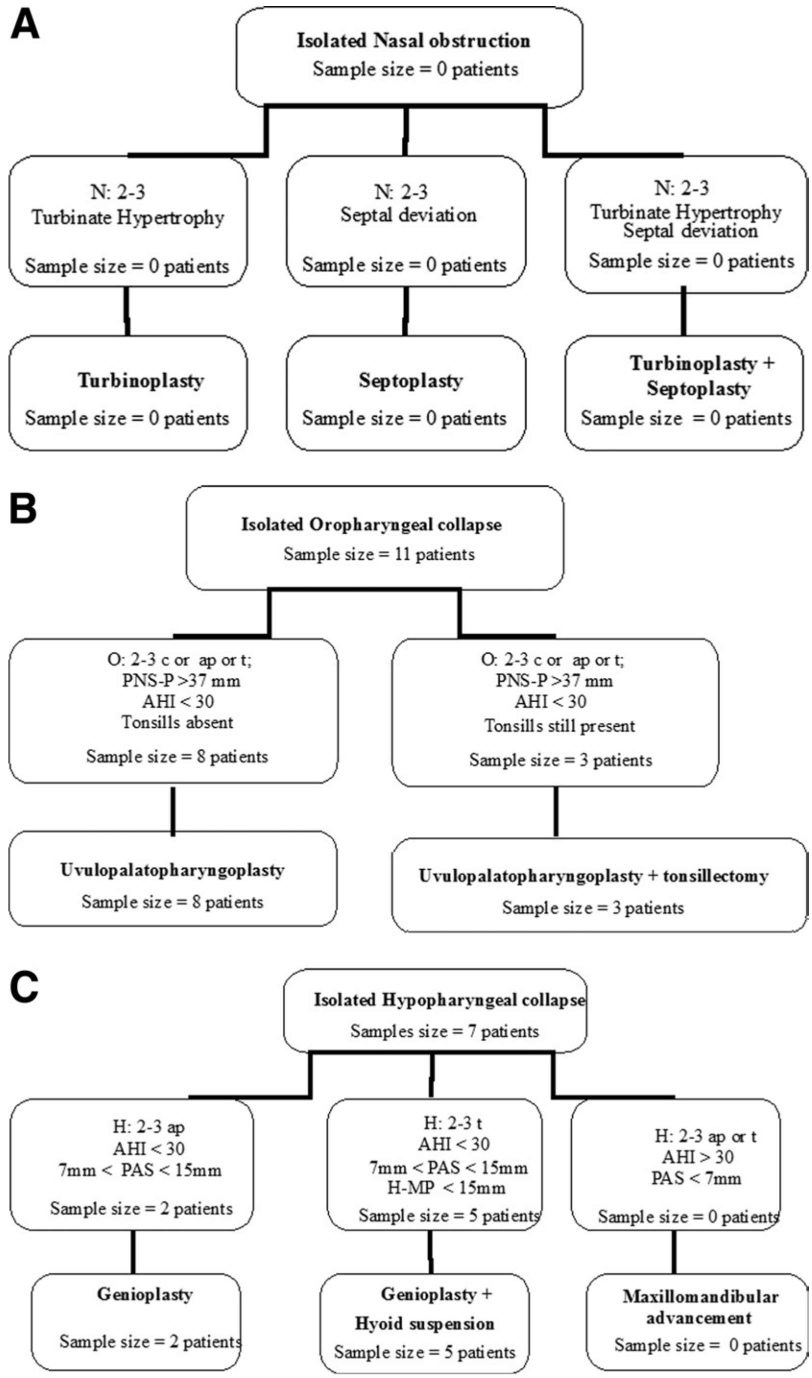


**FIGURE 1.** *A to G,* Preoperative algorithms, with 2 examples to facilitate reading. *A,* For an isolated grade 2 to 3 nasal obstruction, the authors recommend turbinoplasty if the turbinates are hyperplastic, septoplasty for a septal deviation, and turbinoplasty plus septoplasty for a septal deviation and turbinate hypertrophy. *B,* For an isolated grade 3 to 4 circular, anteroposterior, or transversal oropharyngeal collapse identified by endoscopy, with an increased distance from the posterior nasal spine to point P (>37 ± 3 mm), the authors recommend an isolated uvulopalatopharyngoplasty in the absence of tonsils or uvulopalatopharyngoplasty with tonsillectomy if the tonsils are present. AHI, apnea/hypopnea index; ap, anteroposterior; c, circular; H, hypopharynx; H-MP, distance from hyoid bone to mandibular plane; N, nose; O, oropharynx; PAS, posterior airway space; PNS-P, distance from posterior nasal spine to point P; SNA, sella-nasion-point A; SNB, sella-nasion-point B; t, transversal; UPPP, uvulopalatopharyngoplasty.

*Giarda et al. Presurgical Algorithm for OSAS. J Oral Maxillofac Surg 2012.*

pharyngeal lumen in all directions and prevents upper airway collapse, thus leading to major benefits in morbidity and quality of life.[7-10] The described side effects (a feeling of choking, dry mouth, conjunctivitis, rhinitis, pressure ulcers, and bloating) are not serious and can be easily managed. However, the problem with ventilation therapy is poor compliance, because patients find the mask

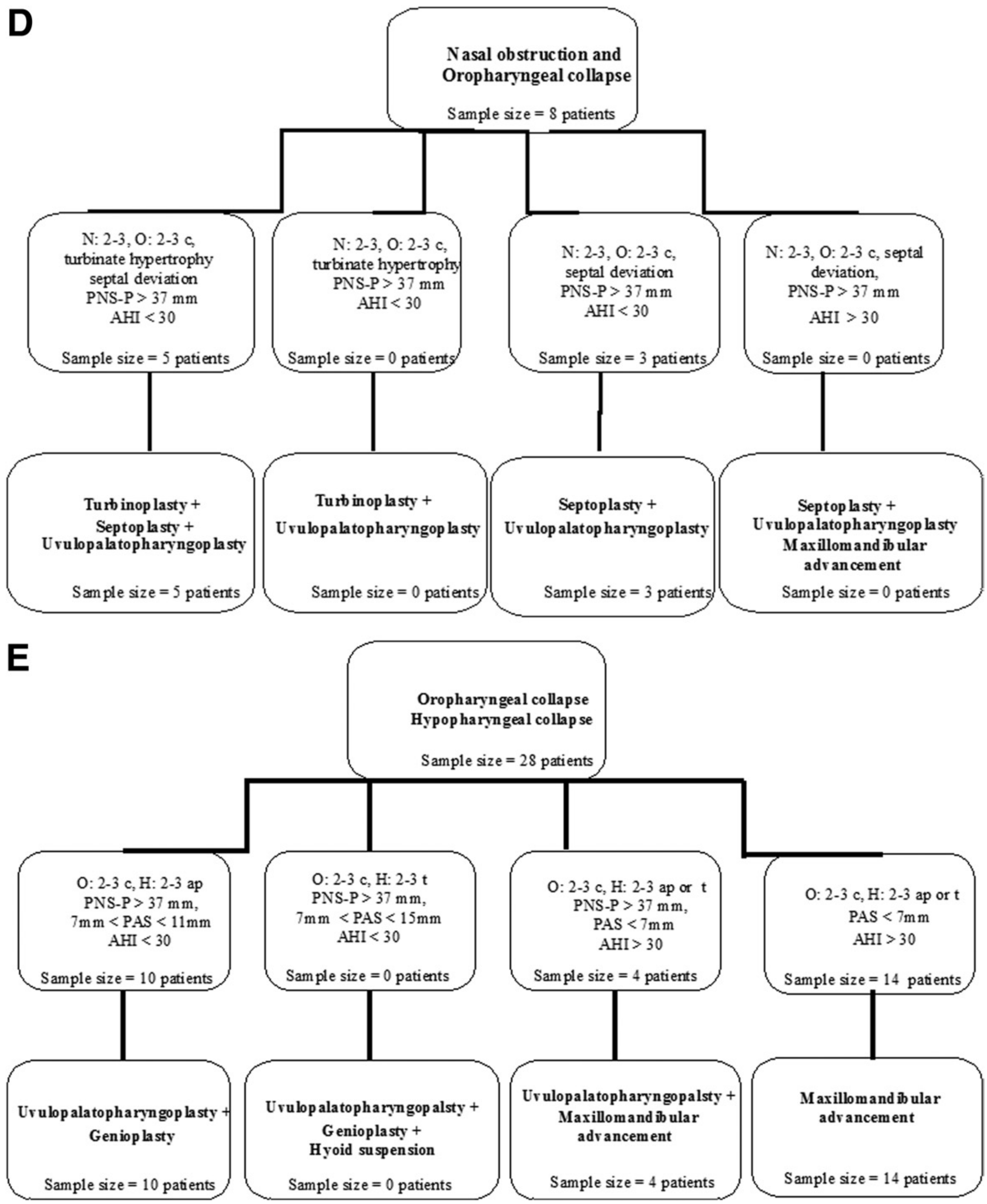


**FIGURE 1.** (continued)

*Giarda et al. Presurgical Algorithm for OSAS. J Oral Maxillofac Surg 2012.*

cumbersome and annoying to use every night for a lifetime.[11] Consequently, surgery is emerging as a possible treatment option, with the goal of removing the cause of the obstruction.[12-15]

The aim of this study was to formulate a preoperative diagnostic algorithm for patients with OSAS based on the 3 potential sites of upper airway obstruction: the nose, oropharynx, and hypophar-

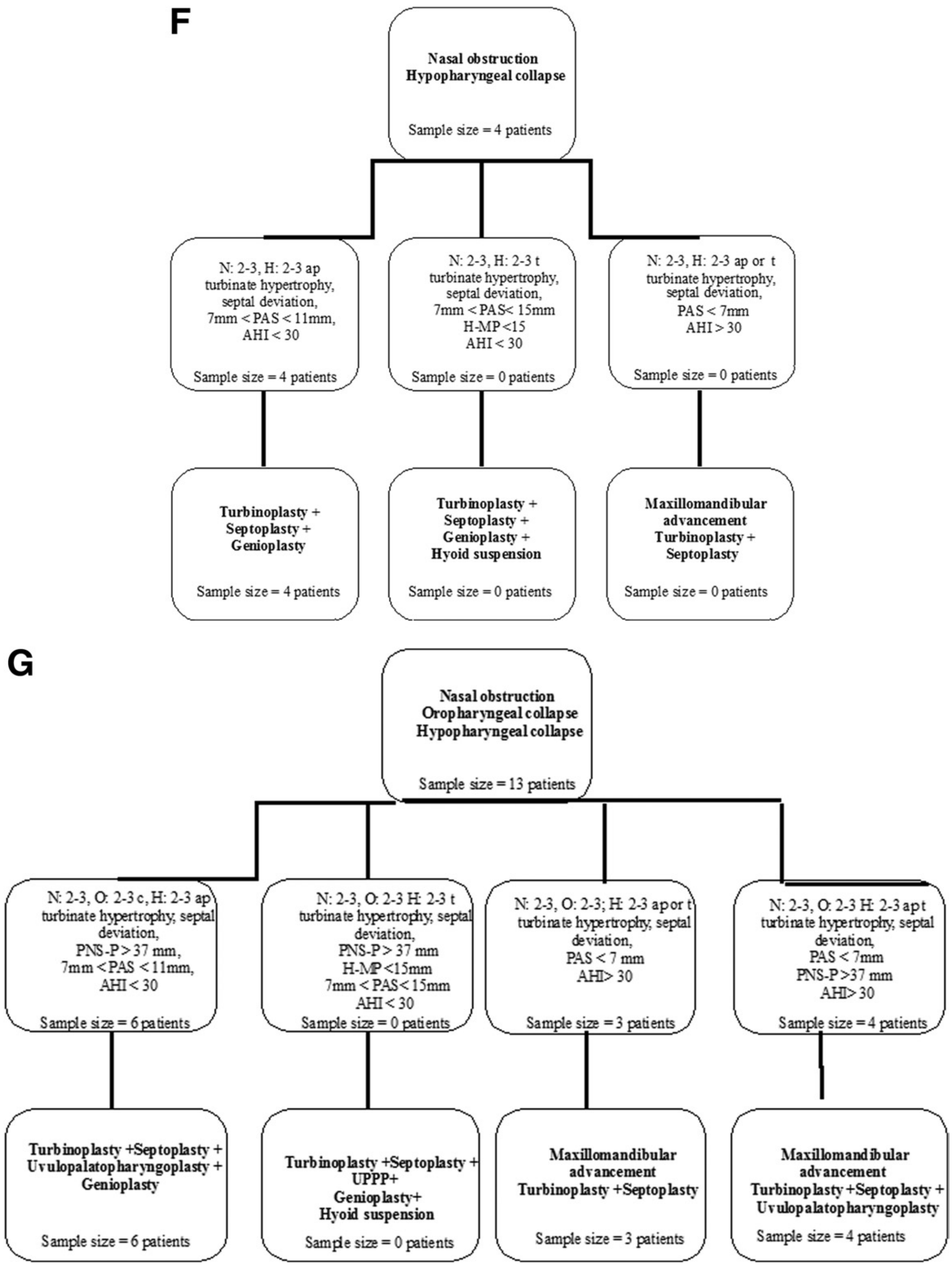


**FIGURE 1.** (continued)

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**Table 1. ENDOSCOPIC NOSE, OROPHARYNX, AND HYPOPHARYNX CLASSIFICATION**

| | |
|---|---|
| Sites of collapse | |
| N | Nose |
| O | Oropharynx |
| H | Hypopharynx |
| Pattern of collapse | |
| c | Circular |
| t | Transversal |
| ap | Anteroposterior |
| Grade of collapse | |
| 0 | No collapse/obstruction |
| 1 | Collapse <25% of pharyngeal lumen |
| 2 | Collapse 25%-50% |
| 3 | Collapse 50%-75% |
| 4 | Collapse >75% |

*Giarda et al. Presurgical Algorithm for OSAS. J Oral Maxillofac Surg 2012.*

ynx. The preoperative hypothesis was that the surgical treatment of the specific site of obstruction would lead to effective postoperative results and avoid useless treatments. The authors therefore reviewed the surgical outcomes using the pre- and postoperative apnea/hypopnea index (AHI) and the Epworth Sleepiness Scale (ESS) as clinical parameters.

## Materials and Methods

After creating a comprehensive flow chart based on the preoperative site of obstruction (Fig 1), the authors designed a prospective cohort study and enrolled patients with OSAS. The inclusion criteria were an age younger than 70 years, good general health, an intolerance to continuous positive airway pressure, and a motivation to solve the problem; the exclusion criteria were cardiovascular diseases, diabetes, and psychiatric disorders.

**Table 2. SITES OF COLLAPSE/OBSTRUCTION SHOWN BY FIBROENDOSCOPY USING THE MUELLER MANEUVER WITH THE PATIENT IN A SUPINE POSITION**

| Site(s) of Collapse/ Obstruction | Patients, n (%) |
|---|---|
| Single* | 18 (25.3) |
| Double† | 40 (56.4) |
| Triple‡ | 13 (18.3) |

*Isolated nasal obstruction, isolated oropharyngeal collapse, or isolated hypopharyngeal collapse.

†Nasal obstruction plus oropharyngeal collapse, nasal obstruction plus hypopharyngeal collapse, or oropharyngeal plus hypopharyngeal collapse.

‡Nasal obstruction plus oropharyngeal collapse plus hypopharyngeal collapse.

*Giarda et al. Presurgical Algorithm for OSAS. J Oral Maxillofac Surg 2012.*

**Table 3. SITES OF COLLAPSE/OBSTRUCTION SHOWN BY FIBROENDOSCOPY USING THE MUELLER MANEUVER WITH THE PATIENT IN A SUPINE POSITION**

| Site(s) of Obstruction/Collapse | Patients, n (%) |
|---|---|
| Isolated nasal site | 0 (0) |
| Isolated oropharyngeal site | 11 (15.5) |
| Isolated hypopharyngeal site | 7 (9.8) |
| Oropharyngeal and hypopharyngeal sites | 28 (39.5) |
| Oropharyngeal and nasal sites | 8 (11.3) |
| Hypopharyngeal and nasal sites | 4 (5.6) |
| Oropharyngeal, hypopharyngeal, and nasal sites | 13 (18.3) |

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The presurgical diagnostic algorithm involved upper airway endoscopy and cephalometry. The sites of collapse were evaluated using the endoscopic nose, oropharynx, and hypopharynx classification[16] to identify the site(s) of collapse (nose, oropharynx, and/or hypopharynx), the pattern of collapse (circular, transversal, and/or anteroposterior) and the degree of collapse (grades 0 to 4; Table 1). The cephalometric examination was performed using lateral-lateral teleradiography. Skeletal relations were evaluated by angular measurements (sella-nasion-point A and sella-nasion-point B), and the soft tissue measurements included the air space between the base of the tongue and the posterior wall of the pharynx (posterior airway space), the length of the soft palate (distance from the posterior nasal spine to point P), and the distance between the hyoid bone and the mandibular plane.[13]

Based on all the characteristics and the severity of the OSAS, the subjects were assigned to different treatments (Fig 1). The surgical procedures included septoplasty, turbinoplasty, genioplasty, maxillomandibular advancement, and uvulopalatopharyngoplasty (UPPP), associated or not with tonsillectomy and/or hyoid suspension, performed alone or in various combinations to ensure an optimal outcome for each patient.

Six months after surgery, the patients were clinically followed by polysomnography and the ESS. A paired Student *t* test was used to compare the pre- with the postsurgical AHI (apnea/hypopnea events per hour) and the pre- with the postsurgical ESS scores.

The study was approved by the institutional review board.

## Results

One hundred forty-two patients (132 male and 10 female; mean age, 50.5 yrs; age range, 35 to 70 yrs) underwent the multidisciplinary preoperative evaluation; 116 were considered suitable for surgical treatment, but 45 patients declined, so 71 patients (61 male and 10 female) were actually treated. The mean preoperative AHI was 40.98 events/hour (range, 14.7 to 87.6 events/hr), and the mean preoperative ESS score was 15 (range, 9 to 17).

Upper airway fibroendoscopy using the Mueller maneuver with the patient in a supine position identified an isolated obstruction site in 18 patients (25.3%), a double obstruction in 40 (56.4%), and a triple obstruction in 13 (18.3%; Tables 2, 3).

The mean postoperative AHI was 13.96 events/hour (range, 0 to 20.5 events/hr), and the mean postoperative ESS score was 5 (range, 0 to 7). The data were analyzed using a paired Student *t* test, which showed that the differences were statistically significant ($P < .001$).

## Discussion

The decision algorithm was developed on the principle that every patient with OSAS should be considered individually and seems to have been validated by the significant decreases in the postoperative AHI and the ESS scores.

It is widely accepted that apneic events in patients with OSAS are related to the collapse of a narrow upper airway, which is not isolated in most cases and frequently involves multiple regions. The goal of surgery is to remove the cause of the obstruction by acting on the involved sites.

The diagnostic algorithm, which is based on an upper airway endoscopic examination and a cephalometric analysis, confirmed the frequent involvement of multiple sites in 67.5% of cases (52% with 2 sites and 15.4% with 3 sites; Table 2). Based on the results of the multidisciplinary examinations, the patients were offered 1 of many treatment options (Fig 1). Nasal obstruction indicates nasal surgery (septoplasty and/or turbinoplasty; Fig 1A). However, although 35.2% of patients showed nasal involvement, none of them had an isolated nasal obstruction (septal deviation, turbinate hypertrophy) capable of generating apnea (Table 3).

Oropharyngeal collapse identified by endoscopy (grades 3 to 4) and an increase in distance from the posterior nasal spine to point P ($>37 \pm 3$ mm) at cephalometry indicate UPPP (with tonsillectomy when the tonsils are present; Fig 1B).

Hypopharyngeal collapse identified by endoscopy (grades 3 to 4) and confirmed by a decrease in posterior airway space ($<11 \pm 1$ mm) suggests genioplasty. If the collapse has a transversal pattern and is associated with a decrease in distance between the hyoid bone and the mandibular plane ($<15 \pm 3$ mm), the authors propose genioplasty and hyoid suspension in the same surgical session (Fig 1C).

Maxillomandibular advancement with or without other procedures (septoplasty, UPPP, etc) is proposed for patients with moderate or severe disease, multiple obstruction sites, or alterations in the relation of the jaws. It has positive effects for circular and transversal patterns of collapse (Fig 1C-G).

Even if it includes multiple procedures, the treatment plan is performed during the same surgical session because multiple sessions discourage the patients.

The palatal component was involved in the genesis of OSAS in 84.6% of patients, which is in line with published data indicating the pivotal role of the retropalatal region, but was isolated in only 15.5% of cases (Table 3). In patients with oropharyngeal collapse, the flaccidity of the palate causes its posterior displacement during sleep in a supine position. The hypopharyngeal components were solely responsible for OSAS in only 9.8% of cases, but were jointly involved in 73.2% (Table 3), which may explain why UPPP alone is often insufficient to control apnea. This large percentage of multiple collapse sites supports the need for therapeutic procedures selected based on an individual patient to ensure long-term success.

Upper airway fibroendoscopy during the Mueller maneuver is a simple means of morphologically analyzing the nasal cavity and the retropalatal and retrolingual regions. Although it is a subjective procedure, the use of video recordings allows the findings to be assessed and discussed by different physicians.[16]

The use of cephalometry to study OSAS in patients was introduced by Riley et al.[13] It is easy to perform, does not expose patients to a significant dose of radiation, and allows the analysis of the soft tissue and bony structures of the craniocervical region. However, it is limited because it provides only an anteroposterior view of the airway and does not show the presence of any lateral-lateral narrowing. Furthermore, because it is performed with the patient awake and standing, it does not allow any evaluation of the postural factors present during sleep.[13]

The published results of the surgical treatment of OSAS are divided into "surgical successes" and "surgical cures." Surgical success is defined as an AHI of fewer than 20 events/hour or a greater than 50% decrease in the AHI, and surgical cure is defined as an AHI of fewer than 5 events/hour.[12] The authors observed a considerable decrease in the AHI, which decreased from 40.98 to 13.96 events/hour. However, because the authors considered the results of the different surgical procedures in the same statistical analysis, a more specific and comprehensive statistical evaluation is essential.

Although the present study has the weaknesses and limitations of a descriptive report and there was no control group, the authors believe that it provides a reasonable reflection of the usefulness of the present standard diagnostic flow chart for patients with OSAS, which was developed by a multispecialty team of otorhinolaryngologists, pulmonologists, maxillofacial surgeons, and anesthesiologists, allows an integrated approach, and allows the targeting of a specific surgical procedure to an individual case.

OSAS has a multifactorial etiology/pathogenesis and requires a multidisciplinary approach to reach a correct diagnostic definition. The authors believe that the preoperative evaluation of patients with OSAS using a comprehensive diagnostic algorithm that takes into account the different sites of obstruction is a reasonable means of simplifying the complex presurgical approach to OSAS. However, further prospective clinical studies, possibly associated with more sophisticated clinical and radiologic parameters, are necessary to refine it.

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