OSAHS

Treatment of primary epiglottis collapse in OSA in adults with glossoepiglottopexy: a 5-year experience

Glossoepiglottopessia per il collasso epiglottico primario negli adulti affetti da OSA: esperienza quinquennale

Marco Fragale1,1, Claudio Sampieri1,2, Gregorio Santori2, Caterina Tripodi3, Francesco Missale1,5, Valeria Roustan6, Fabiola Incandela7, Marta Filauro1,2,8, Andrea Marzetti1, Giorgio Peretti1,2, Marco Barbieri1,2

1 Unit of Otolaryngology, Head and Neck Surgery, IRCCS Ospedale Policlinico San Martino, Genoa, Italy; 2 Department of Surgical Sciences and Integrated Diagnostics (DISC), University of Genova, Genoa, Italy; 3 Department of Medical and Surgical Sciences and Advanced Technologies “GF Ingrassia”, ENT section, University of Catania, Catania, Italy; 4 Department of Otorhinolaryngology, Fabrizio Spaziani Hospital, Frosinone, Italy; 5 Department of Molecular and Translational Medicine, University of Brescia, Brescia, Italy; 6 Unit of Otorhinolaryngology, ASL 4 Liguria, Ospedale Sestri Levante, Sestri Levante, Italy; 7 Department of Otorhinolaryngology, Maxillofacial and Thyroid Surgery, Fondazione IRCCS, National Cancer Institute of Milan, University of Milan, Milan, Italy; 8 Department of Experimental Medicine (DIMES), University of Genoa, Genoa, Italy

SUMMARY
Objective. To review our 5-year experience with a modified version of glossoepiglottopexy for treatment of obstructive sleep apnoea syndrome (OSA) in two hospitals.

Methods. A retrospective analysis was carried out on a cohort of adult patients affected by OSA suffering from primary collapse of the epiglottis who underwent a modified glossoepiglottopexy. All patients underwent drug-induced sleep endoscopy, polysonomographic and swallowing evaluation, and assessment with the Epworth Sleepiness Scale (ESS).

Results. Forty-nine patients were retrospectively evaluated. Both the apnoea-hypopnoea index (AHI) (median AHI post-AHI pre = -22.4 events/h; p < 0.001) and oxygen desaturation index (ODI) showed a significant postoperative decrease (median ODI post-ODI pre = -18 events/h; p < 0.001), as did hypoxaemia index (median T90% post-T90% pre = -5%; p < 0.001). The ESS questionnaire revealed a significant decrease in postoperative scores (median ESS pre-ESS post = 9; p < 0.001). None of the patients developed postoperative dysphagia.

Conclusions. Our 5-year experience demonstrates that modified glossoepiglottopexy is a safe and reliable surgical technique for treatment of primary epiglottic collapse in OSA patients.

KEY WORDS: OSA, glossoepiglottopexy, epiglottis collapse, surgery

RIASSUNTO
Obiettivo. Analisi della nostra esperienza a 5 anni con una versione modificata di glossoepiglottopessia su una coorte di pazienti affetti da sindrome delle apnee ostruttive del sonno (OSA) e collasso primario dell’epiglottide in due diversi centri ospedalieri.

Metodi. Un’analisi retrospettiva è stata effettuata su una coorte di pazienti affetti da OSA e collasso primario dell’epiglottide trattati con glossoepiglottopessia modificata. Tutti i pazienti sono stati valutati con endoscopia in sedazione, valutazione polisonomografica e swallowing evaluation, e con il questionario ESS (mediana ESS post - ESS pre = 9; p < 0.001). Nessuno ha sviluppato disfagia postoperatoria.

Conclusioni. La nostra esperienza dimostra che la glossoepiglottopessia modificata è una tecnica chirurgica sicura e affidabile per il trattamento dei collassi epiglottici primari nei pazienti affetti da OSA.

PAROLE CHIAVE: OSA, glossoepiglottopessia, collasso epiglottide, chirurgia
Introduction

Obstructive sleep apnoea syndrome (OSA) is a prevalent disease affecting around 20% of the population (reaching up to 60% in those over 65 years) with potentially life-threatening consequences as it is associated with other comorbidities such as cardiovascular events, neurocognitive impairment and stroke. The gold standard in the management of upper airway collapse in OSA is continuous positive airway pressure (CPAP). Despite its proven efficacy, a significant number of patients cannot tolerate this form of treatment and seek other alternatives. In this regard, surgery has a role in non-compliant patients who are not willing to receive CPAP therapy and in cases where CPAP therapy fails to restore normal breathing. In this setting, the effectiveness of surgical treatment in reducing OSA-related cardiovascular morbidity and mortality has been demonstrated.

In recent years, the role of surgery in the management of OSA has been evolving: the development of new techniques, together with a better understanding of their indications, has allowed for more precise selection of patients in order to tailor surgery to the multitude of anatomical conditions that characterise OSA. When choosing the right technique, structured pre-operative work-up is essential: drug-induced sleep endoscopy (DISE) is crucial, as it is the only exam that can recreate sleeping conditions and allow surgeons to identify the site and mechanism of obstruction. Moreover, DISE facilitates the recognition of obstructive patterns that are not evident during awake flexible transnasal video endoscopy, such as epiglottic collapse. Epiglottic collapse is well known in the literature as one of the possible conditions implicated in paediatric laryngomalacia. In adults, while laryngomalacia is more of an anecdotal entity that has not been clearly described, primary collapse of the epiglottis can be related to treatment failure of CPAP. This happens as CPAP-generated airflow pushes down the epiglottis, closing the laryngeal aditus, and consequently worsening the airway obstruction. Non-surgical treatment has been demonstrated to be inadequate to treat this condition, with mandibular advancement devices (MADS) leading to disappointing results. In this respect, a surgical modification of the Monnier’s glossoepiglottopexy was developed and published with preliminary data in 2017, demonstrating encouraging results. Herein, we describe our experience with this technique together with the results obtained in a cohort of patients suffering from primary collapse of the epiglottis treated at two hospitals.

Materials and methods

Study design and population

A retrospective multicentric analysis was carried out on a period from January 1, 2015 to December 31, 2019 on a cohort of patients affected by OSA who underwent glossoepiglottopexy at the Department of Otorhinolaryngology and Head and Neck Surgery of the University of Genoa and the Department of Otorhinolaryngology - Fabrizio Spaziari Hospital in Frosinone.

For patients in whom multilevel surgery was performed, all procedures were considered in the analysis. Tonsillectomy was carried out by preserving the palatoglossus and palatopharyngeus muscles. Septoplasty and turbinoplasty were performed under rhinoscopy. Non-resective pharyngoplasty was performed using the barbed suspension pharyngoplasty technique (BSP), barbed reposition pharyngoplasty (BRP), functional expansion pharyngoplasty (FEP), modified expansion sphincter pharyngoplasty (MESP), or barbed anterior pharyngoplasty (BAPh).

Inclusion criteria were: OSA confirmed by polysomnography study with an apnoea-hypopnoea index (AHI) > 15 episodes/h; body mass index (BMI) < 35 kg/m²; primary epiglottic collapse diagnosed by DISE; and ease of laryngeal and oropharyngeal exposure (Laryngoscore < 6). The latter was evaluated with the Laryngoscore instrument, which is commonly employed in our hospitals to select patients for transoral procedures. As is standard policy at our clinics, we strongly suggest CPAP therapy, especially to patients with an AHI > 30, and reserve surgical treatment only for those who are not compliant or who do not respond to non-surgical therapy. Major comorbidities, severe tongue base hypertrophy, cranio-facial malformations, laryngeal dysfunction (swallowing, motility disorders, and laryngeal stenosis) and other sleep-related disorders were considered exclusion criteria.

All patients underwent a standard preoperative evaluation protocol consisting of awake flexible transnasal video endoscopy, polysomnographic assessment and DISE evaluation. Postoperative evaluation was performed at 6 months after surgery by clinical, polysomnographic and endoscopic assessment. All data were extracted from a single database.

Clinical evaluation

Preoperatively, all patients underwent thorough otolaryngologic physical examination. Clinical history was collected focusing on sleep habits and sleep disturbances. BMI was also reported. The Epworth Sleepiness Scale (ESS) was used to rate daytime sleepiness, while swallowing function was assessed by the Eating Assessment Tool (EAT) and the penetration aspiration scale.

Respiratory polygraphic study

All patients underwent a sleep study with cardiorespiratory monitoring (Vital night, Vital aire, Milan Italy). The
cardiorespiratory analysis comprised nocturnal snoring sound, arterial oxygen saturation, body position, nasal and mouth airflow, thoracic and abdominal respiratory movements and heart rate. To determine the severity of sleep apnoea, we considered the AHI, oxygen desaturation index (ODI) and T < 90% (percent of total time with oxygen saturation less than 90%).

**Drug-induced sleep endoscopy**

At both centres, DISE was performed with the patient in a supine position. Transnasal flexible endoscopy was performed using a high definition fiberoptic video-endoscope connected to an Evix Exera II CLV-180B light source (Olympus Medical Systems Corporation, Tokyo, Japan).

During the examination, head rotation and positioning of the patient in lateral decubitus were performed to assess the positional component of the collapse. Moreover, chin lift and mandibular pull up manoeuvres were routinely performed to evaluate the possible benefit in applying a MAD. Midazolam was administered with intravenous repeated bolus in a range of 1-3 mg, while propofol was administered intravenously via target-controlled infusion. At the end of the procedure, flumazenil was used to antagonise the effects of midazolam. The use of a low dose of midazolam and propofol allows sedation to be as physiologic as possible, with snoring, apnoea events, controlled desaturations and rapid recovery. The NOHL classification was used to assess the obstruction severity at multiple levels.

**Surgical glossoepiglottopexy**

The glossoepiglottopexy procedure has been previously described; the main steps are briefly summarised as follows. The procedure is carried out under microlaryngoscopy with the patient lying in Boyce-Jackson’s position; firstly, the surgeon with a Sataloff laryngoscope (Microf rance Sataloff Laryngoscopes 124, Medtronic ENT, Jack sonville FL USA) exposes the base of the tongue, the entire valleculae and the epiglottis. Secondly, with a CO₂ laser (Ultrapulse Dualpro Laser CO₂, Lumenis, Yokneam, Israel) coupled with a microscope, the operator vaporises the mu cosa overlying the valleculae and the base of the tongue. Finally, from outside of the neck, two 16-gauge needles are inserted projecting out of the valleculae, serving as a guide to apply, through a loop, number 1 Premilene® sutures (Premilene, Braun, Melsungen Germany) that embrace the hy oid bone and stitch the lingual surface of the epiglottis to the base of the tongue. Both wires are then fixed outside of the neck, anteriorly to the larynx, using a Silastic sheet to protect the skin from local trauma.

**Outcome evaluation**

Surgical success was evaluated at least 6 months after surgery, performing a respiratory polysomnographic study and repeating the ESS questionnaire. Criteria for evaluation of the outcomes are in agreement with Montevecchi et al. The NOHL index (ODI) and T < 90% (percent of total time with oxygen saturation less than 90%).

**Statistical analysis**

The results are expressed as mean ± standard deviation, median, or percentage. Sample size was calculated by assuming effect size = 0.45, α = 0.05, power (1-β error probability) = 0.80 for a two-tailed paired test. With these parameters, a minimum sample size of 43 patients was required. The Shapiro-Wilk test was used to assess normal distributions of continuous variables. Categorical variables were analysed with χ² test or Fisher’s exact test as appropriate. Comparisons between continuous variables were performed with the Mann-Whitney-Wilcoxon rank sum test. The evaluation of the continuous variables before and after treatment was carried out using the Wilcoxon signed-rank test, plotting them with paired boxplot and adding lines to points for each patient to show the trend change. Considering the binary successful outcome, pre-treatment clinical and polysomnographic covariates were investigated with univariable and multivariable logistic regression models. Statistical significance was assumed in each test with a two-tailed p value < 0.05. Statistical analysis was carried out using the R software/environment (version 3.6.3; R Foundation for Statistical Computing, Vienna, Austria).

**Results**

From January 2015 to December 2019, 49 patients affected by OSA with primary epiglottic collapse underwent glossoepiglottopexy. By DISE, the most frequent pattern of epiglottic collapse was complete anteroposterior collapse, followed by partial anteroposterior collapse; in our series, no patients showed a lateral collapse of the epiglottis. In 37 patients (75.5%), concomitant to glossoepiglottopexy, a non-resective pharyngoplasty was also performed according to the palatal collapse. Furthermore, tonsillectomy was performed in 26 patients (53.1%), and septoplasty and turbinoplasty in 9 patients (18.4%). The main patient characteristics are reported in Table 1. During the postoperative period, concomitant with polysomnographic assessment, no significant change in BMI was observed [mean ΔBMI = 0.035 (95% CI -0.123, 0.193), p = 0.66]. Complications occurred in 2 of 49 procedures: one patient...
had suture breakage at 7 days post-operatively, but flexible transnasal video endoscopic control revealed the stability of the glossoepiglottopexy, while the other had the epiglottis lacerated by the sutures that were probably placed too high. Neither bleeding, dysphagia, nor aspiration occurred in any case, and postoperative AHI improved from 66 to 10 and from 37 to 9, respectively.

Comparisons between paired parameters measured before and after surgery are reported in Table II, whereas the trends for each patient are shown in Figure 1. AHI showed a significant postoperative decrease [median AHI\textsubscript{post} - AHI\textsubscript{pre} = -22.4 events/h (95% CI -25.7, -19.0; p < 0.001)], as did ODI [median ODI\textsubscript{post} - ODI\textsubscript{pre} = -18 events/h (95% CI -13.0, -20.0); p < 0.001] and T\textsubscript{90%} [median T\textsubscript{90% post} - T\textsubscript{90% pre} = -5% (95% CI -5.0, -7.0); p < 0.001]. Daytime sleepiness, assessed by the ESS questionnaire, also showed a significant decrease in postoperative scores evaluated at 6 months after surgery [median ESS\textsubscript{post} - ESS\textsubscript{pre} = -9.63 (95% CI -7, -11); p < 0.001].

Clinical swallow evaluation was negative and EAT-10 scored 0 in all patients after surgery. All patients received a score of 1 at the penetration-aspiration scale evaluation postoperatively. Post-treatment AHI was < 5 in 40.8% of patients (n = 20) and postoperative ESS scored less than 7 points in 89.8% of cases (n = 44).

Considering the criteria for outcome evaluation, a successful procedure was obtained in 34 cases (69%) and failure in 15 (31%); notably, 8 of these failures were due to ESS\textsubscript{post} > 10 (1 patient) or its improvement < 50% (7 patients); on the other hand, only 4 failures were due to an AHI\textsubscript{post} > 20, as shown in Figure 2. The analysis of pre-treatment clinical and polysomnographic covariates showed that higher ESS\textsubscript{pre} values were associated with a higher chance of successful surgery at both univariable (OR = 1.24, 95% CI 1.08-1.47, p = 0.005) and multivariable analysis (OR = 1.22, 95% CI 1.06-1.46, p = 0.013), whereas older age was related to a lesser chance of success (OR = 0.94, 95% CI 0.88-0.99, p = 0.035), which was not confirmed after adjustment for the ESS effect (p = 0.152; Tab. III, Fig. 3). None of the other clinical variables were associated with post-treatment outcomes.

Discussion

In adult patients suffering from OSA, collapse of the epiglottis may be primary or secondary: the latter occurs when a bulky tongue base pushes the epiglottis backward. On the other hand, primary collapse of the epiglottis may result from an altered conformation of the epiglottis (cartilage deformation due to pharyngeal wall compression during sleep or laxity of the glossoepiglottic ligament) in combination with the high negative intrathoracic pressure.

| Variable | Before surgery | After surgery | P value |
|----------|----------------|---------------|---------|
| AHI      | 29.37 ± 1.81   | 7.02 ± 6.51   | < 0.001 |
| ESS      | 13.65 ± 5.41   | 4.02 ± 3.15   | < 0.001 |
| ODI      | 27.87 ± 13.79  | 7.75 ± 9.92   | < 0.001 |
| T\textsubscript{90%} (%) | 7.96 ± 6.55 | 1.35 ± 1.79 | < 0.001 |
| SpO\textsubscript{2} (%) | 86.80 ± 2.86 | 95.04 ± 2.14 | < 0.001 |

AHI: apnoea-hypopnea index; ESS: Epworth sleepiness scale; ODI: oxygen desaturation index; T\textsubscript{90%}: percent of the total time passed with an oxygen saturation level lower than 90%; SpO\textsubscript{2}: mean peripheral capillary oxygen saturation.
generated during obstructive events. This deformity of the epiglottis can be congenital or created by the pressure of parapharyngeal fat pads and chronic collapse of the retroglottal airway.

In OSA patients, both medical and surgical treatment must be tailored to the physiopathology of the individual case. New tools have been developed to improve patient selection and the therapeutic solutions that can be offered. One such tool is DISE, which allows to accurately identify patterns of collapse that cannot otherwise be seen with awake investigations. In awake findings, the laryngeal obstruction may be only hypothesised as being due to the deformed epiglottic shape, while the direct visualisation of the laryngeal collapse in many cases is possible only during the sedated state. The introduction of DISE in the diagnostic routine has revealed the high incidence of laryngeal obstruction due to primary and secondary collapse of the epiglottis, as widely documented in the literature, reaching up to 73% of cases.
including positive airway pressure devices, surgery, behavioural treatment and oral appliances, but when approaching epiglottic collapse the therapeutic choices are limited. CPAP has demonstrated suboptimal results with these patients who often require higher pressures to be effective, with possible consequences on patient compliance. Vonk et al. analysed the presence of primary epiglottis collapse in non-apnoeic snoring patients, non-positional OSA patients and position-dependent OSA patients, while evaluating the impact of head-turning, chin-lift, mandibular pull-up manoeuvres and body position during DISE in 324 patients. Their results indicate that in the vast majority of cases, primary epiglottis collapse was position-related. Nevertheless, they did not explain the pathophysiological mechanism underlying non-positional OSA and position-dependent OSA patients, while suggesting the need for new trials to evaluate other therapeutic solutions that possibly combine position-therapy with surgery.

Surgery remains the treatment of choice in many cases of epiglottic collapse, and different surgical approaches have

### Table III. Univariable and multivariable logistic regression models with a successful surgical procedure as the dependent variable, considering AHI and ESS and applying Montevecchi’s criteria.

| Variable                        | Failure | Success or cure | OR (95% CI, p value) (univariable) | OR (95% CI, p value) (multivariable) |
|---------------------------------|---------|-----------------|------------------------------------|--------------------------------------|
| Age                             | Mean (SD) | 56.2 (13.0) | 48.3 (10.3) | 0.94 (0.88-0.99, p = 0.035) | 0.96 (0.90-1.01, p = 0.152) |
| Sex                             | F | 2 (22.2%) | 7 (77.8%) | - | - |
| | M | 13 (32.5%) | 27 (67.5%) | 0.59 (0.08-2.88, p = 0.549) | - |
| Tonsillectomy                   | No | 5 (21.7%) | 18 (78.3%) | - | - |
| | Yes | 10 (38.5%) | 16 (61.5%) | 0.44 (0.12-1.53, p = 0.210) | - |
| Septoplasty / Turbinoplasty     | No | 12 (30.0%) | 28 (70.0%) | - | - |
| | Yes | 3 (33.3%) | 6 (66.7%) | 0.86 (0.19-4.59, p = 0.845) | - |
| AHI pre                         | Mean (SD) | 29.3 (10.7) | 29.4 (12.4) | 1.00 (0.95-1.06, p = 0.999) | - |
| ESS pre                         | Mean (SD) | 10.1 (5.0) | 15.2 (4.9) | 1.24 (1.08-1.47, p = 0.005) | - |
| ODI pre                         | Mean (SD) | 29.6 (12.7) | 27.1 (14.4) | 0.99 (0.94-1.03, p = 0.556) | - |
| T90% pre                        | Mean (SD) | 5.5 (3.9) | 9.0 (7.2) | 1.19 (1.02-1.46, p = 0.061) | - |
| SpO2 pre                        | Mean (SD) | 86.9 (3.1) | 86.7 (2.8) | 0.98 (0.78-1.21, p = 0.822) | - |

AHI: apnoea-hypopnoea index; ESS: Epworth sleepiness scale; F: female; M: male; PRE: before surgery; ODI: oxygen desaturation index; T90%: percent of the total time passed with oxygen saturation level less than 90%; SpO2: peripheral capillary oxygen saturation.
been described. Tongue base advancement or hyoid suspension are theoretical surgical options in OSA, but to date there are no studies that have demonstrated their direct effect on epiglottis collapse. Partial epiglottectomy has been the most widely described technique; however, it should be noted that excessive resection of the epiglottis can lead to aspiration, whereas insufficient resection might not cure the OSA. Moreover, there is no standard method to assess the volume of the epiglottis to excise without causing postoperative sequelae. Subsequently, more cautious approaches have been developed. Bouroulias et al. proposed a transoral conservative technique to treat epiglottic collapse. A laser beam was delivered on the lingual surface of the epiglottis in order to model it in a new curved shape, warping towards the direction of laser beam application thus freeing the laryngeal inlet. Nevertheless, the technique has been studied only on anatomical ex-vivo models.

In order to treat primary epiglottic collapse without ablating it, a surgical technique called epiglottis stiffening was recently developed: it consists of cauterising the lower half of the lingual side of the epiglottis in the area between the lateral glossoepiglottic folds, and avoiding reaching the free margin of the epiglottis itself. By maintaining the free edge unharmed, the risk of dysphagia and aspiration is overcome. However, in our view, adding two nylon sutures to embrace the hyoid bone ensures safer and long-lasting results, while maintaining the important epiglottic function of glottic plane protection.

In the present work, this technique was demonstrated to be a safe and reliable choice to treat primary collapse of the epiglottis in OSA patients. In our series, the complication rate was very low (4%) and none of these cases experienced dysphagia or inhalation. Regarding outcomes, our results showed significant (p < 0.001) post-operative improvement of AHI, ODI, T95% and ESS after surgical treatment with mean values approaching the normal population. In our opinion, these results are consistently achievable if reasonable selection criteria are respected. As a general rule, patients should not be affected by severe OSA with > 30 AHI and should also not be obese: otherwise, CPAP should be always advised in the first instance and surgical treatment should be reserved only for those who do not respond to or who refuse treatment with positive airway pressure.

Further research needs to be carried to determine if glossoepiglottopexy can enhance compliance and increase the effectiveness of CPAP in this category of patients. In our cohort, considering pre-treatment clinical and polysomnographic variables, ESS score was the only covariate that independently associated with surgical outcomes as previously observed in patients treated with palatal or lateral oropharyngeal collapse. This finding may be explained by the role of ESS reduction in defining successful treatment in the applied classification. In 7 (47%) of our patients, the definition of failure was due only to not achieving ESS reduction < 50%, despite having an ESS < 10 and obtaining recovery of AHI parameters. In fact, low values of baseline ESS in non-symptomatic patients are less likely to change, despite recovery by polygraphy. These findings may help to improve this classification in defining surgical outcomes.

Finally, we acknowledge that the present study has intrinsic limitations considering its retrospective nature. Moreover, the cohort of patients analysed is limited, even though to our knowledge it is one of the largest case series present in the literature on this specific category of patients. In fact, OSA is a complex disease, and many factors can contribute to upper airway collapse. A clear understanding of such a complex condition, by identifying the key factors that play a role in the different upper airway obstruction patterns can aid in the definition of better therapeutic protocols and targeted compound surgical strategies.

Conclusions
Our 5-year experience demonstrates that glossoepiglottopexy is a safe and reliable surgical technique for the treatment of primary epiglottic collapse in OSA patients. By not producing major anatomical alterations, it maintains oropharyngeal and laryngeal functions. In addition, it is capable of improving the main polysomnographic parameters and has the potential to increase compliance and efficacy of positive airway pressure devices in this category of patients.

Conflict of interest statement
The authors declare no conflict of interest.

Funding
This research did not receive any specific grant from funding agencies in the public, commercial, or not-for-profit sectors.

Authors’ contributions
Conceptualisation: MF, MB. Data curation: MF, CS, FM. Formal analysis: FM, GS, CS. Investigation: CT, RV, FI, MF. Methodology: MF, FI, AM, CT, GS, VR. Supervision: GP, MB, AM. Writing – original draft: CS, MF. Writing – review and editing: FM, MB, GP.

Ethical consideration
This study was approved by the Institutional Ethics Committee (CER Liguria) (approval number/protocol number/protocol number).
The research was conducted as a retrospective study on patient records in accordance with the ethical standards of the institutional and/or national research committees and with the 1964 Helsinki Declaration and its later amendments or comparable ethical standards. Informed consent for disclosure of privacy in managing personal data for scientific purposes was obtained from all participants included in the study.

References

1. Iannella G, Maniaci A, Magliulo G, et al. Current challenges in the diagnosis and treatment of obstructive sleep apnea syndrome in the elderly. Polish Arch Intern Med 2020;130:649-654. https://doi.org/10.20452/pamw.15283
2. Browtza SE, Ishman SL, Cohen S, et al. National database analysis of single-level versus multilevel sleep surgery. Otolaryngol - Head Neck Surg 2017;156:955-961. https://doi.org/10.1177/0194599817696503
3. Torre C, Camacho M, Liu SYC, et al. Epiglottis collapse in adult obstructive sleep apnea: a systematic review. Laryngoscope 2016;126:515-523. https://doi.org/10.1002/lary.25589
4. Missale F, Fragale M, Incandela F, et al. Outcome predictors for non-resective pharyngoplasty alone or as a part of multilevel surgery, in obstructive sleep apnea-hypopnea syndrome. Sleep Breath 2020;24:1397-1406. https://doi.org/10.1007/s11325-019-01985-2.
5. Kezirian EJ, Hohenhorst W, De Vries N. Drug-induced sleep endoscopy: the VOTE classification. Eur Arch Otorhinolaryngol 2011;268:1233-1236. https://doi.org/10.1007/s00405-011-1633-8
6. Cavaliere M, Russo F, Iemma M. Awake versus drug-induced sleep endoscopy: evaluation of airway obstruction in obstructive sleep apnea/hypopnea syndrome. Laryngoscope 2013;123:2315-2318. https://doi.org/10.1002/lary.23881
7. Roustan V, Barbieri M, Incandela F, et al. Transoral glossopilegnototomy in the treatment of adult obstructive sleep apnea: a surgical approach. Acta Otorhinolaryngol Ital 2018;38:38-44. https://doi.org/10.14639/0392-100X-1857
8. Kent DT, Rogers R, Soose RJ. Drug-induced sedation endoscopy in the evaluation of osa patients with incomplete oral appliance therapy response. Otolaryngol Head Neck Surg 2015;153:302-307. https://doi.org/10.1177/0194599815586978
9. Barbieri M, Missale F, Incandela F, et al. Barbed suspension pharyngoplasty for treatment of lateral pharyngeal wall and palatal collapse in patients affected by OSAHS. Eur Arch Otorhinolaryngol 2019;276:1829-1835. https://doi.org/10.1007/s00405-019-05426-4
10. Vicini C, Hendawy E, Campanini A, et al. Barbed reposition pharyngoplasty (BRP) for OSAHS: a feasibility, safety, efficacy and teachability pilot study. “We are on the giant’s shoulders.” Eur Arch Otorhinolaryngol 2015;272:3065-3070. https://doi.org/10.1007/s00405-015-3628-3
11. Sorrenti G, Piccin O. Functional expansion pharyngoplasty in the treatment of obstructive sleep apnea. Laryngoscope 2013;123:2905-2908. https://doi.org/10.1002/lary.23911
12. Lorusso F, Dispensa F, Modica DM, et al. The role of modified expansion sphincter pharyngoplasty in multilevel obstructive sleep apnea syndrome surgery. Int Arch Otorhinolaryngol 2018;22:432-436. https://doi.org/10.1055/s-0038-1648248
13. Salamanca F, Costantini F, Mantovani M, et al. Barbed anterior pharyngoplasty: an evolution of anterior palatoplasty. Acta Otorhinolaryngol Ital 2014;34:434-438.
14. Piazza C, Mangili S, Bon F Del, et al. Preoperative clinical predictors of difficult laryngeal exposure for microlaryngoscopy: the laryngoscope. Laryngoscope 2014;124:2561-2567. https://doi.org/10.1002/lary.24803
15. Vignatelli L, Piazzal G, Barbaro A, et al. Italian version of the Epworth sleepiness scale: external validity. Neurol Sci 2003;23:295-300. https://doi.org/10.1007/s100720300004
16. Belaïfsky PC, Moudabed DA, Rees CJ, et al. Validity and reliability of the eating assessment tool (EAT-10). Ann Otol Rhinol Laryngol 2008;117:919-924. https://doi.org/10.1177/0003489408011701210
17. Robbins JA, Coyle J, Rosenbek J, et al. Differentiation of normal and abnormal airway protection during swallowing using the Penetration-Aspiration Scale. Dysphagia 1999;14:228-232. https://doi.org/10.1007/PL00009610
18. Llatas MC, Porras GA, Gonzalez MTC, et al. Drug-induced sleep endoscopy: a two drug comparison and simultaneous polysomnography. Eur Arch Otorhinolaryngol 2014;271:181-187. https://doi.org/10.1007/s00410-013-2548-3
19. Vicini C, De Vito A, Benazzo M, et al. The nose oropharynx hypopharynx and larynx (NOHL) classification: a new system of diagnostic standardized examination for OSAHS patients. Eur Arch Otorhinolaryngol 2012;269:1297-1300. https://doi.org/10.1007/s00405-012-1965-z
20. Montevcchi F, Meccariello G, Firrim E, et al. Prospective multicentre study on barbed reposition pharyngoplasty standing alone or as a part of multilevel surgery for sleep apnoea. Clin Otorhinolaryngol 2018;43:483-488. https://doi.org/10.1111/coa.13001
21. Gazayerli M, Bleibel W, Elhoror A, et al. A correlation between the shape of the epiglottis and obstructive sleep apnea. Surg Endosc Other Interv Tech 2006;20:836-837. https://doi.org/10.1007/s00464-005-0641-4
22. Vonk PE, Ravesloot MJL, Kasius KM, et al. Floppy epiglottis during drug-induced sleep endoscopy: an almost complete resolution by adopting the lateral posture. Sleep Breath 2020;24:103-109. https://doi.org/10.1111/sbe.12684
23. Bac MR, Chung YS. Epiglottic collapse in obstructive sleep apnea. Sleep Med Res 2021;12:15-19. https://doi.org/10.1007/s10072-020-01985-Z
24. Boussof F, Hajoanou M, Sobel E, et al. Epiglottis reshaping using CO2 laser: a minimally invasive technique and its potent applications. Head Face Med 2008;4:5-8. https://doi.org/10.1186/1746-160X-4-15
25. Salamanca F, Bogn F, Bianchi A, et al. Surgical treatment of epiglottis collapse in obstructive sleep apnoea syndrome: epiglottis stiffening operation. Acta Otorhinolaryngol Ital 2019;39:404-408. https://doi.org/10.14639/0392-100X-N0827