Sleep apnea: peripheral action, central impact

Original Article

Authors

Gustavo Pedrosa Rocha
Hospital Fernando da Fonseca, Unidade Local de Saúde Amadora / Sintra, Portugal

João Carvalho
Hospital Fernando da Fonseca, Unidade Local de Saúde Amadora / Sintra, Portugal

Carolina Marinho
Hospital Fernando da Fonseca, Unidade Local de Saúde Amadora / Sintra, Portugal

Marco Menezes
Hospital Fernando da Fonseca, Unidade Local de Saúde Amadora / Sintra, Portugal

Cristina Adónis
Hospital Fernando da Fonseca, Unidade Local de Saúde Amadora / Sintra, Portugal

Filipe Freire
Hospital Fernando da Fonseca, Unidade Local de Saúde Amadora / Sintra, Portugal

Correspondence:
Gustavo Pedrosa Rocha
g.pedrosarocha@gmail.com

Article received on April 8, 2025.
Accepted for publication on November 3, 2025.

Abstract

Objectives: To retrospectively determine and compare the success of surgical treatment for Obstrutive Sleep Apnea (OSA) on mixed and central apneas.
Study design: Patients who underwent surgical treatment for OSA between 2019-2023 were analyzed.
Material and Methods: Inclusion criteria were defined as the presence of at least one mixed or central apnea at the baseline polysomnography (PSG) and the availability of a postoperative PSG. Total surgical success was defined as a 50% reduction in AHI and partial success as a 50% reduction in the number of obstructive apneas.
Results: In patients who achieved total success, this was associated with an improvement in mixed apneas (p=0.047) and in central apneas (p=0.010). Although a reduction in the mean number of obstructive apneas was observed in patients with partial success, there was no statistically significant difference for mixed apneas (mean 18.3 to 3.5) (p=0.492) nor for central apneas (mean 2.3 to 1.5) (p=0.178).
Conclusion: Our findings corroborate that the mechanisms underlying central and obstructive sleep apnea are tightly intertwined. An extension of mixed and central apneas should not be regarded as a contraindication for surgery and may, in fact, represent an indication for surgery.

Keywords: obstrutive sleep apnea; central apnea; mixed apnea

Introduction

Apnea, defined as the cessation of breathing, is a common physiological and pathophysiological phenomenon. Obstructive sleep apnea (OSA) is the most prevalent form and is characterized by recurrent episodes of airway occlusion, typically associated with peripheral obstruction. However, this may be an oversimplification, as the mechanisms underlying OSA may not be exclusively peripheral. Similarly, the mechanisms underlying central sleep apnea (CSA) may not be exclusively central in origin. Apnea results from a dynamic interaction between chemo- and mechanosensory receptors and differential activation of the respiratory center.[1]

In practical terms, the possibility of overlap **between OSA and CSA** can be suspected based on three premises. First, the first-line treatment for OSA and CSA is the same: positive airway pressure therapy.[2] Second, during each spontaneous central apnea, partial or complete pharyngeal collapse occurs even in the absence of subatmospheric pressure, such as that occurring during inspiration.[3] Third, patients with OSA treated for peripheral obstruction, either with positive airway pressure therapy or surgery, frequently experience Treatment Emergent Central Sleep Apnea (TECSA).[4,5]

In this study, we used OSA as a template to discuss the complex interactions underlying apnea pathogenesis and retrospectively compared the outcomes of surgical treatment for OSA between patients with mixed and central apneas.

Materials and methods

Clinical records of patients who underwent palatoplasty and/or base-of-tongue surgery due to a diagnosis of OSA over a five-year period (2019–2023) were reviewed. The inclusion criteria were all patients who had a preoperative polysomnography (PSG) demonstrating at least one mixed or central apnea and subsequent postoperative PSG. Total surgical success was defined as a 50% reduction in the apnea-hypopnea index (AHI), while partial success was defined as a 50% reduction in the number of obstructive apneas on postoperative PSG. Demographic and clinical data were collected, including sex, age, disease severity, oxygen desaturation index (ODI), and the number of obstructive, mixed, and central apneas.

Patients were categorized by the surgical outcome into three groups:

1. **No success**
2. **Partial success**
3. **Total success.**

For each group, central and mixed apneas were assessed pre- and postoperatively. Statistical comparisons were performed using the Wilcoxon signed-rank test, the nonparametric alternative to the paired t-test, as the samples did not demonstrate a normal distribution. Statistical significance was defined as $p < 0.05$. Statistical analyses were performed using IBM SPSS Statistics (version 29.0; IBM Corp., Armonk, NY, USA). The analysis was supported by a review of the literature.

Results

Between January 2019 and December 2023, 29 patients met the inclusion criteria and underwent surgery, comprising 13 men and 16 women. The mean age was 50.62 ±12.21 years. AHI ranged from 9.3 to 70.6 events/hour (mean 25.95 events/hour). ODI ranged from 4.5 to 67.3 events/hour (mean 20.25 events/hour). The number of obstructive apneas ranged from 0 to 220 (mean 32.93), mixed apneas from 0 to 204 (mean 10.89), and central apneas from 0 to 153 (mean 8.48).

Regarding surgical outcomes, six patients had **no success**, 12 achieved **partial success**, and 11 attained **total success**.

In the total success group, there was a statistically significant reduction in the number of mixed ($p = 0.047$) and central apneas ($p = 0.010$) (Table 1).

In the partial success group, although the mean number of obstructive apneas decreased by more than 50%, there was no statistically significant difference in the occurrence of mixed apneas (mean 18.3–3.5; $p = 0.492$) or central apneas (mean 2.3–1.5; $p = 0.178$) (Table 2).

Discussion

This study provides an overview of the outcomes of surgical treatment for OSA and mixed and central apneas in a Portuguese otorhinolaryngology service. The primary goal of treating OSA is to control symptoms and reduce long-term morbidity by decreasing the frequency of apneas and hypopneas. The measurement of AHI during PSG confirms the

Table 1
Comparison of various types of apneas pre- and postoperatively in the TOTAL success group (N = 11)

Type of apnea	Period	Min.-Máx.	Mean	Standard deviation	Wilcoxon Z	p
Obstructive sleep apnea	Preoperatively	0 - 84	25,8	29,87	-2,295	0,010
	Postoperatively	0 - 21	3,2	6,26		
Mixed apnea	Preoperatively	0 - 12	4,0	4,65	-1,778	0,047
	Postoperatively	0 - 8	0,8	2,40		
Central apnea	Preoperatively	0 - 28	4,6	8,03	-2,393	0,010
	Postoperatively	0 - 2	0,5	0,82		

Table 2
Comparison of various types of apneas pre- and postoperatively in the PARTIAL success group (N = 12)

Type of apnea	Period	Min.-Máx.	Mean	Standard deviation	Wilcoxon Z	p
Obstructive sleep apnea	Preoperatively	2 - 220	43,3	67,19	-2,432	0,006
	Postoperatively	0 - 51	11,8	17,93		
Mixed apnea	Preoperatively	0 - 204	18,3	58,54	-0,085	0,492
	Postoperatively	0 - 18	3,5	6,61		
Central apnea	Preoperatively	0 - 15	2,3	4,16	-0,953	0,178
	Postoperatively	0 -11	1,5	3,32		

diagnosis of OSA: however, once surgery is conducted, postoperative PSG is not required from a clinical standpoint.[6] In this study, postoperative PSG was an inclusion criterion because it is essential for assessing and validating surgical outcomes. However, many patients discontinue follow-up after surgery, and in the absence of a clinical mandate, several patients do not undergo postoperative PSG. Consequently, although 58 patients underwent the surgery (palatoplasty and/or base-of-tongue procedures) between January 2019 and December 2023, only 29 completed postoperative PSG, which consequently limited the study sample size. The traditional definitions of "success," "response," or even "cure" after surgical treatment have included a reduction of at least 50% in the AHI.[7] Accordingly, we applied this criterion to define total success. The definition of partial success was established to increase the statistical proximity coefficient between the two variables investigated and was based on a reduction in the number of apneas.

The statistically significant results observed in the total success group ($p < 0.05$), along with a reduction in the number of mean mixed and central apneas in the partial success group, support the hypothesis that the mechanisms underlying OSA and CSA are closely related and overlapping. Loop gain,[8] a term originally derived from engineering, has been applied to the electrophysiology of breathing. In respiration, loop gain represents the ventilatory system's response to any disturbance, such as a change in the blood gases during an apnea. It is calculated by multiplying the sensitivity of the respiratory center (controller gain), effect of ventilation on gas levels (system gain), and timing interaction between the two gains (mixing gain). A high loop gain predisposes to an excessive oscillatory reaction, whereas a low loop gain produces a weak and inadequate response. In CSA, the loop gain is typically elevated, with small increases in CO_2 triggering excessive ventilatory responses, resulting in hyperventilation that rapidly lowers CO_2 below the threshold required to stimulate breathing, producing central apnea.[9]

In our sample of patients with unstable OSA (high loop gain with some degree of central /mixed apneas), there may have been desensitization of the partial CO_2 (PCO_2) chemoreceptors (~52 mmHg). In the total success group, following surgical treatment aimed at improving the airway patency, PCO_2 levels normalized to approximately 42 mmHg. This normalization may have led to the following phenomena: 1. Initially, because the new PCO_2 value was lower than the patient's prior chronic threshold, ventilation was not activated, resulting in central apnea. This early phenomenon corresponds to TECSA, which occurs in up to 20% of the treated patients during the first two months. 2. Subsequently, once the PCO_2 balance was restored, a reduction in obstructive, mixed, and central apneas was observed in the total success group.

Conclusion

The study results reinforce the notion that the mechanisms underlying central and obstructive sleep apnea are closely linked and overlapping. Therefore, the presence of mixed and central apneas in patients with OSA should not be considered a contraindication to surgical treatment.

Conflict of interests

The authors declare that there is no conflict of interest regarding the publication of this paper.

Data confidentiality

The authors declare having followed the protocols used at their working center regarding patient data publication.

Protection of humans and animals

The authors declare that the procedures were followed according to the regulations established by the Clinical Research and Ethics Committee and the 2013 Helsinki Declaration of The World Medical Association.

Funding sources

This work did not receive any contribution, funding, or scholarship.

Availability of scientific data

There are no datasets available, or publicity related to this work.

References

1. Ramirez JM, Garcia AJ 3rd, Anderson TM, Koschnitzky JE, Peng YJ, Kumar GK. et al. Central and peripheral factors contributing to obstructive sleep apneas. Respir Physiol Neurobiol. 2013 Nov 1;189(2):344-53. doi: 10.1016/j.resp.2013.06.004.
2. Locke BW, Sellman J, McFarland J, Uribe F, Workman K, Sundar KM. Predictors of initial CPAP prescription and subsequent course with CPAP in patients with central sleep apneas. Res Sq [Preprint]. 2023 Jul 27:rs.3.rs-3199807. doi: 10.21203/rs.3.rs-3199807/v1.
3. Badr MS, Toiber F, Skatrud JB, Dempsey J. Pharyngeal narrowing/occlusion during central sleep apnea. J Appl Physiol (1985). 1995 May;78(5):1806-15. doi: 10.1152/jappl.1995.78.5.1806.
4. Liu D, Armitstead J, Benjafield A, Shao S, Malhotra A, Cistulli PA. et al. Trajectories of emergent central sleep apnea during CPAP therapy. Chest. 2017 Oct;152(4):751-760. doi: 10.1016/j.chest.2017.06.010.
5. Testani E, De Corso E, Losurdo A, Fiorita A, Vollono C, Marca GD. et al. Treatment-emergent central sleep apnoea after surgery for obstructive sleep apnoea. Acta Otorhinolaryngol Ital. 2018 Oct;38(5):476-479. doi: 10.14639/0392-100X-1476.
6. Hobson JC, Robinson S, Antic NA, McEvoy RD, Windler S, Mackay S. et al. What is "Success" following surgery for obstructive sleep apnea? The effect of different polysomnographic scoring systems. Laryngoscope. 2012 Aug;122(8):1878-81. doi: 10.1002/lary.23342.
7. Elshaug AG, Moss JR, Southcott AM, Hiller JE. Redefining success in airway surgery for obstructive sleep apnea: a meta-analysis and synthesis of the evidence. Sleep. 2007 Apr;30(4):461-7. doi: 10.1093/sleep/30.4.461.
8. Naughton MT. Loop gain in apnea: gaining control or controlling the gain? Am J Respir Crit Care Med. 2010 Jan 15;181(2):103-5. doi: 10.1164/rccm.200909-1449ED.
9. Orr JE, Malhotra A, Sands SA. Pathogenesis of central and complex sleep apnoea. Respirology. 2017 Jan;22(1):43-52. doi: 10.1111/resp.12927