

# The Role of Drug-Induced Sleep Endoscopy with Positive Airway Pressure Titration in the Individualized Treatment of Obstructive Sleep Apnea: A Report of Three Illustrative Cases

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**Purpose:** Drug-induced sleep endoscopy with positive airway pressure titration (DISE-PAPT) can assess the effect of varying positive pressure levels on upper airway collapse in patients with obstructive sleep apnea (OSA) under simulated sleep condition. But it remains unclear whether DISE-PAPT can facilitate the development of personalized therapeutic interventions for OSA and further improve the therapeutic efficacy.

**Patients and Methods:** We present three adult patients with severe OSA exhibiting distinct clinical profiles: one case of continuous positive airway pressure (CPAP) treatment failure, one case of intolerance to high CPAP, and one case of psychological resistance to CPAP therapy.

**Results:** According to the DISE-PAPT evaluation findings, CPAP combined with positional therapy was administered in Case 1. CPAP with surgical management was performed in Case 2, resulting in significant therapeutic improvements. Additionally, real-time DISE-PAPT visualization of CPAP-mediated upper airway patency restoration enhanced CPAP adherence in Case 3.

**Conclusion:** The personalized treatment strategies based on the DISE-PAPT technique hold promise for improving the overall therapeutic efficacy and adherence among patients with OSA.

**Keywords:** DISE-PAPT, CPAP, obstructive sleep apnea, therapy

## Introduction

Obstructive sleep apnea (OSA) represents one of the most prevalent sleep-disordered breathing conditions, with an estimated 936 million individuals aged 30 to 69 affected globally.<sup>1</sup> OSA is linked to multisystem impairments, including cardiovascular, cerebrovascular, and metabolic disorders, thereby posing a significant public health burden.<sup>2</sup> Continuous positive airway pressure (CPAP) therapy stands as the first-line treatment for OSA in adults. However, due to the dynamic heterogeneity of upper airway collapse, a subset of patients with OSA exhibits suboptimal response to CPAP. Furthermore, psychological resistance to CPAP therapy in certain individuals contributes to poor adherence rates.<sup>3,4</sup>

The integration of drug-induced sleep endoscopy with positive airway pressure titration (DISE-PAPT) provides a novel approach to overcoming the challenge associated with CPAP therapy in patients with OSA.<sup>5-9</sup> This technique enables direct visualization of upper airway obstruction in patients with OSA under simulated sleep conditions, dynamically assessing the effect of varying positive pressure levels on upper airway collapse. DISE-PAPT can not only promote the identification of patients with OSA eligible for CPAP therapy,<sup>5</sup> but also provide insights into the underlying mechanisms of CPAP treatment failure.<sup>6-9</sup> However, it remains unclear whether DISE-PAPT can facilitate the development of personalized therapeutic interventions for OSA and further improve the overall therapeutic efficacy and adherence.



This study presents three adult patients with severe OSA exhibiting distinct clinical profiles: one case of CPAP treatment failure, one case of intolerance to high CPAP, and one case of psychological resistance to CPAP therapy. The three cases all underwent the individualized comprehensive treatment based on the evaluation results of DISE-PAPT, ultimately achieving optimal therapeutic outcomes.

## Materials and Methods

Written informed consent was provided by the three patients to have the case details and any accompanying images published. The study adhered to the CARE guidelines. DISE was conducted by a pulmonologist (P.J. LI) and an anesthesiologist (X. ZHANG), following the updated 2017 European protocol.<sup>10</sup> Continuous electrocardiographic and bispectral index (BIS) monitoring (BIS™ Vista, Medtronic, Minneapolis, USA) were employed during the procedure. Propofol and midazolam were administered, targeting a BIS range of 55–75 to achieve conditions of snoring and intermittent hypoxia. A video-flexible endoscope (BF-XP290, OLYMPUS, Tokyo, Japan) was used to assess upper airway obstruction with the VOTE classification system, analyzing baseline anatomy and obstruction severity at levels of velum, oropharynx, tongue base, and epiglottis.<sup>11</sup>

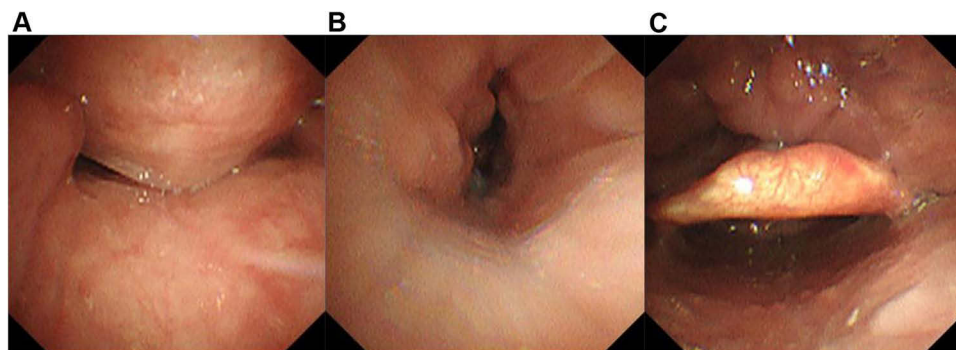
Subsequently, DISE-PAPT assessment was conducted.<sup>5</sup> The endoscope was inserted through a customized port of the modified nasal-oral mask into a nasal cavity. CPAP machine (S10, ResMed, California, USA) was connected with initial pressure at 4 cm H<sub>2</sub>O, followed by stepwise pressure escalation by 1 cm H<sub>2</sub>O until achieving airway stabilization and hypoxia resolution. Upper airway collapse requiring a pressure of 15–20 cm H<sub>2</sub>O for patency was defined as high CPAP demand. If upper airway obstruction remained unresolved at a pressure of 20 cm H<sub>2</sub>O or higher, CPAP therapy was considered ineffective.

## Report of Cases

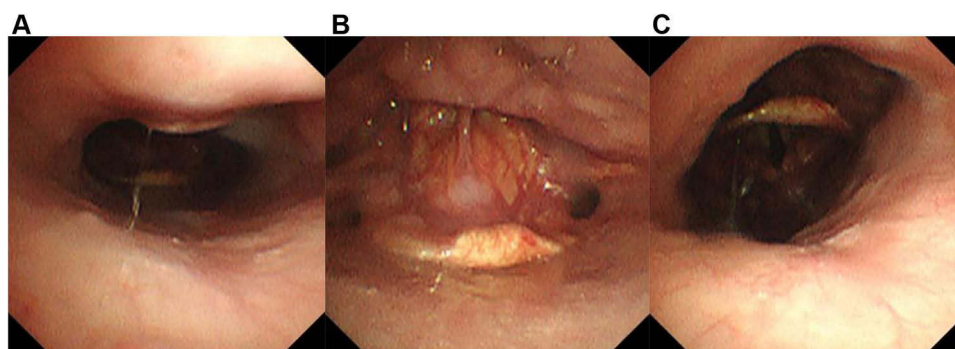
### Case 1

A 61-year-old man presented with a 2-year history of nocturnal snoring and daytime fatigue. The patient had transient sinus arrest, with 678 episodes of R-R intervals exceeding 2 seconds during 24-hour Holter monitoring. The longest nocturnal pause duration (3.6 seconds) significantly exceeded the maximum daytime pause (2.3 seconds). Polysomnography (PSG) revealed an apnea-hypopnea index (AHI) of 36.9 events/hour with a minimum oxygen saturation (SpO<sub>2</sub>) of 83%, meeting diagnostic criteria for severe OSA. Auto-CPAP therapy was initiated with a pressure range of 4–20 cm H<sub>2</sub>O for automated titration. However, the patient reported intolerable chest tightness during CPAP therapy, leading to fragmented sleep and discontinuation of ventilator treatment.

DISE demonstrated complete anteroposterior obstruction at velum (Figure 1A), partial lateral obstruction at oropharynx (Figure 1B), and partial anteroposterior obstruction at tongue base and epiglottis (Figure 1C). Subsequent DISE-PAPT revealed the resolution of velum and oropharyngeal obstruction at 8 cm H<sub>2</sub>O pressure (Figure 2A), whereas the epiglottic anteroposterior collapse progressed from partial to complete obstruction (Figure 2B). Despite titrating pressure



**Figure 1** Baseline upper airway collapse visualized by DISE in Case 1. (A) Complete anteroposterior obstruction at velum. (B) Partial lateral obstruction at oropharynx. (C) Partial anteroposterior obstruction at tongue base and epiglottis. DISE, drug-induced sleep endoscopy.



**Figure 2** Changes of upper airway collapse under CPAP therapy or CPAP combined with positional therapy via DISE-PAPT in Case 1. **(A)** Resolution of velum and oropharyngeal obstruction at 8 cm H<sub>2</sub>O pressure. **(B)** Epiglottic anteroposterior collapse progressed from partial to complete obstruction at 8 cm H<sub>2</sub>O pressure. **(C)** Complete resolution of upper airway obstruction when combining CPAP (8 cm H<sub>2</sub>O) with 90-degree rightward head rotation.

**Abbreviations:** CPAP, continuous positive airway pressure; DISE-PAPT, drug-induced sleep endoscopy with positive airway pressure titration.

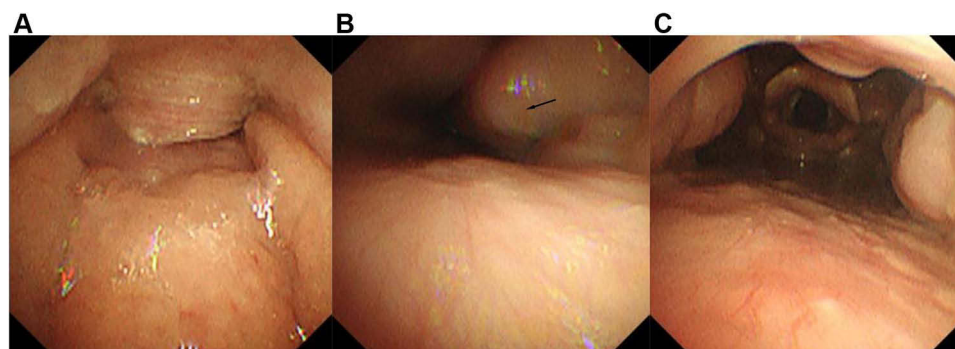
to 20 cm H<sub>2</sub>O, complete anteroposterior epiglottic collapse persisted. When combining 90-degree rightward head rotation with 8 cm H<sub>2</sub>O pressure, complete resolution of upper airway obstruction was observed (Figure 2C) (Video S1).

Consequently, the treatment protocol was modified to CPAP therapy (8 cm H<sub>2</sub>O) combined with right lateral positioning. The patient exhibited excellent therapy adherence, with marked alleviation of snoring and daytime fatigue. At the 1-month follow-up, simultaneous PSG and 24-hour Holter monitoring were performed under CPAP with positional therapy. Post-treatment PSG demonstrated a significant improvement in obstructive events with an AHI of 4.0 events/hour and a minimum SpO<sub>2</sub> of 92%. Holter monitoring indicated significant improvement in sinus arrest, recording 267 episodes of R-R intervals exceeding 2 seconds, with maximum nocturnal and daytime pauses of 2.2 and 2.0 seconds, respectively.

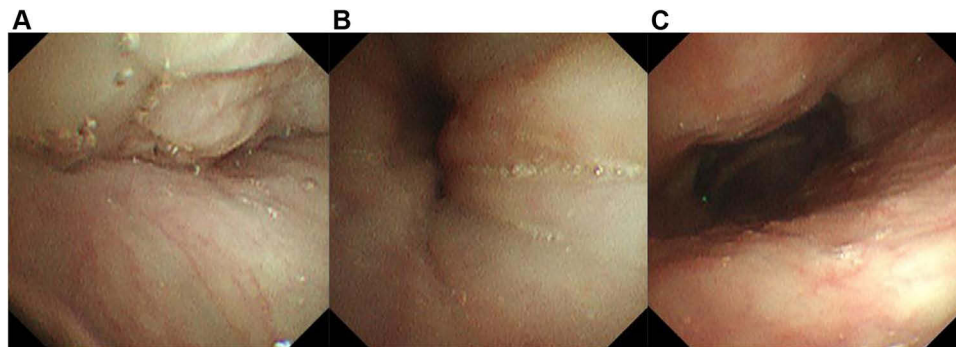
## Case 2

A 34-year-old woman reported a 10-year history of snoring and more than one year of nocturnal choking and daytime somnolence. PSG demonstrated severe OSA with an AHI of 120 events/hour and a nadir SpO<sub>2</sub> of 52%. Auto-CPAP therapy was prescribed with a pressure range of 5–20 cm H<sub>2</sub>O. However, the patient experienced persistent intolerance to CPAP attributed to airflow pressure-related discomfort.

DISE showed complete anteroposterior collapse at velum (Figure 3A) and complete lateral obstruction at oropharynx due to hypertrophic tonsils (Figure 3B), with no significant obstruction at tongue base and epiglottis. DISE-PAPT revealed the resolution of velum and oropharyngeal obstruction at 16 cm H<sub>2</sub>O pressure (Figure 3C) (Video S2). Due to persistent intolerance to high CPAP, surgical intervention involving tonsillectomy and uvulopalatopharyngoplasty was



**Figure 3** Baseline upper airway collapse through DISE and post-CPAP therapeutic changes via DISE-PAPT in Case 2. **(A)** Complete anteroposterior obstruction at velum. **(B)** Complete lateral obstruction at oropharynx due to hypertrophic tonsils (black arrow). **(C)** Resolution of velum and oropharyngeal obstruction at 16 cm H<sub>2</sub>O pressure. **Abbreviations:** CPAP, continuous positive airway pressure; DISE, drug-induced sleep endoscopy; DISE-PAPT, drug-induced sleep endoscopy with positive airway pressure titration.



**Figure 4** Baseline upper airway collapse through DISE and post-CPAP therapeutic changes via DISE-PAPT in Case 3. **(A)** Complete anteroposterior obstruction at velum. **(B)** Complete lateral obstruction at oropharynx due to soft tissue laxity. **(C)** Resolution of velum and oropharyngeal obstruction at 12 cm H<sub>2</sub>O pressure. **Abbreviations:** CPAP, continuous positive airway pressure; DISE, drug-induced sleep endoscopy; DISE-PAPT, drug-induced sleep endoscopy with positive airway pressure titration.

conducted. Postoperative PSG indicated partial improvement in obstructive events, with an AHI of 28 events/hour and a minimum SpO<sub>2</sub> of 85%. CPAP therapy was resumed postoperatively, with a manually titrated therapeutic pressure of 8 cm H<sub>2</sub>O. The patient reported markedly improved tolerance to CPAP therapy, with the disappearance of both daytime hypersomnolence and nocturnal respiratory disturbances. A follow-up PSG three months postoperatively confirmed good therapeutic efficacy, with a residual AHI of 1 event/hour.

### Case 3

A 54-year-old man complained of a 20-year history of snoring with recent progression to nocturnal dyspnea awakening for six months. PSG demonstrated severe OSA with an AHI of 48.7 events/hour and SpO<sub>2</sub> nadir at 72%. The patient declined CPAP therapy and expressed a preference for surgical intervention.

DISE identified complete anteroposterior collapse at velum (Figure 4A) and complete lateral obstruction at oropharynx due to soft tissue laxity (Figure 4B), with no significant obstruction observed at tongue base and epiglottis. Subsequent DISE-PAPT demonstrated the resolution of velum and oropharyngeal obstruction at a pressure of 12 cm H<sub>2</sub>O (Figure 4C). Based on the video analysis of DISE-PAPT (Video S3), the patient was counseled that the obstruction at oropharynx was attributed to attenuated muscle reactivity of upper airway dilators, favoring CPAP therapy over surgical intervention. Following this evaluation, the patient ultimately accepted CPAP therapy, which effectively alleviated the nocturnal snoring and apnea-induced awakening. A follow-up PSG one month later indicated the resolution of obstructive events with a residual AHI of 2 events/hour.

### Discussion

This study presents three cases of OSA with CPAP therapy failure, intolerance to high CPAP, or psychological resistance to CPAP therapy, indicating that DISE-PAPT can identify the anatomical mechanisms underlying CPAP treatment failure and high CPAP requirement. These insights provide a foundation for personalized precision therapy in patients with OSA.

Compared to obstruction at tongue base or epiglottis, CPAP demonstrates superior efficacy in resolving collapse at velum and oropharynx.<sup>12–15</sup> Notably, in certain OSA with tongue base or epiglottic collapse, elevated CPAP may induce anterior displacement of epiglottis, compressing posterior pharyngeal wall and exacerbating obstruction,<sup>6,13,16–18</sup> as observed in our Case 1. These findings highlight that empirical pressure escalation in patients with OSA with suboptimal CPAP response may worsen airway obstruction, underscoring the critical role of DISE-PAPT in identifying complex upper airway obstruction mechanisms.

Head rotation may achieve similar effect compared to whole-body rotation on relieving positional airway collapse.<sup>19</sup> In Case 1, the patient's head was rotated 90 degrees to the right to alleviate tongue base and epiglottis obstruction. The combination of CPAP and positional therapy not only resolved the patient's sleep-disordered breathing events but also

significantly reduced cardiac pause duration, thereby avoiding pacemaker implantation in Case 1. However, a meta-analysis by Sia et al concluded that CPAP therapy may not substantially decrease the risk of daytime or nocturnal bradycardia in patients with OSA.<sup>20</sup> Large-scale prospective controlled trials are needed to further explore the impact of CPAP therapy on arrhythmias in patients with OSA.

Surgical intervention constitutes an effective therapeutic approach for oropharyngeal stenosis secondary to tonsillar hypertrophy.<sup>21,22</sup> In Case 2, DISE-PAPT revealed that tonsillar hypertrophy-induced oropharyngeal obstruction required high CPAP to resolve. Following tonsillectomy, therapeutic pressure demand was markedly reduced, thereby enhancing the patient's tolerance for CPAP therapy. However, not all oropharyngeal obstruction can be resolved by surgical intervention. In Case 3, DISE-PAPT also indicated oropharyngeal obstruction, but the obstruction was due to collapse of oropharyngeal lateral wall soft tissue rather than tonsillar hypertrophy. This pattern of collapse was attributed to attenuated muscle reactivity of upper airway dilators rather than fixed anatomical narrowing, making it difficult to benefit from surgical intervention. Dynamic visualization of CPAP-mediated upper airway obstruction reversal via DISE-PAPT procedural videos enhanced the patient's comprehension of therapeutic mechanisms and thus improved CPAP adherence.

DISE can provide direct visualization of upper airway anatomical characteristics, but it offers limited assessment of airway collapsibility. In Case 2 and Case 3, the two patients exhibited the same obstruction at the velum and oropharyngeal levels, while the titration pressure to relieve the obstruction differed. The initial titration pressure showed no significant correlation with the pattern of airway collapse.<sup>23</sup> Gouldman et al demonstrated that simultaneous measurement of critical closing pressure and pharyngeal opening pressure during DISE-PAPT may provide more comprehensive characteristics of airway collapsibility and OSA pathophysiology.<sup>24</sup>

In contrast to previous studies,<sup>7,9,12,13</sup> our team not only developed the individualized treatment plans for the three cases based on the DISE-PAPT evaluations, but also conducted subsequent follow-up assessment to validate the clinical efficacy of proposed treatment strategies. However, as a case series, this study has inherent limitations in generalizability. Prospective controlled clinical trials with adequate sample size are needed to further assess the impact of DISE-PAPT on therapeutic outcomes and adherence in patients with OSA.

Additionally, alternative non-CPAP treatment should be carefully considered in patients with OSA unsuitable for CPAP therapy. Orthopedic treatment for mild to moderate OSA is an option only when skeletal discrepancies exist.<sup>25</sup> A diagnostic trial oral appliance may be used to distinguish treatment responder from nonresponder patients.<sup>26</sup> Besides, if the resolution of upper airway obstruction with a jaw thrust is observed through DISE, this strongly suggests favorable outcomes with oral appliance therapy.<sup>27</sup> Thus, DISE can be helpful to identify patients with OSA who will benefit from oral appliance treatment. For patients with OSA considered unsuitable for CPAP therapy following DISE-PAPT evaluation, future research should incorporate DISE with jaw thrust maneuvers to determine their candidacy for mandibular advancement therapy.

## Conclusion

The DISE-PAPT technique integrates anatomical visualization with CPAP effect, facilitating the identification of collapse mechanisms for CPAP treatment failure or intolerance in patients with OSA. The personalized comprehensive treatment strategies based on the DISE-PAPT technique hold promise for enhancing the overall therapeutic efficacy and adherence among patients with OSA.

## Abbreviations

AHI, apnea-hypopnea index; BIS, bispectral index; CPAP, continuous positive airway pressure; DISE, drug-induced sleep endoscopy; DISE-PAPT, drug-induced sleep endoscopy with positive airway pressure titration; SpO<sub>2</sub>, oxygen saturation; OSA, obstructive sleep apnea; PSG, polysomnography.

## Data Sharing Statement

The data and materials supporting the results in our paper will be made available on reasonable request from the corresponding author.

## Author Contributions

P.J. LI was responsible for conceptualization, data curation, formal analysis, methodology, visualization, writing - original draft, and writing - review and editing. L.J. GONG was responsible for conceptualization, data curation, formal analysis, methodology, visualization, and writing - original draft. Z.Y. HUANG and X. ZHANG were responsible for conceptualization, data curation, and writing - original draft. D. LIU and Z.A. LIANG were responsible for conceptualization, data curation, and writing - review and editing. All authors gave approval of the version to be published, approved the submission of this manuscript to this journal, and agree to take academic responsibility for this content.

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## Disclosure

All authors report no conflicts of interest in this work.

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