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Evaluation of Upper Airway Dynamics Using Multichannel Drug-Induced Sleep Endoscopy in Patients With Obstructive Sleep Apnea-Multichannel Drug-Induced Sleep Endoscopy

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Drug-induced sleep endoscopy (DISE) is an essential diagnostic tool for assessing upper airway obstruction in patients with obstructive sleep apnea (OSA). However, traditional single-channel DISE (SDS) often fails to capture important external maneuvers, vital signs, and dynamic changes in the airway. To address these limitations, we developed and implemented a multichannel DISE (MDS) protocol, which has been routinely used since 2018 at Chonnam National University Hospital for OSA patients undergoing polysomnography. This system integrates up to six synchronized video channels, including endoscopic views, vital sign monitoring, patient positioning, continuous positive airway pressure (CPAP) status, external maneuvers, and acoustic signals. The procedure consists of three phases: awake evaluation, sedation, and CPAP titration to determine the optimal therapeutic pressure. The MDS system allows for a comprehensive assessment of both anatomical and functional factors contributing to obstruction. Real-time visualization and maneuver testing enhance procedural safety, enabling trained residents to perform the examination under supervision, with no complications reported to date. Additionally, the ability to review recorded videos aids in clinical interpretation and facilitates patient education and treatment compliance. In conclusion, MDS offers a practical and scalable improvement over conventional DISE. It enables detailed evaluation of upper airway dynamics and supports individualized therapeutic decision-making, demonstrating strong potential for both clinical practice and research in OSA management. **Sleep Med Res 2025;16(4):255-260**

Keywords Obstructive sleep apnea; Larynx; Airway obstruction; Patient noncompliance; CPAP ventilation.

BACKGROUND AND RATIONALE

Background and Rationale

Drug-induced sleep endoscopy (DISE) is essential for pinpointing specific sites and patterns of upper airway obstruction in patients with obstructive sleep apnea (OSA), enabling more targeted and effective treatment strategies. However, traditional single-channel DISE (SDS), commonly used in clinical settings, offers a limited view of the airway. It is unable to assess critical factors such as patient positioning, physiological signals, continuous positive airway pressure (CPAP) response, or external maneuvers simultaneously during the procedure.

This narrow focus can lead to an incomplete understanding of airway dynamics and patient physiology, potentially compromising diagnostic accuracy and limiting its effectiveness as a diagnostic tool. Additionally, the requirement for direct physician involvement in the examination restricts scalability and delegation within routine workflows.

To overcome these limitations, we developed a multichannel DISE (MDS) system that

incorporates multiple synchronized video and physiological data streams. This manuscript presents our standardized MDS protocol and its implementation strategy in clinical practice, emphasizing its potential as a scalable, safe, and educational tool to improve individualized diagnosis and therapeutic decision-making in OSA management.

Interest in multimodal or multichannel approaches to DISE has increased internationally; however, fully integrated clinical systems are still rare. Arigliani et al. [1] developed a synchronized three-channel DISE platform that combines endoscopic video, patient body positioning, and respiratory signals. Nonetheless, their system primarily focuses on video synchronization and documentation, lacking integrated physiological monitoring or therapeutic simulation capabilities. At Brigham and Women's Hospital in Boston, USA, Wellman and Huyett's research-oriented DISE framework incorporates endoscopy with pressure modulation via Spike-based physiological recording systems [2]. This platform is optimized for experimental airway modeling rather than routine clinical practice. In contrast, the MDS system described in this manuscript is specifically tailored for clinical implementation, integrating endoscopic imaging, bispectral index (BIS) monitoring, CPAP titration, external views, posture information, and acoustic signals into a single synchronized workflow. This integration allows for real-time therapeutic simulation, making the system suitable for routine diagnostic use in a tertiary hospital setting. These differences underscore the clinical practicality of the MDS platform compared to existing multimodal DISE approaches.

PROCEDURE AND IMPLEMENTATION

Patient Selection and Setting

At our institution, we perform multichannel DISE for patients being evaluated for OSA. Typical candidates include individuals scheduled for nasal or upper airway surgery, those who have trouble adapting to CPAP therapy, and patients exploring alternative treatments like oral appliances or surgical options.

We do not perform this procedure on patients classified as American Society of Anesthesiologists physical status IV (defined as patients with severe systemic disease posing a constant threat to life), pregnant individuals, or those with known hypersensitivity to sedative agents, as pharmacologic sedation is necessary.

All examinations take place in an operating room equipped with standard anesthesia monitoring systems to ensure patient safety. This controlled environment allows for continuous monitoring of oxygen saturation, blood pressure, heart rate, electrocardiography, and sedation depth, creating optimal conditions for DISE and enabling synchronized multichannel data recording throughout the procedure.

Sedative Protocol

For DISE sedation, we adhere to the guidelines set forth in the European Position Paper [3,4]. At our institution, propofol is the primary sedative due to its rapid onset, short half-life, and consistent sedation depth. While midazolam or dexmedetomidine may be used selectively based on patient-specific factors, propofol is the standard choice for most examinations.

Sedation is initiated using a Target-Controlled Infusion (TCI) system. We start with an effect-site target concentration of 2.0–2.5 μg/mL, preceded by a small bolus of approximately 2 mg to ensure stable induction. Sedation depth is continuously monitored using the BIS, with a target range of 60–70 to approximate natural sleep while allowing safe airway visualization.

During the procedure, we monitor oxygen saturation, blood pressure, heart rate, and electrocardiography in real time. If oxygen desaturation occurs, simple bag-valve-mask (Fig. 1) ventilation is typically sufficient to restore oxygenation and maintain procedural safety. This approach, combining controlled sedation, BIS monitoring, and prompt ventilatory support, ensures reliable and reproducible conditions for observing dynamic airway behavior.

Multichannel setup

The MDS system is configured to display and record multiple synchronized data streams in real time [5]. At our institution, we use a commercially available platform (HI-MED), which supports up to eight video input channels; six channels are routinely utilized for clinical examinations (Fig. 2).

The endoscopic view is captured using a 2.7-mm or 4-mm nasal endoscope connected to a high-definition imaging system (Olympus CV-170, Olympus) (Fig. 2A). To monitor the patient's external movements and simulation maneuvers, two additional cameras are used: one providing a wide view of the operating room (Hikvision 2 MP Fixed Mini Bullet Camera, Hikvision) and another focusing on the patient's upper body and procedural maneuvers (Fig. 2B and E).

Physiologic monitoring is integrated through a standard anesthesia monitoring system (Carescape B850, GE Healthcare), providing continuous tracking of oxygen saturation, blood pressure, heart rate, and electrocardiography. BIS monitoring (Covidien) and TCI pump output (Agilia SP TIVA KR, Fresenius Kabi) are also fed into the system to allow synchronized observation of sedation depth (Fig. 2C).

For positive airway pressure (PAP) titration, data from the CPAP device (AirSense 10 AutoSet for Her, ResMed) are displayed in real time, enabling correlation between pressure changes and airway behavior (Fig. 2F). Acoustic input from a microphone is included to capture snoring characteristics and breathing patterns.

All channels are displayed simultaneously on a single monitor, allowing the operator to evaluate endoscopic findings, physiologic signals, pressure changes, patient posture, and maneuver

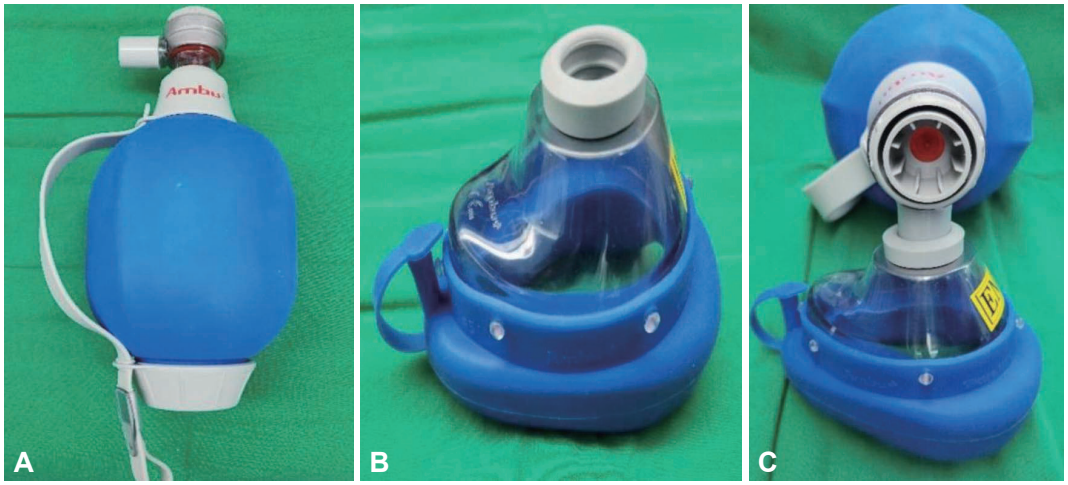

Fig. 1. Images (A-C) depict a series of pictures of a simple bag-valve-mask. Image (A) shows the soft bag element, which is squeezed to expel air to the patient. Image (B) displays the flexible mask designed to create a seal over the patient's face. Image (C) illustrates the combination of the two parts.

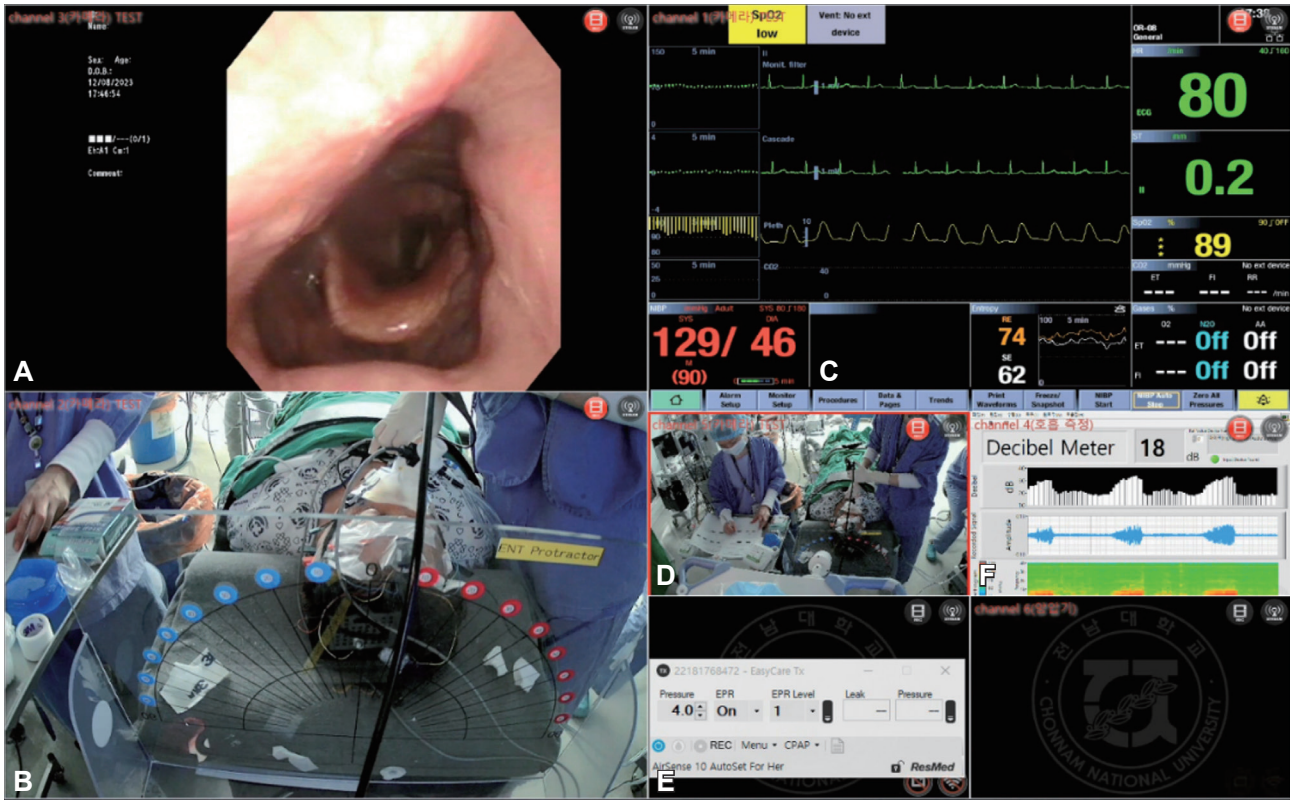

Fig. 2. This image captures the multichannel drug-induced sleep endoscopy recording during the examination. The upper left quadrant displays the recorded image of the upper airway obtained via endoscopy (A). The lower left quadrant features the external camera view (B). The upper right quadrant shows vital signs (C). The lower right quadrant, arranged counterclockwise, includes maneuvers (D), continuous positive airway pressure titration (E), and the sound analyzer (F).

responses in a unified view. This integrated setup enhances procedural efficiency and provides a comprehensive understanding of dynamic airway behavior during DISE.

Step-by-Step Procedure

The MDS examination consists of three sequential phases: Awake, Sedation, and PAP titration (Fig. 3). The procedure takes place in an operating room designed to minimize noise and light, simulating natural sleep conditions. To reduce motion and ensure stable multichannel recordings throughout the examination, standard restraints are applied around the arms, chest, and abdomen.

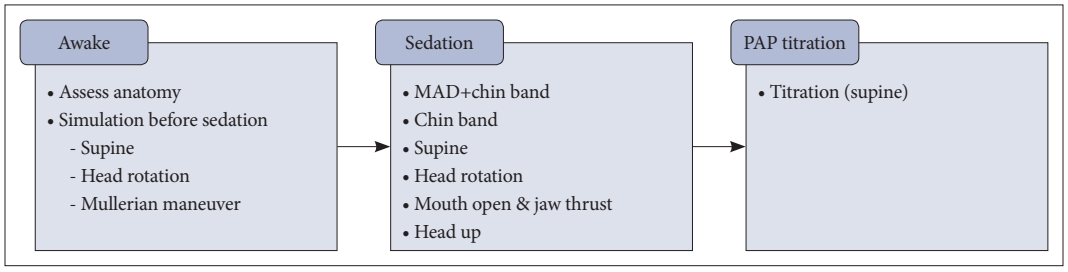

Fig. 3. Procedure overview and simulation of various states. MAD, mandibular advancement devices; PAP, positive airway pressure.

Step 1. Awake Phase

During the awake evaluation, we begin by assessing the upper airway anatomy using either a flexible or rigid nasal endoscope. We evaluate structural parameters such as Mallampati grade, tonsil size, septal deviation, salpingopharyngeal hypertrophy, and other anatomical factors relevant to OSA.

Since the patient is awake and cooperative, this phase also allows us to safely perform simulation maneuvers that may be difficult or unsafe once sedation begins. These maneuvers include mandibular advancement, jaw thrust (JT), head rotation, and upper-body elevation. Conducting these actions in advance enables us to compare responses in the awake state versus the sedated state, helping to avoid unexpected mobility limitations during sedation.

If we plan to test mandibular advancement devices (MAD) or CPAP masks during the examination, we fit them at this stage, as placement becomes more challenging after sedation.

Step 2. Sedation Phase

Sedation is induced following the previously outlined protocol, aiming for a BIS of 60–70 to mimic natural sleep. Once a stable level of sedation is achieved, the examination proceeds with a series of standardized assessments.

MAD test: If an MAD was used during the awake phase, the airway is first evaluated with the device in place to assess its functional impact, after which the device is removed.

Baseline supine airway evaluation: The airway is examined in a neutral supine position to document the patient's primary obstruction pattern while sedated.

Head rotation testing: The head is rotated 30° and then 60° to each side [6]. The MDS system facilitates simultaneous visualization of both endoscopic changes and external head-angle recordings, allowing for accurate correlation and subsequent review.

Mandibular opening and JT: These maneuvers are conducted sequentially to assess how mandibular positioning influences airway patency.

Upper body elevation: Elevating the upper body enables us to evaluate positional responsiveness and simulate common treatment postures.

During this phase, all channels—including endoscopic images, vital signs, external camera views, acoustic signals, and CPAP status—are continuously recorded for synchronized analysis.

Step 3. PAP Titration Phase

The final phase involves real-time CPAP titration using a multichannel system.

Pressure adjustment: CPAP begins at 4 cmH_2O and is increased in increments of 2 cmH_2O until the airway opens. Once adequate airway opening is achieved, the pressure is decreased in 1 cmH_2O increments to identify the minimum effective therapeutic pressure.

Stability confirmation: The airway is monitored for approximately one minute to ensure that the selected pressure maintains patency without any desaturation.

High-pressure assessment (up to 20 cmH_2O): Following our protocol, the pressure is raised to 20 cmH_2O to evaluate epiglottic behavior under high airflow conditions. This step is crucial for identifying patients at risk of epiglottic collapse or intolerance to elevated CPAP pressures [7,8].

All changes in CPAP pressure, snoring patterns, and endoscopic findings are displayed simultaneously, enabling real-time visualization of structure–pressure interactions.

During the examination, findings from each step are systematically documented using a structured reporting form, which is provided as Supplementary Fig. 1 (in the online-only Data Supplement).

Step 4. Post-Procedure Review

The entire examination is video-recorded and reviewed with the patient during the follow-up appointment. This visual explanation helps patients understand their obstruction pattern, compare the effects of various maneuvers, and engage actively in selecting their treatment. As a result, this step enhances treatment adherence and promotes shared decision-making.

CLINICAL EXPERIENCE AND APPLICATIONS

The MDS system has proven to be highly effective in clinical practice by offering a dynamic and comprehensive view of the upper airway during sedation. By integrating endoscopic imaging with physiological monitoring, external posture, and PAP

pressure data, clinicians can observe in real time how anatomical structures respond to various maneuvers and therapeutic interventions. This enhances the role of DISE from merely diagnostic visualization to a practical decision-support tool for managing OSA.

In patients with epiglottic collapse, the synchronized recording of CPAP pressure and airway behavior has revealed that certain collapse patterns can persist even with increased pressure. These insights help identify individuals who are unlikely to benefit from autotitrating CPAP therapy, steering clinicians toward alternative options such as fixed-pressure devices or epiglottopexy [7]. Additionally, real-time correlation of pressure and airway behavior clarifies the mechanisms behind CPAP intolerance in these patients.

The MDS system facilitates positional therapy planning by capturing endoscopic views, external camera images, and head-angle data simultaneously. This allows clinicians to assess how varying degrees of head rotation—such as 30° or 60°—affect multilevel obstruction [6]. As a result, clinicians can accurately identify patients who may benefit from positional therapy devices or structured sleep-position training.

Additionally, maneuver simulations, including mandibular opening, JT, and mouth-closure techniques, enhance personalized treatment planning [9]. Testing these maneuvers during sedation enables clinicians to evaluate the potential effectiveness of interventions like MAD, chin-support techniques, or oral-sealing strategies before committing to formal therapy.

For patients needing PAP therapy, MDS aids in identifying the most suitable mask interface. Real-time monitoring of air leaks, anatomical responses, and oxygenation during PAP titration helps determine whether a nasal or oronasal mask is preferable. This approach enhances patient education and promotes long-term adherence [10].

For surgical candidates, MDS offers detailed characterization of collapse patterns and responsiveness to positional or mechanical maneuvers. This information enables focused surgical planning and better patient selection. Additionally, recorded videos are reviewed with patients after the procedure to enhance understanding, improve acceptance of recommended treatments, and support shared decision-making [11].

Together, these applications show that MDS serves not only as a diagnostic examination but also as an integrated clinical tool that informs personalized treatment strategies for CPAP therapy, oral appliances, positional therapy, and airway surgery.

Summary and Practical Insights

MDS offers a structured and clinically accessible approach for assessing dynamic upper airway obstruction in patients undergoing DISE. By integrating endoscopic views, physiological signals, positional data, and PAP titration into a synchronized multichannel display, MDS provides a comprehensive understanding of airway behavior that surpasses traditional SDS methods.

The standardized protocol outlined in this article ensures that examinations can be conducted safely and consistently, even by trainees under supervision, while preserving high diagnostic value. Real-time maneuver testing and PAP titration allow clinicians to simulate therapeutic strategies during the procedure, providing immediate insights into the potential effectiveness of CPAP therapy, positional adjustments, mandibular advancement, or surgical intervention.

In everyday practice, the enhanced visualization, structured workflow, and postoperative video review improve patient education and facilitate shared decision-making. Consequently, MDS functions not only as a diagnostic tool but also as a practical guide for personalized treatment planning.

This adaptable approach can be implemented in various clinical settings, making it valuable for both routine DISE examinations and advanced airway phenotyping. With increased integration into clinical workflows, MDS has the potential to improve the precision and effectiveness of OSA management.

Supplementary Materials

The online-only Data Supplement is available with this article at https://doi.org/10.17241/smr.2025.03286.

Availability of Data and Material

The datasets generated or analyzed during the study are available from the corresponding author on reasonable request.

Author Contributions

Conceptualization: Hyung Chae Yang. Data curation: Seonwoo Jeong, Hyunseo Oh. Formal analysis: Jisun Kim, Seungsoo Ryu. Funding acquisition: Hyung Chae Yang. Investigation: Seonwoo Jeong, Chungman Sung. Methodology: Hyung Chae Yang, Chungman Sung. Project administration: Hyung Chae Yang. Resources: all authors. Software: Seungsoo Ryu. Supervision: Hyung Chae Yang. Validation: Jisun Kim. Visualization: Seonwoo Jeong. Writing—original draft: Seonwoo Jeong, Hyung Chae Yang. Writing—review & editing: Hyung Chae Yang.

Conflicts of Interest

HY is the inventor of patents registered in South Korea (Patent Numbers: 1017706140000, 1017164050000, 1022667990000) related to the device used in this study. The intellectual property has been licensed to SEO Corp., and HY is not currently receiving any financial compensation from this licensing agreement. The author declares that these interests have not influenced the study design, data collection, analysis, or interpretation of the results presented in this manuscript.

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REFERENCES

1. Arigliani M, Toraldo DM, Montevecchi F, Conte L, Galasso L, De Rosa F, et al. A new technological advancement of the Drug-Induced Sleep Endoscopy (DISE) procedure: the "all in one glance" strategy. *Int J Environ Res Public Health* 2020;17:4261.
2. Vena D, Op de Beeck S, Yang H, Sumner J, Mann D, Wang TY, et al. Lateral wall collapse from sleep endoscopy and airflow shape predicts hypoglossal nerve stimulation efficacy in obstructive sleep apnoea. *Eur Respir J* 2025;66:2500236.
3. De Vito A, Carrasco Llatas M, Ravesloot MJ, Kotecha B, De Vries N, Hamans E, et al. European position paper on drug-induced sleep endoscopy: 2017 Update. *Clin Otolaryngol* 2018;43:1541-52.
4. De Vito A, Carrasco Llatas M, Vanni A, Bosi M, Braghiroli A, Campanini A, et al. European position paper on drug-induced sedation endoscopy (DISE). *Sleep Breath* 2014;18:453-65.
5. Yang HC, Jung EK, Yoon SH, Cho HH. The efficacy of drug induced sleep endoscopy using multimodality monitoring system. *PLoS One* 2018;13:e0209775.
6. Tan SN, Kim JM, Kim J, Sung CM, Kim HC, Lee J, et al. Head rotation improves airway obstruction, especially in patients with less severe obstructive sleep apnea without oropharyngeal collapse. *PLoS One* 2022;17:e0268455.
7. Sung CM, Kim HC, Kim J, Kim JG, Lim SC, Shin MH, et al. Patients with epiglottic collapse are less adherent to autotitrating positive airway pressure therapy for obstructive sleep apnea. *Ann Am Thorac Soc* 2022;19:1907-2.
8. Kim HY, Sung CM, Jang HB, Kim HC, Lim SC, Yang HC. Patients with epiglottic collapse showed less severe obstructive sleep apnea and good response to treatment other than continuous positive airway pressure: a case-control study of 224 patients. *J Clin Sleep Med* 2021;17:413-9.
9. Yang H, Huyett P, Wang TY, Sumner J, Azarbarzin A, Labarca GPT, et al. Mouth closure and airflow in patients with obstructive sleep apnea: a nonrandomized clinical trial. *JAMA Otolaryngol Head Neck Surg* 2024;150:1012-9.
10. Kim J, Koo D, Sung CM, Kim J, Ryu SS, Lim SC, et al. The impact of nasal mask versus oronasal mask CPAP treatment on the site of collapse and the differences in physiologic state. *Sleep Breath* 2025;29:341.
11. Sung CM, Tan SN, Shin MH, Lee J, Kim HC, Lim SC, et al. The site of airway collapse in sleep apnea, its associations with disease severity and obesity, and implications for mechanical interventions. *Am J Respir Crit Care Med* 2021;204:103-6.