Diagnosis and Evaluation of Upper Airway Disorders in Noninvasive Ventilator Support: Endoscopy Evaluation

Eleni Tzitzili, Thomas Kanteres, Achilleas Lazopoulos, and Nikolaos Barbetakis

Introduction

As noninvasive ventilation (NIV) is the application of ventilator support using the natural airway defined. The efficacy of NIV can be greatly affected by the anatomy and coexisting abnormalities or dysfunction of the upper airway structures. More specifically, the upper airway's patency and elasticity or spasticity play a predominant role in the ventilatory support achieved through the application of NIV. In addition, pathophysiological changes of the upper airways function can be caused by certain body positions, obesity, sedation, and exercise. Characteristic examples are the obstructive sleep apnea syndrome (OSAS) and the obesity hypoventilation syndrome (OHS) [1]. Endoscopic evaluation of such patients can be key in deeply understanding the pathophysiological mechanisms that are at play in such patients and, hence, optimizing their treatment [2]. Moreover, chronically ventilated patients with persistent upper airway obstruction or restrictive respiratory disorders may benefit from endoscopic evaluation through its contribution in the identification of the mechanisms of the underlying disorders, although the currently published information on this topic are scarce and the indication of endoscopy in those patients is currently on debate.

Endoscopy Evaluation in Patients with OSAS

As already state above, the pathophysiological mechanisms of reduced upper airway patency involve both the skeletal and the soft structures of the anatomical region. In patients with obstructive sleep apnea syndrome (OSAS), the collapse of

E. Tzitzili (✉) · T. Kanteres · A. Lazopoulos · N. Barbetakis
Department of Thoracic Surgery, "Theagenio" Cancer Hospital, Thessaloniki, Greece

A. M. Esquinas et al. (eds.), *Upper Airway Disorders and Noninvasive Mechanical Ventilation*, https://doi.org/10.1007/978-3-031-32487-1_40

the soft palate or other upper airway structures is recurrent and characteristically exacerbated when the patient is asleep and in the supine position. Apart from anatomical abnormalities, other contributing factors include insufficient respiratory central control and reduced activity of the laryngeal dilatator muscle. Special mention should be made in regard to obesity as a risk factor in the development of OSAS, mainly due to increased volume of the upper airway soft tissues [3]. The severity of the disease is frequently measured by the apnea-hypopnea index, which is the number of incidents of apnea or hypopnea during 1 h of sleep. The endoscopic evaluation, however, especially when sleep induced, offers a more accurate assessment of the grade of the reduction of the upper airway diameter and can detect the anatomical site of obstruction. Studies of drug-induced sleep endoscopy (DISE) in patients with OSAS have revealed that the obstruction of the upper airway can be due to the collapse of various structures (epiglottis, soft palate, lateral pharynx wall, base of the tongue) or a combination of those. More specifically, DISE has identified the collapse of the epiglottis in 12–30% of the cases [2]. In addition, it has been shown that epiglottis collapse responds to positional therapy, while tongue base obstruction occurs frequently in the non-supine position [4]. Endoscopy contributes also to the appropriate choice of an interface, while evaluating directly the effect of each mask to the airway patency correspondingly [5].

Endoscopy Evaluation in Patients with ALS

Patients suffering from ALS often experience UA obstruction caused by upper motor neuron dysfunction and impairment of the bulbar function. This, in turn, leads to spasticity of the UA structures, significantly reducing the effectiveness of NIV in some cases. The negative prognostic impact of persisting obstructive events and the consequential hypoventilation have been proven [6]. Andersen et al. studied the impact of the different levels of pressures provided by mechanical insufflation-exsufflation (MI-E) in patients with ALS with different levels of bulbar involvement [7]. The authors showed that even slight changes in pressure levels produced significant reduction of the laryngeal diameter that could be avoided with stricter regulation and appropriate adjustment of pressure settings. Azkona et al. determined in a prospective study that in 6% of the cases studied with ALS evaluated by dynamic endoscopy, the application of NIV alone caused laryngeal obstruction, while patients with bulbar involvement where more prone to UA obstruction both spontaneously and while receiving NIV [8]. While endoscopy is not routinely part of the evaluation of the UA of patients with ALS receiving NIV, patients with bulbar involvement demonstrating severe residual obstruction events could greatly benefit by the adjustment of ventilation settings after endoscopic evaluation.

Endoscopic Evaluation in Patients Treated with NIV Support

The data in the literature regarding the study and more specifically the endoscopic evaluation of the upper airway in patients treated with NIV support is scarce. The efficacy of NIV can be greatly affected by disorders of the upper airway compromising the airway patency. Endoscopic evaluation of the upper airway in patients receiving NIV support can provide important information regarding the possible causes of residual obstructive events or persistent hypoventilation, the possible soft tissue collapse location, and the role of the body position and, hence, contribute to the selection of the most appropriate interface mask for each patient. Although it has been shown that obstructive or hypoventilation effects that result in hypoxia have a significantly negative prognostic impact, little research can be found on the underlying pathophysiological mechanisms and the role of the endoscopy in their identification.

Among the proposed pathophysiological dysfunctions responsible for such events are the collapse of the soft palate, obstruction at the tongue base or at the level of the epiglottis [2]. Ventilator settings can also affect the patency of the upper airway. Recent studies have shown that patient-ventilator asynchrony is associated with decreased diameter of the glottis, which in turn increases upper airway resistance. Suboptimal synchronization between the ventilator support and the patient's neural drive and upper airway muscle movement has been associated with significantly reduced efficacy of the ventilation and prolonged treatment with NIV [9]. The effect of NIV on the constrictor and dilator muscles of the glottis has been studied by Moreau-Bussière et al. on nonsedated lambs [10]. The researchers showed that when pressure support during NIV was applied, the activity of the cricothyroid muscle (dilator) disappears and that of the constrictor muscle (thyroarytenoid) increases, therefore causing a decrease of the glottal diameter and reduced ventilation.

A similar response in humans has been shown in some studies where the researchers exposed normal subjects to NIV and then monitored the patency of the glottis and the effects on airway resistance. Rodenstein et al. monitored the effects of NIV on the upper airway patency through fiber-optic bronchoscopy and showed the glottic aperture decreased proportionally to the increase of the positive pressure support applied [11]. Though limited data can be found in the literature, it is indicated that endoscopy can provide critical information in determining the upper airway patency in patients receiving NIV and contribute to optimizing the ventilation parameters and, therefore, the ventilation efficacy.

Endoscopy: Setting the Indication for Surgical Treatment

Upper airway video endoscopy may also be useful in setting the indication for operative treatment patients with upper airway obstruction. The flexible pharyngoscopy with Müller maneuver was first introduced by Sher et al. as a diagnostic tool in the selection of patients eligible for uvulopalatopharyngoplasty. During the Müller maneuver, the patient attempts to inhale with his mouth and nostrils closed, which causes the airway to collapse. The process is monitored via flexible fibroscopy of the pharynx to identify the collapse of the airway and isolated weakness spots [12]. Drug-induced sleep endoscopy (DISE) has more recently been proposed as a valuable method in the selection of patients for surgical treatment of upper airway obstruction.

The technique includes the administration of a sedative agent that should ideally stimulate natural sleep without affecting the upper airway collapse. Such an ideal sedative agent does not yet exist, but most commonly propofol, midazolam, and dexmedetomidine are being used [13]. Issues have been raised in the literature concerning the assessment of the information obtained from DISE, as drug-induced sleep is not identical to the natural sleeping process. The update on the European position paper on DISE, published in 2017, indicates the use of this method in patients with socially disturbing snoring and OSAS not eligible for or not tolerating continuous positive airway pressure (CPAP) therapy and in patients where CPAP therapy and surgery have previously failed [14].

There is constant development in the field of endoscopic evaluation of the upper airway. De Vito et al. compared in a prospective randomized controlled study the conventional DISE to the target controlled infusion sedation endoscopy (TCI-DISE), where a manual bolus injection of the sedative agent is administered to induce with increased accuracy snoring and obstruction patterns comparable to natural sleep. A complete apnea event was recorded in 30% of the patients in the DISE group compared to 81% in the TCI-DISE group. The authors proposed the use of the TCI-DISE technique as method of first choice in patient selection for surgical treatment as it proved more accurate and safer [15]. Other techniques that are currently under research are awake procedures, such as fiber-optic nasopharyngoscopy with modified Müller maneuver, nasal snoring endoscopy, and oral snoring endoscopy [16]. In some studies, the results where promising and comparable to those obtained from the DISE technique [17]. However, more data is required regarding the techniques' accuracy in predicting the level and grade of the airway collapse and their effectiveness as a diagnostic tool in patient selection for surgical therapy.

Classification Systems

Some objective classification systems for the evaluation of the endoscopic findings have been proposed. De Vries et al. introduced the VOTE classification aiming to objectively describe the endoscopic findings during drug-induced endoscopy of the upper airway. The VOTE classification evaluates the degree of obstruction and the configuration of the obstruction related to the most commonly involved structures in the upper airway collapse. The structures included in the classification are the velum, the tongue base, the oropharyngeal lateral walls, and the epiglottis [18]. Although the VOTE classification is commonly used among physicians, no consensus has been reached regarding the use of one specific classification system, but it is strongly recommended that the level, degree, and configuration of the obstruction are evaluated [14]. The assessment of the nose, nasopharynx, and glottis is not of the highest priority in adult patients, but no agreement has been reached on the exact structures that should be individually assessed or the number of levels that should be described during the endoscopic evaluation. As to the severity of the obstruction, it has been graded by some systems with only three degrees of obstruction, while others apply the use of percentages to more precisely evaluate the degree of the obstruction. Regarding the configuration, agreement has been reached on the three forms of obstruction: anteroposterior, lateral, and concentric.

Use of NIV During Endoscopic Evaluation of the Upper Airway

Endoscopic procedures for the evaluation of the upper airways are frequently performed in patients with reduced respiratory reserve due to the underlying condition. Important reference should be made to the use of simultaneous noninvasive ventilatory support during the performance of such procedures to prevent the development of hypoxia and respiratory failure in patients at high risk. In addition, the development of such symptoms often leads to interruption of the procedure before obtaining the necessary diagnostic information, which can be prevented with the use of NIV [19].

Periprocedural NIV has been used to improve oxygenation and avoid general anesthesia. Thanks to technological advancements, new masks that allow the insertion of an endoscopic probe for diagnostic purposes or even the conduction of interventional procedures are now available [20]. Routinely, the parameters that are closely monitored for patients treated with NIV during endoscopic procedures are electrocardiography, pulse oximetry and capnography, noninvasive arterial pressure measurement, respiratory rate, and minute ventilation, when possible [21].

Although most commonly the use of NIV in endoscopic procedures is indicated for patients undergoing a transesophageal echocardiography (TEE) assessment, it also has a role in the endoscopic evaluation of the upper airway structures [22].

Despite the advantages of applying NIV during the performance of endoscopic procedures and thus avoiding general anesthesia, it could also expose the patient to a higher risk of aspiration, while leaving the airway unprotected. Therefore, individual patient factors should be considered while choosing the applied approach during the endoscopic evaluation of the patient [23].

Conclusion

The pathogenetic mechanisms involved in upper airway disorders are various and include both anatomical and functional disorders. Among the diagnostic tools at the physician's disposal, endoscopy holds an important position. In the primary evaluation of patients with UA obstruction and OSAS, drug-induced endoscopy offers valuable information regarding the pathogenesis of the obstruction. A direct evaluation of the level of the obstruction and the structures involved can be obtained, thus contributing to the prediction of the response to positioning therapy or ventilation support therapy and the choice of the most suitable interface for its application. Especially in patients with ALS, research has proven the negative prognostic effect of obstructive events of the upper airway. Evaluation of patients at high risk for such events, in particular those with bulbar involvement, could greatly benefit from dynamic endoscopic evaluation and adjustment of ventilation settings accordingly.

Treatment-induced upper airway obstruction or residual events and persisting obstruction in chronically ventilated patients and patients currently undergoing NIV therapy reduce the efficacy of ventilation support and pose a complex problem in the treatment of such patients. Endoscopy can provide invaluable information as to the type of obstruction caused, determining the anatomical structures involved and the degree of the reduction of the airway patency. More importantly, it can associate the UA disorder with the ventilation parameters under direct observation and identify a possible patient-ventilator asynchrony, hence guiding the titration of the positive pressure and other ventilation settings.

While, overall, the contribution of endoscopy in the evaluation of the patient with UA disorders is long known and valued, still to this day, no consensus has been reached regarding the classification system of the endoscopic findings.

In some studies, the assessment of endoscopic findings has been used as a diagnostic tool in the selection of patients eligible for uvulopalatopharyngoplasty with promising results. While the most extensively studied method in this regard is DISE, more recently, awake endoscopy procedures are being implemented with promising results, although more research is needed in this field. The synchronous application of NIV during the endoscopic procedures has achieved the conduction of such examinations on patients at high risk of hypoxia and respiratory failure, exposing them, though, at the same time to an increased risk of aspiration. The need for further optimization of such procedures and for individual planning of the diagnostic and treatment course still remains of utmost importance.

Conflict of Interest The authors have no conflict of interest to declare.

References

1. Sequeira TCA, BaHammam AS, Esquinas AM. Noninvasive ventilation in the critically ill patient with obesity hypoventilation syndrome: a review. J Intensive Care Med. 2017;32(7):421–8.
2. Conde B, Martins N, Brandão M, Pimenta AC, Winck JC. Upper airway video endoscopy: assessment of the response to positive pressure ventilation and mechanical in-exsufflation. Pulmonology. 2019;25(5):299–304.
3. Genta PR, Schorr F, Eckert DJ, Gebrim E, Kayamori F, Moriya HT, et al. Upper airway collapsibility is associated with obesity and hyoid position. Sleep. 2014;37(10):1673–8.
4. Marques M, Genta PR, Sands SA, Azarbazin A, de Melo C, Taranto-Montemurro L, et al. Effect of sleeping position on upper airway patency in obstructive sleep apnea is determined by the pharyngeal structure causing collapse. Sleep. 2017;40(3):zsx005.

5. de Andrade RGS, Piccin VS, Nascimento JA, Viana FML, Genta PR, Lorenzi-Filho G. Impact of the type of mask on the effectiveness of and adherence to continuous positive airway pressure treatment for obstructive sleep apnea. J Bras Pneumol. 2014;40(6):658–68.
6. Georges M, Attali V, Golmard JL, Morélot-Panzini C, Crevier-Buchman L, Collet JM, et al. Reduced survival in patients with ALS with upper airway obstructive events on non-invasive ventilation. J Neurol Neurosurg Psychiatry. 2016;87(10):1045–50.
7. Andersen T, Sandnes A, Brekka AK, Hilland M, Clemm H, Fondenes O, et al. Laryngeal response patterns influence the efficacy of mechanical assisted cough in amyotrophic lateral sclerosis. Thorax. 2017;72(3):221–9.
8. Azkona MS, Pascual Y, Farrero E, Cordoba A, Frutos NCD, Ferrer MD, et al. Effects of non-invasive mechanical ventilation (NIV) on the upper airway (UA) in patients with amyotrophic lateral sclerosis (ALS) and role of respiratory endoscopy in their assessment. Eur Respir J. 2020;56(suppl 64) https://erj.ersjournals.com/content/56/suppl_64/2952.
9. Oppersma E, Doorduin J, Gooskens PJ, Roesthuis LH, van der Heijden EHFM, van der Hoeven JG, et al. Glottic patency during noninvasive ventilation in patients with chronic obstructive pulmonary disease. Respir Physiol Neurobiol. 2019;259:53–7.
10. Moreau-Bussière F, Samson N, St-Hilaire M, Reix P, Lafond JR, Nsegbe E, et al. Laryngeal response to nasal ventilation in nonsedated newborn lambs. J Appl Physiol (1985). 2007;102(6):2149–57.
11. Parreira VF, Jounieaux V, Aubert G, Dury M, Delguste PE, Rodenstein DO. Nasal two-level positive-pressure ventilation in normal subjects. Effects of the glottis and ventilation. Am J Respir Crit Care Med. 1996;153(5):1616–23.
12. Sher AE, Thorpy MJ, Shprintzen RJ, Spielman AJ, Burack B, McGregor PA. Predictive value of Müller maneuver in selection of patients for uvulopalatopharyngoplasty. Laryngoscope. 1985;95(12):1483–7.
13. Kotecha B, De Vito A. Drug induced sleep endoscopy: its role in evaluation of the upper airway obstruction and patient selection for surgical and non-surgical treatment. J Thorac Dis. 2018;10(Suppl 1):S40–7.
14. 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(6):1541–52.
15. De Vito A, Agnoletti V, Zani G, Corso RM, D'Agostino G, Firinu E, et al. The importance of drug-induced sedation endoscopy (D.I.S.E.) techniques in surgical decision making: conventional versus target controlled infusion techniques-a prospective randomized controlled study and a retrospective surgical outcomes analysis. Eur Arch Otorhinolaryngol. 2017;274(5):2307–17.
16. Lovato A, Kotecha B, Vianello A, Giacomelli L, Staffieri A, Marchese-Ragona R. Nasal and oral snoring endoscopy: novel and promising diagnostic tools in OSAS patients. Eur Arch Otorhinolaryngol. 2015;272(7):1793–9.
17. Van de Perck E, Vroegop AV, Op de Beeck S, Dieltjens M, Verbruggen AE, Van de Heyning PH, et al. Awake endoscopic assessment of the upper airway during tidal breathing: definition of anatomical features and comparison with drug-induced sleep endoscopy. Clin Otolaryngol. 2021;46(1):234–42.
18. Kezirian EJ, Hohenhorst W, de Vries N. Drug-induced sleep endoscopy: the VOTE classification. Eur Arch Otorhinolaryngol. 2011;268(8):1233–6.
19. Murgu SD, Pecson J, Colt HG. Bronchoscopy during noninvasive ventilation: indications and technique. Respir Care. 2010;55(5):595–600.
20. Cabrini L, Landoni G. A novel non-invasive ventilation mask to prevent and manage respiratory failure during fiber optic bronchoscopy, gastroscopy and transesophageal echocardiography. Heart Lung Vessel. 2015;7(4):297–303.
21. Holley K, Mac Nabb CM, Georgiadis P, Minasyan H, Shukla A, Mathews D. Monitoring minute ventilation versus respiratory rate to measure the adequacy of ventilation in patients undergoing upper endoscopic procedures. J Clin Monit Comput. 2016;30(1):33–9.

22. Pieri M, Landoni G, Cabrini L. Noninvasive ventilation during endoscopic procedures: rationale, clinical use, and devices. J Cardiothorac Vasc Anesth. 2018;32(2):928–34.
23. Skoczyński S, Ogonowski M, Tobiczyk E, Krzyżak D, Brożek G, Wierzbicka A, et al. Risk factors of complications during noninvasive mechanical ventilation -assisted flexible bronchoscopy. Adv Med Sci. 2021;66(2):246–53.