Noninvasive Ventilation in Dynamic Airway Collapse

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Introduction and Definition

Dynamic airway collapse (DAC) is a benign entity characterized by tracheal collapse entirely because of the laxity of the posterior membranous portion of the trachea with structurally intact tracheal cartilage [1].

Tracheal dimensions are largely preserved during inspiration, and the airway collapse predominantly occurs during expiration in a patient with DAC. In normal airways, the diameter of the trachea can be reduced up to 50% during a cough [2]. The exaggeration of the normal narrowing of the trachea to more than 50% during expiration can be aptly referred to as excessive dynamic airway collapse (EDAC) [3]. This exaggeration occurs when intrathoracic pressure increases, resulting in a clinical picture of coughing, difficulty clearing secretions, dyspnea, stridor, and respiratory insufficiency.

Large airway collapse is also seen in tracheomalacia, which is relatively grave. The trachea collapse in tracheomalacia happens due to abnormality in the fibrocartilaginous part. Therefore, differentiation of DAC from tracheomalacia is of prime importance, as tracheomalacia warrants aggressive treatment, portends a poor prognosis, and avoids mistreatment.

Pathophysiology

The usual collapse is accentuated in increased intrathoracic pressures because of changes in the velocity of airflow along the airways, i.e., trachea. As explained by Bernoulli's principle, a focal area of increased airflow may result in increased

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transmural pressure, ultimately resulting in collapse. In chronic airway diseases, loss of elastic recoil combined with positive pleural pressures, especially during exercise or vigorous expiratory maneuvers, can increase the propensity to airway collapse. Thus, EDAC should be viewed as comorbidity rather than a primary pathological problem or disease state per se. Patients usually have respiratory insufficiency, and a reduction in the maximum voluntary ventilation is the nearly consistent finding in the pulmonary function tests of such patients [1]. In dynamic bronchoscopy or computed tomography, the tracheal shape is better maintained in inspiration than expiration. While DAC patients show laxity of the posterior membranous parts, tracheomalacia patients show laxity of the cartilaginous part leading to distorted shape and diameter of the trachea [1].

Etiology

DAC commonly occurs in patients with chronic airway inflammation. The prevalence is unknown because of the significant overlap with tracheomalacia and differences in the diagnostic threshold. Important causes include, but are not limited to, chronic obstructive pulmonary disease, asthma, emphysema, recurrent respiratory infections, gastroesophageal reflux disease, obesity, relapsing polychondritis, inhalation of chemical irritants, and chronic use of inhaled corticosteroids [4]. The increased risk in obese patients at risk of obstructive sleep apnea (OSA) is attributable to mechanical compression and airway inflammation. The severity of OSA in the general population is independently associated with increased expiratory tracheal collapse [5].

Diagnosis

Dynamic (functional) bronchoscopy and paired inspiratory–expiratory dynamic CT images are now routinely used to diagnose dynamic central airway collapse and differentiate DAC from tracheobronchomalacia. Dynamic bronchoscopy entails real-time observation of the central airways in response to various maneuvers and is performed under conscious sedation when patients can follow instructions [6]. While several drugs like propofol, dexmedetomidine, and local anesthetics can be used, ketamine is usually avoided as it increases secretion and causes a hallucinosis-type state where the required patient cooperation for the dynamic bronchoscopy might be lost. Recently, noninvasive diagnostic imaging modalities like dynamic computed tomography (CT) and magnetic resonance imaging have shown good promise in assessing airway morphology and its relation during inspiration and expiration [7]. Dynamic CT imaging correlates well with dynamic bronchoscopy findings, offers an excellent display of anatomic detail of the airway and adjacent structures, and provides objective interpretation and quantitative measurement of the degree of airway collapse [8]. There is no universally accepted cutoff, but many published articles used the 50% reduction in circumference criterion during forced exhalation [9].

Treatment

Both medical and surgical modality of treatment is considered [4]. Initial treatment of symptomatic EDAC includes supportive treatment and optimal management of comorbidities. If an infection is suspected, appropriate empiric followed by a specific antibiotic as per the culture sensitivity report should be initiated. Nebulization using bronchodilators and pulmonary hygiene with airway clearing devices such as flutter valves could be utilized. Maximization or escalation of medical therapy for concomitant diseases such as obstructive sleep apnea, asthma, or COPD, along with proper education about inhalers for such patients, is essential. Furthermore, patients are trained in using pursed-lip breathing and referred to pulmonary rehabilitation, humidified oxygen therapy, and weight loss program as appropriate. Airway stenting with silicone or metallic stents is also an option but is associated with stent migration, infection, and mucus plugging risks.

Regardless, the detection and characterization of EDAC are essential, given that several studies have now highlighted clinically meaningful improvements in exercise tolerance and quality of life with targeted intervention, e.g., with the application of continuous positive airway pressure [10] and tracheobronchoplasty [11].

Stenting of the trachea has also been described [4]. Such a patient might develop mucus plug due to poor secretion clearance. Secretion management in patients with ineffective airway clearance is challenging yet feasible using various noninvasive techniques even during NIV [12]. The high-frequency chest wall oscillator is used for the clearance of secretion in patient with EDAC treated with metal stenting [13]. However, stenting is frequently useless when the EDAC is diffuse, but NIV might be beneficial in such cases [14].

Role of Noninvasive Ventilation in EDAC

An experimental study has shown that the application of continuous positive airway pressure (CPAP) of more than 6 cmH20 leads to a significant improvement in collapse [15]. Therefore, CPAP or other noninvasive ventilation modes are used for pneumatic stenting of the airway. It is a better alternative for patients at high risk for surgical management, such as patients with OSA. Expiratory positive airway pressure (EPAP) provides the pneumatic stenting that prevents the expiratory collapse of the airway. However, NIV is only a temporal measure to prevent and/or treat EDAC. It is regarded chiefly as bridging therapy in severe cases till definitive surgery or intervention is planned. It can also be applied to the patients who are not a candidate for the definitive procedure or deny to undergo surgeries and need palliation of the severe symptoms.

Patients with EDAC also present with weaning difficulty [16], and extubation on NIV is effective in such difficult to wean cases [15].

EDAC in the Perioperative Period

EDAC has been reported to contribute to postoperative respiratory failure anecdotally [17]. The increasing prevalence of COPD and obesity and the need for surgical care for such patients increases the likelihood of getting such patients in the perioperative period as EDAC is prevalent in COPD and morbid obesity [18]. People at high risk for EDAC like smokers, female sex, COPD, OSA, and the elderly are identified preoperatively. Symptomatic EDAC should be subjected to diagnostic testing to assess the severity of obstruction. Patients with critical narrowing (i.e., more than 70%) should undergo definitive surgical treatment for EDAC [4]. Risk mitigation should include smoking cessation, minimizing airway secretions, and bronchodilator therapy.

Nevertheless, EDAC has been shown to present as the cause of increased peak airway pressure with shark-fin pattern capnogram resistant to bronchodilator therapy [19]. General anesthesia, muscle relaxation, and mechanical ventilation should be tailored as they precipitate airway collapse. Vigilance for intraoperative airway collapse should be there with regional techniques as well. Postoperative NIV may be instituted either prophylactically or therapeutically to prevent respiratory failure.

Conclusion

DAC is a distinct entity of tracheal collapse, which is probably less evaluated and diagnosed by clinicians. High suspicion of the condition is required in patients having risk factors and showing the expiratory problem with respiratory insufficiency or difficult weaning. Dynamic bronchoscopy or dynamic CT can help in diagnosis. Noninvasive ventilatory approaches might help severe EDAC patients as a bridging, adjunct, and palliative therapy. Further, NIV can even be used for weaning from invasive mechanical ventilation for patients having EDAC and difficulty in weaning. However, there is still a lack of randomized trials and even well-controlled studies. Future studies will be required to ascertain the extent of the benefit.

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