Tracheobronchomalacia and Excessive Dynamic Airway Collapse

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KEYWORDS

• Tracheobronchomalacia • Excessive dynamic airway collapse • Airway stents • Tracheoplasty
• Noninvasive positive pressure ventilation • Airflow dynamics • Choke points
• Functional bronchoscopy

KEY POINTS

- Tracheobronchomalacia is characterized as weakened or destroyed cartilage in the central airways resulting in expiratory flow limitation.
- Excessive dynamic airway collapse is characterized by excessive bulging of the posterior membrane inside the central airway lumen.
- A careful physiologic assessment of the impact of expiratory central airway collapse on airflow and functional status is warranted before treatment.
- Identification of the flow-limiting airway segments can be obtained by performing functional bronchoscopy before invasive interventions.
- Even when the central airway collapse is identified as responsible for symptoms, we suggest a conservative approach with medical treatment and noninvasive positive pressure ventilation before committing patients to potentially harmful effects resulting from airway stents or open surgical procedures.

DEFINITIONS AND CLASSIFICATIONS

Unambiguous definitions and clinically useful classifications provide a common language for health care providers managing expiratory central airway collapse (ECAC). By applying accepted terminology in their practices, clinicians and scientists can stratify patients according to predefined objective criteria and analyze data. Consensual frameworks offered by classification systems allow comparison of data within populations over time and between populations at the same point in time, thus facilitating meaningful research.[1,2]

In this regard, the collapse of the intrathoracic trachea and mainstem bronchi in adult patients has been described using a variety of terms, including tracheobronchomalacia (TBM), tracheobronchial collapse, expiratory tracheobronchial collapse, expiratory tracheobronchial stenosis, tracheobronchial dyskinesia, dynamic airway collapse (AC), and ECAC.[3] However, these terms do not distinguish between collapse of the pars membranosa and collapse of the cartilaginous wall. ECAC is an accepted term to describe the narrowing of the central airways during expiration; it is a

Disclosure: The authors have no relationship with any commercial company that has a direct financial interest in the subject matter or materials discussed in this article or with any company making a competing product.
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Clin Chest Med 34 (2013) 527–555
http://dx.doi.org/10.1016/j.ccm.2013.05.003
0272-5231/13/$ – see front matter © 2013 Elsevier Inc. All rights reserved.

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syndrome comprising 2 different pathophysiologic entities: TBM, characterized by weakness of the tracheobronchial cartilaginous structures, and excessive dynamic AC (EDAC), defined as excessive bulging of the posterior membrane into the airway lumen during expiration without cartilage collapse.[2–6]

A major controversy in the published literature and among experts managing these patients is represented by the amount of collapse labeled as excessive. The frontier between normal and abnormal narrowing of the central airways during exhalation has not been clarified, and investigators propose various cutoff values.[6–12] There is variability among studies in regards to anatomic location and respiratory maneuver used to measure narrowing of the expiratory airway (**Table 1**).[10–15] These facts may be the main source of inconsistency in reported prevalence of these disorders. The anatomic site used for measuring the collapse needs to be standardized, because physiologic airway narrowing is more pronounced in the bronchus intermedius and main carina than at the aortic arch or cricoid level.[12]

Results of dynamic computed tomography (CT) studies show that 70% to 80% of normal individuals meet the 50% criteria used for abnormal collapse.[6,12,16] Healthy volunteers with normal lung function have shown mean levels of expiratory collapse of 54% in the trachea, 67% in the right main bronchus (RMB), 61% in the left main bronchus (LMB), and even total collapse in the bronchus intermedius.[12] A different study showed that the mean % collapse of normal volunteers was 66.9% in the RMB and 61.4% in the LMB, with 73% of participants exceeding the currently accepted cutoff value of 50% threshold for defining bronchomalacia.[17] Even in a disease process such as chronic obstructive pulmonary disease (COPD), in which the central AC is more pronounced, the degree of narrowing may be independent of disease severity and does not correlate significantly with physiologic parameters.[6,11] Excessive expiratory tracheal collapse defined as more than 80% expiratory reduction in tracheal luminal cross-sectional during dynamic CT was shown to not significantly correlate with the pulmonary function tests (PFTs) or quality-of-life (QOL) measures.[6,11]

To reduce false-positive diagnoses and avoid unwarranted treatments, EDAC may be defined only if clinically relevant excessive collapse is noted during tidal breathing (**Fig. 1**). The degree of pathologic expiratory collapse has not yet been established on physiologic basis because work of breathing and symptoms depend not only on the degree of airway narrowing but also on its geometry and flow velocity.[18] Therefore, the accurate assessment of the reduction in airway lumen cross-sectional area becomes relevant for the purpose of having a common language when evaluating patients and communicating about TBM and EDAC, and not necessarily only to decide on need for therapeutic interventions.

The degree of narrowing is only 1 factor involved in flow limitation; it is only 1 criterion included in classifications for this syndrome. Most systems are limited by inconsistent definitions or by criteria addressing only the extent, severity, or cause but not the 2 separate morphologic types of TBM and EDAC or the patient's functional impairment (**Table 2**).[10,13–15,19] A classification based on objective quantifiable criteria has been developed and can be applied before and after therapeutic interventions to objectively document not only the changes in the extent and severity of AC but also the impact of these changes on functional class (**Table 3**).[2] The criteria of this system can be grouped in 2 sets: the descriptive factors including morphology and etiology, and stratification factors that can be scored objectively. The morphology criterion describes the shape of the airway lumen, which is reduced during expiration as assessed by bronchoscopy or radiologic studies. ECAC has 5 morphologic types (**Fig. 2**). Origin (etiology) describes the underlying mechanism responsible for the abnormality: idiopathic or secondary to other disorders (**Table 4**). To describe functional class, this system used the World Health Organization functional impairment scale, because of its easy clinical applicability and because it does not address just dyspnea but the overall impact of symptoms on patient's functional status. The extent criterion describes the location and distribution of the abnormal airway segment as assessed by bronchoscopy or radiographic studies. The severity criterion describes the degree of the AC during expiration as assessed by bronchoscopy or radiographic studies. Since its introduction in 2005, the terminology proposed in this system has been applied in clinical research of these disorders.[5,6,20–24] This classification allows monitoring of the progression or improvement of the disease process and the outcome and durability of different treatment strategies on airway lumen patency and patient symptoms. Five domains are addressed: functional class (F), extent (E), morphology (M), origin (O), and severity of AC (S). The F, E, and S parts of the system have an ordinal scale of 1 to 4 (see **Table 3**). Outcomes are documented as subscripts, for example F_2 E_2 S_4, and should not be combined to form a single number. This information can be tabulated or plotted to provide a visual temporal treatment

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