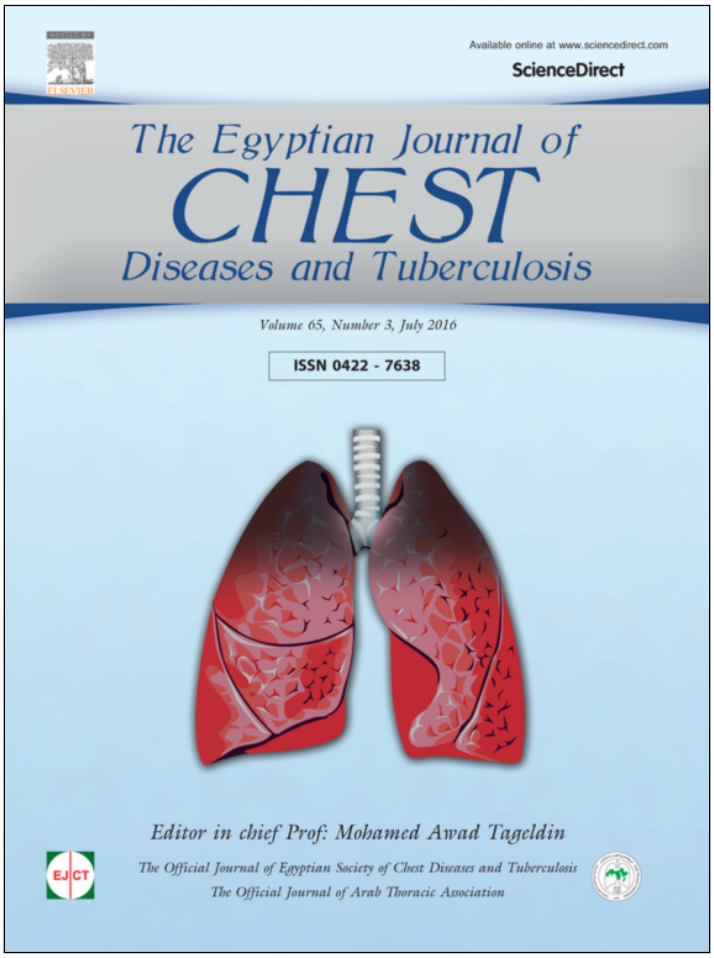

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ORIGINAL ARTICLE

Diagnostic utility of dynamic CT in tracheomalacia in COPD patients

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KEYWORDS

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Abstract *Background:* Investigators have suggested a correlation of tracheomalacia with chronic inflammation and irritants, such as cigarette smoke. Recent advances in CT imaging provide an opportunity to non-invasively diagnose the condition with a high level of accuracy. Dynamic CT of the chest exhibits tracheal collapse with crescentic bowing of the posterior membranous trachea during expiration.

Aim of the work: To determine the prevalence of tracheomalacia identified on computed tomography of the chest in patients clinically diagnosed with COPD.

Subjects and methods: Thirty COPD patients were included in the study and the diagnosis of COPD was based on lung function and reversibility test. The CT protocol focused on the central airways and included imaging during two phases of respiration. The percentage of luminal collapse was calculated by dividing the dynamic expiratory cross-sectional area by the end-inspiratory cross-sectional area and multiplying by 100. If luminal collapse is more than 50% the case is diagnosed as tracheomalacia.

Results: This study showed that 20% (6 of 30) of COPD subjects showed evidence of tracheomalacia based on the criteria of a $\geqslant$50% reduction in the cross-sectional trachea lumen area at end expiration. FEV1 and FEV1/FVC were statistically significant lower in subjects with tracheomalacia than those without tracheomalacia.

Conclusion: The results of this study clarify that a significant subgroup of patients with a reported clinical diagnosis of COPD has features consistent with tracheomalacia on dynamic CT scanning of the chest. This indicates that tracheomalacia may be a hidden comorbidity in COPD.

Introduction

Tracheomalacia is a condition characterized by excessive airway collapsibility due to increased flaccidity of the membranous portion of the central airways and weakness of the

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airway walls and supporting cartilage [1]. Tracheomalacia can be congenital or acquired; associated symptoms include dyspnea, wheeze, cough, sputum production, and hemoptysis. Investigators have suggested a correlation of tracheomalacia with chronic inflammation and irritants, such as cigarette smoke [2,3]. Due to its non-specific symptoms, it may be an underdiagnosed condition. The diagnosis of tracheomalacia can be established by the identification of a reduction in the cross-sectional area of the airway greater than or equal to 50% at expiration or during coughing [4,5].

Although bronchoscopy has been widely considered to be the gold standard for the diagnosis of tracheomalacia, recent advances in CT imaging provide an opportunity to non-invasively diagnose the condition with a high level of accuracy. Dynamic CT of the chest exhibits tracheal collapse with crescentic bowing of the posterior membranous trachea during expiration [6,7]. Examining the airway with flexible bronchoscopy during passive exhalation (functional bronchoscopy) can confirm collapse of the central airway typical of tracheomalacia [8].

Patients with COPD typically exhibit a progressive increase in dyspnea; determining the underlying causes of their symptoms is essential for effective clinical care of these patients. Zhang et al. [9] observed a higher frequency and greater severity of air trapping in patients with tracheobronchomalacia compared to a control group. Considering the relatively high incidence of tracheomalacia in patients with dyspnea and other nonspecific respiratory symptoms, we hypothesized that a significant number of cases of airway collapse could be detected on CT scanning of the chest in patients diagnosed with COPD. This study aims to determine the prevalence of tracheomalacia identified on computed tomography of the chest in patients clinically diagnosed with COPD.

Subject and methods

Thirty COPD patients were included in the study and the diagnosis of COPD was based on lung function and reversibility test as all patients showed obstructive pattern and reversibility less than 12%. All subjects were recruited from the chest department, faculty of medicine, Cairo University, in the period between January 2014 and January 2015 after having their written informed consent prior to participation in the study.

All patients were subjected to through history taking and clinical examination, laboratory tests, Chest X-ray, pulmonary function test including reversibility test and dynamic CT of the chest.

All patients underwent the same CT protocol on an 64-MDCT scanner (LightSpeed, GE Healthcare, USA) with a gantry rotation time of 0.5 s. (170 mAs, 12 kVp, 2.5-mm collimation, high speed mode, pitch equivalent of 1.5). The CT protocol focused on the central airways—from the thoracic inlet to the carina—and included imaging during two phases of respiration: end-inspiratory and dynamic expiratory phases. Subjects were instructed to suspend breath after breathing deeply twice, and then inhaling as deeply as possible, at which point the imaging would commence. The RV series were obtained after instructing participants to breathe deeply twice, then exhaling as completely as possible before breathholding, at which point the imaging would commence.

Quantification of the percentage of airway luminal collapse during expiration for the levels of the trachea, was performed using an analysis tool available on our CT software to measure the cross-sectional area of the airway lumen in millimeters squared on end-inspiratory and dynamic expiratory scans. The percentage of luminal collapse was calculated by dividing the dynamic expiratory cross-sectional area by the end-inspiratory cross-sectional area and multiplying by 100. If luminal collapse is more than 50% the case is diagnosed as tracheomalacia.

Table 1 Prevalence of tracheomalacia.

Tracheomalacia	Count	%
No tracheomalacia	24	80.0
Tracheomalacia	6	20.0
Total	30	100.0

Results

Table 1 showed that 20% (6 of 30) of the subjects showed evidence of tracheomalacia based on the criteria of a $\geqslant 50\%$ reduction in the cross-sectional trachea lumen area at end expiration.

Table 2 showed no statistically significant difference regarding age between COPD patients with or without tracheomalacia.

Table 3 showed that all measures were lower in those with tracheomalacia, yet it was only significant for FEV1 and FEV1/FVC.

Table 4 showed that smoking index was higher in those with tracheomalacia, yet it is of no clinical significance.

Discussion

The incidence of tracheomalacia in patients with a reported history of COPD has not been extensively studied. However, several large studies in the general population suggest that the overall incidence of tracheomalacia is 5–10% [10,11].

Patients with advanced COPD often have a variable degree of atrophy of the cartilaginous support of the airway, which can lead to symptomatic tracheobronchomalacia if it is severe

Table 2 Comparison of age according to tracheomalacia.

Tracheomalacia	*N*	Mean	Std. deviation	Median	Minimum	Maximum
No	24	62.29	10.71	65.00	45.00	80.00
Positive(a)	6	61.33	7.81	61.00	52.00	75.00

p value = 0.78.

Table 3 Relation of pulmonary functions and tracheomalacia.

	Tracheomalacia										
	No tracheomalacia $N = 24$					Tracheomalacia $N = 6$					p value
	Mean	SD	Median	Min	Max	Mean	SD	Median	Min	Max	
FVC	83.96	9.56	84.00	64.00	102.00	77.17	12.21	82.00	56.00	90.00	0.321
FEV1	58.17	10.83	56.50	41.00	77.00	44.83	10.13	43.00	32.00	63.00	0.015
FEV1/FVC	58.67	8.17	61.50	34.00	68.00	48.33	6.53	46.50	40.00	58.00	0.005
FEF25-75	46.38	17.96	48.00	8.00	75.00	32.67	15.00	35.00	9.00	52.00	0.082

p value $\leqslant 0.05$.

Table 4 Relation of smoking index and tracheomalacia.

Tracheomalacia	Mean	Std. Deviation	Median	Minimum	Maximum
No tracheomalacia	862.50	524.871	750.00	300	2400
Tracheomalacia	908.33	586.870	950.00	150	1800

p value $= 0.78$.

[12,13]. Why some patients are susceptible to this complication and most others are not is unclear.

Previous studies have suggested that tracheomalacia may be an underdiagnosed condition [8,11,14]; this is possibly due to its unspecific symptoms, which may be associated with other diseases. In this study, we observed a large degree of tracheal collapse $\geqslant 50\%$ at end-expiration (tracheomalacia) in 20% of patients in COPD patients. It is hypothesized that chronic irritation and coughing occurring in COPD may weaken the airway walls and damage elastic fibers of the pars membranosa, contributing to increased compliance and resulting in excessive dynamic airway collapse [15].

In a similar study Inoue et al. [16] investigated the incidence in patients with emphysema. The incidence of tracheomalacia associated with pulmonary emphysema was 7.1%. This lower incidence may be explained that our study was done in COPD patients not only emphysema.

In small cross-sectional studies, tracheomalacia is seen more often in smokers with chronic irritation of the airway [2].

In conclusion, the results of this study clarify that a significant subgroup of patients with a reported clinical diagnosis of COPD has features consistent with tracheomalacia on dynamic CT scanning of the chest. This indicates that tracheomalacia may be a hidden comorbidity in COPD. Dyspnea in COPD may be worsened by tracheomalacia. Further researches are suggested on treatment of severe tracheomalacia in COPD including stenting, tracheostomy, external tracheal stabilization and the use of continuous positive airway pressure (CPAP).

Conflict of interest

There is no conflict of interest.

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