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CASE REPORT

# Vocal cord dysfunction diagnosed by four-dimensional dynamic volume computed tomography in patients with difficult-to-treat asthma: A case series



Wei-Tso Cheng<sup>a</sup>, Huan-Wen Chen<sup>a</sup>, I-Hao Su<sup>b</sup>, Ji-Tseng Fang<sup>a,c</sup>,  
Han-Pin Kuo<sup>a,d</sup>, Chien-Da Huang<sup>a,d,\*</sup>

<sup>a</sup> Department of Medicine, Chang Gung University College of Medicine, Taoyuan, Taiwan

<sup>b</sup> Department of Medical Imaging and Intervention, Chang Gung University College of Medicine, Taoyuan, Taiwan

<sup>c</sup> Department of Nephrology, Chang Gung Memorial Hospital, Taoyuan, Taiwan

<sup>d</sup> Department of Thoracic Medicine, Chang Gung University College of Medicine, Taoyuan, Taiwan

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Patients with asthma may also have vocal cord dysfunction (VCD), which leads to poor control of the asthma. Once patients are diagnosed with difficult-to-treat asthma with poor control, VCD should be excluded or treated accordingly. The gold standard for diagnosis of VCD is to perform a laryngoscopy. However, this procedure is invasive and may not be suitable for patients with difficult-to-treat asthma. Four-dimensional (4D) dynamic volume computed tomography (CT) is a noninvasive method for quantification of laryngeal movement, and can serve as an alternative for the diagnosis of VCD. Herein, we present a series of five cases with difficult-to-treat asthma patients who were diagnosed with VCD by 4D dynamic volume CT. Clinicians should be alert to the possibility of VCD when poor control is noted in patients with asthma. Early diagnosis by noninvasive 4D dynamic volume CT can decrease excessive doses of inhaled corticosteroids.

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\* Corresponding author. Department of Thoracic Medicine, Chang Gung Memorial Hospital, 199 Tun-Hua North Road, Taipei, Taiwan.  
E-mail address: [cdhuang@adm.cgmh.org.tw](mailto:cdhuang@adm.cgmh.org.tw) (C.-D. Huang).

## Introduction

Asthma is defined as a chronic inflammatory disease of the airways, and the symptoms can usually be relieved with inhaled corticosteroids.<sup>1</sup> However, in 5–10% of asthma patients the symptoms may continue to deteriorate even with high-dose inhaled and oral corticosteroid treatment.<sup>2</sup> The patients with difficult-to-treat asthma may require repeated hospital admissions, which results in increased health-care costs and the patient's work performance being affected.<sup>3</sup> Thus, it is necessary to investigate the etiological factors for the difficulties experienced by the patients with severe asthma while treating them. Once the underlying causes of these difficulties are known, treatment can be adjusted accordingly and excessive medication can be reduced, especially inhaled corticosteroids.

Vocal cord dysfunction (VCD), also known as paradoxical vocal cord motion, is a common etiology leading to difficulty in treating asthma patients.<sup>4,5</sup> Because of involuntary closure of the vocal cords, which occurs most commonly during inspiration, VCD can masquerade the symptoms of asthma such as episodic and severe respiratory distress.<sup>6</sup> The diagnosis of VCD is traditionally based on a combination of inspiratory flow volume loops and laryngoscopy during symptom attack. However, recent studies have reported that four-dimensional (4D) dynamic computed tomography (CT) is a noninvasive method for the quantification of laryngeal movement, and can serve as an alternative for the diagnosis of VCD.<sup>5,7</sup> In recent years, CT has progressed from 64 slice to 320 slice, thereby providing far more detailed images of structures, making it possible to model the airflow in the respiratory system and provide more accurate imaging of laryngeal function during the phases of respiration. Therefore, 320-slice CT has the potential to become the new standard for VCD diagnosis. One study used 320-slice CT to survey upper airway dysfunction in a patient who had severe asthma,<sup>7</sup> and another study defined the normal parameters for laryngeal movement in the context of this new imaging modality.<sup>5</sup>

In the case series in this study, we used 4D dynamic volume CT to survey patients with difficult-to-treat asthma. A retrospective analysis has been performed in these patients. A 4D dynamic volume CT (Toshiba Aquilion ONE, 320-slice CT system) was performed with the following parameters: 80 kVp, 50 mAs, detector collimation,  $0.5 \times 0.5$  mm<sup>2</sup>; gantry rotation, 0.5 seconds; scanning time, 10 seconds; scanning range, 16 cm; reconstructed slice thickness/interval, 3 mm/3 mm. The radiation dose of 4D CT was in a range of approximately 3–5 mSv. The CT protocol and respiratory instructions were fully explained and given to all patients by the same radiographer. All patients were requested to breathe normally to determine their own respiratory tempo lasting for 10 seconds without a breath hold and swallowing, during the preprocedure respiratory practice and 4D-CT study.

Dynamic sagittal and coronal multiplanar images and dynamic 3D volume rendering images from approximately the hyoid level to the distal trachea including vocal cords were reconstructed using Toshiba Aquilion ONE Manufacturer's Model version V4.74ER011. We selected the mid-phase inspiration and expiration to take a steady vocal cord

**Table 1** Characteristics of the study patients.

Patients	Age (y)	Sex	Smoking status	Asthma onset age	FEV1/FVC (%)	FEV1 (% of pred.)	FVC (% of pred.)	Medication	Nonpharmacologic management	Improvement time (mo)
1	52	M	No	10	55.3	17	25	Inhaled combination therapy + anticholinergics	Speech therapy + breathing control + psychological support	3
2	65	F	No	27	74.8	64	72	Inhaled combination therapy + theophylline	Speech therapy + breathing control + psychological support	2
3	64	M	Ex-smoker	60	71.5	50	51	Inhaled combination therapy + theophylline + leukotriene receptor modifier	Speech therapy + breathing control + psychological support	1
4	49	M	Ex-smoker	20	82.1	75	78	Inhaled combination therapy + theophylline + leukotriene receptor modifier + Anti-IgE	Speech therapy + breathing control + psychological support	3
5	81	M	No	71	46.1	73	63	Inhaled combination therapy + anticholinergics + leukotriene receptor modifier	Speech therapy + breathing control + psychological support	2

FEV1 = forced expiratory volume in one second; FVC = forced vital capacity; Pred. = predicted value.

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