Dynamic CT evaluation and follow up of adult patients with suspected vocal cord dysfunction

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Purpose

Breathing is a complex physiological process that requires delicate co-ordination between laryngeal muscles regulating upper airway opening and closing and respiratory muscles mediating changes in airway pressure. Abnormal functional coordination between the upper and lower airways is typified by a condition known as vocal cord dysfunction (VCD), also named paradoxical vocal cord motion, laryngeal dyskinesia, episodic laryngeal dysfunction, laryngeal dyskinesia, paradoxical vocal fold dysfunction or paradoxical laryngospasm [1]. Vocal cord dysfunction is often mistaken as asthma leading to inappropriate treatment with high-dose steroids [2,3]. During VCD attacks, high pitched wheeze may be heard over the chest and larynx. The degree of respiratory distress and wheeze varies from minimal to severe, as does the reduction of oxygen saturation [4].

VCD is often paroxysmal and may be precipitated by both organic and non-organic causes. The condition can resolve spontaneously, through the use of sedatives, speech therapy or breathing exercises. The gold standard for diagnosis remains invasive direct laryngoscopy during attacks which is often not available in the acute clinical setting [5]. The recently developed dynamic 320-slice volume CT scanner (320 CT) uses an unique 320 slice detector array to scan a 16cm z-axis ‘volume’ in a single gantry rotation, all without table movement (axial mode). When this volume scan is repeated over time, it provides an excellent 4-D assessment of the entire laryngeal airway during the respiratory cycle [6,7,8].

The purpose of this study is to evaluate the efficacy of the CT in assessing the laryngeal morphology and movement in VCD.
Methods and Materials

Studies were approved by the Southern Health Human Research Ethics Committee.

11 patients (10 males and 1 female) with a history of severe long-standing asthma were studied. VCD was suspected on a combination of suggestive history (tight throat, breathless after emotion or stress, brittle disease), 'noisy' sounds over the larynx on auscultation and relatively normal lung function.

Lung function testing comprised pre- and post-bronchodilator spirometry, lung volumes and diffusion capacity for carbon monoxide (TLCO). Measurements were done within 7 days of having presented with increased wheeziness [9,10].

At the time of CT, all patients retained symptoms of poorly controlled asthma. They were asked to breath in their normal breathing manners. CT of the larynx was performed in supine position using the 320 CT to scan a 16 cm Z-axis 'volume'. Parameters were 80kVp, 300-350mA and gantry rotation 350 milliseconds. Images were obtained continuously over the entire respiratory cycle. Laryngeal and vocal cord pathology, vocal cord movement during respiration, Laryngeal luminal dimension and area, and tracheal luminal area (immediately below larynx) were measured using integrated software.

Studies in normal individuals have suggested that narrowing should not occur during inspiration and that maximal narrowing of the vocal cord during expiration does not exceed 40% [11]. Any paradoxical adduction of the vocal cords also had to be sustained to diagnose VCD.

The clinical responses of the positive patients to treatment were assessed.
Results

11 patients, aged between 30-75 years, were scanned. Measurements of vocal cord luminal areas at the level of vocal cords were recorded.

6 patients showed no paradoxical movement of vocal cords to suggest any VCD or any laryngeal abnormality (Figure 1). Their symptoms were thought to be related to true asthma. One patient (9%) had unrelated infraglottic stenosis.

VCD with paradoxical cord movement was conclusively detected in 5 patients (45.5%), all during expiration (Figure 2,3), except for one patient who also had laryngeal narrowing during inspiration (Figure 4). One patient had a confirmatory endoscopy. Median reduction of laryngeal luminal area at vocal cord level was 90.8% (48.2 to 92.5%) during expiration and 63.9% during inspiration as compared to 10.4% in those patients without VCD.

4 out of 5 positive VCD patients showed marked improvement in their symptomatology after they had undergone speech therapy. The remaining patient also showed an initial moderate improvement with speech therapy, but failed to attend follow up sessions.
Fig. 0: Non-contrast reconstructed 3-D volume rendering coronal images in a 75 year old female at inspiration (a) and expiration (b) as well as sagittal images during inspiration (c) and expiration (d) are shown. The images demonstrate normal upper airway function with no evidence of vocal cord dysfunction. All these reconstructed images can be viewed in cine mode on workstation to exclude any paradoxical movement.

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Fig. 0: Non-contrast axial CT images of a 75 years old female showed normal lumen during inspiration (a) and slit-like lumen at the vocal cord level on expiration (b), consistent with vocal cord dysfunction. Virtual endoscopy images matched the axial CT appearances at inspiration (c) and at expiration (d). These images can be viewed in cine mode on workstation.

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Fig. 0: Volume rendering reconstruction techniques on the same 75 years old female patient (upper airway displayed in blue colour) showed coronal images during inspiration (a) and expiration (b), as well as sagittal images during inspiration (c) and expiration (d), confirming marked persistent adduction of the vocal cords during expiration.

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Fig. 0: Non contrast CT scan of a 43 years old female with wheeze demonstrated paradoxical vocal cord movement on both inspiration and expiration. Virtual endoscopy confirmed the adduction of vocal cords giving rise to slit laryngeal lumen at inspiration (a) and at expiration (b). Volume rendering coronal reconstruction techniques (upper airway displayed in blue colour) confirmed the VCD during inspiration (c) and expiration (d).

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Conclusion

VCD is not a rare condition and is a frequent presentation in the non-referral emergency room population [12]. Direct endoscopy for the diagnosis of VCD is not promptly available in most acute settings. The use of 320 CT scanner improves our ability to distinguish VCD rapidly and non-invasively without having to depend on endoscopic assessment of the vocal cords. This technique can be readily available and may revolutionise the standard care for wheeziness and asthma. It also allows better understanding of the underlying pathophysiology.

The number of patients in our series was relatively small and additional validation studies are now needed to assess the prevalence of VCD and to examine its role in acute airway obstruction.
References


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