Original Article

A Novel Scoring System to Distinguish Vocal Cord Dysfunction From Asthma

Russell S. Traister, MD, PhD[a], Merritt L. Fajt, MD[a], Douglass Landsittel, PhD[b], and Andrej A. Petrov, MD[a]   Pittsburgh, Pa

> *What is already known about this topic?* Distinguishing vocal cord dysfunction from asthma can be difficult. Laryngoscopy remains the current criterion standard for the diagnosis of vocal cord dysfunction, although it is not available to all practitioners. Currently, there is no clinical scoring system to help distinguish the 2 disorders.
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> *What does this article add to our knowledge?* We developed a useful clinical scoring system to help distinguish vocal cord dysfunction from asthma.
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> *How does this study impact current management guidelines?* The Pittsburgh Vocal Cord Dysfunction Index may be a useful clinical tool to help prevent the misdiagnosis and mistreatment of vocal cord dysfunction as asthma.

BACKGROUND: Vocal cord dysfunction is often misdiagnosed and mistreated as asthma, which can lead to increased and unnecessary medication use and increased health care utilization.
OBJECTIVE: To develop a valid scoring index that could help distinguish vocal cord dysfunction from asthma.
METHODS: We compared the demographics, comorbidities, clinical symptoms, and symptom triggers of subjects with vocal cord dysfunction (n = 89) and those with asthma (n = 59). By using multivariable logistic regression, we identified distinguishing features associated with vocal cord dysfunction, which were weighted and used to generate a novel score. The scoring index also was tested in an independent sample with documented vocal cord dysfunction (n = 72).
RESULTS: We identified symptoms of throat tightness and dysphonia, the absence of wheezing, and the presence of odors as a symptom trigger as key features of vocal cord dysfunction that distinguish it from asthma. We developed a weighted index based on these characteristics, the Pittsburgh Vocal Cord Dysfunction Index. By using a cutoff of ≥4, this index had good sensitivity (0.83) and specificity (0.95) for the diagnosis of vocal cord dysfunction. The scoring index also performed reasonably well in the independent convenience sample with laryngoscopy-proven vocal cord dysfunction and accurately made the diagnosis in 77.8% of subjects.
CONCLUSION: The Pittsburgh Vocal Cord Dysfunction Index is proposed as a simple, valid, and easy-to-use tool for diagnosing vocal cord dysfunction. If confirmed by a prospective evaluation in broader use, it may have significant clinical utility by facilitating a timely and accurate diagnosis of vocal cord dysfunction, thereby preventing misdiagnosis and mistreatment as asthma. Future prospective validation studies will need to be performed.   © 2013 American Academy of Allergy, Asthma & Immunology (J Allergy Clin Immunol Pract 2014;2:65-9)

Key words: *Vocal cord dysfunction; Asthma; Clinical scoring index*

[a]Division of Pulmonary, Allergy, and Critical Care Medicine, Department of Medicine, University of Pittsburgh Medical Center, Pittsburgh, Pa
[b]Division of General Internal Medicine, Department of Medicine, and Center for Research on Health Care Data Center, University of Pittsburgh, Pittsburgh, Pa
Corresponding author: Andrej A. Petrov, MD, Pulmonary, Allergy and CCM, University of Pittsburgh Medical Center, UPMC Montefiore Hospital NW628, 3459 Fifth Avenue, Pittsburgh, PA 15213. E-mail: petrovaa@upmc.edu.

Vocal cord dysfunction (VCD), also known as paradoxical vocal fold motion disorder, is a common and often overlooked disorder characterized by abnormal adduction of the vocal cords, primarily during inspiration. Although the exact prevalence of VCD is not known, it has a higher incidence among women.[1,2] Symptoms of VCD, which include dyspnea, cough, dysphonia, and throat tightness, are often absent at rest but can sometimes be exacerbated by specific irritants.[3-5] The exact cause of VCD is unknown, although laryngeal hyperresponsiveness might be secondary to inflammation and/or irritation of the vocal cords. Gastroesophageal reflux disease, rhinitis with postnasal drip, viral upper respiratory tract infections, cold air, and chemical or occupational irritants have all been suggested to trigger VCD.[3-5] Psychosocial factors have been found to play a role in VCD as well.[6,7] The differential diagnosis for VCD is broad and includes anatomic defects of the upper airway, vagus or recurrent laryngeal nerves lesions, laryngeal edema, and uncontrolled asthma.[3-5] Proposed guidelines for the diagnosis of VCD include appropriate clinical history, evidence of abnormal vocal cord motion on laryngoscopy, and pulmonary function test criteria.[8] The management of VCD includes treatment directed at underlying comorbid conditions in addition to speech and behavioral therapy.[3]

Given its symptom overlap with asthma, VCD can remain misdiagnosed as asthma for a long period of time.[9,10] Our

Abbreviations used
ANOVA- Analysis of variance
BMI- Body mass index
CI- Confidence interval
GERD- Gastroesophageal reflux
IBS- Irritable bowel syndrome
IQR- Interquartile range
N/A- Not available
NPV- Negative predictive value
OR- Odds ratio
PPV- Positive predictive value
SOB- Shortness of breath
VCD- Vocal cord dysfunction

TABLE I. Patient demographics

	VCD (n = 89)	Asthma (n = 59)	P value
Age (y), median (IQR)	47.0 (37.0-56.0)	38.0 (28.0-53.8)	.01*
BMI (kg/m^2), median (IQR)	29.0 (23.4-36.0)	26.9 (22.6-33.2)	.54
% Women (95% CI)	91.0 (83.3-95.4)	63 (53.2-71.8)	<.0001*
% Tobacco use (95% CI)	27.0 (18.8-37.0)	29 (21.0-38.5)	.26

BMI, Body mass index; IQR, Interquartile range.
*P < .05 was considered statistically significant.

previous study found that 42.4% of patients with VCD were misdiagnosed with asthma for an average of 9 years.[11] Although both disorders can exist in isolation, there appears to be a population of patients in which both asthma and VCD coexist, although the nature of the relationship between the two has been debated.[12-14] Accurate and timely diagnosis of VCD has become ever more important, because a delay in diagnosis can result in increased asthma medication use and health care utilization.[11]

Although laryngoscopic examination remains the criterion standard for a diagnosis of VCD, the examination may be normal in between attacks if the appropriate trigger is absent. Conversely, abnormal vocal cord motion may be present during laryngoscopy in the absence of symptoms.[15] In addition, general practitioners are unlikely to perform laryngoscopy in the office setting, which necessitates referral to a specialist for diagnosis. In this study, we aimed to develop a simple, weighted scoring system based on patient symptoms and comorbidities to aid in the diagnosis of VCD in the clinical setting. This scoring system could be used to timely and accurately diagnose VCD, and it is hoped will result in decreased medication use and health care utilization in this population.

METHODS
Study design

We previously conducted a retrospective analysis of patients with isolated or coexisting VCD and asthma seen in an outpatient university asthma-allergy center.[11] In this study, we used the demographic, historical, and clinical information of subjects who were determined to have isolated VCD and isolated asthma. We specifically excluded any subjects with confirmed diagnoses of coexistent VCD and asthma to best differentiate between the 2 conditions. The diagnosis of VCD was based on the following diagnostic criteria: a consistent clinical history (prolonged symptoms, recurrent or intermittent episodes, reproducible inciting factors), symptoms (including dyspnea, upper airway stridor or wheezing, throat tightness, chest tightness, cough, or dysphonia), and positive findings on laryngoscopy.[8] Laryngoscopy was performed in all of the subjects by a single provider (A.A.P.), during which abnormal vocal cord motion or vocal cord collapse was noted. If no abnormal motion or collapse of the vocal cords was detected but the subject related a history of irritants, such as strong scents, odors, or exercise, that elicited his or her symptoms, a laryngoscopy was repeated with provocation (exercise challenge or exposure to a strong perfume), and the vocal cords were observed for abnormal motion and/or collapse.

If there were no laryngoscopic findings of VCD, then these subjects were excluded from analysis. A total of 89 subjects with isolated VCD were included in this analysis.

For our asthma-alone group, 100 computer-generated randomly selected asthma patients (International Classification of Diseases, Ninth Revision, code of 493) were evaluated objectively for the presence of asthma. Fifty-nine subjects met criteria for an asthma diagnosis by using currently accepted criteria, including a consistent history, evidence of obstruction and bronchodilator response on spirometry, and/or positive bronchoprovocation challenge testing with methacholine, consistent with the 2007 National Asthma Education and Prevention Program Guidelines.[16]

Demographic and clinical data were obtained for all the subjects. Comorbidities were extracted from the patient's reported medical history. No attempt was made to prove or disprove any of the diagnoses examined, except for asthma and VCD, as described above. This study was approved by the institutional review board at our facility.

Statistical analysis

Statistical analysis was performed by using JMP software (SAS Institute Inc, Cary, NC). Pearson χ^2 tests compared categorical variables. For normally distributed data, ANOVA was used, whereas, for nonparametric numerical demographic data, the Kruskal-Wallis test was used to compare average ranks across groups; 95% CIs also were recorded.

To develop a scoring system, symptom and comorbidity variables to be included were guided by a review of the literature.[3-5,11] An unadjusted analysis was first performed to identify significant factors (with a liberal threshold of $P < .2$ for statistical significance) that might help distinguish VCD and asthma. Variables found to be significant in the unadjusted analysis were included in a multivariable logistic regression model. Those variables that were found to be independent predictors for the outcome ($P < .05$) were selected for the final model, and a stepwise backward elimination process used the likelihood ratio test to eliminate variables that did not significantly contribute to the model. Scores were assigned to each independent predictor found to be significant in the final model, with weights assigned according to the regression coefficients from the final model and rounding to the nearest integer. Receiver operating characteristic curves and the resulting area under the curve were also determined.

After determining the appropriate cutoff score, the scoring system was applied to an independent convenience sample, which consisted of an additional 72 subjects with VCD (confirmed on laryngoscopy) that were not included in our previous retrospective study nor used to develop the original scoring system. In *post hoc* analysis, the scoring system rule was