

PHYSIOLOGY

Lung Sound Analysis in a Patient with Vocal Cord Dysfunction and Bronchial Asthma

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Objective. Vocal cord dysfunction (VCD) is a condition characterized by adduction of the vocal cords, resulting in narrowing or even closure of the glottis during inspiration. This can cause wheezing that originates at the site of narrowing. Some patients have both VCD and asthma. In such cases, an acute episode of VCD can be difficult to differentiate from that of asthma. We tested the usefulness of lung sound analysis (LSA) in such a condition. **Methods.** We performed an LSA in a patient with asthma and coexisting VCD diagnosed using laryngoscopy. **Results and conclusion.** The LSA during an acute VCD episode revealed monophonic continuous adventitious sounds that were distributed symmetrically over both lung fields. The time domain analysis revealed that the adventitious sounds originated in the neck. These LSA findings clearly indicated that the acute episode was not due to asthma but due to VCD. This case illustrates that the LSA may be a useful tool to differentiate between an acute episode of asthma and that of VCD.

Keywords bronchial asthma, lung sound analysis, vocal cord dysfunction, wheezing

INTRODUCTION

Vocal cord dysfunction (VCD) is an upper airway obstruction caused by abnormal adduction of the vocal cords (1). The recognition of VCD is very important, because VCD is frequently misdiagnosed as refractory asthma (2). Wheezing, which is a symptom of VCD, is observed mainly during inspiration but is sometimes observed during inspiration and/or expiration (3). The present case had a long-standing history of bronchial asthma. Although no prospective study has evaluated the relationship between VCD and asthma (4), a retrospective study reported that among 95 patients with VCD, 53 patients also had asthma (5). Thus, the occurrence of VCD and asthma together is not uncommon (6). In such cases, acute episodes of asthma and VCD can be very difficult to differentiate. Truncation of the inspiratory flow volume loop (FVL) is assumed to be an indicator of VCD. However, studies evaluating the diagnostic ability of FVL during a VCD attack have suggested that the absence of an FVL sign cannot exclude a diagnosis of VCD (7, 8).

Direct visualization of the upper airway during an acute episode is the gold standard for making a definitive diagnosis of VCD (5). However, laryngoscopic examination can be difficult to perform during an attack. Auscultation is useful, but VCD cannot be diagnosed based only on the presence of laryngeal wheezing because wheezing originating from the peripheral bronchus is sometimes heard only at the anterior neck.

CASE REPORT

The present case was a 14-year-old girl with a history of bronchial asthma since the age of 5 years; the patient gradually became maladjusted while in school and was diagnosed as having Asperger syndrome at the age of 13 years. She responded well to the conventional treatment for acute episodes of asthma, including bronchodilator inhalation and intravenous corticosteroid therapy when she was younger. However, the wheezing episodes increased in frequency and became refractory to treatment after she entered junior high school. She was hospitalized at the Fukuoka National Hospital to investigate the etiology of her condition. The patient's heart rate, respiratory rate, and oxygen saturation were 114/min, 24/min, and 98%, respectively, at the time of admission. She had persistent symptoms of dyspnea and wheezing that were audible during both inspiration and expiration over the entire lung field almost constantly during the daytime. A spirometry examination revealed an expiratory airflow limitation, particularly in the lower half of the lung volume. However, no change in the flow-volume loop was observed after the inhalation of a bronchodilator, suggesting the possibility of VCD (Figure 1). A laryngoscopy was performed while she was experiencing the above-mentioned symptoms, and a closure of the vocal folds during both inspiration and expiration was observed; these findings were compatible with a diagnosis of VCD (Figure 2). Although we did not perform a laryngoscopy examination while the patient was not wheezing, we suspected that the VCD might be reversible because she did not wheeze while she was sleeping. A videofluoroscopy examination was performed, and no signs of tracheomalacia were observed. The patient had a history

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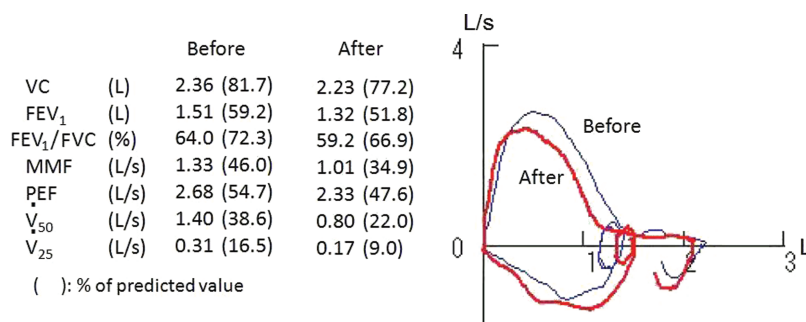


FIGURE 1.—Flow-volume curve before and after bronchodilator inhalation. The FEV₁ did not improve after bronchodilator inhalation.

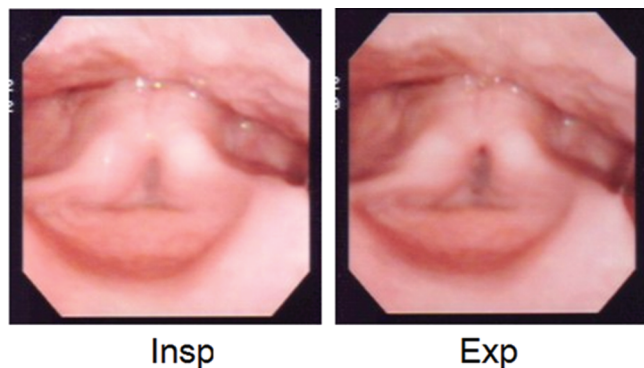


FIGURE 2.—Laryngoscopic view of the vocal folds during a wheezing attack. The vocal folds were closed during both inspiration and expiration.

of bronchial asthma, and the wheezing was audible not only over the larynx but also over the entire lung field. Thus, determining whether the wheezing originated from only the larynx was problematic. Consequently, we performed a lung sound analysis (LSA) to investigate the relation between the wheezing sounds over the larynx and those over the lung field.

RESULTS

The LSA was performed during the VCD episode (Figure 3). The recording system comprised seven microphones (ECM-PC60; Sony, Tokyo, Japan), amplifiers, a pneumotachograph, an A/D converter, and a personal computer. The microphones were air-coupled to the anterior neck over the trachea and to six sites on the chest wall. The sound signals from the seven microphones and the respiratory flow signal from the pneumotachograph at the mouth were digitalized (sampling rate 12.5 kHz) and recorded on the personal computer using a custom-made data acquisition program. The data were analyzed using a custom-made program for the LSA. This program can display the sound spectrograms for the seven channels and the respiratory flow rate simultaneously as an overview of the respiratory sound profile, enabling the detection of adventitious sounds and analysis of such sounds using a time-expanded waveform analysis or a cross-correlation analysis.

The sound spectrogram showed monophonic continuous adventitious sounds with a fundamental frequency of

100–250 Hz during both the inspiratory and expiratory phases that were distributed symmetrically over both lung fields. The time-expanded waveform revealed that the start of the continuous sound was earliest at the anterior neck, followed by the right and left upper lung fields (both anterior and posterior) and thereafter by the right and left lower lung fields. A cross-correlation analysis was performed for the 12 samples of continuous adventitious sounds. As a result, the mean time lags from the neck to the six sites of the lung fields were 2.8 ms (anterior right upper), 2.7 ms (anterior left upper), 2.4 ms (posterior right upper), 2.2 ms (posterior left upper), 5.0 ms (posterior right lower), and 4.8 ms (posterior left lower), respectively. The time lags were not different between the inspiratory and expiratory phases. These time lags were compatible with experimental low-frequency sound transit times from the neck to the respective chest wall sites. Collectively, the LSA results were interpreted as indicating that the continuous adventitious sound originated from a site in the neck.

DISCUSSION

We performed an LSA in a patient with VCD and coexisting bronchial asthma who presented with wheezing that was audible not only over the larynx but also over the entire lung field. The LSA revealed a symmetrical distribution of wheeze over the chest wall on the sound spectrograph, indicating that the wheezing did not originate at the bronchus or bronchiole. Moreover, the LSA demonstrated that the time lag between the wheezes detected at the neck and those detected at the chest wall was compatible with the known sound transmission speed from a laryngeal region to the chest wall (9). These LSA results indicated that the wheezes originated from a region in the neck that included the larynx. Therefore, the LSA results confirmed that the wheezing episodes did not arise from asthma and strongly suggested that they were due to VCD. However, the LSA results could not exclude the possibility of other conditions with reversible tracheal or laryngeal narrowing, including tracheomalacia and laryngomalacia. We performed videofluoroscopy and demonstrated that the inner diameter of the trachea was not narrowed during cough. However, the possibility of coexisting tracheomalacia is not completely excluded because a recent study demonstrated the relatively poor sensitivity of videofluoroscopy

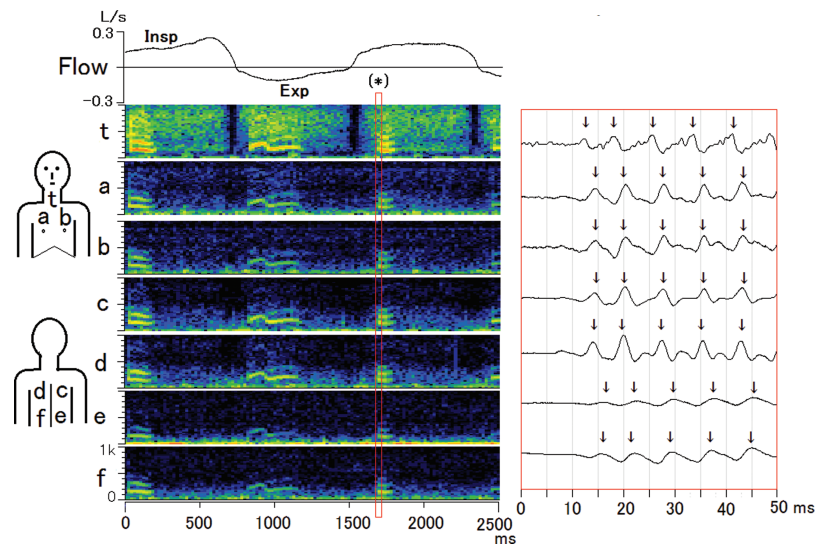


FIGURE 3.—Lung sound analysis during a wheezing attack. (a) The sound spectrogram (x-axis: time, y-axis: frequency; 0–1 kHz, color: power spectra) shows the continuous adventitious sounds during inspiration and expiration not only at the neck but also over bilateral lung fields. (b) The time-expanded waveform of a continuous sound (*) revealed the earliest start of it at the neck. The time-expanded waveform of the neck sound shows that the continuous sound consists of repetitions of a complex sound structure mimicking snoring.

for the diagnosis of tracheomalacia (10). To our knowledge, this is the first report to describe the acoustic features of wheezing in a patient with VCD; whether LSA can be effectively used to diagnose VCD remains to be determined. Currently, LSA is not performed in conventional clinical practice because the usefulness of LSA has not been widely recognized and Japanese health insurance does not cover the cost of performing LSA. However, recent progress in computer technology has made it possible to perform two-channel LSA using a system comprising only a personal computer and microphones (11). In the field of otolaryngology, vocal cord instability has been demonstrated using endoscopy with stroboscopy in asymptomatic patients with VCD (12). Therefore, the evaluation of vocal cord instability could be another possible target of acoustic analyses of tracheal sounds in the future.

CONCLUSIONS

The usefulness of LSA to help differentiate VCD from asthma is warranted to be tested among a large number of cases with suspected VCD.

DECLARATION OF INTEREST

The authors report no conflicts of interest. The authors alone are responsible for the content and writing of this article.

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