Vocal Cord Dysfunction Related to Water-Damaged Buildings

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What is already known about this topic? Vocal cord dysfunction (VCD) is the intermittent paradoxical adduction of the vocal cords during respiration, resulting in variable upper airway obstruction. VCD has been described in association with a variety of exposures.

What does this article add to our knowledge? VCD can occur with exposure to damp indoor environments alongside other well-recognized sequelae such as asthma and sinusitis.

How does this study impact current management guidelines? Evaluation for VCD should be considered in patients with exposure to damp indoor environments and asthma-like symptoms. The primary therapy for VCD that occurs in relation to a water-damaged building should be exposure cessation.

BACKGROUND: Vocal cord dysfunction (VCD) is the intermittent paradoxical adduction of the vocal cords during respiration, resulting in variable upper airway obstruction. Exposure to damp indoor environments is associated with adverse respiratory health outcomes, including asthma, but its role in the development of VCD is not well described.
OBJECTIVE: We describe the spectrum of respiratory illness in occupants of 2 water-damaged office buildings.
METHODS: The National Institute for Occupational Safety and Health conducted a health hazard evaluation that included interviews with managers, a maintenance officer, a remediation specialist who had evaluated the 2 buildings, employees, and consulting physicians. In addition, medical records and reports of building evaluations were reviewed. Diagnostic evaluations for VCD had been conducted at the Asthma and Allergy Center of the Medical College of Wisconsin.
RESULTS: Two cases of VCD were temporally related to occupancy of water-damaged buildings. The patients experienced cough, chest tightness, dyspnea, wheezing, and hoarseness when in the buildings. Spirometry was normal. Methacholine challenge did not show bronchial hyperreactivity but did elicit symptoms of VCD and inspiratory flow-volume loop truncation. Direct laryngoscopy revealed vocal cord adduction during inspiration. Coworkers developed upper and lower respiratory symptoms; their diagnoses included sinusitis and asthma, consistent with recognized effects of exposure to indoor dampness. Building evaluations provided evidence of water damage and mold growth.
CONCLUSION: VCD can occur with exposure to water-damaged buildings and should be considered in exposed patients with asthma-like symptoms. (J Allergy Clin Immunol: In Practice 2013;1:46-50)

Key words: *Vocal cord dysfunction; Asthma; Dampness; Mold*

Vocal cord dysfunction (VCD), also known as paradoxical or paroxysmal vocal fold motion, is the intermittent adduction of the vocal cords during respiration. VCD results in variable upper airway obstruction, particularly during inspiration.[1] Symptoms of VCD include intermittent, acute onset of dyspnea, cough, stridor, wheeze, throat or chest tightness, and hoarseness of variable severity.[2,3] Although the symptoms may mimic asthma, they are typically unresponsive to asthma medications and instead may respond to relaxation.[1,4] The pathogenesis of VCD is unknown. Although traditional explanations for VCD have invoked psychogenic and neurogenic factors, a more recent proposal is that the condition may result from the effect of intrinsic or extrinsic irritants on a hyperresponsive larynx, similar to the hyperresponsive airway in asthma.[4,5] VCD has been described in association with a variety of extrinsic irritants, including cleaning solutions, machining fluids, cooking fumes, ceiling tile dust, smoke, eucalyptus, glutaraldehyde, World Trade Center site dust, wood dust, xerographic toner, and persulfate.[6-11]

Exposure to damp indoor environments is a pervasive public health issue. Decades of investigation have shown consistent associations between indoor dampness or mold and respiratory health outcomes, including rhinitis, sinusitis, and asthma.[12-14] However, the role of exposure to indoor dampness or mold in the development of VCD is not well described. We report 2 cases

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Abbreviations used
FEV_1- Forced expiratory volume in 1 second
FVC- Forced vital capacity
FVL- Flow-volume loop
NIOSH- National Institute for Occupational Safety and Health
VCD- Vocal cord dysfunction

of VCD in office workers who were evaluated at the Asthma and Allergy Center of the Medical College of Wisconsin. Concurrently, coworkers experienced respiratory symptoms more typical of exposure to dampness or mold.

METHODS

In response to a request from the management of a private business in a suburban community, the National Institute for Occupational Safety and Health (NIOSH) conducted a health hazard evaluation for respiratory symptoms in 2 water-damaged office buildings. The evaluation included interviews with managers, a maintenance officer, a remediation specialist who had evaluated the 2 buildings, employees, and consulting physicians. In addition, NIOSH staff reviewed medical records and reports of building evaluations. The evaluation revealed 2 cases of VCD among building occupants. We obtained written consent to describe the experiences of each person in detail.

RESULTS

Case 1

A 47-year-old woman with a history of panic attacks had worked in the same one-story building ("Building A") for more than 10 years, during which time repeated episodes of water incursion involving the main floor and basement occurred. Three years before presentation, she noted the onset of headaches, nasal and sinus congestion, and cough when at work, which she reported to management. The symptoms increased in severity and frequency over time. Six months before presentation, she entered a basement office where the ceiling tiles had apparent mold growth. Within minutes, she experienced paroxysmal cough accompanied by chest tightness, hoarseness, and shortness of breath. She then experienced these symptoms whenever she entered the building; observers noted audible wheezing. Because of these symptoms, she was unable to work in the building and was relocated to another building. She did not experience the symptoms after relocation, but they recurred when she returned to Building A for brief visits and for reoccupancy after remediation efforts were complete. She also experienced the same symptoms when she was in other reportedly water-damaged buildings, including the company's "Building B," a first-floor office in a two-story strip mall.

She was evaluated during a symptomatic period weeks after reoccupying Building A. Physical examination was unremarkable. Skin prick and intradermal tests for common indoor and outdoor allergens, including *Aspergillus*, *Stachybotrys,* and more than 30 other molds, were negative. Spirometry showed forced vital capacity (FVC) of 88% predicted, forced expiratory volume in 1 second (FEV_1) of 88% predicted, and FEV_1/FVC ratio of 80%. Methacholine challenge that used a Food and Drug Administration—approved 5-breath technique and concentrations of 0.025, 0.25, 2.5, 10, and 25 mg/mL did not show bronchial hyperreactivity but elicited cough, hoarseness, chest discomfort, and inspiratory dyspnea, similar to the symptoms she experienced in the water-damaged buildings. The flow-volume loop (FVL) suggested a variable extrathoracic obstruction (Figure 1). On flexible laryngoscopy, vocal fold motion was normal during the respiratory cycle and after provocative phonation maneuvers (humming and rapid counting). After she smelled an alcohol wipe, vocal cord adduction during inspiration was observed. Her condition was diagnosed as VCD.

Case 2

A 31-year-old previously healthy woman had worked in Building A for 2 years. One year before presentation, she noted the onset of headaches and nasal and sinus congestion when at work. Six months before presentation, she noted cough, chest tightness, shortness of breath, wheezing, and hoarseness that began 10 minutes after she entered the building and progressed during the day. Because of these symptoms, she was unable to work in the building and was relocated to another building. She did not experience the symptoms after relocation or during her subsequent maternity leave, which coincided with remediation efforts. She returned to Building A after her maternity leave when remediation efforts were complete and immediately experienced these symptoms again. She requested a part-time position and was transferred to Building B, which was undergoing remediation for water damage. In Building B, the symptoms increased in severity and frequency, and she took medical leave for several months. After remediation efforts were complete, she reoccupied Building B, where she again experienced the symptoms. She also experienced the symptoms when she was in a restaurant that had a history of water damage.

She was first evaluated soon after her return to work in Building A after the maternity leave. Physical examination was unremarkable. As in Case 1, skin prick and intradermal tests for common indoor and outdoor allergens, including *Aspergillus*, *Stachybotrys,* and more than 30 other molds, were negative. Spirometry showed FVC of 110% predicted, FEV_1 of 94% predicted, and FEV_1/FVC ratio of 71%. Her condition was initially diagnosed as asthma. Over the next 4 months, she twice underwent methacholine challenge (as described above) and flexible laryngoscopy. On the first occasion, she had been away from work for 3 weeks, and all but the sinus symptoms had resolved. Methacholine challenge and laryngoscopy were unremarkable. On the second occasion, she had recently returned to work in Building B after remediation efforts were complete, and the symptoms had recurred. Methacholine challenge did not show bronchial hyperreactivity but elicited cough. The FVL suggested a variable extrathoracic obstruction (Figure 1). On flexible laryngoscopy, vocal cord adduction during inspiration was noted after provocative phonation maneuvers (humming and rapid counting) (Figure 2). Her condition was diagnosed as VCD.

Coworkers

According to managers, in addition to the two cases described, 11 of their 15 coworkers from the 2 buildings reportedly experienced respiratory symptoms that were temporally related to building occupancy. We were able to interview 7 of these affected coworkers during the health hazard evaluation. Work-related symptoms included nasal congestion, sinus pressure and pain, cough, chest tightness, wheezing, and dyspnea. Of these 7 coworkers, 5 had sought medical care for their symptoms, and 4 released the records of their medical evaluations to NIOSH.

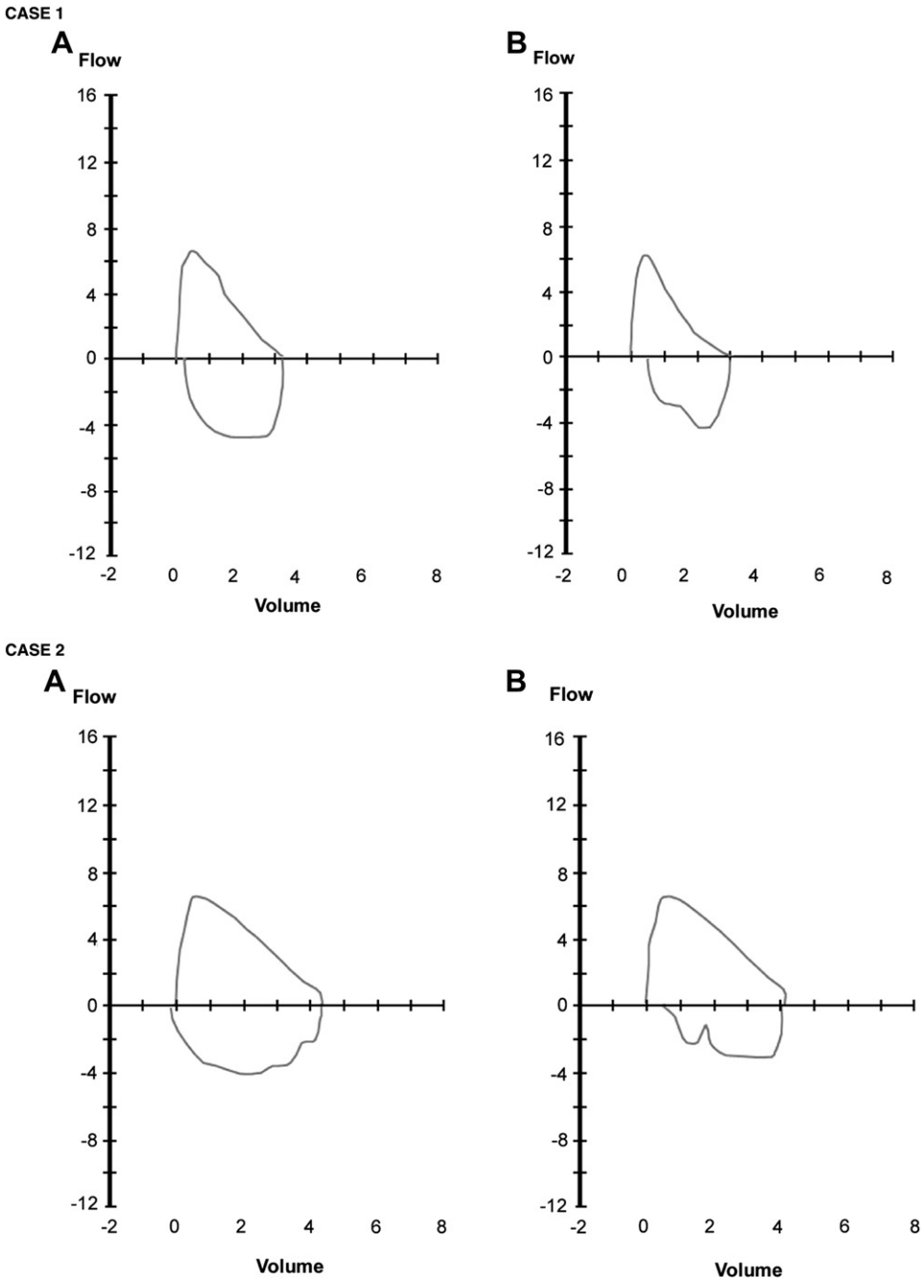

FIGURE 1. Flow-volume loops during methacholine challenge. A, Early in testing (after a 0.025-mg/mL dose in Case 1; before first dose in Case 2), the flow-volume loop appeared normal; the patient was asymptomatic. B, Late in testing (after a 25-mg/mL dose in Case 1; after a 10-mg/mL dose in Case 2), the flow-volume loop showed late inspiratory obstruction; the patient was symptomatic.

Medical records review found diagnoses of asthma (n = 2), sinusitis (n = 1), and sick building syndrome (n = 1). The fifth reported a diagnosis of sinusitis, but this could not be confirmed by medical records review. All diagnoses were made after the onset of work-related symptoms. Both asthma diagnoses were made on the basis of clinical history and methacholine challenge results that showed bronchial hyperreactivity. One of the patients diagnosed with asthma had a history of childhood asthma that had been quiescent for years; the other had no prior asthma history. In all cases, interviewed workers reported that symptoms improved after avoidance of the buildings, although in some cases asthma symptoms persisted in some settings, such as with exertion or on exposure to cold air.

Buildings

In response to employee complaints beginning with the initial work-related symptoms in Case 1, the employer hired 4 different consultants specializing in indoor air quality and building envelope assessments. We reviewed 24 reports that described evaluations of the 2 buildings that were prepared by

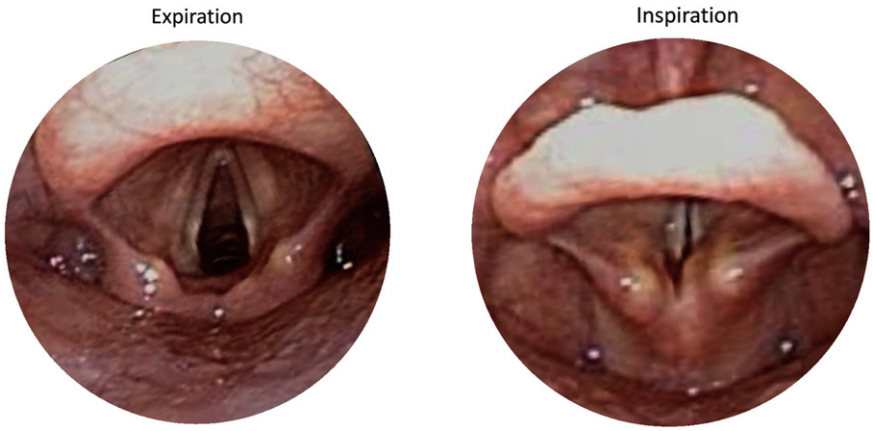

FIGURE 2. Images from laryngoscopy in Case 2. Laryngoscopy was performed immediately after methacholine challenge had induced cough. Images captured after high-pitched humming show vocal cord abduction during expiration *(left)* and paradoxical vocal cord adduction during inspiration *(right)*.

these consultants (with expertise in chemistry, industrial hygiene, and engineering) over the course of 2.5 years. The evaluations documented that the buildings had poor window seals and inadequate or absent vapor barriers. Water damage and mold growth were visible on vinyl wall coverings, drywall, and ceiling tiles. Destructive sampling showed visible mold on the back of drywall and on underlying plywood in some areas. Testing with a moisture meter showed elevated moisture levels in some walls. Short-term (1 to 10 minute) air sampling with the use of spore trap sampling cassettes with a pump calibrated to 15 L/minute showed that, in some areas, mold spore counts by microscopy were higher in indoor air than in outdoor air, suggesting an indoor source. For instance, in Building A, one room had 1800 *Penicillium/Aspergillus* spores/m^3 indoors compared with none outdoors; 2 areas had more *Pithomyces* mold spores in indoor air than in outdoor air. In Building B, spores of *Stachybotrys* mold, which can grow on wet building materials with high cellulose content,[15] and spores of *Penicillium/Aspergillus* were detected by microscopy in some carpet dust samples with counts as high as 190,000 spores/g and 220,000 spores/g, respectively.

DISCUSSION

In these cases of VCD diagnosed by clinical features and laryngoscopy,[2,16] several lines of evidence support a causative role for exposure to the water-damaged buildings. First, there is the clear temporal association: onset occurred in Building A after a period of exposure. Second, once disease developed, the response was consistent: symptoms came on with exposure, resolved with removal from this environment, and recurred with re-exposure. The consistency of the association also is indicated by the experience of the same symptoms in other water-damaged buildings, including Building B. Third, the strength of the association between the water-damaged buildings and respiratory illness among the buildings' occupants is impressive: three-quarters (13/17) of workers who regularly staffed these offices reported adverse respiratory health effects when in the buildings. Symptoms and diagnoses among the patients' coworkers reflected recognized sequelae of exposure to indoor dampness and mold.[12-14]

Exposures in water-damaged buildings are complex and may include dust mites, fungi, protozoa, bacteria, microbial products, and emissions from damp building materials.[13] The particular compound or group of compounds that may be responsible for adverse health effects is the subject of ongoing inquiry.[17,18] It is plausible that extrinsic irritants (of microbial or building material origin) and/or intrinsic irritants (such as from dampness-related rhinosinusitis[16]) may have contributed to VCD in these cases. Although the mechanism of VCD is not certain, one hypothesis is that irritant exposures damage the laryngeal mucosa, leading to hyperexcitation of sensory and motor nerve fibers and resulting in accentuation of cough and glottic closure reflexes intended to protect the lungs from noxious agents.[1,4]

Associations between VCD and psychiatric diagnoses have been recognized in a number of case series,[2,19,20] and 2 reports attributed cases of VCD or pseudo-VCD to mass psychogenic illness.[21,22] Some investigators have argued that patients with VCD do not have a greater incidence of psychological dysfunction than that found in the general population.[23,24] The mechanism that might underlie psychogenic VCD is unclear. Nonetheless, it is possible that anxiety about an environment perceived by the patients to be contaminated contributed to VCD in these cases; in Case 1, the patient's history of panic attacks (although triggered by claustrophobia and well controlled with occasional use of benzodiazepines) must be acknowledged. However, it is notable that the affected occupants of these 2 buildings had a diverse set of upper and lower respiratory symptoms and diagnoses, which occurred over the course of several years. Such a pattern is not consistent with mass psychogenic illness, typically a time-limited incident that involves a triggering event, symptoms related to hyperventilation, and "line of sight" transmission.[25]

The paucity of previous reports of VCD associated with indoor dampness may reflect a lack of disease recognition in this setting. The symptoms of VCD have substantial overlap with those of asthma,[2,16,19] which could lead to misdiagnosis. In addition, increasing evidence suggests that VCD and asthma can occur together.[2,4,5,26] In patients with both conditions related to a water-damaged building, the accurate (but incomplete) diagnosis of asthma may discourage a search for other diagnoses. In the

cases presented here, features such as dysphonia, the lack of convincing evidence for asthma on spirometry and methacholine challenge testing, and possible inspiratory FVL truncation (although not specific for VCD) led to the consideration of VCD.

As has been reported elsewhere, the use of methacholine in conjunction with laryngoscopy excluded a diagnosis of asthma and triggered VCD that was ultimately confirmed by visualization of the vocal cords.[27] Why the first methacholine challenge in Case 2 did not induce VCD is unclear but may be related to the time elapsed since exposure to the water-damaged buildings. One small study suggested that response to methacholine marked by inspiratory vocal cord adduction is specific, but not sensitive, for VCD.[28] In Case 1, VCD was diagnosed after vocal cord adduction after exposure to an alcohol wipe. Such nonspecific chemical provocation challenge testing has been described as a means of reducing false-negatives during laryngoscopy.[4,29] The use of specific provocation challenge testing also has been advocated in the diagnosis of VCD,[20] but it was not practical in these cases, because it would have required medical evaluation in the workplace. Further systematic study of the role of specific and nonspecific provocation challenge testing, including methacholine, in the diagnosis of VCD is needed.[24]

The primary therapy for VCD occurring in relation to a water-damaged building should be exposure cessation.[4] In addition, speech therapy aimed at laryngeal control is the mainstay of treatment for VCD of any cause.[1,4] Unless there is coexistent asthma, therapy with bronchodilators and corticosteroids is not indicated and poses a risk of side effects.[1] Ultimately, prevention will require an emphasis on proper building design and maintenance and prompt recognition and remediation of indoor dampness and mold.

In conclusion, these 2 cases show that VCD can occur with exposure to water-damaged buildings. Consideration of VCD in these cases prompted laryngoscopic evaluation, which was essential to making the correct diagnosis. Both patients were advised by their physician to stop working in the water-damaged buildings after remediation efforts failed to relieve their symptoms. Each ultimately left employment when the employer would not accommodate the prescribed work restrictions. One year later, they reported substantial improvement in their daily lives but occasional recurrence of symptoms in some settings. In Case 1, cough and hoarseness occurred inside several water-damaged buildings (including the temporary worksite of a new employer, a residence, and a church) and with strenuous exercise; speech therapy techniques offered some relief. In Case 2, shortness of breath and hoarseness occurred inside a store with a history of flooding. Their experiences highlight the importance of considering VCD in patients exposed to water-damaged buildings with asthma-like symptoms and the therapeutic challenges that exposure-related VCD can pose.

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