Dysfunctional Breathing – View of Otorhinolaryngologist

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Abstract

Background. Dysfunctional breathing – vocal cord dysfunction (VCD) or paradoxical vocal fold movement (PVFM) is inappropriate vocal fold movement. Adduction of the vocal folds appears during inspiration, resulting in dyspnea and inspiratory and sometimes expiratory stridor, and acute upper airway obstruction. It is a functional disorder, an important mimicker of asthma, leading to unnecessary morbidity and high medical utilization, unnecessary drug use, and high-dose corticosteroid use. The gold standard test for diagnosis of VCD is direct visualization of the vocal folds by laryngoscopy while a patient has symptoms or is combined with special maneuvers that trigger symptoms.

Methods. The recent papers on vocal cord dysfunction were reviewed.

Results. VCD is an important differential diagnosis of refractory asthma, that is widely unrecognized. But concomitant vocal cord dysfunction and asthma are seen in a high degree of patients, up to 50%. VCD is a benign and self-limiting disorder and there are no long-term sequelae. Correct diagnosis is important due to proper treatment. The cornerstone of the VCD treatment is speech therapy like respiratory retraining, learning breathing techniques, and different maneuvers that enable quick release of symptoms. Psychotherapy and hypnosis are important modes of treatment as well. Medications and botulinum toxin are used rarely.

Conclusions. We should suspect VCD in patients with asthma-like symptoms that do not respond to conventional asthma therapy or are induced by stress and exercise. A team of different specialists is necessary to find the correct diagnosis and proper treatment.

Keywords: dyspnea, vocal cords dysfunction, speech, and language therapy, maneuvers

Introduction

More than 70 terms have been used to describe the abnormal movement of the true vocal cords. The two most encountered terms in medical literature are paradoxical vocal fold motion (PVFM) and vocal cord dysfunction (VCD)[9]. PVFM/VCD is a condition characterized by abnormal adduction of the vocal folds during inspiration, leading to episodic dyspnea, wheezing, and stridor[23]. VCD is an intermittent extrathoracic airway obstruction presenting mainly during inspiration leading to dyspnea of varying intensity[21].

Epidemiology

The overall incidence of VCD in the general population is not well defined, because of the lack of uniformity in definitions and diagnostic criteria for VCD. The incidence is underappreciated in clinical practice. Prevalence has been reported to range from 2.5% of patients presenting to an asthma clinic to

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up to 22% of patients with recurrent emergency department visits for dyspnea[8]. Patients with exertional dyspnea are reported to have VCD in 12%, and patients with exercise-induced asthma in 9%. Patients with "refractory asthma" have VCD in 10% alone, 30% of them have both VCD and asthma[36]. VCD affects mainly children, young adults, and athletes, with female predominance (65%: 35%). Family history was not proven[18].

Vocal cord anatomy and function

The larynx is a valve separating the trachea from the upper aero-digestive tract. The glottis consists of the true and false vocal cords and an opening between them, the rima glottidis. The principal muscle for vocal cord abduction is the posterior cricoarytenoid (PCA). Adduction is performed mainly by the lateral cricoarytenoid muscle (LCA). During normal inspiration, the glottic opening is controlled through the medullary respiratory center, via the vagus nerve, which leads to contraction of the PCA muscle and therefore to vocal cord abduction. During normal expiration there is a decrease in the tonic activity of the PCA muscle and contraction of the LCA muscle, resulting in a 10-40% narrowing of the rima glottides, allowing air movement to and out of the lungs[18]. The larynx has the function of protection the lower airway, which is strictly reflective. The other functions of the larynx are respiration and phonation, which are regulated partially by involuntary brainstem reflexes and may be initiated voluntarily. Pulmonary protection is mediated by the glottic closure and cough reflexes, to protect the lower airway from noxious inhaled stimuli and aspiration of foreign material during respiration. The cough reflex is initiated by an adverse stimulus triggering one of the many sensory receptors of the larynx[1,9]. In VCD there is a brief inappropriate adduction of the vocal folds during inspiration. This may manifest with audible inspiratory sounds[32].

Pathogenesis of VCD

The etiology of VCD is complex and multifactorial. VCD is a functional disorder. In the pathogenesis of VCD, there are several pathogenetic mechanisms. The essential pathophysiology is that of a hyper-functional laryngeal reflex to protect the lower airways [21]. The sensitivity of the laryngeal sensory receptors is increased and the response of the glottic closure and cough reflex to several triggers is heightened. It is analogous to bronchial or nasal hyper-responsiveness. Direct stimulation of the sensory nerve endings in the upper or lower respiratory tract and hyperventilation may also lead to glottic narrowing due to underlying laryngeal hyper-responsiveness. Another possible etiology of VCD is neurological, where autonomic neurophysiologic balance is altered. Central brain regions such as the medulla, midbrain, and prefrontal cortex are polysynaptic linked with the larynx and the balance can be altered[37]. The hypothesis is, that there is an initial inflammatory insult, which causes laryngeal hyper-responsiveness and/or altered autonomic balance, which may be short or persistent. Subsequent stimuli (psychological stresses or cold air and irritants) induce local presynaptic reflexes causing airway narrowing[18]. While the etiology of this disease is still unclear, many support the theory that VCD has a psychiatric basis[6,9,25,36].

Specific triggers of VCD

Specific triggers are not always identified, because VCD episodes quickly begin and end. VCD triggers are classified into three groups: irritants, psychological and emotional, and exertional[6]. Initially, one patient has a single trigger, then develop multiple triggers, that were previously benign. Self-reported triggers are upper respiratory tract infection, occupational exposures, talking, laughing, singing, acid reflux, cough, different foods, physical exertion, exercise, postnasal drip, weather changes, emotional stressors, odors, strong

scents and other airborne triggers, chlorine in swimmers and others[9].

The role of psychogenic factors – triggers

Initial reports of VCD emphasized the dominant underlying psychological disorders. It is still thought that psychological stimuli can trigger VCD, including anxiety disorder, stress, somatoform disorders, depression, psychiatric illness, social stress in competitive sports, prior history of sexual abuse, conversional profile, and others. Psychological stimuli can trigger VCD and are considered major precipitating factors for VCD[18]. Not all patients have an underlying psychiatric illness. And anxiety can be also the result of chronic respiratory illness, not the cause[9,17,22].

Irritant triggers

Irritant triggers can be extrinsic including chemical, olfactory, and even visual. Irritants are environmental and occupational irritant exposure to smoke, gasses, vapors, dust, airborne pollutants, and odors. Triggers can be intrinsic such as gastroesophageal reflux, sinusitis, postnasal drip, pharyngitis, and laryngitis. They lead to chronic inflammation and hyper-responsiveness. Reflex adduction of vocal cords might be protective and is responsible for the development of VCD[1,9,18].

The role of gastroesophageal reflux disease – GORD

There is much speculation in different studies. In some, there is a high proportion of GORD in patients with VCD (95%), and in others low proportion of patients with GORD. In a group of elite athletes with exercise-induced laryngeal obstruction (EILO), only 2.3% had GORD[38]. VCD is triggered by acid reflux in some patients. Laryngospasm is induced by hydrochloric acid in the esophagus by sensitization of subglottic chemoreceptors through a vagally mediated mechanism. Reflux events cause vocal cord adduction and apneas. Laryngeal irritation associated with GORD may also contribute to bronchial constriction. It is a vagally mediated reflex[18].

Exercise as a trigger

EILO – exercise-induced laryngeal obstruction is caused by maximal exercise or athletic competitions, it can be also seen during routine exercise, but is related to exercise intensity. EILO symptoms resolve quickly on exercise cessation[16]. Most patients are highly competitive, elite athletes and military personnel, who are required to exercise regularly. EILO is common, affecting 5-7% of adolescents and up to a quarter of athletes presenting with "exertional asthma-type". EILO has a female preponderance and a peak age of onset in the teenage years. It has been speculated that the laryngeal growth difference between genders seen in the peri-pubertal age group might explain this observation[38]. Patients develop wheezing during exercise. The differential diagnosis is asthma, but methacholine challenge testing is negative, as is the bronchoprovocation testing[9]. Some patients can have both asthma and VCD. 35 – 56% of patients with VCD have coexistent asthma. EILO represents a maladaptive response to exercise. Increased work breathing might contribute to exercise limitation. Endurance training induces large and significant adaptations within the cardiovascular, musculoskeletal, and hematological systems. But the structural and functional properties of lungs and airways do not change in response to repetitive physical activity. In elite athletes, the pulmonary system may become a limiting factor to exercise. As a consequence, of this respiratory paradox, the highly trained athlete may develop intrathoracic and extrathoracic obstruction, expiratory flow limitation, respiratory muscle fatigue, and exercise-induced hypoxemia. All of these maladaptations may influence performance[29]. Increased and abnormal ventilation through the narrowest part of the airway causes the collapse of laryngeal

structures. In pediatric patients, it is hypothesized that increased laryngeal diameter due to growth might spontaneously improve their exercise capacity[26]. Asthma is common in endurance sports athletes, likewise the prevalence of EILO is high. Cross-country skiers and biathletes have a very high prevalence of asthma and EILO. Coexisting EILO and asthma seem to be common in skiers, especially females. It is mainly believed to be due to repeated and prolonged inhalation of cold dry air, therefore, leading to osmotic changes and epithelial damage in the airways[19]. Laryngopharyngeal reflux, allergy, infections, irritants, temperature, the humidity of the air in the surroundings, and psychological aspect are also the etiological factors of EILO[15].

Other possible etiologies for VCD

There are some other factors as extubation after general anesthesia. Central neurological disorders like Arnold Chiari malformation, Parkinson's syndromes, ALS (amyotrophic lateral sclerosis), and others may be associated with VCD[18].

Clinical features of VCD

Clinical presentation can be very variable, ranging from no symptoms to mild dyspnea, and acute onset respiratory distress, which can mimic an asthma attack[9]. VCD episodes frequently begin and end abruptly. Patients are not hypoxic and have a normal level of consciousness. If the patient is with altered mental status or hypoxemia, more serious causes should be considered. Symptoms are periodic: shortness of breath, asthma-like symptoms during exercise, and intense emotion, which does not respond to asthma drugs. Other symptoms are air hunger, dyspnea, choking sensation, chest pain, stridor, voice changes, difficulty in speaking and swallowing, globus sensation, intermittent aphonia, dysphonia, chronic cough, throat clearing, panic, and anxiety which worsen respiratory symptoms[9]. The period from symptom onset to diagnosis of VCD is greater than 4 years[8]. Patients with asthma may also have comorbidities, such as VCD, which are associated with worse asthma outcomes, increased symptoms, more exacerbations, and poorer quality of life[24]. Improved VCD control can reduce asthma medication use[18,23].

Important differential diagnosis od VCD

Patients with VCD are often misdiagnosed as having refractory asthma, which can lead to unnecessary morbidity and high medical utilization, unnecessary drug use and high dose corticosteroid use, emergency room visits, hospitalizations, and even intubation. They found that 42% of all VCD subjects had been previously misdiagnosed with asthma for an average of 9 years[9,34]. The differential list for suspected VCD is broad and includes any disorder with episodic dyspnea, cough, and wheezing. There are many mimickers of VCD, with asthma at the top of the list. Other conditions are psychogenic disorders, anaphylaxis, aspiration of foreign body, angioedema, chronic obstructive pulmonary disease, croup, epiglottitis, extrinsic airway compression, laryngomalacia, laryngospasm, laryngeal tumor, laryngeal dystonia, exercise-induced bronchospasm, vocal cord paresis, laryngeal and tracheal stenosis, and others[9,18,35].

Diagnosis of VCD

Diagnosis is made by careful history, physical examination – laryngoscopy, and spirometry or pulmonary function testing[9]. Imaging has no role in the evaluation of VCD[32]. A careful history is very important. We should be suspicious in a patient with asthma-like symptoms unresponsive to bronchodilators or corticosteroids, absence of nocturnal symptoms, and more difficulty with inspiration than expiration. Asthma inhalers can even trigger or exacerbate symptoms[1]. Symptoms in VCD patients are precipitated by stress, emotional factors, or anxiety. The patient has no spu-

tum[18]. We should be suspicious in a patient with exercise-induced asthma-like symptoms, or an athlete with choking sensation during exercise and irritant-induced asthma-like symptoms. But we must be aware that VCD with asthma is possible, and we should be also aware of exercise-induced bronchospasm[32].

Assessment of symptoms

Relevant issues should be discussed with patients. We can use standardized questionnaires, for example, 12-item VCDQ (vocal cord dysfunction questionnaire), which is a valid tool for symptom monitoring and tracking improvement in scores after speech therapy. It also gives insight into which symptoms are important to patients and could guide future therapy refinements[11]. Another one is the Pittsburgh VCD index, which helps distinguish VCD from asthma. This scoring system correctly diagnosed VCD in 77.8% of patients. Since many patients have coexistent VCD and asthma, further diagnostic tests should be performed, if a strong suspicion of asthma exists[33].

Physical examination

The physical examination in patients with VCD is normal when they are not experiencing an acute attack. During symptoms, we can identify high-pitched wheezing, stridor, tachypnea, hoarseness, dysphonia, cough, and respiratory distress. Arterial hypoxemia is usually lacking. The patient has a normal oxygen saturation. Only in a few patients with VCD, we can identify the presence of hypoxemia. Laryngoscopy is the gold standard for the diagnosis of VCD. Direct visualization of the vocal folds via flexible, trans-nasal fiber-optic laryngoscopy should be done while a patient has symptoms. Complete adduction of the vocal folds during inspiration and a formation of a small posterior glottal chink during exhalation is seen[18]. In asymptomatic patients, we can provoke symptoms by deep breathing, cold air, phonation, forced expiration, and exercise[7,21]. Patients with VCD often show inappropriate vocal fold movement during inspiration or expiration when laryngoscopy is performed immediately following a bronchoprovocation challenge with methacholine. Therefore, laryngoscopy should be ideally performed after a bronchoprovocation challenge with methacholine. We should avoid benzodiazepines and lidocaine before the examination. Negative laryngoscopy in an asymptomatic patient does not rule out VCD[5,18].

Continuous laryngoscopy during exercise – CLE test

Video recorded trans nasal flexible laryngoscopy and larynx examination are performed during exercise from the rest to the peak exercise – continuous laryngoscopy exercise test (CLE test). Any form of physical exercise can be used, running, or cycling on stationary bicycles, which provoke symptoms[15]. A flexible laryngoscope is attached to the head via a helmet. The tip of the scope is introduced through the nose into the larynx, allowing visualization of the supraglottic and glottic structures in real time throughout the exercise. During testing cardiopulmonary data is collected, as the patient exercise to peak in an attempt to reproduce EILO symptoms. EILO-related findings on laryngoscopy include vocal fold narrowing, supraglottis narrowing, obstruction, and/or collapse of supraglottic structures. CLE is the test of choice for EILO[32].

Other tests

Pulmonary function tests, methacholine challenge testing, spirometry, and flow volume loops are also done in VCD and EILO patients[1].

Treatment

Correct diagnosis is essential for proper treatment. The patient should be reassured that the condition is benign and self-limited. The treatment approach is multidisciplinary. Pri-

mary care physician, pulmonologist, allergist, ENT doctor, gastroenterologist, neurologist, psychiatrist and psychologist, speech pathologist and athletic trainer participate in the treatment. Effective long-term therapy requires psychosocial support, speech therapy, and biofeedback[9].

Speech therapy

Speech therapy is the cornerstone of the treatment[18]. It is the most common long-term treatment of VCD. Patients are educated about the pathophysiology of VCD and are educated about the suppression of laryngeal abusive behaviors (cough and throat clearing). Patients are trained on how to control the laryngeal area and maintain an adequately open airway during respiration. Patient are allowed to view their laryngoscopy, to understand and accept the disease. Visual feedback allows the patient to modify their breathing, visual feedback enables a reduction in symptoms and the use of medication. Breathing techniques are learned by the speech and language therapist (SLT), and VCD symptoms, and triggers are assessed. Patient education is a crucial component of the treatment. The therapist offers supportive counseling. Respiratory retraining is practiced by the SLT. Desensitization is attempted to be achieved for specific irritants. Voice therapy and different breathing techniques are practiced – quick release techniques and different maneuvers. Studies have shown that speech therapy can achieve symptom control and eliminate emergency department visits in 90% of patients with VCD[8,14,23]. Non-pulmonary-related shortness of breath treated with respiratory retraining can effectively eliminate dyspnea. The patient should perform respiratory retraining exercises three to four times daily for four weeks, and daily exercises for two additional months[13].

Treatment of VCD – maneuvers

Different maneuvers can be used to achieve a quick release of symptoms. It is necessary to repeat them often, to ensure that a patient can respond automatically when acutely symptomatic (5 repetitions 20 times per day). Phonation of soft "s" sound while exhaling, is successful to divert attention from inhalation, and give auditory feedback on air movement. Another maneuver is panting, which activates the PCA muscle, a laryngeal abductor. Coughing and sniffing are also releasing maneuvers. Sniffing reduces air turbulence and shifts the narrowest part of the breath from the larynx to the nose. Common breathing techniques include jaw trust, nasal inspiration with pursed-lip exhalation, and breathing through a large-diameter straw or cut endotracheal tube. These techniques are designed to interrupt the irregular respiratory pattern or spasm and allow familiar neurologic signals to reengage and relax the vocal folds[8,18,30].

EILOBI breathing techniques

In EILO adduction of the vocal folds and/or inspiratory prolapse of the supraglottic structures during high-intensity exercise appears. Although respiratory retraining is a primary therapy of EILO, many patients report symptom persistence despite the adequate performance of traditional techniques. EILOBI (EILO biphasic) inspiratory breathing techniques are novel breathing techniques for EILO therapy[20]. Patients are encouraged to train in biphasic inspiratory breathing: from high inspiratory resistance then rapidly changed to low resistance breathing. High resistance inspiratory phase (tongue variant - inhaling through the nose, tooth variant - inhaling through the teeth placed firmly against the lower lip, lip variant - inhaling through the pursed lips) is followed by low resistance inspiratory phase – inhalation through a wide-open mouth. Thus, optimizing the glottic aperture with maneuvers that can be performed during high-intensity exercise is achieved[8,30].

Inspiratory muscle training devices

Treatment of EILO in athletes and other patients with VCD with inspiratory muscle training devices is possible. It is a conservative treatment tool to achieve better control of the vocal folds. Patients can use resistive flow-dependent devices. The inspiratory valve increases resistance to inspiration and decreases the inspiratory rate of airflow, consequently, there is less turbulence and less stimulation of the vocal folds[4]. Another one is the use of continuous positive airway pressure – CPAP to relieve acute symptoms of VCD. CPAP relieves dyspnea by slowing the expiratory flow, thereby increasing lung volume, which in turn results in a more open glottis. CPAP is also reducing the effort needed for inspiration by establishing a favorable pressure gradient for inhalation[18].

Psychotherapy

Psychotherapy remains an important mode of treatment in patients with VCD. There are many forms of psychotherapy used in VCD, which include relaxation therapy to alleviate the distress associated with symptoms, identification of stressors, development of new coping strategies for dealing with stressors, family therapy, and behavioral cognitive therapy[18]. Hypnosis and self-hypnosis induce relaxation. Biofeedback may be used in conjunction with psychotherapy for treating patients with VCD[2,3,12,17,25].

Surgical treatment

Surgical treatment – supraglottoplasty is used only in refractory cases. It gives good results in selected patients. The most commonly used method is to cut the aryepiglottic folds closer to the epiglottis and to remove the mucosa and cuneiform cartilage from the aryepiglottic fold with the help of a laser. The use of a suture that pulls the epiglottis towards the root of the tongue and lateralization of one vocal fold with the suture are also described[27,39]. EILO surgery appears to be a safe and effective option for individuals with moderate to severe supraglottic-type EILO who have failed initial conservative treatment[10].

Botulinum toxin

Botulinum toxin laryngeal injection is rarely used in VCD treatment. Chemical denervation is achieved and paralysis, the vocal folds are in the open position. It is useful in laryngeal dystonia. It is used only in severe cases of refractory VCD, that do not respond to conventional therapy, and in patients with refractory dyspnea symptoms following appropriate medical therapy and respiratory retraining protocols[28,36].

Treatment of VCD with medications – pharmacotherapy

In persistently symptomatic patients, mild sedatives may facilitate VCD management. Benzodiazepines are effective in terminating acute symptoms and relieving anxiety. Before giving this medication, we should confirm normal oxygen saturation and exclude hypercapnia[18]. When breathing techniques are unsuccessful, helium-oxygen inhalation and noninvasive positive-pressure ventilation may be successful in resolving VCD. Heliox is the mixture of oxygen (20%) and helium (80%), it is less dense than air and reduces the work of breathing. Inhalation of Heliox reduces turbulence in the airway and eliminates respiratory noise[7,18]. In some centers, they use inhalation of anticholinergic drugs. Neuromuscular treatment such as Gabapentin is successful in some patients. GORD treatment is reasonable if GORD is proven, the success of such treatment is very good in those patients in whom reflux has been demonstrated[21,31].

Prognosis

VCD is a benign and self-limiting disorder. The majority of patients respond to speech therapy. There are no long sequelae[18,32].

Conclusions

VCD is an important differential diagnosis of asthma, that is widely unrecognized. If misdiagnosed as asthma, VCD can lead to high medical utilization, unnecessary high-dose steroid use, and other dangerous consequences. We should suspect VCD in patients with asthma-like symptoms that do not respond to conventional asthma therapy or are induced by stress and exercise. The gold standard test for VCD is direct visualization of the vocal cords by laryngoscopy. The cornerstone of VCD treatment is speech therapy. VCD should be included in the differential diagnosis for patients reporting episodic dyspnea or respiratory distress. Patients with asthma may also have comorbidities such as VCD. Identifying and treating VCD should be included in the management of patients with asthma.

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