

The Workings of the Human Voice: Common Pathologies and Holistic Approaches to Vocal Health

Karly Chan

Author Bio:

Karly Chan is currently a junior at Great Neck South High School. She is particularly interested in voice science (i.e. vocal anatomy, physiology, and pathologies). Karly has been part of her school's research program since freshman year, and has previously interned in a chemical virology lab at Cornell University. Karly is also the founder and president of VOCO - Vocology for Singers, a non-profit organization that educates singers on vocal health and the science behind singing. Additionally, she is the founder and president of STEM for FEM's NY Chapter, a branch of a nonprofit organization that aims to provide free science education to girls and other underrepresented gender identities in elementary and middle school.

ABSTRACT

The human voice is produced by an intricate web of structures. Through understanding vocal anatomy and physiology and exploring singer and clinician perspectives, this paper will review common vocal pathologies, evaluate problems that can prevent a singer from being able to perform, and consider possible treatment options. This review will consider different factors that impact vocal fitness and the production of the human voice, including breathing, posture, and emotional well-being. Pathologies that will be covered include those of the voice resonators, larynx, vocal cords, and respiratory tract. By considering multiple perspectives and vocal care habits, it could help readers understand how different sounds are produced and what common problems can affect the workings of the human voice. This paper also aims to provide a holistic approach to vocal health, as opposed to a strictly mechanical method, taking into account various resources, while still analyzing current research on treatments for these pathologies.

Keywords: Vocal Pathologies, Human Voice, Singers Diseases, Vocal Health

Introduction

Everyone uses their voice. The voice is the basis of identity and communication for humans. Through our voices, we convey emotions, ideas, and messages. Our voices also separate us from others and are a means of recognition for other people. However, most people do not understand the anatomy and physiology of their vocal structures and neglect learning the science behind voice production. In a survey done in 2012, it was found that approximately 17.9 million American adults have had a vocal problem in the past year (Bhattacharyya, 2014). In the same survey, it was found that around 12.5% of children between the ages of 11 and 17 and 6.3% of children between the ages of 3 and 10 had vocal problems (Black et al., 2015). Certain people, like telemarketers and singers, are more prone to voice disorders (Jones et al., 2002), (Pestana et al., 2017). Overviewing the pathologies of the voice increases awareness of the consequences of improper vocal use. Evaluating different treatment methods for various pathologies of the vocal structures elucidates current research and shines a light on clinical procedures.

An overview on factors impacting someone's vocal health allows people to understand how they can improve their own vocal fitness and protect their voices. In order to understand all of this, an initial overview of the anatomy and physiology of vocal structures was included to gain a deeper understanding of the tissues, muscles, ligaments, and cartilages involved in voice production. This review also covers proper vocal care habits supported by current research. Although most reviews focus on a mechanical approach to vocal pathologies and health, I analyzed various factors involved and used multiple perspectives: clinicians' experience, singers' experience, and research studies on vocal anatomy and physiology and vocal pathologies. Using medical and scientific journals, medical websites, primary studies on the science of singing and different diseases, comparative studies of treatments, blogs of ENT experiences, and articles on professional singers' accounts on their experiences with various vocal disorders, I assessed different vocal pathologies, treatments, effects, and factors that affect vocal fitness.

Anatomy and Physiology

A proper understanding of the larynx and the cartilages and muscles that are part of it is critical for surgeons, otolaryngologists, and other clinicians because they work in an intricate web to create different qualities and pitches of sounds. They are also sites of numerous pathologies, and are delicate locations that surgeons must be careful around when performing vocal surgery.

The respiratory tract includes the organs and structures that are involved with airflow during inhalation and expiration. The upper airway consists of the pharynx, which is the membrane-lined region that spans from the back of the mouth to the beginning of the esophagus (Mankowski & Bordoni, 2020). This region is extremely important in voice production and serves as the resonators for sound. Changing the shape of the pharynx has great effects on the quality of the voice. Scarring of the tissues in the pharynx or tension of the muscles in this area can cause considerable

changes to the voice that are often recognizable by voice professionals (Mankowski & Bordoni, 2020). The lower airway consists of the trachea, bronchi, bronchioles, alveoli, and lungs (Ball et al., 2020). The trachea is the windpipe that allows for airflow from the larynx to the bronchial tubes. The lungs are the central organ of the respiratory system, and through differences in air pressure, they allow us to inhale and exhale and exchange gases. These organs and structures are extremely important for voice production as they provide a stream of air that then causes the vocal folds to vibrate and create sound. Professional singers train to utilize more air in their lungs, thus increasing respiratory efficiency so that they can sing longer without having to inhale frequently (Ball et al., 2020). The diaphragm is a dome-shaped muscle that allows for proper respiration (Bains et al., 2020). When the diaphragm contracts, it expands the lungs and pushes down on the abdomen, allowing for inhalation. When the diaphragm relaxes, it reduces the

size of the lungs, allowing for exhalation. Along with other abdominal muscles, the diaphragm is able to greatly affect the passage of air (Bains et al., 2020).

The larynx, also called the voice box, functions in protection of the respiratory tract during respiration and swallowing, and the production of sound. The vocal cords, housed in the larynx, produce sound by vibrating when air is passed in between them (Saran et al., 2020). The major muscles involved in voice production are the cricothyroid muscle, thyroarytenoid muscle, and vocalis muscle (as shown in Figure 1). The cricothyroid muscle stretches, thins, and lowers the vocal cords; when it contracts, it increases tension in the vocal cords longitudinally and raises the pitch. The thyroarytenoid muscle adducts the vocal cords, shortening, lowering and thickening them. When air is also passed through the glottis, this shortening and thickening of the vocal cords causes the pitch of the voice to lower (Sataloff et al., 2020). Finally, the vocalis muscle is the muscle that makes up the bulk of the vocal cords and assists in adjusting vocal pitch by contracting or relaxing (Sendic, 2020). The extrinsic muscles (muscles on the outside of the larynx) play a significant role in positioning the larynx so that the intrinsic muscles (muscles in the inside) can effectively work together to produce the human voice (Sataloff et al., 2020). The vocal cords are the mucous membranes that actually participate in sound production. The gradual change from the flexible outer layers to the stiffer inner layers of the vocal cords is thought to help lessen damage to the vocal cords while

it vibrates. The true vocal cords oscillate when air passes through the glottis (the space between the vocal cords), producing the human voice. Above the vocal cords are the false vocal cords that produce resistance in the vocal cords and are speculated to assist in the resonance of the sound as well (Saran et al., 2020).

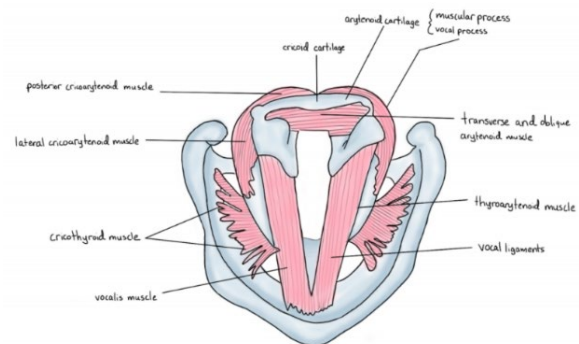


Figure 1. Diagram of the vocal cords and the associated muscles, ligaments, and cartilages (KC, 2021).

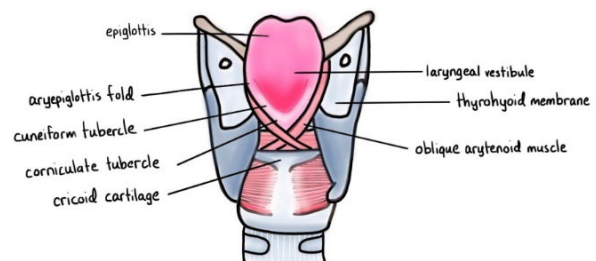


Figure 2. Diagram of the posterior view of the larynx (KC, 2021).

Vocal Pathologies

In this section, the common pathologies of the vocal structures: sinuses, pharynx, respiratory tract, larynx, and vocal cords will be covered. Treatments and effects of some of the more serious pathologies on patients was analyzed through consideration of the perspective of clinicians, researchers, and some famous singers who have publicly addressed their experience with certain pathologies.

Pathologies of the Voice Resonators

Nasopharyngeal Carcinoma, which are tumors located in the pharynx, are commonly linked

to the Epstein-Barr virus or dietary intake (Frazier & Drzymkowski, 2020). Although patients are commonly asymptomatic during the early stages, symptoms include tinnitus (ringing of the ear), impaired function of cranial nerves, headaches, and pain. Due to the anatomical location of the nasopharynx, it is difficult to do surgery on the area. Instead, treatments usually include radiation therapy or chemoradiotherapy for more severe cases. In a randomized controlled trial published in 2010, radiotherapy and supplemental chemotherapy significantly decreased the number of cancer-specific deaths and improved the failure-free

rate (Lee et al., 2010). However, in a study done in 2007 evaluating the quality of life of patients after chemoradiotherapy on the nasopharyngeal carcinoma, it was found that the quality of life of patients post-treatment was extremely poor, a result consistent with previous studies (Oates et al., 2007). Overall, although nasopharyngeal carcinoma is primarily treated through radiation therapy and/or chemoradiotherapy, these treatments lead to unpleasant side-effects that often interfere with the patient's well-being.

Pharyngeal pouch (Zenker's diverticulum) is a protrusion of the throat. It typically causes dysphagia (difficulty in swallowing), aspiration (sucking foreign objects into the windpipe), and a chronic cough. Some treatments include surgery through the neck. However, a vast number of these surgeries are extremely high-risk because of their inherent nature and the increased risk of getting cancer in the pharynx post-surgery (Siddiq et al., 2001). In a study published in 2002, endoscopic stapling resulted in similar outcomes to traditional methods but was found to be safer (Safdar et al., 2002). In a comparative study done in 2011, it was found that transoral stapled diverticuloesophagostomy and the flexible endoscopic approach are effective and minimally-invasive treatment options (Repici et al., 2011). Overall, surgeries done using endoscopes have been found to be effective consistently in studies.

Pathologies of the Larynx

Laryngitis is the inflammation of the vocal cords and larynx (Frazier & Drzymkowski, 2020). Due to the narrow structure of the larynx, symptoms could include trouble breathing. Other symptoms are hoarseness, aphonia (inability to speak), fever, and dysphagia. Treatments of viral laryngitis include complete vocal rest and bed rest in a humidified room, along with an abundance of fluid intake. If bacterial infections are related, antibiotics are used as well. In more severe cases, corticosteroids may be taken to lessen inflammation. In singers, laryngitis can have accentuated negative consequences. Singers may face a heightened amount of stress because of their loss of voice and subsequent loss of income (Jahn, 2002). However, doctors, researchers, and singers usually agree that the best treatment is absolute vocal rest, and although it may be troublesome, as long as further damage is not caused, singers can usually get back to work within 1-2 weeks.

Tumors on the larynx may be malignant or benign (Frazier & Drzymkowski, 2020). Dysphonia (difficulty in speaking) is usually the symptom for tumors on the larynx. Hoarseness or stridor (a high-pitched sound while breathing) may also be present because of the obstruction of the airway. Benign tumors are often treated with management of vocal strain or acid-reflux. Malignant tumors are usually treated with radiation therapy, or in metastasized cases, laryngectomy. However, with laryngectomy, people will lose their voices. For singers, this is obviously a last resort and patients often have to deal with significant psychological trauma. Patients often lose confidence, retreat in social isolation, and develop mental health problems (Moors, 2016). For doctors, total laryngectomy is often avoided for this reason but if there is no other choice, this may be the only option. There has been research done in this field with promising results. In a study published in 2002, use of a DSP device for esophageal speech improved overall speech quality for total laryngectomy patients (Matsui et al., 2002). In a study published in 2013, utilizing a supraglottal voice source was found to improve the quality and acoustics of speech with an electrolarynx (Wu et al., 2013).

Laryngeal Cancer is a neoplasm (tumor) of the larynx - typically squamous cell carcinomas. The treatments for laryngeal cancer include radiation, partial or total laryngectomy, or laser excision. Typically, singers and other patients prefer radiation because it is the option that does not involve the loss of the voice. However, treatments of later stages of cancer often include surgery followed by radiation, which can obviously have negative effects on the quality of life of the patients as described before (Frazier & Drzymkowski, 2020).

Pathologies of the Vocal Cords

Arytenoid granuloma is a benign growth along the posterior region of both or one of the vocal cords (Frazier & Drzymkowski, 2020). It can become painful to swallow or speak and can even inhibit the vocal cords "from closing properly during voice production." It is often useless to remove the growth through surgery, and so botox is usually injected to reduce trauma between the vocal cords and treat granulomas. This is a good option for singers because they do not have to lose their voice, and it is a procedure used by many doctors and found to be effective in research

studies. In a study published in 2016, granulomas were cured in 77% of patients with botox treatments (Yilmaz et al., 2016).

Vocal Cord Cancer is the cancer of the vocal cords, the glottis region of the larynx (Cleveland Clinic medical professional, 2019). Small lesions resulting from this cancer often prompts patients to seek medical help, which typically results in early detection of this cancer. Treatments are often chosen through the consideration of different factors: the effect on the voice and the amount of side effects. A new procedure, KTP laser, has been found to be very effective as well, allowing only the diseased region to be treated, thus minimizing negative effects on the voice (North Shore Voice Center, n.d.). In a comparative study published in 2014, KTP laser treatments in patients was found to be effective and preserved the larynx for between 89 to 99% of the patients (Zeitels & Burns, 2014). However, using KTP laser to treat vocal cord cancer is still a relatively new procedure that needs further research in the field.

Vocal Cord Dysplasia is the pre-cancer of the vocal cords, or the stage right before it is considered vocal cord cancer. Vocal Cord Dysplasia commonly causes leukoplakia (white lesions) or erythroplakia (red lesions) on both or one of the vocal cords and results in hoarseness. Treatments include “vocal cord stripping,” KTP laser, or simply monitored waiting. Aggressive surgery such as vocal cord stripping is detrimental to singers, so it should be used as a last-resort option. Research has found that just monitoring the vocal cords without treatment results in an approximately 20% chance of it turning into cancer (North Shore Voice Center, n.d.), so resorting to one of the treatments mentioned is necessary.

Vocal Cord Nodules is the development of firm scar tissue on opposite regions of each of the vocal cords. These nodules are typically treated using voice therapy with a speech-language pathologist, but if this is not effective, a minimally invasive laryngeal surgery may be needed (North Shore Voice Center, n.d.). One famous singer who had vocal cord nodules was Freddie Mercury. However, he refused surgery and subsequently, his voice suffered over the years (Wurzbarger, 2019). Many singers are often afraid to do surgery on their nodules for fear of their voice being lost, but if surgery is not performed, their voices could get even worst.

Vocal Cord Polyps are protruding gelatinous structures on a vocal cord. It is often a consequence of constant collision or trauma of the vocal cords such as in constant yelling. Treatment usually involves a minimally invasive laryngeal surgery (North Shore Voice Center, n.d.). One famous singer who has publicly addressed her experience with surgery after getting a vocal cord polyp is Bjork, an Icelandic singer. She has had a positive experience with surgery and states that her singing “definitely feel like my cords are as good as pre-nodule” (Wurzbarger, 2019).

Vocal Cord Cysts are spherical-shaped structures that can be fluid-filled or solid and are typically found deeper in the vocal cords than polyps or nodules. Treatment, again, usually involves a minimally invasive laryngeal surgery (North Shore Voice Center, n.d.). One famous singer who has had surgery after getting vocal cord cysts is Christina Perri. After being operated on, her “voice quality improved” and she has been able to fully recover (Buia & Morrill, 2015). Overall, having surgery on vocal cord nodules, polyps, and cysts seems to be effective when done by a certified clinician and seems to be the best option.

Pathologies of the Respiratory Tract

Recurrent Respiratory Papillomatosis (RRP) is caused by HPV and results in wart-like growths on the vocal cords, larynx, throat, or esophagus (Frazier & Drzymkowski, 2020). These growths prevent the cords from vibrating and closing properly, which leads to a raspy voice. No treatment has been determined to be adequately effective for this disease (Ivancic et al., 2018), Human leukocyte interferon was one of the first therapies used but is no longer used because other treatments using cidofovir and bevacizumab have been found to be more effective (Ivancic et al., 2018). However, multiple studies have found cidofovir to cause different side effects ranging from vocal cord scarring to inflammation (Broekema & Dikkers, 2008). Because RRP is a rare disease, it is not well understood and more research is needed to find effective treatments.

Polypoid corditis (Reinke’s edema) is usually a consequence of heavy smoking and acid reflux and causes heavy and large polyps to develop on the vocal cords, which then in turn result in the vocal cords vibrating more slowly during voice production, causing a lower pitched voice (North Shore Voice

Center, n.d.). In severe cases, the laryngeal airway can be restricted, causing dyspnea (difficulty breathing). Surgical excision is the accepted treatment used to treat polypoid corditis for clinicians. In a comparative study done in 1987, it was found that the Hirano technique of surgical excision was the most effective treatment when done with vocal hygiene management as opposed to vocal cord stripping and CO2 laser obliteration (Lumpkin et al., 1987).

Overall, for all of these pathologies, alternate treatments addressing other potential causes of these conditions may be needed. Treatments for acid-reflux, sinusitis, or stress are some examples.

Discussion

Many different elements combine to enable a singer to perform well, affect the quality of the human voice, and contribute to potential vocal pathologies. The health of the respiratory system, posture of the singer, tension of the vocal cords, sleep apnea, congestion, psychological well-being, and the environment are all factors that can affect a singer's vocal fitness.

First, the respiratory system has to be strong and breath has to be controlled well. Professional classical singers often consciously contract the abdominal muscles and expand the rib cage, allowing more air to flow in. It is observed that professional singers usually contract the abdominal muscles to increase the "pressure-generating" ability of rib cage muscles to be able to use more air from the lungs and reap better sound quality; a constant stream of air is provided for the vocal cords by carefully using up air. Concentrating on good breath support is considered an extremely important training to lessen the strain on the vocal cords (Salomoni et al., 2016).

Second, proper posture is another very important aspect of maintaining good vocal fitness. Most professional singers agree that good posture leads to a better singing quality. In a study published in 2007, researchers found that tilting the head upwards could permit greater airflow and cause the sound produced to be louder, while tilting the head downwards could decrease airflow (Luck & Toiviainen, 2007). Proper posture is necessary so that

the vocal tract is not obstructed and so that airflow and resonance space is optimized.

In addition, the timbre and pitch of the voice depend on the tensions of the vocal cords. The intrinsic muscles of the larynx stretch or relax the vocal cords and heighten or lower them as described in the previous section. This is what causes different "tones" of the voice and different pitches. Tightening the extrinsic muscles of the larynx often may strain the voice (Trall, 1875). There needs to be more research in determining if the raising of the larynx plays a role in the changing of pitch and if it causes harmful effects to the voice.

Furthermore, sleeping with the mouth open has harmful effects on the voice as it can negatively affect the vocal structures. In a controlled study published in 2012, hoarseness of the voice was found to be more common in snorers (Hamdan et al., 2012). Congestion of the mucous membrane of the pharynx, nose, and other vocal structures can all cause hoarseness of the voice and other harmful vocal effects (Trall, 1875).

The environment singers live in or are frequently surrounded in can also vastly affect their vocal health. In a study done in 2017, it was found that people who had vocal nodules significantly worked more in environments with high noise levels than control groups. They thus had to use their voices more and talk more loudly, causing vocal damage (Portela et al., 2017). If singers are in an environmentally polluted area, this may also negatively affect their voice. Being in a polluted area could negatively affect the respiratory tract, which can negatively affect the voice because, as described in previous sections, these structures all combine to produce the human voice.

Not only does the environment have an impact on vocal health, but psychological factors also impact vocal fitness. Music performance anxiety can affect a singer's voice. When singing while feeling stressed, a singer may feel increased consequences. For singers, their voice is their actual instrument, and so music performance anxiety can directly impact their ability to sing. Good vocal techniques can be forgotten due to the stress, which can lead to vocal damage. However, in a study published in 2003, it was found that anxiety in high-level singers actually improved their performance (Kokotsaki & Davidson, 2003).

Thus, how music performance anxiety affects a singer may be subject to change depending on the level of the singer (i.e. whether they are professionals or students).

In order to avoid vocal pathologies and to have good vocal health, one needs to be aware of the holistic nature of the human voice. Having good breath support and proper posture, preventing muscle strain in the throat, and avoiding screaming or being in polluted or loud areas can all contribute to good vocal health. Additionally, drinking a minimum of 64 fl. oz. of water per day and being in well-humidified areas are good vocal care practices that have been found to improve efficiency of the vocal structures (Sivasankar & Ciara, 2010). These are all practices that have also been commonly preached by clinicians and voice professionals.

Conclusion

The voice is an integral part of everybody's life, especially for singers. However, the vocal structures are tiny structures that may be resilient, but are still prone to many pathologies, especially if subject to frequent trauma. Not only is it important for people to understand the anatomy and physiology of healthy vocal structures, but it is also important to explore common vocal pathologies. Some pathologies, like nasopharyngeal carcinoma, laryngeal cancer, and other cancers of vocal structures, have not had effective treatments. Future research and clinical studies can test different treatment options and their effectiveness as compared to existing options. Additionally, as in this review, a holistic approach to voice production and vocal pathologies is important. Instead of focusing on a specific vocal structure, muscle, pathology, or treatment protocol, things like the health of the diaphragm, environment, and psychological well-being, should also be considered.

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