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REVIEW ARTICLE

# Management of Bilateral Vocal Folds Immobility

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## ABSTRACT

**Background:** A difficult condition known as bilateral vocal fold immobility (BVFI) can be caused by a variety of conditions, such as vocal fold paralysis, synkinesis, cricoarytenoid joint fixation, and interarytenoid scarring. The majority of patients arrive with stridor and dyspnea, however, breathy dysphonia can also occur. Precise diagnosis and suitable management planning can be achieved with the use of thorough history collection, laryngoscopic assessment under general anesthesia or awake condition, laryngeal EMG, and imaging tests using CT and/or MRI. One of the most prevalent etiologies of congenital neurological disorders in children is believed to be spontaneous recovery in over 50% of instances. Therefore, it is generally believed that before choosing to carry out any harmful treatment, one should observe the patient for more than six months while protecting the upper airway with a tracheostomy if necessary. Children with advanced posterior glottic stenosis may benefit from rib cartilage transplant laryngotracheal repair. Compared to children, adults are more likely to experience BVFI as a post-surgical consequence. Many static or dynamic techniques, such as vocal fold lateralization, endoscopic or open arytenoidectomy, arytenoid abduction and reinnervation, posterior cordotomy, and electrical laryngeal pacing, can be used; however, they must be carefully chosen based on the individual needs of each patient and the pathophysiology of BVFI.
**Keywords:** Bilateral vocal folds; Immobility; paralysis.

## INTRODUCTION

The most common way that a patient with bilateral vocal cord paralysis manifests is with respiratory problems, like stridor and aspiration. Since it may be life-threatening, the airway needs to be secured right away. In patients with bilateral paralysis, voice quality is often adequate although voice fatigue, altered pitch, and limited intensity are common. A complete prior medical history, radiation therapy, cancer, any recent history of URI, and any trauma or surgery related to the neck or mediastinum should also be collected. A comprehensive physical examination is performed, with special attention paid to the head, neck, and lungs **[1].** Flexible fiber-optic laryngoscopy, which allows for the observation of immobility in the vocal cord position, can be used to make a clinical diagnosis. Video stroboscopy and bronchoscopy can exclude subglottic and tracheal pathologies, such as tracheomalacia or subglottic stenosis, and provide more information on the motion wave of the vocal cord vibrations if the diagnosis is still unclear **[2].**

## EVALUATION

To evaluate vocal cord movement, flexible videolaryngoscopy is a crucial component of the initial physical examination. It is carried out in the office while the patient is awake. When a patient's diagnosis is unclear or they have lung pathology, direct laryngoscopy and bronchoscopy are reserved to visualize the lower airway. Palpation of the arytenoid joints can also be done during this operation to rule out vocal cord fixation (Figure 1) **[1].** Laryngeal electromyography is a procedure that is done in an office setting to assess the degree of innervation in the laryngeal muscles following a neurogenic injury. Throughout the healing process,

it is also helpful as a predictive tool **[3].** Blood investigations are based on the patient's medical history and overall condition. Considerations include serum K+, Ca+, Na+, rheumatoid factor test, thyroid function tests, antineutrophil cytoplasmic antibody test, tubercular skin tests, uric acid levels, rheumatoid factor test, and erythrocyte sedimentation rate **[4].**

## IMAGING STRATEGY

***Brainstem and skull base:***

A central cause in the medulla oblongata is indicated by bilateral paralysis of the vocal cords. The start of symptoms suddenly also suggests a primary cause. The most effective method for assessing the medullary nuclei of the vagal nerve is magnetic resonance imaging (MRI), which can be performed using T2-weighted, diffusion-weighted, T1-unenhanced, and gadolinium-enhanced imaging. The medulla oblongata may have intraaxial tumors, infarctions, and demyelinating illnesses. High-resolution, highly T2-weighted sequences and T1-weighted imaging with gadolinium are the best ways to visualize the cisternal portion **[5, 6].** External compression from extra-axial masses, vascular structures, or pathologies affecting the nerve itself, such as paraganglioma, schwannoma, or neuritis, can all have an impact on the vagal nerve. Research on the jugular foramen should be conducted if there is involvement of many cranial nerves. The most accurate way to show pathology in and around the jugular foramen is using an MRI of the posterior fossa that combines gadolinium-enhanced, T2-weighted, and DWI images with T1-unenhanced imaging **[5].**

***Extracranial vagal nerves and recurrent laryngeal nerves:***

Contrast-enhanced computed tomography (CT) from the midbrain to the aortic arch, including the AP (aortopulmonary) window, is preferable to reveal pathology along the length of the extracranial vagal nerves and the recurrent laryngeal nerves (Fig. 2). Using isotropic voxels with a slice thickness of 0.625 mm, the entire volume can be collected using multi-slice detector CT scanners. Because the scan only lasts a few seconds, there can be a minimal amount of motion artifacts from breathing and swallowing that affect the image quality. To get the vocal cords in an abducted position, the CT scan should be performed while the patient is breathing quietly (Fig.2) **[5].**

Reconstructions in any chosen plane are achievable thanks to the isotropic voxels (recommended slice thickness of 2-3 mm). For best diagnostic accuracy, axial reconstructions should always be obtained parallel to the real voice cords. Extracranial vagal or recurrent laryngeal nerve palsy are often caused by lung cancer with metastases to the mediastinal lymph nodes and squamous cell carcinoma of the neck with or without local lymph node metastases. On the other hand, vocal cords paralysis (VCP) can also result from other illnesses such as infectious diseases, benign tumors, or cancers of various tissues in the neck and upper mediastinum **[7].**

## MANAGEMENT

***Operations for treatment:***

In patients with bilateral vocal cord paralysis, surgery is frequently necessary, although medical therapy of inflammatory and infectious diseases, such as syphilis, TB, gout, and recurrent polychondritis, is crucial. Conditions including Wegener's granulomatosis, polychondritis, and sarcoidosis respond well to corticosteroids. Controlling blood sugar levels is essential for helping diabetic people with neuropathy. During the healing phase, reflux management is frequently advised in an effort to reduce unfavorable laryngeal stimulation. In the first 12 months of life, over 50% of children will experience spontaneous symptom remission; nevertheless, the prognosis for bilateral vocal cord paralysis is far more cautious than for unilateral vocal cord paralysis. **[8].**

This fact needs to be taken into account before any invasive procedure that can affect a patient's capacity for swallowing or phonation. When it comes to adults, the prognosis is mostly determined by the etiology, and other investigations, including electromyography (EMG), can be useful in predicting recovery rates in situations involving surgery. Even though a spontaneous recovery is possible, some kind of surgical intervention to restore the airway will be necessary if the patient is experiencing considerable stridor. A reversible treatment such as tracheostomy or injection of botulinum toxin should be carried out if the prognosis for recovery is good. Laryngeal surgery may be explored as a means of trying to decannulate the patient if minimal or no recovery is anticipated **[9].**

***Tracheostomy :***

Historically, the most common surgery used to create a secure airway for individuals with bilateral vocal cords was tracheostomy. It is theoretically reversible without causing long-term consequences because it maintains the laryngeal structure and offers the largest airway diameter. In cases with glottic blockage, tracheostomy is still the standard of therapy; nevertheless, it comes with a high cost, burden of chronic care, psychological impairment, and higher mortality rate. Patients had a lower

quality of life and had to have their tracheostomies managed continuously, which might be unfavorable for kids in particular. **[10].** The in-hospital mortality rate was 14% in a national series of 885 newborns receiving tracheostomy care. It has been demonstrated that endoscopic methods are more economical for managing permanent bilateral vocal cord paralysis than tracheostomy. Even though a number of other techniques have been developed to treat bilateral vocal cord paralysis, they all have the potential to cause permanent abnormalities to the larynx, which could put patients at risk for postoperative dysphonia and aspiration for the rest of their lives **[11].**

***Botulinum toxin:***

Botulinum toxin, which is produced by Clostridium botulinum, is a neurotoxin that causes flaccid paralysis in the target muscle by blocking the release of acetylcholine from pre-synaptic axon terminals. Injecting a poison blocks the abnormal reinnervation of the adductor muscles by inspiratory motor neurons in patients with paralyzed vocal cords. This promotes glottic opening and increases the efficiency of abductor inspiratory motor neurons. For about three to six months at a time, this method only temporarily relieves symptoms; repeated injections are necessary for more substantial alleviation. When full recovery of function is anticipated but at a slow pace, or in situations with idiopathic spasmodic vocal cord impairment, this is a feasible alternative. **[12].**

***Arytenoidectomy :***

Arytenoidectomy, an irreversible process, involves expanding the glottic intake transversely by endoscopically removing the arytenoid cartilage (occasionally only the prolapsed cuneiform cartilages are removed). This creates a larger diameter airway for inspiration. It is called an arytenoid cordectomy and can be done either alone or in conjunction with vocal fold excision. The glottis widens when the mucosa and cuneiform cartilage over the arytenoid are removed. In patients with bilateral vocal cord paralysis, this approach has shown promising outcomes in terms of enhanced breathing, especially in younger patients. Using a CO2 laser to help with procedure precision, achieve hemostasis, and lessen postoperative edema marked a significant improvement in the process. **[13].** In 1916, Baker performed the first arytenoidectomy while also using the laryngofissure technique to execute a partial cordectomy. Iwanoff **[14]** excised the mucous membrane in the larynx's medial line to remove the arytenoid cartilage, and Kelly **[15]** created a window in the thyroid cartilage's inferoposterior region. Woodman proposed an alternative method in which the skin was incised parallel to the anterior edge of the sternocleidomastoid muscle at the level of the superior border of the thyroid cartilage, allowing posterior access to the cricothyroid joint. The remaining vocal process was sutured laterally to the thyroid cartilage's inferior horn in order to preserve the thyroid cartilage plate as a whole. **[16].** Following an arytenoidectomy, some patients may develop severe dysphonia, which may never fully recover. Additionally, this surgery exposes the patient to the risk of scarring and granuloma formation, which might constrict the airway and necessitate repeated surgical revisions. Thankfully, the patient does not need to have a tracheostomy placed in order to undergo endoscopic laser resections. In one study, using an endoscopic plasma cutter instead of a CO2 laser led to less scarring since the surrounding tissues did not sustain as much heat damage. **[17].**

***Cordotomy :***

Another endoscopic surgical technique to widen the glottic airway is cordotomy. During cordotomy, the thyroarytenoid muscle, ligament, and vocal fold are incised posteriorly at the point where they link to the arytenoid. Similar to arytenoidectomy, cordotomy can result in scarring and granuloma formation. Up to 30% of patients may need a revision cordotomy as a result of decreased glottic diameter brought on by scarring or the formation of granulation tissue. The most frequent side effect of cordotomy was changed voice quality as a result of vocal fold injury **[18].** Since laser endoscopic cordotomy is less invasive and has a lower aspiration rate than arytenoidectomy, it has emerged as the preferred therapeutic method for VCP. Resection can result in a decrease in voice quality, but overall voice results are frequently better than those of arytenoidectomy, especially in older patients. **[19].**

***Laterofixation:***

Bilateral vocal fold paralysis in adults and children can be treated reversibly via lateralofixation of the vocal fold and/or arytenoid cartilage. The procedure can be used unilaterally or bilaterally, either alone or in conjunction with other laryngeal microsurgery techniques. Without the phonation-causing tissues being destroyed, the rimaglottidis widens. For two to three months following surgery, he maintained the arytenoid cartilage's laterally directed mobilization by using an intralaryngeal stent. Montgomery employed a similar method, applying a unique stainless-steel pin **[20]. Kirchner [21] and Ejnell [22]** carried out

endoscopic lateralization using sutures. Kirchner used electrocoagulation to achieve thyroarytenoid muscle excision through endoscopy. He then temporarily sutured the vocal fold by inserting a suture into the larynx's lumen. Using direct laryngoscopy, they were able to see the larynx and locate the cricoarytenoid junction. Subsequently, they lateralized the vocal fold and secured a knot using two needles that were put externally. Kirchner's method was improved by **Remsel et al. [23]** by using a CO2 laser for electrocoagulation.

**Lichtenberger [24]** devised endo-extralaryngeal access, a laterofixation technique in which sutures are inserted from the larynx lumen through the thyroid cartilage lamina and out onto the skin using a specially designed needle holder. He also distinguished between three types of laterofixation: laryngo-microsurgical endo-extralaryngeal lateralization, reversible endo-extralaryngeal, and laryngo-microsurgical endo-extralaryngeal lateralization in conjunction with arytenoidectomy. Woodson and Weiss suggested altering the aforementioned methods**.** Sutures were used to conduct lateralization at the level of the arytenoid cartilage. The phenomenon known as "arytenoid abduction" resulted in postero-caudal traction, which in turn triggered the posterior cricoarytenoid muscle to contract.

***Laryngeal stimulation*:**

**Zealear and Dedo [25]** were the first to propose the idea of functional electrical stimulation for paralyzed muscles of the head, neck, and chest. Vocal fold paralysis can be effectively treated with laryngeal stimulation using an external device, as confirmed by **Zealear [26]** in a report published in 1996. Unilateral stimulation was found to be a more effective treatment than posterior cordectomy in terms of postoperative breathing and vocal results **[27]. Mueller et al**. **[28, 29]** also reported research on unilateral electrical laryngeal stimulation. In nine patients suffering from bilateral vocal fold paralysis, they inserted minimally invasive electrodes that were triggered by an external stimulator fastened to the chest wall. In the study group, they noticed a notable improvement in ventilation without any decline in vocal quality. The outcomes that have been provided are encouraging. To evaluate the longevity and migration potential of electrodes, more investigation is needed.

***Reinnervation:***

Reinnervation aims to restore posterior cricoarytenoid (PCA) muscle activation in order to establish vocal cord abduction. Adduction is unaffected by this operation, although it does allow spontaneous vocal cord abduction to recover. Because of its supply's complexity and unpredictability, RLN anastomosis is a challenging process. Reinnervation of the PCA muscle has been accomplished by means of the phrenic nerve; 93% of the cases in a study demonstrated inspiratory vocal fold abduction. **[30].** Within a year, patients with hemidiaphragm paralysis showed significant improvement in diaphragmatic mobility and respiratory function. It was previously demonstrated by **Reardon et al. [31]** that only a phrenic nerve branch could be used to limit diaphragmatic function loss and maintain breathing parameters. A relatively recent method that avoids the diaphragmatic difficulties of the phrenic nerve sacrifice is the use of a pedicled neuromuscular flap from the ansa cervicalis. This is an extremely difficult technical procedure that works best when carried out by a small number of highly experienced surgeons. In cases of unilateral vocal cord paralysis, all of these laryngeal reinnervation techniques are significantly more frequently employed **[32].**

***Gene Therapy :***

Although it is still in the pre-clinical stages, there are a number of potential therapeutic options for this. By using this method, damaged laryngeal muscles can be restored by increasing the development of damaged neurons through gene transfer to injured or denervated muscles. The neurotrophic or growth factors that these genes encode help to promote the differentiation and proliferation of muscles**.** They are taken up by neuronal cell bodies by retrograde axonal transport, either into the RLN or directly into the laryngeal muscles. Peptides that support RLN development, synapse formation, and regeneration are produced by them once they have been properly transduced into target cells **[33].**

***Stem cell therapy:***

One technique that promotes tissue regeneration is stem cell transplantation. Muscle stem cells are a fantastic starting point for slowing down the loss of muscle mass and promoting its growth. In a rat model, bilateral vocal fold paralysis was treated with autologous stem cells derived from muscles, as reported by **Halum et al. [34].** In two of the eight animals in the study group, the glottic closure reflex was activated, and inadequate adduction of the vocal folds was detected; in the control group, no such reaction was recorded. Pigs' denervated vocal folds were injected with adipose-derived regenerative cells by **Nishio et al. [35].** They reported that a month following the injection, the thyroarytenoid muscle's muscular fibers had become larger. Stem cell therapy is a topic of

current research. This approach, like gene therapy, does not stop laryngeal synkinesis **[36].**

## PROGNOSIS

Idiopathic vocal cord paralysis brought on by non-transecting nerve injury, can heal in adults as soon as a year after the injury. While 55% of patients should heal on their own, complete recovery can take a very long time. When there is bilateral vocal cord paralysis as opposed to unilateral, the prognosis for full spontaneous recovery is significantly poorer. The underlying etiology and the overall prognosis of this root cause are the other factors that mostly determine the recovery of glottic function **[36].**

## COMPLICATIONS

The following issues may result from vocal cord paralysis: Changes in voice quality; weak cough; trouble swallowing; trouble feeding; hoarseness; dyspnea; aspiration risk; obstruction of the airway; granuloma formation; arthritic joint; decreased quality of life related to tracheostomy; airway fire caused by laser therapy; formation of scars **[10].**

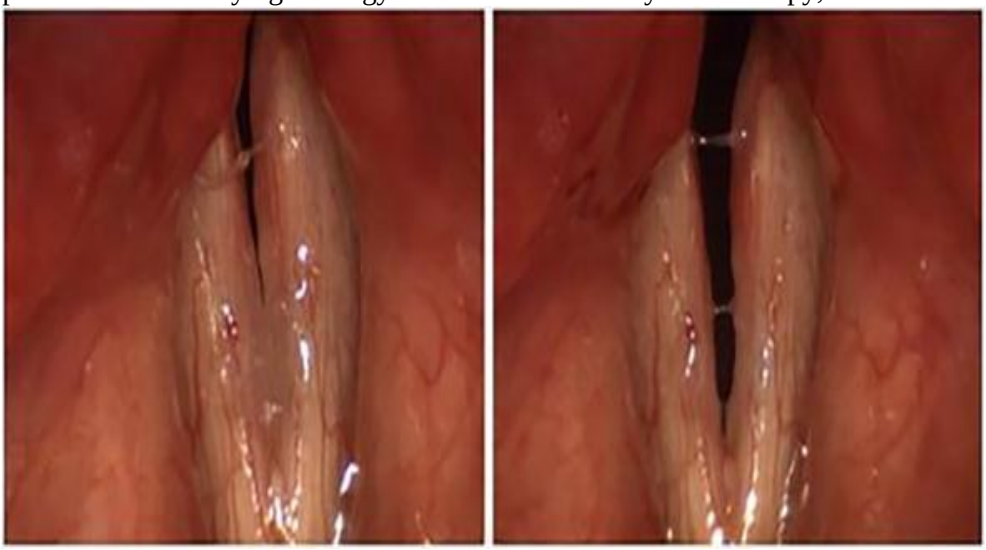

**Figure (1):** Video laryngoscopy pictures showing bilateral vocal cord paralysis **[1]**

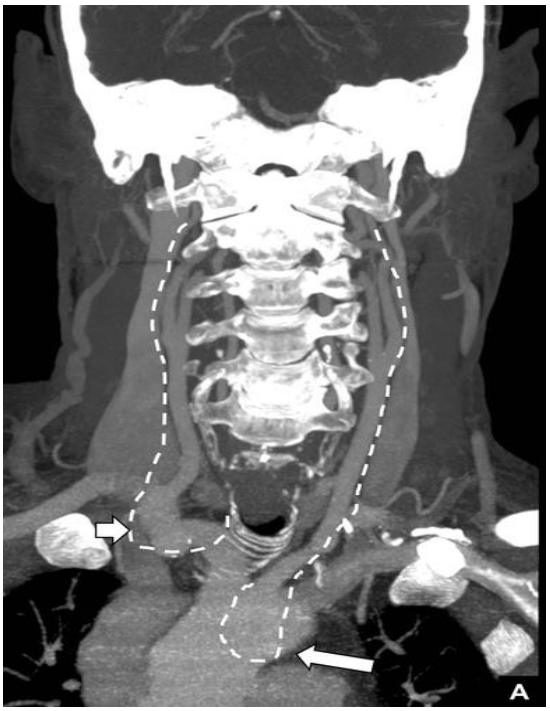


**Figure (2):** The recurrent laryngeal nerves and vagal nerves' path. The predicted path of the vagal nerves within the carotid sheath and the proximal portions of the recurrent laryngeal nerves is depicted in the coronal MIP reformat (dotted lines). The short arrow of the right subclavian artery indicates the branching of the right recurrent laryngeal nerve, which continues over it and enters the trachea-oesophageal groove straight below. Lower than the aortic arch is the left recurrent laryngeal nerve, or long arrow. **[5].**

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