VOCAL CORD PALSY

**DEFINITION:**

- Vocal cord paralysis is caused by paralysis of intrinsic muscles of larynx.
- This is a symptom of an underlying disorder and not a disease by itself. The intrinsic muscles of the vocal cord are supplied by the vagus nerve.
- Unilateral vocal fold paralysis occurs due to dysfunction of recurrent laryngeal or vagus nerve causes a breathy voice.

Anatomy of vagus nerve:

- The vagus nerve arises from three nuclei located in the medulla of brain. They are (DAT):
  1. Nucleus ambiguous (Motor)
  2. Nucleus dorsalis
  3. Nucleus of tractus solitaries
- **Nucleus ambiguus:** Is the motor nucleus of the vagus nerve (upper part give fibres to 9th nerve and lower to 10th).
- The efferent fibers of the dorsal nucleus innervates the involuntary muscles of bronchi, esophagus, heart, stomach, small intestine, and part of the large intestine. The efferent fibers of the nucleus of the tractus solitarius carry sensory fibers from the pharynx, larynx, and esophagus.
- The vagus nerve (wanderer) takes a tortuous path after emerging from the jugular foramen. It has two ganglions. The smaller superior ganglion and a larger inferior or nodose ganglion.
- Neck it runs in carotid sheath
- Supplies most muscles of pharynx and palate.
- Rt Vagus – 32cm whereas Left is 43cm long.
- Due to these variations in the length of vagus nerve, there could be a discernible lag in the movement of left vocal cord in comparison with the right cord. To minimize this lag the left recurrent laryngeal nerve is supposed to contain more larger and fast conducting nerve fibers.

**NERVE SUPPLY:**

- The internal laryngeal branch of superior laryngeal nerve pierces the thyrohyoid membrane and supplies sensation to the larynx above the level of glottis. The external laryngeal branch of superior laryngeal nerve innervates the cricothyroid muscle, which is the only laryngeal muscle not to be innervated by the recurrent laryngeal nerve.
- The right vagus nerve passes anterior to the subclavian artery and gives off the right recurrent laryngeal nerve. This nerve loops around the subclavian artery to reach the tracheo oesophageal groove. It accompanies the inferior thyroid artery for some distance before entering the larynx behind the cricothyroid joint.
- The left vagus does not give off the recurrent laryngeal branch until it reaches the thorax. The left recurrent laryngeal nerve winds around the aorta posterior to the ligamentum arteriosum. It ascends back towards the larynx in the tracheo oesophageal groove.
LARYNGEAL MUSCULATURE:

EXTRINSIC AND INTRINSIC

- Intrinsic
  - The intrinsic muscles of the larynx govern the movements of the vocal cords. These muscles are innervated by the recurrent laryngeal nerve.

1. **POSTERIOR CRICOARYTENOID MUSCLE**: This is the only abductor of the vocal folds. It opens the glottis by rotatory motion on the arytenoid cartilages. It also tenses the cord during phonation.

2. **LATERAL CRICOARYTENOID**: Closes the glottis by rotating the arytenoids medially.

3. **TRANSVERSE ARYTENOID**: Is the only unpaired intrinsic laryngeal muscle. By approximating the bodies of arytenoids it closes the posterior aspect of the glottis.

4. **OBLIQUE ARYTENOID**: This muscle along with transverse arytenoid closes the laryngeal inlet during the act of swallowing.

5. **THYROARYTENOID**: This muscle is very broad and is divided into three portions:
   - **Thyroarytenoidus internus** – Also known as the **vocalis muscle** tenses the vocal cord and thus plays an important role during phonation
   - **Thyroarytenoidus externus** – This muscle is a major adductor of vocal fold
   - **Thyroepiglotticus** – This muscle shortens the vocal ligaments

- The cricothyroid muscle is considered to be an extrinsic muscle of larynx since it is innervated by the external branch of superior laryngeal nerve.

- It basically functions by increasing the tension on the vocal folds especially during high pitch and loud voice production.

- Functionally larynx can be divided into three successive physiologic sphincters at different anatomical levels. These sphincters in cephalo caudal order are:
  1. Aryepiglottic folds
  2. Vestibular folds
  3. Vocal folds

- The muscles controlling these sphincters are derived from the intrinsic muscles of larynx. These sphincters can contract together or independently.

- All these sphincteric components act in unison during the act of swallowing thus preventing effectively any aspiration of food into the airway.

- The vestibular folds cannot be closed independently of the vocal folds, on the contrary the vocal folds adduct without closure of the other two sphincters during phonation.

PATHOPHYSIOLOGY OF VOCAL CORD PARALYSIS:

- Interference with the protection of the tracheobronchial tree and respiration are more serious and life threatening than interference with voice production. In recurrent laryngeal nerve paralysis the vocal folds may assume a number of positions. Six positions have been described. They are median, paramedian, cadaveric (intermediate), gentle abduction and full abduction.
Various theories have been proposed to explain the various positions assumed by a paralysed vocal cord.

**SEMON’S LAW**: In the course of a gradually progressing organic lesion involving the recurrent laryngeal nerve three stages can be observed. In the first stage only the abductor fibers are damaged, the vocal folds approximate in the midline and adduction is still possible. In the second stage the additional contracture of adductors occur so that the vocal folds are immobilized in the median position. In the third stage the adductors become paralysed and the vocal folds assume a cadaveric position.

It was assumed that the nerve fibers supplying the abductors of the vocal folds lie in the periphery of the recurrent laryngeal nerve and any progressive lesion involves these fibers first before involving the deeper fibers that supply the adductors.

It was even suggested that adductors being phylogenetically older are more resistant to insults than the newer abductors.

When recovery takes place the first muscle group to recover will be the adductors before the abductors could recover.

**DIFFERENTIAL INNERVATION THEORY**: This theory was based on the anatomic fact that the recurrent laryngeal nerve often branched outside the larynx. Injury to individual branches could cause paralysis of specific groups of muscles accounting for the varying positions assumed by the paralysed cord.

**CHANGES IN THE CRICOARYTENOID JOINT AND PARALYSED MUSCLES**: These changes have been proposed to explain the position of the cord in vocal fold paralysis. This theory of progressive fibrosis of muscles has no anatomical proof.

**INTERARYTENOID MUSCLE CONTRACTION**

**DISTURBANCE OF AUTONOMIC SUPPLY**

**WAGNER AND GROSSMAN THEORY**

Most popular and widely accepted theory

This theory states that in complete paralysis of recurrent laryngeal nerve the cord lies in the paramedian position because the intact cricothyroid muscle adducts the cord.

If the superior laryngeal nerve is also paralysed the cord will assume an CADAVERIC (INTERMEDIATE) position because of the loss of adductive force. This theory has been confirmed by electro myological studies.

According to this theory, chest lesions should cause recurrent laryngeal nerve paralysis alone, but in many patients with lung cancer the cord assumes a intermediate position.

This has been attributed to the phenomenon of retrograde atrophy of the vagus nerve up to the level of nucleus ambiguus.
Paralysed vocal cords may demonstrate some movement due to the action of **INTERARYTENOID MUSCLE WHICH GETS BILATERALLY INNERVATED**

**PATHOGENESIS OF VOCAL CORD PARALYSIS:**

- Vocal cord paralysis is a sign of disease and is not a diagnosis.
- It may be due to a lesion anywhere from the cerebral cortex to the neuromuscular junction.
- Because of the large size of the nucleus ambiguus, small lesions in it may produce isolated laryngeal and pharyngeal motor losses.
- Lesions involving the nucleus ambiguus may cause bilateral paralysis more often than unilateral palsy.
- Peripherally damage to the laryngeal innervation may be of three types:
  - Damage to the vagus trunk above the nodose ganglion, the origin of superior laryngeal nerve
  - Damage to the vagus nerve below the level or to the recurrent laryngeal nerve
  - Damage to the superior laryngeal nerve alone.
- Vocal cord paralysis may be congenital or acquired.
- Congenital vocal cord palsy:
  - The most commonly associated anomaly in these patients is the presence of hydrocephalus. The mechanism of vocal cord palsy in these children are still not clear. It could be due to stretching of the vagus nerve, due to complicated delivery etc
- Acquired causes of vocal cord palsy

<table>
<thead>
<tr>
<th>Causes of vocal cord palsy</th>
<th>Percentage</th>
</tr>
</thead>
<tbody>
<tr>
<td>Malignant disease (lung cancer, esophageal cancer and thyroid malignancies)</td>
<td>31%</td>
</tr>
<tr>
<td>Surgical trauma (Thyroid surgeries are the commonest)</td>
<td>29%</td>
</tr>
<tr>
<td>Idiopathic</td>
<td>24%</td>
</tr>
<tr>
<td>Non surgical trauma (penetrating neck injuries)</td>
<td>7%</td>
</tr>
<tr>
<td>Inflammatory (tuberculosis MC, jugular vein thrombophlebitis following csom, subacute thyroiditis, meningitis both viral and bacterial)</td>
<td>4%</td>
</tr>
<tr>
<td>Neurologic (brain stem ischemia, multiple sclerosis and head injuries)</td>
<td>1%</td>
</tr>
<tr>
<td>Miscellaneous (hemolytic anemia, thrombosis of subclavian vein, syphilis, collagen disorders, lead and arsenic poisoning)</td>
<td>4%</td>
</tr>
</tbody>
</table>
Causes of Unilateral Palsy
- Ventricular septal defect
- Tetralogy of Fallot
- Abnormalities of great vessels
- Patent ductus arteriosus

Causes of Bilateral Palsy
- Central neurological abnormalities like:
  - Meningomyelocele
  - Hydrocephalus
  - Arnold Chiari malformation
  - Bulbar palsy
- Hereditary

- Causes if congenital VC palsy

**CLINICAL FEATURES:**

**UNILATERAL SUPERIOR LARYNGEAL NERVE INJURY:**
- Slight Hoarseness, main problem only for singers who are not able to maintain its pitch.
- **Diplophonia** is common in these patients (a condition in which the voice simultaneously produces two sounds of different pitch.)
- Pitch range is decreased as cricothyroid muscle is very important in maintenance of vocal cord tension
- IDL – Vocal folds remain normal at quiet respiration. At rest the paralysed vocal fold is slightly shortened and bowed and may lie at a lower level than the opposite cord.
- There is also associated loss of sensation in the supraglottic area causing subtle symptoms like frequent throat clearing, paroxysmal coughing, voice fatigue and foreign body sensation in the throat.

**BILATERAL SUPERIOR LARYNGEAL NERVE INJURY:**
- Fortunately this condition is very rare. It could result in fatal aspiration and pneumonia. This condition is in fact difficult to diagnose as there is no asymmetry between the vocal folds.

**UNILATERAL RECURRENT LARYNGEAL NERVE INJURY**
- MC situation encountered.
- Left Cord > Right
- Voice is breathy, but the normal vocal cord starts to compensate soon
- No stridor.
- IDL – Any of 6 positions described.
- The cord may appear not to move, while the opposite cord will compensate for the lack of mobility.
- When right vocal cord is paralysed then tuberculosis or bronchial malignancies should be considered to be a possibility.
- Left vocal cord is involved in esophageal malignancies, and in viral infections.
UNILATERAL SUPERIOR AND RECURRENT LARYNGEAL NERVE INJURY:

- This occurs usually in high vagal or brain stem lesions. Vocal folds are in intermediate position and the patient tends to have a breathy voice. There is also a tendency to aspirate.

BILATERAL RECURRENT LARYNGEAL NERVE PALSY:

- In this condition both cords assume a paramedian position compromising the airway. This commonly occurs following total thyroidectomy or in thyroid malignancies. The patient will commonly manifest with stridor. The voice will be near normal.

BILATERAL SUPERIOR AND RECURRENT LARYNGEAL NERVE INJURY:

- Bilateral vocal cords are intermediate, flaccid, and motionless. The patient experiences aphonia and is at high risk for aspiration.

INVESTIGATIONS

- The standard diagnostic workup and evaluation of a patient with vocal cord paralysis of unknown etiology is as follows: CXR, cervical spine series, barium swallow, thyroid scan, CT or MRI of head, neck, and possibly thorax, CBC, Thyroid function tests, ESR, Rheumatoid factor, Parathyroid hormone, calcium and glucose levels, PPD, VDRL, fungal titers, lyme titers, and possibly a lumbar puncture, EMG.

TREATMENT:

- Indications of early intervention include:
  1. Life threatening aspiration
  2. A known etiology which leaves no chance of recovery
  3. Psychological and professional factors (relevant in singers)

- wait and watch approach is useful in patients with unilateral idiopathic paralysis of vocal cords. Spontaneous recovery is the order of the day in these patients. The wait period may last up to 6 months in some patients

- Treatment for unilateral paralysis of vocal cord include:
  - 1. Speech therapy
  - 2. Surgical medialisation of the paralysed cord
  - 3. Intracordal injections
  - 4. Selective reinnervation

SURGICAL MEDIALISATION:

- Laryngeal framework surgery was first introduced by Payr in 1915
- 1970 Isshiki made it popular.
This involved displacing and stabilizing a rectangular, cartilaginous window at the level of the vocal cord, therefore pushing the soft tissue medially. This technique gained wider acceptance after Isshiki reported the successful use of Silastic as the implant material.

Performed under LA and thus the degree of medialization can be determined immediately, intraoperatorively by the quality of the patient's voice.

**COMPLICATIONS:**

1. Airway compromise
2. Wound infection
3. Hematoma
4. Extrusion of the implant
5. Laryngocutaneous fistula formation

**ADVANTAGES OF SURGICAL MEDIALISATION PROCEDURE:**

- 1. Reversible
- 2. Can be effective even with fixed cord
- 3. The patient has immediate benefit
- An adjuvant procedure to surgical medialization, also described by Isshiki, is arytenoid adduction. This procedure can help close the posterior glottic chink that medialization alone often fails to do. This procedure can be performed alone, or in combination with medialization.

**INTRACORDAL INJECTIONS:**

- Collagen, Teflon, Gelfoam paste injected via bruning syringe.
- Done under LA.
- Voice quality improvement during the procedure is an important guide to the location and amount of paste injected.
- The needle should be inserted approximately 5 mm and enough paste injected until the cord approaches midline. The patient is asked to say "E". If further improvement is needed, another injection is made.

**COMPLICATIONS:**

- 1. Airway edema
- 2. Granuloma formation
- 3. Results not predictable

**ADVANTAGES:**

- 1. No skin incision required
- 2. Out patient procedure
- 3. Results satisfactory in majority of cases
SELECTIVE REINNERVATION:

NERVE-MUSCLE TRANSFER:

- This procedure uses a branch of the ansa hypoglossi attached to a small block of omohyoid muscle as a nerve-muscle pedicle to innervate the thyroarytenoid muscle on the involved side.
- The technique is performed under local or general anesthesia. A lateral neck-crease incision is made approximating the lower border of the thyroid cartilage. The ansa hypoglossi is identified as it lies on the jugular vein. It is traced to its point of entry into the anterior belly of the omohyoid muscle. A free block (approximately 2-3mm on a side) of muscle from the omohyoid is excised, including the point of entry of the nerve. A window is created in the thyroid ala exposing the thyroarytenoid muscle. The nerve-muscle pedicle is then sutured to this muscle.
- The results of this procedure have been very good.
- This procedure can be combined with surgical medialization for immediate improvement of voice quality.

Advantages:

- 1. The vocal fold is medialised without resorting to any implants
- 2. Better pitch control
- 3. Other methods can be attempted even if this fails
Disadvantages:

- 1. Skin incision
- 2. Prolonged wound healing

MANAGEMENT OF BILATERAL VOCAL CORD PALSY:

- The initial aim is to secure the airway as these patients will manifest with stridor. A tracheostomy should be performed on an immediate basis.

VOCAL CORD LATERALISATION PROCEDURES:

- This involves several techniques that surgically widen the glottic opening. While this improves the airway, the patient's voice quality suffers. The three most commonly utilized techniques are arytenoidectomy, arytenoidopexy, and cordectomy.

CORDECTOMY:

- Dennis and Kashima (1989) introduced the posterior partial cordectomy procedure using the carbon dioxide laser. This involves excising a C-shaped wedge from the posterior edge of one vocal cord. If this posterior opening is not adequate after 6-8 weeks, the procedure can be repeated or a small cordectomy can be performed on the other vocal cord. They claim relief of airway obstruction with preservation of voice quality.

REINNERVATION