UNILATERAL VOCAL FOLD PARALYSIS

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Vocal Fold Paralysis

Three areas where damage can occur:

- Brainstem Nuclei
  - Corticobulbar fibers start from the cerebral cortex and descend through the internal capsule and synapse at the nucleus ambiguus in the Medulla
- Vagus Nerve
- Recurrent Laryngeal Nerve

NOTES: When assessing this, remember that this all a continuum with upper motor neurons and lower motor neurons. The key here is being able to differentiate between the entire vagus nerve being damaged which will also changes superior to the larynx such as a deviated uvula or manifested by involving all laryngeal nerves best noted by loss of sensation throughout the larynx – ex. arytenoids. Whereas a lower injury will be specific to the RLN causing only damage to the muscles of the larynx minus the cricothyroid and loss of sensation below the true vocal folds.
Recurrent Laryngeal Nerve

- Arises from the Vagus
- Travels further on the left where it loops around the arch of Aorta while on the right, it travels around the subclavian artery
- Supplies all the muscles (post. Cricoarytenoid, interarytenoid, lateral Cricoarytenoid, and Thyroarytenoid muscles) except for Cricothyroid
ANATOMICAL ANOMALIES

- Approximately 5 out of 1000 people have a nonrecurrrent laryngeal nerve on the right. A nonrecurrrent laryngeal nerve occurs only on the right, except in the rare case of situs inversus. It branches from the vagus nerve at the level of the cricoid cartilage and enters the larynx directly, without looping around the subclavian artery. This anomaly occurs in conjunction with a retroesophageal right subclavian artery.
LARYNGEAL ANATOMY

NOTES: In the back, posterior cricoarytenoid. Just in front is the interarytenoid – the only muscle with joint innervation from the left and right side. Then the lateral cricoarytenoids and thyroarytenoids in the middle (of which the vocal ligament is the medial edge).
Laryngeal Muscles
**Entrance of Laryngeal Nerves**

- The internal division of the SLN penetrates the thyrohyoid membrane with the laryngeal artery and supplies sensory innervation to the larynx. The external division of the SLN provides motor innervation to the cricothyroid (CT) muscle.
LARYNGEAL ANATOMY WITH NERVES

Superior laryngeal nerve
Internal branch
External branch

Inferior pharyngeal constrictor muscle

Cricothyroid muscle
Cricopharyngeus muscle (part of inferior pharyngeal constrictor)
Recurrent laryngeal nerve

Internal branch of superior laryngeal nerve
Sensory branches to larynx
Anastomosis
Aryepiglottic muscle
Thyroepiglottic muscle
Transverse and oblique arytenoid muscles
Thyroarytenoid muscle
Vocalis muscle
Lateral cricoarytenoid muscle
Posterior cricoarytenoid muscle
Cricothyroid articular facet
Anterior and posterior branches of inferior laryngeal nerve
Recurrent laryngeal nerve

Right lateral view:
thyroid cartilage lamina removed
PARESIS VS PARALYSIS

- Paresis = Hypofunction/Hypomobility secondary to neurologic injury
- Paralysis = Immobility although some intrinsic re-innervation may occur
CONCEPT OF SYNKINESIS

- Axonal Injury
- Wallerian Degeneration
- Misdirected Reinnervation
- Preserved Muscle Tone
- Final Position of True Vocal Fold

NOTES: Paralysis first begins with axonal injury. Following this injury, there is Wallerian Degeneration which we recall as step by step breakdown of the axon distal to the injury. Following this breakdown, there is regrowth as the proximal stump sends out nerve fibers to reconnect. However, in this step, neurons from the proximal neuron may reach any distal site, implying that adductor nerves may innervate abductor (PCA) and abductor nerves may innervate adductors. While the TVF will remain paralyzed, the reinnervation helps by providing neurological stimulation in order to maintain muscle tone. At this point, the level of regeneration and subsequent strength of the abductors and adductors helps determine the final position.
POSITIONS OF THE TVFs

- 4 positions:
  - Median
  - Paramedian
  - Intermediate
  - Abducted
Etiology of TVF Paralysis

- #1 – Malignancy (25%)
- #2 – Iatrogenic Surgical Trauma (25%)
- #3 – Idiopathic (20%)
- #4 – Non-surgical Trauma (11%)
- #5 – Intubation and Neurologic Disorders (Each 7%)
Malignancies

- Laryngeal
- Pulmonary
  - Most common bronchogenic carcinoma with invasion into mediastinum
- Mediastinal
- Carotid Body Tumors
- Paragangliomas near the skull base
- Thyroid

NOTES: This is described as the spread of the tumor into the mediastinum and thus into the aortopulmonary window. This generally results in left RLN paralysis due to the anatomical difference between the path of the L and R RLN.
Surgical Injury

- Anterior Cervical Spine Surgery – 2 to 21.6%
- Thyroid Surgery – 0.3 to 13.2%
- Thoracic Surgery –
  - Repair of the Aortic Arch
  - Esophagectomy
  - Pulmonary Resection
  - Mediastinoscopy
- Vascular Surgery
  - Carotid Endarterectomy
INTUBATION

- Can be a significant source of Compression
- Occurs secondary to trauma from an inflated cuff affecting Anterior Rami of RLN in the subglottis
NEUROVASCULAR
Neurovascular Causes

- Most common is Stroke of an involved artery affecting Brainstem
  - Posterior Inferior Cerebellar Artery
  - Anterior Inferior Cerebellar Artery
  - Superior Cerebellar Artery
PICA SYNDROME

- Wallenberg’s Syndrome, or Lateral Medullary Syndrome
- Most common brainstem stroke
- Symptoms:
  - Vertigo
  - Ipsilateral hemiataxia
  - Dysarthria
  - Ptosis
  - Miosis
  - Hoarseness
AICA Syndrome

- Second Most common stroke
- Manifests with:
  - Vertigo
  - Unilateral Ipsilateral Deafness from labyrinthine artery ischemia
  - Ipsilateral Facial weakness and ataxia
  - Hoarseness
NEUROLOGICAL DISEASES
**Multiple Sclerosis**

- Autoimmune disease directed against the Myelin Sheath
- Usually affecting women in their 20s – 40s
- Viral and Genetic Causes as well as environment have been implicated
- Initial onset presents with Eye symptoms and Muscle weakness or Loss of Muscle control/function
- Hoarseness
Amyotrophic Lateral Sclerosis

- Disease of Upper and Lower Motor Neurons in the CNS
- Atrophy of Muscles
- Breathing and Swallowing Functions may be the first to be affected

Lou Gehrig’s Disease
**Syringomyelia**

- Occurs secondary to the formation of a cyst within the spinal cord
- Any location in the spinal cord or brainstem
- Typical symptoms include:
  - TVF paralysis
  - Ipsilateral Tongue Wasting
  - CN V sensory loss

**NOTES:** If in brainstem, it is known as syringobulbia. It is typically a disease that spares proprioception, pressure, vibration, and touch intact.
**Myasthenia Gravis**

- Autoimmune disorder characterized by Ab against Acetylcholine receptors at the post-synaptic junction
- Manifests as:
  - Fluctuating Muscle Weakness
  - Fatiguability
  - Eye muscle weakness

**NOTES:** Eye muscle weakness defines the characteristics of this disease. There are five classes for MG ranging from minimal eye weakness to severe with associated limb abnormalities or bulbar abnormalities affecting the cranial nerves. Of clinical note, a thymoma, if present, should be excised as there is a strong correlation between MG and a thymoma being present.
GUILLAIN-BARRÉ

- Begins as Ascending Paralysis often starting in the lower extremities
- Characterized by an autoimmune reaction against myelin
- Lower Cranial Nerves can be involved
- 30% of these patients lose respiratory capacity requiring ventilation

NOTES: Guillain-Barre syndrome is also known as Acute Inflammatory Demyelinating Polyneuropathy. It is named for Georges Guillain and Jean Alexandre Barre – two French Neurologists. Usually, the disease does not reach the facial muscles; however if cranial nerves are involved, it involves the lower cranial nerves. By attacking, the disease causes demyelination. It often follows a respiratory or GI infection with several bacterial (ex. Campylobacter) or viral infections.
PARKINSON DISEASE

- Degenerative CNS disease secondary to the loss of Dopamine
- Presents with shuffling gait, muscle rigidity, and resting "pill-rolling" tremor
- Weak and breathy voice and sluggish articulation

NOTES: Laryngealbradykinesia
**Parkinson’s Manifestations**

- Vocal fold adduction is Weak
- Vocal folds appear thin and bowed because of vocalis muscle atrophy
- Patient’s voice is typically strained, much spasmodic dysphonia
Work-Up
EVALUATION

- Begins with a thorough history
  - Include questions regarding past medical history:
    - Rheumatoid Arthritis
    - Gout
    - Neurological Disorders
- Must ask for:
  - Smoking/Alcohol Use
  - Past Surgical History
  - Trauma
  - Recent Infections

NOTES: You want to make sure you can evaluate a patient for possibility of cancers, traumatic involvement, or surgical/anesthesia issues. Prior surgeries in the vicinity or recent surgery with prolonged intubation could be the cause of the complaints.
**Signs Suggesting Neurological Involvement**

- Vocal Fatigue
- Vocal Tremor
- Weak or Breathy Voice
- Vocal Strain or Stoppage
- Altered Resonance
- Acquired Dysarthria
- Associated Dysphagia
Physical Exam

- Evaluate all Cranial Nerves
  - Vagus can be evaluated by observing the palate as well the gag reflex
- Careful analysis of the voice
  - Hoarseness
  - Breathiness

Notes: Remember the base of the uvula will deviate away from the side of the lesion.
Paresis vs Paralysis
**Flexible Laryngoscopy**

<table>
<thead>
<tr>
<th>Paresis</th>
<th>Abducted/Lateral</th>
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![Image of laryngoscopy](image1.png)

![Image of laryngoscopy](image2.png)
TRUE VOCAL FOLD POSITIONS

Median

Paramedian

NOTES: The end result of where the TVF lies is a result of reinnervation and synkinesis. It has nothing to do with mechanism of injury or position at time of injury.
FURTHER WORK-UP

- Laryngeal EMG
- CT of the Neck with contrast
- MRI of the Brain
- Chest X-Ray
- CT of the Chest with contrast
LARYNGEAL EMG

- Electromyography of laryngeal muscles, often thyroarytenoid
- Aids in showing level of activity of the muscle
- Identify
  - 1. Spontaneous Activity – Fibrillations – A sign of Denervation
  - 2. Recruitment – Increase in number and rate of motor units with contraction – A sign of Reinnervation or Normal function
  - 3. Polyphasic – Motor units which are greater than 3 in a group – A sign of injury

NOTES: Polyphasic potentials can be a sign of old injury if large in amplitude, re-innervation if low in amplitude, or absent in denervation.
LARYNGEAL EMG

FIG. 53-1. Electromyography patterns. A: Normal, B: Neuropathy, C: Myopathy.
ARYTENOID CARTILAGE DISLOCATION

- Often noted as an anteriorly overhanging arytenoid
- Infrequent but presents following trauma or intubation
- Noted by changes in the vocal fold level in addition to height
- Absence of “jostle” sign - movement secondary to the opposite arytenoid during closure
- Differentiated from paralysis by use of Laryngeal EMG

NOTES: This is important to note for two reasons. First, what appears like TVF paralysis may simply be arytenoid subluxation. Also, it is possible for both TVF paralysis and Arytenoid dislocation to present at the same time and without repair of both there will not be a good outcome. This can also be diagnosed by absence of the jostle sign. The jostle sign is when the movement of the arytenoids on the abnormal side caused by contact with the mobile side during adduction in cases of vocal fold paralysis.
TVF Paralysis in Children

- #2 cause of stridor and second most common laryngeal congenital anomaly
- If Bilateral, usually related to the Central Nervous System
- Other causes include:
  - Iatrogenic
  - Birth Trauma
  - Blunt Trauma
  - Mediastinal Masses
  - Surgery – Cardiothoracic (PDA ligation and TEF repair)

NOTES: This is seen in about 10% of children and second only to laryngomalacia. Considerations for bilateral TVF paralysis start with Arnold Chiari where herniation of the cerebellum and brainstem can cause compression of the vagus. Other causes of hydrocephalus in children may also cause compression of the nerve.
TVF Paralysis in Children

- Presents with:
  - Stridor
  - Breathy cry
  - Feeding difficulties
  - Aspiration
- Of note, children may recover from true vocal fold paralysis

NOTES: It has been reported that somewhere from 16 to 64% of children recover from paralysis. Therefore, watchful waiting is often the best course with possible placement of a tracheotomy if needed.
DECISIONS PRIOR TO SURGERY

- Many cases of Unilateral TVF paralysis resolve
- Minimum waiting time is usually agreed to be around 12 months after injury
- For children, injection laryngoplasty (fat or Calcium Hydroxylapatite paste)

NOTES: The occurrence of the recovery is greater in children and some reports say as high as 50% recover. The range for recovery in children is quite long with some case reports demonstrating recovery after 10 years. However, the mean tends to be within 12 months with another peak around 2 years if the paralysis is secondary to neurological causes. In children, injections are favored as this will give the most hope in case there is future recovery. Most injection materials last for several months – with calcium lasting the longest – up to about 1 year.
SURGICAL PROCEDURES

Mainstays of surgery:

1. Medialization
   - Injection Laryngoplasty
     - Teflon – causes granulomatous inflammatory reaction
     - Fat – reabsorbed in 3-4 months but can provide long-lasting effects and is easily harvested
     - Gelfoam – absorbed within 3 months and provides a temporizing measure
     - Collagen – incorporates into tissue and can last for up to 3 years

2. Framework Procedures
3. Reinnervation
INJECTION THYROPLASTY MATERIALS

- Calcium Hydroxylapatite
  - Radiesse Voice
  - Biologically Inert Substance
  - In Use since 2003
  - Causes Giant Cell Reaction without Chronic Changes
  - Longevity – greatest benefit
  - Value of Calcium Hydroxylapatite – 0.5 mL injected into a paralyzed vocal fold provides benefit for 18 months

NOTES: Calcium Hydroxyl Apatite is a biologically inert material created by Radiesse. In comparison to fat, collagen, or fascia, this substance lasts for a much greater amount of time with no studies showing negative scarring or permanent complications. A study from 2010 by Carroll and Rosen showed that in 22 patients with UVFP, approximately 0.5 mL was needed for injection and this persisted for an average of 18 months as noted by voice testing.
INJECTION THYROPLASTY MATERIALS

- **Hyaluronic Acid Gels**
  - Restylane, Hyalaform, and Juvederm
  - Glycosaminoglycans
  - Possible replacement for lamina propria
  - Poor results

- **Carboxymethylcellulose**
  - Also sold as the carrier substance for Radiesse Voice
  - Very temporary
  - Preview Material
  - No biologic infection transmission risk

NOTES: Hyaluronic acid gels are either animal or bacterial derived versions of naturally occurring extracellular matrix GAGs. This same material is found in the TVF lamina propria. While it is believed that it should be able to replace the lamina propria, it has shown poor results. Studies suggest that it actually worsens vocal fold vibration if placed superficially. It tends to last from an average of 6 months to even 1 year in some studies. Carboxymethylcellulose can be used a preview material because as an injection it only lasts for 2-3 months but can give an idea of what can be achieved by an injection. It does not cause any scarring.
INJECTION THYROPLASTY, CONT.

-**Indications**
  - 1. Uncertainty regarding state of paralysis
  - 2. Mild Glottic Gap (1 mm)
  - 3. Out-patient procedure desired
  - 4. Ease of Procedure
  - 5. Patient Compliance and Acceptance of need for future procedures

-**Contraindications**
  - 1. Gap greater than 3 mm
  - 2. Posterior Gap

**NOTES:** Injection thyroplasty is excellent for several reasons. First, it can be used as a temporizing measure which is especially good if the patient desires treatment and it is still uncertain if they will regain their function or not. It is also ideal for the ease of performing this procedure which can also be done in clinic. Lastly, for a small glottic gap, this procedure can help rather than a more complicated surgery – thyroplasty. While a posterior gap is harder to correct with injection thyroplasty, this can still be performed as long as an arytenoid adduction is performed at the same time.
Medialization Laryngoplasty
MEDIALIZATION LARYNGOPLASTY

- General Concept – Placement of an Implant through the Thyroid Cartilage which medializes the True Vocal Fold
- Materials used include Gore Tex Strips, Silastic, or preformed blocks made of Silastic or Hydroxyapatite
- Benefits
  - Reversible
  - Ability to “Fine Tune”
  - Augments the Vocal Fold in all 3 dimensions (A-P, S-I, and M-L)
- Complications occur if the Implant is placed too anterior or superior

NOTES: This procedure is performed under local anesthesia so fine adjustments can be made the size of a block that is inserted to increase the Gore Tex strip. There has been no differences shown as far as patient outcome with regard to use of different materials although many surgeons tend to begin the operation with a block and then use strips for adjustment.
ARYTENOID ADDUCTION

A 4-0 Prolene suture on a cutting needle is placed through the posterior plate of the cricoid just medial to the facet and the needle is brought out through the medial aspect of the cricoarytenoid joint. The needle is passed through the body of the arytenoid and then through the inner aspect of the cricoid. The needle is advanced under the cricoid facet and through the posterior plate of the cricoid, where a slip knot is placed.

(Courtesy of WB Saunders)
ARYTENOID ADDUCTION

- Placement of a suture anchoring muscular process of arytenoid to thyroid cartilage
- Achieves 3 things with respect to Vocal Process:
  - Lowers position
  - Medializes and Stabilizes
  - Rotates the arytenoid cartilage
- Recommended if Maximum Phonation Time is less than 5 seconds
- Performed as an adjunct to MedializationLaryngoplasty
COMBINED FRAMEWORK SURGERY
RE-INNERVATION

- Concept that nerve fibers from surrounding areas will re-stimulate the muscles of the Recurrent Laryngeal Nerve
- Can be achieved surgically as well:
  - AnsaCervicalis
  - Phrenic
  - Preganglionic Sympathetic Neurons

NOTES: Re-Innervation is beneficial because muscles tend to atrophy unless they maintain innervation. Whether this is done naturally or surgically, it helps to create stability to the TVF which allows for better contact and voice. Reinnervation of the TA muscle restores tension resulting in a more normal mucosal wave. Reinnervation of the PCA and LA muscles stabilizes the arytenoids and prevents inferior displacement of the vocal process, which may occur in some patients.
RE-INNERRVATION, CONT.

- Typical Connections:
  - Ansa – RLN
  - Hypoglossal – RLN
  - Ansa – Thyroarytenoid Pedicle

- 15 months Pre-Surgical observation time
- Signs of Reinnervation by 4 months post-op
- Thyroid cancer was the most common cause of patients undergoing re-innervation
- Best Measure of Surgical Improvement is Maximum Phonation Time

NOTES: The amount of time following initial visit/event to surgical time was 15 months. In a meta-analysis, most patients were followed around 4 months after surgery. Their improvements were measured by Maximum Phonation Time which was nearly doubled in all studies. Glottic gap was also improved in all studies that reported this finding. While these findings make re-innervation a viable possibility, it is not performed alone with any frequency and not compared to injection thyroplasty or medialization. Most studies reporting on Re-innervation combine this procedure with injection or medialization procedures. Only six studies have demonstrated viable results in humans. There has also been no direct comparison with trials comparing re-innervation with thyroplasty.
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