Treatment of Vocal Fold Paralysis

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Grand Rounds Presentation
The University of Texas Medical Branch (UTMB Health)
Department of Otolaryngology
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Outline

• Anatomy
• Evaluation of a Patient
• Differential diagnosis
• Brief word on pediatric population
• Unilateral Vocal Fold Paralysis
• Bilateral Vocal Fold Paralysis
• Literature update
• Key Points
ANATOMY
Anatomy of the Larynx - Cartilages
Anatomy of the Larynx - Cartilages
Anatomy of Larynx - Muscles
Anatomy of Larynx - Nerves

- Superior laryngeal nerve
- Interarytenoid m. (IA)
- Thyroarytenoid m. (TA)
- Lateral cricoarytenoid m. (LCA)
- Posterior cricoarytenoid m. (PCA)
- Cricothyroid m.
- Recurrent laryngeal nerve
Anatomy of Larynx - Nerves
Anatomy of Larynx - Motion

- Adductors of the Vocal Folds:

Cricothyroid joint (pivot point)

Action of cricothyroid muscles
Lengthening (increasing tension) of vocal ligaments
Anatomy of the Larynx - Motion

- Adductors of the Vocal Folds:
Anatomy of the Larynx - Motion

Abductor of Larynx:

**Action of posterior cricoarytenoid muscles**

Abduction of vocal ligaments
Intrinsic laryngeal musculature and innervation schematic. Note the bilateral innervation of the interarytenoid (IA) muscle by the recurrent laryngeal nerves (RLN).
EVALUATION OF PATIENT
Evaluation – Physical Examination

- Complete Head and Neck Examination
- FOL
- 90 degree Hopkins Rod-lens Telescope
- Adequacy of Airway, Gross Aspiration
- Assess Position of Cords
  - Median, Paramedian, Lateral
  - Posterior Glottic Gap on Phonation
Evaluation - History

• Symptoms:
  – Usually dysphonia or hoarseness
  – Vocal fatigue in compensated cases
  – Aphonia
  – Watery/gurgly noise in high vagal injuries
  – Supraglottic hyperfunction common
  – Swallowing difficulties (worse w high vagal injuries)
Evaluation - Airway

Patient may complain of shortness of breath, which may be related to breathlessness when speaking related to insufficient laryngeal closure.

However, always assure yourself airway is patent.
Evaluation – Vocal Inventory

Important to take a full history to include patient’s profession and voice responsibilities.

May help determine urgency of therapy to allow them to return to work or normal activities.
Evaluation – Physical Exam

• Identify and recognize vocal fold immobility

• May use mirror or rigid laryngoscopy, but fiberoptic exam is important to visualize larynx in normal anatomic state.

• “ee-sniff” maneuver causes cords to fully abduct and adduct.
Evaluation – Videostroboscopy

- Demonstrates subtle mucosal motion abnormalities
- Video-documentation
Evaluation – Unloading

Useful for supraglottic over-compensation

- False cord may obscure view of true cords.
- “hum through the nose”
- Unloading removes compensatory hyperfunction, especially important in long-standing paralysis.
Evaluation – EMG

• Assesses integrity of laryngeal nerves

• Differentiates denervation from mechanical obstruction of vocal cord movement

• Electrode in Thyroarytenoid and Cricothyroid

• Actual incidence of arytenoid subluxation is debated, may be caused by external trauma (MVA) and penetrating injuries.
Evaluation – Arytenoid Dislocation

Clues that raise suspicion of arytenoid dislocation:

– Arytenoid edema
– Difference in vocal fold height (may be seen with Superior LN injury as well)
– Absence of “jostle sign” brief lateral movement caused by movement of contralateral side.
– Pain with phonating

Need to palpate joint for definitive diagnosis.
Evaluation – EMG

- Normal
  - Joint Fixation
  - Post. Scar

- Fibrillation
  - Denervation

- Polyphasic
  - Synkinesis
  - Reinnervation
<table>
<thead>
<tr>
<th>Class</th>
<th>Spontaneous Activity</th>
<th>Recruitment</th>
<th>Motor Unit Morphology</th>
<th>Interpretation</th>
</tr>
</thead>
<tbody>
<tr>
<td>I</td>
<td>Absent</td>
<td>Normal</td>
<td>Normal</td>
<td>Normal</td>
</tr>
<tr>
<td>II</td>
<td>Absent</td>
<td>Reduced</td>
<td>Low-amplitude polyphasics</td>
<td>Reinnervation</td>
</tr>
<tr>
<td>III</td>
<td>Absent</td>
<td>Reduced</td>
<td>Giant polyphasic units</td>
<td>Old injury</td>
</tr>
<tr>
<td>IV</td>
<td>Present</td>
<td>Reduced</td>
<td>Polyphasic units</td>
<td>Equivocal</td>
</tr>
<tr>
<td>V</td>
<td>Present</td>
<td>None</td>
<td>Fibrillations, positive sharp waves</td>
<td>Denervation</td>
</tr>
</tbody>
</table>
Evaluation – Imaging

- Chest X-ray
  - Screen for intrathoracic lesions
- MRI of Brain
  - Screen for CNS disorders
- CT Neck (which should include Skull Base to AP window)
- Direct Laryngoscopy
  - Palpate arytenoids, especially when no L-EMG
Evaluation – Unilateral Paralysis

• Preoperative Evaluation
  – Speech Therapy
  – Assess patient’s vocal requirements
  – Do not perform irreversible interventions in patients with possibility of functional return for 6-12 months
  – Surgery often not necessary in paramedian positioning
Evaluation – Unilateral Paralysis

• Assess extent of posterior glottic gap

• Consider consenting patient for both anterior and posterior medialization procedures
DIFFERENTIAL DIAGNOSIS
Causes of VC Immobility

<table>
<thead>
<tr>
<th>Cause</th>
<th>Percentage</th>
</tr>
</thead>
<tbody>
<tr>
<td>Malignancy (nonlaryngeal)</td>
<td>24.7</td>
</tr>
<tr>
<td>Iatrogenic (surgical trauma)</td>
<td>23.9</td>
</tr>
<tr>
<td>Idiopathic</td>
<td>19.6</td>
</tr>
<tr>
<td>Nonsurgical trauma</td>
<td>11.1</td>
</tr>
<tr>
<td>Intubation</td>
<td>7.5</td>
</tr>
<tr>
<td>Neurologic</td>
<td>7.9</td>
</tr>
<tr>
<td>Thoracic aortic aneurysm</td>
<td>4.3</td>
</tr>
<tr>
<td>Pulmonary or mediastinal tuberculosis</td>
<td>1.1</td>
</tr>
</tbody>
</table>
### Surgical Causes of Vocal Cord Paralysis

<table>
<thead>
<tr>
<th>Surgery or Procedure</th>
<th>Mechanism of Nerve Injury or Relevant Anatomy</th>
</tr>
</thead>
<tbody>
<tr>
<td>Anterior cervical spine</td>
<td>Retraction; stretch injury of RLN (right more common) (6)</td>
</tr>
<tr>
<td>Esophagectomy</td>
<td>RLN injury in tracheoesophageal groove</td>
</tr>
<tr>
<td>Carotid endarterectomy</td>
<td>Vagal injury during dissection</td>
</tr>
<tr>
<td>Mediastinoscopy</td>
<td>RLN injury, usually left</td>
</tr>
</tbody>
</table>
| Coronary artery bypass grafting      | 1. Retraction or direct injury to vagus or RLN during internal mammary artery harvest for grafting (4)  
                                    | 2. Hypothermic nerve injury form ice cardioplegia (3)                              |
| Pulmonary resection                  | Usually left upper lobe or RLN injury                                               |
| Endotracheal intubation              | Possible pressure neuropraxia from compression of anterior rami of RLN caused by a high-riding endotracheal cuff in the subglottis (5) |

RLN, recurrent laryngeal nerve.
BRIEF WORD ON PEDIATRICS
Vocal Fold Paralysis in Children

• 10% of congenital anomalies of the larynx.

• Second most common cause of stridor in the neonate.

• Bilateral VFP has been reported to account for 30–62% of paralyses in children.
Iatrogenic:

- The leading causes of unilateral VFP are iatrogenic; cardiothoracic surgery is the most common.
- Tracheoesophageal fistula repair has also been associated with VFP. (12% incidence)
- Neck Surgery – branchial cleft excision and thyroidectomy.
VFP in Children - Ddx

• Arnold–Chiari malformation classic central nervous system phenomenon associated with bilateral VFP.

• Herniating contents of the posterior fossa exhibit direct pressure on the vagus nerve as it exits the skull base.
VFP in Children - Ddx

• Birth trauma (esp w forceps, breach, or vertex delivery) is a recognized but less common cause of bilateral VFP.

• Other causes: trauma, intubation, cardiovascular anomalies, peripheral neurological disease, and infection including the varicella zoster virus.
TREATMENT
Treatment

Three main strategies:

1) Observation for 6-12 months after injury
2) Referral to speech path for voice strengthening &/or swallow therapy
3) Early surgical intervention
   a) Temporary – augmentation with filler
   b) Permanent – medialization or injection with durable filler
## Treatment – Patient Factors

<table>
<thead>
<tr>
<th>Patient Factor</th>
<th>Influence on Treatment (Early Surgical Intervention vs. Observation)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Presence of clinical aspiration</td>
<td>Favors early surgical intervention</td>
</tr>
<tr>
<td>Nature of nerve injury (transection, stretch, or unknown)</td>
<td>Nerve cut: favors early treatment&lt;br&gt;Nerve intact or stretch injury: favors conservative treatment (observation vs. temporizing injection laryngoplasty)</td>
</tr>
<tr>
<td>Vocal demands of patient</td>
<td>Nonvocal professional or limited voice use: favors observation&lt;br&gt;Vocal professional – favors early surgical treatment</td>
</tr>
<tr>
<td>Medical comorbidity</td>
<td>Minimal comorbidity: all options open&lt;br&gt;Significant comorbidity: favors local anesthetic (office-based injections vs. ML in OR)</td>
</tr>
<tr>
<td>LEMG findings</td>
<td>Good prognosis: favors observation or temporary injection&lt;br&gt;Poor prognosis: favors early ML or permanent injection</td>
</tr>
</tbody>
</table>
Treatment

**Unilateral VFP**
- VF injections
- Thyroplasty
- Arytenoid adduction
- Reinnervation procedures
- Tracheostomy

**Bilateral VFP**
- Tracheotomy
- Laser posterior transverse cordotomy
- Laser medial arytenoidectomy
- Laser total arytenoidectomy
- Endoscopic suture lateralization
- Open arytenoidectomy
- Phrenic to Posterior Cricoarytenoid anastomosis
- Electrical Pacing
Vocal Cord Injection

Short Term

- Bovine gelatin (Gelfoam™, Surgifoam™)
- Collagen-based products (Zyplast™, Cosmoplast™/Cosmoderm™, Cymetra™)
- Carboxymethylcellulose (Radiesse Voice Gel™)
- Hyaluronic acid gel (Restylane™, Hyalaform™)

Long Term

- Autologous fat
- Calcium Hydroxylapatite (Radiesse™)
- Teflon
Vocal Cord Injection

- Augmentation is directed at the posterior and midmembranous vocal fold, along the lateral vocal fold (superior arcuate line). Depth of 3–5 mm.

- The appropriate amount of overcorrection used for most injectables (15–30%, or an additional 0.1–0.2 ml of material).

- Injection into the superficial lamina propria (Reinke’s space) is to be avoided.

- Autologous lipoinjection requires substantial overcorrection.
Vocal Cord Injection
Vocal Cord Injection
Vocal Cord Injection

Key differences between vocal fold augmentation and laryngeal framework surgery:

• VF augmentation is less effective at closing large (3 mm or greater) glottal gaps, especially posterior membranous region of the vocal folds.
• VF augmentation may be less precise than framework surgery
• VF augmentation a more minimally invasive approach, and can be carried out in a clinic-based setting.
Medialization Laryngoplasty
Medialization Laryngoplasty
Medialization Laryngoplasty
Medialization Laryngoplasty
Medialization Laryngoplasty

• The procedure is performed under local with an indwelling FOL so that vocal fold position and the patient’s voice can be used as feedback.

• The inferior muscular tubercle must be exposed to define the true lower border of the thyroid cartilage.

• The inner perichondrium of the thyroid cartilage must be divided to achieve unencumbered medialization.

• The paraglottic space should not be undermined anteriorly so as to avoid violation of the ventricular mucosa.
Arytenoid Adduction

Physiologic effects:

• Lowers the position of the vocal process
• Medializes and stabilizes the vocal process
• Lengthens the vocal fold
• Rotates the arytenoid cartilage
Arytenoid Adduction

Indications:

• Large posterior glottic gap
• Lateralized vocal fold during phonation
• Vertical height differences (generally the paralyzed vocal fold is superiorly located)
• Severely foreshortened vocal fold
• Inability to achieve good voice intraoperatively with ML alone
Arytenoid Adduction
Arytenoid Adduction
Arytenoid Adduction
Arytenoid Adduction
Arytenoid Adduction

- Arytenoid adduction (AA) is a framework surgery where the pull of the LCA muscle is recreated to achieve vocal fold repositioning.
- AA is used as an adjuvant surgical treatment along with ML.
- The pyriform mucosa must be dissected off the muscular process of the arytenoid.
- A double-armed needle is secured at the muscular process of arytenoid and passed anteriorly near the midline of thyroid to recreate pull of the LCA muscle.
- The sutures lie deep to the medialization implant.
Endoscopic Arytenopexy

- Zeitels Modification – Arytenopexy
- Presumably allows a more physiologic positioning of the arytenoid.
- Involves suturing the arytenoid in a more posterior and medial position to allow more tension on flaccid cord.
- Cricothyroid subluxation mimics action of cricothyroid muscle.
- Modifications should be used selectively.
TREATMENT OF BILATERAL VFP
Treatments

• Tracheotomy
• Microlaryngoscopy with laser posterior transverse cordotomy
• Microlaryngoscopy with laser medial arytenoidectomy
• Microlaryngoscopy with laser total arytenoidectomy
• Endoscopic suture lateralization
• Open arytenoidectomy
Treatment
Cordotomy
Cordotomy
Cordotomy

• Cordotomy is extended into the false vocal fold tissue.

• Frequently, a branch of the superior laryngeal artery is seen and bleeding can occur. (Suction and bipolar laryngeal cautery are effective in stopping the bleeding.)

• A complete cordotomy extends laterally 3–4 mm into the false vocal fold tissue/musculature.
LITERATURE UPDATE
Position of Paralyzed Cord

• Initially thought to be related to site of injury. RLN versus vagal (RLN + SLN)
  • Paramedian = RLN injury
  • Lateral = RLN + SLN injury

• Cricothyroid muscle (SLN) was believed to influence the vocal fold position in laryngeal paralysis.
Position of Paralyzed Cord

- 27 Pts with unilateral VF Paralysis underwent FOL and LEMG.
- VF positions were paramedian in 8 patients, intermediate in 7, and lateral in 11.
- LEMG, 13 patients had isolated recurrent laryngeal nerve lesions and 13 patients had combined (superior and recurrent laryngeal nerve) lesions.
- No correlation between the vocal fold position and the status of the cricothyroid muscle.

*Laryngoscope, 1995 Apr;105(4 Pt 1):368-72.*

*The cricothyroid muscle does not influence vocal fold position in laryngeal paralysis.*

Koufman JA, Walker FQ, Joharij GM.

Center For Voice Disorders of Wake Forest University, Winston-Salem, NC 27157-1034, USA.
• Association b/w early VC injection & reduced need for open-neck laryngeal medialization.
• Early medialization → more favorable VC position for phonation maintained by synkinetic reinnervation.
Different from unilateral laryngoplasty:

1. Overcorrection anteriorly must be avoided, since this will cause a harsh, strained voice.
2. The posterior flange of the implant must not contact the arytenoid cartilage. (This requires implants that are shorter in the anterior-posterior dimension when compared with “standard” implants)
### TABLE II.
Distribution of the Study Population by Diagnostic Group and Gender.

<table>
<thead>
<tr>
<th>Diagnostic Group</th>
<th>Male (n)</th>
<th>Female (n)</th>
<th>Total (n)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Presbylaryngis</td>
<td>10</td>
<td>6</td>
<td>16</td>
</tr>
<tr>
<td>Bilateral paresis</td>
<td>5</td>
<td>8</td>
<td>13</td>
</tr>
<tr>
<td>Paralysis/presbylaryngis</td>
<td>3</td>
<td>1</td>
<td>4</td>
</tr>
<tr>
<td>Miscellaneous</td>
<td>2</td>
<td>4</td>
<td>6</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>20</strong></td>
<td><strong>19</strong></td>
<td><strong>39</strong></td>
</tr>
</tbody>
</table>

### TABLE III.
Mean Preoperative and Postoperative Voice Ratings by Clinicians and Patients.

<table>
<thead>
<tr>
<th>Diagnostic Group</th>
<th>N</th>
<th>Clinicians' Ratings</th>
<th>Patients' Ratings</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>Preoperative</td>
<td>Postoperative</td>
</tr>
<tr>
<td>Presbylaryngis</td>
<td>16</td>
<td>3.6</td>
<td>1.6</td>
</tr>
<tr>
<td>Bilateral paresis</td>
<td>13</td>
<td>4.1</td>
<td>1.5</td>
</tr>
<tr>
<td>Paralysis with presbylaryngis</td>
<td>4</td>
<td>4.5</td>
<td>1.5</td>
</tr>
<tr>
<td>Miscellaneous</td>
<td>6</td>
<td>4.0</td>
<td>2.3</td>
</tr>
<tr>
<td><strong>Mean ± SEM</strong></td>
<td>39</td>
<td>3.94 ± 0.11*</td>
<td>1.67 ± 0.12*</td>
</tr>
</tbody>
</table>

*Voice rating scale: 1 = normal, 2 = minimal dysphonia, 3 = moderate dysphonia, 4 = severe dysphonia, 5 = aphony.*
Bilateral laryngoplasty appears to be a safe and effective treatment for patients with glottal incompetence attributable to a wide array of causes, especially if aspiration is present.

Patients with degenerative neuromuscular diseases, however, do not appear to benefit as much from this procedure as do individuals with paresis or presbylaryngis.
• Patient randomized into two groups
• Patients randomized to the ML group, surgeons performed whichever medialization procedure they would have performed if the patient were off-study,
• The reinnervation procedures were all performed using ansa cervicalis-to-RLN anastomosis.
• In one case, it was found that the planned anastomosis could not be performed for technical reasons, and a medialization was performed instead
At 12 months, both study groups showed significant improvement in several scores.

No significant differences were found between the two groups.

However, patient age significantly affected the LR, but not the ML, group results.

Patients older than 52 did better with medialization versus re-innervation.
• 14 studies – 329 patients analyzed.

• 60.2% men, mean age of 51yr (range, 12-79 yrs).

• Most common technique was ansa cervicalis-to-RLN, most commonly performed after thyroidectomy (43.5%).
• Other techniques:
  – Primary RLN anastomosis,
  – ansa-to-RLN combined with cricothyroid muscle-nerve-muscle pedicle
  – ansa-to-thyroarytenoid neural implantation
  – ansa-to-thyroarytenoid neuromuscular pedicle
  – Hypoglossal-to-RLN.
• Mean time to first signs of reinnervation was 4.5 months.

• Visual analysis of glottic gap showed the greatest mean improvement with ansa-to-RLN.

• Reinnervation is effective in the management of UVFP, although the specific method may be dictated by anatomical limitations.
Key Points

• Anatomy
  – TVC positioned at about ½ vertical height of the anterior thyroid cartilage and is anterior to the oblique line

• Causes of Vocal Cord Paralysis
  – Iatrogenic (Surgery and intubation #1)

• Evaluation
  – Realize that some function may return with time (6-12 months)
Key Points

• Management – Unilateral Paralysis
  – Anterior and Posterior Glottic gap must be addressed
  – Arytenoid adduction is irreversible
  – Continued improvement up to 1yr after Type I thyroplasty

• Management – Bilateral Paralysis
  – Preservation of airway is most important goal
When all else fails?

The New England Journal of Medicine

Brief Report

Laryngeal Transplantation and 40-Month Follow-up

Marshall Strome, M.D., Jeannine Stein, M.D., Ramon Esclamado, M.D., Douglas Hicks, Ph.D., Robert R. Lorenz, M.D., William Braun, M.D., Randall Yetman, M.D., Isaac Eliachar, M.D., and James Mayes, M.D.
Laryngeal Transplants

• 2 published reports
  – Cleveland Clinic - 2001
  – UC Davis - 2011
References


3. Early Versus Late Injection Medialization for Unilateral Vocal Cord Paralysis Aaron D. Friedman, MD; James A. Burns, MD, FACS; James T. Heaton, PhD; Steven M. Zeitels, MD, FACS

