Glottal Incompetence: Management Pearls and Pitfalls

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Saturday, May 12, 2012
Goals

• Who?
• Diagnose?
• Treat?
• Complications?
• Cases
Larynx ≠ Voice Production

- Brain
- Lungs
- Larynx (Vocal Folds)
- Pharynx
- Nose/Sinuses (Soft Palate)
- Oral Cavity
  - Tonsils, Tongue, Lips
- EARS
Vocal Fold Anatomy

- Squamous epithelium
  - 0.05mm
  - Basement membrane zone (BMZ)

- Lamina Propria
  - 1.5 mm
  - Superficial (SLLP)
  - Intermediate (ILLP)
  - Deep (DLLP)

- Vocalis muscle
Body-Cover Theory (Hirano & Kakita, 1975)

Vibratory phenomena are produced by difference in stiffness between body and cover

- **Cover**
  - Epithelium
  - SLLP
- **Transition (AKA: Vocal Ligament)**
  - ILLP
  - DLLP
- **Body**
  - Vocalis muscle

Mechanical, not neural
Physiology of Mucosal Vibration

- Three-dimensional phenomenon
  - Vertical
  - Horizontal

- Starting point of vibration
  - Mucosal upheaval starts at the infraglottis (μ)
  - Bernoulli effect
Myoelastic-Aerodynamic Theory of Phonation

- Required for VF vibration
- Myoelastic
  - Rima glottis = pliable
- Aerodynamic
  - Glottis @ nearly closed configuration
- **Glottic closure**
- **Vibratory margin**
Stroboscopy

- Representation of vibration
- Pseudo slow motion
- Examine individual points from successive glottal cycles taking advantage of the persistence of vision to fuse the images into a slow motion picture
  - video documentation
Principle of Stroboscopy
Stroboscopic Findings

• Fundamental frequency
• Periodicity
• Symmetry
  – Amplitude
  – Phase
• Mucosal wave, ± non-vibrating portions
• Glottic closure
Diagnosis

- Vocal fold paralysis
- Vocal fold paresis (RLN/SLN)
- *Vocal fold atrophy*
- *Vocal fold scar/“SLP deficiency” (sulcus)*
Vocal Fold Paralysis

- Etiology
- Implications
- Laryngoscopy
- Workup
- LEMG
- Treatment
### Etiology

<table>
<thead>
<tr>
<th>Etiology</th>
<th>1985-1995 (n=280)</th>
<th>1995-2005 (n=363)</th>
<th>Overall Trends (literature review)</th>
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<tbody>
<tr>
<td>Malignancy</td>
<td>24.7%</td>
<td>13%</td>
<td></td>
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<tr>
<td>Surgical/Iatrogenic</td>
<td>23.9%</td>
<td>46.3%</td>
<td>[↑]</td>
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<tr>
<td>Idiopathic</td>
<td>19.6%</td>
<td>17.6%</td>
<td>[≡]</td>
</tr>
<tr>
<td>Nonsurgical Trauma</td>
<td>11.1%</td>
<td>2.2%</td>
<td>[↓]</td>
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<tr>
<td>Neurologic</td>
<td>7.9%</td>
<td>3.0%</td>
<td>[↓]</td>
</tr>
<tr>
<td>Intubation</td>
<td>7.5%</td>
<td>4.4%</td>
<td>[↓]</td>
</tr>
<tr>
<td>Thoracic aortic aneurysm</td>
<td>4.3%</td>
<td>0.6%</td>
<td>[↓]</td>
</tr>
<tr>
<td>Infectious</td>
<td>---</td>
<td>3.6%</td>
<td>[↑]</td>
</tr>
</tbody>
</table>

Implications of U/L RLN Paralysis

- **Symptoms**
  - Aspiration (liquids)
    - Ineffective cough
  - Dyspnea
    - Exertion
    - Talking
  - Hoarseness
    - Weak, breathy
    - Rough
    - Low volume/projection
    - Effortful
  - Vocal fatigue

- **Physical exam**
  - Glottic incompetence
  - TA atrophy/bulk
  - Vertical height difference
  - Mucosal wave phase asymmetry

- **Directly impact treatment decisions**
Resting Vocal Fold Position (2-D)

**NO relationship to etiology or prognosis for recovery**

Medial  Paramedian  Lateral

c/o Netterville/Courey/Johns
Current Concepts in Glottic Configuration

- Residual innervation
- Reinnervation
- Synkinesis
- Muscular atrophy
- Fibrosis
- Favorable vs. unfavorable

Woodson GE. *Laryngoscope* 1993, 103:1227-1234
Laryngeal Neuroanatomy

- Galen’s Anastamosis
- RLN - ISLN

Laryngeal Neuroanatomy

- IA Plexus
- RLN/RLN, SLN/SLN, RLN/SLN

Laryngeal Neuroanatomy

- Human Communicating Nerve
- ESLN – RLN: 44-68% larynges

Foreign Invaders

- Galen’s anastamosis
- IA plexis
- Human communicating nerve
Prevention?

• Nimodipine
  – Increase rate of growth cone
  – Decrease mis-directed reinnervation from “foreign invaders”

  – Off-label
  – Karolinska
  – Preliminary data
Flexible Videostroboscopic Findings

• Most consistent
  – Vocal fold bowing
  – Salivary pooling
  – Glottic insufficiency

• Least consistent
  – Arytenoid stability
  – Arytenoid position
  – Vertical height mismatch

Determining the Etiology

- Iatrogenic – no testing required
- RLN only
  - CT w/contrast: skull base through aortic arch
  - CXR (no clear support of CT > CXR)
  - Thyroid US
- RLN + SLN/neuro signs
  - MRI brain + MRI/CT length of vagus
- Labs – Lyme titer, FTA-Abs, RF titers, ANA
  - Low yield, but 30-40% ENTs still order

70% ENTs feel imaging is necessary

From Merati A, Halum SL and Smith TL. Diagnostic testing for vocal fold paralysis: survey of practice and evidence-based medicine review. *Laryngoscope* 2006; 116:1539-1552
### “Traditional” Qualitative LEMG

<table>
<thead>
<tr>
<th>Class</th>
<th>Spontaneous Activity</th>
<th>Recruitment</th>
<th>Individual Motor Unit Morphology</th>
<th>Interpretation</th>
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<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>Polyphasic units</td>
<td>&quot;Old injury&quot;*</td>
</tr>
<tr>
<td>III</td>
<td>Present</td>
<td>Reduced</td>
<td>Polyphasic units</td>
<td>&quot;Equivocal&quot;‡</td>
</tr>
<tr>
<td>IV</td>
<td>Present</td>
<td>Absent</td>
<td>Fibs, myokymia, etc.</td>
<td>Denervation</td>
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</table>

Positive predictive value (PPV): 80%  
Negative predictive value (NPV): 67-71%

Synkinesis

- Misdirected re-innervation of the adductor and abductor laryngeal muscle nerve fibers
  - 88% of specimens after nerve injury (animal studies)

Optimal LEMG Interpretation

- Qualitative Motor Unit Characteristics
- Quantitative Mean Turns Analysis
- Presence of Synkinesis

PPV = 100%
NPV = 90%
Accuracy = 91%
Factors Determining U/L VFP Treatment Decisions

- Need for treatment
  - Observation vs. treatment
  - #1: Dysphagia
  - Vocal demands

- Timing of treatment
  - Time since injury
  - Fear of surgery
  - Return to work
  - LEMG prognosis
  - Temporary vs. permanent

- Life expectancy of patient

- Medical conditions
  - Anti-coagulation status
  - Heart
  - Chemotherapy
  - Dialysis
U/L VF Paralysis

• “Easy”
• Voice therapy almost NEVER helps
• Temporary v. permanent treatment
• Voice / swallowing?
• Expect improvement with medialization, but...
  – Level mismatch
  – Foreshortening
  – Tone
“Mr. Osborne, may I be excused? My brain is full.”
VF Atrophy - Prevalence

• 12.9% US population > 65 y.o. (2010)
• Expected 30% US population (2030)

• Voice disorder: 12-35%
  – 23.1% neurologic (CVA, PD, ET, SD)
  – 23.1% VF immobility

  – 38.9% reassurance
  – 56.8% vtx (short course, 1-6, average = 3.6)
  – 6.3% injection trial

Atrophy Tx Success

- 80% vtx $\rightarrow$ 50% perceived improvement
- VHI ($\Delta > 5$)
  - Vtx alone: 36% improved
  - Sx alone: 56% improved
  - Vtx + sx: 17% improved
  - Tone
  - Consistency

Glottic Incompetence - Treatment

• Voice therapy

• Surgery
  – Temporary
    • VF injection
  – Permanent
    • VF injection
    • Laryngeal framework surgery
Vocal Fold Injection

- Indications
- Locations
- Materials
- Techniques
VF Injection - Indication

• Glottal incompetence
  – VF paralysis \(^1, 2\)
  – VF paresis

• Trial augmentation \(^3\)
  – Will augmentation help? Degree of glottal incompetence?
  – VF atrophy
  – VF scar
  – VF level mis-match (vocal fold paralysis / dislocation)
  – VF paresis
  – Multiple sites of communication difficulty
    • Dysphonia, dysarthria,...

1 Yung KC, Likhterov I, Courey MS. Effect of temporary vocal fold injection medialization on the rate of permanent medialization larynplasty in unilateral vocal fold paralysis patients. Laryngoscope 2011;121(10):2191-4
2 Young et al, Voice Outcome after Acute Unilateral Vocal Fold Paralysis. Submitted for publication, presented at COSM 2012.
VF Injection - Location

• Deep
  – Lateral to the VF, medial aspect of the paraglottic space
  – Global augmentation of the vocal fold

• Superficial
  – Replace, restore lamina propria
VF Injection - Location

= Superior arcuate line
VF Injection – Material (Ideal)

• Biocompatible
• Safe from transmission of infectious disease
• Matched mechanical property to host location (viscosity)
• Stable (inert)
• Use a fine-gauge needle (24 g or smaller)
• “Off the shelf” (minimal prep)
VF Injection Material: Present

- Gelfoam
- Collagen
  - Cadaveric – Cymetra
- Radiesse Voice Gel™
- Hyaluronic acid – Restylane, . . .
- Calcium hydroxylapatite (CaHA)
  - Radiesse Voice™
- Fascia (autologous/allogenic)
- Fat (autologous)
Gelfoam™

• Gelatin
  – Bovine gelatin
  – Sterile powder (1 gm)

• Longest track-record of laryngeal injectables
  – 30 years (1970s)
  – #1 injectable, ABEA survey, 2004 (Merati)

• Bottom line
  – Lasts 4 weeks
  – Requires preparation
  – 18g needle
  – Poor vibratory properties
  – Limited use today
Collagen-Based Injectables

• **Cymetra**
  – Micronized cadaveric dermis
  – Prion infection transmission risk?
  – Significant preparation required (hassle)

• **Cosmoplast/Cosmoderm**
  – Human engineered collagen
  – No track record

• **Bottom line**
  – Lasts 2-3 months
Radiesse Voice Gel™

• 3 Basic components
  – Water (82.3%), Glycerin (14.5%)
  – Carboxymethylcellulose (CMC 2.3%)

• Carboxymethylcellulose
  – Cortisone, decadron
  – Common food additive

• Gel carrier for Radiesse™ (CaHA)
  – FDA approved for VF injection

• Bottom line
  – Lasts 1-3 months
Hyaluronic Acid

• Glycosaminoglycan (polysaccharide)
• Found in dermis
• Low tissue reactivity
  – Hypersensitivity 0.6%
• Bottom line
  – Duration: 6-9 months?
Calcium Hydroxyapatite

- CaHA – Long-term, successful solid implant in orthopedics and dentistry
- Radiesse Voice™
  - Spherules of calcium hydroxyapatite (CaHA)
  - Suspended in aqueous-based gel
    - CMC, water, glycerin
    - Voice gel component resorbs
      → over-inject ~10%
- FDA approved for VF injection
- Inflammatory response?
- Bottom line
  - Lasts 1-2 years
Lipoinjection

- Liposuction or open harvest
- Fat preparation
  - Rinse fat, insulin?
- 18-19 gauge needle
- Overinjection by 30-50%
- Unpredictable
- MAC or general anesthesia
Lipoinjection
video
Treatment – VF Injections

• Gelfoam ~ 1 month
• Cymetra ~ 2-3 months
• Radiesse Voice Gel ~ 1-3 months
• Hyaluronic acid Gel ~ 6-9 months
• CaHA (Radiesse Voice) ~ 1-2 years
• Fat ~ forever?
Which injectable should I use?

Why?

Temporary?
- trial
- short
- long

Permanent?
Office-Based Laryngeal Procedures

- 1807 – Bozzini examines the larynx
  - Dx laryngeal infections
    - Membranous debris, inflammation,…
- 1852 – Laryngeal polyp removed (local)
  - Horace Green, Pioneer (1802-1866)
Laryngology - History

• Dark Ages (laryngologic)
• 1950’s – General anesthesia
• 1960’s – Surgical microscope
  – Birth of Microlaryngoscopy
• Teflon Injection (Lewy, 1963)
  – Awake, sitting position, mirror, per-oral (Dedo)
• 1980’s – Thyroplasty (Isshiki)

• 1990’s – Return of office procedures
VF injection techniques: What setting?

Office

Operating room

- General anesthesia
- Local/MAC
Influential Factors

• Technology: Distal chip tip endoscopes
  – Dramatic improvement in resolution
  – Working channel in scope (2mm)

• Advantages of office-based laryngeal treatment

• Financial pressures?
Advantages of Office-based Treatment

• Real-time voice and VF monitoring
  – Closure and vibration

• Upright position
  – Cancer/scar

• Topical anesthesia
  – Drive themselves to and from office

• More advantages
Where we have been...
Where are we going?

- Current practices in injection augmentation of the vocal folds
- COSM 2009
- Multicenter: 7 laryngologists
- 5 year data from 3 of those centers
- Awake/asleep
- Approach – Materials – Complications

5 year trends

<table>
<thead>
<tr>
<th>Year</th>
<th>Number of patients</th>
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<tbody>
<tr>
<td>2003-4</td>
<td>57</td>
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<tr>
<td>2004-5</td>
<td>125</td>
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<tr>
<td>2005-6</td>
<td>155</td>
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<tr>
<td>2006-7</td>
<td>175</td>
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<tr>
<td>2007-8</td>
<td>244</td>
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</tbody>
</table>

- Bedside
- Office
- OR
Location Pros/Cons

**Office**
- **PROS**
  - Real-time monitoring
  - Patient convenience
    - Young et al, *Laryngoscope, 2011*
  - Patient co-morbidities
  - Surgeon time
- **CONS**
  - Patient tolerance (anxiety, gag)
  - Patient anatomy
  - Good assistant
  - Equipment
  - No lipo

**OR**
- **PROS**
  - Patient tolerance (anxiety)
  - Technical precision
  - Resident teaching
  - Patient co-morbidities
- **CONS**
  - Patient inconvenience
  - Surgeon time
  - Cost: 505% more
    - But less reimbursement
Office surgery – Patient selection

• Gagging w/flex scope
  – NOT contraindication
  – Percutaneous?
  – Local only
    • PO Xanax/Ativan?

• Adequate oral opening
  – >2cm for per-oral

• Off anti-coagulants
  – ASA, NSAIDS, coumadin, fish oil, herbals w/anti-coagulant properties
    • Relative contraindication
Local Anesthesia - Nebulatization

• 3 cc 4% plain lidocaine with O₂ tank, 5 min
  – Takes effect in 90 seconds

• Good for 1 - 1.5 hours

• NPO post-procedure
Topical Airway Anesthesia

• Drip lidocaine via flex scope channel and/or Abram’s cannula
  – Tongue base (per-oral)
  – Laryngeal “gargle”
    • While phonating “ee”
      – Pyriform sinus - supplemental
        » Branch of internal SLN runs near mucosal surface

• Assistant must provide dynamic exposure
Office Surgery-Equipment

- Videotower
- Chip-tip scope
  - Working channel
  - Endosheath
- Anesthesia equipment
  - Nebulizer
  - Drip catheter
  - Abram’s cannula
- Injection needles
In-Office VF Injection – Per Oral

- **Per-oral**: Curved needle passed through oral cavity under direct visualization with flexible or rigid (70 deg) scope.
- **Percutaneous**: Needle passed through neck skin with flexible scope in nose for visualization.

- Trans-thyroid cartilage
- Cricothyroid
- Thyrohyoid
Bilateral deep vocal fold augmentation
Trans-Thyroid Cartilage Technique

- Topicalize nasal cavity and larynx
- Needle passed through thyroid cartilage at level of vocal fold
- Movement of needle tip tells location in vocal fold
- Inject under flexible scope visualization
Cricothyroid Technique

- Same setup and prep as previous approach
- 1.5 inch standard injection needle
- Needle inserted through cricothyroid membrane, directed upwards and laterally
- Cannot see needle well
- May enter airway to locate tip
Thyrohyoid Technique

- 1½ - 2¼ “ 24 g needle
- Acute angle at notch
- Come out at petiole
"Whoa! That was a good one! Try it, Hobbs—just poke his brain right where my finger is!"
Vocal fold injection - OR

- Local/MAC
  - Endoscopic

- General
  - MSL
  - Endoscopic
Complications

**Injection**
- Hemorrhage
- Aspiration
- Airway
- Overinject
- Underinject
- Injection misadventure
  - Wrong location
  - Migration

**Office**
- Vasovagal
- Lidocaine toxicity

**MSL/Endoscopic**
- Dental injury
- TMJ injury
- Tongue injury

Office = OR

Sulica et al, Laryngoscope 2010
Type I Thyroplasty
AKA Medialization Laryngoplasty
c. 1974

- Gold standard
- VFP $\rightarrow$ expect improvement
- Implants
  - Silastic
    - Netterville/block
  - VoCom Hydroxyapatite
  - Gore-tex
  - Titanium
Medialization Laryngoplasty

Skin incision

Thyroid cartilage
Medialization Laryngoplasty

Perichondrial flap

Cricothyroid muscle
Medialization laryngoplasty
Medialization Laryngoplasty

Intra-op monitoring

Localization
Medialization Laryngoplasty

Gore-Tex

Silastic
Medialization Laryngoplasty
Pearls of ML

• Excellent window localization

• Implant placement
  – Posterior (toward muscle process)
  – Inferior (infraglottis)
  – Anterior?
    • Often not needed
    • When done, very small amount of implant

• Slight over-correction to compensate for peri-op edema
  – Decadron 8mg PO night before sx
  – Decadron 10-20mg IV pre-op

• Inadvertent entry into airway → stop. NO implant!
New Trends

• No drain, bone wax, glue
• No antibiotics
• Post-op steroids?
• 23 hr. obs?
  – Same day sx: U/L, local
  – 23 hr obs: B/L (atrophy/VFP + atrophy), not local
ML: pros / cons

**BENEFITS**
- Improved glottic closure
- Intraoperative monitoring
- Adjustable
- “Reversible”

**COMPLICATIONS**
- Implant migration
- Implant extrusion
- Implant misplacement
- Under/over-augmented
- Hematoma/edema → airway compromise
- Need to revise
Arytenoid Adduction

• Indications
  – Large posterior gap
  – Unequal vocal fold levels
  – Improve tone?

• Improves acoustical power and increases subglottic pressure
Complications
- Piriform sinus injury
- Over/Under correct
- Thyroid cartilage fx

Basically...
- All the time
- Never
- Sometimes
- Adds 2 hrs
- Increased risks
  - Technically challenging
Cases
Questions?

Arthur answers the eternal questions.

Arthur, when will we know all the answers?

Sometime after we've asked all the questions.

Arthur.