Stroboscopy interpretation: a crash course

Jennifer Long, MD, PhD
UCLA Voice Center for Medicine and the Arts
Department of Head and Neck Surgery
UCLA David Geffen School of Medicine and Greater Los Angeles VAMC
Why we look at the larynx

To diagnose a person’s voice problem.

Laryngeal exam must be considered along with:
- The patient’s history
- Voice use
- Physical exam
- Perceptual voice evaluation
Why else we look at the larynx

To diagnose a problem with:

- swallowing
- breathing
- coughing
- pain
- sleeping
How we look at the larynx

Do I really need all this stuff?

Videolaryngostroboscopy
Stroboscopy principles
History of stroboscopy

• Oertel (1895) – first stroboscopic principles used
  • Mechanically shuttered light source (disk)
  • Laryngeal mirror
  • Subjects would match pitch with frequency of strobe
• Specialized video devices available in 1980s
• Kay Elemetrics (1992) – precisely triggered light source filmed at 60 frames/second
• Now, 3 or 4 major systems on market
Videostroboscopy

- Simulated “slow-motion” to visualize mucosal wave
- Strobe light = Xenon, Constant light = Halogen (KayPENTAX)
- Measures frequency (pitch) of subject’s voice
- Strobe flashes at slower frequency to illuminate gradually progressive location in glottal cycle
- Flashes just fast enough to create illusion

- Disadvantages:
  - Requires sustained periodic note for software to track pitch
  - Often doesn’t “catch,” especially in cases with aphonia, increased jitter
Strobe principles

Principles behind stroboscopy

• Visual phenomena required for stroboscopy to appear as “slow motion”:
  • Perception of apparent motion from sampled images (min 17 Hz)
  • Flicker-free perception of light (min 50Hz)

• Talbot’s law— if more than 5 images are presented per second, brain perceives this as smooth motion
  • Images linger on retina for 0.2 sec
Videostroboscopy

• Using stroboscopy principles with video recording equipment

• Uses NTSC (Natl TV System Committee) guidelines of 60 Hz (fields/second)

• One “flash” per NTSC field to avoid artifact

• Allows video recording and playback for analysis, documentation
Practical stroboscopy
Collecting the data – laryngoscope type
Collecting the data

• Patient preparation
  • Nasal decongestant and anesthetic
  • Oropharyngeal or laryngeal lidocaine can be helpful for very close view in difficult patients positioning
  • Patient positioning

• Digital audio microphone
• Laryngeal microphone
• Trigger – foot pedal or keyboard
Laryngoscopy evaluation

- Presence of masses
- VF movement
- Tremor
- Secretions
- Inflammatory signs
- Ventricle size
- Compression (AP, supraglottic)
- Subglottis
- Respirations
Laryngoscopy evaluation

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- Vibration?
  - Erroneously thought by 1/3 of otolaryngologists (Cohen, J Voice 2006)
Stroboscopy evaluation

- Mucosal wave
  - Amplitude
  - Periodicity
  - Symmetry (amplitude and phase)
  - Non-vibratory segments
- Closure
  - Shape of open glottis
  - Speed of closure
Vocal fold paresis

• “Unexplained” dysphonia often due to laryngeal paresis and vocal fold atrophy

• Laryngeal paresis may go unrecognized during clinical voice evaluation due to lack of an obvious sign, such as reduced vocal fold mobility
Vocal Fold Vibratory Characteristics:

- **Phase of vibration at opening** → symmetric or asymmetric opening of the vocal fold medial edge? If so which one leads/lags?

- **Mucosal wave amplitude** → most lateral excursion of the visible mucosal wave on the superior vocal fold surface

- **Vibratory amplitude** → most lateral displacement of the vocal fold medial edge during the glottal cycle
The Interarytenoid Spatial Relationship: Accuracy and Interrater Reliability for Determining Sidedness in Cases of Unilateral Adductor Paresis

*Ahmed S. Sufyan, †John C. Kincaid, *Todd J. Wannemuehler, and *Stacey L. Halum, †Indianapolis, Indiana
Slow motion vs slow mode

• Video
Clinical Evaluation of Paresis

• Frame-by-frame evaluation of glottic opening cycle to assess vibratory phase asymmetry
  • The normal fold leads in vibratory phase and mucosal wave amplitude; paretic side lags
• Combine with spatial relationship of AE fold and arytenoid cartilages

Left RLN Paresis

Left SLN Paresis
Diagnosis of Vocal Fold Paresis: Current Opinion and Practice

Amy P. Wu, MD; Lucian Sulica, MD

Fig. 2. A 38-year-old woman with atrophy of the left vocal fold, incomplete glottic closure, unilateral (right) supraglottic hyperfunction, and impairment of arytenoid rotation on the left.

Fig. 3. A 30-year-old woman with a left-side decreased left vocal fold adduction.
Analysis of Laryngoscopic Features in Patients With Unilateral Vocal Fold Paresis

Peak Woo, MD; Arjun K. Parasher, MD; Tova Isseroff, MD;
Amanda Richards, MBBS, FRACS; Mark Sivak, MD

<table>
<thead>
<tr>
<th>Category</th>
<th>Finding</th>
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<tbody>
<tr>
<td>Glottis configuration</td>
<td>Axis deviation, shorter vocal fold, thinner vocal fold, vocal fold bowing</td>
</tr>
<tr>
<td>Movement</td>
<td>Abnormal abduction or adduction, kinesis</td>
</tr>
<tr>
<td>Stroboscopy</td>
<td>Phase lag, open phase dominant*</td>
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</tbody>
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Stroboscopy controversies

- Depth of invasion
- Vertical level of approximation
- Paresis
  - RLN
  - SLN
  - RLN+SLN
  - LCA alone – posterior gap, angled vocal process
Paralysis

• Don’t need strobe for this, but it is nice anyway!
  • Audio sample
  • Synkinesis
    • Paresis may indicate a progressing or recovering paralysis

• Bilateral VFP
  • videos
Advanced laryngeal imaging
HD vs SD

- SD: 720 x 480 pixels
- HD: 1920 x 1080 pixels
- Adds spatial resolution compared to SD
- Note pixelation with zoomed image

Mehta DD, Hillman RE (2012)
High Speed Video

- True “slow-motion”
- Shoots at 2000 frames per second (vs 30fps)
  - Can be up to 8000 fps (color) and 20000 (mono)
- More frames = shorter exposure for each frame = more light needed
  - Larger scope needed for more light
  - More heat from brighter light
- More data: 2 seconds at 2000 fps = 1.5GB data
- https://youtu.be/9kHdhbEnhoA
76ms elapsed
477 frames

One strobe flashed during each NTSC video field

Each row = one cycle

At 100Hz, 20 frames each cycle
Videokymography

• High-speed imaging modality for use in irregular vibratory patterns
• Scans vocal fold cross section and compiles images
• Shows medial-lateral excursion
• Benefits: assessment of VF dynamics even if aperiodic wave
• Automated quantitative analysis more feasible with 2D reference point
• Reduces sampling error of HSV
• Downside: Less-intuitive than other methods
Depth Kymography

- Laser-line triangulation technique
- Allows quantitative visualization of vertical VF motion
- Affords precise knowledge of absolute VF dimensions
Optical Coherence Tomography

- Infrared light + interferometry to detail microstructure to 2mm deep
- Vibratory images at 40Hz scan rate

High-resolution MRI

- MR microimaging: imaging of microstructure (studied in excised larynges)
- Dynamic MRI: may be able to assess laryngeal structure and glottal parameters non-invasively
- May afford better 3D understanding of larynx
Female patient, 22 years old; complaint: hoarseness of the voice. Ultrasonography shows transverse scan indicating normal sonographic appearance of the vocal cords and normal mobility in adduction and abduction during respiratory maneuvers.

Narrow band imaging

• Is available on many new digital chip endoscopes
• Uses blue-green light that is absorbed by hemoglobin to enhance visibility of blood vessels
• Does not clearly correlate with pathology

Picture not included
Conclusions

- Stroboscopy is still the standard for capturing VF vibration…
- But you have to look carefully (eg paresis, scar)…
- And diagnosis and treatment planning requires more information than just video.