Endoscopic Management of Subglottic Stenosis: Diagnosis and Surgical Techniques

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OHNS Website: http://ohns.ucsf.edu

Airway Obstruction

- Supraglottis
- Glottis
- Subglottis
- Trachea

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**Unifying Concepts in Endoscopic Management**

1. **Incise** soft tissue stenosis/scar
   - Do not excise the stenosis

2. **Avoid** circumferential disruption of the mucosal surface

3. Evaluate the degree of cartilage involvement
   - If the supporting airway cartilage is involved in the stenosis, then endoscopic techniques are unlikely to be successful

**Predictive Factors of Success in Endoscopic Management**

1. Incomplete circumferential involvement

2. Scarring shorter than 1 cm in vertical dimension

3. Tracheomalacia or loss of cartilage

4. History of bacterial infection associated with tracheotomy

5. PGS with arytenoid fixation

**Etiology**

- Iatrogenic – prolonged intubation for mechanical ventilation
- External trauma
- Idiopathic


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**Adult Subglottic Stenosis**

- Etiology
  - Autoimmune – Wegener’s
  - Idiopathic
- NO cartilage involvement
- Surgical Technique – Endoscopic Laser Radial Incisions with Dilation and Mytomycin c Application
- Average symptom free interval 9 months

Roediger FC, Orloff LA, Courey MS. Laryngoscope. 2008 Sep;118(9):1542-6
**Evaluation/Management**

- Office evaluation and examination
  1. Thorough history – suspect etiology
     - Prior intubation
     - Prior surgery
     - GERD symptoms
     - Autoimmune disorders
        - Nasal crusting
        - Recurrent sinusitis
  2. Careful endoscopic examination

Subglottis
**Evaluation/Management**

- Consider high resolution CT with 3-d reconstruction
  - Underestimates amount of cartilage involvement
  - Standard CT evaluation 5 mm axial images
  - High resolution CT 1 mm axial images
  - Virtual endoscopy
Evaluation/Management

Staging Endoscopy

- Primary purpose
  1. Stage exact area of stenosis
  2. Define position and degree of cartilage involvement

- Be prepared to treat

- Anesthetic technique – Jet ventilation
  - Supraglottic
  - Subglottic

Preoperative conversation with patient: risks and desires
  - Risks
    - Airway obstruction and death
    - Need for tracheotomy
Evaluation/Management

Staging Endoscopy

- Equipment – Operative Endoscopes

Laryngoscopes and Microsubglottoscopes  Bronchoscopes

Microsubglottoscopy

- Binocular visualization with the operating microscope
- Bimanual manipulation
- Used with Jet Ventilation
- Allows treatment of lesions for 5 to 7 cm below TVF
- Works well with the CO₂ laser
Laryngoscopes and Microsubglottiscopes

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Endoscopic Management of Airway Obstruction

- Enhanced by the addition of the surgical laser to our armamentarium

- CO₂ Laser
  - Stuart Strong, MD
  - Geza Jako, MD
  - Wave guide delivery systems

- Nd:YAG
  - Fiber laser delivery systems

Ablation

Computerized Pattern Generators

- Ablates 250 micron wide swath of tissue

Incision
**Modes of Laser Delivery**

1. **Continuous**
   - Laser medium is excited with a constant source of power
   - Provides a constant output of energy

2. **Pulsed**
   - Laser medium is excited with a flash-lamp or an intermittent source of power
   - Provides short “pulsed” output of energy in bursts
   - Tissue can cool between bursts of energy
     - Thermal Relaxation Time of the tissue
**CO₂ Laser - Continuous Delivery Mode**

- In the tissue surrounding the impact zone, energy is absorbed at subablative tissue thresholds

![Image of tissue with labels: Ablation Crater, Coagulum, Subablatative Injury Zone]

Oral Canine Mucosa 7 days after injury with a continuous mode CO₂ laser at 4 watts for 0.1 second

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**Laser - Pulsed Delivery Mode**

- Allows tissue cooling between laser impacts
- Reduces subablative injury
  - Thermal Relaxation
    - Time required for a target structure to dissipate 50% of the energy absorbed to surrounding tissue
    - Roughly equal to the square of the diameter of the target structure
Laser - Pulsed Delivery Mode

Thermal Relaxation Time

Thermal Damage

Ability to Delivery Laser Energy in a Pulsed Mode

Reduces Thermal Damage

Continuous Wave

Pulsed Structure Wave

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**Surgical Precision**
Enhanced by accurate delivery of laser energy

1. Selective phothermolysis – choose a desired chromophore
2. Pulse the laser – thermal relaxation
3. Repeat/Delay or Shuttered laser delivery
   - Laser output in either a continuous mode or a pulsed mode is allowed for a tenth of a second
   - The laser is turned off after a few tenths of a second
   - Allows the surgeon to move the laser beam to avoid:
     1. Drilling into tissue
     2. Overlap of ablation sites

**Settings for Laser Shuttering**
**Repeat/Delay**

- On time – 0.1 second
- Off time – 0.3 to 0.5 seconds
  - Repeat delay
**Shutter vs. Non-Shutter**

Laser energy is delivered for 0.1 to 0.2 seconds

Laser energy is delivered without delay

- Can be accomplished with all laser wavelengths
  - CO2
  - KTP
  - PDL

- Reduces error by allowing the operator to move the laser beam

- Avoids "drilling" into tissue or excessively delivering laser to one area

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Surgical Precision

Enhanced by accurate delivery of laser energy

1. Selective photothermolysis – choose a desired chromophore
2. Pulse the laser – thermal relaxation
3. Repeat/Delay or Shuttered laser delivery
4. Pattern generators
   - Computerized/Mechanical
   - CO₂ laser only

Pattern Generators for the CO₂ Laser

- Mechanically move the laser beam
  - More rapidly than with human movement
  - Minimize overlap inherent with human movement

- Patterns
  - Linear
  - Geometric area
    - Circles
    - Boxes

- Used in a shuttered or non-shuttered mode
- Combined with pulsed delivery systems
Digital Acublade™

- CO₂ laser
- Ultrapulse™ laser mode
  - Reduces laser on time
  - Limits thermal damage
- Computerized Pattern Generator
  - Moves beam more efficiently than human hand
  - Reduces human error

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Surgery with Pattern Generators

- Evaluation of precision – canine model
  - Direction of incision
  - Depth of incision/ablation
  - Thermal damage

- CPG incisions vs. hand made incisions
  CPG incisions were more uniform
  - Depth of incision
  - Thermal damage

Surgery with Pattern Generators

- Evaluation of operative time with prototype scanner
  - Multiple surgeons
  - Short learning curve

- Reduction in operative time by 37%
  - $p < 0.001$

- Outcomes voice and airway not significantly different
Subglottic Stenosis

**Etiology**
- Idiopathic
- Wegener’s
- Prior intubation

Involvement of Extra-Esophageal Reflux Disease

**Subglottic Stenosis – Management Techniques**

- Tracheotomy
  - Best avoided due to increase bacterial count in trachea
- Reflux treatment
  - Aggressive BID therapy
  - Consider surgical intervention – Nissen if LES pH probe positive
- Endoscopic evaluation and POTENTIAL treatment
  - Laser incisions – Mitomycin C application – Dilation
- Mitomycin C
  - Increase interval between treatment 4.9 months to 23 months

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Subglottic Stenosis – Management Techniques

Surgical Technique – Endoscopic Evaluation

- Telescopic Bronchoscopy
- Evaluate length and degree of stenosis
- Do not need to make airway normal
  - Robert Ossoff - “It’s a game of millimeters”
  - Rationale
    - Flow ~ \( r^4 \)
    - Minimal increases in radius improve flow

Subglottic Stenosis

Surgical Technique

- Caution !!
  - Avoid excess exposure/injury to cartilage
  - Avoid injury to vocal folds
- Mitomycin c application
  - 0.4 mg per ml
  - Topical on cottonoid – 3 minutes
  - Wash away excess
  - May lead to crusting
  - Delays re-epithelialization
Subglottic Stenosis – Case Example

- **Office evaluation**
  - Patient history of symptoms
    - Rapidity of onset
    - Degree of DOE
  - Indirect endoscopy

- **Studies**
  - PFT's
    - Fixed extrathoracic obstruction
    - Flattening of the inspiratory and expiratory limbs
    - Peak inspiratory flow should be greater than 1.5 liters
  - CT?
Subglottic Stenosis – Case Example

- CT?

Subglottic Stenosis – Case Example

Surgical Technique

- Exposure
  - Microsubglottiscope
- Jet Ventilation during anesthesia
- Radial incisions
  - To laser or not to laser
- Dilation after radial incision
  - Rigid dilators
  - Bronchoscopes
  - Balloon dilators
Subgottic Stenosis

Preoperative

Postoperative

Laser Radial Incisions for Tracheal Stenosis
Laser Radial Incisions for Tracheal Stenosis

Conclusions and Future Directions

- Endoscopic management principles are well established
- Often alleviates stenosis without need for more aggressive open intervention – Do not need to make airway normal
- CO₂ laser enhances ability to perform most of these endoscopic procedures
Thank You

[Image of four people in a desert setting]