Evaluation and Surgery of the Eustachian Tube

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Introduction

- Eustachian Tube Dysfunction – “The Root of Evil”
- Review of Anatomy
- Past Surgical Treatment Ineffective
- Technical Advances Aid in Current Diagnosis
- New Surgical Treatments
Gross Anatomy of the Eustachian Tube

- 1/3 Osseous and 2/3 Cartilaginous
  - Osseous 11 to 14 mm
  - Cartilage 20 to 25 mm
- Both parts are cone shaped
  - Form an Isthmus
- Form a 160° angle with each other
- Lies against skull base in the sulcus tubarius
- Internal Carotid Artery lies medially
Cartilaginous Tube

- Angles 30° to transverse
- Angles 45° to sagittal
- Nasopharynx
  - Attached to tubercle on medial pterygoid lamina
  - “Crooked” shape mediolateral superior wall – torus tubarius
  - Ostmann fat pad
- Associated muscles
  - Levator Veli Palatini
  - Tensor Veli Palatini
  - Salpingopharyngeus
  - Tensor tympani
Levator Veli Palatini

- Origin: inferior aspect petrous apex
- Insertion: blend with dorsal soft palate
- Forms the lower border of the medial lamina ET
- Related to ET by loose connective tissue only
- Innervated by pharyngeal branch of vagus
Tensor Veli Palatini

- Two distinct bundles
- TVP
  - Origin: schaphoid fossa and lateral osseous ridge of the sulcus tubarius
  - Insertion: around hamulus to horizontal process of palatine bone
  - Receives slip to malleus TT
- DT
  - Origin: posterior 1/3 of lateral membranous ET
  - Insertion: blends into TVP
  - Dilates ET
- Inervation by Trigeminal V₃
Salpingopharyngeus

- Origin: Medial inferior border of ET
- Insertion: blends with palatopharyngeus
- Inervation: branch of pharyngeal trunk of vagus
- Often absent
- Appears to be vestigial
Endoscopic Anatomy
History of Eustachian Tube Surgery

● Earlier work was directed at the Isthmus
  ◆ Zollner 1955 & 1963 report attempts to “stent” the Eustachian Tube
  ◆ Wullstein 1960 drilled ET from a middle ear approach
  ◆ House & Glasscock 1969 used a temporal crainiotomy for middle cranial fossa approach
  ◆ Charachon & Zini both did post auricular drill outs with silastic stenting for 6 to 24 months

● “There have been no reports of long term success using any of these techniques”
Advances in Diagnosis

Optics

- Kimura 1989 first to perform transtubal endoscopy
- Edelstein 1994 passed through nasopharynx
  - .55 to 1.0 mm endoscopes
  - 1000 to 10000 pixel resolution
- Klung 1999 endoscopically evaluated 40 ET in fresh specimens
  - .8mm flexible scope passed 92.5%
- Several authors, Linstrom 2000 have evaluated ET in COM
  - Pass from ME
  - Success 16% to 50%
Poe 2000 suggested the possibility of functional valve problems

- Optics to evaluate nasopharynx
  - Rigid 30° Scopes 4mm, 2.7mm and 1.9mm
  - Flexible 4mm, 2.5mm, 1.6mm and .6mm

Digital recordings via 3 chip camera

- Recorded at 30 frames / sec
- Allowed slow motion playback

Identified 4 phases of ET opening
Four Phases of Opening

1. Palate elevates, medial lamina rotates medially, lateral pharyngeal wall move medially
2. Palate remains elevated, lateral wall moves laterally
3. Tension of lateral wall propagated distal to proximal
4. As wave reaches isthmus tube dilates to open
“Analysis of Eustachian Tube Function by Video Endoscopy” Poe, D. 2000

- 17 patients with 26 affected ears
  - All with chronic ETD
    - 17 ears with cholesteatoma
    - 9 ears with chronic OME and retraction
- 2 patients with patulous ET
- All analyzed by slow motion video endoscopy
- “Identifiable pathologic states in every case”
  - 23 of 26 reduced or uncoordinated
    TVP or DT
  - Mucosal edema or hypertrophy
  - Occasional polyps
“The inferior portion, which contains more mucosal folds and ciliated cells, is likely more active for mucociliary transport.”

“Superior portion of the pharyngeal tube principally regulates opening and ventilation functions.”
Four Fundamental Pathologies

1. Primary Mucosal Disease
2. Reflux From Nasopharynx
3. Muscle Dyskinesis
4. True Anatomic Obstruction
“Analysis of the Dysfunctional Eustachian Tube by Video Endoscopy”  Poe, D.  2001

- 44 Patients with 64 ETs
  - 19 female 25 male
  - 21 to 72 years old
  - 40 patients (58 ears) known pathology ME
  - 4 patients (6 ears) with patulous ET
- 22 Patients clinically normal as controls
- All evaluated by slow motion video endoscopy
  - Awake and sitting upright

Types of Pathology:
- 18 cholesteatoma
- 13 chronic retraction
- 11 OME
- 9 atelectasis
- 7 COM / perforation
Results of Analysis of Dysfunctional ET

- All 58 Dysfunctional tubes showed significant pathology
- 7 (32%) of normal tubes judged abnormal
- 6 patulous tubes open at rest
- Last 10 patients had DNP
  - 7 showed LPR
  - 2 had unilateral mucosal changes
### Results of Video Endoscopy

<table>
<thead>
<tr>
<th>ME Pathology</th>
<th>Normal</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mucosal Edema</td>
<td>48</td>
</tr>
<tr>
<td>Reduced lateral wall motion</td>
<td>43</td>
</tr>
<tr>
<td>Polyp or Obstruction</td>
<td>15</td>
</tr>
<tr>
<td>Reduced tubal dilation</td>
<td></td>
</tr>
<tr>
<td>Moderate</td>
<td>26</td>
</tr>
<tr>
<td>Minimal</td>
<td>21</td>
</tr>
<tr>
<td>None</td>
<td>11</td>
</tr>
</tbody>
</table>
Laser Eustachian Tuboplasty

- Kujawski introduced the procedure in 1997
- Evaluated patients with video endoscopy
- Used CO$_2$ Laser to ablate mucosa, soft tissue and cartilage
Valve – “5mm long portion of cartilaginous tube just proximal to bony cartilaginous isthmus
Laser Eustachian Tuboplasty

Procedure

- Septoplasty if indicated
- Local infiltration of 1% xylocaine to Torus
- Insert Dingman retractor
- Dilation with 2mm merocel in 1:10,000 epi
- Insert 30° 4mm nasal endoscope
- Identify posterior cushion by palpation
- Fiber delivered laser introduced thru mouth
  - 980-nm contact tip diode 7W for .2 sec pulses
  - Argon ion Laser 3W continuous
Laser Eustachian Tuboplasty

Procedure

- Ablation of tissue
  - Start with oval shape defect centered on free edge of lamina
  - Ablate majority of tissue on anterior surface of posterior cushion.
  - Ablation to depth of cartilage proximal to distal
    - 2 to 3 mm from functional valve
  - Severe obstruction – ablation to valve in submucosal plane
  - Dynamic dysfunction – laser vaporization of cartilage
  - Merogel pack at completion
Laser Eustachian Tuboplasty
Laser Eustachian Tuboplasty

Procedure

- Discharged same day
- Antibiotics coverage for one week
- Follow up
  - 1 week
  - 3 mo, 6 mo, 9 mo
- Nasal steroid for one month
- Proton pump inhibitor
- Start tubal speech therapy 10 days PO
Laser Eustachian Tuboplasty
Study 1  Kujawski 2004

- Inclusion criteria
  - 5 or more ventilation tubes
  - 3 consecutive years of ventilation
  - Recurrent effusion / atelectasis at extrusion
    - Grade III or IV atelectasis
    - Type B or C tympanograms

- Pre op treatment
  - 3 mo NSS
  - 3 mo PPI
  - 3 mo weekly speech therapy

- Demographics
  - 30 male
  - 26 female
  - 8 to 59 yo
    - Mean 36
  - 92 ET (48 pt)
## Laser Eustachian Tuboplasty
### Results  Kujawski 2004

<table>
<thead>
<tr>
<th></th>
<th>PreOp</th>
<th>1 year</th>
<th>2 years</th>
<th>3 years</th>
</tr>
</thead>
<tbody>
<tr>
<td>Normal</td>
<td>0</td>
<td>63 (58.3)</td>
<td>53 (54.8)</td>
<td>56 (60.9)</td>
</tr>
<tr>
<td>3 C</td>
<td>45 (41.6)</td>
<td>15 (17.6)</td>
<td>14 (14.3)</td>
<td>11 (11.9)</td>
</tr>
<tr>
<td>3 B</td>
<td>6 (5.6)</td>
<td>4 (3.7)</td>
<td>3 (3.1)</td>
<td>3 (3.3)</td>
</tr>
<tr>
<td>4 B</td>
<td>19 (17.6)</td>
<td>19 (17.6)</td>
<td>19 (17.6)</td>
<td>15 (16.3)</td>
</tr>
<tr>
<td>OME</td>
<td>38 (35.2)</td>
<td>7 (6.5)</td>
<td>9 (9.2)</td>
<td>7 (7.6)</td>
</tr>
</tbody>
</table>
Laser Eustachian Tuboplasty
Complications  Kujawski 2004

- No operative complications
- Post op complications
  - Peritubal synechia 8%
  - Epistaxis .9%
- Mild sore throat 2 to 5 days
- LPR in 71%
Laser Eustachian Tuboplasty
Study 2    Poe 2003

- Inclusion criteria
  - 2 or more ventilation tube for OME
  - 5 years of CHL
  - Recurrence of OME at tube extrusion

- Medical treatment
  - 8 wks Antihistamines if indicted
  - 8 wks omeprazole 20mg qd
  - 8 wks NSS

Demographics
- 10 patients
- 7 male
- 3 female
- 29 – 62 yo
- Mean 42.3 yo
**Laser Eustachian Tuboplasty**

*Results*  Poe 2003

<table>
<thead>
<tr>
<th>Patient No.</th>
<th>Middle Ear</th>
<th>Tymp</th>
<th>6 Months</th>
<th>Middle Ear</th>
<th>Tymp</th>
<th>12 Months</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>nl</td>
<td></td>
<td></td>
<td>nl</td>
<td>A</td>
<td></td>
</tr>
<tr>
<td>2</td>
<td>ome</td>
<td></td>
<td></td>
<td>ome</td>
<td>B</td>
<td></td>
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<tr>
<td>3</td>
<td>neg</td>
<td>C</td>
<td></td>
<td>neg</td>
<td>C</td>
<td></td>
</tr>
<tr>
<td>4</td>
<td>neg</td>
<td>C</td>
<td></td>
<td>nl</td>
<td>A</td>
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<tr>
<td>5</td>
<td>ome</td>
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<td>neg</td>
<td>B</td>
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<td>9</td>
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<td>10</td>
<td>neg</td>
<td>B</td>
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</tbody>
</table>

Tymp = impedance tympanograms results, A = normal, B = flat, C = negative pressure; nl = normal; ome = otitis media with effusion; neg = retracted tympanic membrane but mobile with negative pressure insufflation and aerated middle ear.
Laser Eustachian Tuboplasty
Complications Poe 2003

- 1 patient with severe LPR
  - intranasal synechia
  - delayed orifice granuloma
- 1 patient with clinically insignificant ET adhesion
**VMLT Score**

<table>
<thead>
<tr>
<th>TABLE I. VMLT Eustachian Tube Dysfunction Score.</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>V (valve)</strong></td>
</tr>
<tr>
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<tr>
<td></td>
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<td></td>
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<td></td>
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<tr>
<td><strong>M (mucosal disease)</strong></td>
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<td></td>
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<tr>
<td><strong>L (LVP function)</strong></td>
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<td></td>
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<tr>
<td><strong>T (TVP function)</strong></td>
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</tbody>
</table>

LVP = levator veli palatini; TVP = tensor veli palatini.
Four Fundamental Pathologies

1. Primary Mucosal Disease
   - 83% of patients with ETD
2. Reflux From Nasopharynx
3. Muscle Dyskinesis
4. True Anatomic Obstruction
The Eustachian Tube Dysfunction Questionnaire (ETDQ-7)

- Discriminated between patients with and without Eustachian Tube Dysfunction p=<.001

<table>
<thead>
<tr>
<th>TABLE 1. The Seven-Item Eustachian Tube Dysfunction Questionnaire.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Over the past 1 month, how much has each of the following been a problem for you?</td>
</tr>
<tr>
<td>1. Pressure in the ears?</td>
</tr>
<tr>
<td>2. Pain in the ears?</td>
</tr>
<tr>
<td>3. A feeling that your ears are clogged or “under water”?</td>
</tr>
<tr>
<td>4. Ear symptoms when you have a cold or sinusitis?</td>
</tr>
<tr>
<td>5. Crackling or popping sounds in the ears?</td>
</tr>
<tr>
<td>6. Ringing in the ears?</td>
</tr>
<tr>
<td>7. A feeling that your hearing is muffled?</td>
</tr>
</tbody>
</table>
Microdebrider Eustachian Tuboplasty

- Microdebrider is used to remove inflamed soft tissue from luminal side of the posterior cushion
  - Starts from nasopharyngeal edge and extends up to the valve
  - Mucosa is spared in the valve area to prevent synechiae
- Combined with ESS or adenoidectomy
Balloon Eustachian Tuboplasty

Pre Operative Considerations

- Carefully selected patients with acquired dysfunction
- Evaluate for causes of mucosal edema
  - Reflux
  - Allergies
  - Granulomatous diseases
  - Adenoid hypertrophy
  - Sinus disease
- Pre op CT to assess for dehiscence of the internal carotid artery
**Balloon Dilation**

- 70-degree frontal sinus guide
- 6 or 7 mm X 16 mm balloon
- Advance superiorly until resistance is met. Never past 31 mm, yellow mark
- Inflate to 12 atm
- 1 to 2 minutes
Balloon Catheter Dilation of Eustachian Tube: A Preliminary Study

- 70 adults with ETD
  - Age 18 to 73
  - 30 bilateral
  - 100 cases of ET dilation
- 37% under topical in office
  - 59% had concomitant surgical procedures
- F-70 guide
- 5mm X 16mm balloon
- Inflated to 8 atm for 30 sec

Catalano, PJ 2012
Overall 71% with improvement
- Average follow up 30.3 weeks
- 7 of 8 followed 34 months had persistent improvement

Tympanograms were B or C in 28 ears
- 25 (90%) resolved to type A

One complication on post op day 2 with preauricular subcutaneous emphysema

Catalano, PJ 2012
References

Bluestone, CD. MD; Doyle, WJ. MD Eustachian tube function; physiology and role in Otitis Media. Annals of oto, rhino, Lary supp 1985; 120(sept-oct) 1-60.


Klug, Clemens, Fabinyi: Endoscopy of the Middle Ear through the eustachian tube: Anatomic possibilities and limitations. Am J Oto 1999. 20(3)299-303


Poe, DS, Silvola, J. Balloon Dilation of the Cartilaginous Eustachian Tube. Otol HNS 144(4) 563-569 March 2011


Future Considerations

- Topical application of medications
  - Steroids
  - Hormones
- Eustachian Tuboplasty without Laser
  - Coblation
  - Liposuction
- Histopathologic study of isthmus
- 24 hour Eustachian Tube pH probe