Paragangliomas of the Temporal Bone

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Outline

• Historical Perspective
• Case Presentation
• Tumor Biology
• Tumor Classification
• Diagnosis
• Management
Temporal Bone Paraganglioma: Historical

- Surgical adaptation has occurred with diagnostic advances
- Early operations limited by morbidity/mortality
- 1949 – Lundgren attempted jugular bulb resection
- 1964 – Shapiro and Neues advocated wide exposure of neck anatomy and rerouting of facial nerve
- 1969 – House proposed conservation surgery and extended facial recess approach
- 1977 – Fisch proposed infratemporal fossa exposure for disease that extended beyond temporal bone
- 1980 – Kinney and Fisch addressed issue of intracranial extension
- Jackson emphasized reconstruction, hearing conservation
Patient—History

- 66 y/o female presents with hearing loss and tinnitus
- Hearing loss; slightly worse in the left ear
- Left pulsatile tinnitus
- Imbalance; no true vertigo
- No previous otologic surgery
Patient—Physical Exam

- Otoscopy:

- Tuning Forks
  - Weber midline
  - AC > BC bilaterally with 512 and 1024 Hz

- C.N. Exam
  - Normal
Audiogram
MRI
MRI
Paragangliomas

- Rare tumors derived from the paraganglionic system
  - Sympathetic
  - Parasympathetic
- Incidence of 1:30,000
- Carotid body tumors >> jugulotympanic >> glomus vagale
- Chemoreceptors sensitive to changes in serum pH, pCO2 and pO2
Paragangliomas

- 80% sporadic
  - Autosomal dominant inheritance
- Inherited forms:
  - Multicentric
  - Bilateral
  - Earlier onset of symptoms
  - Lower incidence of malignancy
- Malignant tumors
  - 6.4% for carotid body tumors
  - 17% for glomus vagale
Classification

- Current classification systems highlight importance of locoregional extent
- Accurate classification essential for surgical planning
Question #1

- Which Fisch classification best describes the following tumor?
Tumor Classification

- Fisch:
  - Anatomic classification
  - Related to morbidity
- Glasscock-Jackson
  - Differentiates tympanicum vs jugulare
- De la Cruz
  - Classifies based on surgical approach
### Fisch Classification

<table>
<thead>
<tr>
<th>Class</th>
<th>Location and extension of paraganglioma</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>Paragangliomas that arise along the tympanic plexus on promontory</td>
</tr>
<tr>
<td>B</td>
<td>Paragangliomas with invasion of the hypotympanon; cortical bone over jugular bulb intact</td>
</tr>
<tr>
<td>C₁</td>
<td>Paragangliomas with erosion of the carotid foramen</td>
</tr>
<tr>
<td>C₂</td>
<td>Paragangliomas with destruction of the vertical carotid canal</td>
</tr>
<tr>
<td>C₃</td>
<td>Paragangliomas with involvement of the horizontal portion of the carotid canal; foramen lacerum intact</td>
</tr>
<tr>
<td>C₄</td>
<td>Paragangliomas with invasion of the foramen lacerum and cavernous sinus</td>
</tr>
<tr>
<td>De₁/₂</td>
<td>Paragangliomas with intracranial but extradural extension; De₁/₂ according to displacement of the dura (De₁ = less than 2 cm, De₂ = more than 2 cm)</td>
</tr>
<tr>
<td>Di₁/₂/₃</td>
<td>Paragangliomas with intracranial and intradural extension; Di₁/₂/₃ according to depth of invasion into the posterior cranial fossa (Di₁ = less than 2 cm, Di₂ = between 2 and 4 cm, Di₃ = more than 4 cm)</td>
</tr>
</tbody>
</table>

# Jackson-Glasscock Classification

<table>
<thead>
<tr>
<th>Type</th>
<th>Glomus Tympanicum</th>
<th>Glomus Jugulare</th>
</tr>
</thead>
<tbody>
<tr>
<td>I</td>
<td>Small mass limited to promontory</td>
<td>Small tumor involving jugular bulb, middle ear and mastoid process</td>
</tr>
<tr>
<td>II</td>
<td>Tumor completely filling middle ear space</td>
<td>Tumor extending under internal auditory canal; may have intracranial extension</td>
</tr>
<tr>
<td>II</td>
<td>Tumor filling middle ear and extending into mastoid process</td>
<td>Tumor extending into petrous apex; may have intracranial extension</td>
</tr>
<tr>
<td>IV</td>
<td>Tumor filling middle ear, extending into mastoid or through tympanic membrane to fill external auditory canal; may extend anterior to internal carotid artery</td>
<td>Tumor extending beyond petrous apex into clivus or infratemporal fossa; may have intracranial extension</td>
</tr>
</tbody>
</table>

*Intracranial extension expressed as superscript*

## De la Cruz Classification

<table>
<thead>
<tr>
<th>Classification</th>
<th>Surgical Approach</th>
</tr>
</thead>
<tbody>
<tr>
<td>Tympanic</td>
<td>Transcanal</td>
</tr>
<tr>
<td>Tympanomastoid</td>
<td>Mastoid/extended facial recess</td>
</tr>
<tr>
<td>Jugular bulb</td>
<td>Mastoid/neck (possible limited facial nerve rerouting)</td>
</tr>
<tr>
<td>Carotid artery</td>
<td>Infratemporal fossa ± subtemporal</td>
</tr>
<tr>
<td>Transdural</td>
<td>Infratemporal fossa/intracranial</td>
</tr>
<tr>
<td>Craniocervical</td>
<td>Transcondylar</td>
</tr>
<tr>
<td>Vagale</td>
<td>Cervical</td>
</tr>
</tbody>
</table>
Name that structure:
Tumor Biology

- Paraganglia are associated with the sympathetic ganglia and form the neuroendocrine system
- Glomus tympanicum:
  - Paraganglionic tissue intimately related to Jacobsen’s nerve
- Glomus jugulare:
  - paraganglionic tissue associated with the jugular bulb

Anatomical distribution of paraganglia. Pheochromocytomas arise in the medulla of the adrenal gland, whereas sympathetic paragangliomas arise along the sympathetic chains in the pelvis, abdomen, and chest. Parasympathetic paraganglioma arise along the parasympathetic nerves in the head, neck, and mediastinum, the most common location being the carotid body
Etiology

- Chronic hypoxemic conditions
  - Carotid bodies undergo hypertrophy

- Familial cases:
  - Sympathetic:
    - MEN2
    - NF1
    - Von Hippel-Lindau
  - Parasympathetic
    - Germline mutations in genes encoding mitochondrial complex (Kreb’s cycle)
      - Succinate dehydrogenase
      - AD with maternal imprinting =
        - Affected father will transmit the gene to 50% of his offspring
Describe the histology:

- Characteristic “zellballen” growth pattern
- Delicate fibrovascular network surrounds each ball of chief cells
- Accentuated by reticulin stain

Biochemistry

- Chief cells:
  - Basophilic granular cytoplasm
  - produce neuropeptides and catecholamines

- Symptomatic tumor secretion 1-3%
  - Labile HTN
  - Facial flushing
  - Tachycardia

- Serum catecholamines, norepinephrine, urinary metanephrines, vanillylmandelevic acid
  - If positive, warrants an abdominal CT to look for pheo
Malignant degeneration

- 4%
  - Incidence varies from 1-12% per reports
- Regional lymph nodes, skeleton, lung, liver
- Metastases diagnosed by only by appearance of paraganglioma in sites not known as paragangliial locations
- No clear histopathological criteria

question

• What is the most common physical exam finding in the diagnosis of paraganglioma of temporal bone?

• Vascular middle ear mass
• Middle ear effusion
• Neck Mass
• Blanching of middle ear mass with pneumatic otoscopy
diagnosis

• Clinical:
  • Characteristic reddish bulge behind an intact TM
  • Brown’s sign
    • 10-30%
  • Cranial neuropathies
Question:

- What is in the differential for middle ear mass?
  - High riding jugular bulb
    - Posterior location, bluish hue
  - Facial nerve neuroma
    - Less vascular and confined to upper quadrant
  - Aberrant internal carotid artery
  - Adenoma
  - Cholesteatoma
Question:

- What is the most common presenting clinical symptom in patients with paragangliomas?

- Hearing loss
- Pulsatile tinnitus
- Dizziness
- Otalgia
Symptoms:

- Pulsatile tinnitus
  - 80%
- Hearing loss
  - 60%
  - SNHL: invasion into labyrinth
  - CHL
- Lower CN dysfunction
  - Hoarseness
  - Aspiration
  - Tongue paralysis
  - Shoulder drop
  - Facial Nerve Paralysis
Otoscopy

- Glomus Tympanicum
  - Mesotympanic mass
  - Margins visualized at 360 degrees

- Glomus Jugulare
  - Full extent of margins cannot be identified
Diagnostic WorkUp

• Diagnostic objectives:
  • Determine tumor size and extent
  • Assess for associated lesions
  • Evaluate for neuroendocrine secretion
  • Determine intracranial extension
  • Assess collateral circulation
Imaging

- Thin section temporal bone CT
- Best test to differentiate glomus jugulare tumors from glomus tympanicum
Imaging

- MRI
  - Superior in determining tumor vascularity, extension along nerves/vessels and multicentricity
  - Intracranial extension
  - Relation of tumor to regional neurovascular structures
- On T1WI –
  - Paragangliomas appear hypointense with speckled appearance
- Gad-enhanced-
  - Early, pronounced enhancement
  - Flow void patterns
Imaging

• Carotid angiography
  • Performed in preoperative period so that embolization can be performed simultaneously
    • Has been shown to decreased overall operative time and blood loss\(^1\)
    • Embolization should precede surgery by no longer than 72 hours
    • Ideally 24 hours
  • Evaluates relationship of tumor to internal carotid arteries
  • Determines tumor blood supply

• MRA
  • Sensitivity 90%
  • Specificity 92%

Tikkakoski T. Preoperative embolization in the management of neck paragangliomas. Laryngoscope 1997; 107:821-826
Angiography
Management

- Palliation
  - Observation
  - RT
- Curative
  - Surgery
- Treatment strategy based on patient age, comorbidities, tumor type
Management

- Observation
  - When natural course of patients projected lifespan is not to be affected by morbidity/ mortality of paraganglioma
    - Imaging of tumor periodically to assess biology
  - Propensity for growth and progression of symptoms
Management

- Radiation therapy vs surgery:
  - Debated amongst surgeons and radiation therapists
  - Jackson et al
    - 157 studies analyzed that addressed RT for paraganglioma
    - High incidence of hearing loss, CNS damage, osteoradionecrosis and radiation induced malignancy
    - Risks of RT are long term, unpredictable
  - Cummings et al
    - Stated that relief of symptoms and failure of tumors to grow during the remainder of patients lifetime
Radiation Therapy vs Surgery

- Gottfried et al
  - All published studies between 1994-2004
  - Tumor control rates
    - Surgery = 92.5%
    - RT = 97.7%
  - Long term control rates were not available
  - Complication rates:
    - Surgery = 8.1%
    - RT = 2.1%
- Malignant degeneration?
Management

- Radiation Therapy
  - Stereotactic RT
  - Single session focused radiation
- Current indication:
  - management of bilateral tumors with contralateral cranial neuropathies
  - Adjuvant therapy to subtotal excision
- Patients with advanced age and poor operative candidates
Management

- Elderly patients
  - Willen et al
    - Retrospective review of 5 patients
    - Limited middle ear approach with post op GKRT (15Gy)
    - All patients demonstrated resolution of tinnitus and stabilization of hearing with no cranial neuropathies
  - Cosetti et al
    - 12 patients with incomplete excision of tumor
    - Limited surgery and post op GKRT
    - Reported local control rates with avg follow up 7.8 years
Surgical Management

- Tumor spread is multidirectional and tracts along paths of least resistance

- GT:
  - Peritubal air cells
  - Intrapetrous carotid
  - Petrous apex

- GJ:
  - Erodes floor of hypotympanum
  - Retrofacial air cells
Concepts in Surgical Management

- Middle Fossa
- Infratemporal Fossa
- Transmastoid Retrolabyrinthine
- Transcochlear Translabyrinthine
- Combined
- Suboccipital
- Anterior Craniofacial
Surgical Management

- Surgical approach
  - Access to all tumor margins
  - Intracranial extension
  - Exposure to major vessels and cranial nerves
Management of CN VII and ICA

- Facial nerve
  - Anatomic roadblock to tumor exposure
  - Options include simple exposure, short mobilization, long mobilization, segmental resection
  - When facial nerve function is normal preoperatively, dissection and preservation is the goal
Management of CN VII and ICA

- Internal carotid artery
  - Proximal and distal control
  - Involvement of ICA by tumor cannot always be determined preoperatively
- If sacrificed, reconstitution with interposition graft or extracranial bypass
Surgical Techniques: Glomus Tympanicum

- Usually pedicled on tympanic branch of the ascending pharyngeal artery
- Bipolar/ laser used to shrink tumor
- Involvement of jugular bulb necessitates abortion of procedure
Surgical Techniques: Glomus Tympanicum

- Type I: transcanal
Surgical Management: GT

- Types II-IV: transmastoid
  - Infratympanic extended facial recess approach
  - Fallopian bridge technique
Surgical Management: Glomus Jugulare

- Types I/II: hearing conservation
  - Cervicomastoid approach
  - Complete mastoidectomy with extended facial recess
Surgical Management

- Glomus Jugulare
  - Types III/IV
  - Tumor growth into infratemporal fossa
Surgical Management: Lateral Infratemporal Fossa Approaches

- Fisch approaches
- Prototypic otologic approaches to the ITF
- Facial nerve rerouting with dural exposure for wide access to the lateral skull base
Surgical Management

- Lateral Infratemporal fossa approach:
  - Fisch Type A:
    - Cervical approach with vascular control of carotid and jugular vein
    - Mastoid with skeletonization of jugular bulb with proximal control
    - Blind closure of EAC
    - Anterior rerouting of facial nerve
  - Disadvantages:
    - Conductive hearing loss
    - High incidence of post op facial paralysis
    - Lower cranial neuropathies
Surgical Management

- Fisch type B:
  - Reflection of the zygomatic arch and temporalis with removal of skull base floor to provide access to ITF
  - TMJ dislocation
  - Subtotal petroussectomy with complete exposure of ICA
Surgical Management

- **Fisch C:**
  - Fisch B + resection of pterygoid plates
  - Exposure of the lateral wall of nasopharynx, ET, posterior maxillary sinus

- **Fisch D:**
  - Preauricular incision
  - Conductive hearing not sacrificed
  - Facial nerve not rerouted
  - Orbitozygomotomy with resection of middle fossa floor
Anatomy of the Jugular Foramen

- **Pars nervosa:**
  - Anteromedial
  - IX
  - Jacobsens
  - Inferior petrosal sinus

- **Pars vascularis**
  - Posterolateral
  - X
  - XI
  - Arnolds nerve
  - Jugular bulb
  - Posterior meningeal branch of ascending pharyngeal artery
Intracranial Extension

- Spread through dura into subarachnoid space
  - Spread into posterior fossa:
    - Direct
    - Along cranial nerves by way of pars nervosa
- Resection of entire tumor as a single unit in a single stage is considered current standard
Reconstruction

- Single stage resection is current standard
- Challenges of reconstruction
  - Complex bone/soft tissue defects
  - Lack of local tissue availability
  - CSF pressures exacerbated by venous obstruction
  - Regional tissue affected by RT or carotid artery compromise
Reconstruction

- Reconstruction is size dependent
- However, small defects may still require complicated reconstructions
- End goal is tight closure of CSF leak
  - Vascularized tissue
  - Tissue bulk to reinforce dura
  - CSF decompression via lumbar drain
reconstruction

- Temporoparietal flap
  - +/- abdominal fat
  - Lumbar drain

- Lower trapezius flap
  - Moderate to large defects
  - Cover ICA

- Free flap
Cranial nerve rehabilitation

- Rehabilitation guidelines
  - Netterville et al
  - The Otology Group
- Shorten post surgical rehab time and improve overall outcomes

Outcomes

- **Glomus tympanicum**
  - **Otology Group**
    - 80 patients with GT
    - MC presenting sx: tinnitus, hearing loss, aural fullness
    - Type I: 34% Type II: 52%
    - Type III: 3% Type IV: 11%
  - Urine catecholamines, MR imaging and angio were negative in all but one patient
  - Mastoid approach performed in 89%
  - 2 recurrences (@ 3 and 14 years)
  - One CVA

Outcomes

- Glomus Jugulare
  - The Otology Group
  - 176 patients with skull base paragangliomas
    - 152 for GJ
    - 27 for GV
    - 2 carotid body tumors with skull base extension
  - GJ
    - Type I: 21%
    - Type II: 20%
    - Type III: 34%
    - Type IV: 23%
  - Elevated catecholamines: 9.7%
  - Multicentric lesions: 9%
  - Malignant tumors: 3%
  - Recurrence rate: 5.5%
    - Time to recurrence avg: 98 months
  - Preop CN deficits: 46%
    - VII: 18%; VIII, 13%; IX, 21%; X, 30%; XI, 17%; XII, 24%; any cranial nerve, 46%

references