In practice, patients with AN can currently choose from different therapeutic options, including observation, microsurgery or radiosurgery and the discipline of the attending physician is the greatest predictor of treatment choice.

Dennis I Bojrab, MD; Kyle Robinette, DO
Michigan Ear Institute
Financial Disclosure --- Gamma Knife Center
Trends in Management of Acoustic Neuroma
Trends in Management of Acoustic Neuroma

• Definition / Epidemiology
• Diagnostic dilemma – accuracy vs cost
• Treatment options
  • Observation – who is a candidate
  • Surgery – which approach and when to choose
  • SRS – only with growth or does it matter?
• Paradigm tree for management
# Trends in Management of Acoustic Neuroma

## Incidence

- **Actual Clinical**
  - 5,000-6,000 / yr in US 2 / 100,000

- **Pathologic Occult**
  - Temporal Bones 570 / 100,000

- **Radiologically Incidental**
  - 17 / 24,000 70 / 100,000
Acoustic Neuroma

T M I

- Probable AN US 1995-2015
- 5-6,000/y x 20 years = >100,000 patients/20y
- Papers written during this time
  - 3,000 articles
  - 2,024 Human + English
  - 1,500 from US
    - Otology/ENT 50%
    - Neurosurgery 22%
    - RO, Oncology, Neurology 16%
- Internet searches ????????????
Trends in Management of Acoustic Neuroma

aka: Acoustic Schwannoma

Acoustic neuroma, neurinoma, neurolemoma

Vestibular schwannoma

Vestibular neurilemoma

Schwann cell derived tumor usually arising from vestibular portion of vestibulocochlear nerve, aka acoustic nerve (VIII). Some tumors in this region may originate from the cochlear or facial nerves.
Acoustic Neuroma
Epidemiology

- 6% intracranial tumors (most common PFT)
- Slow-growing, non-cancerous, extra-axial intracranial tumor
- No race but slight gender predilection (F>M)
- Incidence 0.5-2 /100,000 per year (1976 = 49 yo, 2008 = 58 yo)
- Sporadic - 95% (average 50yo)
- Neurofibromatosis II (AD-50%) - 5% (average 25yo) (Avastin)
- Long arm of Chromosome 22 (tumor suppressor protein merlin)
  Overproduction of tyrosine kinases implicated in onconeogenesis
  Obersteiner-Relich zone glial-Schwann cell junction near porous
<table>
<thead>
<tr>
<th>Minor Symptoms</th>
<th>Major Symptoms</th>
</tr>
</thead>
<tbody>
<tr>
<td>SNHL</td>
<td>FN paralysis or HFS</td>
</tr>
<tr>
<td>Tinnitus</td>
<td>Trigeminal hypesthesia</td>
</tr>
<tr>
<td>Vertigo</td>
<td>Ataxia</td>
</tr>
<tr>
<td>Imbalance</td>
<td>Long tract signs</td>
</tr>
<tr>
<td>Headache</td>
<td>Hydrocephalus</td>
</tr>
<tr>
<td>Facial Nerve weakness</td>
<td>Coma</td>
</tr>
<tr>
<td></td>
<td>Death</td>
</tr>
</tbody>
</table>
Trends in Management of Acoustic Neuroma
Diagnostic Dilemmas

- Most common symptom is SNHL and tinnitus
- Symptoms or signs must be taken into account
- Audiogram
  - Asymmetric hearing loss PTA
  - (15 dB 2 consecutive frequencies or SD 15 %)
- ABR 90% accuracy (interaural V latency > 0.2 ms or absent)
  - Stacked ABR calculates summing wave V amplitudes at narrow band segments (tonal)
  - OAE (normal cochlear function)
- MRI + Gadolinium = gold standard but expensive
  - T2W (FSE); T2star (CISS or FIESTA) less costly and no Gadolinium

Murphy MR, Selesnick SH; “Cost-effective diagnosis of acoustic neurmas: OHNS, 2002 253-259
• Slow-growing, non-cancerous, extra-axial intracranial tumor

• Options include
  • Microsurgery (1963 House / HIselberger)
  • Observation
  • SRS introduced in 1984 in US in Pittsburg

• Chemotherapy? (Avastin)

• In practice, patients with AN can currently choose from different therapeutic options, including observation, microsurgery or radiosurgery and the discipline of the attending physician is the greatest predictor of treatment choice.
Trends in Management of Acoustic Neuroma

• Conservative Decision Tree
  • Time to decide
  • Identify Multidisciplinary Center of Excellence
  • Speak with other patients & family
  • Try to stop internet browsing and support groups

• Must treat
  • Large or Giant tumors
  • Facial and balance issues
  • Hydrocephalus
Treatment Considerations

- Patient age, occupation and life style (asymptomatic ?)
- Tumor size (primary or residual)
- Hearing (tumor size, opposite, PTA, SD)
- Balance issues
- Facial nerve issues (paresis, paralysis or HFS)
- Co-morbidities (surgery)
- Patient experiences
- Surgeon experiences (options for approaches)
## MEI Acoustic Neuroma Experience

December 2000 – 2009  (N = 2,875 patients)

- **Treated AN patients**
  - Surgical patients 1,155  40%
  - Large Tumors 153  13% total
- **Observed AN patients** 1,725  60%
- **Total AN patients** 2,875  100%
MEI Acoustic Neuroma Experience
December 2006 – 2010 (N = 765 patients)

• Treated AN patients
  • Surgical patients  291  38%  (75%)
  • Subtotal AN      50   (13%)
  • SRS (GK and Linac) 97  13%  (25%)
  • Total            388  51%

• Observed AN patients  377  49%

• Total AN patients    765  100%
MEI Acoustic Neuroma Experience

- Treated AN patients
  - Single surgery
    - Translabyrinthine
    - Retrosigmoid
    - Combined
    - Endoscopic
  - Staged surgery
    - TL or RS
    - TL and RS
  - Multi-modality
    - Combined surgery and SRS
Approach to Large Tumors

• Planned subtotal reasoning
  • Pre operative
    • Elderly (possible no other treatment)
    • Facial nerve problems
    • Cranial nerve problems (facial numbness, hoarseness, imbalance, etc.)
    • Brain issues (hydrocephalus, BS shift, papilledema, etc.)
  • Intra operative
    • Bleeding
    • Cranial nerve complications
    • Blood pressure or heart rate changes
Approach to Large Tumors

- Surgery either total or planned subtotal
- Subtotal may be near total or planned ST
- Planned subtotal, surgery in 6-9 months or observation
- Near total, observe and follow
- Watch for growth, repeat scans q 6 months for 2 years, then yearly for 3 years then in 3 years and then q 5 years
- Growth of tumor requires surgery or SRS
Acoustic Neuroma
Planned Subtotal
Acoustic Neuroma
Subtotal
Large AN Planned Subtotal
Planned Subtotal

6 months post op

6 months post op
Subtotal Removal

? years post op

? years post op
TL Surgery now what?

Regrowth in 6 months
<table>
<thead>
<tr>
<th>GRADE</th>
<th>(N=153)</th>
</tr>
</thead>
<tbody>
<tr>
<td>I</td>
<td>102 (67%)</td>
</tr>
<tr>
<td>II</td>
<td>18 (12%)</td>
</tr>
<tr>
<td>III</td>
<td>20 (13%)</td>
</tr>
<tr>
<td>IV</td>
<td>6 (4%)</td>
</tr>
<tr>
<td>V</td>
<td>3 (2%)</td>
</tr>
<tr>
<td>VI</td>
<td>4 (2%)</td>
</tr>
</tbody>
</table>

Grades I-III 85% Facial nerve preservation
MEI EXPERIENCE WITH LARGE ANs

Improved Facial Nerve Outcomes

- Approach to Tumor Removal
  - “Take only what the tumor gives.” (Staged removal)
  - Team approach
  - Experience
  - High volume
  - Intraoperative FN monitoring with stimulating dissectors
  - Meatal decompression
MEI EXPERIENCE WITH LARGE ANs

Conclusion

• 153 patients with large (3cm or greater) acoustic neuromas

• 79% of patients with grade I/II facial function compared to 49% grade I/II facial nerve preservation rate in historical review

• High volume, experienced center

• Combination of staged surgery and conventional single stage surgery or multi-modality treatment plans.

• “Take what the tumor gives.”
Trends in Management of Acoustic Neuroma – Hearing Expectations

- Long term results of hearing with modalities of treatment
- Observation / Radiation / Surgery
- Generally small to medium tumors
- Treatment modalities generally with younger patients
- Co-morbidities may push toward one treatment modality with growing tumors
- May go from one treatment to another if symptoms occur
### Committee on Hearing & Equilibrium Guidelines for Evaluation of Hearing Preservation in Acoustic Neuroma


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</tr>
<tr>
<td>D</td>
<td>any level</td>
<td>&lt;50%</td>
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![AAO-HNS Hearing Class Diagram](image-url)
Gardner-Robertson Hearing Classification System
Stereotactic radiosurgery for acoustic tumors

Table 1. Gardner-Robertson Hearing Classification System

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<td>50-89</td>
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<td>Nonserviceable</td>
<td>51-90</td>
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</tr>
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<td>None</td>
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<td>0</td>
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From Linskey ME et al. With permission of W. B. Saunders Company.
Comparison: AAO vs GR
Hearing Nomogram

AAO-HNS Hearing Class

Gardner-Robertson Hearing Class
Hearing Expectations
Observation Results

• “Conservative management of Vestibular Schwannomas, third review of a 10-year prospective study.” Hajioff, D, e. al., 2008 Clinical Otolaryngology 33, 255-64.

• 72 pts; median size 9.8mm; 25% IAC – 75% CPA; 94% small tumors

• 75% of failures are within 5 years over all 45% failed within 10 years

• Audiometric results on 40 patients of conservative group and all had significant HL even if tumors did not grow, growing had more HL

• Baseline 10 year follow up

<table>
<thead>
<tr>
<th>PTA dB</th>
<th>SDS %</th>
<th>PTA dB</th>
<th>SDS %</th>
</tr>
</thead>
<tbody>
<tr>
<td>43 +/- 17.5</td>
<td>63.5 +/- 27.5</td>
<td>35.5 +/- 21</td>
<td>40.5 +/- 28.5</td>
</tr>
</tbody>
</table>
Hearing Expectations

Observation Results (Hajioff)

- Considering the long follow-up, the failure rate of 35–40% and the good clinical outcomes in those who ultimately required active treatment are reassuring. Our large cohort allows an acceptably accurate estimate of the true failure rate as evidenced by the width of the confidence intervals. Previously published failure rates vary widely from 0 to 50%. Three-quarters of our failures occurred during the first half of the 10-year study.

<table>
<thead>
<tr>
<th>Base line hearing at beginning</th>
<th>Added change 10 yr</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>PTA</strong></td>
<td><strong>SDS (%)</strong></td>
</tr>
<tr>
<td><strong>No growth</strong></td>
<td>39+/-15</td>
</tr>
<tr>
<td><strong>Growth</strong></td>
<td>46+/-19</td>
</tr>
</tbody>
</table>
Hearing Expectations
Observation Results

- “Change in Hearing during wait and scan management of patients with VS” Thomsen, J, et. Al., 2008 Journal of Laryngology and Otology (Denmark)

- 636 patients “wait and scan”

- 334 (53%) had good hearing and SD 70% - 10 years follow up - 31%

- 17% SD 100% - 10 years 88% had better than 70% SD

- 13% SD 90% - 10 years 55% had better than 70% SD

- 10% SD > 70% - 10 years 38% of those had better than 70% SD

- At Diagnosis - Mean SD 62% Last eval – SD = 47.7%
“Change in Hearing during wait and scan management of patients with VS” Thomsen, J, et. Al., 2008 Journal of Laryngology and Otology (Denmark)

- AAO classification
- 129/636 (20%) Class A hearing (78% on non tumor side)
- 62/129 (48%) retained Class A hearing
- 314/636 (49%) Class A and B
- 154/314 (49%) retained Class A / B hearing
Hearing Expectations
SRS Gamma Knife Results

- “Hearing preservation after GKRS for VS presenting with high level hearing” Tamura, Regis, et al, Neurosurgery vol.64, number 2; February 2009 (Marseille, France) (no waiting period to treat)

- 74 with GR I, 3-11 yr follow up (median 4 yr)

- 50% GR I ; 78% GR I or II ; 8 % lost all hearing (3yr)

- Better outcome if <4 Gy to cochlea

- If presentation HL, then worse outcome, if tinnitus or dizziness then hearing results were better.
Hearing Expectations  
SRS Gamma Knife Results


<table>
<thead>
<tr>
<th>GR Class</th>
<th>I</th>
<th>II</th>
<th>I</th>
<th>II</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 year</td>
<td>95%</td>
<td>96%</td>
<td>84%</td>
<td>87%</td>
</tr>
<tr>
<td>3 years</td>
<td>89%</td>
<td>93%</td>
<td>65%</td>
<td>73%</td>
</tr>
<tr>
<td>5 years</td>
<td>77%</td>
<td>88%</td>
<td>33%</td>
<td>55%</td>
</tr>
<tr>
<td>10 years</td>
<td>51%</td>
<td>64%</td>
<td>29%</td>
<td>55%</td>
</tr>
</tbody>
</table>
Hearing Expectations
SRT > SRS Results (LINAC)


- Physical examination and magnetic resonance imaging to assess tumor size was performed every 6 months or more frequently, depending on clinical indication. Hearing was categorized as useful hearing, poor hearing, or no hearing on physical examination. Useful hearing was defined as the capacity to use the phone unaided and to discriminate normal speech in the affected ear. Hearing preservation was defined by either stable or improved hearing at the last clinical follow-up compared with pre-treatment baseline hearing.

- SRT had 90% while SRS had 32-71%
Hearing Expectations
Fractionated Stereotactic RT Results


- 42 with 21pts with GR I or II hearing; minimum 2 year follow up
- 54 Gy in 27-30 fractions over 5-6 weeks
- 8/21 or 38% at 2 years and none at 10 years
- 1.8 times higher HL than control no treatment group
- Tumor control – 91.5% 4 years and 85% at 10 years
“Long Term Hearing Preservation after Microsurgical Excision of Vestibular Schwannoma” ; Gantz, B.J., et al., Otology Neurotology 2010

- 49 had mean of 70.5 months (25-163)  96% HB 1 PO

- Looked at WRS; AAO guidelines and Gardner Roberston Scale

- WRS determines most important factor in serviceable hearing

- WRS I PO then 76% initially then 68% retained WRS I at 5 years

- WSR (I or II)  96% retained WSR I or II at latest FU
“Long Term Hearing Preservation after Microsurgical Excision of Vestibular Schwannoma”; Gantz, B.J., et al., Otology Neurotology 2010

- 31/49 (63%) AAO Class A, 15 (31%) Class B and 3 had Class C/D
- 16/31 (51%) preserved Class A PO (6 – A and 9 – B over 5 years)
- 27 Class B PO 81% remained 5 years (some dropped then improved)
- 42 Class A/B PO 85% retained for over 10 years
- 43/46 (93%) GR I/II long term (C is non serviceable but not in GR)
Hearing Expectations
Surgical Results SO approach

- 126 <2cm SO resection
- 43/126 (34%) hearing preservation
- 30 pts min. 3 years Class A/B hearing in 97% pre-op
- 77% early PO and 57% late PO
- 12/30 (40%) significant progressive HL
Acoustic Neuroma
Endoscopic Technique
Acoustic Neuroma
Endoscopic
Trends in Management of Acoustic Neuroma
Review Article

• 21 articles 1989-2003 = 1,345 patients
• Article patients 13-123
• Follow up 3.2 years, 2.2-5 years
• 1 study 5 years; 3 studies >4 years
• Actual length 0.1-18 years
• Average age 62
• Tumor size – 5 studies extra IAC; 7 both IAC and E IAC; 9 ?
• NF II included in 5 studies, excluded in 8, not stipulated in others

Trends in Management of Acoustic Neuroma
Review Article – Criteria for Observation – Type 3 or 4 studies

- Advanced age – 14
- Patient’s decision – 13
- Poor health / medical risk – 12
- Hearing status – 9
- Tumor size – 9
- Asymptomatic – 7
- Other / not stipulated - 5

Trends in Management of Acoustic Neuroma
Review Article – Criteria for Observation – Type 3 or 4 studies

- Hearing status 347 patients from 9 studies
  - Preservation 49% ; Lost 51% ; follow up length not stated

- Predictive Factors
  - 10 studies – 620 patients – no predictive factors
  - 4 – 255 pts – positive growth 1 year predicts future growth
  - 1 – 119 patients – > 2cm predicted growth (widened IAC)

- Failure of Conservative Treatment
  - 15 studies – 1001
  - 20% failed from growth, additional sxs – V, VII, VIII

Trends in Management of Acoustic Neuroma

Observation vs GKRS

- Hearing Results
  - Obs = 76%  
  - GKRS = 64%

- Dizziness or Imbalance
  - Obs = minimal  
  - GKRS = 30%

- Quality of Life Scores were equal
  - Obs = 76%  
  - GKRS = 64%

- Tumor Growth
  - Obs = 65% (3.3 y)  
  - GKRS = 50% (14.5 y)

Brelvik C; Congress of Neurologic Surgeons Vol 73, Number 1, July 2013
Acoustic Neuroma
Conservative Management

- > 60% tumors will grow 1-3 mm y
  - Depends on location IAC or CPA
  - Depends on age of patient
  - Depends on length of follow up
  - > 3.5 y - 17% IAC and 29% CPA
  - > 5 y - 45% IAC

- Hearing will deteriorate over time
  - Regardless of tumor growth
  - Loss of useful hearing (Class A or B)
  - Lose opportunity for hearing preservation microsurgery?

Acoustic Neuroma
Conservative Management

- >55% tumors will grow 1-3 mm yr when followed for 7 yrs
  - Depends on location, IAC or CPA
  - Depends on age of patient (and time of f/u)
  - Ways of measuring tumor growth differs - not consistently reviewed
  - Stable does not equal NO GROWTH
  - Smaller tumors, a period of observation is reasonable
  - LOOK AT YOUR OWN SCANS

- Hearing will deteriorate over time
  - Regardless of tumor growth
  - Loss of useful hearing (Class A or B)
  - May loose opportunity for hearing preservation microsurgery?
  - What are the facts?
### Guidelines for Evaluation of Hearing Preservation in Acoustic Neuroma

**Committee on Hearing & Equilibrium Guidelines for Otolaryngol Head Neck Surg 1995; 113:179-180**

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<td>&gt;50dB</td>
<td>&gt;50%</td>
</tr>
<tr>
<td>D</td>
<td>any level</td>
<td>&lt;50%</td>
</tr>
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#### Figure:

- **SDS:**
  - A: 100%
  - B: 70%
  - C: 50%
  - D: 0%

- **PTA:**
  - A: <30dB
  - B: >30dB
  - C: >50dB
  - D: any level

- **SDS Range:**
  - 100%
  - 70%
  - 50%
  - 0%

- **PTA Range:**
  - <30dB
  - >30dB
  - >50dB
  - any level

- **Color Coding:**
  - A: Red
  - B: Green
  - C: Blue
  - D: Yellow

- **AAO-HNS Hearing Class:**
  - A
  - B
  - C
  - D
## Gardner-Robertson Hearing Classification System

Stereotactic radiosurgery for acoustic tumors


### Table 1. Gardner-Robertson Hearing Classification System

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Comparison: AAO vs GR
Hearing Nomogram

AAO-HNS Hearing Class

Gardner-Robertson Hearing Class

SDS

PTA
Acoustic Neuroma
Management GKRS

• Experienced multidisciplinary team approach
  • Neurotologist, Neurosurgeon and Radiation Oncologist

• Long term results are necessary (>20 years)

• Gamma Knife Center Plan
  • Audio, Vestibular, Facial Nerve (pre / post)
  • Questionnaires: HL, T, D, QOL
  • 1, 3, 6, 12, 18, 24, 36 months etc.
  • MRI – q6m x 4, then q1y X 3, then q3y
  • Surgical salvage

MEI = 112 pts 2007, ave size 0.9 cm, 50% with AB hearing, 14% prior surgery
Other = 74 pts 2007, ave size 2 cm, 30% hearing, 32% prior surgery
Indications SRS

• Preferred
  • Older or infirm patient with a small to medium growing tumor
  • Hearing preservation in growing tumor?
    • Size should be \( \leq 2.5 \) cm
  • Large tumor (>2.5 cm) – consider combined treatment with microsurgery sub total and then if growth use SRS
  • Some SRS centers are “experimenting” with large tumors (>2.5 cm) consider partial SRS treatment then wait couple of years and re treat!
  • Some centers will do any AN and do not pre assess H or D
Contra-Indications

• Strong
  • Tumor $\geq$ 3 cm
  • Long attachment to the brainstem
  • Pre operative facial nerve paresis or HFS

• Relative
  • Young < age 30
  • Previous cranial RT or SRS for same tumor
  • Compliance with follow-up

Not fair to state that this is for preservation of hearing when one looks at long term
GKRS Results

• Tumor control – 92% mean (27.2 months f/u 0.2 – 65)

• Hearing conservation
  • 64% with serviceable hearing (mean of 2.5 y)
  • 45% with Class A hearing, 70% with Class B hearing

• Dizziness Pre treatment D = 40% ; Pre Treatment ND = 90% S

• Facial Nerve function 95%

• Hydrocephalus 4.4% but no morbidity

Arthurs BJ, et al; “Gamma knife radiosurgery for vestibular schwannomas: tumor control and functional preservation in 70 patients” 2011; Spokane Washington
Trends in Management of Acoustic Neuroma

Tumor size

- Intracanalicular
  - Elderly
    - Conservative treatment
  - 45-65 y/o
    - Hearing status
      - Class A/B
        - Conservative treatment
      - Class C/D
        - XRT or Surgery
    - < 45
      - Surgery
  - > 2.5 cm
    - Surgery
Any Bad News with SRS?

- Non-control 10-15%? Need longer term follow up
- Hearing loss 35-70%, imbalance 5-20%
- Facial palsy, paresis or HFS 1-2%
- Facial numbness 3-4% (large tumors)
- Facial burning & trigeminal neuralgia 1-2%
- Pin site infection or numbness
- Need for long-term follow-up > 20 years
- Concern of malignancy 1 / 1,000 (>over years?)
- Surgery after SRS seems to be same results

Lee 2003, MEI experience
Is it Safe?

- Radiation causes DNA damage and is oncogenic.
- The true incidence is not known; estimates are extrapolations from single case reports.
- Current estimate is 1/1000 over 10 to 30 years.
- NF-2 patients safe? Studies are marred with different types of radiation and many occurred in larger tumors.

Flickinger J 2007, personal communication.
Is SRS Safe?
Is Surgery Safe?

Glioblastoma Multiforme; 2y po
Hoa et al., OHNS, 2008; 139, 323-324
SRS

- Yes, it really works
- Yes, it is safe
- Yes, there are some controversies and disagreements about the indications
- Yes, it has limitations
- Yes, it is here to stay
Trends in Management of Acoustic Neuroma

Conclusion

• The best management is controversial but multidisciplinary

• Early identification will continue to be important for best hearing

• The trend away from MS toward SRS will probably continue, except in large tumors

• MCF or Suboccipital surgery important for hearing (ideal patient)

• Larger tumors require surgery, if near total then observation

• Regrowth after SRS requires surgery

• Long term follow up necessary for SRS (>20 years) (malignancy ?)