JUGULAR FORAMEN TUMOR

R1 蔡明叡/VS 王懋哲

2014/09/12

Reference

- Bailey, Head & Neck Surgery - Otolaryngology, 5th Edition, Chapter 159
- Adams And Victors Principles Of Neurology 9th Edition, Chapter 31
- Construction Of A Three-dimensional Interactive Model Of The Skull Base And Cranial Nerves- Neurosurgery 60:901–910, 2007
- Jugular Foramen: Microscopic Anatomic Features and Implications for Neural Preservation with Reference to Glomus Tumors Involving the Temporal Bone- Neurosurgery, Vol. 48, No. 4, April 2001
- Molecular genetics of paragangliomas of the skull base and head and neck region implications for medical and surgical management- Neurosurg 120:321–330, 2014
- Importance of Preserved Periosteum Around Jugular Foramen Neurinomas for Functional Outcome of Lower Cranial Nerves: Anatomic and Clinical Studies- Neurosurgery 69[ONS Suppl 2]:ons230–ons240, 2011
- Tumors Of The Jugular Foramen: Diagnosis And Management-Neurosurgery 57:ONS-59–ONS-68, 2005
- Microsurgical Management of Jugular Foramen Schwannomas-Neurosurgery 72:42–46, 2013
- Jugular Foramen Tumors: Clinical Characteristics and Treatment Outcomes- Otology & Neurotology 31:299-305, 2010.

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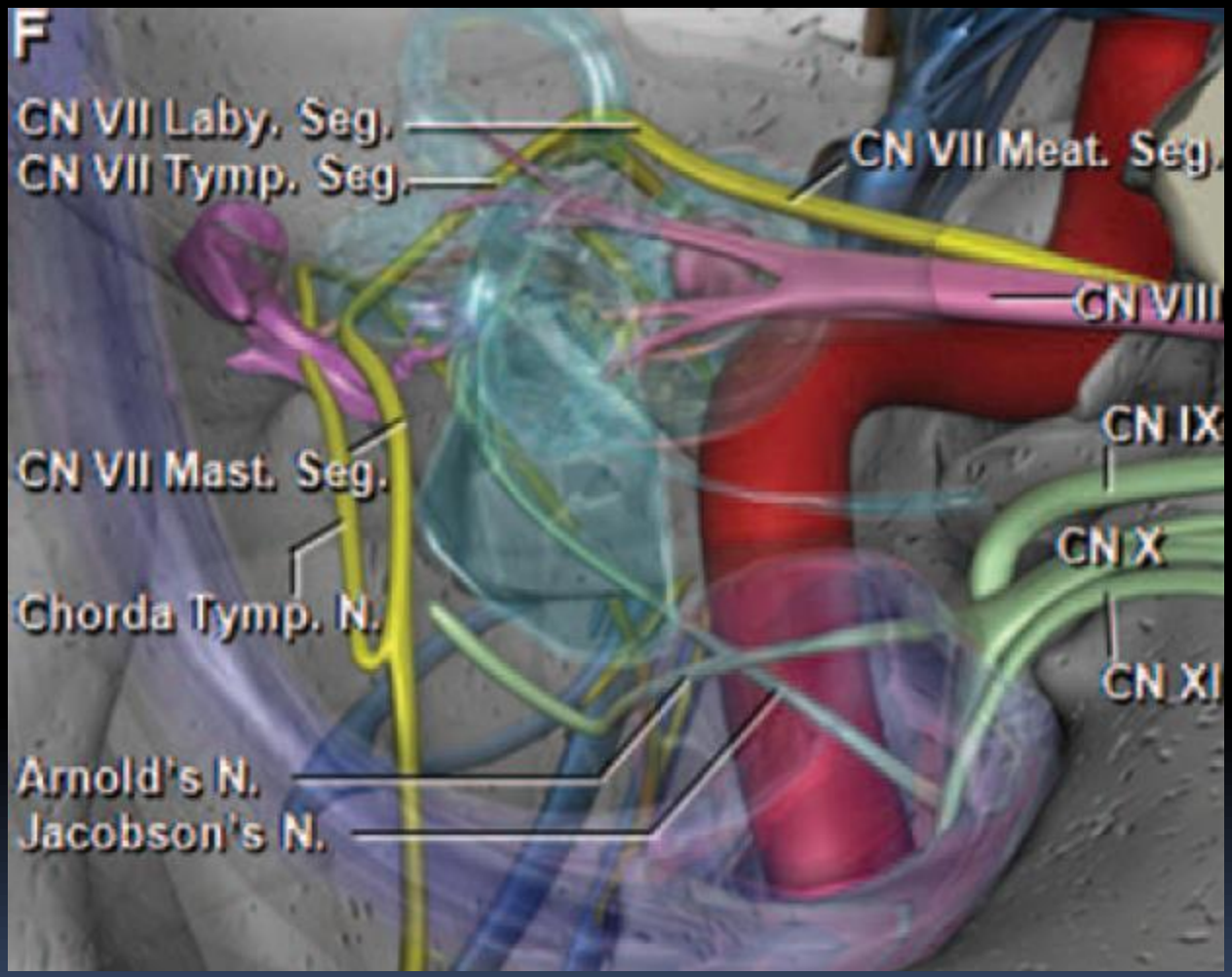
A.Introduction

- Tumors of the jugular foramen (JF)
  - Important neurovascular structures at JF
  - Cranial base, high cervical, and posterior fossa regions are involved by these lesions.
  - Paraganglioma
    - Most frequent JF tumor
    - Hearing loss and tinnitus initially
  - Combined expertise
    - NS, ENT, Neuroradiologist
    - Better diagnosis, preoperative evaluation, management
  - Radical resection with preservation of cranial nerves and vessels is the aim of treatment.

B.ANATOMY



Construction of A Three-dimensional Interactive Model of The Skull Base And Cranial Nerves- Neurosurgery 60:901–910, 2007

Horizontal section through the left jugular foramen.

The jugular bulb (JB) is separated from the cranial nerves by a bony septum.

CN IX
CN X
CN XI
V =Inferior petrosal sinus
Arrowheads=Sympathetic nerves.

Jugular Foramen: Microscopic Anatomic Features and Implications for Neural Preservation with Reference to Glomus Tumors Involving the Temporal Bone- Neurosurgery, Vol. 48, No. 4, April 2001

C.INTRA-CRANIAL TUMOR

Table 31-1 Types of Intracranial Tumors in the Combined Series of Zülch, Cushing, and Olivecrona, Expressed in Percentage of Total (Approximately 15,000 Cases)

Tumor	Percent of Total
Gliomas[a]	
Glioblastoma multiforme	20
Astrocytoma	10
Ependymoma	6
Medulloblastoma	4
Oligodendroglioma	5
Meningioma	15
Pituitary adenoma	7
Neurinoma (schwannoma)	7
Metastatic carcinoma	6
Craniopharyngioma, dermoid, epidermoid, teratoma	4
Angiomas	4
Sarcomas	4
Unclassified (mostly gliomas)	5
Miscellaneous (pinealoma, chordoma, granuloma, lymphoma)[b]	3
Total	100

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Table 31-2 Age-Specific Frequency of Tumor Types with Age			
Tumor	**Childhood, Percent**	**Adult, Percent**	**Older Adult, Percent**
Neuroepithelial tumors (glial origin)	78.1	44.6	41.9
Pilocytic astrocytoma	19.8	0.7	0
Glioblastoma	3.8	23.2	29.3
Malignant glioma	8.9	1.5	3.1
Diffuse astrocytoma	1.5	0.8	0.6
Anaplastic astrocytoma	2.5	4.4	2.7
Other astrocytoma	9.2	4.1	3.8
Oligodendroglioma	2.3	3.4	0.7
Anaplastic oligodendroglioma	0.8	1.5	0.4
Ependymomas	6.4	0.5	0.4
Mixed glioma	0.8	1.1	0.2
Embryonal/primitive/medulloblastoma	16.0	0.5	0
Meningeal tumors	4.3	29.9	39.6
Meningioma	3.1	28.4	39.1
Hemangioblastoma	0.8	1.2	0.4
Lymphoma	0.5	2.4	2.7
Sellar tumors	6.4	8.7	3.9
Pituitary adenoma	0.8	8.0	3.8
Craniopharyngioma	3.6	0.6	0
Cranial and spinal nerve tumors	2.0	11.3	3.4
Germ cell tumors	4.3	0	0
Local extension from regional tumors	0.5	0.2	0
Unclassified	3.8	2.8	8.5
Total	100.0	100.0	100.0

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WHO Brain Tumor Classification & GRADE	I	II	III	IV
Astrocytic tumors				
Glioblastoma(GBM)				◎
Oligodendroglial tumors				
Oligoastrocytic tumors				
Ependymal tumors				
Choroid plexus tumors				
Other neuroepithelial tumors				
Neuronal and mixed neuronal-glial tumors				
Gangliocytoma	◎			
Ganglioglioma	◎			
Anaplastic ganglioglioma			◎	
Paraganglioma of the spinal cord	◎			
Pineal tumors				
Embryonal tumors				
Tumors of the cranial and paraspinal nerves				
Schwannoma	◎			
Neurofibroma	◎			
Perineurioma	◎	◎	◎	
Malignant peripheral nerve sheath tumor (MPNST)		◎	◎	◎
Meningeal tumors				
Meningioma	◎			
Atypical meningioma		◎		
Anaplastic/malignant meningioma			◎	
Tumors of the sellar region				

D.CP ANGLE TUMOR

- Extraaxial lesions
  - Vestibular schwannoma
    - 6% of all intracranial tumors
    - 85% of all CPA tumors
  - Nonvestibular cranial nerve schwannomas
    - 2~3% of tumors within the CPA
  - Meningioma
    - 20% of all primary intracranial tumors.
    - 10~15% of all CPA tumors
  - Epidermoid cysts
    - 5% of all masses in CPA

- Extraaxial lesions
  - Dermoid cysts
  - Arachnoid cyst
  - Lipoma
  - Metastasis
- Intraaxial lesions
- Skull base lesions
  - Paraganglioma/glomus tumors
  - Cholesterol granuloma
  - Chondromatous lesions
  - Chordoma
  - Endolymphatic sac tumors

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E.JUGULAR FORAMEN TUMOR

- Jugular foramen (JF) tumors
  - Rare cranial base lesions
  - Deeply located
  - Adjacent jugular bulb, carotid artery, middle ear, petrous apex, clivus, infratemporal fossa, posterior fossa

- Glomus jugulare (GJ) tumors
  - Paraganglioma
  - Most frequent JF tumors
  - From the paragangliar system of the temporal bone
  - Adventitia of the dome of the jugular bulb, and over the promontory
  - Glossopharyngeal nerve
  - Tympanic branch of the glossopharyngeal nerve (Jacobson nerve)
  - Auricular branch of the vagus nerve (Arnold nerve)

- Glomus jugulare (GJ) tumors
  - Highly vascularized
  - Most histologically benign
    - Invade bone, blood vessels, dura mater and CNs
  - Usually
    - Conductive hearing loss
    - Pulsatile tinnitus
  - Growth of the tumor can cause facial nerve (FN) paralysis, vertigo, hoarseness, and paralysis of lower CNs.

TABLE 1: Nomenclature of SHN-PGs*

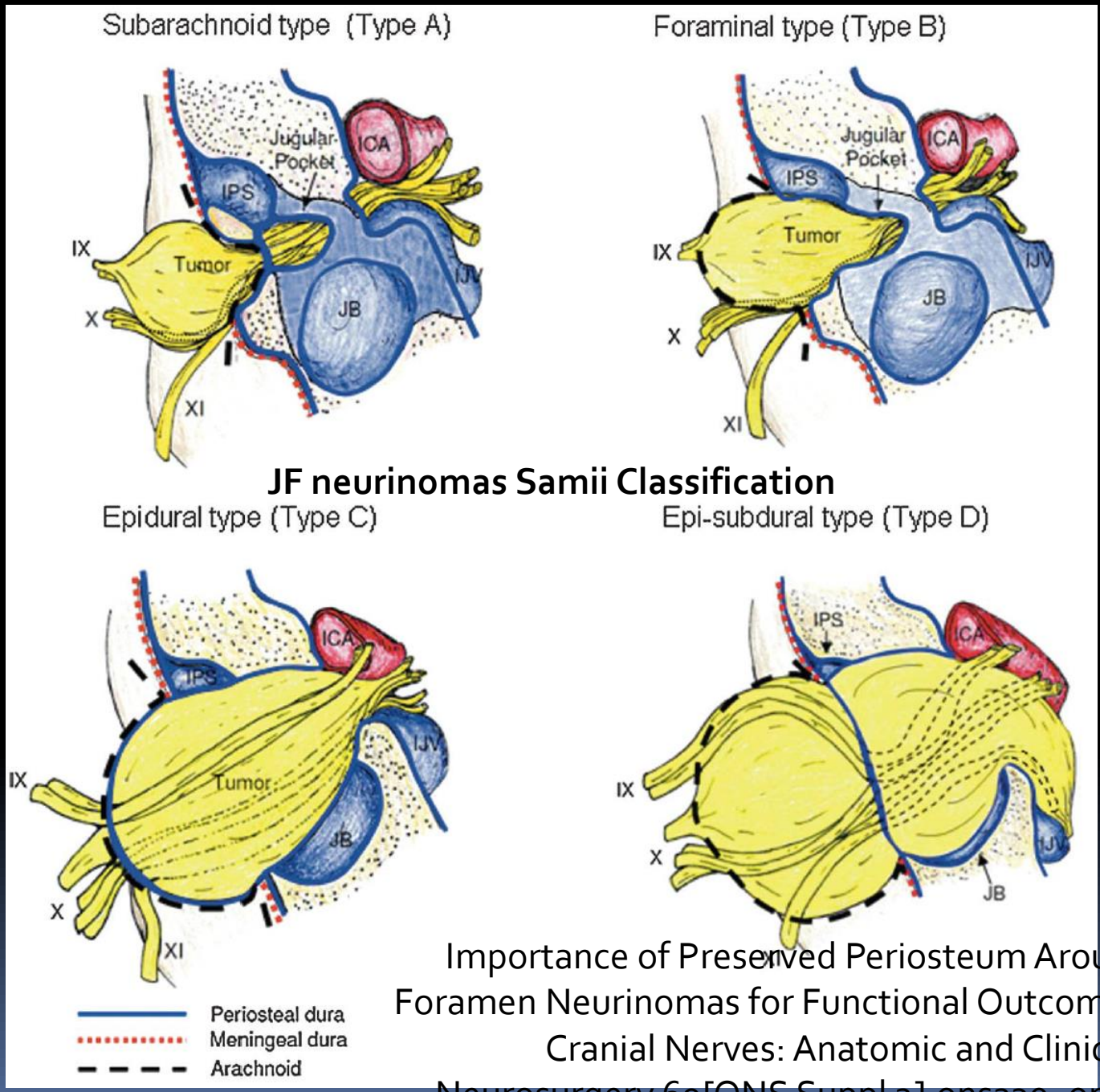
Location/Associated Structure	Historical Term(s)	Preferred Terminology	% of SHN-PGs	% Malignant
carotid body	carotid body tumor, chemodectoma	carotid body paraganglioma	44–58	6
jugular fossa/bulb (temporal bone)	glomus jugulare	jugular paraganglioma†	33–34	3–4
middle ear (temporal bone)	glomus tympanicum	tympanic paraganglioma†	7–13	3–4
vagus nerve	glomus vagale	vagal paraganglioma	1–7	10–16

TABLE 2: Familial paraganglioma syndromes*

Disease	Gene	Genomic Location	Inheritance	% w/ SHN-PG	Risk of Malignancy
familial paraganglioma Type 1 (PGL1)	*SDHD*	11q23	AD w/ paternal imprinting	79–98	low
familial paraganglioma Type 2 (PGL2)†	*SDHAF2 (SDH5)*	11q12.2	AD w/ paternal imprinting	0–42	low
familial paraganglioma Type 3 (PGL3)	*SDHC*	1q23.3	AD	88	low
familial paraganglioma Type 4 (PGL4)	*SDHB*	1p36.1–p35	AD	29–43	high
NA	*SDHA*	5p15	insufficient data	<3	insufficient data
NA	*TMEM127*	2q11.2	insufficient data	2–4	insufficient data
NA	*MAX*	14q23	insufficient data	<1	insufficient data

Molecular genetics of paragangliomas of the skull base and head and neck region implications for medical and surgical management- Neurosurg 120:321–330, 2014

- Schwannomas of the lower cranial nerves (CNs)
  - Often present with hearing loss and paralysis of lower CNs
  - Benign, noninfiltrative lesions
  - From the glossopharyngeal, vagus, or accessory nerves or the cervical sympathetic chain
  - Most schwannomas of the JF (90%) originate from the glossopharyngeal or the vagus nerve



Importance of Preserved Periosteum Around Jugular Foramen Neurinomas for Functional Outcome of Lower Cranial Nerves: Anatomic and Clinical Studies- Neurosurgery 69[ONS Suppl 2]:ons230–ons240, 2011

- Meningiomas
  - In the jugular bulb
  - Benign but locally aggressive
    - Infiltrate the temporal bone and posterior cranial fossa
    - High risk of recurrence unless totally removed
  - Worse postoperative CN outcomes than glomus or schwannoma patients

F.DIAGNOSIS

- Diagnosis of JF tumors
  - Otolaryngologist + Radiologist
  - Most frequent complaints : hearing and swallowing
- HRCT
  - Tumor presence
  - Analysis of bone structures of the cranial base
  - Tumor calcification
  - Hyperostosis
  - Bone erosion

- Pre-OP MRI + gadolinium / MRA
  - Tumor vascularization
  - Extension
  - Relationship with neighboring structures
- MR venography
  - Venous circulation and occlusion of the sigmoid sinus
- Digital subtraction angiography(DSA)
  - Diagnosis
  - Preoperative embolization in cases of highly vascularized lesions

Lesion	T1 (Relative to Brain)	T2 (Relative to Brain)	Contrast Enhancement	CT	Other Findings
Cranial nerve schwannoma	Isointense	Isointense, with foci of high intensity	Strong, with cystic areas	• Smooth expansion of bone (IAC, jugular foramen, fallopian canal)	Fundal cap—VS Ice cream cone—VS
Meningioma	Isointense	Isointense	Strong	• Calcifications • Hyperostosis	
Paraganglioma	Isointense	Isointense	Strong	• Permeative erosion of bone • Erosion of caroticojugular spine	Salt and pepper appearance
Endolymphatic sac tumors	Hyperintense	Hyperintense	Strong	• Extensive bony destruction	Characteristic location
Metastases	Variable	Hyperintense	Strong, but heterogeneous	• Irregular bony destruction	Melanoma—T1 hyperintensity
Chordoma	Hypointense	Hyperintense	Moderate	• Central skull base destruction	Originate at the clivus
Chondrosarcoma	Hypointense	Hyperintense	Weak	• Irregular bony destruction • Calcified central matrix	Occur along petroclival suture
Epidermoid cyst (cholesteatoma)	Hypointense	Hyperintense	None	• Erosion of bone	Bright on T2 FLAIR Bright on DWI
Dermoid cyst	Hyperintense	Hyperintense	None	• Erosion of Bone • Calcification	Bright on T2 FLAIR
Arachnoid cyst	Hypointense	Hyperintense	None	• Sculpted bone	Dark on T2 FLAIR
Lipoma	Hyperintense	Hypointense	None	• Lower density than fluid	Suppresses with fat sat
Cholesterol granuloma	Hyperintense	Hyperintense	None	• Smooth expansion of bone	

Bailey, Head & Neck Surgery - Otolaryngology, 5th Edition, Chapter 159

G.TREATMENT

- Options
  - Observation
  - Radiation therapy
  - Surgery

- The ideal management of JF tumors is complete surgical excision with preservation of lower CNs and major vessels.
  - Infratemporal fossa
  - Modified infratemporal fossa
  - Transmastoid
  - Mastoid + neck approach
- Limitation
  - Extension into Cavernous sinus / Clivus
  - Extension to the posterior fossa
  - Hypervascularization
  - Involvement of CNs / Vessels
  - Infiltration of the brainstem
  - Bone infiltration at the cranial base

- External beam radiotherapy
  Stereotactic radiotherapy
  - Alternative treatments
  - Especially in elderly
    - To avoid postoperative morbidity
  - To treat unresectable tumors
  - To treat residual or recurrent tumors

H.Journal review-1

Tumors of The Jugular Foramen: Diagnosis And Management

Ricardo Ramina, Joao Jarney Maniglia
Yvens Barbosa Fernandes, Jorge Rizzato Paschoal
Leopoldo Nizan Pfeilsticker, Maurício Coelho Neto

Neurosurgical Department
Ear, Nose, and Throat Department
State University of Campinas, Campinas, Brazil

Neurosurgery 57[ONS Suppl 1]:ONS-59–ONS-68, 2005

- January 1987 - November 2004
  - 106 consecutive patients
    - 77 women (73%)
    - 29 men (27%)
  - Neurological Institute of Curitiba(INC)
  - State University of Campinas (UNICAMP)
- 1987-1990
  - Computerized tomography (CT)
  - Digital subtraction angiography (DSA)
- 1990-2004
  - MRI +/- MRA
- Hearing loss, tinnitus, CN IX and CNX dysfunction

- Paragangliomas (61 cases)
  - 48 women and 13 men
  - 42.5 years (SD=12, 18 –72 yr).
- Low cranial nerve schwannomas (18 patients)
- Meningiomas (10 patients)

TABLE 1. Histological findings and grade of tumor resection

Histological finding	No. of cases	Total	Subtotal
Paragangliomas	61	49[a]	12[b]
Schwannomas	18	18	0
Meningiomas	10	5	5
Aneurysmic bone cyst	2	2	0
Chondrosarcoma	4	1	3
Chordoma	2	0	2
Malignant tumors (carcinomas)	4	0	4
Cholesteatoma	2	1	1
Chondroma	1	1	0
Lymphangioma	1	1	0
Inflammatory granuloma	1	1	0
Total	106	79 (74%)	27 (26%)

[a] Three presented with recurrence of tumor.
[b] Four malignant, three reoperation.

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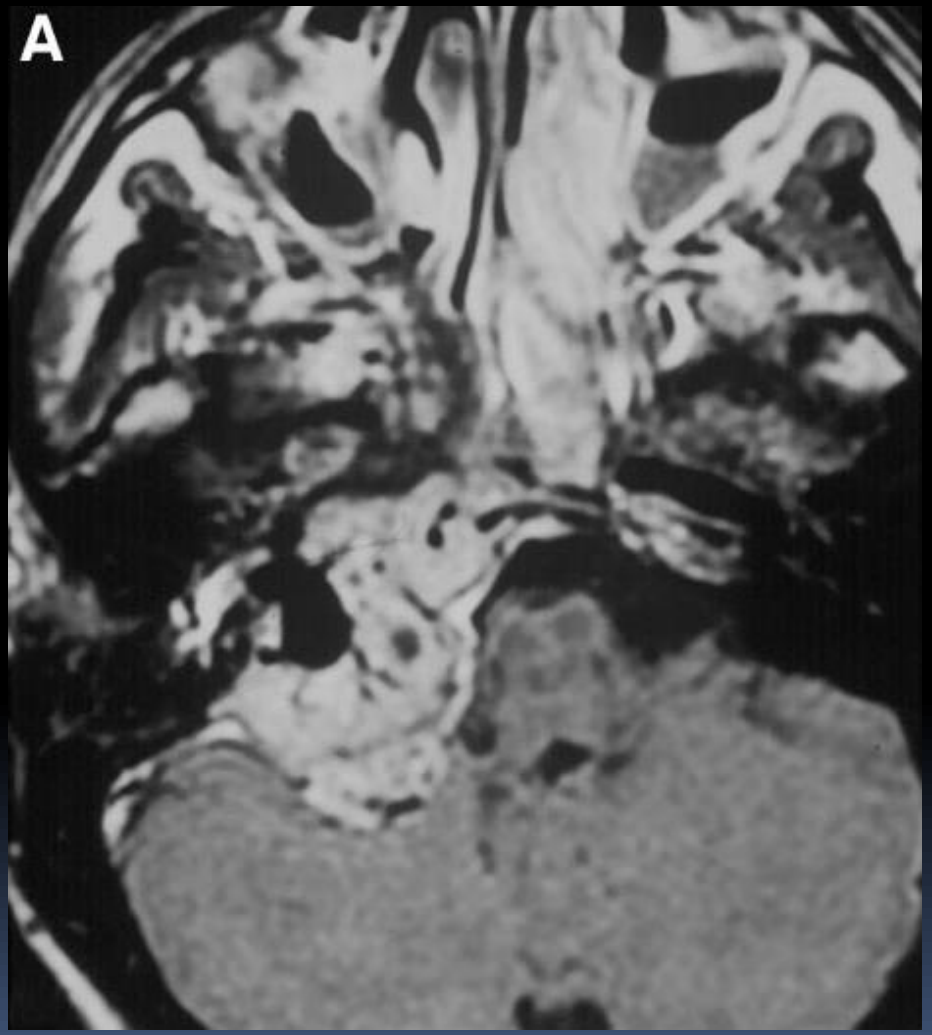
Neurosurgery 57[ONS Suppl 1]:ONS-59–ONS-68, 2005

Radiological Examination

- Paragangliomas
  - Well vascularized lesions
  - Heterogeneous gadolinium enhancement
  - "salt and pepper"



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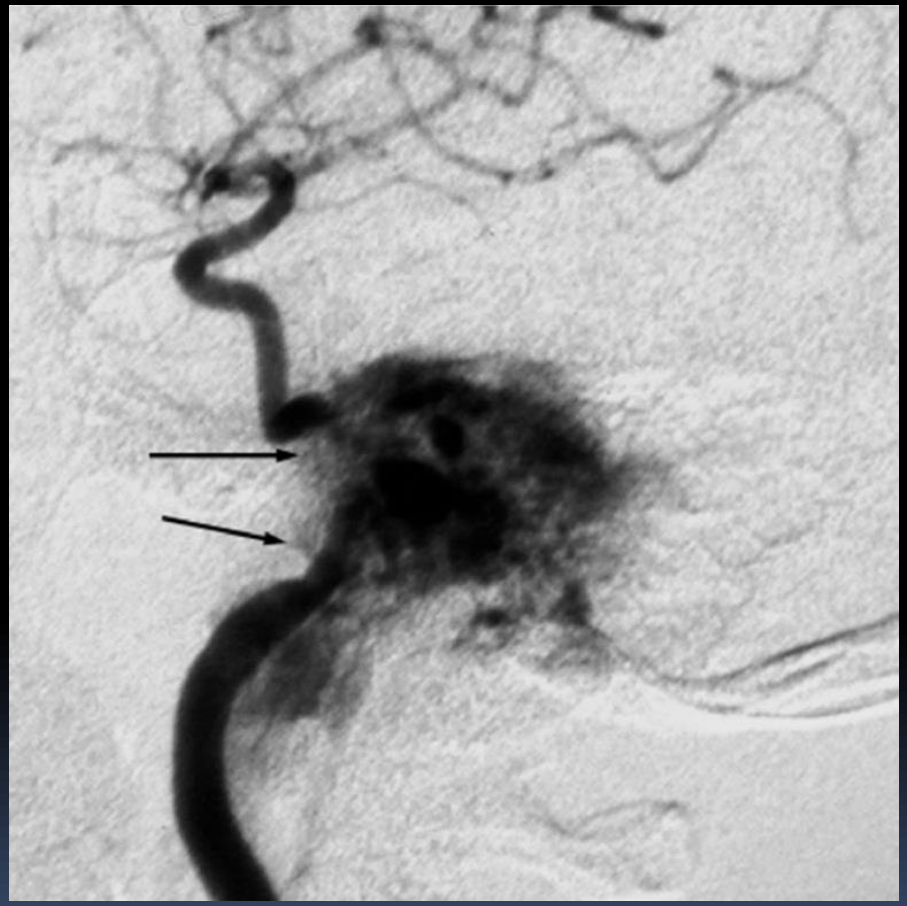
Neurosurgery 57[ONS Suppl 1]:ONS-59–ONS-68, 2005

Radiological Examination

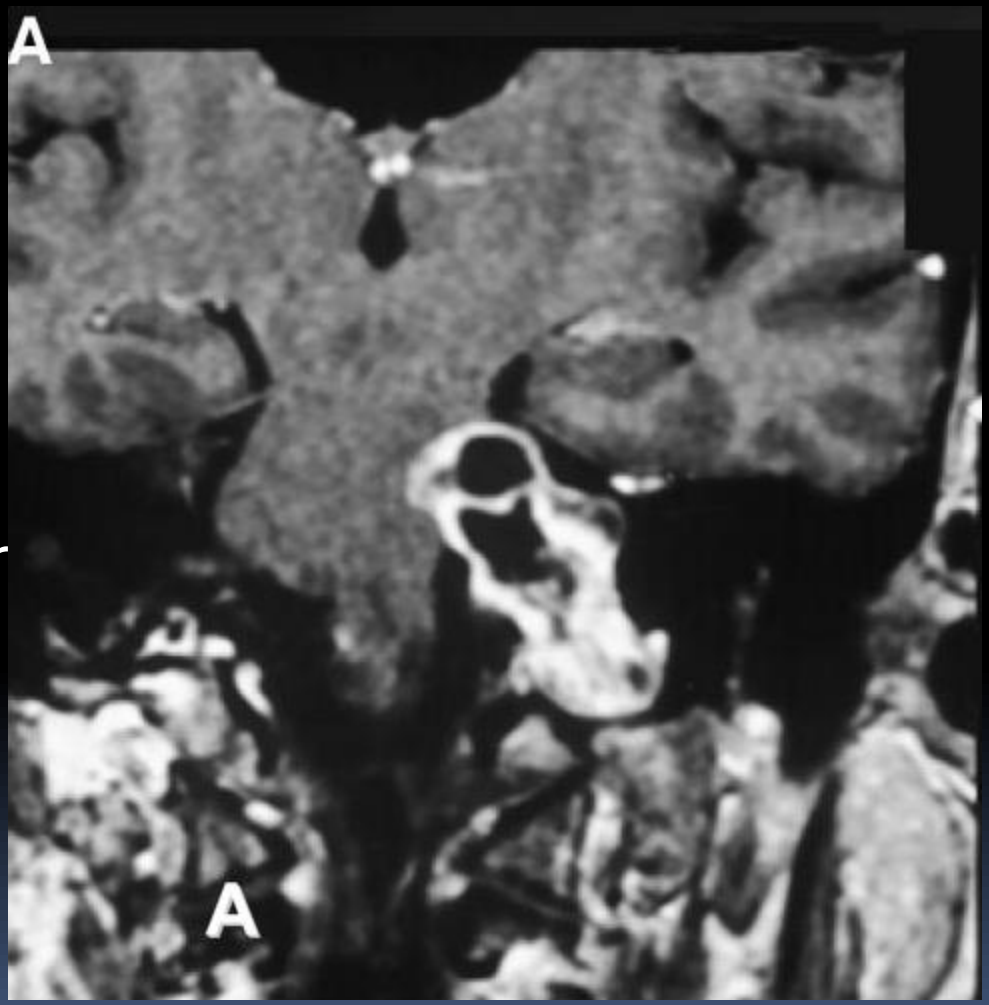
- Paragangliomas
  - Usually fed by branches of ECA
    - Ascending pharyngeal artery
  - May invade the walls of the ICA
- DSA
  - Venous circulation
  - Hypertrophic jugular bulb
    - Tinnitus
    - Hearing loss



Tumors of The Jugular Foramen: Diagnosis And Management
Neurosurgery 57[ONS Suppl 1]:ONS-59–ONS-68, 2005

Radiological Examination

- Schwannomas
  - Regular contour
  - May be cystic
  - Enhance strongly
  - "Hour glass" tumor



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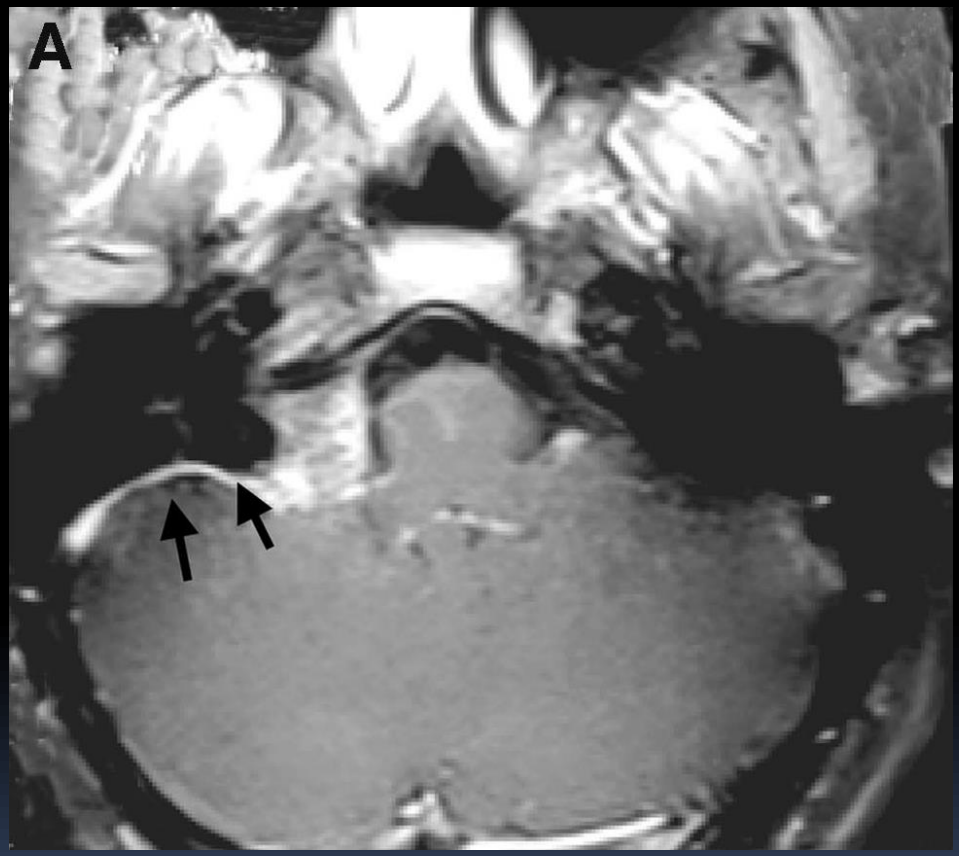
Neurosurgery 57[ONS Suppl 1]:ONS-59–ONS-68, 2005

Radiological Examination

- Meningiomas
  - Dura tail
- Chordomas Chondrosarcomas
  - Heterogeneous
  - Some areas with contrast enhancement
  - Bone destruction



Tumors of The Jugular Foramen: Diagnosis And Management
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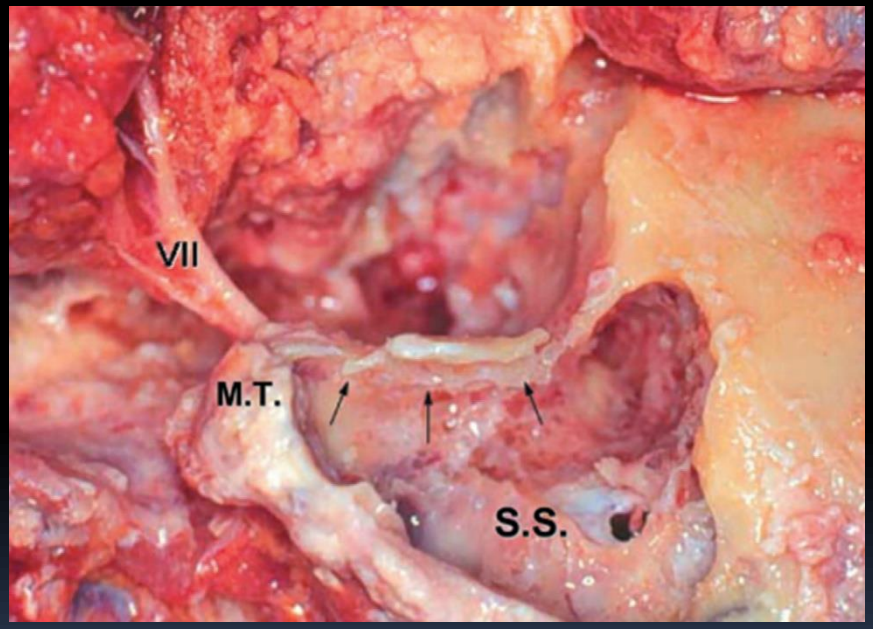
Surgical Anatomy

- JF
  - Nervous part
    - Glossopharyngeal nerve
    - Inferior petrosal sinus
    - Meningeal branches of ascending pharyngeal artery
  - Venous part
    - Sigmoid sinus
    - Vagus nerve
    - Accessory nerve

- Cranial nerves
  - Anteromedial to the jugular bulb
  - Multifascicular histoarchitecture
    - Vagus nerve - Multiple fascicles
    - Glossopharyngeal – One
    - Accessory nerves - Two fascicles
  - Lower cranial nerves (IX, X, XI)
    - Through a septum of connective tissue in continuity with the dura mater and the pericranium
  - Cross the JF
    - Tympanic branch of glossopharyngeal nerve (Jacobson's nerve)
    - Auricular branch of vagus nerve (Arnold's nerve)

- Muscle
  - SCM, Digastric, Splenius capitis,
  - Obliquus capitis superior and inferior
  - Splenius cervicis
- Vessels:
  - CCA, ECA, ICA, VA
  - Common facial vein, EJV, IJV
- Nerves:
  - Greater auricular nerve
  - CN X, XI, XII
  - Sympathetic trunk
  - CN VII
    - Stylomastoid foramen region
    - Mastoid tip posteriorly
    - Posterior belly of the digastric muscle inferiorly



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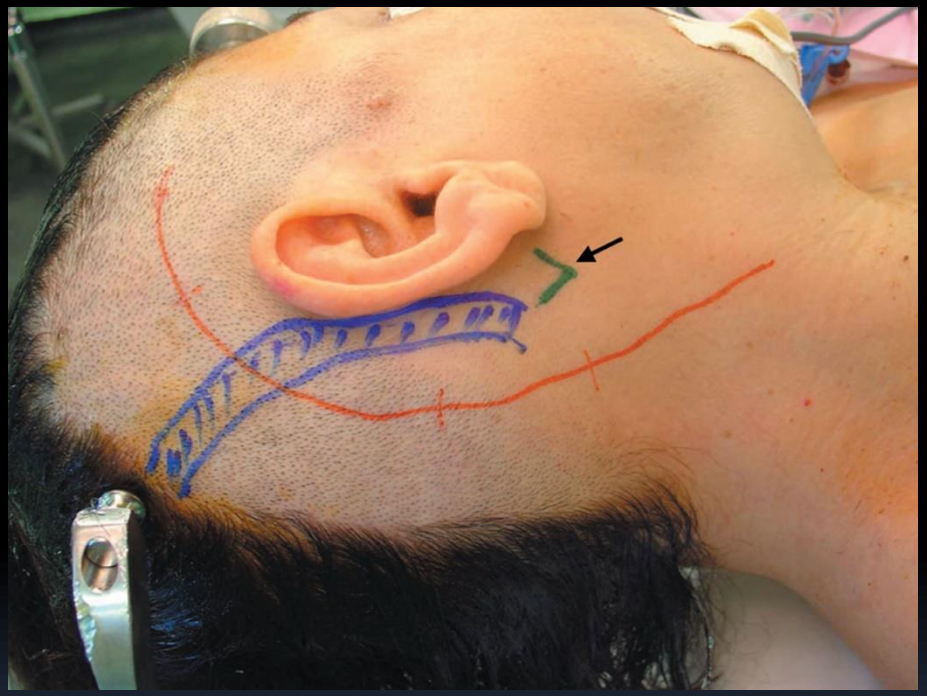
Surgery

- C-shaped incision
  - Temporal region
  - Circumscribing the ear
  - Anterior border of the SCM
- EAC
  - Tumor anterior extension + hearing loss
  - Cut at osteocartilaginous junction



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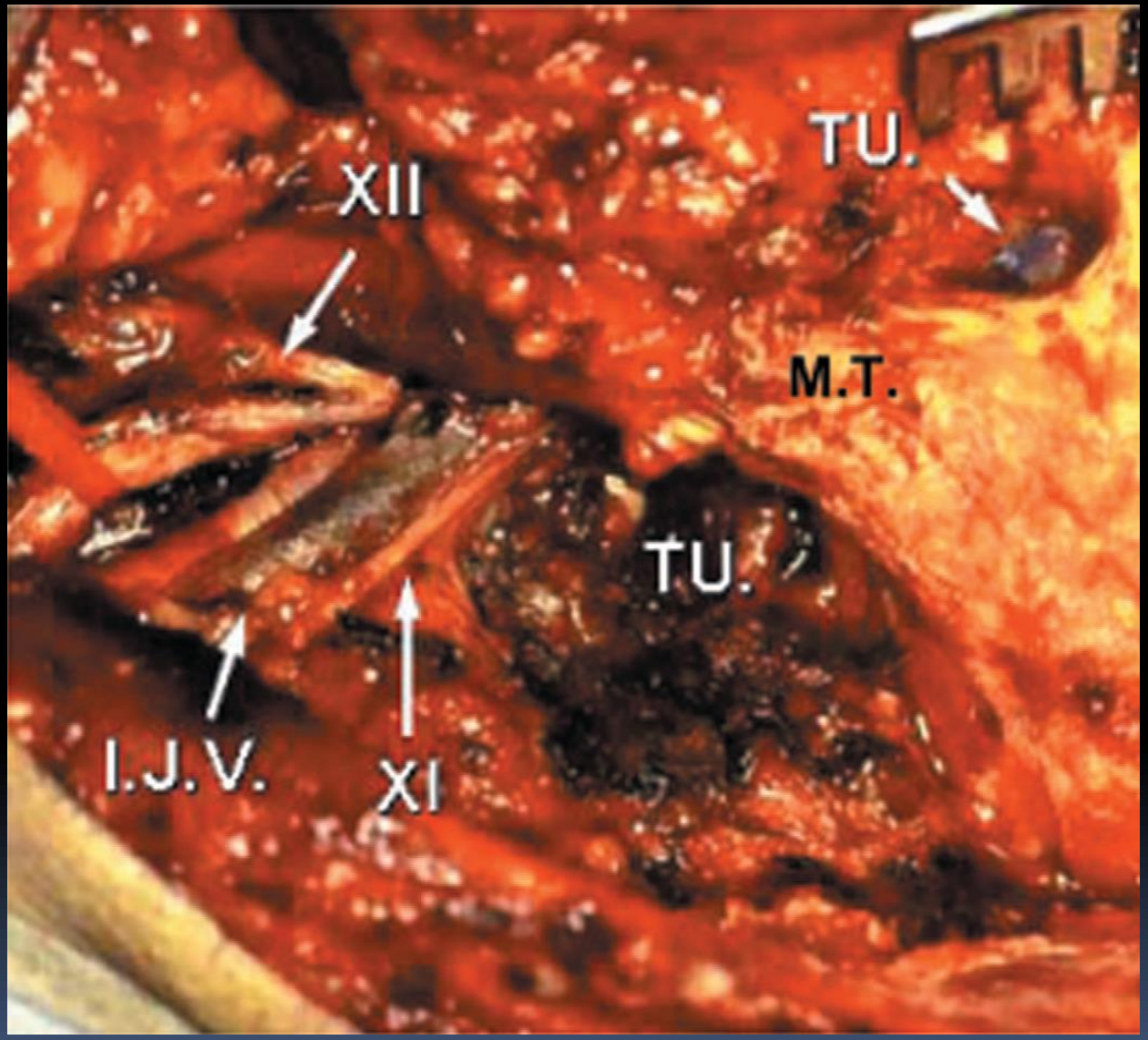

*Paraganglioma (*TU)
IJV
CN XI
CN XII
MT, *mastoid tip*

Tumors of The Jugular Foramen: Diagnosis And Management
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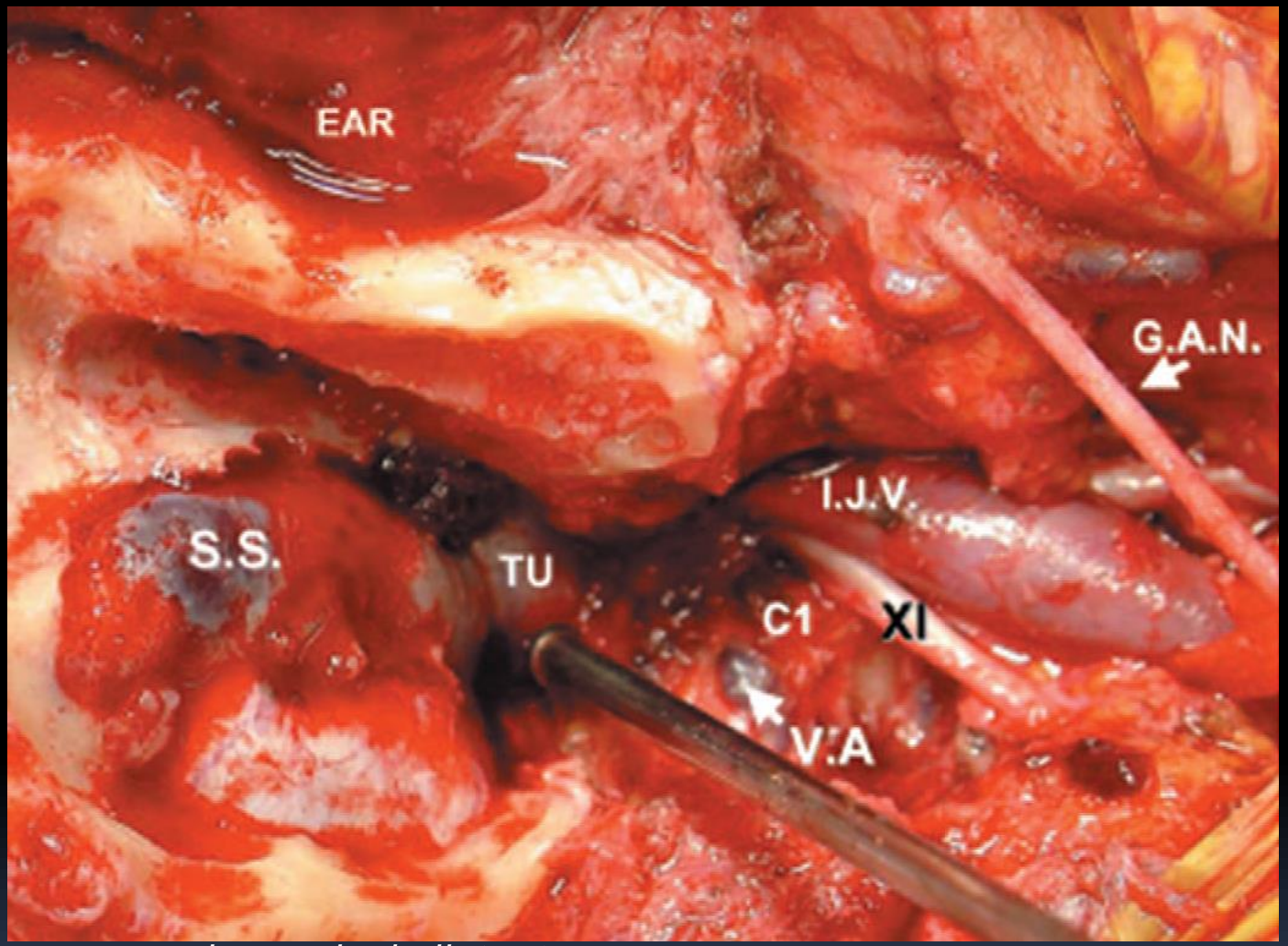

*Tumor in the jugular bulb (*TU)
SS, *sigmoid sinus*
VA, vertebral artery
C1 *lateral process*
G.A.N., *great auricular nerve*

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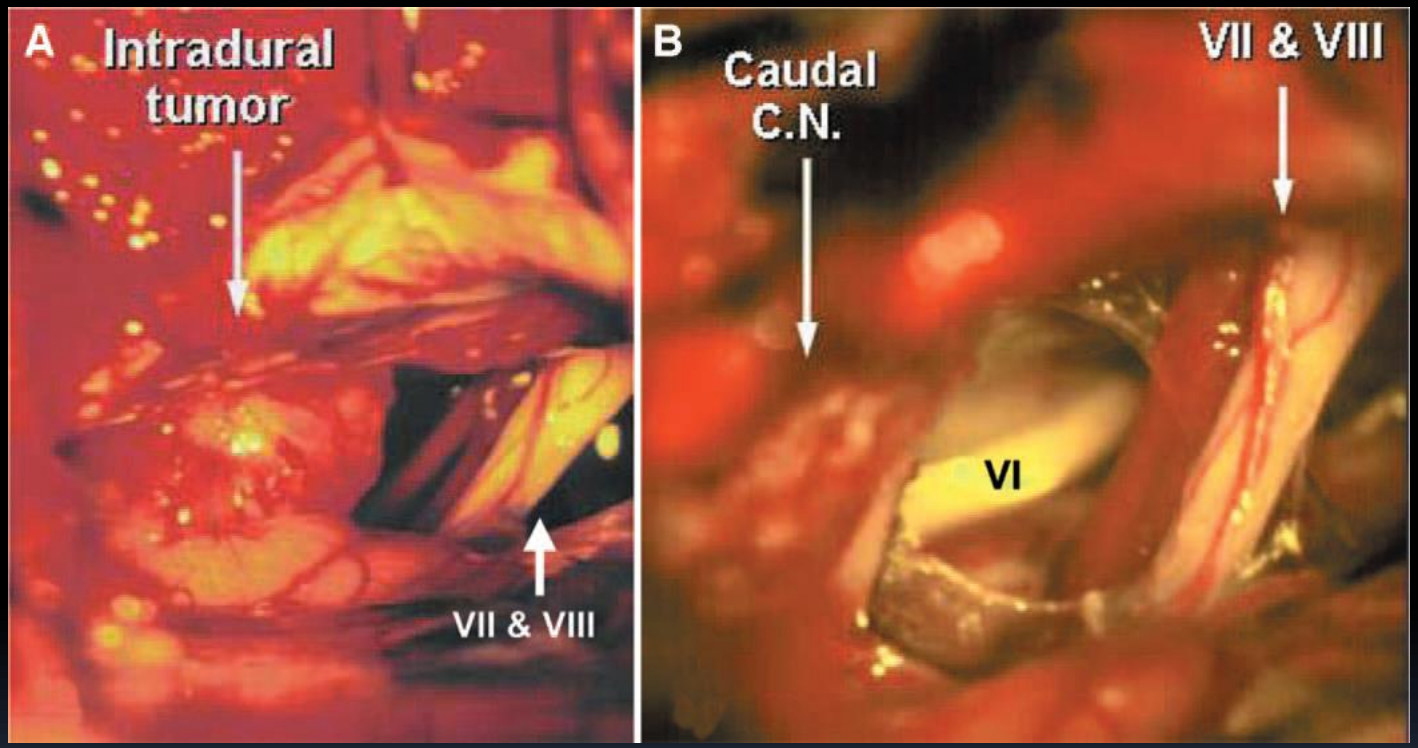
Neurosurgery 57[ONS Suppl 1]:ONS-59–ONS-68, 2005



A, Intradural exposure of a JF paraganglioma
B, Total removal of the lesion with preservation of the caudal cranial nerves

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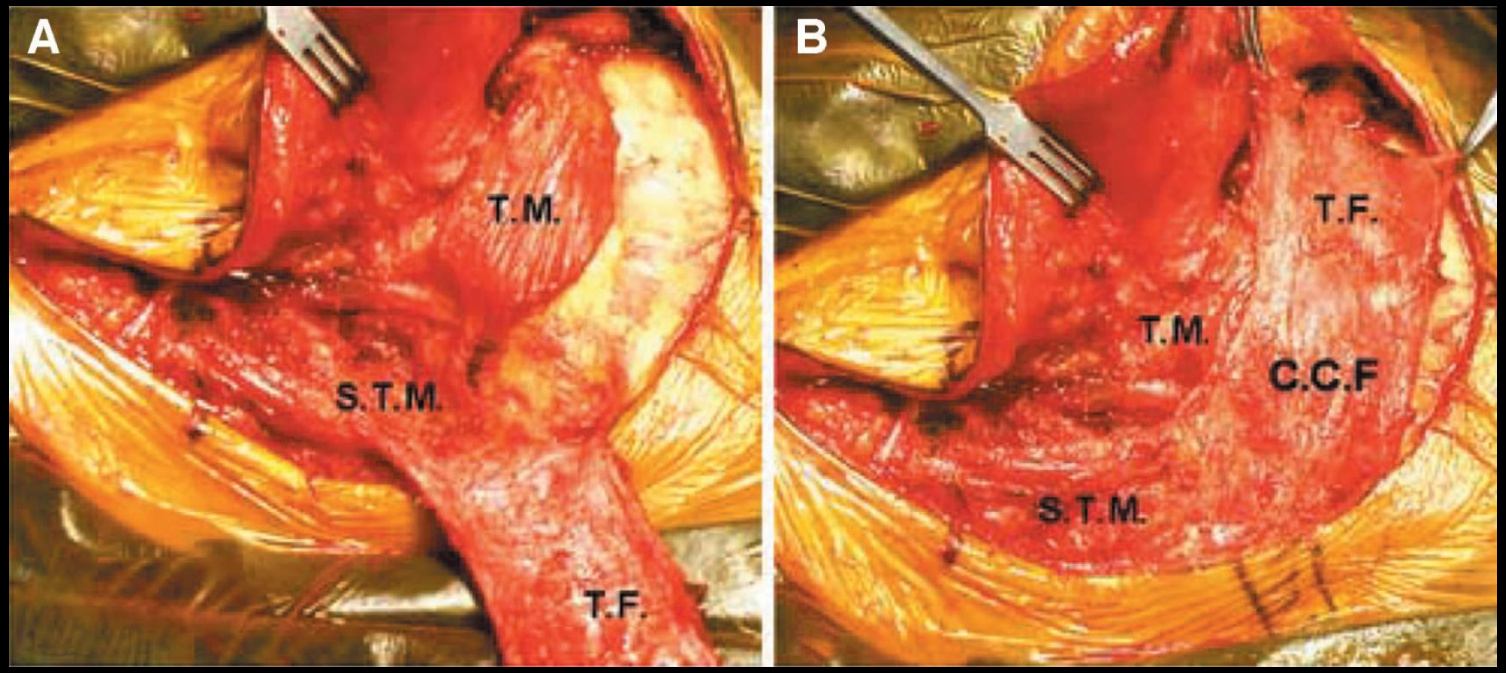

Cranial base reconstruction with myofascial flaps.
A, *rotation of the temporalis muscle (*T.M.*) to cover the mastoidectomy and craniotomy.*
B, *the temporalis fascia (*T.F.*), craniocervical fascia (*C.C.F.*), and sternocleidomastoid muscle (*S.T.M.*) are sutured back to cover the entire surgical defect.*

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Result

- 79 Radical tumor resection (74%)
  - 89% of benign tumors
- 49 paragangliomas (80%) were complete excised
- 3 paraganglioma recurred
  - Post-OP 3 years
  - RE-OP
- 12 paraganglioma - Subtotal removal
  - 8 Infiltration of lower cranial nerves
  - 4 Infiltration of the cranial nerves, brainstem, and bone structures
    - 3 undergone previous operations elsewhere
- 4 paragangliomas were histologically malignant.

- Chondrosarcomas
  Chordomas
  Malignant tumors
  - Could not be totally resected
  - Extensive infiltration of cranial nerves, dura, and bone
  - Postoperative radiotherapy

TABLE 2. Surgical complications[a]

New cranial nerve deficits	
VII	8 (3 transient)
VIII	8
IX, X, XI	10 (4 transient)
CSF leak	4
Hemiparesis	1
Mortality	4 (3.7%)

[a] CSF, cerebrospinal fluid.

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- 10(9.4%)
  - Lower cranial nerve palsy
  - 6 Permanent
  - 3 Tracheotomy
- 8(7.5%)
  - Cochlear nerve paralysis
- 8(7.5%)
  - Facial nerve
    - 3 Facial nerve function returned spontaneously
    - 5 Tumor infiltration, resection, reconstruction(GAN or Cranial Nerve XII–VII anastomosis)
  - Functional recovery
    - Grade III*4
    - Grade IV*4

- CSF leakage
  - 4(3.7%)
  - 3 meningitis
- 4 (3.7%) died after surgery
  - Pulmonary embolism *1
    - Massive pulmonary embolism 3 days after surgery
  - Aspiration pneumonia + Sepsis *2
  - Cervical hematoma + hypoxia *1
    - Ligated internal jugular vein 2 days after surgery

I.Journal review-2

Jugular Foramen Tumors: Clinical Characteristics and Treatment Outcomes

Jose N. Fayad
Bahar Keles
Derald E. Brackmann

House Ear Institute and House Ear Clinic
Los Angeles, California, U.S.A.

Otology & Neurotology 31:299-305 2010

- January 1997-May 2008
  - 83 patients with a JF tumor
  - Pre-OP
    - Vocal cord - Flexible fiberoptic laryngoscopy
    - Hearing - PTA
    - HRCT
    - MRI + MRA
    - DSA +/- Balloon test occlusion + Embolism
  - Post-OP
    - PTA, HRCT, MRI

TABLE 1. *Demographic characteristics of patients with JF tumors by tumor type*

	GJ, n = 67	Schwannoma, n = 9	Meningioma, n = 7	All, n = 83
Sex, female/male (%)	85.1/14.9	44.4/55.6	71.4/28.6	79.5/20.5
Side, right/left (%)	44.8/52.2	55.6/44.4	71.4/28.6	48.2/49.4
Age, mean yr (SD)	50.2 (16.1)	43.8 (16.1)	39.0 (16.4)	48.5 (16.3)
Tumor size, mean cm (SD)[a]	2.6 (1.2)	3.6 (1.1)	3.5 (1.4)	2.8 (1.2)
PTA, mean dB (SD)	43.5 (31.2)	51.3 (50.0)	17.5 (11.3)	42.6 (32.7)

[a] ANOVA, $p < 0.03$.

66 (79.5%) women, 17 (20.5%) men
no statistically significant differences between PTA

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TABLE 2. *Symptoms and findings (% of patients) for 83 patients with JF tumors by tumor type*

Symptoms	GJ, %	Schwannoma, %	Meningioma, %	All, %
Pulsatile tinnitus	89.6	55.6	71.4	84.3
Hearing loss	80.6	55.6	57.1	75.9
Hoarseness	28.4	55.6	57.1	34.9
Dizziness	20.9	33.3	26.6	22.9
Vertigo	16.4	33.3	0.0	16.9
Headache	16.4	44.4	14.3	19.3
Swallowing problem	13.4	22.2	14.3	14.5
Aural fullness	12.1	0.0	0.0	9.8
Otalgia	10.5	0.0	0.0	8.4
Unsteadiness	7.5	11.1	14.3	8.4
Dysphagia	6.0	1.1	14.3	6.0
Discharge	6.0	22.2	0.0	7.2
Signs				
Retrotympanic mass	91.0	11.1	42.9	78.3
Vocal cord paralysis	11.9	11.1	42.8	13.3
Shoulder weakness	9.0	22.2	28.6	12.0
Absent GAG reflex	7.5	33.3	26.6	12.0
Glossal atrophy	9.0	11.1	28.6	10.8
Facial nerve dysfunction	3.0	0.0	0.0	2.4

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TABLE 3. *Tumor severity/extent classifications for the 67 GJ tumors*

	Patients, %
Fisch classification	
Type C1 (limited involvement of vertical portion of carotid canal)	41.8
Type C2 (invading vertical portion of carotid canal)	26.9
Type C3 (invasion of horizontal portion of carotid canal)	10.6
Type C4 (invading foramen lacerum and cavernous sinus)	2.9
Type D1 (intracranial extension <2 cm in diameter)	14.9
Type D2 (intracranial extension >2 cm in diameter)	2.9
De La Cruz classification	
Jugular bulb	44.8
Carotid artery	40.3
Transdural	17.9
Jackson/Glasscock classification	
Type 1 (small tumor involving JB, middle ear, and mastoid process)	22.4
Type 2 (extending under internal auditory canal; may have intracranial extension)	35.8
Type 3 (extending into petrous apex; may have intracranial extension)	37.3
Type 4 (extending beyond petrous apex into clivus or infratemporal fossa; may have intracranial extension)	4.5

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TABLE 4. *Treatment modality by tumor type (% of patients)*

	GJ, %	Schwannoma, %	Meningioma, %	All, %
Surgery	71.6	100.0	57.1	73.5
Radiotherapy	20.9	0.0	14.3	18.1
Observation	7.5	0.0	28.6	8.4

- Tumor size
  - No statistically significance
  - Observation
    - Smaller tumor size
    - Small number, p<0.08
    - OBS 1.9 cm, SD=0.4
    - Surgery 2.9 cm, SD=1.2
    - RT 2.8 cm, SD=1.2
- Mean ages
  - P<0.003
  - Surgery (44.9 yr, SD=15.6)
  - Radiotherapy (58.9 yr, SD=12.8)
  - Observation (58.2 yr, SD=17.1)
  - post hoc pairwise
    - OP vs RT p<0.003
    - OP vs OBS p<0.03

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TABLE 5. *Surgical technique for the 61 patients undergoing surgical tumor resection by tumor type (% of patients)*

Approach	GJ, % (n = 48)	Schwannoma, % (n = 9)	Meningioma, % (n = 4)	All, % (n = 61)
Infratemporal fossa Type A	54.2	11.1	75.0	49.2
Modified infratemporal fossa (no rerouting FN)	21.3	55.6	0.0	24.6
Mastoid and neck	10.4	0.0	0.0	8.2
Mastoid and neck with limit (FN rerouting)	4.2	0.0	0.0	3.3
Retrosigmoid	0.0	22.2	0.0	3.3
Transotic	2.1	0.0	0.0	1.6
Combined approach	8.3	11.1	25.0	9.8

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- Average blood loss=1,232.4 ml(500~6,900 ml)
- Mean OP duration=6.6 hours(2~12 hours)
  - Blood loss vs Tumor size($r = 0.30$; $p<0.03$)
  - Blood loss vs OP duration ($r = 0.34$; $p<0.01$)
- 81.4% Total tumor removal
- 11 Subtotal tumor removal-protect lower CNs or ICA / intracranial extension
  - 4 γ knife radiosurgery
  - 3 proton beam
  - 1 reoperation

- 15 Primary RT
  - 8 γ knife radiosurgery
  - 7 proton beam radiation
  - GJ *14
  - >65 yr *8
  - Intracranial extension *5
  - ICA extension *3
  - 3* <65 yr, localized to the jugular bulb, only pulsatile tinnitus + mild CHL
- Observation
  - 2 Meningioma
  - 5 GJ

TABLE 6. *House-Brackmann FN grade at postoperative intervals for patients treated by surgery, by tumor type (% of patients)*[a]

	GJ, % (n = 47)	Schwannoma, % (n = 9)	Meningioma, % (n = 3)	All, % (n = 59)
Immediate postoperation				
I–II	70.2	77.8	66.7	71.2
III–IV	19.1	11.1	0.0	16.9
V–VI	10.6	11.1	33.3	11.9
Last follow-up	n = 46	n = 9	n = 4	n = 59
I–II	93.5	88.9	25.0	88.1
III–IV	2.2	0.0	75.0	6.8
V–VI	4.3	11.1	0.0	5.1

[a]All patients had normal preoperative facial function, with the exception of 1 patient with HB Grade II.

GJ tumors = best long-term FN outcomes

Meningioma = poorest

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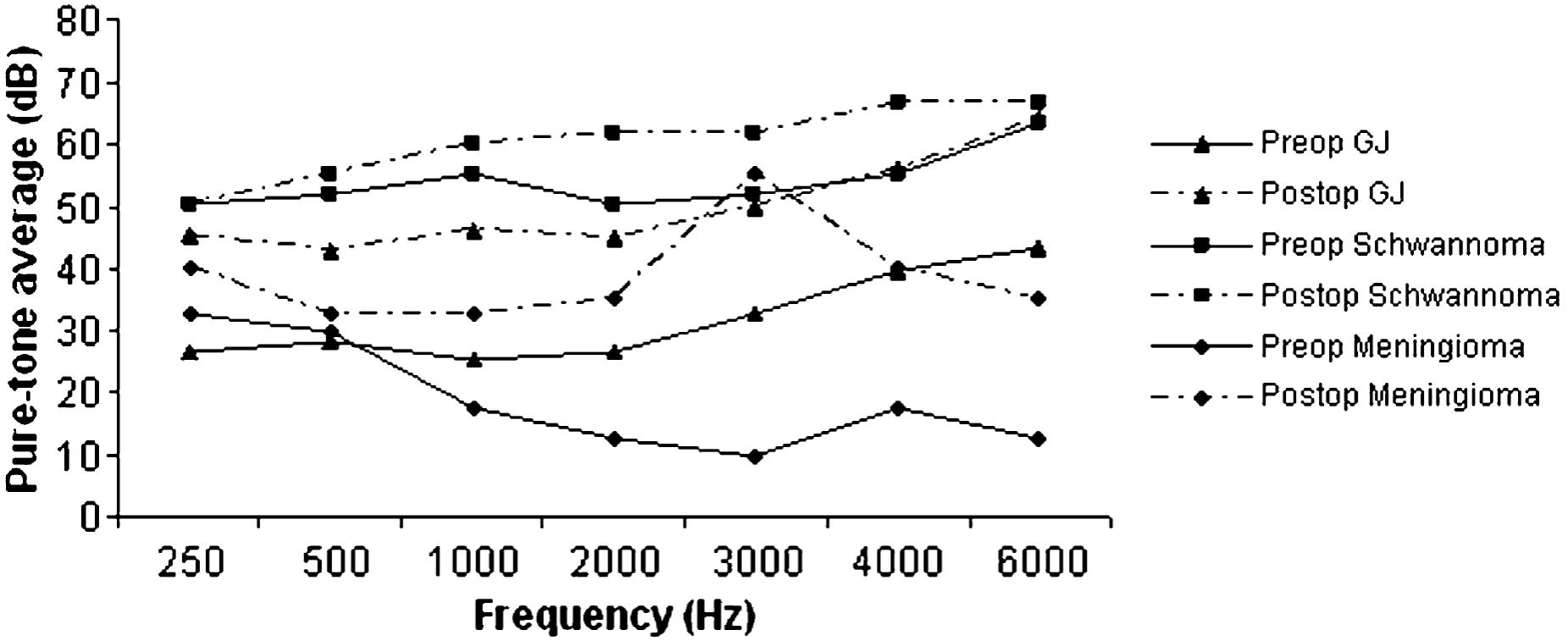

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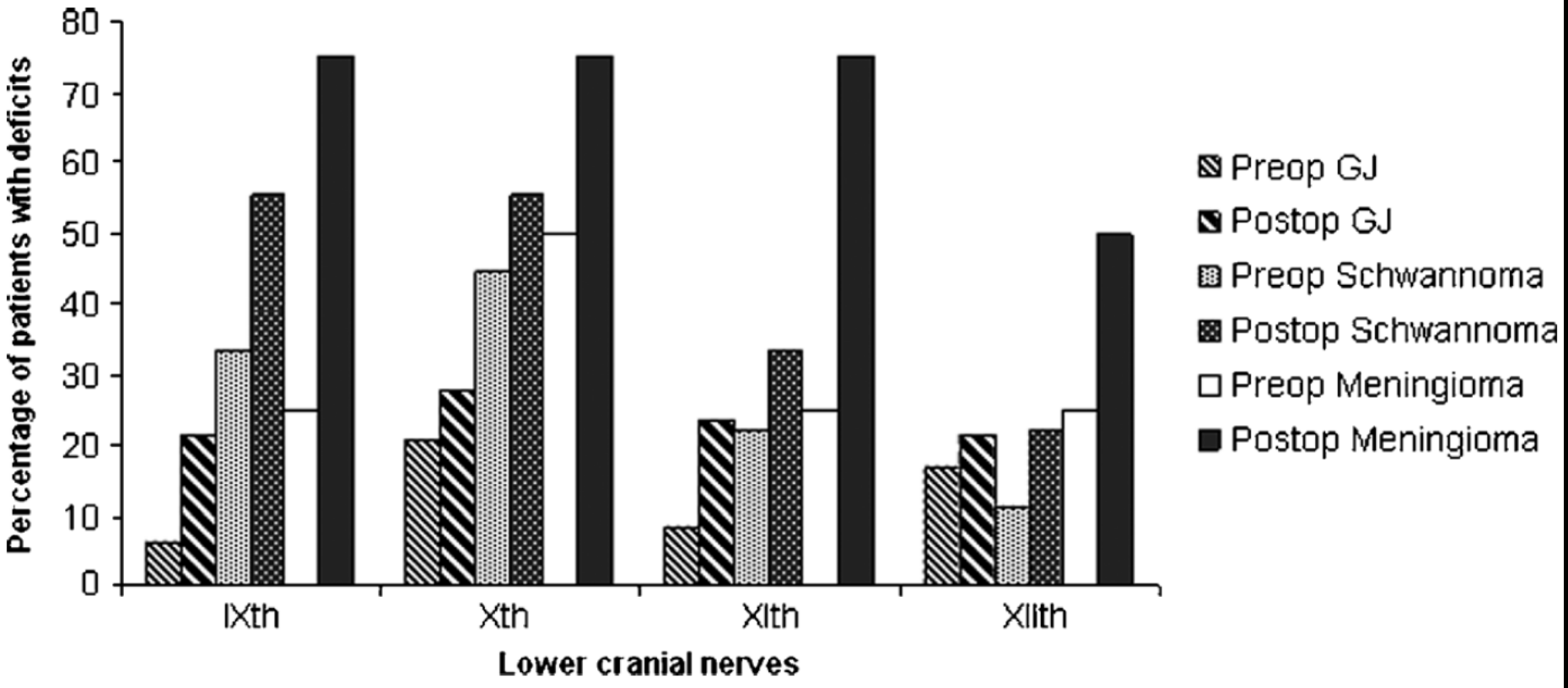

	GJ	Schwannoma	Meningioma
No CN dysfunction	77.6%	55.6%	57.1%
1+ CN dysfunction	18.9%	22.2%	50%
All 4 CN dysfunction	4.5%	11.1%	28.6%

Post-OP new CN deficits - 20.3 IX, 10.0 X, 18.6 XI, 8.3% XII

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- 12 vocal cord paralysis
  - Vocal cord medialization
  - 9 Thyroplasty
  - 2 Aspiration pneumonia
    - Temporary tracheostomy.
  - 21 Dysphagia
    - Speech and swallowing rehabilitation
    - 11 Temporary gastrostomy.
  - 15 CN XI paralysis
    - PT
- GJ tumors
  - Tumor size vs Post-OP lower CN deficits
  - $p<0.001\sim0.044$

TABLE 7. *Early and late postoperative complications in patients treated by surgery by tumor type (% of patients)*

	GJ, %	Schwannoma, %	Meningioma, %	All, %
Early complications				
None	66.7	55.6	75.0	65.6
Vocal cord paralysis	27.1	33.3	25.0	27.9
CSF leak	4.2	22.2	0.0	6.6
Meningitis	2.1	11.1	0.0	3.3
Pulmonary embolus	4.3	0.0	0.0	3.3
Other[a]	10.4	22.2	0.0	11.5
Late complications				
None	58.3	22.2	25.0	50.8
Speech/swallow problems	27.1	66.7	75.0	36.1
Dysphagia	27.1	66.7	75.0	36.1
Prolonged nasogastric tube feeding	22.9	44.4	75.0	29.5
Vocal cord paralysis	29.2	50.0	75.0	35.0
Shoulder dysfunction/pain	16.7	44.4	75.0	24.6
Aspiration pneumonia	6.3	0.0	0.0	4.9
Diplopia	0.0	11.1	25.0	3.3
Other[b]	16.7	0.0	25.0	14.8

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- 18(29.5%) developed a recurrence
  - 26 months (maximum, 7 yr)
  - 16 GJ group
  - 2 Schwannomas
  - 10 Radiotherapy
  - 2 Additional surgery
  - 1 Chemotherapy
    - Malignant GJ because of bone metastasis
  - 4 Observation

J.Journal review-3

Microsurgical Management of Jugular Foramen Schwannomas

Cara L. Sedney, Yoichi Nonaka
Ketan R. Bulsara, Takanori Fukushima

Department of Neurosurgery,West Virginia University, Morgantown, West Virginia; Division of Neurosurgery, Duke University Medical Center, Durham, North Carolina; Department of Neurosurgery, Yale University, New Haven, Connecticut

Neurosurgery 72:42–46, 2013

- 1980 ~ 2010
  - Retrospective review and case-control analysis
    - Operative technique
    - Examining the extent of resection
    - Morbidity
    - Recurrence
  - Change in surgical technique
    - Early (series 1) treatment group
    - Later (series 2) treatment group

- Earlier series 1
  - Aggressive surgical resection
    - Total resections + Removal of the total tumor mass
      - Peeling of tumor from critical structures with blunt or sharp dissection
  - This included all patients operated on from 1980 to 2004, a total of 53 patients.
- Late series 2
  - More conservative
  - Maximum preservation of neurovascular structures
    - Pars nervosa, CN6/7/8, PICA, brainstem surface
  - Total resection was accomplished only if no adherence to surrounding structures
  - A near-total resection was considered acceptable.
  - These patients (n = 28) were operated on from 2005 to 2010.

- Category 1, gross total resection
  - No residual tumor detected on post-OP contrasted MRI
- Category 2, near-total resection
  - Small trace(<0.5 mm) of the tumor capsule remaining
  - Post-OP MRI showing a thin line of enhancement (<1%~2% of original mass)
- Category 3, subtotal resection (STR)
  - Few millimeters of tumor capsule is left
  - Post-OP MRI showing a residual mass approximately 5% to 10% of the original volume

TABLE 1. Overall Cohort and Individual Series Data of Jugular Foramen Schwannoma Patients

	Series 1	Series 2	Overall Cohort	*P*
Patients, n	53	28	81	
Average patient age, y	52	45	50	
Sex, n				
Male	12	13	25	
Female	41	15	56	
Tumor type, n				
A	25	14	39	
B	22	9	31	
C	4	4	8	
Extent of resection, n (%)				
Subtotal	0	1 (4)		.32
Near-total	5 (9.4)	18 (72.1)		< .001
Total	48 (90.1)	6 (24)		< .001
Determinable nerve of origin, n (%)	"Rare"	15 (54)	[a]	
Mortality, n	0	0	0	
Recurrence, n (%)	3 (7.0)	3 (12.7)	6 (8.9)	.66
Cerebrospinal fluid leak, n (%)	3 (7.0)	0	3 (4.5)	.55
Reoperation, n	0	2	2	
Thyroplasty, n	[a]	3	[a]	
Vocal cord injection, n	[a]	1	[a]	
Percutaneous endoscopic gastrostomy placement, n	[a]	5	[a]	

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TABLE 2. Transient and Permanent Cranial Nerve Deficits in Each Series of the Overall Cohort[a]

	Type of Deficit					
	Transient Deficits			Permanent Deficits		
	Series 1	Series 2	*P*	Series 1	Series 2	*P*
CN 6	0	0	NA	0	1	.34
CN 7	6	0	.08	2	1	1
CN 8	4	0	.29	4	1	.65
CN 9/10	16	7	.79	14	2	.04[b]
CN 11	9	0	.02[b]	6	1	.41
CN 12	9	0	.02[b]	7	1	.25

Microsurgical Management of Jugular Foramen Schwannomas
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Surgical Strategy for JFS Resection

Approach planning using Fukushima/Bulsara grading scale

Preoperative planning

- CSF cleft around brainstem margin → **Favors complete resection**
- Age greater than 60 → **Favors conservative resection**

Intraop Observations

- Adherence to CN6, CN7, AICA, PICA → **Favors conservative resection**
- Determinable Nerve of Origin → **Favors complete resection**

Post-operative management

- **Conservative resection** → consider yearly serial MRIs; avoid radiation without documented recurrence
- **Complete resection** → standard followup
- **Subtotal resection** → consider stereotactic radiosurgery of residual

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- JFSs
  - Near-total resection technique provides improved surgical morbidity
  - Without a statistically significant increase in tumor recurrence
  - Priority to preserve critical neurovascular structures
    - Although there is a trend toward increasing recurrence
    - A variety of alternative methods
  - Preservation of pars nervosa
    - CN 9/10 function on patient quality of life

K.SUMMARY

- Intracranial tumor
  - Glioma
  - Meningioma
  - Pituitary adenoma
  - Neurinoma
- CP angle tumor
  - Vestibular Schwannoma
  - Meningioma
  - Epidermoid cyst
  - Nonvestibular Schwannoma
- Jugular foramen tumor
  - Paraganglionma / Glomus tumor
  - Schwannoma
  - Meningioma

- Diagnosis
  - HRCT
  - MRI
  - DSA
- Treatment
  - Observation
  - Radiotherapy
  - Surgery
- Outcome
  - Facial N
  - Cochlear N
  - CN IX, X, XI, XII
  - Recurrence

The End

THANKS EVERYONE