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The Combined Transmastoid Transjugular Transtubercular High Cervical Approach for Resection of Jugular Foramen Tumors

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The Combined Transmastoid Transjugular Transtubercular High Cervical Approach for Resection of Jugular Foramen Tumors

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Objective : Deep location, hypervascularization, involvement of cranial nerves and vessels, and large extension within the posterior fossa are the main difficulties for surgical resection of the jugular foramen tumors. We describe a combined transmastoid transjugular transtubercular high cervical approach for radical resection of these tumors.

Methods : Six patients with jugular foramen tumors were surgically treated using combined transmastoid transjugular transtubercular high cervical approach between January 2000 and June 2008. The complex approach for total jugular foramen exposure can be simplified in a stepwise fashion: 1) postauricular infratemporal incision; 2) retrolabyrinthine mastoidectomy; 3) high cervical exposure; 4) Lateral suboccipital craniotomy and transtubercular exposure; 5) removal of the internal jugular vein (IJV), jugular bulb, and sigmoid sinus; and 6) intradural exposure.

Results : Gross total resection was achieved in 5 patients and subtotal resection in one patient. The histologic examination of the tumors revealed as follows: schwannoma (3 cases), meningioma (1 case), paraganglioma (1 case), and chondrosarcoma (1 case). The most frequent complication was a new deficit of lower cranial nerves. There were no facial nerve injury or cerebrospinal fluid leakage.

Conclusions : The combined transmastoid transjugular transtubercular high cervical approach described above allows for single-staged radical resection of large complex jugular foramen tumors. This approach has the advantage of providing total exposure of the jugular foramen with multidirectional angles of attack without facial nerve transposition.

Key Words *Jugular foramen, Skull base, Surgical approach, Paraganglioma, schwannoma, meningioma.*

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Introduction

Jugular foramen tumors are deeply located, may be highly vascularized, and involve important neurovascular structures and bone at the cranial base. They are rare and most commonly include paraganglioma, schwannomas, and meningiomas.[5] Surgical removal of these lesions remains a challenge, in spite of new developments of cranial base surgical techniques. Several surgical approaches have been developed to overcome these difficulties. According to Rhoton,[7] jugular foramen approaches can be subdivided into three main groups: a lateral group (the postauricular transtemporal approach subdivided in infralabyrinthine, translabyrinthine, and transcochlear approaches); a posterior group (retrosigmoid approach and its more extensive far-lateral and transcondylar variants); and an anterior group (preauricular subtemporal-infratemporal approach). Two other groups also exist but are not suitable alone for lesion resection: the superior group (middle fossa approach); and the inferior group (cervical approach upward to the jugular foramen).

The standard surgical approach is lateral, the infratemporal transpetrosal approach.[3] It permits one to gain superior and lateral access to the jugular foramen by drilling of the petrous bone. During this procedure, the facial nerve is frequently transposed anteriorly for allowing the drilling of the bone inferior to the labyrinth.[2] Manipulation of the facial nerve exposes the patient to a non-negligible risk of facial nerve palsy.[6] To limit the risk of facial nerve palsy, some surgeons advocate keeping the facial nerve in its bony canal if the nerve is not infiltrate by the tumor.[1]

Total exposure of the jugular foramen can be achieved, and multidirectional approaches can be performed, including suprajugular (infralabyrinthine), transjugular, infrajugular (retrosigmoid/trranscondylar) exposures.[4] Both intracranial and extracranial tumor can be removed in one-stage procedure. Paragangliomas, schwannomas of the lower cranial nerves, meningiomas, and chondrosarcomas at the jugular foramen and high cervical region are accessible through this approach. Transection of the external ear canal and permanent rerouting of the facial nerve is not necessary.

The complex approach for total jugular foramen exposure can be simplified in a stepwise fashion: 1) postauricular infratemporal incision; 2) retrolabyrinthine mastoidectomy; 3) high cervical exposure; 4) Lateral suboccipital craniotomy and transtubercular exposure; 5) removal of the internal jugular vein (IJV), jugular bulb, and sigmoid sinus; and 6) intradural exposure.

Methods

Patient population

Six patients with jugular foramen tumors were surgically treated using combined transmastoid transjugular transtubercular high cervical approach between January 2000 and June 2008. The relevant patient demographic characteristics, location of tumor, and surgical outcomes for the 6 patients underwent surgery via a juxtacondylar approach are listed in Table 1. There were 4 men and 2 women whose mean age was 42.7 years (range 27-55 years).

Table 1. Patient demographics, location of tumor, and surgical outcomes in 6 patients with jugular foramen tumor underwent surgery via a combined transmastoid transjugular transtubercular high cervical approach.

Patient	Age(yr)/Sex	Preoperative CN deficits	Site of tumor	New CN deficits	Extent of resection	Pathology
1	42/M	IX, X, XII	JF, CPA	-	Total	Schwannoma
2	42/F	X, XII	JF, CPA	IX	Total	Schwannoma
3	44/M	X	JF, CPA	-	Total	Schwannoma
4	46/F	IX, X, XII	JF, CPA, ME	-	Subtotal	Meningioma
5	27/M	-	JF, ME		Total	Paraganglioma
6	55/M	X, XII	JF, CC	X	Total	Condrosarcoma

CN=cranial nerve; JF=jugular foramen; CPA=cerebellopontine angle; ME=middle ear; CC=carotid canal.

The most common symptoms at the time of presentation included dysphonia, unsteadiness, and dysphagia. One patient with paraganglioma was presented with pulsatile tinnitus and hearing loss. Four patients were found to be suffering from at least one cranial nerve deficit in the preoperative evaluation.

Surgical Procedure

Position of Patient and Skin Incision

After induction of general anesthesia, the patient is placed in supine position with the head held in a Mayfield clamp and turned 45 degree to the opposite side. The opposite jugular vein must be free from compression. A nasogastric tube is inserted and intraoperative monitoring of facial and lower cranial nerves is performed. All contact areas are protected with foam pads or water bags. The skin incision had a question mark-shape, starting in the temporal region and circumscribing the ear as far as the anterior border of the sternomastoid muscle. The skin flap is elevated in two layers. The galeal layer is undermined from the skin flap and subsequently elevated with periosteum. The scalp is reflected anteriorly, and the posterior auricular muscle is seen behind the external ear canal. The posteolateral neck muscles are reflected posteiorly to expose the body of the mastoid.

Retrolabyrinthine Mastoidectomy

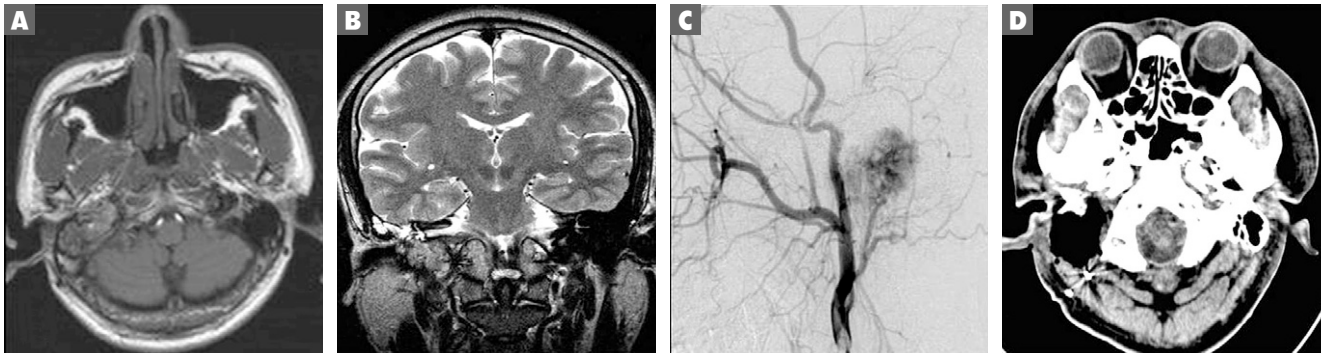
The entire body and tip of the mastoid, the spine of Henle, the posterior point of the root of the zygoma, the supramastoid crest, and the asterion must be exposed before the mastoidectomy performed. The outer mastoid triangle, which is formed by the posterior point of the root of the zygoma, the mastoid tip, and the asterion, marks the area of initial drilling for the mastoidectomy. The mastoid air cells are then systematically removed by saucerization. The sigmoid sinus and jugular bulb are completely skeletonized, and the mastoid air cells totally removed to expose the presigmoid dura, the superior petrosal sinus, sinodural angle, the middle fossa dura, and the retrosigmoid dura.

As air cells are removed from the mastoid tip region, the digastric ridge is encountered. For a retrolabyrinthine exposure, the bony labyrinthine must be clearly defined with diamond burr. The facial nerve is carefully skeletonized by using a diamond burr under contrast, copious irrigation to prevent thermal injury. The retrofacial air cells are removed to skeletonize the jugular bulb further.

High Cervical Exposure

To identify the extracranial portions of the lower cranial nerves, the internal carotid artery, and IJV, high cervical exposure should be performed. The digastric muscle is used as a guide for dissection of the XII and VII cranial nerves. The

Fig. 1



T1-weighted axial
A. and T2-weighted coronal
B. MR images showing a jugular foramen mass extending to middle ear cavity. Preoperative DSA image
C. revealing a hypervascular tumor supplied by ascending pharyngeal artery and occipital artery. Postoperative CT scan
D. demonstrating complete removal of paraganglioma.

XII cranial nerve crosses the external carotid artery inferior to the digastric muscle. The accessory nerve runs laterally to the IJV in the majority of cases. The vagus nerve run latero-inferior to the common carotid artery. Posterior retraction of the IJV helps expose the carotid branch of the glossopharyngeal nerve.

Suboccipital and Transtubercular Exposure

A lateral suboccipital craniotomy is then performed. The sigmoid sinus and jugular bulb must be totally exposed with rongeurs and a high-speed drill. Bone removal is next directed superiorly toward the jugular tubercle, a rounded prominence found at the junction of the basilar and condylar parts of the occipital bone. The jugular tubercle should be drilled away as much as possible. To minimize the heat injury to lower cranial nerves, the center of the tubercle is cored out with a high-speed diamond drill and copious irrigation, leaving an eggshell-thin layer of bone covering the dura that can be elevated with microdissector. The lower cranial nerves take a hairpin bend and exit under the jugular vein and bulb. The inferior petrosal sinus enters the anterior medial aspect of the jugular bulb by multiple channels coursing between the glossopharyngeal and the vagus nerve.

Removal of Internal Jugular Vein, Jugular Bulb, and Sigmoid Sinus

After complete exposure of the sigmoid sinus, jugular bulb, and IJV, the internal jugular vein is ligated just inferior to the tumor mass. The sigmoid sinus is occluded just above the tumor mass with a suture ligature. The lateral wall of the IJV is incised and removed with the tumor up to the jugular bulb and sigmoid sinus. The plane of dissection between the tumor and the medial wall of the jugular bulb is preserved.

Retrosigmoid Intradural Exposure

The dura mater is incised in the medial wall of sigmoid sinus. Minimal cerebellar retraction is needed to open the cerebellopontine cistern, exposing the intradural jugular foramen region. Sharp arachnoid dissection is performed, and the following structures can be visualized: Vth through XIIth cranial nerves, basilar artery, vertebral artery, posterior inferior cerebellar artery, and anterior inferior cerebellar artery.

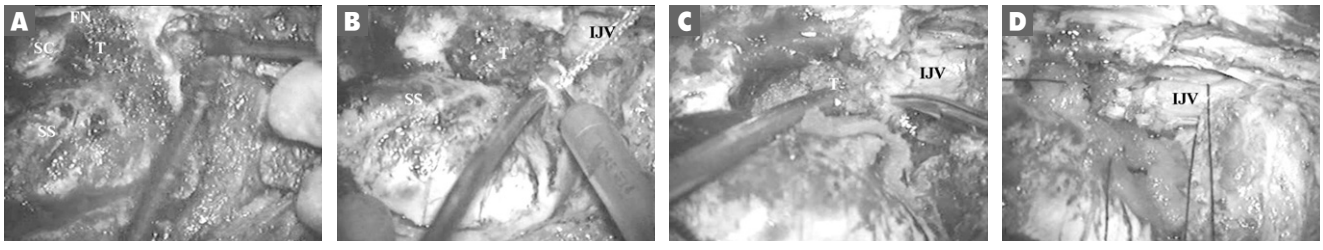
Closure

After adequate hemostasis, the wound is irrigated with antibiotic saline solution. Cranial base reconstruction and prevention of a cerebrospinal fluid leak is paramount to the success of surgery. A watertight dural closure should be the goal. If there is a large defect, an autologous fascial graft or pericranial flap followed by fibrin glue may be used. Autologous fat is used to pack the mastoid defect and remaining anatomic dead space. Temporary lumbar drainage can be used to facilitate healing of the dural closure.

Results

The location and the extent of the lesions were determined

Fig. 2



A. Intraoperative photograph (right-sided approach) demonstrating a glomus jugular tumor after retrolabyrinthine mastoidectomy and skeletonization of sigmoid sinus.
B. Extradural reduction of jugular tubercle is the key maneuver in this approach. The jugular tubercle should be drilled away as much as possible.
C. The tumor is carefully removed from the pars nervosa with care taken not to damage the lower cranial nerves.
D. After complete exposure of the sigmoid sinus, jugular bulb, and internal jugular vein, the internal jugular vein and sigmoid sinus were ligated.

FN=facial nerve; IJV=internal jugular vein; SC=semicircular canal; SS=sigmoid sinus; T=tumor.

preoperatively using the radiology reports (high resolution computed tomography with bone windows and magnetic resonance imaging), which was subsequently confirmed intraoperatively. The frequency of involvement of the various structures was as follows: jugular foramen, cerebellopontine angle, middle ear, carotid canal. The jugular bulb was already closed by the tumor in 3 cases. One patient underwent preoperative embolization.

Gross total resection was achieved in 5 patients and subtotal resection in one patient. The histologic examination of the tumors revealed as follows: schwannoma (3 cases), meningioma (1 case), paraganglioma (1 case), and chondrosarcoma (1 case). Meningioma showed no clear cleavage plans and total removal is not possible.

The most frequent complication was a new deficit of lower cranial nerves. Two patients developed lower cranial nerve palsy temporarily. There were no facial nerve injury or cerebrospinal fluid leakage. Postoperative radiosurgery was performed in one patient with meningioma.

Discussion

The combined transmastoid transjugular transtubercular high cervical approach described above allows for single-staged radical resection of large complex jugular foramen tumors. This approach has the advantage of providing total exposure of the jugular foramen with multidirectional angles of attack without facial nerve transposition.

In our experiences, the expanding tumors, such as schwannomas or chondrosarcomas, are fairly easy to remove and can be done without facial nerve transposition. However, facial nerve transposition may be needed in surgery for infiltrative tumors such as meningiomas or malignant tumors.

In anatomic study of the jugular foramen, cranial nerve, jugular bulb, and IJV are surrounded by a single connective tissue sheath.8) Therefore, jugular bulb and internal jugular vein can be separated from internal carotid artery and cranial nerves by microsurgical techniques. Dissection of dense connective tissue around the IJV is important for wide exposure of jugular foramen with gentle retraction of IJV instead of facial nerve transposition.

The multidisciplinary approach gives the best chance of radical removal with preservation of cranial nerves and vessels. To avoid postoperative complications, an adequate surgical exposure and reconstruction of the cranial base are required. Surgical morbidity and mortality are usually associated with damage to the lower cranial nerves. Identification and dissection in the neck and at the foramen magnum is helpful in the preservation of these nerves. When they are infiltrated yet still functioning, our strategy is to leave a small piece of tumor around them and if necessary (if there is proven postoperative residual tumor growth) administer radiotherapy.[5)]

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