Paparella: Volume III: Head and Neck

Section 2: Disorders of the Head and Neck

Part 7: The Neck

Chapter 45: Parapharyngeal Space Masses: Diagnosis and Management

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A clear understanding of the normal anatomy of the neck and a high index of suspicion are fundamental to the recognition of pathologic processes involving the parapharyngeal space. This potential space may be invaded by inflammatory or metastatic disease. Alternatively, the neurovascular structures that pass through the parapharyngeal space may be involved with these pathologic processes or may be the source of primary neoplastic degeneration. Under most circumstances, the physician familiar with the head and neck will be able to formulate an appropriate differential diagnosis based upon history, physical examination, and imaging techniques so that a therapeutic plan can be developed.

Anatomy of the Parapharyngeal Space

A study of the fascial spaces of the head and neck may leave the clinician more confused than knowledgeable because the information available in the literature is often unclear and contradictory. The description of the parapharyngeal space contained herein reflects a surgical approach to the pathologic processes that may be encountered.

The parapharyngeal space is, in fact, a *potential* space, which is defined by fascial planes of lesser and greater resistance so that pathologic processes that come to lie within the parapharyngeal potential space tend to grow and spread along the planes of least resistance while being contained by the planes of greatest resistance.

This space has been variously termed the *pterygomaxillary space, pharyngomaxillary space, lateral pharyngeal space,* and *pterygopharyngeal space.* The term *parapharyngeal space* has been most commonly used in the recent surgical literature and will be used in this chapter.

The parapharyngeal space is filled with loose connective tissue, associated lymphatics, and nodes. Clinicians consider the contents of the carotid sheath to be within the parapharyngeal space. The fascia of the posterior aspect of the carotid sheath serves as its posterior margin. The space has been described as being pyramidal, with the apex directed inferiorly toward the lesser cornu of the hyoid bone. The base and superior limit of the parapharyngeal space is bounded by the skull base.

The lateral aspect of the parapharyngeal space is limited anteriorly by the ascending ramus of the mandible and medial pterygoid muscle. Posterior to the ascending ramus of the mandible, the parotid gland and its surrounding fascia form the lateral limit of the space. The medial wall of the parapharyngeal space consists of the fascia surrounding the pharyngeal constrictor muscles and the fascia of the tensor and levator muscles of the velum palatini.

Anteriorly, the space is bounded by the joined interpterygoid fasciae, whereas inferiorly the space is closed by the fascia lateral to the angle of the mandible. Inferiorly, the parapharyngeal space ends at the level of the hyoid bone, which approximates the inferior pole of the palatine tonsil.

The parapharyngeal space may be divided into compartments, which include the anterior or prestyloid compartment, a posterior or retrostyloid compartment, and a medial or retropharyngeal compartment.

The prestyloid compartment contains the internal maxillary artery, the inferior alveolar nerve, the lingual nerve, and the auriculotemporal nerve. This prestyloid compartment is related to the lateral wall of the nasopharynx superiorly and the tonsillar fossa inferiorly.

The poststyloid compartment has within it the contents of the carotid sheath - namely, the internal carotid artery; the internal jugular vein; cranial nerves IX, X, and XII; the cervical sympathetic chain; and numerous lymph nodes. The spinal accessory nerve is technically within the space, but its course along the sternocleidomastoid muscle effectively protects it from most entities that develop within the parapharyngeal space.

The retropharyngeal space is often described as being a separate entity from the parapharyngeal space; however, the fascial planes that separate the parapharyngeal space from the space immediately posterior to the fascia of the superior constrictor muscle are such that tumors may freely communicate to the midline.

Lymphatics within the parapharyngeal space communicate abundantly with many sites from the head and neck. Any neoplasm that metastasizes to the superior jugular group of nodes - for example, from the nasopharynx, tongue base, parotid gland, or oropharynx - is a likely source of the primary tumor; however, the parapharyngeal space may occasionally be the site of metastasis from any site in the body.

Clinical Manifestations

Infection

Involvement of the parapharyngeal space by infection has been termed *deep neck infection.* These disease processes most likely originate from involvement of the parapharyngeal lymph nodes by bacteria from associated oropharyngeal sites, such as dental abscesses and tonsillitis; however, in up to 50 per cent of cases, the initiating site of infection may not be identified. Subsequent progression of the infection in the lymph nodes may lead to suppuration and involvement of the parapharyngeal space by abscess. Expansion of the abscess causes displacement of the tonsil and lateral pharyngeal wall toward the midline. This is often associated with erythema and a purulent exudate. Involvement of the adjacent pterygoid and paraspinal muscles with the inflammatory process results in trismus and a stiff neck, the latter of which may be misinterpreted as a sign of meningitis. The thickness of the overlying sternocleidomastoid muscle prevents the detection of fluctuance.

Patients with deep neck infection characteristically exhibit the cardinal signs of infection - namely, fever, leukocytosis, and pain. Distinguishing deep neck infection from

other pathologic entities is rarely difficult. With progression of the infectious process, the abscess may spread along the plane of the carotid sheath into the mediastinum. Alternatively, the structures of the parapharyngeal space may become involved with infection, resulting in jugular vein thrombosis, carotid artery erosion, or paralysis of the cranial nerves or cervical sympathetic chain.

Therapy should be directed at supportive measures such as maintaining adequate hydration and protecting the airway. This may frequently require tracheotomy. Cultures of blood and suspected sites of infection should be obtained, following which antibiotic therapy is started empirically. Choice of antibiotic reflects the physician's best guess as to the pathogenic bacteria involved. Antimicrobial agents directed against oral flora (eg penicillin, cephalosporins, or clindamycin) are often combined with an antibiotic that is effective against gram-negative bacteria (eg gentamicin) until culture reports are available. The pathologic process can frequently be well localized with computed tomography (CT) so that surgical exploration and drainage can be planned. A full and complete discussion of deep neck infection is beyond the scope of this chapter and is dealt with elsewhere in this book.

Tumor

Tumors of the parapharyngeal space produce symptoms by exerting pressure on neighboring structures. These tumors are frequently benign, and symptoms may be subtle and insidious in nature. Expansion of the tumor occurs in the plane of least resistance - namely, medially toward the tonsil and lateral pharyngeal wall, laterally between the tail of the parotid and submandibular glands, and posteriorly into the retromandibular area. The diagnosis should be suspected when a mass is encountered that displaces the tonsil and lateral pharyngeal wall toward the midline, or when a mass is encountered in the neck near the angle of the mandible. Bimanual palpation of the mass may lead the observer to recognize that the parapharyngeal space is involved by tumor.

Tumors of the parapharyngeal space that are palpated in the neck may pass through the stylomandibular tunnel. This tunnel is formed by the posterior aspect of the ascending ramus of the mandible and the ligament that extends from the tip of the styloid process to the mandible. The superior aspect of this tunnel is formed by the skull base. Tumors passing through the stylomandibular tunnel have, of necessity, a dumbbell shape. These tumors will be palpable as a retromandibular mass externally, whereas they displace the medial wall of the pharynx and tonsil with the midline intraorally. Dumbbell tumors are almost always benign pleomorphic adenomas that have developed in the deep lobe of the parotid glands.

Other manifestations of parapharyngeal space tumors are related to the tissue of origin and the effect upon surrounding structures. For instance, hearing loss resulting from a middle ear effusion may be encountered when the eustachian tube is functionally obstructed. Motor nerve disturbance may reflect compression of a nerve. Involvement of the vagus nerve results in paralysis of the ipsilateral vocal cord, whereas hypoglossal injury results in paralysis of the ipsilateral side of the tongue, with deviation of the tongue toward the side of the defect. Involvement of the cervical sympathetic chain results in Horner's syndrome (miosis, anhydrosis, and ptosis).

Dysarthria may occur when large tumors present in the lateral pharyngeal wall and associated soft palate. This may be associated with dysphasia.

Trismus is a common feature, which implies either irritation of the pterygoid muscles or, perhaps, mechanical obstruction to motion of the mandible.

Diagnostic Procedures

CT scanning with intravenous contrast enhancement is the most useful radiographic modality currently employed in the evaluation of the parapharyngeal space. CT scans serve to precisely define the location and extent of the lesion. The location of the lesion subsequently determines the need for further examinations such as arteriography. The finding of a vascular neoplasm in the parapharyngeal space is highly suspicious of a paraganglioma. On occasion, however, a benign neurofibroma may mimic the vascularity of the vagal paraganglioma.

With CT, the radiologist is able to localize the lesion to the pre- or poststyloid parapharyngeal space. Displacement of parapharyngeal fat with tumor helps to define the origin of the tumor. Poststyloid lesions push parapharyngeal adipose tissue anteriorly, creating a radiolucent crescent that remains anterior and lateral to the lesion, separating it from the pterygoid muscles. These lesions are medial and posterior to the styloid process. In contrast, prestyloid lesions that arise in the anterolateral portion of the parapharyngeal space tend to push the parapharyngeal fat medially and posteriorly, once again leaving a crescent of radiolucent fat separating the lesion from the muscles of deglutition.

Many prestyloid lesions arise in the deep lobe of the parotid gland from which they may extend through the stylomandibular tunnel to involve the parapharyngeal space. CT may demonstrate that the prestyloid lesion is clearly separate from the deep lobe of the parotid gland. This suggests that the salivary gland neoplasm has arisen from a minor salivary gland in the soft palate - lateral pharyngeal area rather than from the deep lobe of the parotid gland. This situation may at times be better evaluated employing simultaneous CT imaging and parotid sialography. Under most circumstances, however, the parotid gland, which has a specific density on CT, can be precisely defined.

Carotid arteriography may be indicated in most patients with poststyloid lesions. Surgical planning is facilitated through evaluation of the relationship between the tumor and the major neurovascular elements of the carotid sheath. The most common lesions are tumors of neural origin, such as neurofibromas and paragangliomas. Angiography may serve to differentiate between these two lesions. It also determines the blood supply and can help to detect unsuspected secondary tumors, which may be encountered in some patients with paragangliomas.

The paraganglioma of the carotid body may be distinguished from the vagal paraganglioma by its location. The carotid body tumor is found in the angle between the internal and external carotid arteries, whereas glomus vagale is more superior and displaces the carotid body anteriorly. Glomus jugulare tumors are separated from vagal tumors most easily by CT. Glomus jugulare tumors erode the walls of the jugular foramen.

Parapharyngeal involvement with metastatic carcinoma usually results in lymph nodes with a characteristic central lucency and associated enhancing rim. Arteriography is rarely necessary.

In summary, CT scanning is the most useful radiographic modality currently employed in evaluation of the parapharyngeal space. CT determines the location and extent of the lesion and helps to determine the need for arteriography or sialography. The developing role of magnetic resonance imaging (MRI) in evaluating the pathologic features of the parapharyngeal space is acknowledged.

Fine Needle Aspiration Biopsy

Fine needle aspiration biopsy may be helpful in the preoperative evaluation of tumors involving the parapharyngeal space. This procedure is easily applied in patients in whom the tumor is clearly palpable in the retromandibular or submandibular areas. Transoral aspiration is possible in some cases; however, it may be technically more demanding. Deeply seated parapharyngeal masses may be aspirated percutaneously with fluoroscopic guidance. Fine needle aspiration may serve to confirm the presumptive clinical diagnosis. In some instances in which a malignant tumor is suspected by virtue of involvement of adjacent structures and destruction of bone, a fine needle aspiration biopsy may help in treatment planning.

Open Biopsy

An open biopsy preoperatively is rarely indicated and should perhaps be performed only if the lesion is regarded as inoperable. One should never be tempted to perform an open biopsy via the intraoral route. This technique is fraught with potential problems, not the least of which is bleeding from a vascular tumor or displaced carotid artery and damage to other vital structures.

Tumors of the Parapharyngeal Space

The tumors most commonly encountered in the parapharyngeal space include salivary gland neoplasms, neurogenic tumors, and metastatic deposits from primary carcinoma elsewhere in the body. The neurogenic tumors most commonly encountered include neurofibroma and paraganglioma. A vast array of other benign and malignant neoplasms may be rarely encountered. These lesions represent neoplastic degeneration of the tissues that exist in this potential space. We have encountered occasional patients with lipoma, rhabdomyoma, rhabdomyosarcoma, lymphoma, meningioma, and chondrosarcoma in the parapharyngeal space.

Metastatic involvement of the parapharyngeal lymphatics may be suspected in the patient with a known primary focus of carcinoma. The parapharyngeal space may be the first site of metastasis for patients with carcinoma of the nasopharynx, nasal cavity, palate, or maxillary sinus. In circumstances in which a primary neoplasm is unsuspected, the diagnosis may not be made until a tissue sample has been obtained. Paralysis of the cranial nerves in the jugular foramen as they enter the parapharyngeal space results in the jugular foramen syndrome or Vernet's syndrome.

Salivary Gland Tumors

Less than 5 per cent of parotid tumors start in the deep portion of the parotid gland and extend into the parapharyngeal space. Nevertheless, 50 per cent of all primary parapharyngeal space tumors, excluding metastasis, are of salivary gland origin. Neoplastic degeneration of minor salivary glands situated within the soft palate, lateral pharyngeal wall, and tonsillar pillars may result in a parapharyngeal space mass as well.

A presumptive diagnosis is often possible based upon physical examination and the characteristic radiographic findings. Pain is unusual. Bimanual palpation allows identification of a firm, relatively mobile mass. The preferred treatment for these tumors is surgical excision. Excisional biopsy is preferred. Incisional biopsy should be employed only for tumors considered inoperable. In circumstances in which histologic evaluation is considered necessary prior to excisional biopsy, fine needle aspiration is a useful tool.

Neurogenic Tumors

Paragangliomas

Paragangliomas are neoplasms that arise from the paraganglionic bodies of the autonomic nervous system. These microscopic composites are composed of granular cells that contain catecholamines. These cells are of neuroectodermal origin. The carotid paraganglioma or carotid body is sensitive to changes in pH, PO_2, and PCO_2.

Paragangliomas are well-encapsulated brownish tumors with a firm consistency. Microscopic examination shows clusters of epithelial cells (Zellballen) in a highly vascular fibrous stroma. These lesions are histologically similar to the pheochromocytoma that may develop in the adrenal medulla. In contrast to pheochromocytoma, however, cervical paragangliomas rarely secrete catecholamines. There have been isolated reports of secreting jugular, laryngeal, and carotid paragangliomas; however, routine preoperative screening for vasopressors in patients with solitary paragangliomas of the head and neck is not indicated unless the patient's clinical findings suggest the secretion of vasoactive substances. Fluctuating systemic hypertension, palpitations, and blushing would be an indication for further evaluation. Approximately 10 per cent of patients with paragangliomas have a family history of the disease. Patients with familial paraganglioma may demonstrate multiple lesions. These patients are at higher risk of having an associated pheochromocytoma and should undergo preoperative screening for vasoactive substances. Patients with familial paraganglioma should undergo angiography to rule out multiple clinically recognized lesions.

The paragangliomas are named according to their site of origin. Paragangliomas of the jugular bulb are the glomus jugulare paragangliomas. Technically, the glomus jugulare develops in the jugular bulb cephalad to the parapharyngeal space. Enlargement of the tumor may result in expansion along the great vessels into the parapharyngeal space. The site of origin may be difficult to demonstrate in large tumors. Paragangliomas originating in the parapharyngeal space at the site of the carotid body (between the internal and external artery) are called carotid paragangliomas or chemodectomas, whereas a paraganglioma associated with the vagus nerve is called a vagal paraganglioma or a glomus intravagale.

Approximately 3 per cent of all paragangliomas are associated with the vagus nerve. Metabolically active tumors secreting catecholamine have not been described. The vagal paraganglioma most commonly arises in association with one of the vagal ganglia. The jugular ganglion (superior) lies within the jugular fossa. One centimeter caudal to this lies the nodose ganglion. The tumors tend to be spindle-shaped and displace the carotid artery anteriorly.

The most common presenting symptom of a vagal paraganglioma is hoarseness and aspiration of fluids resulting from injury of the vagus nerve with subsequent motor and sensory deficits caused by injury to both the superior and recurrent laryngeal nerves. The finding of vocal cord paralysis in association with a mass along the course of the vagus nerve is highly suggestive of vagal paraganglioma.

Tumors developing in the area of the jugular ganglion may be dumbbell in shape with an intracranial and extracranial component. It is important to identify this entity preoperatively so that adequate presurgical planning can be undertaken.

Neoplastic degeneration of the carotid body was termed *chemodectoma* by Mulligan in 1950. The term *carotid paraganglioma* better described this neoplasm and its location. The most common presenting symptom of a carotid paraganglioma is a mass in the neck located at the bifurcation of the common carotid artery. Large lesions may produce pressure, dysphasia, cough, or hoarseness. Characteristically, the mass may be distinguished from a cervical lymph node by virtue of the fact that it is mobile in the lateral direction but cannot be moved in a cephalocaudal direction. Carotid pulsations may be transmitted through the mass. Arteriographic evaluation demonstrates the findings of a vascular mass with early venous shunting in the bifurcation of the carotid artery. The diagnosis can be established preoperatively through CT scanning with enhancement or arteriography. Biopsy should not be undertaken prior to definitive operative removal.

The incidence of malignancy in paraganglioma is estimated to be less than 10 per cent. Histologic evaluation may not adequately distinguish malignant from benign lesions. The finding of invasion of surrounding structures and metastases are indicators of malignancy.

Surgical management of a paraganglioma is the treatment of choice. The indolent natural history of paragangliomas has led some authors to recommend no treatment for patients deemed too ill to tolerate surgical management or for elderly asymptomatic patients. Others have recommended radiation therapy.

Cole treated 22 patients with paraganglioma of the jugular foramen using radiation therapy. He reported that visible tumor typically remains unchanged for many years without progression of disease. Forty to 50 gray (Gy) was recommended. Patients treated with orthovoltage radiation therapy incurred a higher incidence of recurrence and severe complications. He subsequently recommended supervoltage radiation therapy.

The deferment of definitive surgical therapy has been associated with the development of pain and cranial nerve deficits, as uncontrolled tumors become larger. Current understanding of these lesions, skill in vascular reconstructive surgery, and the observation of progressive symptomatology in patients with paragangliomas suggest the advisability of

surgical excision as the treatment of choice.

Other Neurogenic Tumors

Neurogenic tumors constitute 30 per cent of primary tumors found in the parapharyngeal space. The vagus nerve is the cranial nerve most often involved; however, these tumors may arise from any other nerves in the parapharyngeal space and, in some cases, it may not be possible to identify the nerve of origin.

Embryology of the Peripheral Nerve. The neural tube gives rise to somatic motor axons and the preganglionic autonomic axons. All other peripheral axons, including postganglionic, sympathetic, and parasympathetic axons come from the neural crest. All peripheral axons are covered by Schwann cells. It is generally believed that Schwann cells are derived from the neural crest.

A number of terms are employed to describe lesions involving peripheral nerves, including *neurofibroma, neurinoma, neurilemmoma,* and *schwannoma.* The parent cell of all of these lesions is, most likely, the Schwann cell. For practical purposes, only the terms *schwannoma* and *neurofibroma* are used in practice. Differences exist between neurofibroma and schwannoma, which have treatment implications.

Schwannoma. The schwannoma is a solitary lesion that is almost never associated with von Recklinghausen's disease. Individual nerve fibers do not actually pass through the lesion but are draped over its surface. Therefore, it is possible to dissect the main trunk of the nerve away from the lesion during removal.

Pain and neurologic dysfunction are unusual. Unpleasant paresthesia with light palpitations are characteristic. Malignancy rarely, or never, occurs.

The histologic pattern of a schwannoma demonstrates degenerative and cystic changes. A pallisading array of nuclei around the central mass of cytoplasm is termed *Antoni type A.* When little distinctive pattern exists of stroma surrounding nerve fibers, the term *Antoni type B* is used. Occasionally, one type predominates over the other, but tumors are often composed of both patterns. The cells interwoven into palisades with fibrillary zones are termed *Verocay bodies.* Some schwannomas demonstrate hemorrhage and associated hemosiderin deposits. Pleomorphism with enlarged nuclei, irregular shapes, and occasional mitotic figures may be observed. These features do not imply malignancy. Schwannomas arising in cranial nerves in close proximity to a bony foramen may extend through the foramen, forming a dumbbell-shape tumor. The schwannoma is uncommonly found in the lateral portion of the neck, however.

Neurofibroma. The neurofibroma also arises from the Schwann cell. Neurofibromas are often subcutaneous and may be multiple.

The neurofibroma is not encapsulated. Nerve fibers are incorporated within the tumor and pass through it. This contrast with the schwannoma. Cystic and degenerative changes are uncommon.

Von Recklinghausen's disease is associated with a multiple neurofibroma. Sarcomatous transformation is reported in 6 to 16 per cent of patients with von Recklinghausen's disease.

Von Recklinghausen's Disease. Von Recklinghausen's disease is an autosomal dominant disorder observed in approximately 1/3000 births. In spite of this, only 50 per cent of cases have a family history of the disease.

Characteristically, patients have light brown macules 1.5 cm or greater in diameter called café au lait spots. Five or more café au lait spots are considered diagnostic. Other neurologic abnormalities such as spina bifida and glioma may be observed.

Patients with von Recklinghausen's disease most commonly have cutaneous neurofibromas. However, the cranial nerves may be affected, with the acoustic and optic nerves most commonly involved. Neurofibroma may arise on the cranial nerves in the parapharyngeal space.

Malignant Neurofibroma. Invasion of adjacent tissue or metastasis is an indication of malignancy. Malignant neurofibroma may occur sporadically; however, it is more frequently found in patients with von Recklinghausen's disease. The clinical findings include sudden growth or recurrence after apparent complete removal of a benign neurofibroma. Malignant neurofibroma may be histologically indistinguishable from fibrosarcoma, except for its relationship to a nerve trunk. Electron microscopy demonstrates a basement membrane in malignant neurofibroma that is lacking in fibrosarcoma. Nevertheless, many pathologists will not make a diagnosis of malignant neurofibroma unless the patient has von Recklinghausen's disease.

Surgical Approach to the Parapharyngeal Space

When a benign prestyloid parapharyngeal space tumor is diagnosed, a cervical skin incision is placed in a submandibular skin crease. The ramus mandibularis nerve is identified and elevated with the superior skin flap to preserve it. Tumors originating in the deep lobe of the parotid gland require total parotidectomy; therefore, the submandibular skin incision is extended superiorly around the ear lobe and anterior to the tragus. Superficial parotidectomy is carried out to fully identify the facial nerve, following which the lower divisions of the facial nerve are dissected from the parotid tissue and elevated.

To facilitate exposure, the external facial artery may be divided along the posterior belly of the digastric muscle, allowing anterior displacement of the submandibular gland. These benign tumors are well encapsulated, and removal by blunt dissection is typically possible.

Benign neurogenic tumors of the poststyloid parapharyngeal space may be removed through a similar submandibular incision; however, superficial parotidectomy is not required. When the size of the tumor requires more exposure, some authors have advocated midline mandibulotomy, with mandibular swing to afford improved accessibility to the poststyloid space at the skull base.

Special Considerations

Surgical resection of a carotid paraganglioma requires exposure and identification of the carotid artery both proximal and distal to the tumor. Every effort must be made to preserve the vagus, hypoglossal, and spinal accessory nerves. Subadventitial dissection is undertaken to remove the tumor. The external carotid artery is ligated in order to gain exposure to the tumor as it extends superiorly and posteriorly. Infiltration of the adventitia of the carotid artery with lidocaine will control local vasospasm.

Preoperative embolization of vascular lesions has been advocated by many authors. We do not, however, advocate embolism of carotid body paragangliomas. The multiple vascular connections are difficult to embolize, and accidental intracranial embolization may occur. More importantly, embolization may precipitate an intense inflammatory response, which, in turn, makes subadventitial dissection more difficult or impossible. Kumar and associates reported two patients embolized preoperatively for carotid paragangliomas. Moderate blood loss occurred in one patient because of accidental carotid laceration, and carotid artery resection was reportedly necessary in the second patient. Similar experience has led us to believe that damage to the carotid artery occurs less commonly when preoperative embolism is avoided.

Inadvertent damage to the carotid artery should be repaired whenever possible. Patients with recurrent or very large tumors may be best served if evaluated preoperatively with balloon occlusal studies so that carotid artery replacement or resection can be planned.

The cervical-transpharyngeal approach to the parapharyngeal space calls for a transverse incision at the level of the hyoid bone, which is extended superiorly in the midline in a vertical direction to split the lip. A midline mandibulectomy allows incision of the floor of the mouth mucosa along the lingual alveolus to the anterior tonsillar pillar. Lingual and hypoglossal nerves are identified and preserved. This allows good exposure of the poststyloid parapharyngeal space to the skull base. The great vessels can be identified and preserved during tumor removal. The mandibular osteotomy is repaired at the conclusion of the procedure. Tracheotomy is mandatory. Attia and co-workers advocated a second osteotomy on the ascending ramus of the mandible proximal to the superior alveolar foramen to preserve the neurovascular bundle. This approach was advocated for extremely large and vascular tumors that required maximal exposure.

Paraganglioma of the vagus nerve proximal to the jugular foramen may have both intracranial and extracranial components. This dumbbell tumor requires a trans-mastoid-trans-cervical approach.

A curvilinear excision is begun in the postauricular crease and is brought down into the neck on the anterior border of the sternocleidomastoid muscle. Skin flaps are elevated and the facial nerve is identified for future protection. The carotid artery and jugular vein are identified and preserved. The vagus nerve is located low in the neck and is followed in a cephalad direction until the caudal border of the tumor is found. The lesion is dissected from the adjacent structures. Care is taken to preserve the hypoglossal nerve. Dissection of the cephalad portion of the tumor requires that the mastoid cortex be taken down. The facial nerve is identified in its vertical portion and preserved. Large tumors may require dislocation

of the facial nerve out of the canal anteriorly. Black and colleagues advocated division of the facial nerve in extreme cases, with subsequent immediate reanastomosis following tumor removal.

The transverse process of the cervical vertebra may limit exposure to the jugular foramen. Amputation of this lateral process with ligation of the posterior occipital and posterior auricular arteries may be required. Intracranial extension can then be undertaken by joining this approach with a posterior fossa craniotomy.

Rehabilitation of the voice may be undertaken following vagus nerve resection by injection of the vocal cord under direct vision with an absorbable gelatin sponge (Gelfoam) paste. This improves vocal quality and decreases aspiration.

Malignant tumors of the parapharyngeal space that were previously considered inoperable because of the proximity to the great vessels and to the middle fossa may now be removed by a surgical team conversant with the lateral approach to the skull base. These techniques, which may require combined neurosurgical and otolaryngologic teams, are beyond the scope of this text and are discussed elsewhere in this book.