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Jugular fossa tumors: Role of imaging

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We review the anatomy of the jugular fossa in the context of current computed tomography and magnetic resonance techniques with examples of common and unusual presentations of these masses. Contrast-enhanced computed tomography and magnetic resonance imaging both can suggest etiology; define the size and full intracranial, transforaminal, and extracranial extent; and evaluate the regional anatomy to optimize surgical approach and minimize cranial nerve deficits. As inadequate exposure is a leading contributor to incomplete resection and recurrence, the ability to reformat high-resolution imaging in multiple planes is an asset to surgical planning.

Introduction

The jugular fossa or foramen complex is a natural skull base opening between the jugular plate of the occipital bone and the undersurface of the petrous temporal bone. It contains the jugular bulb as it receives the inferior petrosal vein; sigmoid sinus; mastoid and emissary veins; cranial nerves (CNs) IX, X, and XI, including short segments of dura; and meningeal branch arteries.[1,2] Accordingly, masses within the jugular fossa may have neural, vascular or perivascular, cartilaginous or epithelial origin, or arise from meninges, embryonal rests, or metastases. Patients with jugular fossa masses can present with complex and vague symptoms, including abnormal swallowing or phonating, hearing loss, pulsatile tinnitus, neck or shoulder weakness, syncope, or hypotension. In addition to identifying a mass within the jugular fossa, computed tomography (CT) and magnetic resonance imaging (MRI) are helpful at defining margins as well as clarifying regional anatomy that may have implications for the surgical approach. In this article, we review the anatomy of the jugular fossa in the context of current CT and MR techniques with examples of common and unusual presentations of these masses obtained from a 5-year IRB-approved retrospective review of the imaging database at an urban university medical center.

Anatomy

The jugular fossa is a depression in the inferior surface of the petrous bone behind the carotid foramen, has variable size and depth, and contains the bulb of the internal jugular vein. The jugular foramen is the irregular hiatus between the jugular fossa of the petrous bone and the jugular notch of the jugular plate of the occipital bone (Figure 1). Anteriorly, the foramen is separated from the carotid canal by the osseous carotid ridge, which overlies the tympanic nerve and the tympanic branch of CN IX (Jacobson nerve) en route to the middle ear. At the superiomedial boundary of the jugular foramen is a triangular notch in the bone at the site of the inferior ganglion of CN X (*ganglion nodosum*). The cochlear aqueduct opens at the apex of this notch. This notch is more easily identified on the internal surface of the jugular foramen and may be prominent, with its projecting edge reaching toward the basiocciput near the petro-occipital fissure.[1,2]

Although the individual microanatomical contents of the jugular fossa cannot be individually resolved on routine clinical CT or MRI, lesion growth patterns and secondary

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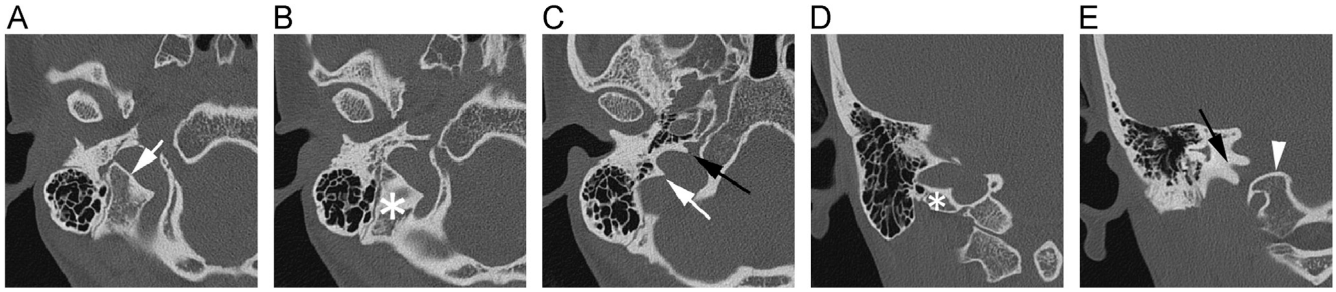

Figure 1 Normal anatomy of jugular fossa or foramen as defined on bone-window algorithm CT projections in the axial (A-C) and coronal (D and E) planes. The "jugular surface" (A, white arrow) is cartilage covered and articulates with the jugular plate or process of the basiocciput (B and D, white asterisk). The jugular notch projects from the jugular plate (C, white arrow). The cochlear aqueduct is evident at the superiomedial boundary of the jugular foramen (C and E, black arrow) opposite the occipital condyle or condyloid tubercle (E, white arrowhead).

signs evident on imaging reflect the underlying altered anatomy. The anterior portion of the foramen transmits the inferior petrosal sinus running along the petro-occipital fissure. The intrajugular compartment (*pars nervosa*) contains CNs IX, X, and XI. These enter via 2 separate dural openings on the medial aspect of the fossa[3]: the glossopharyngeal meatus for CN IX is superiorly located relative to the vagal meatus, which contains both CNs X and XI.[4,5] The external opening of the cochlear aqueduct is immediately adjacent to the glossopharyngeal meatus[5] and considered a landmark for the identification of the superior ganglion of CN IX.[3,6,7] The posterior portion of the foramen (pars vascularis) holds the bulb of the internal jugular vein.

The lateral wall of the jugular fossa is pieced by the tiny canals of the mastoid canaliculus, which transmits the auricular branch of CN X (Arnold nerve).[2] CN IX is further separated from X and XI within the jugular fossa by the confluence of the petrosal sinus with the sigmoid sinus, forming the jugular bulb.[8] All 3 lower CNs extend along the medial aspect of the internal jugular vein as it leaves the jugular foramen.[8,9]

Which study to use?

Both CT and MRI are widely used in the diagnosis of lesions at the jugular fossa, partly because the information that they provide is complementary and partly because there is a lack of evidence about the diagnostic efficacy of the two.[10] Patient factors, such as renal function, claustrophobia, or contraindications to MRI, may restrict which modality is available for evaluation.

High-resolution CT of the skull base is effective at detecting osseous changes in the jugular fossa, differentiating expansile (schwannoma) from permeative (paraganglioma) or destructive (metastasis) masses. CT should be performed on a multidetector scanner with minimum detector collimation and slice interval (eg, 0.6 mm and 0.2 mm, respectively), resulting in isotropic in-plane and through-plane dimensions allowing multiplanar reformations. Images also should be filtered in both a soft tissue and bone algorithm for evaluation. Routine noncontrast head CT is not recommended as it lacks sufficient contrast and resolution.

Some authors advocate multidetector CT angiography as a "one-stop-shop" examination as it includes lesion definition and enhancement, and the data set can be reformatted for evaluation of regional osseous anatomy as well as vascular anatomy with no additional radiation exposure.[10] This may be particularly useful in patients who have a contraindication or are unable to tolerate an MR examination. Angiographic technique with a 40-second delay after bolus contrast injection allows for arterial and venous definition. It has been proposed that the enhancement, measured in Hounsfield units (HU), may help to differentiate pattern of enhancement of a paraganglioma (210 HU) vs schwannoma (69 HU).[10]

MR of the skull base without and with contrast is an effective tool to detect large or small lesions within the jugular fossa, as these masses are generally characterized by some degree of enhancement.[11-13] Volumetric heavily T2-weighted images and fast field-echo T1-weighted images offer an exquisite depiction of the vascular and nervous regional structures. T2*-weighted images are sensitive for detecting prior hemorrhage. Diffusion-weighted images are particularly helpful if epidermoid, lymphoma, or myeloma is in the differential, as these lesions show restricted diffusion. Postcontrast fat-saturated T1-weighted sequences may help in diagnosing intraosseous infiltrative patterns and in the evaluation of large vessel contact or invasion.

Catheter angiography should be reserved for paragangliomas amenable to endovascular embolization.

General considerations

As inadequate exposure is a leading factor for incomplete resection[6] and a higher rate of recurrence,[9] imaging clarification of mass size and any intraosseous, intracranial, or cervical extension or carotid artery encasement are important for presurgical planning. The ideal surgical approach should adhere to the basic tenets of obtaining a wide access to the mass with minimal brain and CN manipulation, with the goal of preservation of the inner ear, middle ear, and facial nerve function.[14] The radiologist can help define the epicenter of the mass, alerting the surgeon to the expected location of the CNs, for appropriate preoperative