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Jugular Foramen: Anatomic and Computed Tomographic Study

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The computed tomographic (CT) appearance of the jugular foramen was examined in detail, and anatomic and CT sections were correlated. The pars nervosa and pars vascularis were identified, and, with intravenous contrast enhancement, a rapid sequence of scans at a gantry angle of +30° to the canthomeatal line demonstrated cranial nerves IX, X, and XI. The osseous margins of the jugular foramen were best shown by CT at planes of sections parallel and positive (0°–30°) to the canthomeatal line. CT can be used to evaluate osseous anatomy and the jugular foramen with precision sufficient to confidently exclude an intracanalicular mass.

The computed tomographic (CT) appearance of glomus jugulare tumors has been described [1–3], but the normal configuration of the foramen and its contents has not yet been completely analyzed by CT. We undertook a correlative study with head and skull specimens and clinical subjects.

Materials, Subjects, and Methods

In preliminary studies, we found that a plane of section 30° cephalad to the canthomeatal line (CML) just below the internal auditory canal, was nearly tangential to the endocranial opening of the jugular foramen (fig. 1). Dissecting fresh, frozen cadavers with a hand-held rotary grinder (Dremel Moto-tool), we identified cranial nerves IX, X, and XI in the jugular foramina (figs. 2–4). We also studied the appearance of the jugular foramen in a dry skull by removing bone in 1 mm increments with the rotary grinder (fig. 5).

To determine the CT appearance of the jugular foramen, we imaged a dry skull and some patients at several planes between –15° and +30° to the CML (figs. 6–8). We also reviewed the appearance of the jugular foramen in our conventional posterior fossa CT studies, done at –15° with respect to the CML [5].

Four patients with symptoms of a jugular foramen lesion (pulsatile tinnitus, cranial nerves IX, X, and/or XI deficit, etc.) were placed supine in the GE CT/T 8800 scanner with their heads elevated about 30° on a foam pad. CT images were obtained at a plane +30° to the CML determined with the lateral localizer scan. On the basis of our anatomic dissections, this plane is perpendicular to the intraforaminal course of cranial nerves IX–XI. Five- and 1.5-mm-thick sections were obtained about 5 mm below the internal auditory canal to locate the jugular foramen. We injected 50 ml of 60% iodinated contrast agent manually and rapidly in an antecubital vein via an 18 gauge Angio-cath needle. CT images were obtained at a single level; the first scan was 5 sec after the initiation of the injection and then every 10–15 sec until four scans were obtained. Technical factors included 1.5 mm collimation, 120 kVp, 9.6 sec scan time, pulse width of 2 msec, and 356 or 409 mAs (figs. 9 and 10). Subsequently, 150 ml of 30% iodinated contrast agent was infused and contiguous CT scans were obtained through the region of interest.

Results and Discussion

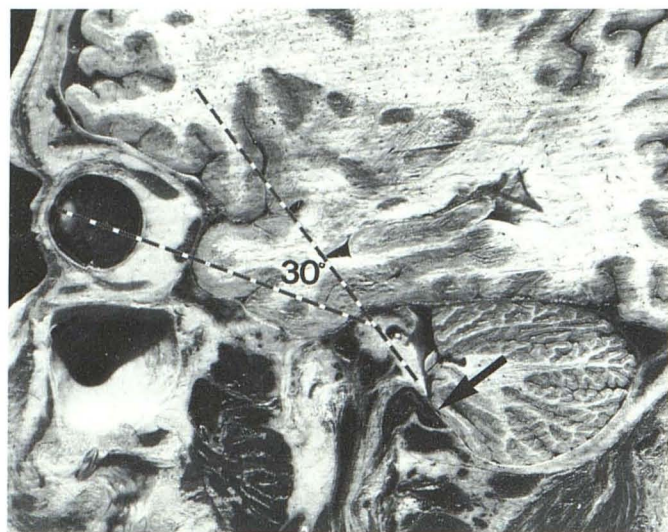
The anatomic and radiographic appearance of the jugular foramen has been described in detail [4, 6–8]. Briefly, the jugular foramen is a canal that extends

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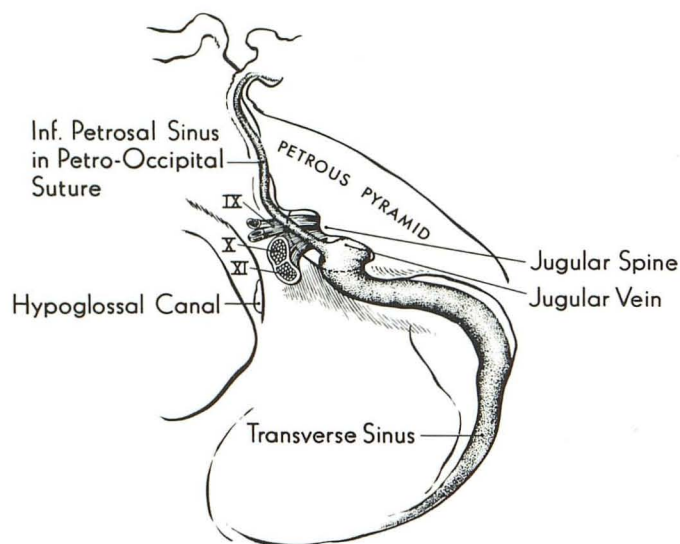
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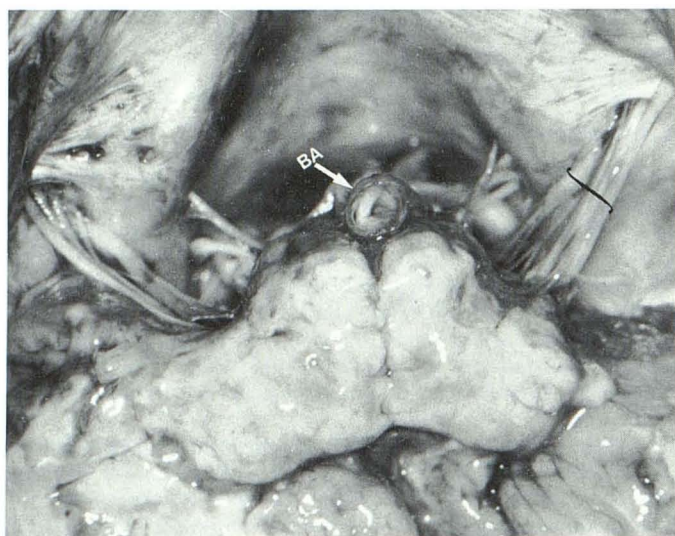
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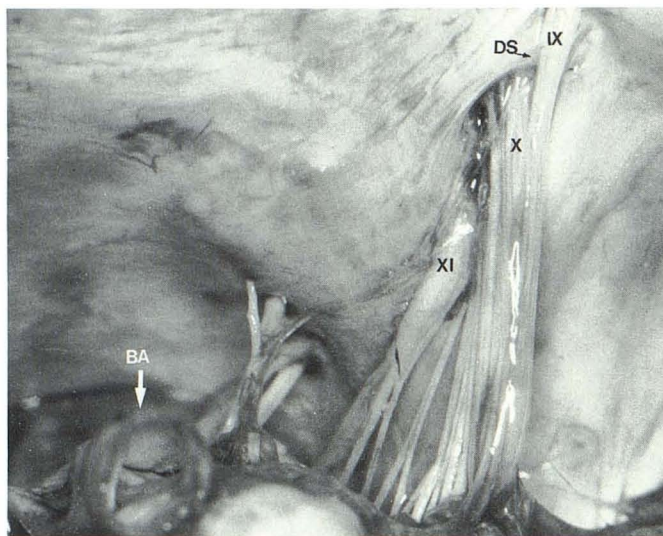
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Fig. 1.—Parasagittal anatomic section. Plane of endocranial opening (arrow) of jugular foramen forms 30° angle with CML. Plane is just below internal auditory canal.

Fig. 2.—Skull base from above. Common sheath of cranial nerves X and XI in pars vascularis and cranial nerve IX in pars nervosa. (Adapted from [4].)



A



B

Fig. 3.—Sections through medulla of fresh, frozen cadaver viewed from above and posteriorly. A, Cranial nerves IX, X, and XI (bracket) extend to jugular foramen. B, Dural septum (DS) separates meatus of IX and X-XI. BA = basilar artery.

anteriorly, laterally, and inferiorly from the endocranium to the exocranium between the temporal and occipital bones. The foramen is divided into two parts by a fibrous or osseous bridge that connects the jugular spine on the petrous part

of the temporal bone and the jugular process of the occipital bone. The foramen's anteromedial compartment, the pars nervosa, contains the glossopharyngeal (IX) nerve and the inferior petrosal sinus. The pars vascularis contains the

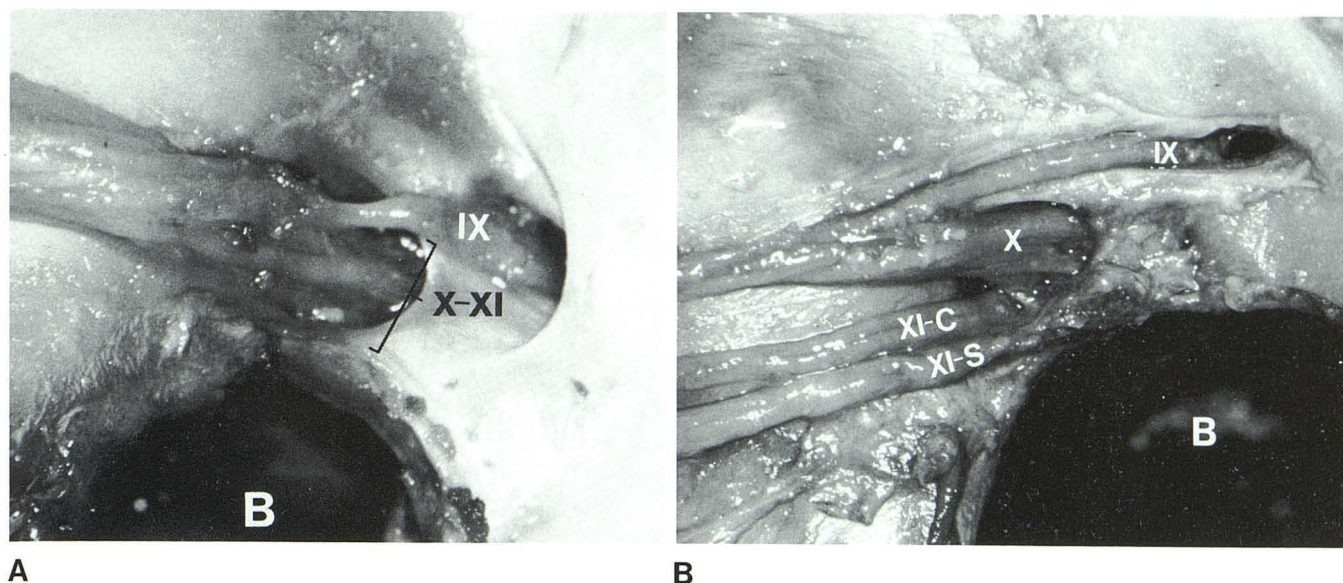


Fig. 4.—Jugular foramen after removal of dura covering jugular bulb (B). A, Cranial nerve IX has separate meatus. B, After removal of dura covering cranial nerve IX, cranial nerve X and cranial (C) and spinal (S) parts of cranial nerve XI are identified as they join in jugular foramen.

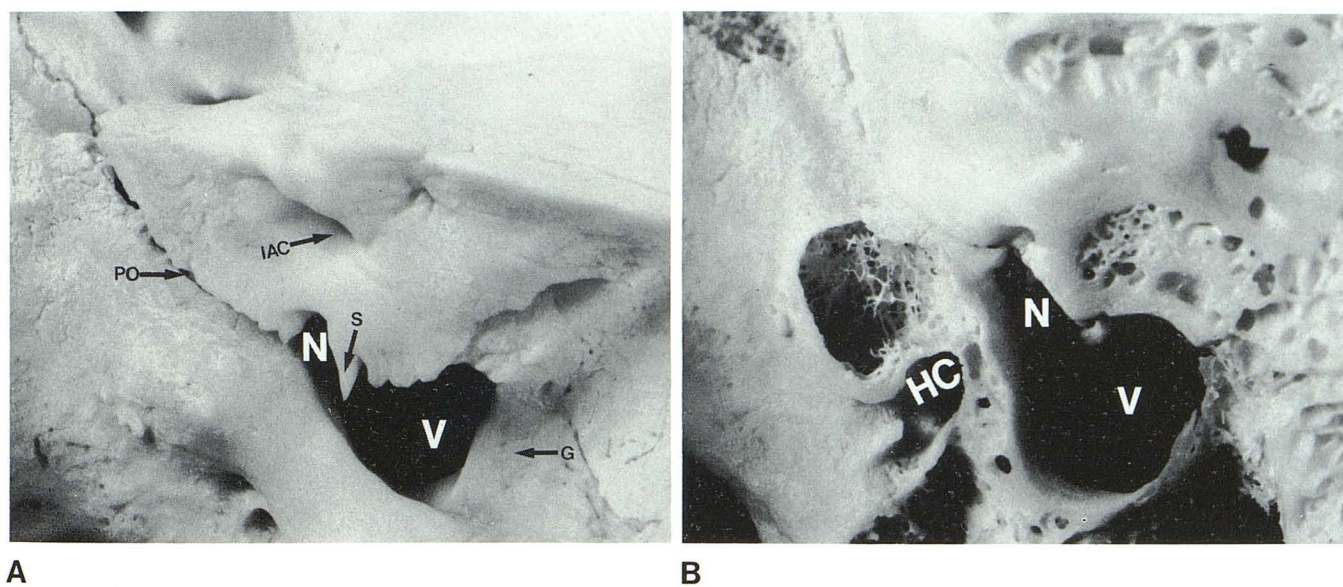


Fig. 5.—Endo- (A) and exo- (B) cranial openings of jugular foramen. Pars nervosa (N) and vascularis (V) are at endocranial opening. With endocranial end of canal removed, exocranial opening is identified. PO = petrooccipital fissure; IAC = internal auditory canal; HC = hypoglossal canal.

jugular bulb and the vagus (X) and spinal accessory (XI) nerves. The pars vascularis is usually larger on the right causing asymmetry of the jugular foramina.

Cranial nerves IX, X, and XI have a constant position in

the jugular foramen (figs. 2–4). Cranial nerves X and XI are in a common sheath near the anteromedial wall of the jugular bulb. Anterior to them and separated from them by a dural septum at the foramen's endocranial opening is cranial

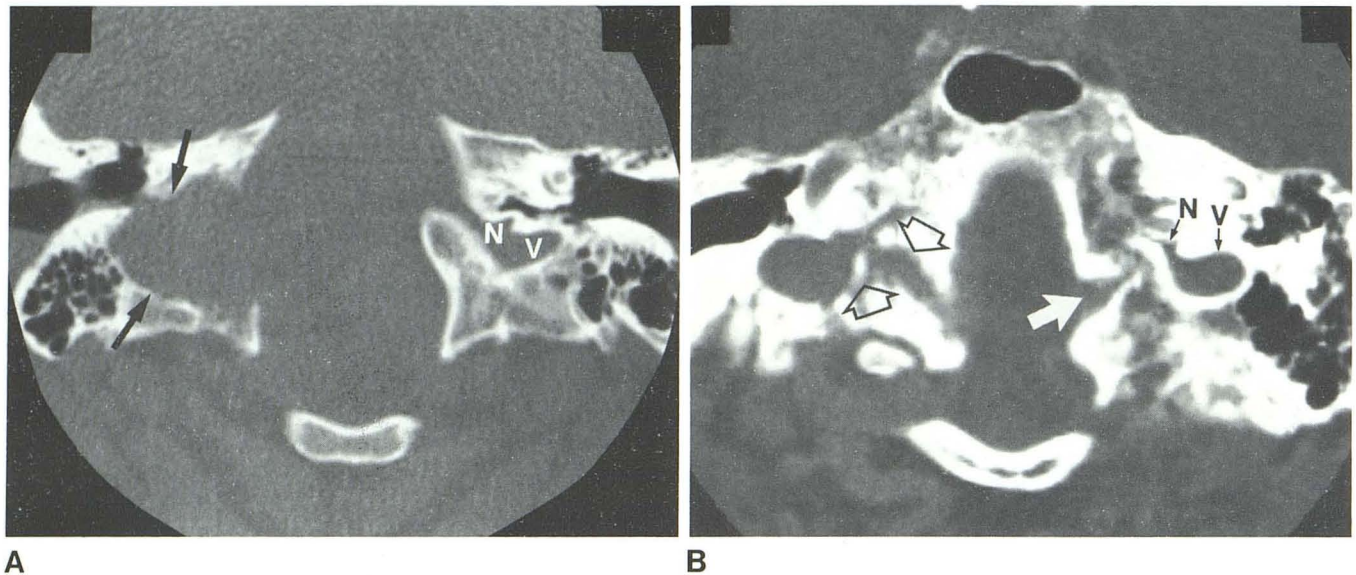


Fig. 6.—**A**, Normal pars nervosa (N) and vascularis (V) (left) and eroded jugular foramen (right) in patient with large glomus jugulare tumor (arrows). CT section is $+30^\circ$ to CML. **B**, Normal left hypoglossal canal (solid arrow) and jugular foramen in patient with metastatic breast carcinoma eroding right jugular foramen and hypoglossal canal (open arrows). CT section is $+30^\circ$ to CML.

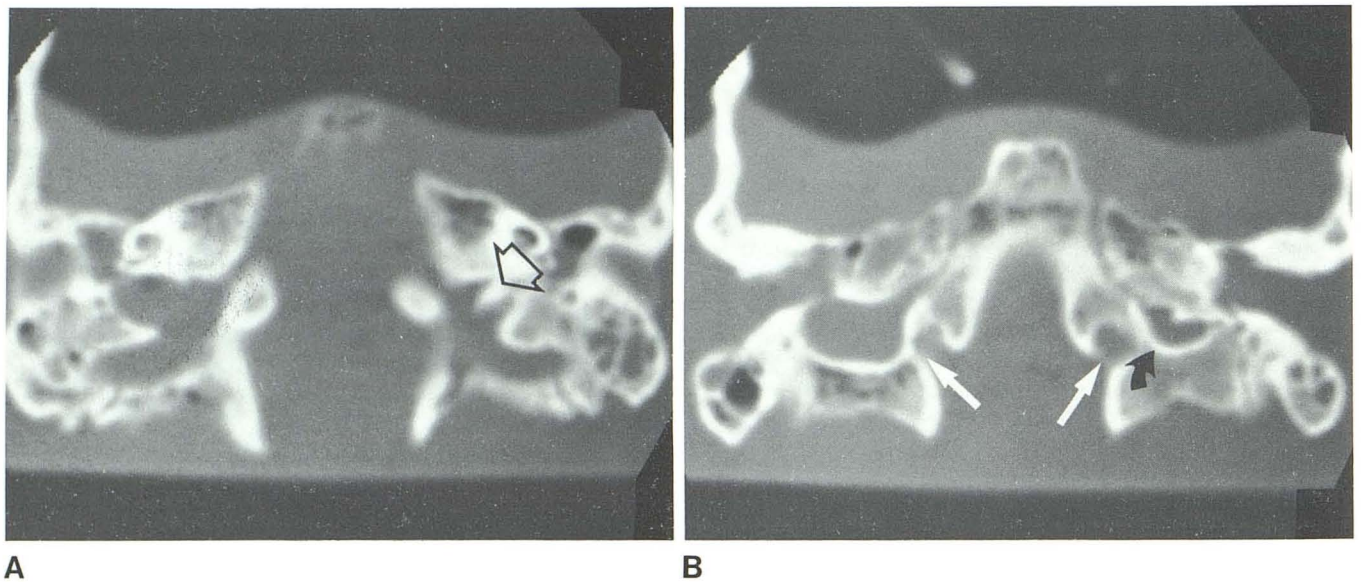


Fig. 7.—**A**, M-shaped anterolateral edge (arrow) of jugular foramen of dried skull embedded in paraffin. **B**, Smoother posteromedial edge (black arrow) in section 5 mm caudad. Hypoglossal canals (white arrows) are medial to jugular foramina. Plane of section $+10^\circ$ to CML.

nerve IX. The inferior petrosal sinus has a variable course from the petrooccipital fissure around cranial nerves IX, X and XI to the jugular bulb.

The pars vascularis and nervosa together are seen on CT at planes parallel and positive (0° – 30°) to the CML (figs. 6 and 7). In this range of gantry angulations because of the

oblique course of the jugular foramen, sequential axial sections demonstrate the anterolateral M-shaped edge of the endocranial opening; then, in sections 2–5 mm more caudad, the posteromedial straighter edge of the endocranial opening; and then, the intracanalicular and exocranial parts of the foramen. At an angle of section -15° to the CML, the

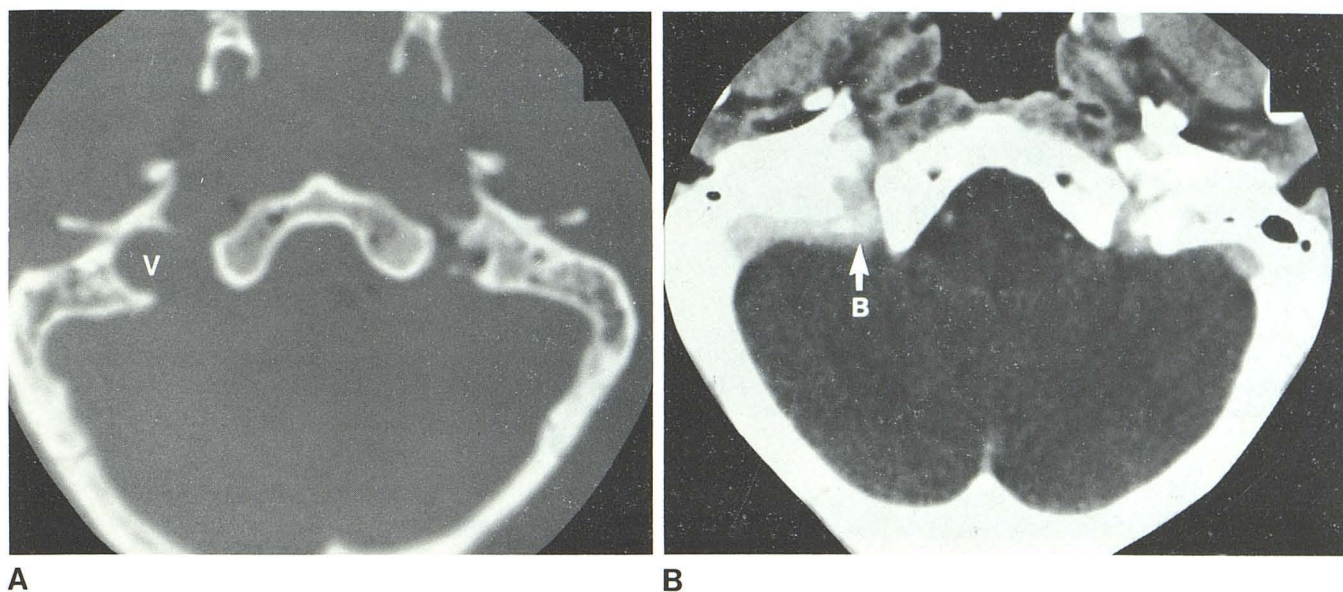


Fig. 8.—Pars vascularis (V) and jugular bulb (B) in CT sections -15° to CML. A is from dried skull embedded in paraffin; B is a patient after infusion of intravenous contrast agent.

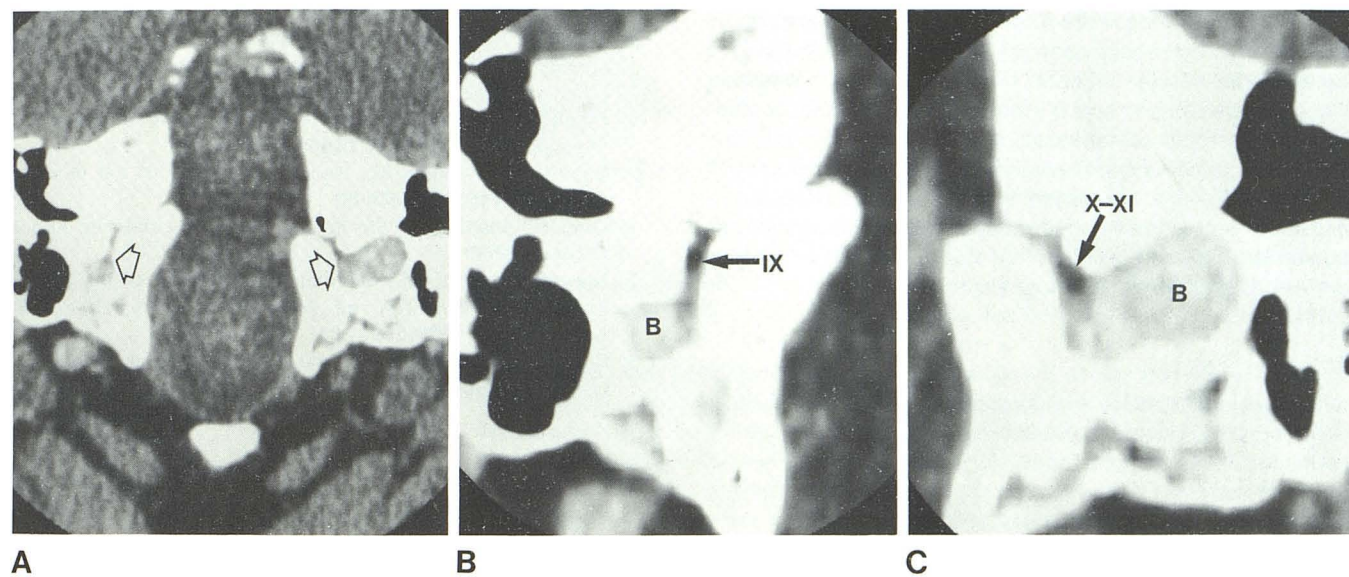


Fig. 9.—Jugular foramina (arrows) at plane of section $+30^{\circ}$ to CML with jugular bulb (B) maximally enhanced during rapid sequence of scanning (A). Cranial nerve IX in pars nervosa and cranial nerves X-XI in pars vascularis are seen. B and C are higher magnification of right and left foramina, respectively.

pars vascularis is well visualized, but the pars nervosa is not (fig. 8).

The filling defects in the enhanced jugular foramen on CT images correlate with cranial nerves IX, X, and XI in anatomic dissections (figs. 9 and 10). Cranial nerves X and XI together appear on axial CT as an oval-shaped defect near

the anteromedial wall of the jugular bulb. Cranial nerve IX appears on axial CT as a small, round, or linear defect in the pars nervosa. Nerves in the jugular foramen were visualized best about 35 sec after intravenous injection of a bolus of contrast agent when the gantry was angled $+30^{\circ}$ to the CML. Cranial nerves X-XI were seen consistently,

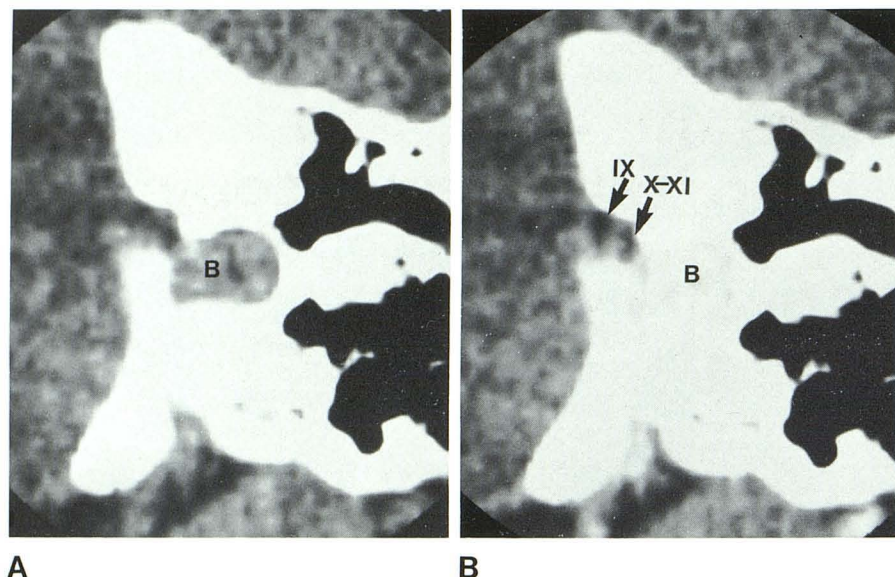


Fig. 10.—Sequential scans of jugular foramen obtained at rapid rate and after intravenous contrast medium injection. As jugular bulb (B) enhances, cranial nerves IX and X-XI are seen anterior to bulb.

and IX was seen in two of four patients. These nerves were not well visualized in images obtained 5–30 min after infusion of contrast medium.

To evaluate the osseous anatomy of the jugular foramen and exclude osteolytic changes, we recommend using a gantry angle parallel or positive to the CML. To visualize cranial nerves IX, X, and XI and the jugular bulb or suspected intracanalicular masses, a gantry angle 30° positive to the CML, a bolus injection of contrast agent, and a rapid sequence of scans are suggested. From this limited study of clinical subjects, we believe the structures within the jugular foramen can be identified with enough precision to confidently exclude an intracanalicular mass.

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