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Neuroanatomical Study

An anatomical and radiological study of the high jugular bulb on high-resolution CT scans and alcohol-fixed skulls of adults

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ABSTRACT

Although many reports mention a "high jugular bulb" (HJB), it is often not clearly defined. We examined the relationship between the jugular bulb (JB) and the internal auditory canal (IAC) in 200 temporal bones on high resolution CT scans and alcohol-fixed skull bases of adults. The average distance (±standard deviation) between the IAC and the JB was 7.5 ± 2.3 mm (range, 1–16 mm). The JB was higher on the right side than its companion in 53.3% of patients (left side only in 22%; no side dominance in 23.7% of bases). When the JB reached or exceeded the floor of the IAC (16.5%), it was defined as a HJB; 61% of HJB were found in females. Bilateral HJB was found in 0.5% of patients. The HJB was not associated with a contralateral flat JB. Preoperative multiplanar high resolution CT reconstructions make the most detailed assessment of structural topography.

1. Introduction

The internal jugular vein (IJV) is an anatomic continuation of the sigmoid sinus (SS), which drains most of the venous blood from the intracranial cavity. The jugular bulb (JB) is its first slightly enlarged segment and is directed against the base of the hypotympanum. The bulb surrounded by the bony jugular fossa is situated on the base of the pyramid, inferior and posterior to the inner auditory canal (IAC). It is separated from the IAC by compact bone, which is only rarely pneumatized. The highest part of the bulb is called the apex.[1] The most common and clinically most important anatomic variety of the temporal bone (TB) is the so-called "high jugular bulb" (HJB) (Fig. 1A). The HJB is found in 3.5% to 65% of reports.[2–10] However, a JB might not develop, and the IJV is then formed directly from the SS. The first clinical report concerning a HJB was presented by Page in 1914.[11] Myringotomy of a dark-blue tympanic membrane in a 10-year-old boy with acute otitis media led to massive venous bleeding. The bleeding was stopped by packing with gauze; nonetheless, the young boy died after a few days in sequel to thrombosis of the dominant SS.

An HJB is mostly asymptomatic; however, patients present occasionally with the associated clinical symptoms, which are hearing disorders, pulsating venous tinnitus or vestibular dysfunction.[12–16] Conductive hearing disorders are the most common symptoms, due to obturation of the fenestra rotunda or protrusion against the pars tensa by the HJB. Sensineural hearing disorders can arise due to contace between the JB with the vestibulocochlear nerve in the IAC.[14] Vertigo and a Meniere-like syndrome may be caused by the dehiscence of the HJB and the vestibular aqueduct.[2]

We describe two basic positions of the HJB: (i) the medial; and (ii) the lateral. The medial position of the HJB is characterized by its very close relationship to the internal acoustic meatus or the endolymphatic sac, while the JB may be situated in any direction from the IAC. The lateral position is characterized by the protrusion of the HJB into the middle ear region, to the hypotympanum or the mesotympanum. The apex of an HJB is not always covered by a bony lamella (Fig. 1B). The diameter of the JB is very variable: from wide bulbs that protrude into the middle ear and the posterior fossa to narrow bulbs that resemble a diverticle. This is different to the JB that continues as a finger-like process via a genuine diverticle over the level of the bulbar apex. The diverticle mostly originates directly from the summit of the bulb; however, it is not uncommon for the diverticle to originate from the walls or from the base of the JB (Fig. 1C).[8,12,17]

2. Materials and methods

The position of the JB in relationship to the IAC was analyzed in 200 TB in two phases. Other anatomical variations and anomalies of the TB were excluded from the study. In phase 1, the relationship between the IAC and the JB was analysed in 100 TB of 50 alcohol-fixed skull bases of adults (25 male and 25 female). The TB were cut vertically through the apex of the JB and IAC parallel to

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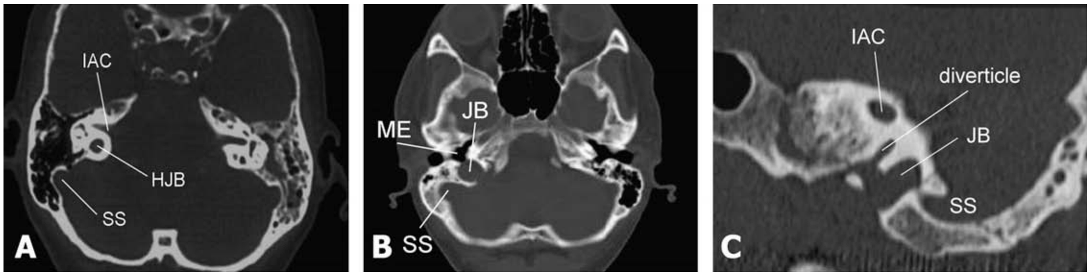

Fig. 1. Axial high resolution CT (HRCT) scans (A, B) showing (A) a high jugular bulb (HJB) limiting posterolateral access to the internal auditory canal (IAC); and (B) a dehiscent type of JB where the bulb is not covered by bony lamellae from the middle ear and from the posterior fossa. (C) A multiplanar reconstruction HRCT in a plane parallel to the petrous ridge showing a genuine diverticle originating from the anterior wall of the JB. ME = middle ear, SS = sigmoid sinus.

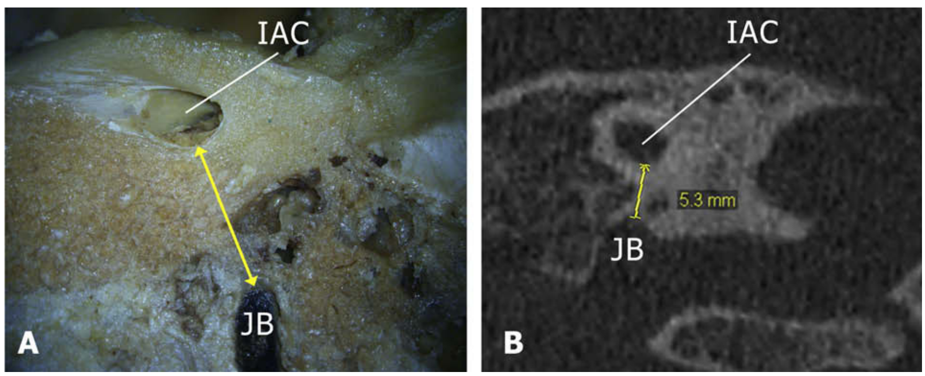

Fig. 2. The arrows indicate the shortest distance measured between the jugular bulb (JB) and the nearest part of the internal auditory canal (IAC) on: (A) an alcohol-fixed skull base in the cadaver group (measured by caliper) and (B) the same distance measured automatically on a multiplanar reconstruction (MPR) high-resolution CT scan. (This figure is available in colour at www.sciencedirect.com.)

the long axis of the pyramid. Measurements were performed with a caliper. To evaluate the potential operating space for lateral–transtemporal approaches, the shortest distance was measured between the JB and the nearest part of the IAC (Fig. 2A). The distances of the jugular apex, roof and floor of the IAC to the superior margin of the pyramid were compared in the same plane.

In phase 2, 100 randomly chosen high-resolution CT (HRCT) scans of the TB of adults (25 male, 25 female) stored in the hospital's digital archive were analyzed. The examination was performed using a multidetector CT Somatom Sensation 16 (Siemens, Erlangen, Germany) using the following parameters: collimation, 0.75 mm; 120 kV; 250 mA; field of view, 20 cm; 512 × 512 matrix; table movement 9.4 mm and 12 mm/rotation. The data were reconstructed in a width of 0.75 mm with 0.5 mm increments. The examination was performed in a bone window with a gantry inclination parallel to the orbitomeatal line. The measurements were performed with Syngo software (Siemens, Erlangen, Germany) using the source images on the work station. To compare the HRCT scans to the cadaver skull bases (phase 1 of the study) for metric analysis, we obtained identical topographic evaluations of the scans by using multiplanar reconstructions (MPR) in the same plane (Figs. 2, 3).

The JB position was divided into 4 types based on its location: (i) high (HJB): the apex either reached, or traversed, the base of the IAC; (ii) extremely high: the apex reached over, or to, the roof of the IAC; (iii) flat: the SS transferred directly into the IJV without forming an ascendant dome of the bulb; and (iv) normal: the bulb was formed but did not reach the lower edge of the IAC (Table 1, Fig. 4). All data from both phases were processed separately. The data were analysed for differences between sides and sexes.

3. Results

The anatomical measurements are listed in Table 2. Across the whole study of 200 temporal bones, the average distance (±SD) between the IAC and the apex of the JB was 7.5 (±2.3) mm. The dis-

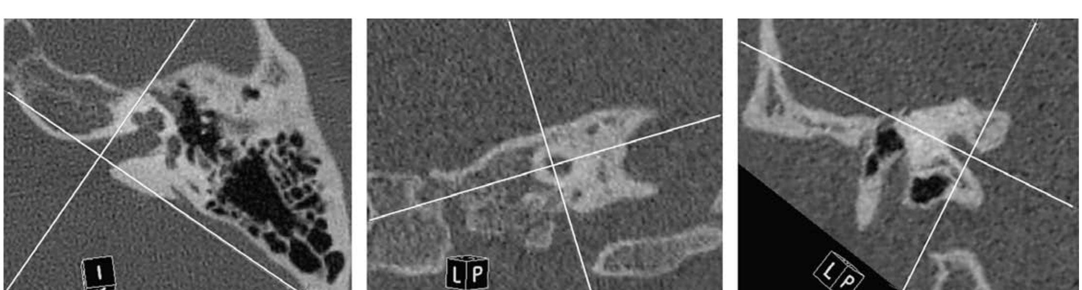

Fig. 3. Multiplanar reconstructions of high resolution CT (HRCT) scans in the same plane as in the cadaver study to obtain the identical parameters for metric analysis in the radiological group. The white lines represent the other two perpendicular planes shown in this image, I = inferior, L = left P = posterior planes.