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Original Research Article

Osteological studies of skull base neurovascular area in reference to infratemporal approach to skull basec

Harsh Sharma[1,*]

[1] *Dept. of Otorhinolaryngology, King George's Medical University, Lucknow, Uttar Pradesh, India*

A R T I C L E I N F O

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A B S T R A C T

Surgical approaches to the lateral skull base often lead to tearing of vessels and piecemeal removal of the tumour. This study is aimed to delineate exact relationship of the various foramina at the lateral skull base. The coronal dimensions of the jugular foramina are larger as compared to sagittal with right sided dominance also noticed in the case of carotid canal. The width of "Keel" separating the carotid and jugular foramina normally varies from 0.4 to1.4 centimetres and may not always suggest the erosion of the foramen of skull base scans, unless the erosion is associated with irregularity or demineralization the thickness of this keel really depends upon relative size of the vessels and location of foramina. Area between stylomastoid foramen, carotid canal and jugular foramen is roughly wedge shaped. The angle subtended by carotid and jugular at the stylomastoid foramen is about 36.84^{0}whereas the location of stylomastoid foramen and internal carotid axis pose an angle of $83:16^{0}$. The angle subtended by stylomastoid and jugular at carotid on an average $59:31^{0}$. The space between these structures is measured to be 0.642centimetres which can be verified on tomograms.

By using these measurements, the precise location of the upper end of the vessels could be predicted, whereas the superior stump could be clamped with minimal exposure of the skull base and identification and location of the last four cranial nerves is found out. This could avoid injuries and subsequent morbidity while carrying out surgery in this region.

1. Introduction

The vascular area of lateral skull base, considered inaccessible is now surgically treatable. House &Histelberger[1] preferred to deal it with translabyrinthine route, Biller et al.[2] proposed inferior approach whereas Fisch and pillsbury[3] and Fisch[4] have established the lateral infratemporal approach. In either case, the lesion of this region specially large glomus, clivus chordomas, neurofibromas surround the neurovascular elements of the region and shift to the unexpected positions within the tumours. The transdural approach may be preferential in this respect in locating the upper end of carotid artery, veins and nerves thereby helping in orientation of possible course of these structures within the tumour. However, this approach often results in leakage of cerebrospinal fluid and predisposes to severe complications. Tracing the vessel from below involves tearing and piecemeal removal of tumour which may not be very easy and advisable. Fisch[5] in his type A approach mentioned that the facial nerve can be identified at stylomastoid foramen and thence on dissecting the parotid region the neurovascular structures of this region could be traced. However, the surgical procedure is often very cumbersome in patients with large tumours.[6]

Therefore, the present neuroanatomical study was undertaken to determine the precise relationship of these

* *Corresponding author*.
E-mail address: drharsh60@gmail.com (H. Sharma).

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structures at the skull base where it may help in their proper orientation without opening dura.

2. Materials and Methods

For the present study, 6 cadavers were dissected on both sides to precisely localize these structures in the neurovascular area. Specially thedisposition of veins and tributaries in relation to the carotid arteries and their branches, cranial nerves and styloid structures were studied. Petrosectomyand total exposure of facial nerve in view of its forward orientation by anterior tunnelling[5] was considered. The exact measurements were carried out using fine callipers.

In 100 Skulls the relationship dimension's, angulation between stylomastoid foramen, carotid canal and jugular fossae were measured on both the sides. The largest sagittal and coronal dimensions of these vessels and their distances and angulations were noted. The length of intrapetrous carotiod artery was also measured.

In another 50 temporal bones, the contact photoprints were obtained keeping squamous temporal bone exactly perpendicular to the film and therein from these points the measurements of these vascular channels were taken and impressions of minor vessels like caroticotemporal, stylomastoid artery etc. were recognized.

On general inspection, these 3 structures namely stylomastoid foramen and axes of carotid and internal jugular vein form a triangle in cross section (Figure 1) where their relationship could be geometrically expressed and the angular projections of these could be determined mathematically. The distance between the centre of these axes was measured, hence angular dispositions were calculated by determining the angle ("s") subtended at stylomastoid foramen by carotid and jugular and angle 'c' at carotid subtended by stylomastoid foramen respectively by the equation –

Cos B= a^2+ b^2—-(1)

Ac

Consequently, the Cos 's' = $J^2 + c^2 — S^2$

2jc

cos'C'= $J^2 + s^2 — c^2$

2js

cos'j'= $c^2 + s^2 — j^2$

2sc

Subsequently from these the angulation could be calculated as

J= cas J^{-1}

S= cas S^{-1}& C+ Cos c^{-1}

Having known these parameters the area of wedge or keel of the bone of skull separating these two vessels could be calculated by general formula:-

Area of triangle S-1/2 ab sin B———(2) substituting here the values of C and J for ab and angle "S" for B the area for both right and left were calculated

Fig. 1: Structures namely stylomastoid foramen and axes of carotid and internal jugular vein form a triangle in cross section

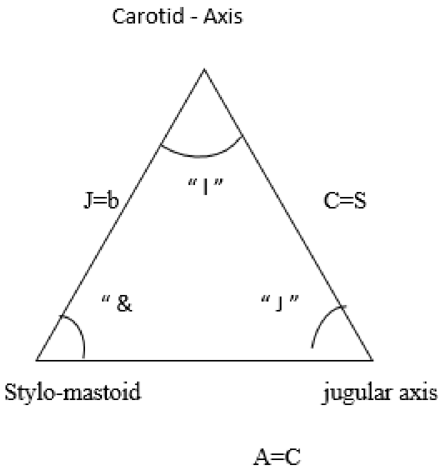

Fig. 2: The triangle formed by the stylomastoid foramen and axes of carotid and internal jugular vein.

3. Observation

The facial nerve could be easily identified in cadavers as in living by locating it at the midpoint of imaginary line extending form the pointer of tragal cartilage and the mastoid tip by just retracting or detaching the upper most fibres if the sternocleidomastoid muscle. Attempts were made to identify the jugular vein which unlike carotid artery and vagus is devoid of any tough facial sheath. In cadavers and in detached skulls the carotid artery appears anteromedial to the internal jugular vein with vagus nerve almost in between the two. The accessory nerve, however, is exactly lateral and hence 2-5 mm superficial to the vagus with an oblique course just lateral to the internal jugular vein lying deep to styloid structures and digastric muscles. Hypoglossal is medial to both the vein and arteries and also medial to vagus and turns forward lateral to the carotid axis in upper part of the parapharyngeal space.

The glossopharyngeal nerve descends just lateral to jugular vein and with a forward predisposition laterally crosses the carotid in the upper part of parapharyngeal space. The sympathetic plexus is oriented medial to vagus nerve in the skull base and parapharyngeal space. The vascular channels are therefore in close approximation leaving a wedge shaped or roughly triangular area of the bone in between separating them at skull base, which has been recognized as keel. A bony septum has been observed to continue from it posterior medially to divide the jugular fossae in 2% of case (Figure 2). In one temporal bone carotid canal was devoid of any bony covering (Figure 3). In rare instance (1%) the carotid canal is situated anteromedial to jugular foramen and the three structures namely stylomastoid foramen, Jugular axis and carotid appear almost in one line. The size of both jugular fossae as well as foramen for internal carotid canal, have been observed to be slightly wider on right side as compared to the left.

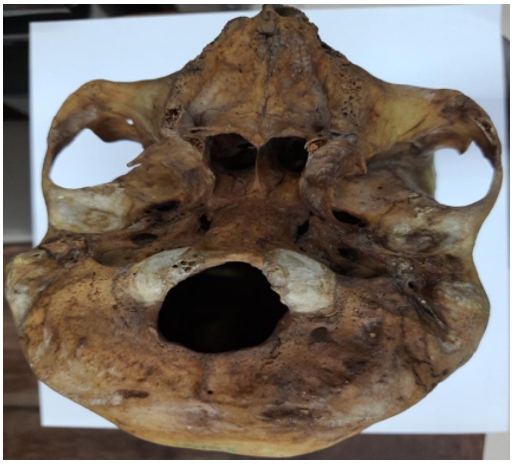

Fig. 3: A bony septum has been observed to continue from it posterior medially to divide the jugular fossae in 2% of case

Fig. 4: One temporal bone carotid canal was devoid of any bony covering

Discusssion

Surgical exposure of extracranial surface of floor of the middle and posterior cranial fossae is difficult using the conventional techniques of surgery, Amongst these, the medial part of the skull base forming rood of the nasopharynx and infratemporal fossae, is relatively accessible from anterior exposure including transpalatal[7] and infratemporal approach.[8] This is because only the course of sensory cranial nerves baring motor division of trigeminal is to be crossed and no important blood vessel assumes a tortuous course in this region. Even the exposure to clivus and cervical spines could be achieved without crossing the part of great vessels and nerves of major clinical importance.[2] On the contrary, the exposure of the lateral part of skull base particularly, auditory and neurovascular area involves crossing the course of major blood vessels like internal carotid, internal jugular vein, last four cranial nerves and the facial nerve, which may pose catastrophic sequelae. Fisch[5] has perfected and popularized the surgical approach to skull base with fairly satisfactory results. Even then the incidence of perforation of carotid artery has been encountered in 6 % of the cases of surgery for glomus tumour in this region.[4] Hence the precise location and understanding of the course of these vessels and nerves is of utmost importance.

In this region the tumours may originate from the neurovascular structures like nerve sheath tumours[6–9] or may invade from outside like nasopharyngeal angiofibroma[5–10] These tumours may displace and encircle the neurovascular axis of the region and pose serious technical problems in tumour resection. Therefore, the course and anatomical variation need precise understanding.

Fundamentally the most important structures of this region appear to be facial nerve and the internal carotid artery. The internal jugular vein could be ligated without problem so also the facial nerve could be routed,[5] yet the control or haemorrhage from inferior petrosal sinus may be troublesome, until the jugular bulb is precisely located. The location of carotico tympanic artery depends on the location of the inlet for internal carotid at the skull. Barring parotid tumours, the stylomastoid foramen and exit of facial nerve is least disturbed in regional tumour which may grow in between and displace internal jugular vein from internal carotid which are supposed to be just intimately connected except at the base. There exists a keel of bone of variable size separating the two foramina at the skull base.

On tomography and scanning of the skull base of "Keel" of bone separating the jugular and carotid foramina is seen. Bailey[11] claims that erosion of this keel of bone is the early indication of the glomustumours. As observed in this study, thickness of this wedge of bone depends on the relative size of the vessels and location of the foramina the coronal dimensions of the jugular foramina are large (1.48+0.28 centimetres) as compared to sagittal one (Table 1). The latter, however, have a right sided dominance i.e. the right being 1.02+ 0.28 centimetres as compared to 0.91+ 0.24 centimetres on the left side. This clearly indicates that size of right internal jugular is wider than left and that too at the expense of the sagittal dimensions. This is however expected from the fact that superior sagittal sinus drains mostly in right internal jugular vein.

Table 1: Maximum size of jugular foramen and carotid canal in sagittal and coronal plane

Measurements N= 150	**Jugular Foramen Right Left**	**Carotid canal opening Right Left**
Maximum size in coronal plane	1.48 (+.28) 1.48 (+.30)	0.78 (+.20) 0.74 (+.19)
Maximum size in sagittal plane	1.02 (+.28) 0.91 (+.24)	0.72 (+.23) 0.68 (+0.16)

The dimensions of internal carotid canal also similarly revealed right sided dominance in coronal section (Table1), the width of foramen is 0.78+0.20 centimetres on right as compared to 0.74+.19 centimetres on left and so also in sagittal section 0.72+ 0.23 on right side as compared to 0.68+0.16cm on left side. The mean length of the horizontal part of intraosseous course of carotid artery is however, 1.71 (+.20) centimetres (Table 2) and is equal on both sides thence it turns upwards within foramen lacerum to enter the cavernous tissues.

Table 2: Length of carotid canal

MeasurementsN+150	**Right(cm)**	**Left(cm)**
Maximum Minimum Mean	2.1, 0.7,1.71, (+0.20)	2.0, 0.6,1.71, (+0.20)

3.1. *Osteometry of lateral skull base*

The surgical approach to this region designed as Type A approach of Fisch[4] involves location of the facial from the geniculate ganglion to the stylomastoid and dissection from the parotid to transpose it anteriorly by carrying out tympanomastoidectomy. From this region the great vessels and nerves could be oriented inspite of tumours of the region occupying the area of under surface of skull base.

Table 3: The distance between the stylomastoid and the central axis of jugular (c)

Measurements N= 150	**Right CM**	**LeftCm**
Maximum Minimum Mean	1.9, 0.5, 1.355, (+0.252)	1.9, 0.8, 1.376, (+0276)

Table 4: The distance between various axes:

Measurements in centimetres N= 150	**Between stylomastoid foramen & carotid axes**		**Between carotid and jugular axes**	
	Rt	Lt	Rt	Lt
Maximum Minimum Mean	2.1,1.1,1.572, (+.234)	2.1,0.72,1.565 (+ 0.031)	1.4,0.4,1.018, (+1.14)	1.3,0.6,0.887 (+0.180)

The internal jugular vein is located anteromedially at a distance of 0.5 to 1.9 centimetres (average 1.365+0.26) (Table 3). The lower part of internal jugular vein and internal carotid artery could be dissected in neck and upper end when anteromedially oriented give clear idea of its possible course. The carotid foramen is situated far or anteriorly at a distance for 0.72 to 2.1 centimetres from the stylomastoid (average 1.569+0.23) (Table 4). The distance between carotid axis and that of the "Keel" therefore normally varies from 0.4 to 1.4 centimetres and may not always suggest erosion of foramen on skull base scans, unless the erosion is associated with irregularity or demineralization.

In fact, the area between these structures appears to be roughly wedge shaped, the angle subtended by carotid and jugular at the stylomastoid foramen and internal carotid axis pose an angle of 83.16^0(81.63-84.57^0). The angle subtended by stylomastoid and jugular at carotid on an average is 59.31^0 (58.51^0-60.04^0). The space between these structures is measured to be 0.642 centimetres (0.678 to 0.606 centimetres). This area could be verified in the tomograms as in scans and destruction of hypotympanic region or auditory area of the base of skull in case of glomus tympanicum of Stage A & B of these tumours could be verified. Furthermore, the extension of the tumour in relation to these vascular axes could be achieved.

The jugular vein is devoid of sheath to allow its expansion and has scope of distending anterolaterally .Expanding lesions of this region tend to collapse the vein much more often than artery, which could be verified by retrograde venography. In rare circumstances, particularly when the jugular vein is very much enlarged the carotid foramen appears. On the contrary, the ossification of the partitions of the jugular foramina increase the distance between the internal jugular and carotid and then inferior petrosal sinus appears to join it relatively inferiorly. Fisch[5] had instances when these vascular axes were incorporated within the tumour and when even ligation of the internal carotid was desired. Under these circumstances, the precise location of the upper end could be predicted using these measurements whereas the superior stump could be clamped with minimal exposure of the skull base and the identification and location of the last four cranial nerves found out. This could avoid serious injuries and subsequent morbidity while carrying out surgery in this region.

4. Source of Funding

None.

5. Conflict of Interest

None.

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Author biography

Harsh Sharma, Joint Director

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