

An anatomical study of inter carotid distances in the sellar region with a surgical perspective

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Abstract

There may be significant variations in the distance between the carotid sulci on both sides of the sphenoid bone. This distance varies throughout the entire length of the carotid sulci. It is important to be aware of the anatomical variations in these distances during trans-sphenoidal surgery to avoid potential catastrophic injury to the carotid arteries. The distance between the carotid sulci was measured in 26 disarticulated sphenoid bones at the anterior most and posterior most points on the medial borders of the carotid sulci and at the level of maximal sellar depth. The shortest distance was found to be at the anterior most and posterior most points in about 35% each of all specimens studied while in about 26% of specimens the shortest distance was at the level of maximum sellar depth. The minimum inter carotid distance was found to be 7.63 mm. The present study documented significant variations in the inter carotid sulci distances along the course of the carotid artery in the cavernous sinus. The knowledge of this fact may be of possible help while planning transsphenoidal surgery and in avoiding carotid artery injury.

Keywords: carotid sulcus, sphenoid bone, trans-sphenoidal surgery, internal carotid artery, vascular injury.

1 Introduction

The cavernous part of carotid arteries and their bony canals lie on either side of the sphenoid sinus. Cavernous carotids can be quite tortuous and in some cases the carotid arteries may come into contact with each other in the sella (LAWS Jr., 1999). The anatomical variations of the carotid arteries in this region are therefore important during trans-sphenoidal approach for removal of pituitary adenomas. In this approach, mucosa is dissected from the nasal septum and the sphenoid sinus is entered after removing the alae of the vomer bone and the floor of the sphenoid sinus. The floor of the sella bulges into the sphenoid sinus and is opened to expose the sellar dura and the pituitary tumor. Carotid artery injury during trans-sphenoidal surgeries has been reported in a large number of studies (AHUJA, GUTEMAN and HOPKINS, 1992; CIRCIC, RAGIN, BAUMGARTNER et al., 1997; LANDOLT, 1990; PIGOTT, HOLLAND and PUNT, 1989; RAYMOND, HARDY, CZEPKO et al., 1997; ZERVAS, 1984). Injuries to the carotids in this region can be the cause of significant morbidity and mortality (ZERVAS, 1984). Therefore it is important to know the transverse separation of carotid arteries on each side of the sella before trans-sphenoidal route to the sellar region is undertaken. There are studies measuring the variability and range of the carotid artery separation but relatively little information is available about the distances between the two carotids over the entire course in the cavernous sinus in the parasellar region. The carotid sulci house the carotid arteries in the parasellar region and these sulci are reliable landmarks for calculating the intercarotid distances in bony specimens. Since detailed information of this anatomy is the most reliable and effective way of avoiding vascular complications during trans-sphenoidal approach, the present study was under-

taken to measure the intercarotid distance at different points along the course of the carotids in the parasellar region.

2 Material and methods

The present study was conducted in the Department of Anatomy at the HSJ Institute of Dental sciences and Hospital, Panjab University, Chandigarh, India. Twenty-six disarticulated sphenoid bones of adult skeletons were used. Carotid sulci on the sphenoid bones were identified in each specimen on both sides. Three points A, B, and C were marked on each carotid sulcus. These points were defined as follows:

- Point A: The anterior most point at the medial border of the carotid sulcus;
- Point B: Point on the medial border of the carotid sulcus at the level of the maximum depth of the sella; and
- Point C: The posterior most point of the medial border of the carotid sulcus.

Distance 1 was measured as the distance between the two A points on the carotid sulci across the sella. Similarly distances 2 and 3 were the respective distances between the two B and C points (Figure 1). All the measurements were taken by a digital caliper (Mitutoyo Corporation, Japan, accurate up to 0.01 mm). Measurements were taken twice and the mean was calculated.

3 Results

The mean distance between the two carotid sulci at the anterior most points (distance 1) was found to be 14.34 mm (range 10.62-17.70 mm). The mean distance between

the posterior most points (distance 3) was 14.30 mm (range 7.63-18.99 mm) and the intercarotid distance at the level of the deepest point of the sella was 13.71 mm (range 8.66-16.73 mm) (Table 1).

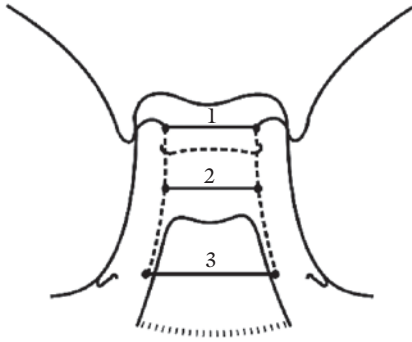


Figure 1. Line diagram depicting the various distances measured between the carotid sulci on both sides of the sphenoid bone. 1 - Distance between the anterior most points at the medial border of the carotid sulci; 2 - Distance between the corresponding points on the medial border of the carotid sulcus at the level of maximal sellar depth; and 3 - Distance between the posterior most points on the medial border of the carotid sulci.

The carotid sulci were found to be closest to each other at the anterior most points (distance 1) in 34.62% of specimens, at posterior most points (distance 3) in the same number (34.62%) while they were closest to each other at the deepest point of sella (distance 2) in 26.92% of specimens.

4 Conclusion

The proximity of the carotid arteries to each other in their cavernous course is important during trans-sphenoidal approach to the pituitary (Figure 3). Vascular complications during this approach due to carotid artery injury can cause serious morbidity and mortality. The incidence of this complication ranges from 0.4-1.4% (CIRCIC, RAGIN, BAUMGARTNER et al., 1997; RAYMOND, HARDY, CZEPKO et al., 1997). Carotid artery injury can lead to exsanguinating hemorrhage, formation of pseudoaneurysm, carotid-cavernous fistula, intracranial infarcts or a stroke-like presentation, delayed epistaxis or complications secondary to carotid artery spasm (AHUJA, GUTEMAN and HOPKINS, 1992; BRITT, SILVERBERG, PROLO et al., 1981; CABEZUDA, CARRILLO, VAQUERO et al., 1981; CIRCIC, RAGIN, BAUMGARTNER, et al., 1997; FUKUSHIMA and MAROON, 1998; HALBACH, HIESHIMA, HIGASHIDA et al., 1987; HARDY, McCUTCHEON,

Table 1. Inter carotid distances at different levels of the carotid sulci.

S.No.	Distance I	Distance II	Distance III	Shortest distance
1.	13.48	12.82	11.52	III
2.	14.78	16.47	17.55	I
3.	13.52	12.18	14.68	II
4.	14.27	12.81	11.57	III
5.	15.42	13.96	15.48	II
6.	13.25	12.66	11.10	III
7.	13.96	13.80	17.81	II
8.	15.84	12.27	12.49	III
9.	16.13	15.52	18.99	II
10.	14.24	12.44	11.73	III
11.	15.61	14.67	16.68	II
12.	17.51	13.14	10.55	III
13.	15.40	14.12	15.19	II
14.	15.04	16.54	18.16	I
15.	11.48	11.43	13.11	II
16.	12.35	16.04	18.18	I
17.	17.70	12.67	12.13	III
18.	13.49	13.89	14.07	I
19.	16.47	8.66	7.63	III
20.	11.68	13.98	15.38	I
21.	12.72	12.74	14.97	I
22.	15.76	16.73	15.19	III
23.	14.66	15.55	15.33	I
24.	11.74	14.04	15.79	I
25.	10.62	11.26	12.53	I
26.	15.71	16.03	15.78	I
Mean	14.34	13.71	14.30	-
Range	10.62 to 17.70	8.66 to 16.73	7.63 to 18.99	-

All measurements are in millimeters. I - Distance between the anterior most points at the medial border of the carotid sulci; II - Distance between the corresponding points on the medial border of the carotid sulcus at the level of maximal sellar depth; and III - Distance between the posterior most points on the medial border of the carotid sulci.

1992; KACHHARA, MENON, BHATTACHARYA et al., 2003; KADROY, FRIEDMAN, NICHOLS et al., 2002; KURSHEL, LEBER, SCARPATETTI et al., 2005; LAWS Jr., 1999; McCORMICK and BEALS, 1978; OSKOUIAN, KELLY and LAWS Jr., 2006; REDDY, LESIUK, WEST et al., 1990; WILSON and DEMPSEY, 1978). Local hematoma formation can cause hypothalamic compression leading to unconsciousness. It is well known that cavernous carotids can be quite tortuous and in some cases can actually come into contact with each other within the sella ('kissing carotids'). The arteries can also be quite atherosclerotic and may lie just behind the dura where they are vulnerable to injury during opening of the sellar dura (LAWS Jr., 1999).

Fujii, Chambers, Rhoton (1979) measured the transverse separation between the carotid prominences on each side and noted that the shortest distance between the carotid prominences was located just below the tuberculum sellae in 72%, at the level of the floor of the sella in 20% and at the clivus in 8%. In another study (RENN and RHOTON Jr., 1975) the shortest distance between the two carotid arteries was found in the supraclinoid area in 82% cases and in cavernous sinus on the side of the sella in 14%. In the present study the intercarotid sulcal distance was measured at three points along the course of the cavernous carotids. There was significant variation in the intercarotid distances in different bone specimens (Figure 2a-d). The shortest distance was found to be at the anterior most and posterior most points in about 35% each of all specimens studied while in about 26% of the specimens the shortest distance was at the level of maximum sellar depth. In some cases the cavernous carotids can be as close as 4 mm to its counterpart, sometimes covered only with mucosa (BERGLAND, RAY and TORACH, 1968). Arterial communication between the cavernous segments of the carotid arteries associated with agenesis of unilateral carotid artery has also been reported (KISHORE, KAUFMAN and MELICHAR, 1979). In the present study the least inter carotid distance was found to be 7.63 mm in one specimen. The surgical trajectory through the nasal cavity and the sphenoid sinus is depicted in Figure 3. The transverse distance between the two internal carotid arteries should be known at both the anterior and posterior ends of the cavernous carotid arteries in addition to the distance at the sellar depth. The surgeon usually works in the space between the two carotid arteries; therefore the knowledge of these distances is important as it determines the safety zone available.

The anatomical variations in the inter carotid distances may be different in diverse ethnic groups. In a study from Turkey (UNAL, BADEMCI and BILGILI et al., 2006), evaluation of the carotid artery in its relation to the sphenoid sinus was done using CT scans, cadaveric dissections and endoscopy. The authors observed 9 cases with extreme medial course of the internal carotid artery. In 34 cases there were protrusions of the internal carotid artery into the sellar region while bony dehiscence was demonstrated in 6 cases. In two different microsurgical anatomical studies involving caucasians, the shortest distances between the carotid prominences was located below the tuberculum sellae (FUJII, CHAMBERS and RHOTON Jr., 1979) or at the supraclinoid level (RENN and RHOTON Jr., 1975) in most cases. We could not come across any reference in literature reporting gender-based analyses of transverse separation of the carotid arteries in the sellar region.

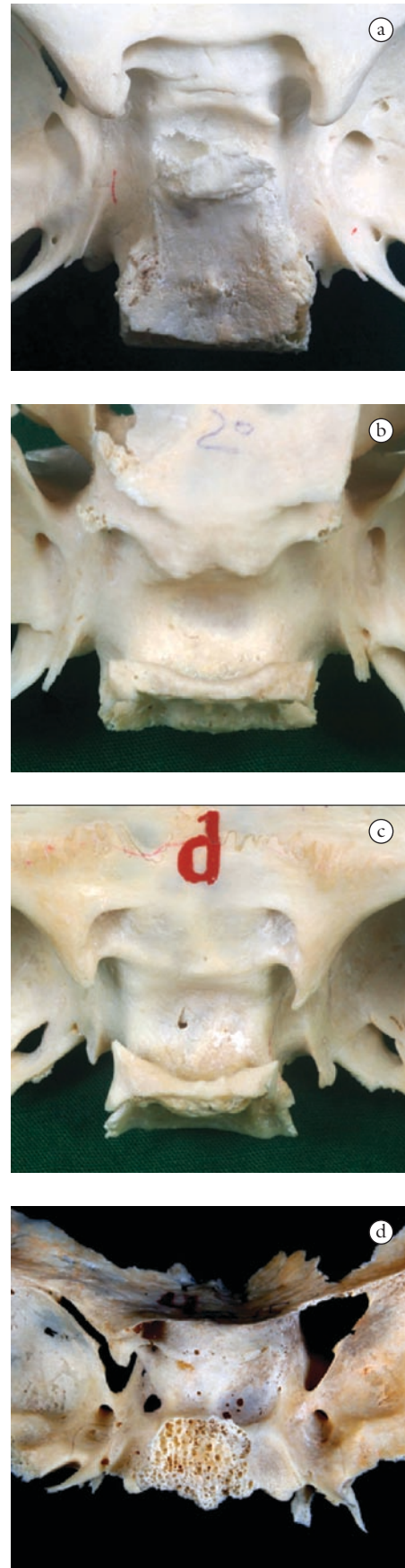


Figure 2. a-d) Photographs of sphenoid bones depicting the anatomical variations in the distances between the carotid sulci.

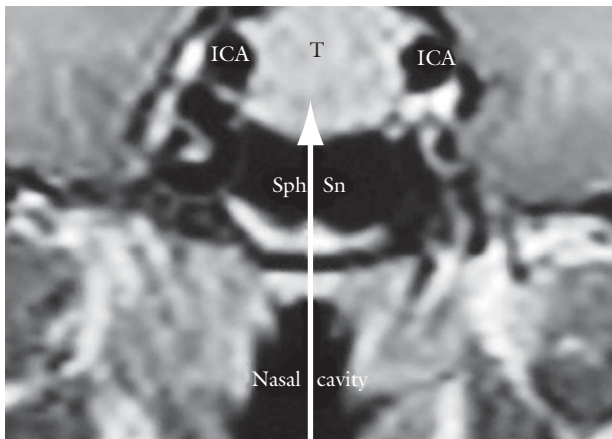


Figure 3. MRI (coronal section) with white arrow showing trans-sphenoidal approach through nasal cavity and sphenoid sinus (Sph.sn) to the pituitary tumor (T). The internal carotid arteries (ICA) are seen on both sides of tumor.

Thus there is significant variation and range of intercarotid distances along the length of the carotid artery in the cavernous sinus, as evidenced in the present study. This is an important observation to be kept in mind during trans-sphenoidal surgery so that the surgeon has preoperative evaluation of the cavernous carotids throughout the entire length in each patient. Lesions in the sellar region expand and push the carotids laterally, so that there is adequate space to enter the tumor from below. In general, the surgeon focuses his attention to the site of maximal tumoral size, where the carotids are displaced laterally. However, the anterior and posterior ends of the cavernous carotids are relatively fixed and more prone to injury. The distances between the carotids at these points are therefore important and the surgeon has to be aware of this. Therefore a preoperative detailed radiological assessment of the intercarotid distances throughout the parasellar region is necessary.

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Received May 14, 2008

Accepted May 21, 2009