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PJBS

ISSN 1028-8880

Pakistan Journal of Biological Sciences

ANSInet
Asian Network for Scientific Information
308 Lasani Town, Sargodha Road, Faisalabad - Pakistan

Pakistan Journal of Biological Sciences 12 (6): 522-525, 2009
ISSN 1028-8880

Anatomical Variations of Neurovascular Structures Adjacent Sphenoid Sinus by usimg CT Scan

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Abstract: The aim of this research was to study of the relationship between anatomical variations of neurovascular structures adjacent sphenoid sinus with sex and position of appearance by using CT scan. In this retrospective study paranasal sinuses CT scan has been taken from 399 patients (210 male, 189 female) that referred to Imam Khomeini and Apadana Hospitals, Ahwaz, Iran. Furthermore, protrusion and dehiscence of Internal Carotid Artery (ICA), Maxillary Nerve (MN), Vidian Nerve (VN) and Optic Nerve (ON) into the sphenoid sinuses cavity have been investigated by using CT scan results. In 210 male patients the protrusion of interested variables were noticed as: ICA in 102 (48.5%) cases, ON in 80(38%) cases, MN in 74 (35.5%) cases, and VN in 60 (28.5%) cases, respectively. Also in 189 female patients group the protrusion of ICA, ON, MN, VN were noticed in 65 (34.3%), 66 (34.9%), 62 (32.8%) and 43 (22.7%) cases, respectively. The statistical analysis show significant difference ($p = 0.001$) of protrusion of ICA between male and female groups. In 210 male patients the dehiscence of ICA, ON, MN, VN were noticed in 82 (39%), 60 (28.5%), 60 (28.5%) and 66 (31.4%) cases, respectively. Also in 189 female patients the dehiscence of interested variables were noticed as: ICA in 85 (44.9 %), ON in 87 (46%), MN in 69 (36.5%), VN in 71 (37.5%) cases, respectively. The statistical analysis show significant difference ($p = 0.03$) of dehiscence of on variable in male and female groups. In order to increase the risk of intra-operative complications detailed preoperative investigation of neurovascular structures in sphenoid sinuses by use of CT scan images should be done properly.

Key words: CT scan, anatomical variation, sphenoid sinus, neurovascular structure, Apadana Hospital

INTRODUCTION

Sphenoid bone consists of a central part and two wing-like structures that extend sideways toward each side of the skull. This bone helps to form the base of cranium, the sides of the skull and the floors and sides of the orbits. The sphenoid bone also contains two sphenoid sinuses, which lie side by side and are separated by a bony septum that projected downward into the nasal cavity. Sphenoid sinus is extremely variable in size, shape and relation to the sella. It is divided by one or more vertical septa that are often asymmetric (Gray, 2005). The endoscopic endonasal transsphenoidal approach was proposed in past decade as a minimally invasive surgical technique for removal of pituitary tumors (Janskowki *et al*., 1992). Because the sphenoid sinus is surrounded by vital structures, such as the internal carotid artery, optic nerve and cavernous sinus additional radiological assessment of sphenoid sinus and related neurovascular structures before surgery is required. The variability in the anatomy of the sphenoid sinus and related neurovascular are well documented (Cheung *et al*., 1993; Mafee *et al*., 1993; Delano *et al*., 1996; Hewadi *et al*., 2009). Injury to internal carotid artery or optic nerve is a serious complication of transsphenoidal surgery (Ahuja *et al*., 1992; Fukushima and Maroon, 1998). According to the extent of sinus pnumatization, the bone covering the carotid

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artery, optic nerve, maxillary nerves and vidian nerves can be thin or even absent, making these structure susceptible to iatrogenic injury (Liu *et al*., 2002). Many researches claimed that Computed Tomography (CT) is the best tool to demonstrate paranasal sinuses (Arslan *et al*., 1999; Delano *et al*., 1996; Zinreich, 1998). The aim of this study was to demonstrate the relationships of anatomic variations neurovascular structures with adjacent sphenoid sinus as well as investigate the effect of sex differentiation.

MATERIALS AND METHODS

This retrospective study comprised 412 (218 male and 194 female, aged between 16 and 97 years with mean age of 47±15.8 year). Computerizes tomography scans of patients who referred to Imam Khomeini and Apadana Hospitals of Ahwaz, Khuzestan, Iran during 4 years course from 2004 to 2008. Earlier study showed that computed tomography is a recommended method that helps to differentiation of anatomical variation in sphenoid sinuses (Abdullah *et al*., 2001). All patients underwent a complete medical history and head and neck physical examination. Out of 412 total patients 399 selected and the rest were excluded from the study. The exclusion criteria were: patients with prior sinus surgery; sinonasal tumors; nasal polyposis; severe cervical arthropathy; head or neck injury. Patients younger than 16 years were also excluded because the extension of the nasal cavity into the body of the sphenoid bone to form the sphenoid sinus is present before birth but does not reach its full extension until adolescence (Gray, 2005). For the tomographic studies, systemic studies of the sphenoid sinus region were performed in coronal scans on all the patients. In all the patients, the existence of the following variations was investigated: (1) Protrusion of Internal Carotid Artery (ICA), Optic Nerve (ON), Maxillary Nerve (MN) and Vidian Nerve (VN) and (2) Dehiscence is defined as absence of visible bone density separating the sinus from the course of the concerned structure. Whenever a clear decision between very thin bony wall and total dehiscence was not feasible, the results were accepted as dehiscence. Protrusion of ICA and ON was determined by finding any degree of protrusion of the structure into the sinus cavity. All areas of the sphenoid sinus were explored with special attention to relationship of sphenoid sinus with related neurovascular structure.

Statistical analysis: The data about anatomical variations of sphenoid sinuses as well as their differences related to gender and the location of variation were analyzed statistically by using Chi-square test. $p<0.05$ were accepted statistically significant.

RESULTS

Among 399 patients (210 male and 189 female, aged ranged from 16 to 97 years with the mean age of 47±15.8 years), who fulfilled the study inclusion criteria. The related frequencies of anatomical variation in each sex group calculated and presented separately (Table 1, 2).

Internal carotid artery: A protruding internal carotid artery into the sphenoid sinus was found in 102 male patients (48.5%), of whom 48 (47%) were bilateral, 26 (25.4%) were right sided and 28 (27.4%) were left sided. Also in 65 female patients (34.3%) the protruding internal carotid artery into the sphenoid sinus include: 28 (43%) cases as bilateral, 17(26.1%) cases as right sided and 20 (30.7%) cases left sided. Dehiscence of the bony wall on the internal carotid artery was seen in 82 male patients (39%) include: 31 (37.8%) patients as bilateral, 26 (31.7%) patients as right sided and 25 (30.4%) patients as left sided. Furthermore, in 85 female patients (44.9%) the dehiscence of the bony wall on the internal carotid artery were found in 47 (55.2%) bilateral, 19(22, 3%) right sided and 18(21.1%) left sided.

Table 1: Frequencies of anatomical variation in sphenoid sinus structure among 210 male patients

	Unilateral				
Characteristics	Left side No. (%)	Right side No. (%)	Total No. (%)	Bilateral No. (%)	Total No. (%)
Protrusion					
ICA	28(27.4)	26(25.45)	54 (25.7)	48(47)	102(48.5)
ON	20(25)	15(18.7)	35 (16.7)	45(56.2)	80 (38)
MN	19(25.6)	17(22.9)	36 (17.1)	28(37.8)	74 (35.2)
VN	17(28.3)	14(23)	31 (14.7)	29(48.3)	60(28.5)
Dehiscence					
ICA	25(30.2)	26(31.7)	51 (24.2)	31(37.8)	82 (39)
ON	14(23.3)	15(25)	29 (13.8)	31(51.6)	60 (28.5)
MN	17(28.3)	13(21.6)	30 (14.8)	30(50)	60 (28.5)
VN	18(27.2)	17(25.7)	35 (14.2)	31(46.9)	66 (31.4)

ICA: Internal carotid artery; ON: Optic nerve; MN: Maxillary nerve; VN: Vidian nerve

Table 2: Frequencies of anatomical variation of related structures of sphenoid sinus in 189 female patients

	Unilateral				
Characteristics	Left side No. (%)	Right side No. (%)	Total No. (%)	Bilateral No. (%)	Total No. (%)
Protrusion					
ICA	20(30.7)	17(26.1)	37 (19.5)	28(43)	65(34.3)
ON	16(24.2)	18(27.2)	34 (17.9)	32(48.4)	66(34.9)
MN	17(27.4)	15(24.1)	32 (16.9)	30(48.3)	62(32.8)
VN	9(20.9)	12(27.9)	21(23.5)	24(55.8)	43(22.7)
Dehiscence					
ICA	8(21.1)	19(22.3)	37 (41.5)	47(55.2)	85(44.9)
ON	23(26.4)	20(22.9)	43 (22.7)	41(47.1)	87(46)
MN	23(33)	19(27.5)	42 (22.3)	27(39.1)	69(36.5)
VN	18(25.3)	23(32.3)	41 (21.6)	30(42.2)	71(37.5)

ICA: Internal carotid artery; ON: Optic nerve; MN: Maxillary nerve; VN: Vidian nerve

Optic nerve: A protruding optic nerve into the sphenoid sinus was found in 80 male patients (38%), include: 45 (56.2%) bilateral, 15(18.7%) right sided and 20(25%) left sided. Also in 66 female patients (34.9%) the protruding optic nerve into the sphenoid sinus was found consist of 32 (48.4%) bilateral, 18(27.2%) right sided and 16 (24.2%) left sided. Dehiscence of the bony wall on the optic nerve was seen in 60 patients (28.5%) include: 31(51.6%) bilateral, 15(25%) right sided and 14(23.3%) were on the left sided. Also in 87 female patients the dehiscence of the bony wall on the optic nerve (46%) were seen in 41 (47.1%) as bilateral, 20 (22.9%) as right sided and 23 (26.4%) as left sided.

Maxillary nerve: A protruding maxillary nerve into the sphenoid sinus was found in 74 male patients (35.2%) consist of 28 (37.8%) bilateral cases, 17 (22.9%) right sided cases, and 19(25.6%) left sided cases. In case of female patients 62 (32.8%) cases fulfilled protruding maxillary nerve into the sphenoid sinus criteria include: 30 (48.3%) bilateral cases, 15 (24.1%) right sided cases and 17 (27.4%) left sided cases. Dehiscence of the bony wall on the maxillary nerve were seen in 60 male patient (28.5%) consist of 30(50%) bilateral, 13(21.6%) right sided and 17(28.3%) left sided cases. Indeed in 69 female patient (36.5%) the Dehiscence of the bony wall on the maxillary nerve were seen include: 27 (39.1%) bilateral, 19 (27.5%) right sided and 23 (33.3%) left sided patients.

Vidian nerve: A protruding Vidian nerve into the sphenoid sinus were found in 60 (28.5%) male patients, of whom 29 (48.3%) were bilateral, 14 (23%) were right sided, and 17 (28.3%) were left sided. In case of female patients 43 patients (22.7%) were shown protruding Vidian nerve into the sphenoid sinus, of whom 24(55.8%) were bilateral, 12(27.9%) were right sided and 9 (20.9%) were left sided. Dehiscence of the bony wall on the vidian nerve was seen in 66 (31.4%) male patients of whom 31(46.9%) were bilateral, 17 (25.7%) were on the right and 18 (27.2%) were on the left sided and in 71 female patients (37.5%) of whom 30 (42.2%) were bilateral, 23 (32.3%) were on the right and 18 (25.3%) were on the left sided.

The statistical analysis show that the significant difference ($p = 0.001$) of protrusion of ICA between male and female groups. Also there was significant difference ($p = 0.03$) of protrusion of ON between male and female.

DISCUSSION

Combination of the transsphenoidal route with the endoscope or neuronavigation may improve the effectiveness of the operation. Sphenoid sinuses are the most inaccessible paranasal sinuses and are surrounded by significant anatomical structures like the orbit and its content, cavernous sinus and ICA and the anterior cranial fossa. Only thin bones separate these structures from the sphenoid sinus. Hewadi *et al.* (2009) determined the percentage of protruding ICA into the sphenoid sinuses was 41%. In some cases, a dehiscence in the bony margin was present. If the surgeon is not aware of such a variation, even fatal result can happen. It is hardly possible to control the bleeding from a ruptured ICA within the sphenoid sinuses. In this study we found that protrusion of the ICA was bilaterally in 25.7% of male patients and unilaterally was found 25.7%. Furthermore, this disorder was bilaterally in 43% of female patients and unilaterally was found 19.5%, respectively. Earlier studies reported a wide range of variation rates ranging from 8 to 70% (Dessi *et al.*, 1994; Kantarci *et al.*, 2004).

In the case of protrusion, an ON injury can occur due either to a surgical trauma or as a complication of sinus disease. The risk of blindness is high if the surgeon damages the nerve within the sinus (Maniglia, 1989). Moreover, visual deficits may result from a sphenoid sinus infection or from a mucocele compressing the ON in the canal. Precise knowledge of these normal and variant anatomies should be demonstrated for accurate interpretation of sinonasal surgery and safe performance of these interventional procedures. In this research we found that protrusion of the ON was bilaterally in 56.2% of male patients and unilaterally was found 16.7%. Furthermore, this disorder was bilaterally in 48.4% of female patients and unilaterally was found 17.9%.

Choosing one of the axial and coronal planes also provides patients to expose less radiation and more time and money to spare. Present study suggests that coronal scans are superior to detect some variations in sphenoid sinus. Coronal screening sinus CT focused especially on detection of protrusion of ON and VN and dehiscence of MN and VN, while axial images were superior on assessing septal details and Onodi air cells (Driben *et al.*, 1998). In this research by use of coronal screening we found that protrusion of the MN and VN were bilaterally in 37.8 and 48.3% and unilaterally were found 17.1 and 14.7% of male patients, respectively. Furthermore, these disorders were bilaterally in 48.3 and 55.8% and unilaterally were found 16.9 and 23.5% of female patients, respectively.

ACKNOWLEDGMENT

This study was supported by the Vice-Chancellor for research of Ahwaz Jondishapour University of Medical Sciences.

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