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Sphenoid Sinuses Pneumatization and Association with the Protrusion of Surrounding Neurovascular Structures amongst Beninese

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Abstract

Goal: The aim of this work is to study the relationship between the pneumatization of the adjacent structures of sphenoid sinuses and the protrusion of the neurovascular structures in the sinuses. **Methods:** A review of 225 CT scans skull was done for subjects aged at least 16 years old from November 1st to December 31st 2017. The pneumatization of adjacent structures of sphenoid sinuses and its relation with the protrusion of neurovascular structures surround the sinuses have been investigated. We used Fischer Exact test for comparison. The p value < 0.05 was expressed as significant. **Results:** Statistically significant associations were found between anterior clinoid process bilateral pneumatization and bilateral protrusion of carotid canal ($p < 0.05$) and of optic canal ($p < 0.001$). There were also, statistically significant correlations between bilateral pterygoid process pneumatization and bilateral protrusion of carotid canal and of optic canal ($p < 0.001$); and between pterygoid process bilateral pneumatization and bilateral protrusion of maxillary and vidian nerves ($p < 0.001$). An association was also found between bilateral pneumatization of great wings and bilateral protrusion of maxillary nerves ($p < 0.001$) and of vidian nerves ($p < 0.05$). **Conclusion:** Compared to the literature, the prevalence of pneumatization of the adjacent structures of sphenoid sinuses was lower on Beninese than Caucasian and Asian. But there were the same correlations with the protrusion of neurovascular structures. In case of endonasal surgery of the sphenoid sinuses, surgeon should be aware of

the high possibility the injury of optic nerves and internal carotid artery.

Keywords

Sphenoid, Pneumatization, Neurovascular Structures, Association, Benin

1. Introduction

The variability of the anatomy of the sphenoid sinuses is well documented [1] [2] [3]. Sphenoid sinuses are probably the most variably pneumatized structures of the skull [1] [2] [3]. According to anatomic description, the sphenoid sinuses growth will reach their full extension on adolescence [4] [5]. The pneumatization of sphenoid sinuses is variable and ranges from minimal to extensive [4] [5] and it may occasionally extend into the different parts of the sphenoid bone, such as ACP (Anterior Clinoid Processes), lesser and the great wings, and PP (Pterygoid Processes). Sphenoid sinuses are surrounded by vital neurovascular structures, such as the internal carotid artery, opticnerves, maxillary and vidian nerves. The description of these anatomic variants in different populations gives useful information [6] [7] [8]. A previous work has studied the anatomic variants of sphenoidal sinuses and adjacent structures amongst Beninese [9]. However, few articles studied the relationship between pneumatization of adjacent structures of sphenoid sinuses and protrusion of neurovascular structures in black Africans [6]. The current work aimed to study the relationship between bilateral pneumatization of adjacent structures of sphenoid sinuses and bilateral protrusion of surrounding neurovascular structures at the National and University Teaching Hospital Hubert Koutoukou Maga of Cotonou (CNHU-HKM/Cotonou).

2. Methods

A retrospective descriptive and analytical study was conducted. Computed Tomography (CT scan) images of the skull of Beninese subjects without obvious anomalies in paranasal sinuses were collected in the Radiology Department of National and Teaching Hospital Hubert Koutoukou Maga of Cotonou from 1st November to 31st December 2017. Included subjects aged at least 16 years. Exhaustive recruitment of all patients was done during the period of study. The subjects were scanned on EMOTION SIEMENS 16-slices CT. CT-scan were systematically reviewed in the bone window and soft tissue window after multiplanar reconstruction. The thickness of the reconstructed image slice was 1 mm.

We studied the pneumatization of anterior clinoid processes, of pterygoid processes, of lesser and great wings; the protrusion of carotid canals and of optic canals, the protrusion of maxillary and vidian nerves. The anatomic images were already described in a previous work [9].

Protrusion was defined as the presence of at least one third of the canal circumference into the sinus cavity. Protrusion of the vidian nerves was defined as the presence of air density around the nerves [9].

Data collection was done using a survey form prepared for the circumstance. Data analyses were done by using Epi info software version 3.5.4. A descriptive analysis of the variables was done. Mean age and standard deviation were calculated. For qualitative variables, frequencies and proportions were calculated. The Comparisons of multiple variances were applied with using Fisher Exact test. The p-value < 0.05 was expressed as significant. The risk ratio (RR) was used to measure the association between sphenoid sinuses pneumatization and the protrusion of surrounding neurovascular structures. RR gives an indication of the "strength of association". RR is an intuitive way to compare the risks for two groups. Simply divide the cumulative incidence in exposed group by the cumulative incidence in the unexposed group:

$$\text{Risk Ratio} = \frac{Cle}{Clu}$$

where *Cle* is the cumulative incidence in the "exposed" group and *Clu* the cumulative incidence in the "unexposed" group.

These associations were tested only when both bilateral pneumatization of structures adjacent to sphenoid sinuses and bilateral protrusion of neurovascular structures were present simultaneously.

The ethical commission of CNHU-HKM has given his agreement and the data were used in absolute confidentiality.

3. Results

3.1. Description of Anatomic Variants

225 Skull CT-scans were collected. 224 had two sphenoid sinuses and one had a single sphenoid sinus.

Their age ranged from 16 to 86 years with mean age of 48.8 years ± 17.2. There was male predominance 58.7% with a sex-ratio of 1.42.

Table 1 represents the detailed data about bony anatomic variations. Pneumatization of lesser and great wings of the sphenoid were observed in 3.3% and

Table 1. The prevalence of bony anatomic variations, CNHU-HKM, 2017.

Anatomic variations	Bilateral	Right side	Left side	Total
Pneumatizaton	n (%)	n (%)	n (%)	n (%)
Lesser wing	12 (2.7)	1 (0.2)	2 (0.4)	15 (3.3)
Great wing	14 (3.1)	3 (0.7)	4 (0.9)	21 (4.6)
Anterior Clinoid Process	16 (3.6)	9 (2.0)	7 (1.5)	32 (7.1)
Pterygoid Process	28 (6.2)	-	5 (1.1)	33 (7.3)
Protrusion				
Carotid Canal	208 (46.3)	4 (0.9)	5 (1.1)	217 (48.3)
Optic Canal	44 (9.8)	7 (1.5)	8 (1.8)	59 (13.1)
Maxillary Nerve	72 (16)	3 (0.7)	6 (1.3)	81 (18)
Vidian Nerve	19 (8.4)	0	2 (0.4)	21 (9.5)

4.6% of patients respectively. Pneumatization of Anterior Clinoid Processes (ACP), and of Pterygoid Processes (PP); were found in 7.1% and 7.3% of patients, respectively. Protrusion of Carotid Canal (CC), and Optic Canal (OC) were found in 48.3% and 13.1% of patients, respectively. The Protrusion of Maxillary and Vidian nerves were found in 18% and 9.5% of the cases, respectively.

3.2. Sphenoid Sinuses Pneumatization and Association with the Protrusion of Surrounding Neurovascular Structures

Many protrusion of surrounding neurovascular structures were associated with pneumatization of adjacent structures of sphenoid sinuses.

Statistically significant correlations were found between: ACP bilateral pneumatization and bilateral protrusion of carotid canal ($p < 0.05$), and optic canal ($p < 0.001$), Table 2. There were also, statistically significant association between bilateral PP pneumatization and bilateral protrusion of CC and of OC ($p < 0.001$), Table 2. An association was also found between bilateral PP pneumatization and bilateral protrusion of maxillary and vidian nerves ($p < 0.001$), Table 3. Likewise statistically significant correlations were observed between bilateral pneumatization of great wings and bilateral protrusion of maxillary nerves ($p < 0.001$) and bilateral protrusion of vidian nerves ($p < 0.05$), Table 3.

Table 2. Relationship between ACP pneumatization and protrusion of CC and of OC and between PP pneumatization and protrusion of CC and of OC, CNHU-HKM, 2017.

	Carotid Canal			Optic Canal		
	*RR	**IC	p	*RR	**IC	p
ACP Pneumatizaton						
No	1			1		-
Yes	2.26	1.94 - 2.62	0.0017	15.50	9.33 - 25.72	<0.0001
PP Pneumatization						
No	1			1		-
Yes	2.34	2.00 - 2.74	<0.0001	1.41	1.06 - 1.88	<0.0001

*RR: relative risk, **IC: confidence interval.

Table 3. Relationship between PP pneumatization and protrusion of maxillary and vidian nerves and between Great wings pneumatization and protrusion of maxillary and vidian nerves, CNHU-HKM, 2017.

	Maxillary nerve			Vidian nerve		
	*RR	**IC	p	*RR	**IC	p
PP Pneumatizaton						
No	1			1	-	-
Yes	6.63	4.19 - 10.48	<0.0001	6.95	3.11 - 15.51	0.0003
Great wings Pneumatization						
No	1		-		-	-
Yes	7.51	5.35 - 10.54	<0.0001	5.84	2.20 - 15.51	0.014

*RR: relative risk, **IC: confidence interval.

4. Discussion

The current work aimed to study the relationship between pneumatization of adjacent structures of sphenoid sinuses and protrusion of neurovascular structures on Beninese.

4.1. Prevalence of Pneumatization of Adjacent Structures of Sphenoid Sinuses

Pneumatization of the sphenoid can extend in all its components, like the great and lesser wings, PP, and ACP [10] [11]. These extensions of sinuses bring them in close relations to vessels and nerves of the skull base such as internal carotid artery, optic nerves, maxillary and vidian nerves. The relations of sphenoid sinuses with the structures around are close when sinusesare well pneumatized [10] [12] [13]. When this happens, the surrounding vessels and nerves are seen in sinuses cavity (protrusion) as irregularities or ridges [14].

In this study, the rate of the pneumatization of the adjacent structures of the sphenoid was lower than the rate according to the literature. In our series, pneumatization of PP was 7.3% versus 15.5% - 43.6% [12] [13] [14] [15], pneumatization of ACP was 7.1% versus 11% - 29% [12] [13] [14] [15] and pneumatization of great wings was 4.6% versus 20% according to Hewaidi and Omani [16].

4.2. Prevalence of Protrusion of Neurovascular Structures

Prevalences of the protrusion of surrounding neurovascular structures observed in our study were comparable with the rate seen in other studies. In our series, protrusion of CC was 48.3% versus 34% - 93%, protrusion of OC was 13.1% versus 4% - 37.5%, protrusion of vidian nerves was 9.5% versus 7.5% - 13.3% [12] [13] [14] [15] and protrusion of maxillary nerves was 18% versus 24.3 % according to Hewaidi and Omani [16].

4.3. Associations between Pneumatization and Protrusion

In the current study, there were statistically significant association between the pneumatization of ACP and protrusion of OC ($p < 0.001$). Hewaidi and Omani [16], Kazkayasi *et al.* [17], Sirikci *et al.* [18], and Rahmati *et al.* [14] had reported the same association between ACP pneumatization and protrusion of OC. But these studies did not give the level of risk of protrusion of CO in case of ACP pneumatization. This risk was 15 times higher in our study. Therefore, in the presence of a bilateral pneumatization of ACP, it is necessary to fear a lesion of the optic nerves during an endonasal surgery.

There were also statistically significant correlations between the pneumatization of ACP and protrusion of CC ($p < 0.05$). Protrusion of CC was found to increase as ACP pneumatization increased in three studies [13] [19] [20]. Similarly, our study showed that the pneumatization of ACP and of PP double the risk to see protrusion of CC. This findings means that an inattention in case of endonasal surgery when bilateral pneumatization of both ACP and PP exist, may result

in injury of internal carotid artery in its intrasinusal tract. Such an injury usually leads to bad outcome.

According to our results, there were 7 times higher risk to seeprotrusion of both maxillary and vidian nerves when the PP pneumatization exist. This association between PP pneumatization and protrusion of maxillary and vidian nerves had already pointed out by Hewaidi and Omani [16], by Rahmati *et al.* [14] and Kazkayasi *et al.* [17] without give clearly the level of the association.

As Hewaidi and Omani [16], we had found a relationship between the pneumatization of great wing and the protrusion of maxillary nerves ($p < 0.001$). But the correlations between pneumatization of PP and protrusion of OC, and between pneumatization of great wing of sphenoid and vidian nerve were not seen in other studies.

Despite the relatively low pneumatization rate of adjacent structures within the study population, the prevalence of protrusion of neurovascular structures were consistent with that found in other studies. Correlations between the pneumatization of adjacent structures and the protrusion of neurovascular structures found in our studies have been corroborated by other studies.

4.4. Limitation of the Study

The retrospective characteristic of the study, the number of cases and the absence of additional readers to compare the results of the first reading are limits to this study.

5. Conclusion

The prevalence of pneumatization of the adjacent structures of sphenoid sinus was lower on Beninese than Caucasian or Asian population compared to literature. But there were the same correlations between the pneumatisation of the adjacent structures and the protrusion of surrounding neurovascular structures of sphenoid sinuses amongst Beninese. According to our results, the risk of blindness and hemorrhages seems to be clearly higher among the Beninese, in case of endonasal surgery of the sphenoid sinuses. Thus, the results of this study call our surgeons to more use CT scan before surgery on sphenoid sinuses.

Authors' Contributions

Akanni D conceived the study. de Souza C collected the data. Akanni D and de Souza C analyzed the data. Akanni drafted the manuscript. All authors approved the final version of the article.

Conflicts of Interest

The authors have no conflict of interest to declare.

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