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Assessment of variations of anterior ethmoidal artery evaluated by computed tomography of paranasal sinuses

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Abstract
Computed tomography (CT) has helped not only to evaluate nasosinusal disease, but also to characterize the anatomy of the paranasal sinuses. The coronal plane, in particular, is considered as a map for assessing the anatomy that varies significantly even between both sides in the same individual; this may alert about areas of potential complication risk in nasal endoscopic surgery.
The present study was planned in the Department of Otorhinolaryngology (ENT), Nalanda Medical College & Hospital. Total 100 patients referred to the ENT department from January 2016 to July 2017 for computed tomography of the paranasal sinuses were enrolled in the present study.
The medial notch of the orbit (anterior ethmoidal foramen) and the anterior ethmoidal sulcus on the lateral wall of the olfactory fossae were reliable parameters for identifying the course of the anterior ethmoidal artery. AEA in long mesentery with absent bony canal can be assessed preoperatively on CT PNS. In this scenario there is more chances of injury to vessel during surgery, hence care must be taken to prevent complications like orbital haematoma and haemorrhage.

Keywords: anterior ethmoidal artery, variations, CT PNS, paranasal sinuses

Introduction
The anterior ethmoid artery is a branch of the ophthalmic artery. It supplies the anterior and middle ethmoidal sinuses, frontal sinus, the lateral nasal wall and the nasal septum. It traverses the anterior ethmoidal foramen with the anterior ethmoidal nerve (which is the continuation of the nasociliary nerve) before entering the anterior cranial fossa where it gives off meningeal and nasal branches. The nasal branches continue into the nasal cavity to supply the nasal septum where it contributes to the Kiesselbach's plexus in addition to supplying the lateral nasal wall. The anterior ethmoidal artery is identified via identification of the anterior ethmoidal notch. This notch is reportedly seen in 95-100% of subjects. Location of the anterior ethmoidal artery should be reported by the radiologist on pre-operative studies. If the anterior ethmoidal notch is abutting the lateral lamella or the fovea ethmoidalis, the artery is considered protected during functional endoscopic sinus surgery as it is as the level of the skull base. If a supraorbital cell is seen above the anterior ethmoidal notch, or if the artery is located below the skull base, it is considered at risk [1].
The paranasal sinuses are cavities in the interior of the maxilla and the frontal, sphenoid, and ethmoid bones. The sinuses develop as outgrowths from the nasal cavity; hence they all drain directly or indirectly into the nose. Nasal infection (rhinitis), e.g., during a "cold in the head," may spread to the sinuses (sinusitis). The lining of the sinuses (muco-endosteum) is continuous with the nasal mucosa. The sinuses develop mostly after birth, and their degree of development varies greatly. Their function is obscure but they provide resonance to the voice, shape to the face and some degree of warmth and humidification to inspired air. The paranasal sinuses are supplied by branches of the ophthalmic and maxillary nerves. The sinuses can be examined radiographically, and a light placed again the roof of the mouth enables the maxillary sinus to be transilluminated [2].
The paranasal sinuses are air-filled extensions of the respiratory part of the nasal cavity. There are four paired sinuses, named according to the bone in which they are located; maxillary, frontal, sphenoid and ethmoid. The function of the sinuses is not clear. It is thought that they may contribute to the humidifying of the inspired air. They also reduce the weight of the skull. Sinuses are formed in childhood by the nasal cavity eroding into surrounding bone. As they are outgrowths of the nasal cavity, they all drain back into it – openings to the paranasal sinuses are found on the roof and lateral walls of the nasal cavity. The inner surface is lined by a respiratory mucosa [3].
Paranasal sinuses are a group of four paired air-filled spaces that surround the nasal cavity [4]. The maxillary sinuses are located under the eyes; the frontal sinuses are above the eyes; the ethmoidal sinuses are between the eyes and the sphenoidal sinuses are behind the eyes. The sinuses are named for the facial bones in which they are located. Paranasal sinuses form developmentally through excavation of bone by air-filled sacs (pneumatic diverticula) from the nasal cavity. This process begins prenatally (intrauterine life), and it continues through the course of an organism's lifetime. The results of experimental studies suggest that the natural ventilation-rate of a sinus with a single sinus ostium (opening), is extremely slow. Such limited ventilation may be protective for the sinus, as it would help prevent drying of its mucosal surface and maintain a near-sterile environment with high carbon dioxide concentrations and minimal pathogen access. Thus composition of gas content in the maxillary sinus is similar to venous blood, with high carbon dioxide and lower oxygen levels compared to breathing air [5].

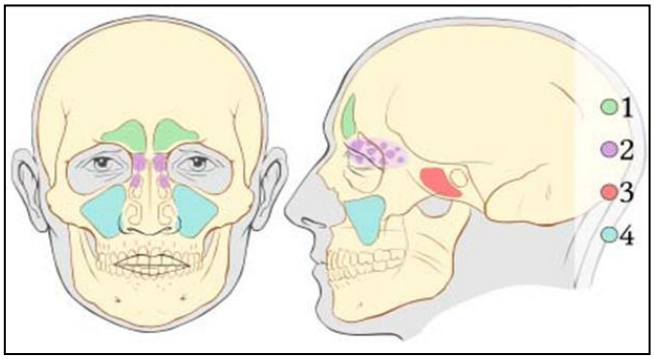

Fig 1: Diagram showing the location of the paranasal sinuses.1 – Frontal sinuses2 – Ethmoid sinuses3 – Sphenoid sinuses4 – Maxillary sinuses (By Patrick J. Lynch and Michał Komorniczak [CC-BY-2.5], via Wikimedia Commons)

At birth only the maxillary sinus and the ethmoid sinus are developed but not yet pneumatized; only by the age of seven they are fully aerated. The sphenoid sinus appears at the age of three, and the frontal sinuses first appear at the age of six, and fully develop during adulthood [6].

Computed tomography [7]. (CT) has helped not only to evaluate nasosinusal disease, but also to characterize the anatomy of the paranasal sinuses. The coronal plane, in particular, is considered as a map for assessing the anatomy that varies significantly even between both sides in the same individual; this may alert about areas of potential complication risk in nasal endoscopic surgery.

Methodology

The present study was planned in the Department of Otorhinolaryngology (ENT), Nalanda Medical College & Hospital. Total 100 patients referred to the ENT department from January 2016 to July 2017 for computed tomography of the paranasal sinuses were enrolled in the present study.

All the patients were informed consents. The aim and the objective of the present study were conveyed to them. Approval of the institutional ethical committee was taken prior to conduct of this study.

Following was the inclusion and exclusion criteria for the present study.

Inclusion Criteria: Patients with computed tomography of the paranasal sinuses

Exclusion Criteria: Patients with 12 years, a history of surgery or trauma in the paranasal sinuses or the skull base, congenital anomalies of the face, paranasal sinus malignancies, osteofibrous lesions, and sinus diseases that opacified the frontal recess and/ or the anterior ethmoidal cells.

Results & Discussion

There is ample variation in the course of the anterior ethmoid canal in the ethmoid sinus [9-10]. Injury of the anterior ethmoidal artery during endoscopic procedures may occur, with severe consequences. Preoperative knowledge of the course of the artery is essential to avoid complications; this important task belongs to CT. Many anatomical studies for locating the anterior ethmoidal artery have been published; most of them use endoscopic measurements related to endonasal anatomical landmarks [8-10]. On the other hand, we found few papers describing studies using CT [11].

Table 1: Position of anterior ethmoidal artery on both sides

Anterior Ethmoidal Artery	No. of Right Cases	No. of Left Cases
Short mesentery	19	20
Skull base	25	25
Long mesentery	6	5
Total	50	50

Table 2: Suprabullar cells correlation with Anterior Ethmoidal Artery (AEA) position

Side	No. of Right Cases	No. of Left Cases
SBC	45	44
AEA (mesentery)	44	44
AEA (skull base)	1	0

Table 3: Rudimentary frontal sinus, AEA position skull base

Side	No. of Right Cases	No. of Left Cases
AEA (skull base)	5	3
Frontal sinus (rudimentary)	5	3

Table 4: Bony canal comparison with mesentery

Side	AEA (mesentery)	Bony canal present in No. of Cases	Bony canal absent in No. of Cases
Right	24	22	2
Left	26	20	6
Total	50	42	8

McDonald *et al*. [12]. analyzed 50 CT exams in the coronal plane with 2.5 mm contiguous slices, and found the anterior ethmoidal foramen bilaterally in 95% of exams, and unilaterally in 5% of exams; these results were similar to ours. These authors did not, however, assess the presence of the anterior ethmoidal foramen, as was done in our study.

Anterior ethmoidal artery is very important artery in functional endoscopic sinus surgery. It is a very good anatomical landmark in frontal sinus surgery and anterior ethmoid surgery [13-14]. The position of anterior ethmoidal artery is an important landmarks as it is considered high risk area in endoscopic sinus surgery [15]. 2-3mm behind the bulla, the anterior ethmoidal artery is seen as a classical breaking of the medial orbital wall. The artery may lies close to skull base or may cross low within anterior ethmoid in which case the orbitocranial canal with its bony mesentery is clearly seen [16]. The anterior ethmoidal artery appears to lie low along the base of skull when that region of skull is pneumatised by supraorbital cell. In such case, the artery has a bony mesentery attaching it to the base of skull or it may even be dehiscent [17]. Injury to this artery may leads to catastrophic complication that depends upon the site of injury. If injury happens near the orbital region then in some cases it may retract in to orbit and leads to orbital haematoma. If it is not managed urgently then optic nerve compression can occur which finally cause blindness. Intraorbital haemorrhage is one of the most serious complications that can occur during endoscopic sinus surgery. It has a high potential to cause visual loss [18]. If damage happens near to cribriform plate then the chances of CSF rhinorrhoea will be much more. So in nutshell the localization of anterior ethmoidal artery is important preoperatively to reduce the chances of injury during surgery. Gotwald *et al*. used coronal scan to analyse the anatomical landmarks for locating AEA and he found that notch in medial wall of orbit (anterior ethmoidal foramen) and focal funneling in the olfactory fossa (anterior ethmoidal groove) were landmark for identification of the position and

orientation of AEA in nasal cavity [19].

In a CT study, Bayram *et al*. [20]. alerted about this possible association, but did not assess the frequency of this finding. Similarly, Simmen *et al*. [21]. also found the anterior ethmoidal artery canal below the ethmoidal roof in the presence of supraorbitary pneumatization in anatomical dissections of 30 half skulls. Thus, preoperative recognition of supraorbitary pneumatization in CT is valuable, as it provides an alert that the anterior ethmoidal artery canal is far from the ethmoidal roof, and courses freely within the ethmoidal cells; this increases significantly the risk of injury of the anterior ethmoidal artery during a surgical procedure.

Conclusion

The medial notch of the orbit (anterior ethmoidal foramen) and the anterior ethmoidal sulcus on the lateral wall of the olfactory fossae were reliable parameters for identifying the course of the anterior ethmoidal artery. AEA in long mesentery with absent bony canal can be assessed preoperatively on CT PNS. In this scenario there is more chances of injury to vessel during surgery, hence care must be taken to prevent complications like orbital haematoma and haemorrhage.

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