ANTERIOR ETHMOIDAL ARTERY; A SURGICAL AND RADIOLOGICAL STUDY

Thesis
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ABSTRACT

Surgical detection of the location of the AEC showed that it was located between 2nd and 3rd lamellas in 84 sides and inside 2nd lamella in 4 sides. Radiological detection of the location of the AEC showed that it was located between 2nd and 3rd lamellas in 82 sides and inside 2nd lamella in 6 sides. Surgical and radiological detection of the location of the AEC showed that it was located inside skull base in 82 sides and below skull base in 6 sides. The mean distance between the AEC and the anterior turbinate axilla was 22.8 mm and the mean distance between the AEC and the superomedial edge of the nostril was 64 mm in all 88 dissections. There was no bony defects in the AEC in all 88 disections.

KEY WORDS

Surgical-Endoscopic sinus surgery-Radiological-CT-Anterior ethmoidal artery-Anterior ethmoidal canal-Middle turbinate-Lamallas-Skull base-Nostrill-Bony defects.

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LIST OF ABBREVIATIONS

CSF: Cerebrospinal fluid

CT: Computed tomography

AEA: Anterior ethmoidal artery

AEC: Anterior ethmoidal canal

PEA: Posterior ethmoidal artery

PEC: Posterio ethmoidal canal

FESS : Functional endoscopic sinus surgery

MRI: Magnetic resonance imaging

MIST: Minimally invasive surgical therapy

JNA: Juvenile angiofibroma

DCR: dacryocystorhinitis

CRS: Chronic rhinosinusitis

ESS: Endoscopic sinus surgery

MT: Middle turbinate

Anatomy

EMBRYOLOGY

Classic anatomic treatises attribute initial paranasal sinus development to lateral nasal wall ridges called ethmoturbinals ***(Stammberger, 1991).*** A series of five to six ridges first appear during the eighth week of development; through regression and fusion, however, three to four ridges ultimately persist (Figures 1, 2, 3). The first ethmoturbinal regresses during development; its ascending portion forms the agger nasi, while its descending portion forms the uncinate process. The second ethmoturbinal ultimately forms the middle turbinate, the third ethmoturbinal forms the superior turbinate, and the fourth and fifth ethmoturbinals fuse to form the supreme turbinate. These structures are all considered to be ethmoid in their origin. An additional ridge, the maxiloturbinal, arises inferior to these structures. This ridge ultimately forms the inferior turbinate but is not considered ethmoid in its embryologic origin ***(Kennedy et al, 2001).***

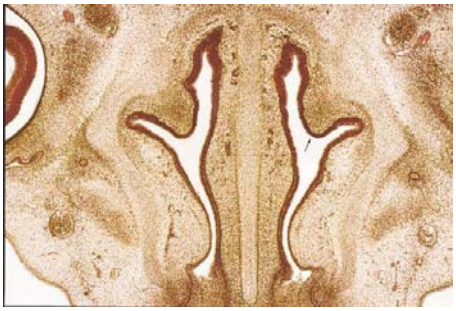

Figure 1: coronal section of a human embryo at approximately 56 days development. The primordial middle turbinate (arrow) and inferior turbinate can be seen emerging from the lateral nasal wall (Quoted from Kennedy, 2001)

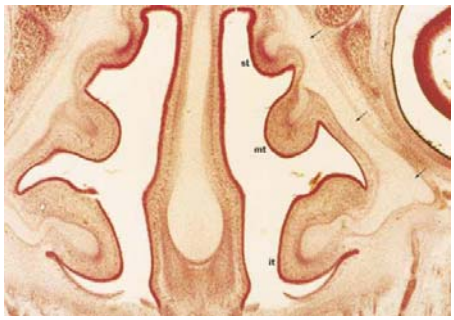

Figure 2: coronal section of a human fetus at approximately 60 days development. The primordial superior turbinate (st); middle turbinate (mt) and inferior turbinate (it) can be seen developing directly from the cartilaginous (arrows) (Quoted from Kennedy, 2001)

Figure 3: coronal section of a human fetus at approximately 63 days development. The primordial uncinate process can be seen as an evagination from the lateral wall with early ossification(arrow) . lateral to the primordial uncinate, a corresponding invagination forms the premordial infundibulum. (Quoted from Kennedy, 2001)

The primary furrows that lie between the ethmoturbinals form various nasal meati and recesses. The first primary furrow is located between the first and second ethmoturbinals. Its descending aspect forms the ethmoidal

infundibulum, hiatus semilunaris, and middle meatus, while its ascending aspect can contribute to the formation of the frontal recess. The primordial maxillary sinus develops from the inferior aspect of the ethmoidal infundibulum. The second primary furrow forms the superior meatus and the third primary furrow forms the supreme meatus. The primordial ethmoid bulla appears to arise as a secondary lateral nasal wall evagination, and the primordial supra-and retrobullar recesses (sinus lateralis) appear to arise from the secondary furrows that form above and behind the primordial ethmoid bulla ***(Schaeffer, 1912) (Davis, 1914).***

Development of the frontal sinus and frontal recess is quite complex and varies greatly among human subjects. The frontal sinus has been cited as potentially arising from a direct extension of the frontal recess, one or more anterior ethmoid cells, or, occasionally, the anterior superior aspect of the ethmoid infundibulum ***(Hanson, 1931) (Van Alyea, 1939).*** Stammberger maintains that the frontal recess is the superior continuation of the ascending aspect of the groove between the first and second ethmoturbinals, and that the frontal sinus originates from the anterior pneumatization of the frontal recess into the frontal bone ***(Stammberger, 1991).*** Schaeffer proposed that a series of up to four folds and furrows arise early in fetal development within the ventral and caudal aspect of the middle meatus. From these secondary folds and furrows, the frontal recess forms. As the furrows evaginate and continue to develop, they form the anlage of the frontal sinus as well as the various anterior ethmoid cells ***(Schaffer, 1916).*** Kasper expanded on the embryologic theme proposed by Schaeffer, maintaining that the first frontal furrow ultimately formed the most anterior ethmoid cell, usually the agger nasi cell; the second frontal furrow most commonly formed the frontal sinus;

and the third and fourth furrows formed other anterior ethmoid cells ***(Kasper, 1936).***

In addition to the ridge and furrow development, a cartilaginous capsule surrounds the developing nasal cavity and has an important role in sinonasal development. Bighman et al. highlighted the role of the cartilage capsule through cross-sectional histologic analysis of fetal specimens (Figure 2). At 8 weeks, three soft-tissue elevations or preturbinates are seen that correlate to the future inferior, middle, and superior turbinates. At 9 to 10 weeks, two cartilaginous projections invade into the soft tissue preturbinates. An additional soft tissue elevation with an underlying cartilaginous bud emerges at this time, corresponding to the future uncinate process (Figure 3). This structure enlarges, and by 13 to 14 weeks, a space develops lateral to the structure that corresponds to the ethmoidal infundibulum. By 16 weeks, the future maxillary sinus begins to develop from the inferior aspect of the infundibulum. The cartilaginous structures resorb or ossify as development progresses. The cartilaginous capsule, therefore, plays an important role in sinonasal development ***(Bingham et al, 1991).***

Development of the sphenoid sinus deserves special attention. During the third month of fetal development, the nasal mucosa invaginates into the posterior portion of the cartilaginous nasal capsule. The invagination expands to form a pouch-like cavity, referred to as the cartilaginous cupolar recess of the nasal cavity ***(Vidic, 1968).*** The wall surrounding this cartilage is ossified in the later months of fetal development, and the complex is referred to as the ossiculum Bertini. In the second and third years, the intervening cartilage is resorbed, the ossiculum Bertini becomes attached to

the body of the sphenoid, and the cavity definitely becomes sphenoid. Pneumatization progresses posteriorly, laterally, and inferiorly, reaching the nerve of the pterygoid canal in approximately the sixth or seventh year. With continued development, the anterior clinoids and pterygoid process can become pneumatized. Sinus pneumatization is completed between the ninth and twelfth years in most human subjects ***(Van Alyea, 1941) (Szolar et al, 1994).***

Anatomy

The ethmoid sinus is commonly referred to as "the labyrinth" due to its complexity and intersubject variability. Fortunately, several rhinologists and surgeons have reduced the complex ethmoidal labyrinth of the adult into a series of lamellae on the basis of embryologic precursors. These lamellae are obliquely oriented and lie parallel. The first lamella is the uncinate process; the second lamella corresponds to the ethmoidal bulla; the third is the basal or ground lamella of the middle turbinate; and the fourth is the lamella of the superior turbinate. The basal lamella of the middle turbinate is especially important, as it divides the anterior and posterior ethmoids. The frontal, maxillary, and anterior ethmoids arise from, and therefore drain into, the middle meatus. The posterior ethmoid cells arise from, and therefore drain into, the superior and supreme meati, while the sphenoid sinus drains into the sphenoethmoid recess. The lamellae are relatively constant features between human subjects, making intra-operative recognition important. They can help the surgeon maintain anatomic orientation when operating within the labyrinth of the ethmoid sinus ***(Kennedy et al, 2001).***

Anterior Ethmoid

Agger Nasi

On anterior rhinoscopy, a prominence can be easily appreciated at and just anterior to the middle turbinate's insertion into the lateral nasal wall. This region was designated the agger nasi, taken from the Latin agger, meaning mound or eminence, and nasi, meaning nose. This mound or eminence is a very consistent feature on nasal examination. In many but not all cases, the agger nasi region is pneumatized by an anterior ethmoid cell, referred to as the agger nasi cell. This cell usually takes its origin from the superior aspect of the infundibulum or the frontal recess region. (Figure 4). The agger nasi cell is bordered anteriorly by the frontal process of the maxilla, superiorly by the frontal recess/sinus, anterolaterally by the nasal bones, inferomedially by the uncinate process of the ethmoid bone, and inferolaterally by the lacrimal bone. . The superior aspect of the cell serves as the anteromedial floor of the frontal sinus and a significant portion of the anterior border of the frontal recess. This is relevant for understanding the pathophysiology of frontal sinusitis and the surgical treatment of the frontal sinus ***(Ritter, 1973).*** The agger nasi can pneumatize inferomedially to pneumatize the uncinate process (Figure 4). In a small percentage of patients, the pneumatization can be significant, and bulla formation of the uncinate may occur ***(Bolger et al, 1990).***

Figure 4: pneumatization is present in the superior portion of the uncinate from a cell from the ethmoid infundibulum (*). The front sinus (fs) and frontal recess (fr) can be seen draining into the middle meatal structures . After removing the lamellar portion of the superior turbinate a view into the posterior ethmoids (pe) is obtained . The open arrows mark the basal lamellae of the middle turbinate which divides the anterior and posterior ethmoids. (Quoted from Kennedy, 2001)

Uncinate Process

The uncinate process is most easily appreciated by viewing a sagittal gross anatomic specimen after deflecting the middle turbinate superiorlv (Figure 5). This ethmoid structure is nearlv sagittally oriented, nearly paralleling the ethmoidal bulla. It is approximately 3 to 4 mm wide and 1.5 to 2 cm in length. Through most of its course, its posterior margin is free as it has no bony attachments. The hiatus semilunaris lies directly behind the posterior margin of the uncinate (Figure 6) ***(Stammberger, 1995).***

Figure 5: lateral wall of the nose . the middle turbinate has been resected to reveal the important structures of the middle meatus: uncinate process (up) ethmoid bulla (eb) and hiatus semilunaris (inferior) (*).(Quoted from Kennedy, 2001)

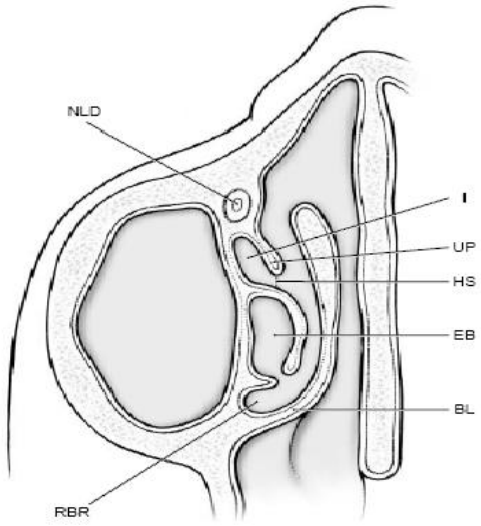

Figure 6: Axial illustration of anterior ethmoid anatomy. NLD = nasolacrimal duct; up = uncinate process EB = ethmoid bulla I= infundibulum HS = hiatus semilunaris RBR= retro bullar recess (Quoted from Kennedy, 2001)

Returning to its superior aspect, the uncinate projects posterior and superior to the middle turbinate attachment and most commonly bends laterally to insert on the lamina papyracea of the orbit (Figure 7). Inferior and lateral to this portion of the uncinate lies the superior aspect of the infundibular air space, the recessus termmalis. Superior and medial to this portion of the uncinate (most commonly) lies the floor of the frontal recess. Alternatively, the uncinate can attach centrally to the skull base or medially to the superior aspect of the vertical lamella of the middle turbinate near the turbinate's insertion to the cribriform plate ***(Onishi, 1981) (Stammberger, 1991).*** It can also fuse with an anterior ethmoid cell, such as the agger nasi.