THE NORMAL AND PATHOLOGICAL PNEUMATIZATION OF THE NOSE AND SINUSES

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The normal process of pneumatization has been explained anew by Perovic. It is known that by the normal process of pneumatization, according to the law of Congdon-Van Gilse, intersinusal septa can never be destroyed. Septa perforations are consequences of pathological processes in the sinuses. Perovic explained this law of Congdon - Van Gilse during his own investigations on the sphenoid and maxillary sinus. He proved that cancellous bone can never be pneumatised by the mucosa, because it never comes in direct contact with it. There must always be a shield of compact bone which can be resorbed by the mucous membrane. The resorption of the bone on one side always goes together with the apposition of the bone on the opposite side of the compact layer. It is an antagonistic parallel process in the region of the compact bone shield.

Perovic calles it "the apparatus of pneumatization". It can function only if both parts function i.e. its positive and its negative part apposition from one side and resorption from the other. When the apposition stops the resorption must also stop immediately. The impuls for pneumatization comes from the cancellous bone and not from the mucous membrane (processus frontosphenoideus Perovic).

This is what happens in the law of Congdon - Van Gilse. When in the formation of the intersinusal septum in the sphenoidal sinus both compact shields reach each other the cancellous bone between them, which was responsible for apposition has disappeared. The resorption ceases immediately too, i.e. the process of pneumatization is stopped and the paper-thin bony plate remains preserved all through life. By this same process the shield of compact bone is shifted backwards in the sphenoidal sinus and thus the sinus becomes larger. This process also occurs in the maxillary and in the frontal sinus.

The maxillary sinus is developed in fetal life in 2/3 of the cases by invasion of two pockets of nasal mucous membrane in the body of the maxilla. The process of bone resorption is slowed down in the region between these two sacs i.e. the future punctum convergii or eventually the partial septum. This process is continued according to the above mentioned law until a small compact septum is left, which cannot be destroyed by the normal process of pneumatization. This is the way in which partial septa in the maxillary sinus are formed. These septa always begin in a place on the upper border of the hiatus sinus maxillaris, which Perovic called punctum convergii and they end on the lower border of the hiatus, which Perovic called punctum palatinum. Between these two fixed points the middle portion of the partial septum can

be displaced forwards or backwards depending on the intensity of pneumatization by the anterior or posterior sac of the mucous membrane. Such partial septa are often seen on an X-ray picture with a thickened mucous membrane. There also exists the possibility of a total division of the maxillary sinus by formation of the so-called secondary sinus, which appears in two shapes. The typical secondary sinus can have various dimensions. It communicates with the upper nasal meatus and develops from an enlarged cell of Haller. The second type i.e. the type of Schlungbaum develops in the cartilaginous nasal capsule and its hiatus opens into the upper nasal meatus. It has the same characteristics as the hiatus semilunaris of the anterior maxillary sinus i.e. the processus maxillaris of the middle concha the processus maxillaris of the palatinal bone and the processus uncinatus. This secondary maxillary sinus is not so rare that it can be neglected. There are cases when only one of these sinuses can be ill, a fact which we must take into consideration when puncturing and operating the maxillary sinus. Such a double sinus can be easily seen on a lateral craniogram.

The maxillary sinus has many recesses but the most important are the alveolar and the palatinal one. The alveolar recess can be divided by two bony ridges into three secondary recesses (Underwood) for the premolars and the first, second and third molar respectively. These recesses may be an obstacle for the radical removal of the mucous membrane in operating the sinus. The palatinal recess is rather rare but it can gain considerable dimensions, which should be kept in mind in trepanation of the sinus. It can be seen as the alveolar recess on a lateral craniogram.

Nemanic described a rare form of recess in the maxillary sinus, which has not yet been mentioned in literature i.e. the case when the maxillary process of the inferior concha and palatinum does not follow the medial wall of the sinus in its development, but remains in a horizontal position thus deliminating an infero-posterior recess. This position of both processus is normal during the development of the sinus. Both of them lie first in the level of the base of the sinus, which is situated in that period very high up. With the development of the sinus its base is lowered and in normal circumstances both processus follow the resorption of the bone in the sinus and pass gradually from the horizontal into a vertical position in order to lean against the medial wall of the sinus. In some cases, however, this process can be interrupted so that the processus remain horizontal, forming the mentioned recess beneath them. In some rare cases the orbital processus of the palatinum may be formed by a prolongation of the maxilla (Perovic) which in extreme cases may reach the frontal bone as the processus frontosphenoideus of the maxilla. This processus is pneumatised from the sphenoethmoidal recess (Perovic) and represents, on a lateral craniogram, a narrow vertical pneumatic space connecting the tuber of the maxilla to the frontal bone.

The relations between the upper border of the hiatus sinus maxillaris and the maxillary sinus are very important. These relations have been studied thoroughly by Perovic and later on statistically by Rudez. The anterior smaller part of this upper border comes into contact with the lacrimal bone. Its posterior part is very complicated. These two parts of the upper border are divided by the punctum convergii of Perovic. The posterior part of the border shows 4 lines bounding 3 fields. To the upper-most line is attached the lamina

papyracea, to the second the medial wall of the ethmoidal labyrinth, to the third the middle concha and finally to the fourth the uncinate processus. The upper-most field corresponds to the ethmoidal labyrinth, the middle to the upper and the inferior to the middle meatus. These lines can be united so that their number and consequently the number of the fields is reduced. For us the most important is the uppermost field i.e. the one which comes into contact with the ethmoidal labyrinth. It is the very place through which the transmaxillar posterior ethmoidectomy can be performed by way of the cells of Haller. If the ethmoidal labyrinth is attached, not by a large but a small base, to the maxilla i.e. if the first and the second line are united so that the upper-most field disappears, we will come transmaxillary first into the nasal cavity and from there into the ethmoidal labyrinth.

There are cases in which the roof of the maxillary sinus is not formed by the whole orbital plate of the maxilla. If the convergence of the two parts of the upper border of the hiatus in the punctum convergii is very marked there is one part of the orbital plate which lies outside the sinus and belongs to the middle meatus. This part of the orbital plate is covered by a processus of the bulla ethmoidea, which can be so large that it even reaches the infra-orbital canal. These are cases in which we can enter into the orbital cavity by performing the transmaxillar ethmoidectomy. In such cases the sinus is shallow because its medial wall has shifted laterally. The bulla can be easily seen as a triangular space on an a—p. X-ray picture.

It is known that the ethmoidal labyrinth, which develops in the cartilaginous nasal capsule has a great invading potency. Thus the ethmoidal cells invade the frontal bone forming the frontal sinus. They may also invade the sphenoidal bone so that a great part of the sphenoidal sinus is nothing else but an enlarged ethmoidal cell.

When invading the frontal bone one or more ethmoidal cells, which were less agressive, may remain at the entrance of the frontal sinus forming there the frontal bullae (Nikolic). These bullae frontales can be affected by a chronic inflammation while the rest of the sinus can remain normal. Later on such an inflamed bulla can give rise to osteomas of the frontal or other sinus (Sunaric).

The invading potency of the ethmoidal cells also results in a formation of the septal recess of the frontal sinus (sinus septi nasi). This recess can be unilateral or bilateral and is due to the invasion of the mucous membrane of the left or right frontal sinus into the spina nasalis of the frontal bone and the lamina perpendicularis of the ethmoidal bone (Sykora, Novoselac). If the sinus septi nasi is bilateral both sinuses are divided by a septum, which can never disappear by normal process of pneumatization.

It is important to realise this possibility because in operating the frontal sinus the inflamed mucosa can remain hidden in this recess. Such a recess cannot be drained by way of the normal or even enlarged opening of the frontal sinus. It must be drained by a special septal incision. It should be stressed that the crista galli can also be pneumatised by the mucous membrane of the frontal sinus.

The frontal sinus can be very large; it can enter e.g. the small wings of the sphenoidal bone and thus come into contact with the optic nerve. The region around the optic nerve can be pneumatised also by an ethmoidal cell and by

the sphenoidal sinus resulting in cases of sinusitis in neuritis optica retrobulbaris. When such serious complications arise the sinuses causing them must be operated radically i.e. frontal sinus by Killian or Riedel and ethmoidal or sphenoidal sinus by lateral rhinotomy.

Further it should be stressed that the roof of the ethmoidal labyrinth, formed by the frontal bone always lies above the level of the cribrous plate. The cribrous plate has a much more complicated shape than is cited in general (Krmpotic, Keros). It is continued laterally in a thin, often dehiscent bony plate, which formes the medial part of the roof of the ethmoidal labyrinth. The lower situated the cribrous plate is, the larger the mentioned thin bony plate. The cribrous plate can lie even more than 2 cm under the roof of the labyrinth. These cases are very dangerous for ethmoidectomy because the mentioned thin plate can be easily injured. It should be stressed that besides the rule that in ethmoidectomy one should always remain with the instrument lateral to the insertion of the middle concha in order to avoid injury of the cribrous plate, one should also keep in mind that one should never press the instrument against the medial part of the roof of the labyrinth so as to prevent injury of the thin bony plate, which separates the ethmoidal labyrinth from endocranial structures.

The process of pneumatization in the region of the ethmoid can be so excessive that it can also invade the middle concha, which appears in such cases as concha media bullosa (Krajina, Pegan). This formation can be seen in an a-p X-ray picture or a-p planigrams.

Another region which is rather often pneumatised by ethmoidal mucous membrane in the region of agger nasi i.e. the anterior extremity of the uncinate processus. Agger nasi can, in rare cases, be represented by a small concha (nasoturbinale) as described by Perovic. The pneumatic cell in the region of agger also called agger-cell, lies in the way when external dacryo-cystorhinostomy is performed. This cell or sometimes two of them cover the region of the fossa sacci lacrimalis from its medial side and must not be confused during the operation with the nasal cavity when a drainage of the saccus lacrimalis into the nasal cavity is done.

The agger-cell as well as agger itself must be removed in endonasal approach to the frontal sinus by Halle. This most anterior situated part of the ethmoidal cells as well as the anterior ethmoid can be operated only by an endonasal and not by transmaxillar approach.

Ethmoidal mucous membrane may, as we have mentioned already, also invade the sphenoidal bone forming there a pneumatic space which communicates with the ethmoidal labyrinth. In general sphenoidal sinuses develop on both sides and open into the sphenoethmoidal recesses. These sinuses are separated by a septum, the position of which depends on the degree of pneumatization. If the process of pneumatization has the same intensity on both sides,the septum lies in the mid-line. If the intensity of pneumatization is bigger on one side the septum is shifted to the opposite side (Jovanovic). There can exist, however, not only two but also three of four sphenoidal sinuses. It occurs in cases when the sphenoid, besides its normal pneumatization is invaded by one or two ethmoidal cells lying laterally to the normal sinus. In rare cases only one sphenoidal sinus develops and it opens into one of the nasal cavities. Cope and Van Gilse have described a formation

of numerous partial septa in the sphenoidal sinus, which must be kept in mind when operating the sinus.

The sphenoidal sinus can have different dimensions. Hammer and Rädberg described several types of sinuses in connection with its relation to the fossa hypophyseos, which is of importance for operations of the hypophysis and for application of radio-isotopes in it. But besides the hypophysis the sphenoidal sinus, when extremely developed can come into contact with the structures of the sinus cavernosus i.e. carotid artery, IInd and IIIrd branch of the trigeminus and optic nerve. If the sinus invades the pterygoid process it comes into contact with the Vidian nerve and may, in case of inflammation, cause trouble in the autonomic innervation of the structures which the Vidian nerve is supplying. The sphenoidal sinus can form a recess in the posterior part of the septum analogous to the sinus septi nasi. Very important and less known is the fact that the sinus, when invading the region of clivus, may enter the basal part of the occipital bone and thus come into contact with the basal artery, pons and medulla oblongata (Novoselac, Nemanic). This is important in cases of chronic inflammation of the sinus as well as for operations.

RÉSUMÉ

Le procédé normal de la pneumatisation a été recemment étudié par Perovic qui a expliqué la loi de Congdon Van Gilse concernant la persistance des cloisons intersinusales. Il a prouvé que l'os spongieux ne pouvait être resorbé par la muqueuse car il n'y a jamais contact entre eux. Il existe toujours entre os spongieux et muqueuse sinusienne une couche d'os compact qui peut être resorbée par la muqueuse nasale. La résorption de l'os d'un coté est toujours assoçiée à l'apposition d'os du coté opposé de la couche osseuse. Au niveau de la table d'os compact, c'est un processus antagoniste et parallèle auquel Perovic a donné le nom de phénomène de la pneumatisation. Ce phénomène ne peut fonctionner que si les deux processus surviennent simultanement, c'est à dire que, si l'apposition d'os compact s'arrête, la resorption cesse egalement. L'influx necessaire à la pneumatisation ne provient pas de la muqueuse mais bien de l'os spongieux. Perovic a étudié ce processus specialement au niveau du sinus sphenoidal. Quand la cloison intrasinusale se forme, il arrive un instant où les deux couches d'os compact se rejoignent par disparition de l'os spongieux. A ce moment, le processus de la pneumatisation est terminé et la mince cloison osseuse persiste toute la vie. Le mecanisme de la formation des cloisons partielles ou complètes du sinus maxillaire ainsi que la forme exacte de l'ostium maxillaire et la structure de son bord postéro-superieur decrit par Pérovic sont exposés. Les relations entre le toit du sinus ethmoidal et l'endocrane (Krmpotic, Keros) ainsi qu'entre ethmoide et sinus maxillaire (Perovic, Rudez) sont ensuite decrites du point de vue anatomique et chirurgical. Les variations de forme et de dimensions des sinus paranasaux et les difficultés diagnostiques et opératoires qui peuvent en decouler sont soulignées egalement. Les radiographies en plusieurs incidences aident au diagnostic.

LITERATURE

Gilse, P. H. van: Über die Entwicklung der Keilbeinhöhle des Menschen, Zeitschr. f. Hals-Nasen- und Ohrenheilkunde, Bd. 16, 1926.

Keros, P.: Über die praktische Bedeutung der Niveauunterschiede der Lamina cribrosa des Ethmoids, Zeitschr. f. Laryng.-Rhinolog.-Otolog. und ihre Grenzgebiete, 41. Jhrg., Nr. 11, Stuttgart, 1962.

Krajina, Z.: Nosna polipoza. Rad Jug. akad. 307, Zagreb.

Krmpotic, J.: Odnos optickog kanala i straznje etmoide celije kod jednog slucaja jako razvijene pneumatizacije, Radovi Med. fak. Vol. VII, fasc. 3, Zagreb, 1959.

Nemanic, Gj.: Les dangers de l'ethmoïdectomie transmaxillaire, Revue de laryngologie-otologie-rhinologie, Bordeaux 82e année, janvrier-février, 1961/18-23.

Pertot, V. und Nemanic, Gj.: Caso instruttivo die meningite rinogena recidivante. Archivio italiano di otologia, rinologia e laringologia, Estratto dal Vol. LXXIII. fasc. 1 1962.

Perovic, D.: Researches concerning the sphenoid and the formerly unknown fronto-sphenoid process of the maxilla and the way of their pneumatization. Bulletin internat. de l'Academie Yougoslave des sciences et des beaux arts. Livre I. Zagreb, 1948.

Perovic, D.: Beiträge zur Kenntnis der Entwicklung und des Baues des menschlichen Oberkiefers sowie des Sinus maxillaris. Bulletin internat. de l'Academie Yougoslave des sciences et des beaux arts. Livre 4. 1954.

Perovic, D.: Die Kausale Lösung des Rätsels, warum die papierdünnen Septen zwischen den pneumatischen Räumen nicht resorbiert werden. Bulletin internat. de l'Acad. Yougosl. Livre 16. 1964. Zagreb.

Radojevic, S. - Jovanovic, S.: Proucavanje morfologije i topografije sfenoidnog sinusa kod coveka. Srpska akademija nauka. Knj. CCI 1956.

Rudez, V.: Odnosi etmoidne bule i maksilarnog sinusa. Radovi Med. fak. Vol. XI, 1963.

Schlungbaum: Über die Bildung mehrerer Nebenräume der Nasenhöhle im Oberkiefer und ihre Deutung, mit Berücksichtigung der Beziehungen der Zähne zu ihnen. Vierteljahrschr. f. Zahnheilk. 43 Jahrg., 1921. Heft 1.

Stupka, W.: Die Missbildungen und Anomalien der Nase und des Nasenrachenraumes 1938.

Underwood, A. S.: An Inquirey into the Anatomy and Pathology of the Maxillary Sinus J. of Anatomy and Phys. Vol. 44, 1910.

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