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Key words: nasal region, comparative embryogenesis, mammals, human.

Надійшла: 16.11.2016
Прийнята: 22.12.2016

DOI: <https://doi.org/10.26641/1997-9665.2016.4.77-83>
UDC 611.21.013.019:591.421

COMPARATIVE MORPHOGENESIS OF NASAL REGION IN HUMAN AND SOME MAMMALS

Research has been conducted as a part of a planned comprehensive scientific research work “Gender and age structural regularities, topographic and anatomical interrelations of structures and organs during human ontogenesis. Peculiarities of age and gender embriotopography” (state registration number 0105U002927).

ABSTRACT. Background. Comparative anatomical and embryological research has not lost its relevance in the wide field of human body structures and systems studying. Analysis of current scientific literature concludes that the problem of prenatal morphogenesis of the nasal cavity structures in comparative embryological aspect still remains unsolved. **Objective.** The aim of the study was to clarify specific structural features of nasal region structures during prenatal morphogenesis in human and some mammals. **Materials and methods.** Research was conducted on 75 specimens of human fetuses and embryos and 85 mammals’ specimens in different periods of prenatal development by using complex of morphological methods (anthropometry, morphometrics, microscopy, three-dimensional computer reconstruction and statistical analysis). **Results.** At the end of the fetal period of ontogenesis, nasal region in studied mammalian species acquires features of a definitive structure. It is surrounded by cartilaginous nasal capsule, to the exterior surface of which are adjacent dorsally - nasal and partly frontal bones, lateral - maxillary bones. Nasal cavity is delimited from the cranial cavity by cribriform plate of sphenoid, which consists of cartilage. Nasal cavity is divided into two halves by cartilaginous nasal septum, which aborally proceeds into cartilaginous skull base, dorsally – into the vault of nasal capsule. Ventral wall of nasal cavity consists of paraseptal cartilages and secondary bone palate. **Conclusions.** It was found that differences of nasal region structure in studied mammals were associated with form of nasal cavity, structure of secondary palate bone, number and developmental degree of nasal cavities and paranasal sinuses. This differences are caused by nutrition features, nature of dental armament, degree of brain development, intensity of respiration and animals’ conditions of existence. In humans lateral nasal gland is absent, however respiratory, olfactory and maxillary glands are well developed.

Morphologia. – 2016. – Т. 10, № 4. – С. 77-83.

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Кузник Н.Б., Цигикало О.В., Олійник І.Ю., Попова І.С. Порівняльний морфогенез носової ділянки людини та деяких ссавців.

Реферат. З метою з’ясування видових особливостей будови структур носової ділянки людини та деяких ссавців в пренатальному періоді онтогенезу, досліджено препарати передплідів та плодів з використанням комплексу методів морфологічного дослідження. Встановлено, що видові відмінності будови носового апарату пов’язані з формою носової порожнини, структурою вторинного кісткового піднебіння, кількістю та ступенем розвитку носових раковин, приносних пазух, і зумовлені особливостями харчування, мірою розвитку головного мозку, інтенсивністю дихання, умовами існування.

Ключові слова: носова ділянка, порівняльний ембріогенез, ссавці, людина.

Citation:

Kuzniak NB, Tsyhykalo OV, Oliinyk IYu, Popova IS. Comparative morphogenesis of nasal region in human and some mammals. *Morphologia*. 2016;10(4):77-83.

Background

Comparative anatomical and embryological research hasn’t lost its relevance in the wide field of human body studying. Comparative investigation helps to determine morphogenetic peculiarities of

organs and systems in various animals; to identify common features and characteristics of morphofunctional organization of living matter [1-4]. Among vertebrate animals, only mammals’ nasal cavity has achieved the highest degree of development. This

degree of development besides air conducting function also includes immune, defensive, chemoreceptor functions and is involved in thermoregulation [5-8]. Analysis of current scientific literature concludes that the problem of prenatal morphogenesis of the nasal cavity structures in comparative embryological aspect still remains unsolved [9-12]. Consequently, there is a necessity of using a comprehensive methodological approach for studying problems of development and structure of the nasal apparatus; this study should be emphasized on a comparative aspect in different mammals' species in interconnection with location and manner of their existence [9, 12].

Aim

The aim of the study was to clarify specific structural features of nasal region structures during prenatal morphogenesis in human and some mammals.

Material and methods

Research was conducted on 75 specimens of human and 85 mammals' specimens in different periods of prenatal development. We have studied

five species which belong to 4 rows of mammals' class: human, white rat, domestic cat, domestic dog, domestic pig. Animals for comparative and anatomical studies were selected considering conditions of their existence, nutrition features, reproduction, degree of brain and senses development. Material (human embryos and fetuses) was received from obstetrical and gynecological clinics in Chernivtsi. Series of histological sections of mammalian embryos, human embryos and fetuses were used from Museum in Department of Human Anatomy named after M.H. Turkevich and Scientific Foundation in Department of Histology, Cytology and Embryology in Higher Educational Establishment of Ukraine "Bukovynian State Medical University."

We used the classification of mammals' prenatal ontogenesis on 16 consecutive stages by Tiatenkova N.N. [13]. Considering the fact that specific features of morphogenesis are clearly manifested during big organogenesis, we began describing this period from the third stage.

Table 1

Conformity to stages of mammals' development, parieto-coccygeal length (PCL) (mm) *

Number of stage	Human	Domestic cat	White rat	Domestic dog	Domestic pig
3	4,0-6,0	4,0	10	4,0-5,0	-
4	6,0	5,0	11	6,0-8,0	-
5	7,0-11,0	6,0	12	9,0	-
6	12,0-13,0	8,5-9,0	13	10,0	9,0-13,0
7	14,0-15,0	10,0-11,0	14	11,0-12,0	14,0-15,0
8	16,0-17,0	11,0-12,0	15	13,0-15,0	16,0-18,0
9	18,0-20,0	14,0-17,0	15	16,0	19,0-23,0
10	21,0-24,0	18,0-21,0	16	17,0-19,0	24,0-27,0
11	25,0-29,0	22,0-23,0	16	22,0-28,0	28,0
12	30,0-38,0	25,0-27,0	16-17	28,0-39,0	33,0-34,0
13	39,0-79,0	28,0-35,0	17	30,0	36,0-50,0
14	80,0-189,0	36,0-59,0	18-19	31,0-69,0	51,0-54,0
15	190,0-279,0	60,0-100,0	20-21	70,0	55,0-150,0
16	280,0-370,0	101,0-120,0	22	140,0	-

Note: * age of white rats is given in days.

Research was conducted on embryos, fetuses and fetuses specimens of human and mammals without any pathology of nasal region.

Results and discussion

At the end of ontogenesis fetal period, nasal region in studied mammalian species had fully acquired features of a definitive structure. It is surrounded by cartilaginous nasal capsule, to the exterior surface of which are adjacent dorsally to nasal and partly frontal bones, lateral - to maxillary bones. Nasal cavity is delimited from the cranial cavity by cribriform plate of sphenoid, that consists of cartilage. Nasal cavity is divided into two halves by cartilaginous nasal septum, that aborally proceeds into cartilaginous skull base, dorsally - into the vault of nasal capsule (Fig. 1). Ventral wall of nasal cavity

consists of paraseptal cartilages and secondary bone palate.

Nasal cavity in white rat newborn is elongated dorso-ventrally and holds 45% of the whole facial skull length (Fig. 2). This type of nasal cavity in cross-section has oval shape in oral division, and triangular shape in the middle part. Cartilaginous nasal capsule in white rats' newborns is well developed. Maxillary concha has simple form, platen-shaped.

Nasoturbinale passes along dorso-lateral wall and has cartilaginous supporting part (Fig. 3). Ethmoidal conchas are divided on external and internal. General nasal meatus in anterior part is narrowed; in the middle part meatus is acutely expanding. Ethmoidal labyrinth and sinuses are highly developed.

Lower nasal meatus is not precisely marked; middle nasal meatus is wide.

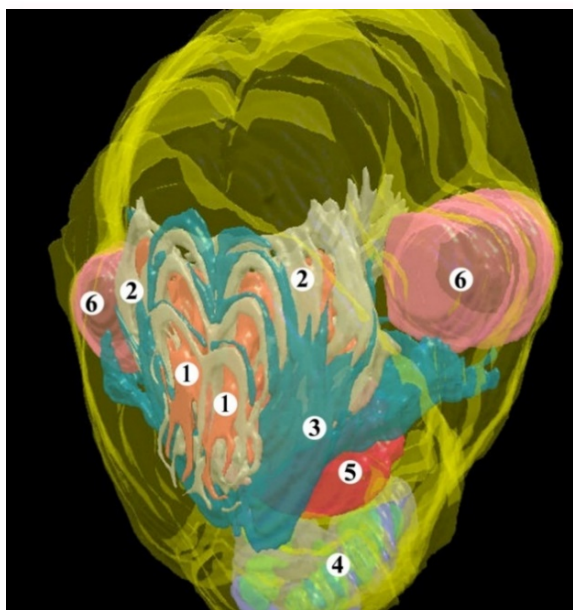


Fig. 1. Three-dimensional computer reconstructed head of a rat 21,0 mm of PCL. Anterio-sinistra view. Magnification 1:12. 1 – nasal cavity; 2 – cartilage capsule, 3 – bone tissue of maxilla; 4 – mandible; 5 – tongue; 6 – eyeballs.

At the end of fetal development in white rat, glands of the nasal cavity are well formed. Buds of maxillary, lateral, anterior medial, respiratory and olfactory glands are identified by this stage of development. The lateral nasal gland in white rat is a compound alveolar gland, branched and well-developed. From the main duct go off ducts of the

first and second order. Mucous membrane is very thickened in terminal portion of gland. There are two anterior medial glands before the birth. These glands are located parallel to each other in the mucosa of nasal septum. Aboral part of glands is helically twisted.

Domestic pigs of 15th stage of prenatal development have elongated nasal cavity that and holds 52% of the total skull length. Anterior part of nasal cavity is narrowed and includes T-shaped maxillary concha (Fig. 4).

Nasoturbinial is platen-shaped, located dorso-laterally with indistinctly expressed bearing part. Nasal septum is massive, evenly thick throughout. Secondary choanas are located in the back third of the nasal cavity and lead to nasopharyngeal airway. Anterior transverse plate orally merges with inferior edge of nasal septum; aborally it remains free and locates almost horizontally. Supraseptal groove is deep. Paraseptal nasal cartilages are well developed. Anterior paraseptal nasal cartilage is shaped as a vertical plate, orally connected with anterior transverse plate; aborally – with nasopalatine cartilage. Nasopalatine cartilage covers canal of the same name. In aboral from nasopalatine cartilage's direction, goes off a short posterior paraseptal nasal cartilage shaped as a horizontal plate. Nasopalatine cartilage is connected with vomeronasal ring-shaped cartilage. Vomeronasal cartilage connects dorsally with anterior paraseptal cartilage. Aboral division of the nasal cavity is broadened and contains five endoturbinals with expanded shape. Secondary bone palate consists of premaxilla, maxilla and palatine bones. Vomer is an azygous bud that borders with ventral edge of nasal septum. Maxillary and frontal sinuses develop from paranasal sinuses. Ossification is detected in buds of palate and vomer.

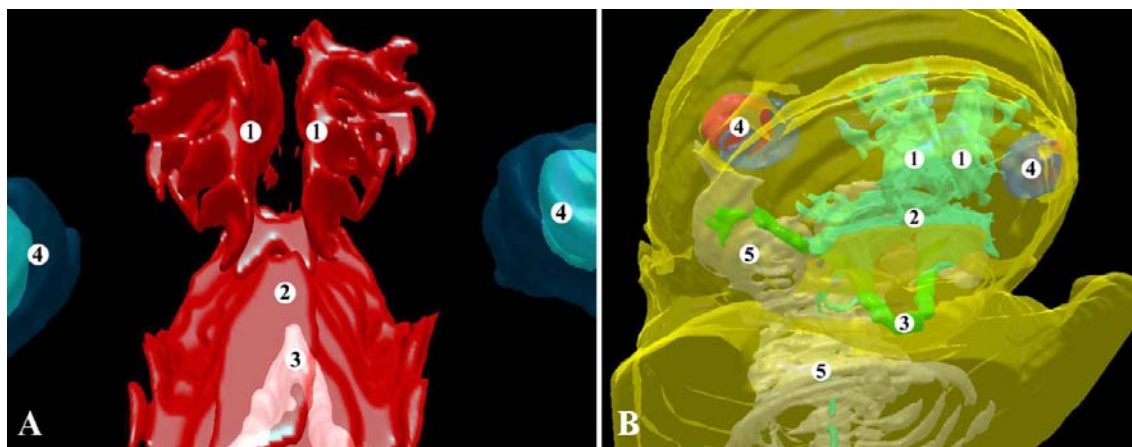


Fig. 2. Three-dimensional computer reconstructed head of a rat 19,0 mm of PCL (A) and 21,0 mm of PCL (B). A – superior-posterior view, B – antero-dexter view. Magnification 1:12. 1 – nasal cavity; 2 – oral cavity; 3 – Meckel's cartilage; 4 – eyeballs; 5 – anlage of skeleton and cranial bones.

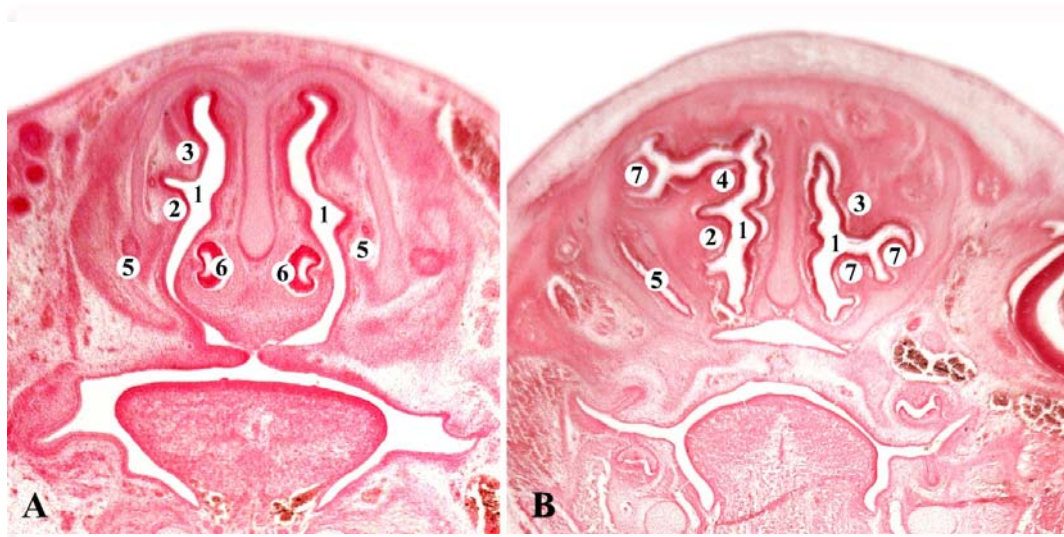


Fig. 3. Frontal sections of nasal region in white rat 18,0 mm of PCL. Hematoxylin-eosin. Microphotographs. $\times 56$. 1 – nasal cavity; 2 – maxilloturbinal; 3 – nasoturbinal; 4 – endoturbinals; 5 – nasolacrimal canal; 6 – vomeronasal organ; 7 – exoturbinal.

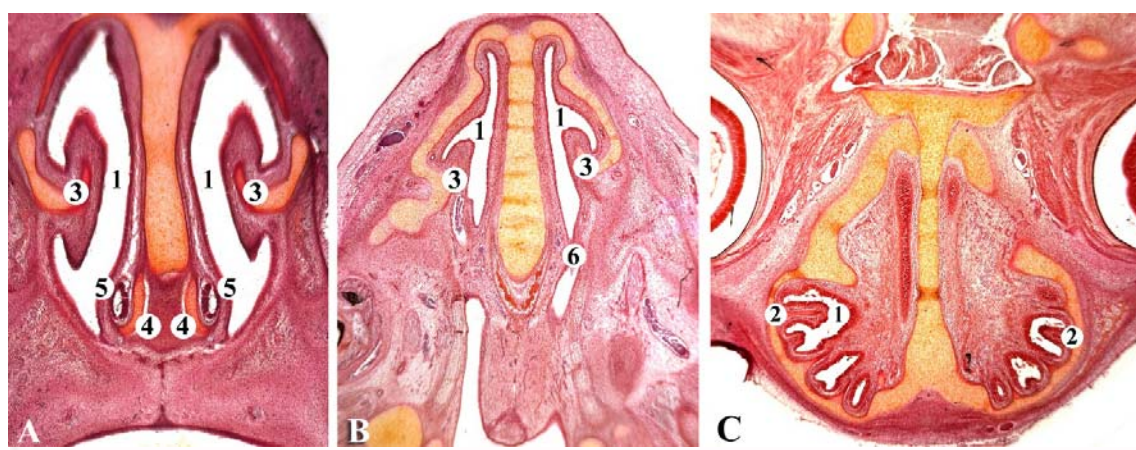


Fig. 4. Horizontal (A, B) and frontal (C) sections of nasal cavity in pigs' embryos 44.0 mm of PCL. Hematoxylin-eosin. Microphotographs. $\times 56$. 1 – nasal cavity; 2 – ethmoidal sinuses; 3 – maxillary sinus; 4 – paraseptal cartilage; 5 – vomeronasal organ; 6 – nasolacrimal canal.

At the end of fetal period of prenatal development in domestic cat, nasal cavity is shortened and holds 38% of the total skull length. General nasal meatus in anterior part is low. Middle part of the nasal cavity is wider, increases in height and contains maxilloturbinal. Sinus is well formed; has a simple, insignificantly down twisted shape (Fig. 5 A, B). From the dorso-lateral wall goes off small platen-shaped nasoturbinal. Abortal division includes a rank of olfactory sinuses: 4 endo- and 5 ectoturbinals. Free edges of internal sinuses bisect and set up a curl (Fig. 5 B). Most of ethmoidal sinuses diverge from lateral wall of the nasal capsule and only part of them diverge from dorsal wall.

Maxillary sinus is well developed; its blind division ends in aboral part of nasal cavity. In cross-section this sinus is dorso-ventrally extended. Secondary bone palate is formed by paired buds of premaxilla, maxilla, palatine bones and vomer. Vomer is a part of palate bone as a small impregnation.

Vomer is also detected in oral division as two vertical plates, located between Jacobson organ. Aborally plates unite and the odd tab covers ventral edge of nasal septum cartilage. The lower half of nasal septum is significantly expanded in area of vomeronasal organ. Supraseptal groove is well-shown. Anterior transverse plate is located horizontally, however in aboral direction it becomes horseshoe-shaped and merges with nasal septum. Anterior paraseptal cartilage has a form of an independent vertical plate. Nasopalatine cartilage accompanies canal of the same name and has a curved vertical plate shape, connected to vomeronasal cartilage. Vomer nasal cartilage has annular shape in the region of Jacobson's organ excretory duct; aborally this cartilage is groove-shaped. Ossification is detected in supporting structures of maxillary and ethmoidal sinuses, in aboral part of nasal septum and in buds of secondary bone palate.

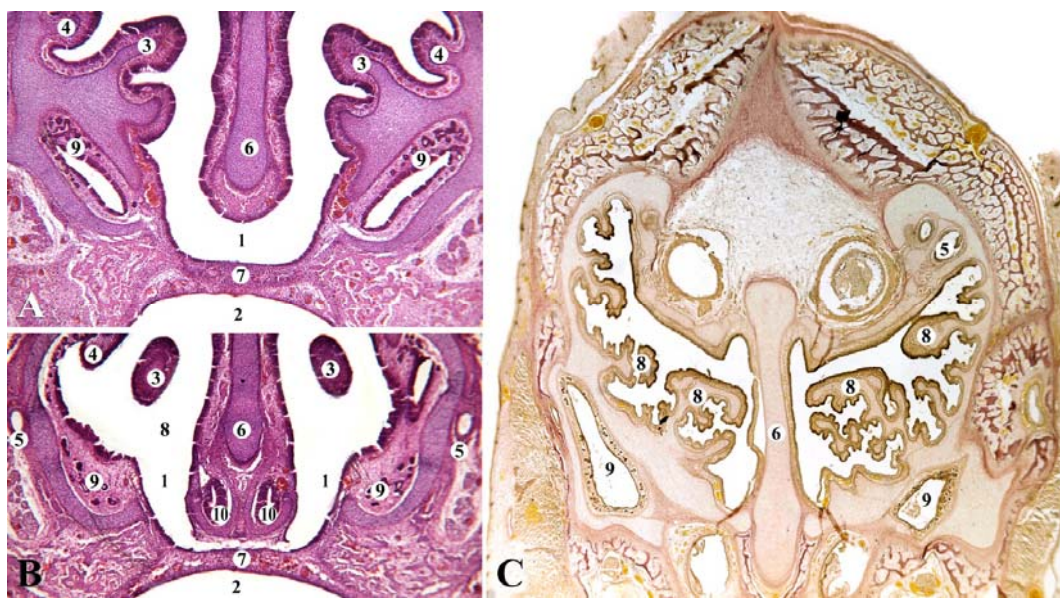


Fig. 5. Frontal sections of newborn domestic cat. A, B – hematoxylin-eosin, B – Van Gizon. Microphotographs. $\times 56$. 1 – nasal cavity; 2 – oral cavity; 3 – maxillary sinus; 4 – nasoturbinal; 5 – nasolacrimal canal; 6 – nasal septum; 7 – secondary bone palatine; 8 – ethmoidal sinuses; 9 – lateral nasal gland; 10 – Vomeronasal organ.

In newborn domestic cat, lateral nasal gland is simple alveolar with relatively short excretory duct and branched terminal part. Lateral nasal gland is developed moderately. Mucous membrane in terminal division of gland is temperately thickened. Anterior medial glands are not found. Anterior division of nasal cavity contains big number of respiratory glands; they are simple alveolar with branched endings. The number of glands in maxillary sinus dramatically increases, they become of complex

alveolar-tubular type. In newborn domestic cat only maxillary and frontal sinuses are detected.

In newborn domestic dog nasal cavity is elongated. There is a deep suprasedal groove in the roof of nasal cavity. Inferior part of nasal septum is slightly thickened. Maxillary concha has complicated spatial form; it's free edge is characterized by plicate structure. Therefore, it significantly increases the area of external surface (Fig. 6 A).



Fig. 6. Frontal sections of domestic dog embryo 12,0 mm of PCL. Microphotographs. $\times 56$. 1 – nasal cavity; 2 – maxillary conchas; 3 – nasal conchas; 4 – endoturbinals; 5 – exoturbinals; 6 – ethmoidoturbinal 7 – vomer; 8 – vomeronasal organ; 9 – vomeronasal cartilage; 10 – tongue.

Nasoturbinal is small, with cartilaginous supporting part. Olfactory conchas are divided on internal and external. They obtain compound branched and twisted shape. There were found four endoturbinals and six exoturbinals. From all paraseptal cartilages, anterior paraseptal, nasopalatine, cartilage of

palate papilla and C-shaped vomeronasal cartilages were found. Vomer is detected as an azygous V-shaped bud. Secondary bone palate consists of maxillary, premaxilla and palatine bones' buds. From additional sinuses only maxillary and frontal sinuses are present. Ossification centers are found in buds of

vomer, maxillary, premaxillary, palatine bones, maxillary and ethmoidal conchas.

In newborn domestic dog glands in the nasal cavity are highly developed. There are found respiratory, maxillary and lateral glands. Lateral nasal gland is simple alveolar with branched terminal ends. Mucous membrane in terminal part of lateral nasal gland is slightly thickened. From paranasal sinuses, only maxillary and frontal are developed.

In human fetuses of 13th stage of prenatal development, nasal capsule, nasal concha and nasal septum are built of cartilaginous tissue. Inferior, medium and superior nasal conchas go off lateral walls of nasal cavity. Medial edges of conchas are directed dorso-ventrally. All the conchas are simple, without any curls in shape (Fig. 7).



Fig. 7. Frontal section of nasal region in prefetus 25,0 mm of PCL. Hematoxylin-eosin. Microphotographs. $\times 56$. 1 – nasal septum; 2 – nasal conchas; 3 – superior nasal meatus; 4 – medial nasal meatus; 5 – inferior nasal meatus; 6 – cartilaginous capsule.

Anterior division of nasal cavity is slit-shaped, elongated in dorso-lateral direction. In the middle division, nasal cavity expands and has a rhomboid form in cross section. Inferior nasal meatus remains mainly as an epithelial cord. Middle nasal meatus is short and wide. Superior nasal meatus has a form of dorso-laterally extended lacuna. There are found small sphenoidal and maxillary sinuses. Secondary palate has a form of a vault that consists of paired buds of maxillary and palatine bones. Aboral above paired buds of maxillary and palatine bones is located azygous horseshoe-shaped bud of the vomer. There are three ossification centers in vomer's bud. In human fetus lateral nasal gland is absent, however respiratory, olfactory and maxillary glands are well developed.

Conclusions

1. Species' differences of nasal region structures in studied mammals are associated with the form of nasal cavity, structure of secondary palate bone, number and developmental degree of nasal cavities and paranasal sinuses; this differences are caused by nutrition features, nature of dental armament, degree of brain development, intensity of respiration and animals' conditions of existence.

2. In humans lateral nasal gland is absent, however respiratory, olfactory and maxillary glands are well-developed.

Perspectives

Perspective direction of comparative embryological research is to identify specificities of blood supply and innervation sources of the nasal region during prenatal period of ontogenesis in human and some animals.

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Кузник Н.Б., Цигикало А.В., Олийнык И.Ю., Попова И.С. Сравнительный эмбриогенез носовой области человека и некоторых млекопитающих.

Реферат. С целью выяснения видовых особенностей строения структур носовой области человека и некоторых млекопитающих в пренатальном периоде онтогенеза, исследованы препараты предплодов и плодов с использованием комплекса методов морфологического исследования. Установлено, что видовые различия строения носового аппарата связаны с формой носовой полости, структурой вторичного костного неба, количеством и степенью развития носовых раковин, околоносовых пазух, и обусловлены особенностями питания, степенью развития головного мозга, интенсивностью дыхания и условиями существования.

Ключевые слова: носовая область, сравнительный эмбриогенез, млекопитающие, человек.