www.ThePharmaJournal.com

The Pharma Innovation

ISSN (E): 2277-7695
ISSN (P): 2349-8242
NAAS Rating: 5.23
TPI 2023; SP-12(10): 686-690

www.thepharmajournal.com
Received: 22-08-2023
Accepted: 30-09-2023

Sukanya T
Department of Veterinary Anatomy, College of Veterinary science, Rajendranagar, Hyderabad, Telangana, India

Pramod Kumar D
Department of Veterinary Anatomy, College of Veterinary science, Rajendranagar, Hyderabad, Telangana, India

Rajendranath N
Department of Veterinary Anatomy, College of Veterinary science, Rajendranagar, Hyderabad, Telangana, India

Gireesh Kumar V
Department of Veterinary Anatomy, College of Veterinary science, Rajendranagar, Hyderabad, Telangana, India

Corresponding Author:
Sukanya T
Department of Veterinary Anatomy, College of Veterinary science, Rajendranagar, Hyderabad, Telangana, India

Morphological studies of ethmoturbinates in Indian pig (*Sus scrofa domesticus*)

Sukanya T, Pramod Kumar D, Rajendranath N and Gireesh Kumar V

Abstract
Morphological features of ethmoturbinates were studied in two frozen heads in five (5) transverse sections of nasal cavity and two heads sectioned longitudinally with intact nasal septum on which impressions of ethmoturbinates were seen. Ethmoturbinates were in two groups *viz*., 4–6 lateral ectoturbinates and seven medial Endoturbinates (EnTI – VII) anchored to convex nasal surface of cribriform plate. First EnT was longest and broadest (7.18 and 1.89 cm) extending into nasal cavity, whereas EnT II was second largest at level of upper last molar followed by next two connected by a common stalk. Ethmoturbinates at level of third upper molar displayed ethmoidal labyrinth in rostro-caudal direction whose ventral ends were attached to ventro-lateral plate inclined towards nasal septum. Present study shows seven well developed EnT in caudal third of nasal cavity in pigs.

Keywords: Morphology, ethmoturbinates, Indian pig

Introduction
Turbinates are specialized 'scroll' like bones in mammalian nasal cavity anchored to nasal, ethmoid and maxillary bones forming the dorsal, middle and ventral turbinates respectively. They play a significant role in conduction of inspired air and warming it to a specific range of temperature to maintain its humidity and olfaction. Turbinates also aid in removal of suspected particles and droplets (Negus 1958 and Nickel *et al.*, 1986) [13, 14].
Middle nasal concha in pig is small and projects to a short extent into nasal cavity from ethmoid labyrinth. Its basal lamella gives rise to dorsal and ventral spiral lamellae which contain recesses. Unlike pigs the ethmoidal conchae of carnivores extends considerably forward into the nasal cavity and also invade the frontal sinus. In mammals the ethmoturbinates are located in posterior roof of the nasal cavity and lined by olfactory mucosa which have receptor cells for detecting and discriminating between different odours (Buck and Axel 1991) [2].
Olfactory organ is unique in the central nervous system since it is the only part which is in direct contact with the environment and also has the ability to regenerate damaged neurons (Jones 2001) [9]. Olfactory mucosa consists of olfactory receptor cells which project their axons in between supporting and basal cells and through the basement membrane.
In most domestic animals the ethmoidal labyrinth is a complex of turbinates which is divided into ecto and endoturbinates which are attached to the cribriform plate of ethmiod. Miller *et al.* (1964) [12] described the presence of four endo and six ectoturbinates in dogs. In sheep the number of ecto and endo turbinates were almost same *viz*. five or six and six respectively (Sharma *et al.*, 1989 and Ganganaik *et al*., 2007) [15, 5]. In large animals like buffaloes there are five endo and 16-20 ectoturbinates (Getty 1975) [6], whereas in Yak fifteen ecto and four endoturbinates were reported by Sharma and Gupta (1991) [16]. In goats the number of ecto turbinates were almost double i.e. 4 – 6 endo and 9 – 12 ectoturbinates in Gaddi goats (Gupta *et al.*, 1992 and Singh *et al.*, 1992) [7, 17]. In pigs ethmo turbinates were well developed a ring from the convex face of cribriform plate of ethmoid bone. The ethmoidal labyrinth in pigs consisted seven ethmo and thirteen ecto turbinates (Hillman 1971, Nickel *et al.*, 1986 and Dyce *et al.*, 2010) [8, 14, 4].

Materials and Methods
Eight fresh intact whole heads of pigs were collected immediately after slaughter. They were washed in clean water and wiped dry. Four heads were kept as such in deep freezer (-20 °C) in polythene cover for more than 48 hours. Remaining four heads and also tissue samples from frozen heads after their morphological study were utilized for microscopic and SEM studies.

Later with an electric saw transverse section (TS) of nasal cavity of two frozen heads were made in rostro-caudal direction at four (4) levels *viz*., First TS in between first and second molar tooth followed by second TS at the level of caudal surface of second molar teeth. The third TS was at the level of caudal surface of third molar whereas the fourth TS was at the level of medial canthus of eye. These transverse sections resulted in three cross sectional slices and the fourth was the remainder of the head (CS-head) at orbital level showing its rostral surface. These sections were utilized to study the exact location of ethmoturbinates and its labyrinth. In the TS slices gross observations of nasal turbinates, meatuses and deeply placed ethmoturbinates were identified, studied and photographed. Related anatomical details were also recorded. Two frozen heads of pigs were sectioned carefully in longitudinal plane keeping the nasal septum intact in both halves. Profile of the nasal cavity with intact nasal septum, its relations and impressions of ethmoturbinates were studied and photographed. Later nasal septum was removed in both halves and contents of the nasal cavity were exposed. Morphological observations and relations of nasal conchae were studied and noted. Ethmoturbinates were identified in caudal third of the cavity. Their gross morphological relations were studied, noted and photographed accordingly. Subsequently, the ethmoturbinates were carefully dissected and isolated for their gross morphology.

Results

Ethmoturbinates of pig were present on either side of septum nasi existing in two groups *viz*., Ecto (EcT) and Endoturbinates (EnT) which appeared distinctly positioned on lateral aspect of the perpendicular plate of ethmoid. Indian pigs in this study revealed seven well developed EnT (I to VII) and 5 to 6 well defined small Ectoturbinates (EcT) lying adjacent to perpendicular plate of ethmoid in nasal cavity. Rest of the EcT were not so well developed. EnT were located on either side of the septum nasi and their length and width diminished in rostro-caudal direction. These 'scroll like' bones were present in the posterio-dorsal aspect of nasal cavity, lying in close apposition with anterior convex surface of cribriform plate. Their mucosal surface was pinkish creamy in color. Dorsally EnT were related to the inner plate of frontal and nasal bones above which was the frontal sinus. Ventrally they were related to the meatuses and floor of nasal cavity and ethmoid-vomer suture. Above the cribriform plate a distinct olfactory bulb was seen. EnT did not have any connection with the frontal sinus. Distinct impressions of ethmoturbinates (Endoturbinalia) were seen on the nasal septum restricted to posterio-dorsal portions of the nasal cavity of pigs. Removal of nasal septum revealed seven ethmoturbinates (endoturbinates - E I to VII) in rostro-caudal sequence.

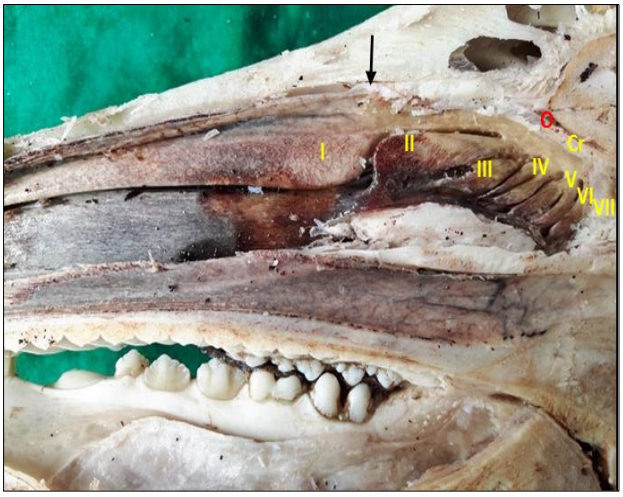

Fig 1: Sagittal section of head of pig at posterio-caudal aspect of nasal cavity after removal of nasal septum showing EnT (E I to VII) and their relation. O – Olfactory bulb Cr – Cribriform plate (basal plate)

The seven endoturbinates were attached to the convex nasal surface of cribriform plate of the ethmoid bone with their longitudinal axis directed anteriorly. Length and width of E I to VII decreased significantly from first to the last one. The first EnT was evidently much longer and broader (7.18 and 1.89 cm) than the other six endoturbinates and projected rostrally into the nasal cavity. It extended rostrally into the nasal cavity attached to the dorsal nasal turbinate enclosing dorsal nasal sinus. The EnT-II was second largest with its anterior end corresponding to upper last molar tooth. Second and third EnT were relatively shorter and had a common stalk at their origin. The shortest endoturbinate measured 1.03 cm from its free end to cribriform plate and it was attached to posterior end of basal plate of ethmoid. On their lateral aspect, attached to the lateral lamina small ectoturbinates were seen. They were restricted to most caudal aspect of the ethmoturbinate mass. Anterio-ventral ends of EnT communicated with middle nasal meatus. The last turbinate (EnT-VII) was the smallest bone restricted to the posterior most aspect of the nasal cavity overlying the vomer.

First transverse section (TS) of swine nasal cavity at the level of rostral face of second upper molar revealed on anterior surface of cross sectional slice 'A' in dorsal ventral sequence dorsal nasal turbinates arising from nasal bone, ventro-laterally placed maxillary turbinates with their characteristic dorsal and ventral scrolls. The latter sprung from the medial crest of lamina of maxilla. Both these structures divided the nasal cavity into dorsal, middle and ventral nasal meatuses. Scrolls of maxillary turbinates diminished on posterior surface of the slice A i.e., at the second TS at the level in between second and third upper molar tooth.

Ethmoturbinates were seen to arise at the level of rostral face of third upper molar tooth in TS (cross sectional slice 'B') of nasal cavity. On the caudal face of slice B i.e., the third TS at the level of caudal face of third upper molar displayed the ethmoidal labyrinth. In both these cut surfaces ethmoturbinates were seen extending towards the midline. From this level

onwards as seen in cross sectional slice 'C', in rostrocaudal direction on both its anterior and posterior surfaces the ethmoidal labyrinth became more extensive, complex and extended caudally upto the cribriform plate of ethmoid. Prominent EnT were dorsomedial in position, whereas the ectoturbinates were poorly defined and were located on the lateral aspect of the labyrinth close to orbital plate.

The present studies revealed that ethmoturbinates were attached on their dorsal and lateral boundaries such as the dorsal 'basal' lamina and laterally placed orbital lamina. The ectoturbinates were closer to the orbital lamina as seen in cross section of head of pig at the level of medial canthus of eye. The ventral ends of EnT scrolls were attached by a ventro-lateral plate which was attached to orbital plate which in turn inclined towards the nasal septum. Nasal meatuses reduced in their diameter in rostro caudal direction. Prominent elliptical dorsal nasal meatus became narrow small triangular space caudally.

Fig 3: Caudal view of Slice 'B' showing Ethmoturbinates. e – Endoturbinates and E – Ectoturbinates

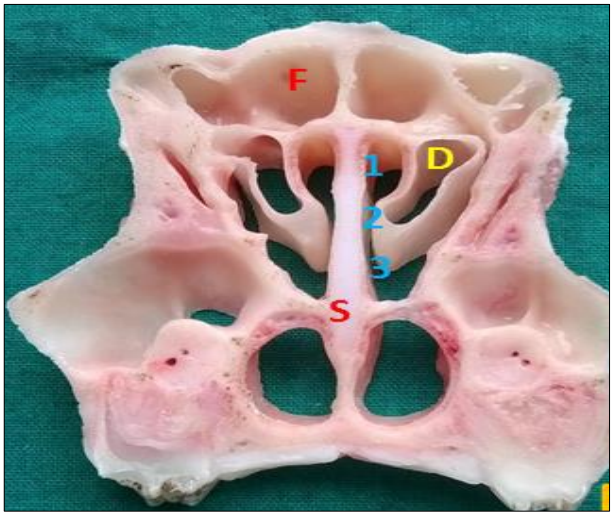

Fig 2: Caudal view of Slice 'A' showing nasal turbinates. F-Frontal sinus. S-Septum. D-Dorsal conchae. 1, 2, 3 – Nasal meatuses (dorsal, middle and ventral)

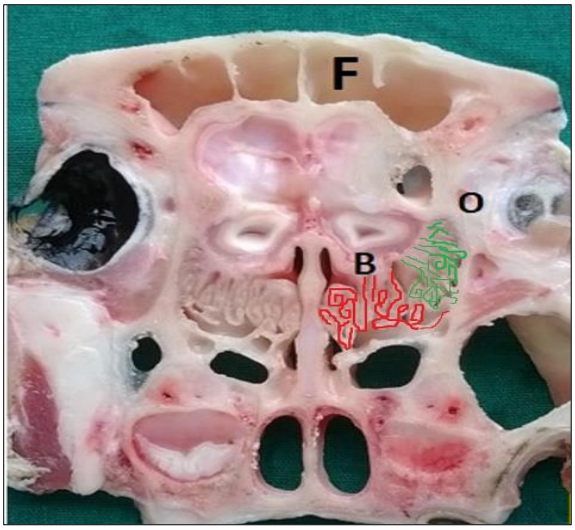

Fig 4: Caudal view of Slice 'C' showing Ethmoturbinates. Red – Endoturbinates and Green – Ectoturbinates

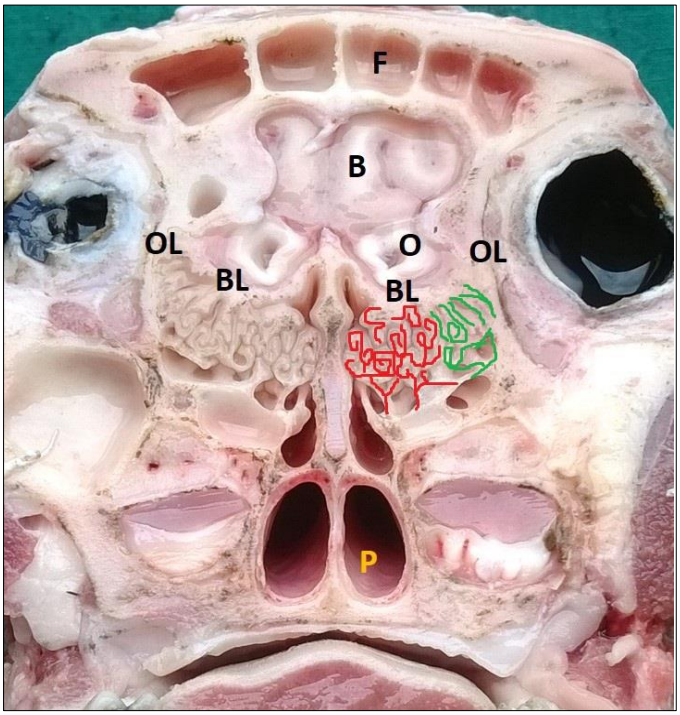

Fig 5: Transverse section of nasal cavity of pig at the level of medial canthus of eye showing Ethmoturbinates. EnT – Endoturbinates and EcT – Ectoturbinates

Discussion

Our findings are in complete agreement with Hillmann (1971 in pigs) [8] and Konig and Leibich (2004) [11] in most domestic animals who described that ethmoturbinates were arranged in two rows originating from dorsal and lateral walls of the ethmoid bone.

In the present investigation though the Endoturbinates (EnT) of pigs extended sufficiently forward into nasal cavity up to the level of upper molars, they were not communicated to frontal sinus. However in carnivores, Nickel *et al.* (1986) [14] mentioned that the ethmoidal conchae extended considerably forward into the nasal cavity and presented many secondary lamellae internally which invaded the frontal sinus.

The above findings are in concurrence with description of ethmoidal labyrinth in pigs by Hillmann (1971) [8] and Konig and Leibich (2004) [11] who reported that twenty ethmoturbinates were developed and originated from lateral lamina of ethmoid bone of which only seven endoturbinates (I – VII) reached the bony plate of ethmoid in midline with their extensive terminal scrolls. Hillmann (1971) [8] further observed that remaining thirteen poorly developed laminae with single scroll were ectoturbinates of which only ten of them were fairly constant and extended almost upto the midline. In contrast only six of them in this study were developed but were comparatively smaller than the EnT.

Similar reports with regards to EnT morphology was described by Konig and Leibich (2004) [11] and Dyce *et al.* (2010) [4] in domestic animals and Tej Parkash (2016) [18] in domestic pigs. They stated that first EnT was the largest one extending well ahead into nasal cavity, whereas the second largest was the second endoturbinate followed by rest of the five EnT. Konig and Leibich (2004) [11] described that these bones diminished in size in all domestic animals with exception in dog which had especially well developed second to fourth endoturbinates. Kavoi *et al.* (2010) [10] reaffirmed that turbinates were more complex in dog than in sheep. They noticed that first ethmoturbinate (designated as endoturbinate III) projected more rostrally with prominent folds of lamellae contrary to sheep wherein it appeared short, distinct cylindrical scroll without lamellar folds. This investigation further strengthens the fact that pigs amongst domestic animals have an elaborate EnT complex which empower them with higher degree of olfaction, but not as effective as in dogs which are endowed with superior olfactory sense and ability as studied by Kavoi *et al.* (2010) [10] and Chamanza and Wright (2015) [3].

In this study the ethmoidal complex in pigs arose at level of rostral face of third upper molar in cross sectional slice 'B' of nasal cavity. The caudal face of slice B at the level of caudal end of third upper molar displayed the ethmoidal labyrinth which continued extensively backwards and also inclined towards midline. Prominent EnT were dorsomedial in position, whereas poorly defined ectoturbinates were located on lateral aspect of the labyrinth close to orbital plate. These findings are in total agreement with the positions and description of EnT by Hillmann (1971) [8] and Tej Parkash (2016) [18] in pigs. Ethmoturbinates of pigs were creamy pink in fresh state on either side of lateral lamina of ethmoid. Olfactory area on EnT was easily identifiable by its yellowish tinge in this study which is almost alike the reports of Arthur *et al.* (2014) [1] who noted that nasal respiratory and olfactory mucosa in dogs could be differentiated in gross specimens by their red to orange and yellow or brown colors respectively.

Conclusion

Morphological and morphometrical features revealed an elliptical and elongated nasal cavity in sagital section of head of pig. Its rostral end was narrow comprising the anterior nares and the height of the cavity increased in rostro-caudal direction ending incaudal choanae. Two thirds of the septum in its anterio-dorsal part was cartilaginous and highly vascular bearing a sphlancnic bone "os rostri" in its rostral end. Distinct impressions of ethmoturbinates (endoturbinalia) were seen on nasal septum restricted to posterio-dorsal portions of the nasal cavity. Pig ethmoturbinates were distinctly positioned on lateral aspect of perpendicular plate of ethmoid in two groups *viz.*, Ecto (EcT) and Endoturbinates (EnT). These 'scroll like' bones in posterio-dorsal aspect of nasal cavity were in close apposition with anterior convex surface of cribriform plate of ethmoid. Ventrally they were related to nasal meatuses. Freshly separated ethmoturbinates were pinkish creamy structures attached to lateral lamina consisting seven well developed EnT flanked by partially developed EcT. The first EnT was evidently much longer and broader (7.18 and 1.89cm) and extended further into nasal cavity joining the ventral aspect of dorsal nasal turbinate. EnT-II was second largest with its anterior end corresponding to upper last molar tooth. Second and third EnT were relatively shorter and had a common stalk at their origin. Smallest EnT (VII) measured 1.03 cm in length and 1.01 cm in width. In TS of swine nasal cavity dorsal nasal turbinates, ventro-laterally placed maxillary turbinates with their characteristic dorsal and ventral scrolls were observed in dorso-ventral sequence in slice 'A'. These scrolls diminished on its posterior surface.

Ethmoturbinates were present from rostral face of slice 'B'. Its caudal surface displayed ethmoidal labyrinth which became more extensive in rostrocaudal direction from this level onwards extending caudally up to cribriform plate of ethmoid. Prominent EnT were dorsomedial in position, whereas the ectoturbinates were poorly defined and were located on lateral aspect of the labyrinth close to orbital plate.

References

1. Arthur W Barrios, Pbalo sanchez-Quinteiro and Ignacio Salazar. Dog and Mouse: toward a balanced view of the mammalian olfactory system. Frontiers in Neuroanatomy. 2014;8. Article 106
2. Buck L, Axel R. A novel multigene family may encode odorant receptors: a molecular basis for odor recognition. Cell. 1991;65:175-187.
3. Chamanza R, Wright JA. A review of the comparative anatomy, histology, physiology and pathology of the nasal cavity of rats, mice, dogs and nonhuman primates: relevance to inhalation toxicology and human health risk assessment. J Comp. Path; c2015. p. 1-28.
4. Dyce KM, Sack WO, Wensing CJG. Textbook of Veterinary Anatomy, Fourth edition, Saunders Elsevier; c2010.
5. Ganganaik S, Jain RK, Pawan Kumar, Gupta AN. Scanning electron microscopic studies on the nasal cavity of sheep (*Ovis aries*) Indian journal of animal sciences. 2007;77(9):878-879.
6. Getty R. In: Sisson and Grossman, The Anatomy of the Domestic Animals, 5th Edn.. Saunders, Philadelphia and London; c1975. p. 113-144, 916-936.
7. Gupta SK, Sharma DN, Bhardwaj RL. Anatomy of the nasal cavity of Gaddi goat. Indian Journal of Animal Sciences. 1992;62(4);294-96.
8. Hillmann DJ. Macroscopic anatomy of the nasal cavity and paranasal sinuses of the domestic pig (*Sus scrofa domestica*). Retrospective Theses and Dissertations. Paper

4460; c1971.
9. Jones Nick. The nose and paranasal sinuses physiology and anatomy. Advanced Drug Delivery Reviews. 2001;51:5-19.
10. Kavoi B, Andrew M, Hassanali J, Carlsson HE, Kiama S. Comparative functional structure of the olfactory mucosa in the domestic dog and sheep, Annals of Anatomy. 2010;192:329-337.
11. Konig HE, Liebich HG. Textbook and color atlas of Veterinary anatomy of domestic mammals. Schattauer publisher, Stuttgart, New York; c2004.
12. Miller ME, Christensen GC, Evans HE. Anatomy of the Dog. WB. Saunders Co. Minnepolis, Philadelphia, USA; c1964. p. 151.
13. Negus VE. Comparative Anatomy and Physiology of the Nose and Paranasal Sinuses. Churchill Livingstone, London; c1958.
14. Nickel R, Schumer A, Seiferle E, Freewin J, Willikens H, Wills KH. The anatomy of the domestic animals. Vol 1. Locomotor System of Domestic Mammals. Verlag Paul Parey, Berlin; c1986.
15. Sharma DN, Gupta SK, Bhardwaj RL. Topographic Anatomy of the nasal cavity of Gaddi sheep. Indian Journal of Animal Sciences. 1989;23(2):85-90.
16. Sharma DN, Gupta SK. Anatomy of the nasal cavity of yak (*Bos grunniens*). Indian Journal of Animal Sciences. 1991;61(5):478-481.
17. Singh I, Kumar S, Singh Y. Gross anatomy of the nasal conchae in goat. Indian Journal of Animal Sciences. 1992;62(12):60-63.
18. Tej Prakash. Gross anatomical, histological, histochemical and scanning electron microscopic studies on the nasal cavity and larynx of young pig (*Sus scrofa*); c2016.