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Unique Lateral Nasal Diverticulum in Dromedaries: Anatomical Structure and Possible Functions

Fatgzim Latifi[1], Kastriot Belegu[2], Ibrahim Girgiri[3]* and Eman Eshrah[4]

[1]*Department of Veterinary Medicine, Faculty of Agriculture and Veterinary Medicine, University of Prishtina, Prishtina Kosovo.*

[2] *Departmnet of Morphofunctional Modules, Faculty of Veterinary Medicine, Agricultural University of Tirana.*

[3]*Department of Veterinary Anatomy, Faculty of Veterinary Medicine, University of Maiduguri, PMB 1069, Nigeria.*

[4]*Department of Anatomy and Embryology, Faculty of Veterinary Medicine, Benha University, Egypt.*

Abstract

The lateral nasal diverticulum is a unique anatomical structure characteristic of dromedaries. However, little known about the anatomy and histology of this diverticulum. The aim of this study was to investigate the macroscopic and microscopic structure of the lateral nasal diverticulum in camels, and to elucidate its possible functions, A total of ten camel heads were used for this study. Grossly, it comprised of intranasal and intramuscular parts, both of which located mostly within the nasal vestibule. It started at the nasal opening, at the junction of vestibular skin and the mucus membrane of nasal cavity proper. It ended as blind sac near the infraorbital foramen. Histologically, it was lined by stratified columnar epithelium with goblet cells. The mucosa presented a number of crypts and clefts. The submucosal glands were well developed and mostly of serous type. The lateral nasal diverticulum aid in narial closure, humidification of nasal mucosa, and detection of olfactory cues as a possible function in dromedaries.

Keywords: Lateral Nasal Diverticulum, Nasal Vestibule, Vestibular Recess, Dromedaries, Camels.

Introduction

The lateral nasal diverticulum (LND) is a blind tube leading from the nasal cavity, namely the nasal vestibule [1-2]. Its nasal opening is situated at the muco-cutaneous junction, within the vicinity of the nasolacrimal duct opening. It extends caudolaterally over the edge of the maxillary bone, and ends blindly near the infraorbital foramen [3-4]. Such nasal diverticulum is uncommon in domestic animals. The horses for example have only a lateral nasal recess leading from the false nostrils, and never form a blind sac or extend beyond the level of nasal bone. However, the lateral nasal diverticulum found in dromedaries is atypical in terms of structure, relations and possible functions, present in nasal vestibular recess of proboscis bearing mammals [5-2]. For example, the *saiga* antelope and the moose (*Alces alces*), possessed lateral nasal recess similar to the LND of camels [6-7].

These animals have a special nasal apparatus known as the vestibular proboscis, in which the nasal vestibule was enlarged, mostly muscular and able to tightly close the nostril in hard environmental conditions [6-7]. Similarly, camel nose has a special nasal vestibule that is muscular and larger, accordingly termed the camel proboscis, which is a much more suitable term than the camel nose [5, 2]. In the proboscideal nose, the recess or diverticulum leading from the nasal cavity and extends over the maxillary bone is a common feature of vestibular proboscis, as moose own three nasal recesses, while the *saiga* antelope have only one recess [6-7].

Earlier, the presence of the lateral nasal diverticulum in camels reported, this first report described the diverticulum as unusual blind sac on the face, with the initial part located in the nasal vestibule. Recently, some studies focus on the role of this diverticulum in narial closure, which is a characteristic feature of camel nose [2, 5].

*Corresponding authors Ibrahim Girigiri, E-mail: ibrahimgirgiri@unimaid.edu.ng, Tel.: +2347035108133
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In terms of comparative anatomy, the presence of this diverticulum placed camels within the group of mammals bearing proboscideal nose [2]. This would be addition to the field of comparative anatomy, and may be used as basis that would help in understanding the narial anatomy in this species in health and disease states. However, little is known about the LND in dromedaries and the physiological role beneath their unique anatomy. The aim of this study was to investigate more closely the anatomy and histology of this diverticulum in camels and to discuss the possible functions.

Material and Methods

Animals

This study was performed following the ethical guidelines approved by the Institutional Animal Care and Use Committee of the Faculty of Veterinary Medicine, Benha University. A total of ten heads obtained from healthy adult one-humped male camels, immediately after slaughter from Toukh abattoir, El-Qalyobia, Egypt. Congenital or acquired abnormalities of the nose were considered exclusion criteria for studying the morphological and histological features of the nasal diverticulum in camels.

Histological examination

The lateral nasal diverticulum was harvested from the camel heads just after slaughter. These samples were fixed in 10% neutral buffered formalin. The fixed specimens were dehydrated in ascending grades of ethyl alcohol (50%, 70%, 90%, and absolute 100% three changes) at an interval of 1 hour each, cleared in several changes of xylene, impregnated, and embedded in paraffin wax. The tissues were blocked, and 5-7 μm thick sections were cut using a rotary microtome. The general histological observations were carried out on paraffin sections stained with hematoxylin and eosin (H&E) and Mallory Trichrome [8].

Results

Gross Anatomy

The nasal opening of the lateral nasal diverticulum located in the nasal vestibule at the junction between the mucus membrane and the skin lining the vestibular floor. This opening related medially to the orifice of the nasolacrimal duct and dorsally to the opening of the straight fold (Figure 1). The LND can be divided into intranasal and intramuscular part. The intranasal portion inclined over the edge of incisive bone to reach the muscular wall of the nasal vestibule (Figure 2). The vestibular wall was made up of the following muscles from lateral to medial, the superficial part of the *levator nasolabialis*, the *maxillolabial* group, and the deep part of the *levator nasolabialis*. The intramuscular part of the LND sandwiched between these layers, namely, the *maxillolabial* group laterally, and the deep part of the *levator nasolabialis* medially. This part is also related distally to the infraorbital nerve. The LND blind end was situated near the exit of the infraorbital nerve (Figure 3).

Histology

The wall of the LND consists of mucosa and submucosa. The mucosa was highly corrugated, particularly within the intranasal part. A number of mucosal clefts and crypts was also noticed (Figure 4a). The mucosal epithelium was stratified columnar epithelium with goblet cells (Figure 4a). The lamina propria consisted of a network of fine connective tissue rich in blood vessels. The submucosal glands were mostly of serous type and presented notable aggregations beneath the mucosal crypts (Figure 4a and b). the trichrome stained sectioned showed different staining ability for lining columnar epithelium (Figure 5 a-c).

Discussion

This study revealed that the LND in dromedaries was a unique anatomical structure, out pouched from the nasal vestibule proper and continue its course in between the muscles of the vestibular wall, these results agreed with those described by [5, 9, 2]. Also, who reported that LND was an integral part of the camel vestibular system, and due to its position between the narial muscles it may have a role in narial closure mechanism in this species. On the other hand, these results disagreed with the first report of this diverticulum by [3], who described that it was a facial blind sac with the initial portion only being the nasal vestibular structure.

Based on the anatomical and the histological investigations, some possible functions have been suggested including, the role in narial closure during hard environmental conditions such as sand storms. The humidification of nasal mucosa is necessary for healthy mucous membrane, and detection of olfactory cues. For its role in narial closure, the vestibular muscles work as a muscular hydrostate that grasp the LND wall, and consequently develop negative pressure (suction) within the LND lumen, this suction force helps in closure of nostrils. Similar mechanism has been suggested in saiga [6, 7, 10] and camel [5].

Microscopically, the LND tissue was rich in glands, namely, goblet cells within the mucosa, and well-developed submucosal glands [3]. Accordingly, the LND may work as a reservoir of glandular secretion, that help in humidification of nasal mucus membrane. This may also substitute the absence of lateral nasal gland in this species [9].

The location of straight fold dorsal to the LND opening, strongly suggested that the LND glandular

secretion may help in detection of olfactory cues. As the straight fold leading to the dorsal nasal concha, where olfactory cues are primarily collected. The glandular secretion could be sprayed out from the nasal opening, especially with the muscular movement. This secretion can reach the straight fold via its wide opening, which is ready to receive such aerosol secretion.

The LND epithelium was stratified columnar epithelium, which is a rare type of epithelial lining, that found in the conjunctiva of the eye [11] parts of the lining epithelium of the anal canal and male urethra [12] and vas deferens [13]. The trichrome stained sectioned revealed different staining presentations of these columnar epithelial cells, which may indicate different cell types with possible sensory functions. This is because sensory protein usually stained red with Mallory [8].

Together, the LND is a part of camel vestibular proboscis. It may have a role in narial closure mechanism characteristic of camels [5]. It may also substitute the absence of the lateral nasal glands in this species [14]. However, further investigations still required to test these functions.

Conclusion

The lateral nasal diverticulum an essential part of nasal vestibular system in camel. It is a blind diverticulum opened in the nasal vestibule and coursed between the vestibular muscles until it ended blindly near the infraorbital foramen. It may work together with the vestibular muscles in narial closure. It had a glandular tissue that may help in humidification of nasal mucosa and detection of olfactory cues.

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Declaration of Conflict of Interest

The authors declare that there is no conflict of interest.

Ethical of approval

This study follows the ethics guidelines of the Faculty of Veterinary Medicine, Benha University, Egypt.

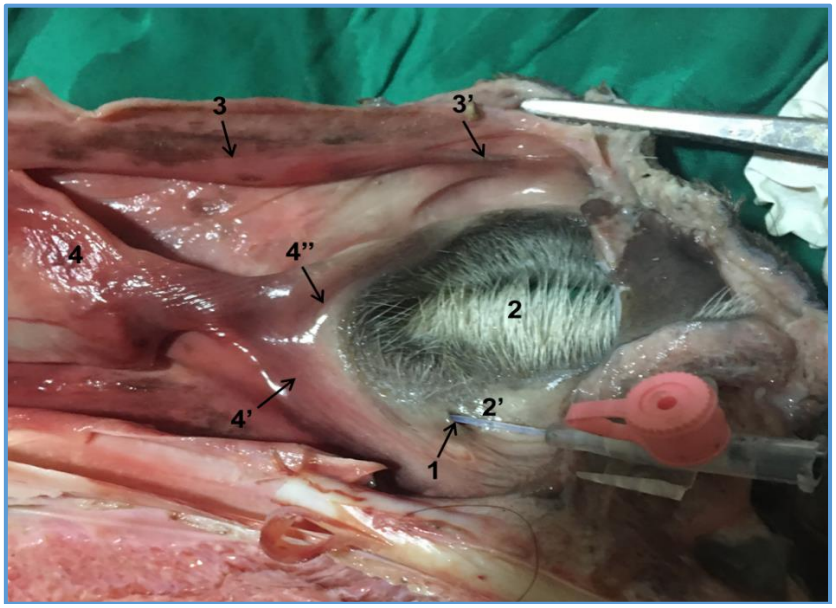

Fig. 1. A sagittal section of the head of dromedary showing; the opening of the lateral nasal diverticulum (catheterized by a plastic catheter) (1) located at the junction between the skin (hairy) of the nasal vestibule (2), and the mucous membrane of the nasal cavity proper (2'), note that the straight fold of the dorsal nasal concha (3), opened widely (3') just above the level of the LND opening, while the ventral nasal concha (4) send both the basal fold (4') and the alar fold (4'') without any nearby opening.

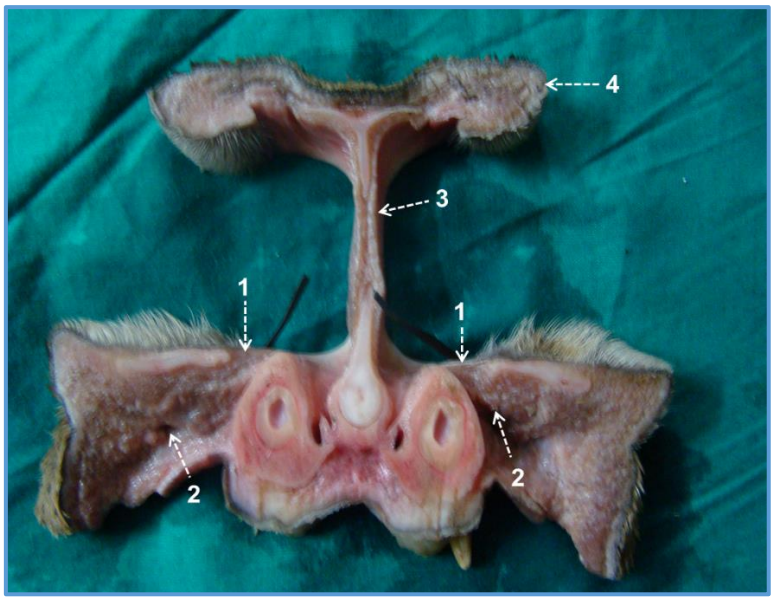

Fig. 2. A cross section of the nasal cavity at the body of incisive bone showing; the opening of lateral nasal diverticulum, where a black rod inserted (1) to show it turned around the body of incisive bone and coursed between the nasal muscles (2), the nasal septum (3), the tip of the snout (4).

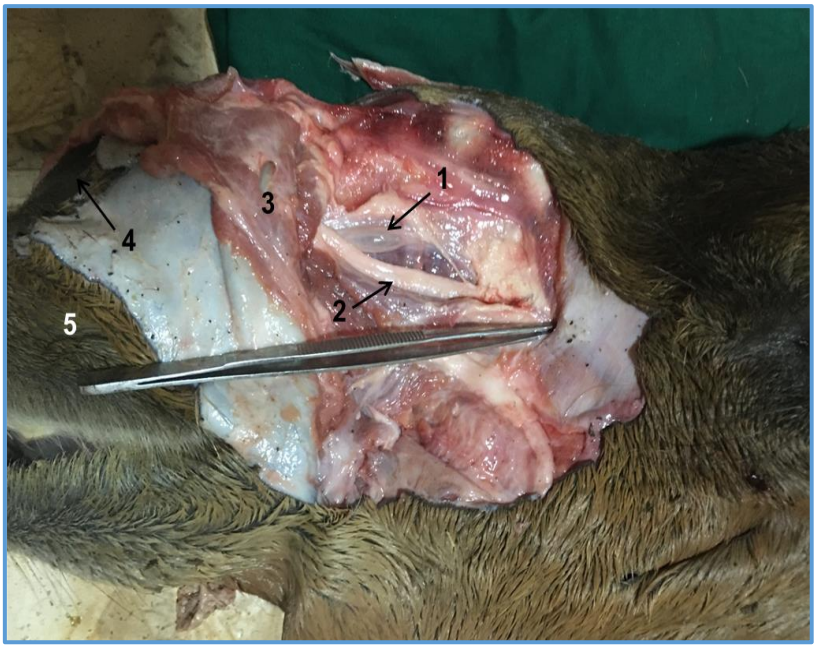

Fig. 3. The face of the dromedary with the skin of the facial region reflected, showing the LND (inflated with water via nasal opening) (1), the infraorbital nerve trunk (2), the superficial part of the *lavetor nasolabialis* (reflected), the nostril (4), the upper tip (5).

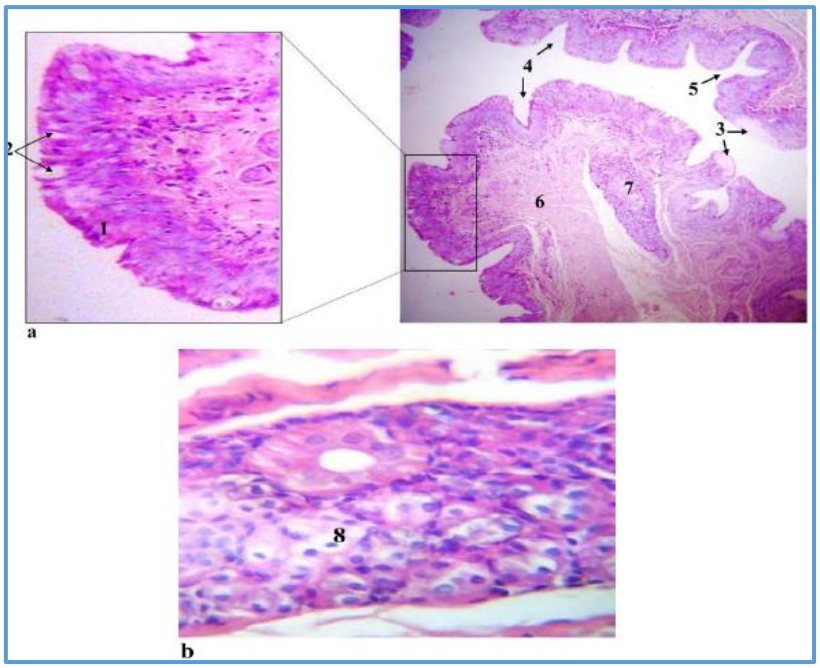

Fig. 4. A micrograph of the lateral nasal diverticulum in camels, H & E, X 20 (a) X 40 (b) showing; a) the lining epithelium, stratified columnar epithelium (1), with goblet cells (2), and goblet cell clusters (3), the epithelium had many clefts (4), and crypts (5), the lamina propria (6) and serous glands (7). b). The submucosal gland at higher magnification formed mainly of serous acini, duct (8).

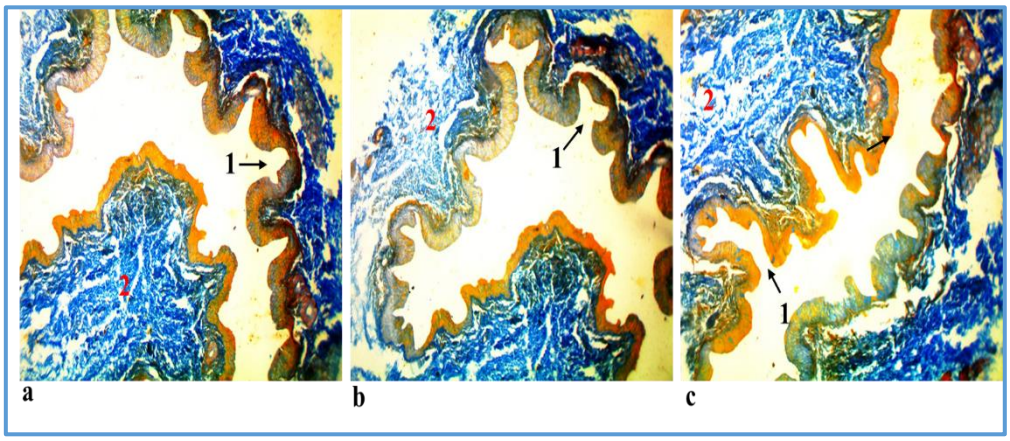

Fig. 5. A micrograph of the lateral nasal diverticulum in camel showing; the wall of the lateral nasal diverticulum, note the highly corrugated epithelium that stained differently to trichrome stain (1), the lamina propria formed of a network of connective tissue (2), H & E X 20.

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