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The Anatomical Differences between the Donkey and the Horse

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Introduction

The anatomy of the donkey and how it differs from that of the horse rarely receives mention in standard veterinary anatomy textbooks used in the western world. There is also limited material on this subject readily accessible in the current literature. As a result, the donkey is often presumed to be morphologically the same as the horse, and there are far more similarities between the two species than there are differences. However, some clinically relevant anatomical differences exist that one should be aware of when dealing with donkey patients. This chapter will attempt to address some of the clinically significant, gross anatomical differences between the donkey and the horse. Much of the information has been gained in the gross anatomy laboratory from the author's observations and dissection of donkeys used for instruction of veterinary students; while some of the information is the result of a literature review using CAB abstracts. This search revealed several references on anatomical studies in the donkey from a variety of journals but most of these journals are very difficult to access. The only anatomical structures that are discussed are those the author found to vary between the two species. There may be anatomical differences that have been overlooked because the author did not observe them on dissection or they were not reported in the author's literature search.

The chapter has been broken down into body regions and then further sub-divided into specific structures within those regions.

Head and Neck Region

Most of the gross anatomical differences between the donkey and the horse are found in the region of the head and neck.

Lacrimal Apparatus

In the donkey, the nasal opening of the nasolacrimal duct is not found on the floor of the nasal cavity as it is in the horse. Instead, it is found on the lateral to dorsolateral aspect of the nostril, near the mucocutaneous junction. Fig. 1 & Fig. 2 are photographs taken in the anatomy laboratory of a donkey cadaver with a catheter placed in the nasal opening of the nasolacrimal duct. This location was observed on several laboratory cadavers and also reported in the literature [1-3]. The course of the nasolacrimal duct was reported to have a more dorsally convex proximal course than the horse [1]. The lacrimal puncta are located in a more bulbar location on the palpebral margins and the openings are narrower in the donkey than in the horse.

Figure 1. Catheter placed in the nasal opening of the nasolacrimal duct on a donkey cadaver; note the location on the lateral to dorsolateral wall of the nostril. - To view this image in full size go to the IVIS website at www.ivis.org . -

Figure 2. Position of the opening relative to the mucocutaneous junction. - To view this image in full size go to the IVIS website at www.ivis.org . -

Cutaneous Mucles of the Neck

The thin, paired cutaneous colli muscle (m.) is a very extensive cutaneous muscle in the cervical region of the donkey. In the horse, this muscle originates from the manubrium and the ventral midline of the neck and it runs craniodorsally, superficial to the sternocephalicus m., external jugular vein and the ventral portion of the brachiocephalicus m. where its

fibers end in the superficial fascia and blend with the brachiocephalicus m. [4,5]. It lies superficial to and covers a portion of the external jugular vein within the jugular groove. From observations in the gross anatomy laboratory, this muscle tends to be of variable size and extent in the horse, but it seldom covers the entire external jugular vein in the neck region. Veterinary anatomy textbooks describe this muscle in the horse as being in the lower or caudal 1/2 to 1/3 of the neck, with fibers occasionally extending into the mandibular region [5,6]. These texts make no mention of this muscle in the donkey. From dissected specimens, the attachments and relationships of this muscle were found to be the same in the donkey. The major difference is that this muscle consistently extended from the manubrium to the mandibular region where it blended with the cutaneous muscle of the face. Thus, on the donkey, the cutaneous colli m. covers the entire external jugular vein within the jugular groove. The extensive nature of this muscle and its ability to tense the skin on the ventral aspect of the neck [5], could make visualization of the external jugular vein, by raising it in the jugular groove, more difficult. Fig. 3 is an image of a donkey prosection that shows the cutaneous colli m. prior to its reflection, demonstrating the fact that it covers the external jugular vein within the jugular groove.

Figure 4 then shows the muscle reflected dorsally to expose the external jugular vein and thesternocephalicus m.

Figure 3. A craniolateral view of the neck showing the cutaneous colli muscle (highlighted with pink). - To view this image in full size go to the IVIS website at www.ivis.org . -

Figure 4. The image on the left shows the cutaneous colli m. reflected dorsally (and a small portion is reflected ventrally), exposing the external jugular vein. The image on the right is the same image with the external jugular vein, sternocephalicus and cutaneous colli mm. highlighted. - To view this image in full size go to the IVIS website at www.ivis.org . -

Lymphocenters

The lymphatics of the head and neck region include the mandibular, parotid, medial and lateral retropharyngeal, cranial, middle and caudal deep cervical and superficial cervical lymphocenters. A study describing the lymphatic system of the head and neck region in the donkey revealed few differences when compared with the horse [7]. The parotid lymphocenter in the donkey consists of nodes located dorsal and ventral to the temporomandibular joint, whereas in the horse these nodes are only found ventral to the joint [7-10]. In this study, the authors describe some of the efferent vessels from the medial and lateral retropharyngeal lymph nodes contributing to the formation of the tracheal trunk in the donkey. Anatomically, the tracheal trunk is formed by the confluence of the efferent vessels from the cranial deep cervical lymph nodes. Therefore, those lymphatic vessels from the retropharyngeal lymph nodes that directly join the tracheal trunk do not pass through the cranial deep cervical lymph nodes. In contrast, in the horse, all of the efferent vessels from the retropharyngeal lymphocenter filter through the cranial deep cervical lymph nodes. This means that in the horse, all lymph draining from the region of the head will filter through the cranial deep cervical lymph nodes, whereas in the donkey some of the lymph from the head will bypass these nodes and directly enter the tracheal trunk.

The Nasal Cavity, Pharynx and Upper Airways

Many of the anatomical variations between the donkey and the horse occur in the region of the pharynx and larynx. A study using endoscopy to examine the upper airways of 24 Spanish donkeys revealed several anatomical differences when compared to the horse [11]. The nasal passage was narrower than in the horse and it was difficult to examine the region of the nasomaxillary opening within the middle nasal meatus. The middle nasal meatus communicates with the maxillary sinus via this opening. The pharyngeal opening of the auditory tube, which is the entrance to the auditory diverticulum (guttural pouch), was more horizontal in the Spanish donkey than in the horse, making it more difficult to pass the endoscope through the opening. Other differences described in this study are included in the discussion below.

The pharyngeal recess in the horse is described in the Nomina Anatomica Veterinaria (N.A.V.) as "a median niche at the caudodorsal angle of the nasopharynx" [12]. Sisson describes the recess as a variable sized cul-de-sac that generally measures about 2.5cm in depth in the horse and that a deeper recess is present in the donkey [13]. The literature and the author’s personal observations confirm that the pharyngeal recess in the donkey is much more extensive than the horse [11,14]. In the donkey, the recess is a deep diverticulum of pharyngeal mucosa extending caudally between the two

auditory diverticula. It has a triangular or round opening in the caudodorsal nasopharynx that measures 1.5 cm in diameter. This opening leads into a diverticulum of considerable length, measuring 4 - 6 cm long and 2 - 3 cm in diameter. It was observed, via endoscope *in vivo*, that during forced inspiration or the initial high pitched phase of braying the caudoventral walls of the recess protrude into the lumen and sometimes through the opening of the recess.

Figure 5 and Figure 6 are endoscopic views of the caudal nasopharynx in a donkey. The opening to the pharyngeal recess as well as the pharyngeal openings of the auditory tubes have been labeled.

Figure 5. Endoscopic view of the caudal nasopharynx in a donkey. - To view this image in full size go to the IVIS website at www.ivis.org . -

Figure 6. Endoscopic view of the caudal nasopharynx in a donkey. - To view this image in full size go to the IVIS website at www.ivis.org . -

Fig. 7 is a median section of an embalmed donkey head. The pharyngeal recess has been circled with a blue oval and a scalpel handle has been placed dorsal to the recess to demonstrate its length in centimeters. Note that on this cadaver the recess extends approximately 5.5 cm caudally from its rostral opening. The pharyngeal opening of the auditory tube has been marked with a dotted red line. Fig. 8 is a closer view of this region on the same cadaver. On this cadaver the normal relationship between the soft palate and epiglottis has been disrupted. Normally the rostral tip of the epiglottis sits dorsal to the caudal free edge of the soft palate. The position shown here, with the soft palate located dorsal to the epiglottis, occurred post mortem, most likely during preparation of the median section.

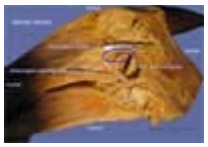

Figure 7. Photograph of a median section of a donkey head showing the medial aspect of the right half of the head. - To view this image in full size go to the IVIS website at www.ivis.org . -

Figure 8. Closer view of caudal pharyngeal region on the same cadaver head. - To view this image in full size go to the IVIS website at www.ivis.org . -

The lumen of the nasopharynx in both the horse and the donkey is constricted at its middle and expanded dorsally and ventrally [14]. In the donkey the nasopharynx is much more constricted in its middle part and more flared dorsally and ventrally than in the horse. The measurement for the middle portion of the nasopharynx was taken just ventral to the pharyngeal openings of the auditory tubes, in a horizontal plane.

The entrance to the larynx (aditus laryngis), which is bound by the epiglottis, aryepiglottic folds, and corniculate processes of the arytenoid cartilages, has a more caudal angulation in the donkey than in the horse [11,14]. To further explain this angulation, imagine a line drawn from rostral to caudal, from the apex of the epiglottis to the dorsal level of the corniculate processes and this line represents the angulation of the aditus laryngis. In relation to a vertical axis; this line forms an angle of 95.5 degrees measured caudal to the vertical axis in the donkey, whereas in the horse it forms an angle of 92.5 degrees measured rostral to the vertical axis. The aryepiglottic folds are also shorter rostrocaudally in the donkey pulling the epiglottis closer to the corniculate processes. Therefore, in its normal, resting position, the epiglottis is pulled closer to the arytenoid cartilages. The above described anatomical configurations in the donkey result in the aditus laryngis facing more

caudally with a narrowing of its dorsoventral diameter. The apex of the epiglottis in the donkey is also more pointed than in the horse.

Marked differences in the laryngeal ventricles and median laryngeal recess also exist between the two species [11,14]. There are two bilateral; and a single unilateral mucosal cul-de-sacs or out-pouchings of mucous membrane extending outward from the laryngeal cavity in the donkey. The first, the bilateral laryngeal ventricles, are shallow, lateral depressions of mucosa situated between the vestibular and vocal folds. At the rostroventral margin of the vestibular fold, the second, more extensive, bilateral cul-de-sac is found. From the laryngeal cavity, a small, circular opening in this area leads to an extensive out-pouching of mucosa or saccule. This saccule extends between the vestibularis and vocalis muscles medially and the thyroid lamina laterally, and from the floor of the larynx ventrally to just below the dorsal border of the thyroid cartilage. This saccule is lined with respiratory epithelium containing many goblet cells. Both the laryngeal ventricle and the above mentioned saccule are present on the right and left sides of the larynx. The third cul-de-sac, a median laryngeal recess, opens on the midline, on the floor of the laryngeal vestibule, just caudal to the base of the epiglottis. This single, circular opening leads to a mucosal recess that extends laterally on both sides between the thyroid cartilage and basihyoid bone, forming bilateral pouches.

In contrast, the horse only has the bilateral laryngeal ventricles and the median laryngeal recess. The laryngeal ventricles [a] open between the vestibular and vocal folds, as they do in the donkey, but they consist of a deep lateral out-pocketing of mucosa that extends between the vocalis and ventricularis muscles medially and the lamina of the thyroid cartilage laterally [16-18]. There is no separate opening near the ventrolateral margin of the vestibular fold that leads to a second out-pouching of mucosa or saccule. The laryngeal ventricles are more extensive in the horse and the outpouching of mucosa associated with them is in a similar location as the second cul-de-sac or saccule described in the donkey. The median laryngeal recess in the horse is a shallow depression on the floor of the vestibule, just caudal to the base of the epiglottis. It is far less extensive than the recess of the donkey.

The image in Fig. 9 is a median section of a donkey cadaver head with coloured wires placed in the median laryngeal recess, the laryngeal ventricle, and the mucosal saccule unique to the donkey. They are numbered 1 - 3 respectively. The blue dotted line is on the edge of the vocal fold. A portion of the loop of blue wire is in the laryngeal ventricle, demonstrating the shallow nature of this structure. The area outlined by the square gray box in figure 9 has been magnified in Fig. 10. Fig. 11 is a closer image of the laryngeal cavity without all the wires in place. Rostral is to the right and dorsal is to the top.

Figure 9. Photograph of a median section of a donkey cadaver head showing the medial aspect of the left half of the head. Rostral is to the right and dorsal it to the top of the photograph. - To view this image in full size go to the IVIS website at www.ivis.org . -

Figure 10. Closer view of the region outlined by the gray box in Fig. 9. The orientation is still the same with rostral to the right and dorsal to the top of the photograph. - To view this image in full size go to the IVIS website at www.ivis.org . -

Figure 11. Image of the laryngeal cavity with the wires removed. Rostral is to the right. - To view this image in full size go to the IVIS website at www.ivis.org . -

In the closer view of the laryngeal cavity in Fig. 11 (median section of the larynx), the white wire is still in place and it is passing into the opening of the median laryngeal recess from the left. A portion of the wall of the median laryngeal recess has been removed and the area is circled with the red oval, demonstrating a fairly deep mucosal cul-de-sac associated with this recess. The double arrows are pointing toward the laryngeal ventricle, and the purple dots are on the vocal fold. The black oval is circling the entrance to the mucosal saccule found only in the donkey. The opening is at the base of the vestibular fold which is indistinct on this image.

As an incidental finding, varying degrees of pigmentation of portions of the larynx were reported in Spanish donkeys during endoscopic examination [11]. It was observed in 3 out of 24 animals examined. Pigmentation of the proximal portion of the esophagus was also noted on approximately 1/3 of these animals. This study also found that the trachea of the donkey, when compared with that of similar sized horses, was more flattened in a dorsoventral direction and of a narrower

diameter.

Salivary Glands

The parotid salivary gland in the donkey has a slightly more caudal orientation than in the horse [19]. It is located caudal to the ramus of the mandible in the retromandibular fossa and it extends as far caudally as the second cervical vertebra. On a lateral radiograph, the gland covers the shadow of the larynx and first few tracheal rings. Rostrally, it does not cover the vertical portion of the ramus of the mandible or the masseter muscle. In the horse, a portion of the parotid salivary gland extends as far rostrally as the temporomandibular joint and the rostral edge is associated with the ramus of the mandible, overlying a portion of the masseter muscle [13,18,20]. The caudal border of the parotid salivary gland is concave and follows the ventral slope of the wing of the atlas.

Dentition

A range of studies have been conducted detailing the anatomy, morphology, morphometry and development of the teeth in donkeys, revealing very few differences between the dentition of the donkey and that of the horse. The dental formulae and the eruption dates for the deciduous and permanent teeth reported in these studies are within the same range as those given for the horse. The one exception is, in the donkey, the second permanent molar (Triadan 110,210,310,410) was reported to erupt 5 to 9 months earlier than in the horse, erupting at 15 months according to two papers and at 19 months according to another [21-23]. These papers also showed that the premolars and molars (cheek teeth) have all reached their maximum length by four years of age. In horses, the cheek teeth continue to grow in length until the animal is 6 to 7 years of age [24]. On comparison of all the studies, there were some inconsistent findings on the number of roots present on the cheek teeth. In general, the superior cheek teeth were reported to have three roots and the inferior cheek teeth were reported to have two roots, as in the horse, with the exception being that the last inferior molar (Triadan 311,411) was reported to have three roots, an extra root when compared with the horse [23-26]. The first premolars (wolf teeth; Triadan 105 and 205) are frequently present (up to 90% of the time) on the superior arcade but rarely present on the inferior arcade [23,27]. The canine teeth are similar to the horse. They are present and erupt in the male; whereas in the female, the canine teeth, or vestiges thereof, are rarely observed [25,28]. The donkey has a greater degree of anisognathia when compared with horse [29]. Anisognathia is a difference in width between the superior (maxilla) and inferior (mandible) jaws.

Paranasal Sinuses

In the donkey, the maxillary sinus is divided into a rostral and caudal compartment by a ventrally located, low bony ridge [30]. This incomplete septum allows for free communication between the two compartments. A complete, oblique bony septum divides the sinus in the horse, such that the rostral and caudal compartments only communicate with one another via their common opening with the nasal cavity, the nasomaxillary opening [17,18,31]. The middle nasal meatus communicates with the maxillary sinus via this opening and the nasomaxillary opening is the only direct communication between the nasal cavity and the paranasal sinuses in both species. The volume of the maxillary sinus is smaller in the donkey and it does not extend as far rostrally as it does in the horse [30]. The frontal sinus and its communication with the maxillary sinus are similar between the two species.

Blood Vessels

It is not uncommon for normal variations in the origin, branching, course and distribution of blood vessels to occur within a species. As well, or possibly as a result of this, the descriptions of blood vessels given in anatomy textbooks will occasionally differ between texts. For this reason, the Nomina Anatomica Veterinaria [PDF] (2005) or N.A.V. will serve as the definitive reference for the normal vascular pattern in the horse for the following comparative discussion. Some of this information may seem academic, but a knowledge of significant variations in location or branching of vessels is essential when performing surgery or dealing with injuries, such as lacerations.

<u>Veins</u>

In the rostral facial region, the following tributaries of the facial vein (v.) differ between the donkey and the horse. The angularis oris v., that runs rostrally towards the commissure of the lip in the horse, is absent in the donkey [32,33]. The lateral nasal v. is also absent in the donkey but present in the horse. There is a communication or an anastomosis between the dorsal nasal v and the superior labial v. in the donkey that isn't found in the horse. This communication branches off the superior labial v. in the mid-diastemal region and runs dorsocaudally to join the dorsal nasal v. just caudal to the nasoincisive notch. It runs in the same region of the nose as the lateral nasal v. of the horse. A slight variation exists with the inferior and superior labial vv. In the donkey, these veins join caudal to the lips to form a common labial v. This common trunk then runs caudally to join the facial v. just rostral to the masseter m. Just before the common labial v. empties into the facial v., it receives the rostral termination of the large buccal v. This combined vessel then empties into the facial v. In the horse, the rostral end of the buccal v. drains directly into the facial v. The superior and inferior labial vv. do not form a common labial v., but join the facial v. independently. The rostral extent of the buccal v. where it joins either

the common labial v. in the donkey or the facial v, in the horse, is in the same proximity in both animals.

In the region of the eye, there are a superior and inferior subcutaneous palpebral plexuses found in the donkey that are not found in the horse. A superior and an inferior vessel run rostromedially from these plexuses and converge to form the angularis oculi v. Veins running caudolaterally from the plexus join the transverse facial v. The plexuses and associated vessels drain the skin of the palpebrae and neighboring structures. In the horse the inferior and superior medial palpebral veins drain the medial palpebral area but they do not arise from a plexus. The medial palpebral v.v. join to form the angularis oculi v.. The N.A.V. gives no mention of lateral palpebral veins in the horse.

The venous drainage of the ear varies in that the medial auricular v. drains into the rostral auricular v. in the donkey. It empties into the caudal auricular v. in the horse.

Lastly, the submental v. in the donkey empties directly into the facial v. whereas in the horse, the submental v. drains into the sublingual v. In both species the sublingual v. drains into the lingual v.

Arteries

The course and distribution of the maxillary and linguofacial arteries on the head are very similar in the donkey and the horse [34,35]. The few variations that occur are found in some of the tributaries of the linguofacial artery. As with the vein, the angularis oris artery (a.) is present in the horse but absent in the donkey [35,36]. It is a branch of the inferior labial a. in the horse. In the donkey, as the inferior labial a. courses rostrally toward the lower lip, it gives rise to a significant branch at the level of the 3rd inferior premolar. This branch, which is similar in size to the parent artery, runs rostrodorsally through the buccinator muscle, supplies the upper lip and then joins with the major palatine a. This branch of the inferior labial a. is absent in the horse. The lateral nasal a. is occasionally double in the donkey. The lingual a. rather than the facial a. gives rise to the sublingual a. in the donkey. The submental a. is then a direct branch of the facial a. in the donkey whereas it branches from the sublingual a. in the horse.

Thyroid Gland

The isthmus of the thyroid gland in the donkey is glandular, whereas in the horse it is generally fibrous [37,38]. The isthmus runs across the ventral surface of the trachea, connecting the right and left laterally located lobes. The relative position of the thyroid is the same as the horse, but the size differs. The donkey's thyroid gland is about half the length, thickness and weight when compared with the horse, but close to equal in width.

Vertebral Column

On examination of twelve donkey skeletons it was determined that the general vertebral formula was C7, T18, L5, S5, Cd15-17 [39]. There was an occasional variation in the number of thoracic and lumbar vertebrae. In this study, a donkey with 17 thoracic vertebrae had 6 lumbar vertebrae, with the 6th lumbar vertebra being fused with the sacrum. A donkey with 19 thoracic vertebrae had the usual 5 lumbar vertebrae. The most common number of caudal vertebrae was 15. In general, the donkey has one less lumbar vertebra than the horse and fewer caudal vertebrae. The general vertebral formula in the horse is C7, T18, L6, S5, Cd 15-21. The most frequent variation is a reduction in the number of lumbar vertebrae from 6 to 5, especially in the Arabian horse [40-42]. Occasionally 17 or 19 thoracic vertebrae are present. The average number of caudal vertebrae is 18.

The relationship of the spinal cord segments to the vertebrae is very similar between the donkey and the horse. There are some subtle differences. A study that examined 16 adult donkeys demonstrated that the 8th (last) cervical spinal cord segment lies entirely within the caudal portion of the vertebral foramen of the 7th cervical vertebra [43]. Therefore, the cervical spinal cord does not extend beyond the bodies of the cervical vertebrae. Whereas, the 8th cervical cord segment in the horse occupies the cranial portion of the vertebral foramen of the 1st thoracic vertebra [44].

In the thoracic region, the 1st and 10th thoracic cord segments correspond with the vertebrae of the same number in the donkey. The 2nd through 9th segments are displaced slightly cranially whereas the 11th thoracic through the 1st lumbar cord segments are displaced slightly caudally. The 2nd lumbar cord segment is entirely within the 2nd lumbar vertebral foramen and the remaining cord segments are displaced progressively further cranial with the last lumbar cord segment, which is the 5th in the donkey, being housed within the 4th lumbar vertebra. The remaining sacral and caudal spinal cord segments are within the vertebral foramina of the 5th lumbar, the 1st and cranial part of the 2nd sacral vertebrae. The spinal cord generally terminates at the junction of the 1st and 2nd sacral vertebrae [45]. In contrast, in the horse the 1st thoracic through the 4th lumbar spinal cord segments have a slight caudal displacement, with the displacements being lesser from the 3rd to 9th segments. The remaining spinal cord segments are displaced cranially. The 5th and 6th lumbar cord segments are within the 5th lumbar vertebra; the first 3 sacral segments are within the 6th lumbar and the last 2 sacral vertebrae and all of the caudal segments are within the 1st and cranial part of the 2nd sacral vertebrae. The spinal cord terminates at the

level of the 2nd sacral vertebra.

Footnotes

a. To avoid possible confusion, it should be mentioned that older terminology used to refer to the opening of the laryngeal ventricle as the lateral ventricle and the out-pocketing of mucous membrane as the laryngeal saccule. The current nomenclature refers to the entire structure, opening and mucosal out-pocketing, as the laryngeal ventricle [15,16].

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