



Morphological Observation of the Rostral Epidural Rete Mirabile (*Rete Mirabile Epidurale Rostrale*) in the Saanen Goat

Şükrü Hakan ATALGIN¹, İbrahim KÜRTÜL², Sevinç ATEŞ^{2✉}

1. Department of Anatomy, Faculty of Veterinary Medicine, Balıkesir University, Balıkesir.
2. Department of Anatomy, Faculty of Veterinary Medicine, Mustafa Kemal University, Hatay.

Abstract: The rostral epidural rete mirabile in small ruminants is bilaterally located next to the hypophysis in the cranial cavity, lies in the cavernous sinus, and regulates arterial blood flow of the brain. In this study, structural peculiarity of the rostral epidural rete mirabile in the ten male mature Saanen goats (11 months old, approximately 42 kg in weight, with a known pedigree, and obtained from Bolu region) was examined by corrosion cast technique using Takilon. Dissections have demonstrated that general architecture of the rostral epidural rete mirabile in the Saanen goat agrees with that in other small ruminants. It is structured by the branches from the arteria maxillaris only. The triangular shaped right and left components (the right and left parts) anastomose, forming a rostrally V-shaped structure. This anastomose was not observed in one of the materials. Thus, gross views and diameters of the retial arteries were not markedly different on the left and right sides. The maxillary artery, the rostral and caudal rami, and the rostral epidural rete mirabile were visualized by the corrosion cast technique. The caudal epidural rete mirabile and the chiasmatic rete were observed to lack in the Saanen goat.

Key words: *Rostral Epidural Rete Mirabile*, Saanen Goat.

Saanen Tekesinde *Rete Mirabile Epidurale Rostrale*'nin Morfolojik Görünümü

Özet: Rete mirabile epidurale rostrale küçük ruminantlarda cavum cranii içinde, hipofiz bezinin her iki yanında, sinus cavernosus içinde yer alan ve beynin arteriel kan akışını düzenleyen bir yapıdır. Bu çalışmada, Takilon ile korozyon kast tekniği kullanılarak, Bolu bölgesinden temin edilmiş 10 adet Saanen tekesinde (11 aylık, yaklaşık 42 kg ağırlığında ve seçereli) rete mirabile epidurale rostrale'nin yapısal özellikleri gözlemlenmiştir. Yapılan diseksiyonda bu anatomik yapının, genel özellikleri itibarıyla diğer küçük ruminant türlerinde gözlemlenen yapı ile benzerlik gösterdiği belirlenmiştir. Bu atardamar ağının sadece arteria maxillaris'ten köken alan dallar tarafından oluşturulduğu ortaya konmuştur. Sağ ve sol tarafta yer alan ve üçgen görümlü olan ağ bölümlerinin (pars dextra ve pars sinistra) ağzlaşarak ön tarafta "V" şeklinde bir yapı oluşturduğu gözlemlenmiştir. Fakat bu ağzlaşma bir bireyde görülmemiştir. Ayrıca, atardamar ağının sağ ve sol yarımının makroskopik görünümleri arasında bir farklılık bulunmamıştır. Arteria maxillaris, ramus caudalis ad rete mirabile epidurale rostrale, rami rostrales ad rete mirabile epidurale rostrale adlı dallar korozyon kast tekniği ile net bir şekilde ortaya çıkartılmıştır. Yine, diseksi edilen hayvanlarda rete mirabile epidurale caudale ve rete chiasmaticum'un şekillenmediği ortaya konulmuştur.

Anahtar Kelimeler: *Epidurale Rostrale Rete Mirabile*, Saanen Tekesi.

INTRODUCTION

The brain in the artiodactyls is supplied by a unique and compact vascular network intercalated in the course of different arteries contributing to the nourishment of this organ, the rete mirabile epidurale. Overall, the rete is constituted bilaterally by the various branches of the arteria maxillaris and basioccipital arterial plexus (Sisson and Grossman, 1964; Gillilan, 1974; Pastea et al., 1986; Dursun, 2000), and by the arteria carotis interna present at neonatal stage (Getty, 1975; Uehara et al., 1978; Zguigal and Ghosal, 1991). However, only the rete mirabile epidurale rostrale and caudale are formed and connected in the ox, only rostral one is present in the sheep and goat (NAV, 2005).

The presence of the epidural rete mirabile, both the rostral and caudal ones, has been stimulating the particular interest of researchers who seek to reveal its physiological function. It has been documented amply in artiodactyls such as oxen, sheep, goat, and camel (Pastea et al., 1986; Zguigal and Ghosal, 1991; Ocal and Aslan, 1994). However, very little focus has so far been given to the variations of the rete among the different species of the same genus; in this study, it is the small ruminantia. Therefore, this study was conducted to document the structural nature of the rete mirabile epidurale rostrale in the Saanen goat. The findings were compared with those reported in the literature.

MATERIALS and METHODS

The heads of ten male mature Saanen goats (11 months old, approximately 42 kg in weight and with a known pedigree) were obtained from a local slaughterhouse immediately after slaughter. The blood was washed out of the vascular system with acetone ($\text{CH}_3\text{COOCH}_3$) and 0.9 % physiologic saline through the common carotid artery. Takilon (100 ml liquid monomethylmethacrylate, 21 gr powder

polymethylmethacrylate, and 8 gr red dye), used as the filling content for corrosion cast, was then injected through the same vessel as described by Sindel et al. (1990) and Tompsett (1970). The specimens were kept for 24 hours for polymerization in tap water at room temperature, and were put in an oven at 35-40°C in 30 % KOH solution for maceration. The remnants of the soft tissue were cleaned and the photographs of the rete were taken. *Nomina Anatomica Veterinaria* (NAV, 2005) was employed for the anatomical nomenclature.

RESULTS

The rete mirabile epidurale rostrale (Fig. 1/A) in the Saanen goat was determined to be highly complex. It was formed by branches from the arteria maxillaris (Fig. 1/1). Bilaterally, there were two different branch origins arising from this artery; a caudal thick rete branch (Fig. 1/2), ramus caudalis ad rete mirabile epidurale rostrale, and a number of 3-5 rostral thinner rete branches (Fig. 1/3), rami rostrales ad rete mirabile epidurale rostrale. These branches constructed a meshwork of various size arteries and arterioles consisting clearly of two lobes, which were linked posteriorly by means of several anastomotic branches.

The caudal thick rete branch, r. caudalis ad rete mirabile epidurale rostrale, arose from the arteria maxillaris at the level of the 1/3 of the rete, and joined the rete mirabile epidurale rostrale from the caudal aspect. Each branch later gave bilaterally 2-3 subbranches for the formation of the caudal component of the rete. The rostral rete branches, rami rostrales ad rete mirabile epidurale rostrale, arose from the arteria maxillaris either as a main trunk immediately sending the thinner subbranches right after its origin or as separate ones.

The distance between the origins of the ramus caudalis and rami rostrales was approximately 15.19 mm. Likewise, the distance between the entrances

of the right and left ramus caudalis to the rete was measured as meanly 23.24 mm. Besides, the distance between the entrances of the ramus caudalis and rami rostrales to the rete was approximately 26.24 mm. The triangular shaped right and left components of the rete mirabile epidurale rostrale were observed to anastomose, showing a rostrally V-shaped extension. This anastomose was not seen in one of the materials.

Each arteria carotis interna on both sides was the only one arising from the rostro-dorsal aspect of the rete as a thick vessel (approximately 2.16 mm in diameter). It descended caudally with a sharp angle right after its origin, joining the circulus arteriosus cerebri while giving off the caudal communicans artery.

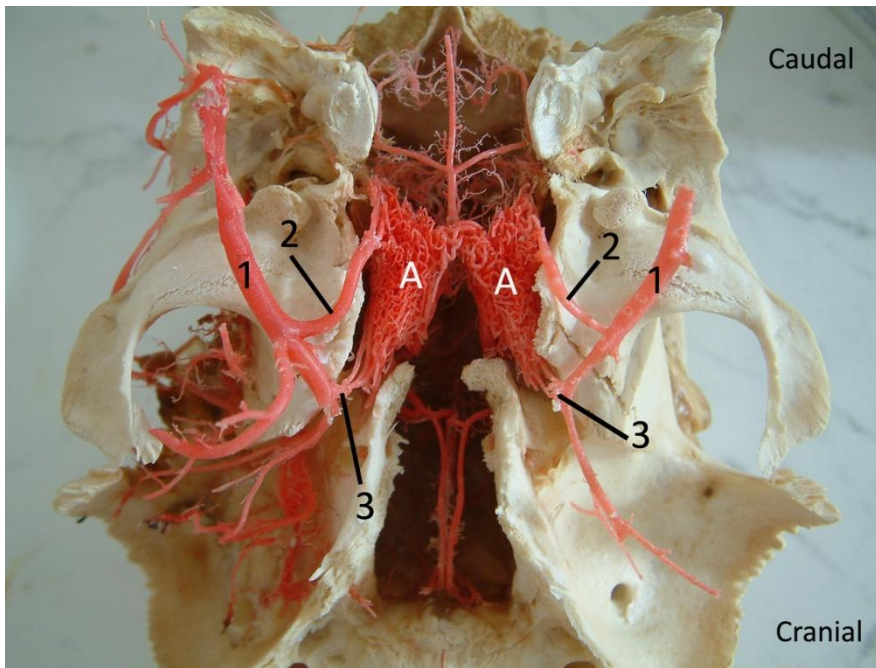


Figure 1. Ventral view of the rostral epidural rete mirabile in the Saanen goat, displaying the structural pattern. A) the rostral epidural rete mirabile, 1) the maxillary artery, 2) the caudal thick rete branch, 3) rostral thinner rete branches.

Şekil 1. Saanen tekesinde rete mirabile epidurale rostrale'nin ventralden görünümü. A) rete mirabile epidurale rostrale, 1) arteria maxillaris, 2) ramus caudalis ad rete mirabile epidurale rostrale, 3) rami rostrales ad rete mirabile epidurale rostrale

DISCUSSION

The rete mirabile epidurale in artiodactyls is a meshwork of various size arteries and arterioles, exerting very essential functions such as buffering the blood pressure and flow to the brain since the retial arteries are thicker than the afferent and efferent vessels joining into and leaving the rete, respectively (Edelman et al., 1972), regulating brain tissue temperature, and playing a role on the passage of some steroids and peptides from venous vessels to these arterial ones (Krzymowski et al., 1992). A decrease in the cerebral blood flow, particularly in the goat which has a thinner caudal communicans artery, obviates the importance of the epidural rete mirabile which compensates the

arterial blood flow to the brain in case of any blood requirement (Edelman et al., 1972; Dyce et al., 1987). Likewise, we thought that revealing the structural nature of the rete mirabile epidurale in the Saanen goat might contribute to clinical researches in this area. Consequently, we observed that the gross structure of the rete, in general, agrees with the reports of the literature with the exceptions indicated. Since, gross views and diameters of the retial arteries did not seem to differ markedly on the left and right sides, we did not focus on the side variation.

The rete mirabile epidurale in artiodactyls, namely large ruminants is formed mainly by the

branches from the arteria maxillaris, arteria meningeae media, arteria vertebralis, and arteria condylaris (Sisson and Grossman, 1964; Uehara et al., 1978; Pastera et al., 1986; Zguigal and Ghosal, 1991; Dursun, 2000). However, it has been shown in small ruminants including Akkaraman sheep and Angora goat, as indigenous Turkish breeds, that the rete is constructed by the caudal and rostral rami of the arteria maxillaris (Nur, 1992), just as we have conclusively observed in the Saanen goat. Besides, the rete has been shown to be formed by the branches of the arteria maxillaris, arteria ophthalmica externa, arteria carotis externa, and arteria meningeae media in the one-humped camel (Zguigal and Ghosal, 1991). It is noteworthy to mention that both the rete mirabile epidurale rostrale and caudale have been documented to be absent in small tropical ruminants such as lesser and greater mouse deer which have either an involuted or no arteria carotis interna even though they are ruminants (Katsuhiko et al., 2007). This literature report expresses new perceptions into the evolution of the arterial system in artiodactyls.

Studies have documented exact locations of the rete mirabile epidurale in various animals. It was located on both sides of the hypophyseal gland, yet has shown a V-shaped extension through the orbital foramen cranially and oval foramen caudally (Bamel et al., 1975; Uehara et al., 1978; Nur, 1992). Each side components of the rete mirabile epidurale are interconnected by several retial arteries. This connection has been reported to form loosely in sheep while very strong and resembling a "V" shape in goat (Nur, 1992; Dursun, 2000). We also observed this strong shape in the model of our study, the Saanen goat. Again, it is noteworthy that this connection was not observed in one species we observed in this study.

The rete mirabile epidurale rostrale and caudale display anastomoses through several retial arteries (Getty, 1975; Bamel et al., 1975; Nur, 1992). Of course, this was not the case in our study since

small ruminants lack the rete mirabile epidurale caudale, in our study it is the Saanen goat. Likewise, several reports indicate that the rete sends an extension along the optic nerve, which unites with its counterpart, forming a structure called rete chiasmaticum (Nur, 1992). Also, no such rete was observed in our study.

Overall, the finding of this study has shown that the general organisation of the rete mirabile epidurale rostrale of the Saanen goat resembles greatly that of the other small ruminants, yet the rete mirabile epidurale caudale and rete chiasmaticum lack.

ACKNOWLEDGEMENTS

We are very grateful to Dr. Orhan BULUT and the Goat Milk Products Unit of Bolana of Bolu Feed A.C./Turkey for their valuable sample donation.

REFERENCES

- Bamel SS., Dhingra LD., Sharma DN., 1975. Anatomical studies on the arteries of the brain of buffalo (*Bubalus bubalus*) I. The rete mirabile cerebri, *Anat. Anz. Bd.*, 137, 440-446.
- Dyce KM., Sack WO., Wensing CJG., 1987. *Textbook of Veterinary Anatomy*, WB. Saunders Company, Philadelphia, USA.
- Dursun N., 2000. *Veteriner Anatomi II*, Medisan Yayınevi, p. 123, Ankara, Turkey.
- Edelman NH., Epstein P., Cherniack NS., Fishman AP., 1972. Control of cerebral blood flow in the goat; role of the carotid rete, *Am. J. Physiol.*, 223, 615-619.
- Getty R., 1975. *The Anatomy of the Domestic Animals*. 5th Ed., WB. Saunders Company, Philadelphia, USA.
- Gillilan LA., 1974. Blood supply to brains of ungulates with and without a rete mirabile caroticum, *J. Comp. Neur.*, 153, 275-290.
- Katsuhiko F., Hiroshi K., Motoki S., Junpei K., Dahlan bin I., Hideki E., 2007. Absence of carotid rete mirabile in small tropical ruminants: implications for the evolu-

- tion of the arterial system in artiodactyls, *J. Anat.*, 210, 112-116.
- Krzymowski T., Skipor J., Grzegorzewski W., 1992. Cavernous sinus and carotid rete of sheep and cows as a possible place for countercurrent exchange of some neuropeptides and steroid hormones, *An. Reprod. Sci.*, 29, 225-240.
- NAV 2005. *Nomina Anatomica Veterinaria*. International Committee on Veterinary Gross Anatomical Nomenclature, 5th Ed. Gent, Belgium.
- Nur IH., 1992. Akkarama koyunu ve Ankara keçisinde a. carotis communis'in son dalları üzerinde karşılaştırmalı makro-anatomik ve subgross çalışmaları, Doktora tezi, S.Ü. Sağ. Bil. Ens., Konya, Turkey.
- Ocal MK., Aslan K., 1994. A quantitative study on the retial arteries in the bovine fetus, *Ann. Anat.*, 176, 151-153.
- Pastea E., Cornila N., Nicolescu V., 1986. A comparative study of the aspect of the epidural rete mirabile in the ox, pig, dog and cat. *Lucr. St. Seria C.*, 29, 7-20.
- Sindel M., Ucar Y., Ozkan O., 1990. Renal arterial system of the domestic rabbit (*Oryctolagus cuniculus*). Corrosion cast study, *I. Anat. Soc. India* 39,31-40.
- Sisson S., and Grossman JD., 1964. *The Anatomy of the Domestic Animals*. 4th ed. W.B. Saunders Company, Philadelphia, pp. 626, 720.
- Tompsett DH., 1970. *Anatomical Techniques*, 2nd Ed. Edinburgh: E. & S. Livingstone.
- Uehara M., Kudo N., Sugimura M., 1978. Morphological studies on the rete mirabile epidurale in the calf, *Jap. J. Vet. Res.*, 26, 11-18.
- Zguigal H., Ghosal NG., 1991. Gross and histologic study of the rostral epidural rete mirabile and the cavernous sinus in one-humped camels, *Am. J. Vet. Res.*, 52, 1173-1177.