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Terminal branches of the common carotid artery in mule with emphasis on the carotid body and carotid sinus

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ABSTRACT

Ten adult mules were used in this study for gross anatomy, light and electron microscopy. The branching of the terminal portion of the common carotid artery was found to be similar to that of the horse. The carotid body of the mule is compact and located at the angle of bifurcation of the internal and external carotid arteries. Groups of cells surrounded by connective tissue capsule were clear, with light as well as electron microscopy. The amounts of electron dense granules differ in the two cell types of the carotid body (Types I and II). The carotid sinus is located at the origin of the internal carotid artery. Both the carotid sinus and the carotid body were described in detail, with their blood and nerve supply in the mule and compared to other domestic animals.

Key words: termination of common carotid artery, carotid body, carotid sinus, mule

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Introduction

The common carotid artery usually divides at the retromandibular space at the cranial part of the neck, ventral to the wing of the first cervical vertebra (atlas), into either three branches (viz., external carotid, internal carotid and occipital) or into two branches where the internal carotid artery disappears in ruminant (BALDWIN, 1964; KHAMAS and MAHDI, 1984; KHAMAS et al., 1984). At this site, the carotid body and the carotid sinus are usually present and which play a role in regulation of partial pressure of CO_2 and O_2 levels in the blood destined to supply the brain, and in the blood pressure inside these vessels. This area was studied in different domestic animals (GETTY, 1975; NICKEL et al., 1981); in camel (ETEMADI, 1975; DARWEESH et al., 1989); in ox (KHAMAS and MAHDI, 1984); in Indian buffalo (PRASAD et al., 1973; PRAKASH and RAO, 1976); in sheep (MOLENDA, 1976; SADIK et al., 1993); in hedgehog (ADAMS, 1957); in otter (DE KOCK, 1959); in horse (BRADELY, 1946; FURUHATA, 1964); in cat (ROSS, 1957); in pony (HENRY and HAYNES, 1989) and in dog (DE CASTRO, 1951; CHRISTENSEN and EVANS, 1979).

The pattern of terminal branches of the common carotid artery in the mule are not described in the available literature, nor is a description of the carotid body and the carotid sinus despite their importance as chemoreceptor and baroreceptor. This study was therefore undertaken to describe the above mentioned branching pattern and structure in the mule.

Materials and methods

Ten adult mules (cross-bred: mare x donkey) were used in this study. Animals were divided into two groups (five in each). The first group was used for gross study, while the second group was used for light and electron microscopic study. In both cases the animals were sedated by Rompun (Xylazine hydrochloride 20 mg/ml) (Miles, U.S.A.), then anaesthetized with chloral hydrate. The common carotid artery was cut open to completely bleed the animal to death. Careful dissection to collect the carotid body and the carotid sinus from the second group was performed and the tissues were placed in 4% glutaraldehyde solution diluted in cacodylate buffer.

The first group of animals was injected through the common carotid artery with a mixture of solutions (10% formalin solution, 8% glycerine, 25% ethyl alcohol, and 10% phenol) coloured with best carmine to facilitate dissection. Animals were left for 72 hours in a cooler and then routinely

dissected. Standard procedures were followed for the specimens for light as well as electron microscopy. Ultra thin sections were stained with uranyl acetate and lead citrate, while methylene blue stain was used for semi-thin sections. Nomenclature used was adopted after International Committee on Veterinary Anatomical Nomenclature (1983). Second edition, Ithaca, New York, U.S.A.

Results

Gross findings. Few differences in the terminal branching pattern of the common carotid artery were observed between animals or between sides of the same animal. The common carotid artery divided at the site of the cricopharyngeal muscle, directed craniodorsally into the following branches:

1 – Internal carotid artery, which has a dilated portion at its origin as the carotid sinus.

2 – External carotid artery, which is the largest branch and the direct continuation of the common carotid.

3 – Occipital artery, which furnishes the following branches:

a - Caudal meningeal artery. This artery supplies the dura matter after entering through the mastoid foramen. In one case only the caudal meningeal artery supplies muscular branches to the obliquus capitis cranialis and caudalis, in addition to a small ramus to the atlanto-occipital joint capsule. The artery then enters through the mastoid foramen, through the temporal canal, to supply the cerebral dura matter.

b - Small branches to supply the rectus capitis ventralis and longus capitis, rectus capitis lateralis muscles, in addition to small branches to the mandibular salivary gland, parotid lymph nodes and the guttural pouch.

c – Condylar artery. This artery courses rostrodorsally lateral to the guttural pouch to divide into 4-6 radicles supplying the rectus capitis, longus capitis and rectus capitis lateralis. It also, furnishes the small middle meningeal artery which enters the cranium through the foramen lacerum.

d – Cranial portion of the occipital artery courses dorsorostrally and leaves the atlantal fossa after giving muscular branches, passing through the alar foramen, and enters the vertebral canal through the lateral vertebral canal where it anastomoses with the vertebral artery. It supplies the

complexus, splenius, caudal auricular muscles and the skin surrounding the auricle or pinna of the ear.

e – Descending branch of the occipital artery is the last branch, which passes through the transverse foramen of the atlas and passes over the atlanto-occipital joint to anastomose with the vertebral artery, at the same time supplying the caudal obliquus capitis muscle.

Light microscopic findings. Carotid body. The carotid body of the mule appeared to be compact and located at the angle between the internal and external carotid arteries (Fig. 1).

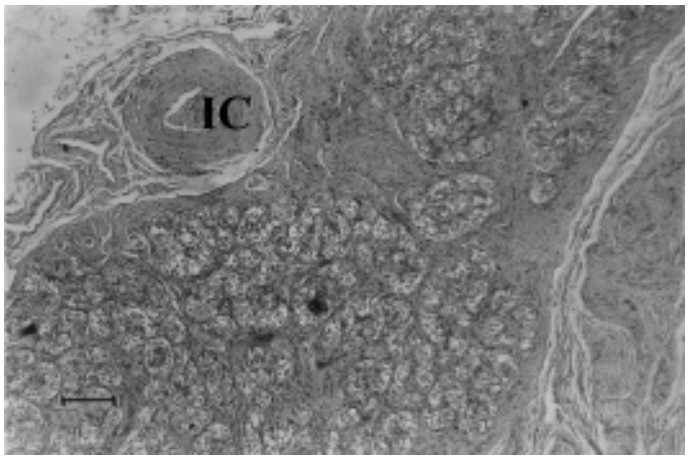

Fig. 1. Photograph of the main portion of the carotid artery of mule showing medium-sized muscular artery having intimal cushion (IC), intra-arterial bolster. H&E; ×280; scale bar = 36 μm.

It is surrounded by a thick connective tissue capsule composed mainly of collagen bundles. Several trabecullae penetrate the body, which separate it into lobules. Each of these lobules consists of groups of five to six cells with fibroblasts present between the groups separating them from well demarcated adjacent lobules (Figs. 2 and 3). The carotid body is highly vascularized and richly innervated. In one case, intra-arterial bolster (intimal cushion) was observed inside a medium-sized muscular artery that supplies

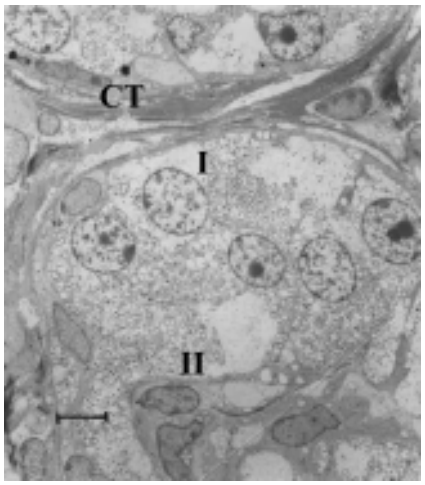

Fig. 2. Semi-thin section of mule carotid body showing type I cells (I) surrounded by supporting cells (II) and connective tissue (CT). Methylene blue stain; ×2800; scale bar = 3.6 μm.

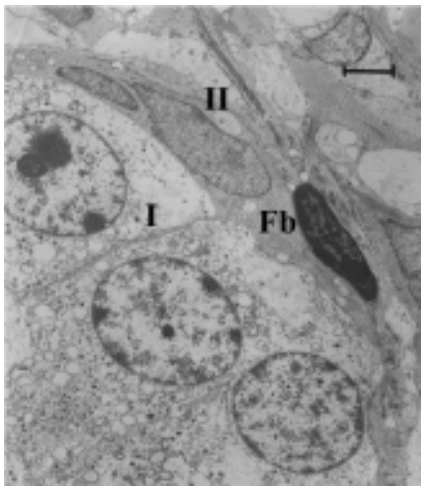

Fig. 3. Enlargement of a group of carotid body cells with type I cells (I) and type II cells (II) with darkly stained nucleus of a fibroblast in the field (Fb). ×5500; scale bar = 1.8 μm.

the carotid body (the glomic artery). Two types of cell were predominantly observed with light microscopy, viz., small darkly stained (Fig. 2 II) and large lightly stained cells (Fig. 2 I).

Electron microscopic findings. Electron microscopy revealed two types of cell, mostly with clear nucleoli (Fig. 4); one with large number of small dense membrane-bounded granules and relatively large electron lucent membrane bound structure (type I), while the other type (II) were usually with a lesser number of such granules. The amount of granules differs in different cells of the carotid body (Fig. 5).

Carotid sinus. The carotid sinus is a very extensive structure near the origin of the internal carotid artery, as it appeared through both light and electron microscopy. Smooth muscle cell layers of the tunica media are substituted by concentric bundles of elastic fibres. The carotid sinus nerves afferent of the glossopharyngeal supplies the carotid sinus area and are obvious in the tunica adventitia of the internal carotid artery (Fig. 6).

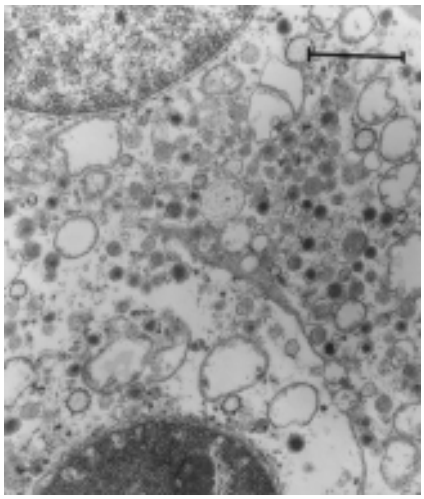

Fig. 4. Electron micrograph of two adjacent carotid body type I cells packed with electron lucent and electron dense membrane-bounded granules. ×21800; scale bar = 0.9 μm.

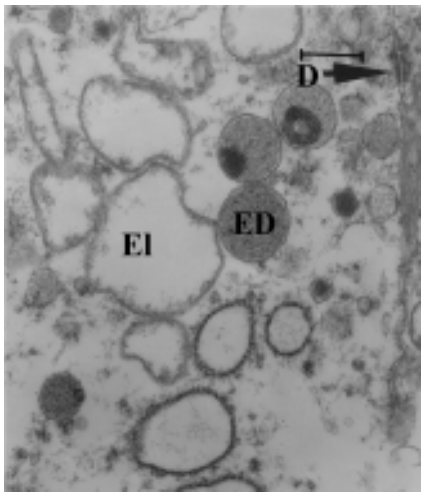

Fig. 5. Enlargement of membrane-bounded granules, (El) electron lucent, (ED) electron dense inside the carotid body cells with clear junctional complexes between the cells (D). ×43700; scale bar = 0.46 μm.

Discussion

The common carotid artery divides into internal and external carotid arteries in most domestic animals (GETTY, 1975) with the exception of the ruminant, where the internal carotid artery disappears early in life (BALDWIN, 1964; KHAMAS and MAHDI, 1984; KHAMAS and GHOSHAL, 1982). Therefore, the common carotid artery divides into external carotid artery and occipital in these species. The branching pattern of the common carotid artery is similar to that reported in horses. However, in the mule the caudal meningeal artery rises from the occipital artery, whereas in camel it was reported to rise from the caudal auricular artery (YOUSIF et al., 1989).

Intimal cushion or bolsters were considered to represent a developmental defect (DAHL, 1976), while STEHBENS (1960) considered these cushions to

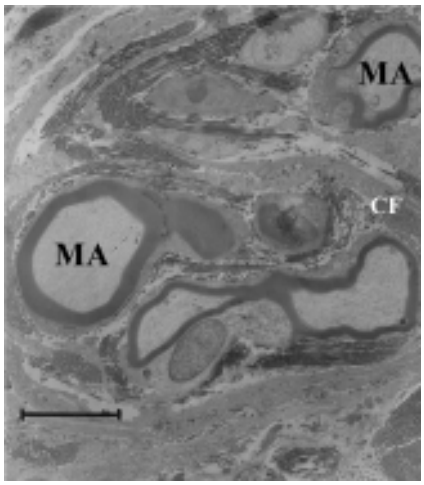

Fig. 6. Electron micrograph of myelinated axons (MA) of the afferent carotid sinus nerve embedded in the tunica adventitia (collagen fibres, CF) of the internal carotid artery of mule. ×5500; scale bar = 3.6 μm.

be normal occurrence in all arteries of all sizes having internal elastic laminae, because they were present in human foetuses and infants. In this study, intimal cushion was found in the main artery (glomic artery) supplying the carotid body and it is speculated that the cushion acts to control blood flow. These kinds of cushion were described by several investigators in the nasal cavity of different mammalian species (STEHBENS, 1960; DAHL, 1976; KHAMAS and GHOSHAL, 1982; GHOSHAL and KHAMAS, 1984).

The findings concerning the presence of sensory nerve endings within the tunica adventitia of the internal carotid artery are similar to those reported by KIMANI (1992). Electron microscopy disclosed the presence of sensory nerve endings within parts of the tunica adventitia adjoining the preponderantly elastic zone of the internal carotid artery. Bundles of collagen fibres in the tunica adventitia from convolutions or whorls around the nerve terminals and after termination on the surface of the elastic fibres, or into the basement membranes of the neuronal profiles (KIMANI, 1995).

The glomic arteries resembled the carotid sinus in being highly elastic and with rich supply of non-myelinated nerve fibres (JAGO et al., 1982).

Description of the human carotid sinus glomic tissue was mentioned by GARFIA (1980), while other investigators described the structure of the glomic arteries (JAGO et al., 1982). Furthermore, desmosomes were observed between adjacent carotid body cells, which has not been previously reported.

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SAŽETAK

Istražena je anatomska, mikroskopska i elektronskomikroskopska građa završnog dijela zajedničke karotidne arterije u deset mula te je utvrđena sličnost onoj u konja. Karotidno tjelešce mule je kompaktno i smješteno u kutu račvanja unutarnje i vanjske karotidne arterije. Jasno se uočava skupina stanica okružena vezivnotkivnom čahurom što je potvrđeno svjetlosnom i elektronskom mikroskopijom. Količina elektronski gušćih zrnaca razlikovala se u dva tipa stanica karotidnog tjelešca (tip I i II). Karotidni sinus smješten je na početku unutarnje karotidne arterije. Detaljno je prikazana građa karotidnog sinusa i karotidnog tjelešca zajedno s opisom dotoka krvi i inervacije te uspoređena s građom u ostalih domaćih životinja.

Ključne riječi: završetak zajedničke karotidne arterije, karotidno tjelešce, karotidni sinus, mula