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THE CAROTID ARTERIES AND THEIR RELATION TO THE CIRCLE OF WILLIS IN THE CAT.

BY H. W. NORRIS.

The value of the domestic cat as an object of dissection in work introductory to comparative anatomy in general and to mammalian anatomy in particular, makes it important that our knowledge of this form should be as exact as possible.

Of the comparatively few works that deal specifically with the anatomy of the cat only three attempt any detailed description of the smaller subdivisions of the carotid arteries. These descriptions are so at variance with each other and with the actual structures as found by the writer that it would seem that in some cases they must be based upon individual variations or aberrant conditions. That blood vessels in general are subject to great variations in their individual relations is well known. This is as certainly true of the carotid arteries as of other blood vessels. This paper is based upon specimens whose arteries were injected through the dorsal aorta with chrome yellow starch injection mass. They were prepared for ordinary student dissection and not for any special investigation.

One of the most striking characteristics of the published descriptions of the carotid arteries of the cat is the contradictory statements made regarding the origin and distribution of their branches. According to Mivart[1] the internal carotid artery is "a very minute vessel" that arises from the common carotid, passes into "a slender canal between the basi-occipital and basi-sphenoid, and the adjacent part of the temporal bone", and enters the cranial cavity by the middle lacerated foramen. Reighard and Jennings[2] state that it arises near or in common with the occipital artery, passes anteriorly along the ventral border of the auditory bulla, and enters the latter together with the Eustachian tube, to pass into the skull by the middle lacerated foramen. Wilder and Gage[3] say that the internal carotid "passes along the carotid canal and unites with a larger vessel extending along the mesal side of the bulla". Tandler[4] states that by a common trunk from the common carotid there arise three arteries: the internal carotid, the occipital, and the ascending pharyngeal. He is essentially in agreement with Mivart as to the passage of the internal carotid through the bulla into the skull. The internal carotid artery of Reighard and Jennings is the ascending

1. Mivart, St. George. The Cat. New York, 1881.
2. Reighard, J. and Jennings, H. S. Anatomy of the Cat. New York, 1901.
3. Wilder, Burt G. and Gage, Simon H. Anatomical Technology as applied to the Domestic Cat. New York, 1886.
4. Tandler, J. Zur vergleichenden Anatomie der Kopfarterien bei den Mammalia. Denkschr. d. Math-Naturwiss. Classe d. kaiserl. Akad. d. Wissensch. Wien, Bd. LXVII, 1898.

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pharyngeal of Tandler. The latter vessel arises separately from the common carotid, or together with the occipital, or from the common trunk as described by Tandler. It passes anteriorly along the median ventral border of the auditory bulla and after giving off branches to the wall of the pharynx enters the auditory bulla along with the Eustachian tube and at the middle lacerated foramen joins the internal carotid. Wilder and Gage are the only ones who have heretofore recognized this union of the anterior pharyngeal with the internal carotid. The two arteries are not usually equaly well developed; where one is of considerable size the other is likely to be vestigial.

The writer finds no evidence to support the statement of Tandler that there are two auricular arteries arising from the external carotid. Tandler is also in error in saying that the superficial temporal and transversal fasciei arise by a common trunk from the external carotid just anterior to the ear. This common trunk divides as described by Reighard and Jennings into a superficial temporal, a branch to the masseter muscle, and an auricular branch. At about the same level as that of the inferior alveolar artery, that is, opposite the condyloid process of the mandible, arises an artery that supplies the deeper muscles of the temporal fossa. Mivart speaks of a branch "going to the muscles of the temporal fossa", but he evidently refers to the superficial temporal. Reighard and Jennings describe an artery arising at this level, but call it the middle meningeal, although in one of their figures the branch called middle meningeal is represented as running antero-dorsally into the temporal fossa. This artery going to the deeper portions of the temporal muscle probably represents in part the *A. temporalis profunda posterior* of human anatomy, and properly may be designated as such here. According to Mivart the meningeal artery arises from the carotid plexus and passes into the skull through the sphenoidal fissure. Reighard and Jennings state that the middle meningeal starts from the internal maxillary at about the same level as the inferior alveolar and enters the cranium through the foramen ovale. I find that the middle meningeal artery arises variously. More often it arises from the intracranial portion of the carotid plexus. Less frequently it takes its origin essentially as described by Reighard and Jennings. Occasionally it springs from a vessel that runs from the internal maxillary artery through the foramen ovale to the intra-cranial part of the carotid plexus. In most cases the small branch of the internal maxillary that enters the foramen ovale has nothing to do with the middle meningeal artery, but passes to the posterior surface of the tentorium. The branch figured by Reighard and Jennings as the middle meningeal is evidently the posterior deep temporal. The latter arises at the point where the external carotid makes a sharp dorsal bend, and passes antero-laterally and dorsally across the ventral median portion of the condyloid process of the mandible into the temporal fossa.

In the region of the sphenoidal fissure the internal maxillary artery gives off a number of small branches that by subdivision form the carotid plexus about the exit of the maxillary branch of the trigeminal nerve.

Reighard and Jennings are incorrect in stating that the internal maxillary after giving off the middle meningeal artery "divides into three or four branches", which "redivide and the twigs form a complicated plexus, the carotid plexus". I agree with Tandler that the internal maxillary artery does not completely break up into the plexus, but its main trunk passes through the network of vessels formed from the small branches above mentioned. In many cases the vessels to form the plexus begin to appear as far back as the inferior alveolar artery. One small branch commonly arises from the base of the deep temporal artery. A small muscle, that runs from the external pterygoid fossa to the extreme inner border of the condyloid process of the mandible, is partly enclosed in the posterior part of the plexus. This muscle seems to have escaped previous notice.

From the carotid plexus there arise a number of small vessels, and as one might suppose, they are subject to considerable individual variation. From the inner border of the plexus spring three or four vessels that pass into the skull through the sphenoidal fissure and after uniting into a single trunk join the internal carotid artery. The latter vessel then joins the circle of Willis. The circle of Willis is formed by the union of the two lateral divisions of the basilar artery with the median cerebral arteries. At the point of juncture the internal carotid artery unites with them. Or we may adopt the view of Tandler that the internal carotid unites with the intra-cranial part of the carotid plexus, and that the latter joins the circle of Willis. That the carotid plexus in the cat is in any way connected with the circle of Willis seems to have been overlooked by Mivart. According to Reighard and Jennings a large branch of the carotid plexus passes into the skull through the sphenoidal fissure and divides into a short posterior communicating branch with the internal carotid, and into the median and anterior cerebral arteries. Davison[5] does not give any description of a communication between the carotid plexus and the circle of Willis, but in one of his illustrations such a connection is certainly figured. I find no evidence of the occurrence of a posterior communicating branch in the sense in which Reighard and Jennings use that term. For according to them the internal carotid unites with the basilar artery, or the posterior cerebral branch of the same, and the intra-cranial branch from the carotid plexus joins the anterior and median cerebral arteries. Then between the median cerebral and the internal carotid arteries there is supposed to occur a communicating branch. There may be recognized a vessel that corresponds to the posterior communicating branch of the circle of Willis in man, but this is quite different from that which Reighard and Jennings believe to occur.

From the dorsal side of the carotid plexus is given off a small branch that almost immediately passes into the cranial cavity through a small foreman between the alisphenoid and the orbitosphenoid bones and is distributed to the dura mater in the anterior part of the cranium. It

5. Davison, A. Mammalian Anatomy with special reference to the Cat. Philadelphia, 1903.

should be called the anterior meningeal artery. The small foramen between the alisphenoid and the orbitosphenoid bones through which the anterior meningeal enters the skull, apparently has been recognized by Jayne[6] alone. He figures it but does not describe it or name it. From the plexus there run a number of small vessels to the pterygoid, masseter, and temporal muscles. At the antero-lateral border of the plexus there are usually two branches larger than the other muscular branches, that pass laterally between the orbit of the eye and the temporal muscle, and are distributed to the latter. They seem to correspond to the *A. temporalis profunda anterior* of man. Tandler speaks of them as the deep temporal branches. I am unable to identify the bucco-labial vessel that Tandler says passes laterally from the plexus. Close to the origin of the deep temporal branches from the plexus there arises a branch that passes dorso-medially around the border of the structures in the orbit and enters the skull though the ethmoidal foramen in the frontal bone. In its course it gives off a lachrymal branch to the lachrymal gland and adjacent region, and a frontal branch to the region of the upper eyelid. This is evidently the vessel from the carotid plexus that Reighard and Jennings call the ophthalmic artery. But it does not supply all the structures in the orbit, very few muscles receiving vessels from it. Only in part does it correspond to the ophthalmic artery of man. It were better named the ethmoidal, as its main portion is the ethmoidal artery. According to Tandler a common trunk arising from the internal maxillary artery divides into the lachrymal, ethmoidal and frontal arteries. I find that this common vessel arises from the carotid plexus rather than from the main artery, but it is quite likely that the origin described by Tandler occurs sometimes. The muscles of the orbit for the most part receive their blood supply from small vessels of the plexus, but there seems to be no regularity in their arrangement. From the internal maxillary artery in the midst of the plexus there passes into the orbit a vessel of considerable size. This artery after a somewhat tortuous course through the plexus goes to the eyeball along with the optic nerve. It gives off a pair of arteries that enter the eyeball at about the equator of the latter, and that evidently correspond to the long posterior ciliary arteries in man. Many other smaller short banches are given off to the posterior wall of the eyeball, and may be designated as the short posterior ciliary arteries, since they have the same general distribution as these latter arteries in man. The central artery of the retina enters the bulb along with the optic nerve, and is a very small vessel. This vessel supplying the eyeball is the ciliary artery. Tandler states that it arises from the carotid plexus. It may have such an origin occasionally, but in general it comes directly from the internal maxillary artery. Near the eyeball it is joined by one or two small vessels from the plexus. At about the same region there sometimes unites with it a vessel that emerges from the cranial cavity through the optic foramen. This latter vessel may be traced to the circle of Willis a little posterior to the point of divergence of the anterior and median cerebral arteries. This vessel arising from the circle of

6. Jaynes, Horace. Mammalian Anatomy, Part I, The Skeleton of the Cat. Philadelphia, 1898.

Willis and passing into the orbit is beyond question the ophthalmic artery. It may be a well developed large vessel, or rudimentary, or merely vestigial, or apparently, even absent. Tandler is the only one who has recognized the occurrence and the homology of this vessel. From the antero-median border of the carotid plexus there run one or two small branches that soon unite and pass as a single vessel into the skull through the optic foramen. Here it unites with its fellow of the opposite side, runs anteriorly and after anastomosing with branches of the ethmoidal and anterior cerebral arteries forms a meningeal network in the dura of the olfactory fossa.

The other branches of the carotid arteries and of the circle of Willis seem to need no additional description beyond that given by Reighard and Jennings. It has seemed worth while to describe the vessels that the ordinary student finds either undescribed or described so incorrectly as to cause confusion.