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## ANOMALY OF THE ABDUCENS NERVE

An anomaly of interest to both the anatomist and historian of medicine was noted in the course of dissection of the cadaver of a 77-year-old white male. No abducens nerve existed on the right side. Careful examination of both the brain stem and the ocular muscles revealed that in its stead, two distinct branches of the oculomotor nerve supplied the right lateral rectus muscle.

When discussing the morphology of the cranial nerves that supply the extra-ocular muscles Neal wrote, "In the great majority of vertebrates the number and nerve relations of the eye muscles remain unchanged. Nature seems to have pursued with regard to them the policy of 'letting well enough alone.' "[1] Several anomalies of the sixth nerve have been described, however. Whitnall cites the following variations in the origin or course of the nerve to the lateral rectus muscle: origin from the olive; origin by means of two roots which may not unite until they reach the cavernous sinus; origin 8 mm. above the inferior border of the pons; branch received from the otic or pterygopalatine ganglion; entrance into the orbit outside of the common tendinous ring (of Zinn); branch furnished to the superior rectus in addition to the usual supply from the oculomotor; root to the ciliary nerve or ciliary ganglion.[2] Bremer has described aberrant roots and recurrent branches in the human embryo as well as total absence of the abducens in one 18 mm. embyro whose lateral rectus was supplied by the oculomotor. Bremer states, however, that this embyro was in a poor state of preservation.[3]

The current textbooks of orbital and ocular anatomy as well as those of ophthalmology mention only one documented case of total absence of the abducens nerve. Many of these authorities cite the name, Generali, yet no reference to a source or date is mentioned. A careful search of the pertinent material, available in the Historical Library of the Yale School of Medicine, revealed that the first mention of Generali's work in English is in the 1876 edition of *Quain's Anatomy,* but no source is included.[4]

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The information apparently came from Henle's *Handbuch der Nervenlehres des Menschen* where the reader is referred to Guiseppe Generali's article in the Italian journal, *Annali universali di medicina compilati dal dottore A. Omodei* of 1842.[5] Generali's article, reminiscent of the early nineteenth century dissecting room, embodies a style long foreign to the terse, factual accounts found in today's literature.

> When finding myself on the morning of April 4, 1842, in the anatomy room I saw half a head from which the brain had been removed. Interested as I was in repeating my observations and in varying the manner of teaching, the case led me to reveal a rare anomaly. . . . That fragment of cadaver belonged to an old lady of about 90 years of age, blind for some time and almost completely deaf. It was the left half of the head; I searched along the basilar canal under its silvery rug, beneath the posterior clinoid process for the nerve of the sixth pair, ordinarily situated there in the dural sheath, in order to be able to follow it along its course; and not having found it, I supposed that it might have been torn in the process of removing the cerebral mass; nevertheless, I insisted upon discovering the opening through which that nerve trunk ordinarily passes, and I was struck by surprise and curiosity when I realized there was no trace of the canal I sought. . . .
>
> With hammer blows I reduced the orbital vault to fragments thus uncovering the neuromuscular apparatus contained in that cavity; and occupying myself in examining the external rectus muscle, or abductor of the ocular bulb, I revealed that that muscle received two small nerve fibers which penetrated it on the superior aspect of the posterior third and a large branch which penetrated it on the corresponding part internally (on the ocular side); these branches were immediately derived from the nerve of the third pair or oculomotor nerve.[6]

Since Generali's time the very complex embryology of the extra-ocular muscles and the cranial nerves which supply them has been studied, chiefly in fish and amphibia. The initial stage of differentiation of the mesoderm of the human head is so abbreviated that the development of the cephalic somites has never been carefully observed; therefore, any evidence on this problem must be derived from phylogeny.[7]

The most popular concept for the embryology of the eye muscles and their relations to the cranial nerves is expressed by Neal. He states that there are three head cavities which give rise to the extra-ocular muscles. From the first, or premandibular cavity, arise the muscles innervated by the oculomotor nerve, namely the superior rectus, inferior rectus, medial rectus, and inferior oblique. The second, or mandibular myotome, differentiates into the superior oblique muscle, innervated by the trochlear nerve. The third, or hyoid cavity, gives rise to the lateral rectus muscle, innervated by the abducens nerve.[8]

Edgeworth, in contrast to this view, believes that the primary source of all the ocular muscles is the premandibular somite, and that in ganoids

and plagiostomes the origins of the superior oblique and lateral rectus have been shifted back. He concludes from this study that the IVth and VIth nerves are not segmental nerves, but are separated portions of the IIIrd nerve, and that their motor nuclei in the brainstem are separated portions of the IIIrd motor nucleus. Thus he concludes that the external ocular muscles form a single morphological unit.[9]

## CASE REPORT

During the dissection of a 77-year-old, white, male cadaver, the absence of the right VIth cranial nerve was noted, and the lateral rectus muscle of the right eye was innervated by the oculomotor nerve of the same side (see Fig. 1). The complete absence of the right abducens nerve was noted at the time the brain was removed from the cranial vault. The left abducens nerve emerged normally from the ventral surface of the medulla oblongata in the sulcus at the inferior border of the pons and the upper end of the pyramid, and extended forward in the usual course through the subarachnoid cistern to the upper border of the petrous portion of the temporal bone where it pierced the dura mater to enter the cavernous sinus. Further dissection of the right orbit revealed that the lateral rectus muscle received its innervation from two twigs arising from the oculomotor nerve, instead of being innervated by the abducens nerve. The two branches of the oculomotor nerve each measured 1.3 cm. from their origin to their insertion on the medial aspect of the lateral rectus muscle. The right lateral rectus muscle seemed normal; it measured 2.8 cm. from the central tendinous ring to its insertion on the eyeball. Dissection revealed that the left orbit was entirely normal; the abducens nerve followed its usual course to the medial aspect of the normal left lateral rectus muscle. No other anomalies were found in either orbit.

Although Generali reported one case of absence of the abducens nerve with supply of the lateral rectus by the oculomotor nerve, he did not make sections of the brain stem to determine whether abducens nuclei were actually present on both sides of the pons. Therefore, histological study of the brain stem was undertaken in this case to ascertain whether abducens nuclei were present in the usual position in the pons. Microscopic sections of the brain stem of the pons and mesencephalon were stained with thionine to demonstrate nuclei. These sections showed normally appearing abducens nuclei on both right and left sides of the pons. (See Fig. 2). The oculomotor nuclei were also present on both sides of the mesencephalon and appeared approximately equal in size.

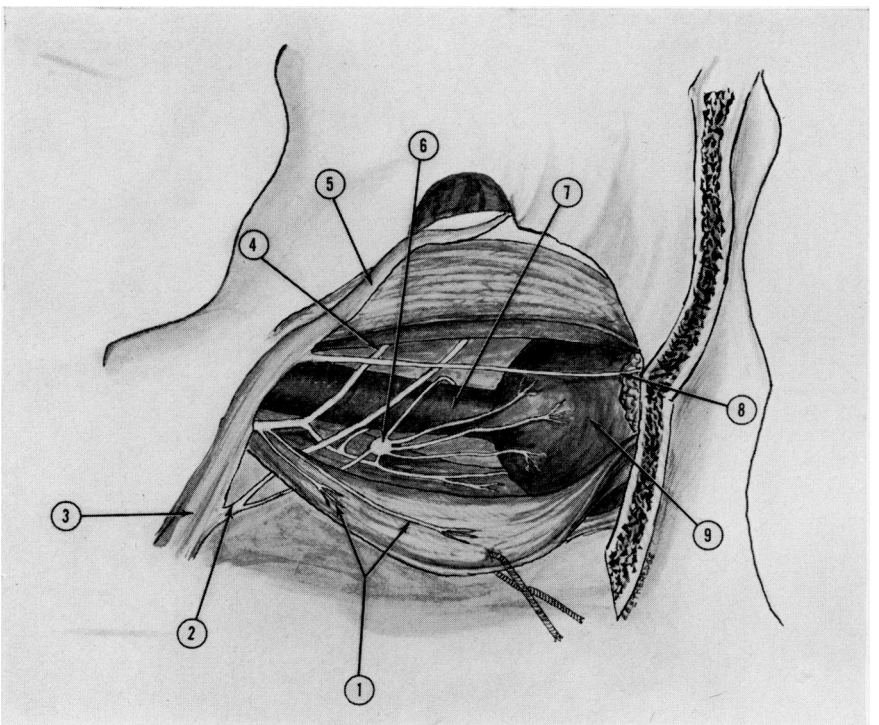


FIG. 1. Lateral view of right orbit. (1) Anomalous branches of oculomotor nerve to lateral rectus muscle; (2) nasociliary nerve; (3) ophthalmic division of trigeminal nerve; (4) superior division of oculomotor nerve to levator palpebrae and superior rectus muscles; (5) frontal nerve; (6) ciliary ganglion; (7) optic nerve; (8) lacrimal nerve; (9) eyeball.

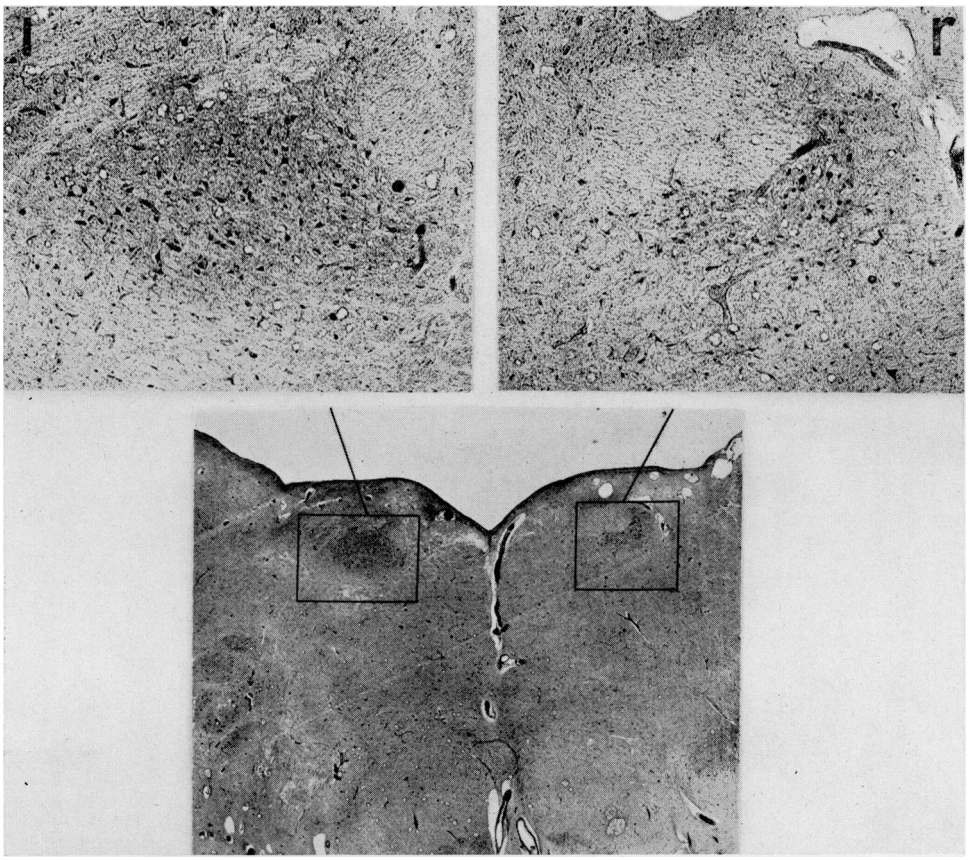


FIG. 2. Left and right abducens nuclei and surrounding structures in the pons are indicated by the black outlines in the lower photomicrograph (13X). Above are higher magnifications (45X) of the left and right abducens nuclei. It can be seen that a right abducens nucleus is present in the pons. Although measurements were not taken, microscopic examination at several levels throughout the abducens nuclei would indicate that no significance can be attached to the smaller size of the right nucleus. The clear area at the upper border of the right nucleus represents the genu of the VIIth cranial nerve. Thionine stain.

The clinical history of the patient was non-contributory. Death was caused by arteriosclerotic heart disease. Physical examination of the patient prior to death revealed no abnormalities of external ocular movements, and there were no complaints recorded of strabismus, nystagmus, or diplopia.

## DISCUSSION

Study of the published reports of the embryology of the extra-ocular muscles and associated cranial nerves indicates that there is considerable confusion regarding the development of these structures. All theories stress, however, the close developmental association of the IIIrd, IVth, and VIth cranial nerves to the extra-ocular muscles. Edgeworth's theory that the VIth nerve is a separated portion of the IIIrd nerve lends itself well to this report since it may help to explain how the oculomotor nerve in this cadaver assumed the normal function of the abducens nerve.

The fact that this reported case showed absence of the right abducens nerve but normally appearing VIth nuclei bilaterally in the pons requires explanation. It is known that all of the fibers arising in the abducens nucleus do not pass into the VIth nerve trunk. Some fibers ascend in the median longitudinal fasciculus of the same and opposite sides and terminate near the median cell group of the nuclei of the oculomotor nerve from which impulses are conveyed to the opposite medial rectus, thus aiding conjugate movement of the eyes.[10] Since some abducens fibers normally pass into the median longitudinal fasciculus of the same side, the authors postulate that fibers from the right abducens nucleus of this cadaver either synapsed with fibers in the median longitudinal fasciculus or traversed it and traveled directly to the right lateral rectus muscle through the oculomotor nerve. Thus the two twigs that branched from the oculomotor to innervate the lateral rectus muscle are probably not truly oculomotor, but have their origin in the right abducens nucleus.

Absence of the sixth nerve, although extremely rare, must be kept in mind clinically. Pathology of the third nerve with apparently inexplicable loss of abduction could well be explained by a repetition of the condition found in this reported case. Whether nystagmus, strabismus, or diplopia can sometimes be attributed to such a variation is indeed a point of consideration.

## SUMMARY

A case of absence of the right abducens nerve is reported. The only other such case, reported in 1842, is reviewed, together with the

embryological considerations of such a finding and the probable anatomical and clinical ramifications.

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