

Early division of the abducens nerve's prefissural segment: Report of the rarely described variant

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ABSTRACT

Background: The abducens nerve palsy may be associated with various disease processes, as nerve damage may occur at any point of its transit from the pons to the lateral rectus muscle.

Aim: Our case report presents a rarely described variant of the abducens nerve's cavernous segment and an outline of the potential developmental background of the finding.

Case description: Early division of the abducens nerve's prefissural segment was found during the cavernous sinus dissection. The nerve was divided into the superior (of 0.68 mm diameter) and inferior (of 0.54 mm diameter) divisions before reaching the superior orbital fissure just after crossing the internal carotid artery. Both divisions entered the orbit separately through the superior orbital fissure. The innervation of the lateral rectus muscle was typical.

Conclusions: Early division of the abducens nerve can be defined as the presence of two separate nerve trunks in the anterior cavernous sinus, superior orbital fissure, and orbit. Anatomical variations of the abducens nerve should be kept in mind during diagnostic and surgical procedures.

1. Introduction

The abducens nerve emerges from the brainstem between pons and medulla oblongata, travels through the subarachnoid space, Dorello's canal, and cavernous sinus to enter the orbit through the superior orbital fissure within the common tendinous ring [1]. The nerve is responsible for the innervation of the lateral rectus muscle [1]. The nerve's palsy may be associated with various disease processes, as nerve damage may occur at any point of its transit from the pons to the lateral rectus muscle [2]. Based on the microanatomic and endoscopic study of the abducens nerve, Iaconetta et al. divided the nerve into five segments, of which three are intracranial (cisternal, gulfar, and cavernous) and two are orbital (fissural and intraconal) [3]. Another study subdivided the cavernous segment of the nerve into carotid (directly transversing the proximal part of the internal carotid artery cavernous segment) and prefissural subsegments [4]. The abducens nerve is then characterized by the numerous possible anatomical variations and the complex anatomy of individual segments, which can be vital in clinical practice. Graham et al. provide information that abducens nerve palsy is the most common isolated palsy in adults and the second most common cranial nerve palsy in children [2]. Cited authors categorize abducens nerve

palsy reasons as vasculopathic (e.g., diabetes) and non-vasculopathic (trauma, inflammation, or compression) [2]. Hence, the validity of research and reports on anatomical variations of the abducens nerve.

Our case report presents a rarely described variant of the abducens nerve's cavernous segment and an outline of the potential developmental background of the finding.

2. Case description

The sagittal section of the male head (left hemi-head) fixed in 10% formalin solution was routinely dissected for scientific and teaching purposes. Early division of the abducens nerve's prefissural segment was found during the cavernous sinus dissection. The cavernous segment of the abducens nerve was 26.85 mm long (including the carotid part of 6.58 mm and the prefissural part of 20.27 mm length). The abducens nerve diameter after leaving the Dorello's canal was 0.97 mm. At the point of contact with the posterior vertical segment of the internal carotid artery, the nerve was flattened (2.09 mm width). The nerve was divided into the superior (of 0.68 mm diameter) and inferior (of 0.54 mm diameter) divisions before reaching the superior orbital fissure just after crossing the internal carotid artery (Fig. 1). At this point, the

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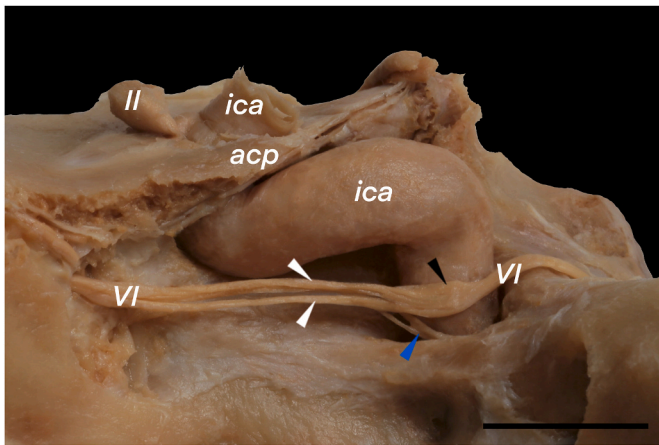


Fig. 1. Anatomical variations of the cavernous segment of the left abducens nerve. Flattening of the abducens nerve's carotid segment (black arrowhead) and early division of the nerve's prefissural segment (two white arrowheads) are visible. The blue arrowhead indicates the sympathetic plexus reaching the prefissural segment of the abducens nerve. II – optic nerve; VI – abducens nerve; acp – anterior clinoid process; ica – internal carotid artery. (For interpretation of the references to colour in this figure legend, the reader is referred to the Web version of this article.)

internal carotid plexus crossed medial aspect of the abducens nerve (Fig. 1). Both divisions entered the orbit separately through the superior orbital fissure. The orbit was dissected according to the previously described protocol by removing the superior and lateral walls [9]. The innervation of the lateral rectus muscle was typical. The anatomy of individual cranial nerves in their intracranial segments (excluding the abducens nerve) was typical.

3. Discussion

Branching pattern, territory, and clinical significance of the abducens nerve are widely discussed in the literature [2–18]. Iaconetta et al. stated, that "The classification of five segments for the abducens nerve seems anatomically valid and is surgically oriented with respect to both the microscopic and endonasal endoscopic approaches [3]." Thus, knowing the anatomical variations occurring within individual nerve segments is important from the clinical point of view.

Numerous variants of the abducens nerve may occur. The single trunk of the nerve may leave the brainstem and then be duplicated in the subarachnoid space into two trunks that reunite within the cavernous sinus. Also, two nerve trunks may leave the brainstem separately,

uniting within the cavernous sinus. Jain presented a report on the abducens nerve duplication throughout its entire course [15]. There was also a report on the unusual variant of the abducens nerve duplication with two nerve trunks merging within the orbit [16]. Thus, duplication of the abducens nerve may occur in numerous types. Early division of the abducens nerve into terminal sub-branches proximal to the superior orbital fissure can also be considered an example of "distal duplication" of this nerve, involving its prefissural, fissural, and orbital segments. This variant is rare, with a reported frequency of 5% [4] and 7.5% [17]. Our report presents such a rarely described variant of the cavernous segment of the abducens nerve, in which an unusual, early division of the main abducens nerve stem into two terminal branches (sub-divisions) was observed.

The abducens nerve variant described in this report may be explained by segmental innervation of the lateral rectus muscle. Reaching the lateral rectus muscle, the nerve divides into two groups (superior and inferior) of primary muscular subbranches, which split into secondary sub-branches and undergo numerous further divisions [6–10] (Fig. 2). This specific intramuscular innervation pattern involves consistent segregation of intramuscular motor nerve arborization, which reflects the compartmentalization of function of the selected extraocular muscle [6–12]. Then, it can be hypothesized that the abducens nerve described in our report showed an atypical early (prior to the superior orbital fissure) segregation of nerve fibers into two longer-than-usual subdivisions targeting various segments of the lateral rectus muscle. Most commonly, the abducens nerve enters the superior orbital fissure as a single nerve and is divided into superior and inferior groups of subbranches anteriorly to the fissure [3–6].

When crossing the vertical segment of the intracavernous part of the internal carotid artery, the abducens nerve may also be divided into a few filaments, which reunite into one trunk after (so-called "pseudobranching") [4,17,18]. In our case, the nerve was flattened at the point of crossing the vertical portion of the internal carotid artery, which can resemble "pseudobranching" of the nerve. To summarize these brief considerations, various deviations from the typical anatomical variant of the abducens nerve are not uncommon. However, variations of the distal segments of the abducens nerve are rarely described.

4. Conclusions

Early division of the abducens nerve can be defined as the presence of two separate nerve trunks in the anterior cavernous sinus, superior orbital fissure, and orbit. Anatomical variations of the abducens nerve should be kept in mind during diagnostic and surgical procedures.



Fig. 2. Typical intramuscular innervation of the lateral rectus muscle revealed using Sihler's stain. The two groups of the abducens nerve (VI) terminal sub-branches – the superior (sup) and inferior (inf) are presented. The scale bar shows 10 mm. The photograph was taken and adapted from Haladaj [10] (Copyright © 2019 Robert Haladaj) under the Creative Commons Attribution License (CC BY 4.0 DEED), which permits unrestricted use, distribution, and reproduction in any medium.

Ethical statement

The authors state that every effort was made to follow all local and international ethical guidelines and laws that pertain to the use of human cadaveric donors in anatomical research [19].

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Declaration of competing interest

None declared.

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