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Herophilus of Chalcedon (ca. 330-250 BC) and ocular anatomy. A review

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Abstract

Herophilus of Chalcedon (ca. 330-250 BC) was considered as one of the most important figures of anatomy during the antiquity. Apart from his other works in anatomy very important are also his observations in ocular anatomy. He discovered first the optic nerve and described four tunics in the eye.

Key words

Herophilus of Chalcedon, ocular anatomy, Alexandria, Medical School.

Introduction

Herophilus of Chalcedon (ca. 330-250 BC) is remembered in the world history of medicine as one of the most prominent physicians of the Hellenistic age (Potter, 1976). He was a student of Praxagoras of Kos (2nd half of 4th century BC) and Chrysippus of Cnidos (4th century BC). He flourished in Alexandria of Egypt during the reign of Ptolemies, when the famous medical school of the town was found and Herophilus of Chalcedon became its first professor (Von Staden, 1989). He focused his interest on anatomy and physiology (Reverón, 2014). He was known in antiquity for performing vivesection (Ganz, 2014). Quintus Septimius Florens Tertullianus (150-240 AD) reported that he had performed vivesection in 600 men sentenced to death (Waszink, 1947). He used the experiment, therefore we can understand this special method for anatomy (Longrigg, 1993). His interest for the brain and the nerves made him a pioneer in the study of the nervous system. He made the distinction between sensory and motor nerves, he differentiated the cerebrum from the cerebellum and place the intellectum in the brain (Pearce, 2013). Among the achievements in his anatomical studies is his description of ocular anatomy.

Herophilus of Chalcedon and ocular anatomy

Herophilus of Chalcedon was very interested in the structure of the eye and its diseases. Therefore he wrote a special treatise on the subject as we are informed by the Byzantine physician Aetius of Amida (mid-5th - mid-6th century AD) (*Iatrico-*

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rum liber vii 48.48-49: Olivieri, 1950) which now is lost as the majority of his works. The information about this treatise came indirectly by other physician and writers of the later years. This later sources give us the image about the anatomy of the eye which was formed by this physician. Herophilus of Chalcedon was the first one who described in detail the optic nerve, believing that the optic nerve has a duct (Greek; poros) through which passed the sensory pneuma, in order to arrive at the eye. He pointed the optic chiasm and expressed the idea that the eye has four tunics, tunica fibrosa (sclera and cornea), tunica vasculosa (chorioid), tunica interna (retina) and tunica cystallina (the capsule of the lens) (Prioreschi, 2004).

Galen (ca. 129-210 AD) wrote about Herophilus' ocular anatomy in his works, *De libris propriis libri iii* 19.30.1-4 (Marquardt, 1891), *De symptomatum causis libri iii* 7.88.17-7.89.2 (Kühn, 1894), *In Hippocratis Epidemiarum 2.4.2 commentarius 4* (as saved by the Arab physician Hunain: Von Staden, 1989) . Rufus of Ephesus (1st-2nd century AD) mentions Herophilus' anatomical concept of eye in his works, *De corporis humani appellationibus* 153.1-10 (Daremberg and Ruelle, 1879) and *De partibus corporis humani* 23.2-24.2 (Daremberg and Ruelle, 1879). The rest sources about the subject are in Latin. Aulus Cornelius Celsus (c. 25 BC – 50 AD) mentioned Herophilus' ideas in his work *De medicina* 7, 13 (Spencer, 1935-38) and Chalcidius (4th century AD) in his work, *Procli Diadochi in Platonis Timaeum commentaria* 246 (Diehl, 1903-06).

Galen gave the information about Herophilus' concept of optic nerve and ocular tunics in three different treatises, reporting Herophilus' opinions in order to compare them with those of Marinus of Alexandria (1st half of 2nd century AD) and Hippocrates (ca. 460-375/351 BC) and to indicate that Herophilus was the first to describe in detail the optic nerve. Rufus of Ephesus focused on the tunics described by Herophilus pointing that he was the first to describe retina. Celsus focused also on ocular tunics underlining that Herophilus was the first to describe retina and Chalcidius gave an overall view of Herophilus' ideas about ocular anatomy but referring that Alcmeon of Croton (ca. 570-500 BC), Callisthenes (4th century BC) and Herophilus, all these three described the optic nerve which has a duct and also spoke about the four tunics of the eye. Chalcidius is the only writer who attributes these discoveries to three people, but having in mind the rest of the literature and the context of this reference we infer that it is a mistake and Herophilus has the merit, because the ideas described are in accordance with Herophilus' concept of soul, brain and nerves (Von Staden, 1989).

The special interest of Herophilus for the nervous system probably was the main motive factor for his interest in the optic nerve and bulb which were considered as a continuance of the brain (Longrigg, 1998). Herophilus managed to describe more accurate than before the route of the optic nerve and its connection to the bulb. Herophilus pointed the earlier error presented by Aristotle (384-322 BC) according to whom the optic nerve consisted of three branches and affirming the earlier of Alcmeon's of Croton hypothesis that the optic nerve is single (Kirke and Raven, 1957). Nevertheless he was a follower of Alcmeon's of Croton idea which was also accepted by all the physicians and the philosophers until his time, that the optic nerve was not solid but in it existed a duct (Nutton, 2004). This idea was formed on the basis that the pneuma or a 'fire' came out of the brain through the optic nerve and the eye, in order to emit rays from the eye, which make the vision. This concept of vision had a long history starting from Pythagoras of Samos (580 - 496 BC) and Alcmeon of

Croton passing with minor revisions through Empedocles of Acraganta (495-435 BC), Epicharmos of Kos (540-450 BC), Dimocretus of Abdera (460-370 BC), Plato (428/427-348/347), Euclid (350-270 BC) and Claudius Ptolemaeus (90-168 AD) (Smith, 2015). Only Aristotle, although he believed also in the existence of the duct, expressed the idea that the eye does not emit but receive rays. However Aristotle did not manage to form an accurate theory of vision, which was achieved for the first time many centuries later by Abū ʿAlī al-Ḥasan ibn al-Ḥasan ibn al-Haytham (ca. 965-1040 AD), known by his Latinized name as Alhazen (Arrington and Mart-Ibanez, 1959).

This false impression of the duct in the optic nerve, which was also accepted by Rufus of Ephesus and Galen, was used although could not be confirmed by dissection, in order to be complied with the false theory of vision due to the fact that in antiquity it was impossible to understand ocular physiology. Galen when stated Herophilus' ideas about the eye described the pneuma emitted by the duct as sensory pneuma, while Chalcidius as natural, meaning the pneuma which nourishes the living in distinction to psychic pneuma which controls all the types of intellectual activity of the man. But having in mind that Herophilus had distinguished sensory from motor nerves and in accordance with the theory acceptance of the duct in the nerves, it seems more obvious the recognition of the sensory character of pneuma (Von Staden, 1989).

By the time of Herophilus three ocular tunics were identified, sclera and cornea as one tunic (white tunic), arachnoid and chorioid. Herophilus' interest in the anatomical structure of the brain and the thorough examination of the arachnoid mater and also the cerebral vascular system probably endorsed him to point the chorioid tunic grace to its vascular net and to describe retina as a tunic which covers the chorioid as a net, as it was stated by Rufus of Ephesus, thus identifying retina as an extra, fourth, tunic (Daremberg and Ruelle, 1879). Celsus on the other hand, probably due to the fact that he was not a physician but an encyclopaedist (Barwick, 1960), described the arachoid tunic without further details and not distinguishing clearly the retina but stating that Herophilus gave its name due to its thinness, which contradicts to Rufus of Ephesus who declared that the name arachnoid was used earlier than Herophilus. Therefore we can reach the conclusion that Herophilus described arachnoid tunic better. Chalcidius assigned the description of the four ocular tunics to all three physicians and philosophers, Alcmeon of Croton, Callisthenes and Herophilus as he did for the optic nerve. As it known that Alcmeon of Croton and Callisthenes did not speak about retina, we can infer that Chalcidius made a confusion (Von Staden, 1989).

Conclusion

Although Herophilus did not manage to develop ocular physiology, he offered a more accurate description of ocular anatomy than earlier. His ideas on the theme constituted the basis on which Galen developed his description of ocular anatomy which lasted over a millennium as neither Andreas Vesalius (1514-1565), the founder of modern anatomy, nor any other anatomist succeeded in giving a correct anatomical description of the eye before Johann Gottfried Zinn (1727-1759) in 18th century (De Laye, 2011).

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