

Historical Perspective

The Contribution of Alexandrian Physicians to Cardiology

GEORGE ANDROUTSOS¹, MARIANNA KARAMANOU¹, CHRISTODOULOS STEFANADIS²

¹History of Medicine Department, ²First Cardiology Department, Hippokration Hospital, University of Athens, Medical School, Athens, Greece

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Address:
Marianna Karamanou

4 Themidos St.
145 64 Kifissia
Athens, Greece
e-mail:
[mariannakaramanou@
yahoo.com](mailto:mariannakaramanou@yahoo.com)

Alexandria was an important Greek cultural and intellectual center and its famous library used to contain more than five hundred thousand papyri. However, the medical school of Alexandria flourished as a result of the progressive decline of Cos medical school. Its fame was founded on the ancient Egyptians' access to medical knowledge, and mainly the practice of human dissection.

Prohibited by Greeks, human dissection was authorized in Alexandria during the first half of the third century BC. This parenthesis to history was closed after the renewed influence of religion opposed the handling of human corpses.¹ However, the period during which human dissection was authorized remains one of the most definitive moments in the development of medical thinking.

For the first time, Alexandrian physicians applied the teachings of Aristotle (384-322 BC), seeking to establish a corpus of theoretical medical knowledge, even though clinical practice (diagnosis and therapeutics) continued to follow the Hippocratic doctrines. Moreover, they explored the constitution and the functions of the human body (anatomy and physiology), entities almost unknown to the Hippocratic followers. Polybius (fourth century BC) writes that medicine was born in Alexandria, "medical theory became more important than dietetics, surgery

and pharmacology; physicians knowing theory enjoyed a reputation far surpassing that of other practitioners."²

This development could not have reached its full extent without the medical institutions founded in Alexandria by king Ptolemy I Soter (367-282 BC). Medicine left the medical families, in favor of state run institutions from which graduated a class of medical practitioners freed from the constraints of usual medical practice.²

The protagonists of the golden age of Alexandrian medicine

That medical revolution had four protagonists: two teachers, Praxagoras of Cos and Chrysippus of Cnidus, and their pupils, Herophilus of Chalcedon and Erasistratus of Chios. According to Aristotle these physicians, practicing anatomy and physiology, opened the "black box" of the human body.

Praxagoras of Cos (fourth century BC), influenced by Aristotle, adhered to cardiocentrism and considered the heart as the seat of the soul, of thought and psychic functions, a belief seen also in Ancient Egypt.³ In contrast to Aristotle, Praxagoras distinguished the veins from the arteries, not by the differences in their wall, but by examining the fluids flowing through them. According to Praxagoras, the veins contained blood and the arter-

ies, like the left ventricle, were filled with *pneuma*, vital spirit (air). He believed that the air transported by the pulmonary veins of the lungs to the heart was transformed into vapor thanks to cardiac heat. It was then sent through the arteries, explaining the phenomenon of pulse. In 330 BC, he presented the diagnostic value of the pulse, as a guide to illness.³ From the clinical and therapeutic point of view, Praxagoras remained faithful to the Hippocratic tradition.

On the other hand, Chrysippus of Cnidus (fourth century BC) is less known. He distanced himself from the Hippocratic method and became a follower of Aristotelian teachings. Around 350 BC, he attempted to reconcile the conceptions of Cos medical school and those of Empedocles of Agrigento (490-430 BC).³

Thanks to their pupils, Herophilus and Erasistratus, anatomical knowledge made tremendous progress during the short period when dissection of human corpses was allowed. However, their work is known through other writers, such as Galen and Celsus. According to Celsus (42 BC-38 AD): “As pain and various diseases originate in the inner part of the body, Herophilus and Erasistratus argue that no one can apply remedies to these parts if he ignores them. For this reason, it is necessary to open human cadavers and to examine the internal organs. Herophilus and Erasistratus did it as by far the best: they used to open the corpses of alive men (criminals) and to observe, while these men were still breathing, the human organs; their location, color, form, consistency, neighboring structures etc.”²

Herophilus of Chalcedon (323-285 BC) was born in the city of Chalcedon in Asia Minor and practiced medicine in Alexandria. Herophilus was considered by Galen (130- c.201) as a reference in anatomy. He was the first to practice dissections in human corpses and his research shocked his contemporaries. Public rumor accused him of practicing vivisection on those awaiting the death penalty and he was described as a “butcher who dissected six hundred persons in order to examine the human body.” Celsus defends him and justifies his actions: “It is not cruel to seek, by torturing criminals, cures for the innocent.”²

Herophilus was the first to use the term “venous artery” for the vessel that we call today the “pulmonary artery”. He described the carotid artery, the subclavian vein, the splanchnic vessels and the vessels of the genital apparatus. He also described the lymphatic system. He recognized the presence of blood in arteries, denied the role of the heart in respiration and, arguing that the heart is involved in the generation of

pulses, he studied the pulses’ intensity and rhythm, drawing conclusions about their clinical application in his treatise entitled *Manual of pulses*.⁴

Like his teacher Praxagoras, he believed that veins conducted the blood and the arteries the *pneuma*, arguing that the heart did not pump the *pneuma* into the arteries, but that the arteries attracted the *pneuma* by dilatation. In his masterpiece *Manual of pulses*, Herophilus makes an extensive study of the arterial pulse, referring to it as a water clock (“clepsydra”). However, some of his considerations regarding the pulses were already described in the papyrus of Smith and were well known before the establishment of Greek physicians in Egypt.

Herophilus rejected the “cardiocentric” system of Aristotle for the nervous one. He clearly differentiated the nerve endings of small vessels and located the origin of the nervous system at the level of the cerebellum and spinal cord.⁴

Erasistratus of Chios (310-250 BC), like Herophilus an anatomist, was also a great physiologist. The contribution of Erasistratus to our knowledge of cardiac anatomy is considerable. His conceptions were a curious mixture of progress and remarkable premonitions that approached very closely to the blood circulation theory, together with gross errors that are difficult to understand. He defended the idea that arteries contained *pneuma* (air), and in order to explain the phenomenon of blood spurting from a torn artery, he reasoned that venous blood forced its way to the artery through tiny connections.⁵

According to Erasistratus, the auricles were not part of the heart but were just a dilatation of the *vena cava*. He described the route of blood from the liver to the heart through the inferior *vena cava* and from the heart to the lungs through the arterial vein (pulmonary artery), and he was the first to report the role of the tricuspid and pulmonary valves.⁵ His principal contribution to cardiology consists of recognizing the role of the heart valves, as he realized that they ensured the unidirectional flow of blood. We owe to him a great anatomical description of vessels, renal arteries, mesenteric arteries, *vena cava*, pulmonary artery and venous valves.⁵

Discussion

Despite the significant progress made in anatomy, the works of the Alexandrian physicians contained a lot of digression and errors concerning heart physiology. They described the arteries and the veins, but

remained loyal to the ancient Greeks who believed that the veins contained blood and the arteries air. Although Erasistratus assumed “synastomoses” or communications between the arteries and veins, this was mainly to explain why an incised artery gave out blood. Willius and Dry recognize, on the other hand, that Erasistratus was the first to describe the venous valves.⁶ Galen, demonstrating the constant presence of blood in the arteries, explains the erroneous approach of Erasistratus.

Mistakenly, these Alexandrian physicians continued to believe that the liver was the place of blood formation. From there, it was transported to different organs by the *vena cava*, whose lower part passed by the right heart in order to nourish the lungs through the pulmonary arteries. For this reason, the role of the lungs in blood oxygenation was completely unknown. Even if they understood the simultaneity of the cardiac systole and arterial diastole, they did not conceive of attributing the dilatation of the arteries to a passive phenomenon due to the cardiac pulse.

Their mistakes would be largely repeated by Galen, whose doctrines dominated medicine for almost

1500 years, until 1628, when William Harvey (1578-1657) published his revolutionary discovery of the blood circulation.⁷

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