



Review

The cardiovascular system in the pre-Hippocratic era

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Abstract

Although Hippocrates has been traditionally recognized as the father of medicine and one of the major early writers regarding the cardiovascular system, very little is known of about the knowledge of the cardiovascular system in the pre-Hippocratic period. We reviewed the literature and examined available references regarding the cardiovascular system in the pre-Hippocratic era of the Chinese, Indians, Egyptians, and Ancient Greeks including Asclepius, Alcmaeon, Empedocles and Diogenes. All pre-Hippocratic civilizations attributed the illnesses and the structures of the human body to divine powers. Pre-Hippocratic medicine was largely based on religious beliefs and not in scientific observations. Interestingly, despite these erroneous methods, the pre-Hippocratics were able to identify pipes carrying air into the body and name the air carriers (arteries). Unfortunately, the arteries were not associated with blood but rather with air, however, this ancient word still remains in use in our days. This paper reviews the evolution of thinking and discovery regarding the different aspects of the cardiovascular system in the pre-Hippocratic era.

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Keywords: Ancient medicine; Cardiovascular system; Asclepius; Alcmaeon; Empedocles; Diogenes

1. Introduction

When researching the history of man's knowledge of the cardiovascular system, one finds many references to the small incremental contributions that provided the foundations for modern cardiovascular (CV) medicine. Such a pattern is seen throughout the history of science, yet fundamental questions regarding the CV system remain unanswered. Were any ancient investigators or cultures able to accurately describe the cardiovascular system? If not, then what ancient ideas have persisted into modern times? The beginning of medicine, especially in the pre-Hippocratic era,

is not easy to investigate because only a few historical fragments in disconnected quotations are available to us. We choose to divide these ancient periods into pre-Hippocratic and Hippocratic (and post-Hippocratic) periods for a major fact. Hippocrates developed medicine into a science and based this art on observation, experiments and critical thinking. "Pre-Hippocratic doctors" were very different in the approaches compared to Hippocrates. This paper presents the changing views of the CV system throughout antiquity.

2. Egypt, China, India and Mesopotamia

The earliest depiction of the heart is found in cave paintings. Singer described the Paleolithic bowman's explicit understanding of the heart's vital purpose [1]. In the cave paintings of Mas d'Auzil (in France, about 20 km west of Foix in the Pyrenees), an archer is shown selectively

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targeting his victim's heart with his arrows. Rather than being randomly riddled with arrows, the prey is specifically transfixated through this central CV organ, the heart.

Written reports exist that describe the ancient Egyptians' CV beliefs. Documents attributed to the 3rd dynasty (circa 2900 B.C.) discuss the heart as the center of the CV system and describe its beating and pulse [2]. Interestingly, the ancient Egyptians believed that the heart was the center of all of the body's channels, conveying not only blood but also air, urine, and feces [2,3]. Consequently, the Egyptian word "mt", translated loosely as "vessel" and whose hieroglyphic symbol was an erect penis, is used to mean artery, vein, tendon, muscle, windpipe, and nerve. The function of most of these "mt" was to bring air from the nose via the heart to all the parts of the body [1]. The Egyptologist Ebers provided the following translation of an Egyptian medical treatise: "as to breath which enters the nose, it enters into the heart and the lungs, and these give to the whole body" [1]. It is important to note that the ancient Egyptians were the first to associate air with the blood and the cardiovascular system. As will be seen later, the ancient Greeks of the pre-Hippocratic era continued to associate air with blood and the CV system.

However, according to many authors, the Egyptians were the first to establish the importance of the pulse and its relationships with the contractions of the heart [3–5]. Willerson and Teaf in their study quote the translation of the Ebers papyrus, by Ebbell in 1937, that an unknown physician was measuring the heart (measuring the pulse) in order to recognize its indications [4].

Wong and Wu describe the Nei Ching (2689–2599 BC), the ancient medical treatise of the Chinese Emperor Huang Ti (Hwang Ti) [6]. This text suggests that the Chinese had some understanding of circulation. More specifically, the Nei Ching stated that "the blood flows continuously and is under the control of the heart." Huang Ti divided the internal organs into five Tsangs and six Fus. The Tsangs were solid organs and included the liver, spleen, lungs, kidneys and heart, while the Fus were hollow organs [6–8]. However, it is difficult to understand, though, if "solid" and "hollow" are used as distinguished criteria, why the lung and heart should be grouped together with the liver and the spleen. According to Unschuld, Tsang and Fu are two examples of culture-bound terms reflecting culture specific concepts and carrying environmental images to illustrate these concepts [9]. Dzitkowiak in his study reported that in China the blood was one of the chief doctrines and that the Chinese distinguished between 28 different types of blood pulse [10].

Medical education in ancient India was restricted by birthright, with only members of the priestly Brahmin caste being permitted to study and practice medicine. The Organon of Medicine, or collection of medical knowledge, was a book entitled "Vagadasastir". It was not systematically arranged, and demonology played a large role in this ethno-medical system. It was believed that the human body consisted of 100,000 parts, of which 17,000 were vessels. Each one of these vessels was composed of seven tubes which could give

passage to ten species of gas. These gasses and vessels were central to their ideas of pathogenesis and diseases and arose when characteristics of these gasses conflicted with each other. Unlike the Egyptians and Chinese, Indians mistakenly placed the origin of the pulse in a reservoir located behind the umbilicus. This reservoir was described as being four fingers wide by two long, dividing into 72,000 canals as it distributed blood to all parts of the body [8,11].

Similarly, accounts of surgical procedures were recorded by the early Mesopotamian civilizations. These procedures seem to convey an understanding of anatomical knowledge. The code of Hammurabi (circa 1950 B.C.), perhaps the Amraphel of Scripture history (Genesis xiv, 1), described a complex surgical procedure and knowledge of the heart [8,11].

3. Asclepios

The earliest Greek references to anatomy and physiology occurred in the writings of Homer (circa 900 BC) and Hesiod (circa 750 BC) [1]. During the period preceding the Trojan War (circa 1300 BC), there was little but myth and tradition in regards to these basic sciences. Leclerc catalogued some thirty divinities, heroes, or heroines who were supposed to have developed some branch of medicine in the Greek ethno-medical system [11].

The most famous of these deities during the pre-Hippocratic period was Asclepios, the Greek God of the healing arts (Fig. 1). Asclepios is also known by his more familiar Roman name, Aesculapius, although Asklepios or Asclepios is the preferred spelling owing to its closer translation from the original Greek spelling "Ἀσκληπιός" [12]. According to the earliest known writings on this topic (circa 1500 B.C.), Asclepios was the son of Apollo and his mortal mistress Coronis. Apollo killed Coronis in a fit of jealous rage after she was unfaithful to him, but as her body was placed on the funeral pyre, Apollo discovered that she was pregnant. Stricken with remorse, Apollo delivered their unborn child, Asclepios, from her womb and gave him to the centaur Cheiron to raise and train him in the art of healing [13]. Unfortunately, Asclepios could not save himself from the obligatory tragedy of the Ancient Greeks and died by violence, symbolically showing that even the greatest medicine cannot indefinitely ward off death (Zeus stroke him with a thunder). Asclepios became the symbol of the healer in ancient Greek society and, later, throughout the Roman Empire. For centuries, physicians were referred to as followers of Asclepios. Hippocrates referred to himself as such and appealed to Asclepios in the first line of the Hippocratic Oath (Fig 1). Asclepieia were temples dedicated to Asclepios which sprang up around the Mediterranean and served as therapeutic centers to the local citizenry [14,15]. One such sanctuary of Asclepios existed on the island of Kos. Pre-Hippocratic medicine was based on religious belief, surgery, and regimen (Fig. 2). The physician was closely connected with religion and was, predominantly, an herb gatherer.

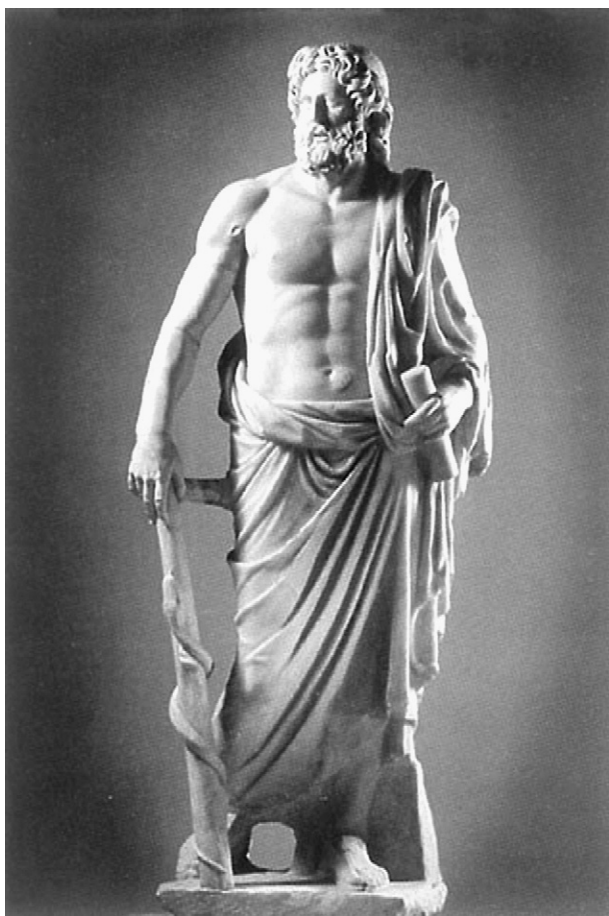


Fig. 1. A sculpture of Asclepius, from the Italian National Archeologic Museum in Rome.

The poet Pindar (Πίνδαρος), who lived 700–800 years after Asclepius, stated that he cured wounds, fever and pain. In addition, in order to heal a wound someone must be aware of the vascular system, Asclepius is often depicted as a surgeon, holding a surgical knife or even performing surgery [13].

During the Trojan War two men, Machaon and Podalirius, were frequently mentioned by Homer as possessing great surgical skills. They were regarded as sons of Asclepius and were proponents of venesection [11]. The first Greek doctors also knew how to treat wounds and unavoidably combined practical methods with magical incantations, as we note in Homer's *Odyssey* (Od. 19.455–8). Homer here reports that Odysseus' wound was bandaged, the flow of blood being checked by means of an incantation [16]. Asclepius daughters, Hygeia and Panacea, were remembered for their healing abilities and were made goddesses. Hygeia was the goddess of health and became almost as famous as her father. Panacea (means to cure all) was the goddess of remedies and herbal preparations that relieved pain or cured illness [17].

4. Alcmaeon

The first Greek writer on medicine was Alcmaeon (500–450 B.C.), who is said to have been a student of Pythagoras

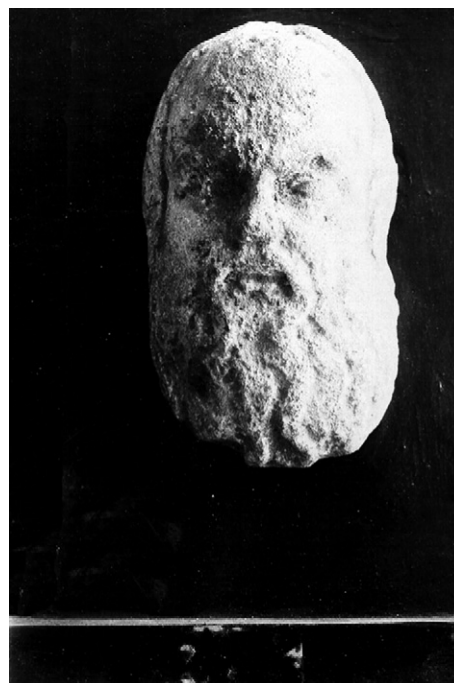


Fig. 2. A facial sculpture of Hippocrates, from the Greek National Archeologic Museum in Athens.

and a native of the Greek colony of Croton in southern Italy [18] (Fig. 3 Clendening Library Portrait Collection). Debate surrounds Alcmaeon's dissection practices, with some historians contending that he practiced dissection of injured persons while others maintaining that he practiced dissection only on cadavers [19]. His importance rests on three fundamental contributions to medical thinking. Firstly, the



ALCMAEON Crotoniates Pirichi filius septuagesima vixit Olympiade. Pythagoram audiuit, & vt plurimum in medicina versatus est. Disputauit de natura, dicens multas rerum humanarum causas. Primus de naturæ ratione scripsit. Sempiternam naturam Lunam habere dixit: animam verò immortalem, moueriq; perpetuò instar Solis.

Fig. 3. The picture depicts Alcmaeon. Clendening Library Portrait Collection.

concept of the brain as the seat of consciousness; secondly, his recognition of separate arterial and venous systems; and thirdly, his theory of disease as the “unbalance” of opposite qualities [20]. Theophrastus, in his treatise “De Sensu”, tells us that Alcmaeon taught that all the senses were somehow connected with the brain. (διό καί πηρουσθαι κινουμένου καί μεταλλάττοντος τήν χωραν επιλαμβάνειν γάρ τους πορους διωναί αἰσθήσει ς) [21].

Furthermore, Harris believed that the main ideas expressed in the Hippocratic treatise, “On the sacred disease,” were derived from Alcmaeon, whom he looked upon as the originator of the notion that “πνεύμα-pneuma” (spirit) was breathed directly into the brain through the vessels [18]. In addition, Alcmaeon described the distinction between arterial veins (αἰμορροὶ φλέβες) and venous veins (φλέβες) without qualification, and implicated them in the theory of sleep. According to Aetius, Alcmaeon theorized that sleep occurs through the retreat of blood into the blood-running veins, and that awakening occurs through its dispersal and that complete retreat results in death. (Αλκμαίων ἀναχωρήσει τὸν αἵματος εἰς τὰς αἰμόρρους φλέβας ὕπνον ἵνεσθαι φησι, τήν δέ ἐξέγερσιν διάχυσιν, τήν δέ παντελή ἀναχώρησιν θάνατον) [18] Lastly, Alcmaeon believed that all blood vessels originated in the head [22]. This excited a great curiosity as to the distribution of the vessels and led his followers such as Acron (about 480 B.C.) and Pausanias (about 480 B.C.), the contemporary of Plato, to make anatomical investigations [1].

5. Empedocles

Empedocles (492–432 B.C.) a native of the Greek colony of Acragas in Sicily, provided a basis for ancient Greek science with his theory of the four elements which remained the most generally accepted hypothesis during the whole of the classical age (Fig. 4). However, his relationship with the cardiovascular system was derived from his notion of respirations through skin pores. According to Aristotle Empedocles stated [23]: “γίγνεσθαι δέ φησι τήν αναπνοήν ἰ εκπνοήν διὰ τὸ φλέβας εἶναι τινας, ἐν αἷς ἐνεσσι μὲν αἷμα, οὐ μὲντοι πλήρεις εἰσὶν αἵματος, ἔχουσι δέ πορους εἰς τὸν ἔξω αέρα, τήν μὲν τοῦ σώματος μορίων ἐλάττους, τῶν δέ τοῦ αέρος μεῖζους, διό τοῦ αἵματος πεφυκὸς κινεῖσθαι ἄνω καὶ κάτω, κάτω μὲν φερομένου, εἰσρεῖν τὸν αέρα, καὶ γίγνεσθαι αναπνοήν ἄνω δ'ιόντος, ἐκπίπτειν θύραζε, καὶ γίνεσθαι τήν εκπνοήν, παρεϊκάζων τὸ συμβαίνον ταῖς κλεψύδραις: the inspiration and expiration take place because there are certain blood vessels in which there is some blood, though they are not filled completely with blood. They have passages to the outside air, smaller than the particles of the body, but greater than those of air. Wherefore, since blood has a natural motion of up and down, when it moves down the air flows in, and inspiration takes place. When the blood goes up, the air is expelled outwards and expiration takes place. He compares the process to the working of the water clock”.



Fig. 4. Empedocles.

Empedocles wrote of pipes (syringes) through which air was sucked into the body. These pipes were described as being too narrow to permit the passage of blood through their terminations, but these blood-impermeable pipes were described as being continuous with blood vessels (of which he provides no description, nor of their connections with the heart). Empedocles seems to have conceived the blood vessels as ending in capillaries opening into the pores of the skin; the word poros (πόρος) means channel [18].

According to Cicero, Macrobius, and Tertullian, Empedocles believed that the blood was the vehicle for the soul. Some other reports expressed his view that the blood carried not the soul, but the “innate heat” — the blood is life [7]. His teaching led to the belief that the heart was the centre of the vascular system and the chief of the “pneuma” (spirit), which was distributed by blood vessels. This pneuma was equivalent to both the soul (frenes-φρένες) and life and was identified by air and breath.

Similarly Pythagoras taught that the soul was divided into three parts: into νοῦς, means consciousness, φρένες, means mind or soul and θυμός, means emotion or anger. The principle of the soul or life was located in and moved from the heart to the brain, the emotional part existed in the heart, but both consciousness and mind were seated in the brain [18]. It also interesting to note that frenes (φρένες) stands for both soul and heart. The word schizophrenia literally translates into split soul or split heart, because the emotions existed in the heart.

In addition, Alcmaeon and Empedocles, developed theories regarding the principal element from which the universe composed. The four humors: blood, phlegm, black bile and yellow bile in addition to hot, cold, moist and dry compose the elements of the universe [24,25].

6. Diogenes

Diogenes of Apollonia (425 B.C.) was influenced by Empedocles and believed that the universe was composed of a single substance, “air.” He was also the first physician known to make a systemic description of the vascular system. However, there is debate among historians as to whether Diogenes’ description was the first [18]. Aristotle reported that before Diogenes, Syennesis of Cyprus described the blood vessels. Syennesis believed that the main blood vessels started from the head, and continued into the thorax as a kind of chiasma, passing from left to right and right to left sides of the body. No mention was made of the heart by either Diogenes or Syennesis. Diogenes explained that the body contained two large veins that stretched through the abdomen along the spine, one to the right and one to the left. Each of them extended to the corresponding leg and reached to the head. From these two, veins branched off and extended to the whole body. Furthermore, the two largest veins each had large branches leading to the heart. Diogenes did not distinguish between arteries and veins, both being called φλέβες (“phlebes”, or veins) [18]. The word *arteria* was not used for the simple reason that *arteria* means wind pipe (αἶρ τέρυν). The first person to correctly distinguish between the two types of blood vessels was Praxagoras of Kos in 330 B.C. The anatomical difference between the two kinds of blood vessels would later be described by Herophilus.

Diogenes was one of the founders of the theory that *pneuma* co-existed with, and moved, the blood within the blood vessels. Erhard and Krause came to the conclusion that Diogenes believed that certain parts of the body contained air, including empty arteries and the empty left ventricle of the heart [26]. They concluded that Diogenes surmised that these were part of the brain, the seat of sensation and intelligence.

7. Conclusion

Fundamental questions regarding the CV such as “Were any ancient investigators or cultures able to accurately describe the cardiovascular system?” From our historical investigation, none of the civilizations in the pre-Hippocratic era described the cardiovascular system satisfactory. The main reason stems largely from the fact that all pre-Hippocratic civilizations attributed the illnesses and the structures of the human body to divine powers. Furthermore, the pre-Hippocratic medicine was based on religious belief, on surgery and on regimen. The physician was closely connected with religion and was predominantly, an herb gatherer [25]. Interestingly enough, few words in modern medicine are true curiosities related to

erroneous beliefs about physiology and anatomy that were held by such ancient people. The best examples are the words “arteries” and *phrenos* (schizophrenia, phrenic nerve etc). However, we were able to observe the evolution of thinking and discovery regarding the different aspects of the CV in the pre-Hippocratic era.

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