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Review Article

Anatomy of Blood Vessels in Greeko-Arab Medicine: A Review of Classical Texts

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Abstract

Understanding the evolution of cardiovascular knowledge requires exploring the classical insights of Greek and Arab physicians. This study examines historical perspectives on arteries, veins, blood, and pneuma from early Greek philosophers like *Alcmaeon* and *Buqrāt* (Hippocrates) to *Jalinūs* (Galen), and their subsequent refinement by Arab scholars such as Ibn Sīnā (Avicenna) and *Ibn Al-Nafīs*. The study reveals the contributions of Greek and Arab scholars to the understanding of vascular anatomy and function, including the concept of pneuma, the distinction between arteries and veins, and the idea of blood circulation. The results of the studies and experiments conducted by the ancient Greek and Greeko-Arab scholars led to a greater understanding of the anatomy and function of blood vessels, including the discovery that arteries contain blood and the differentiation between arterial and venous blood. Through critical analysis of classical texts of *Herophilūs*, *Erasistrātūs,* Jalinūs*, and Rabbān al-Tabarī,* this paper highlights how translation, observation, and commentary shaped the foundational concepts of vascular anatomy and function. The study highlights the continuity and transformation of vascular concepts across eras, emphasizing their impact on modern vascular anatomy as well cardiovascular physiology. These insights underscore the importance of historical perspectives in comprehending current medical knowledge and may inform future integrative approaches in medical education and research.

Keywords: Blood Vessels, Vascular Anatomy, Pulmonary Circulation, Capillary Network.

INTRODUCTION

The Greco-Arabic era forms the historical backbone of Unani medicine, representing a period where classical Greek medical knowledge was preserved, translated, and significantly expanded by Arab and Persian scholars. Unani medicine (Tibb-e-Unani) traces its origins to the teachings of *Buqrāt* (460–377 BCE), *Arastū* (384-322 BCE), *Herophilūs* (335-280 BCE), *Erasistrātūs* (304-250 BCE), and *Jalinūs* (129–200 BCE), whose theories on humors, anatomy, and physiology laid the foundation of this medical system. During the medieval era of Islamic scholarship, renowned physicians including *Rabbān al-Tabarī* (838-870 CE), *Zakriyā Al-Rāzī* (854–925 CE), *Ibn Sīnā* (980–1037 CE), *Al-Zahrāwī* (936–1013 CE), *Abū Al-Ḥasan Aḥmad Ibn Moḥammad Al-Ṭabarī* (?-978 CE), *Ibn Hubal Baghdādī* (1122-1213 CE), *Ibn Al-Nafīs* (1213–1288 CE), and *Ibn al-Quff* (1233–1286 CE) made significant contributions. Through their detailed writings and practical medical insights, they shaped Unani medicine into an organized and holistic system of healthcare [1].

Within this era, Unani medicine evolved as a herbo-animo-mineral system, with nearly 90% of its formulations derived from plants, 4–5% from animals, and 5–6% from minerals. Beyond its therapeutic applications, the Greco-Arabic period of Unani medicine emphasized philosophical principles, clinical reasoning, and holistic care, leaving a profound legacy that influenced both medieval and early modern medicine [1].

Ibn Sīnā, widely recognized as *Ibn Sīnā* (Avicenna) and a prominent authority in Unani medicine, emphasized that medical study should concentrate on identifying organs and understanding their respective functions, which correspond to anatomy and physiology [2].

In the modern era, the heart is often considered the king of the body, supplying blood to various organs [3]. The heart functions not only as a muscular pump but also influences both the physical and mental well-being of the human body [4]. The cardiovascular system operates as a closed network of blood vessels, where blood is circulated by the contractions of the heart. It consists of two primary circuits; pulmonary and systemic, comprising arteries, capillaries, and veins [5].

The heart has traditionally been seen as the center of life. While the ancient Egyptians considered the heart to be the center of cognitive reasoning, emotion, will, and intention, the ancient Mesopotamian cultures saw it as the home of the soul, motivation, and conscience [6]. *Arastū* (Aristotle) later proposed that the heart was the locus of sensation. The heart is intricately linked to sensation, attitudes, acquaintance, ailments, desires, faithfulness, deeds, and intentions [3].

According to *Empedocles* of Agrigento (5th century BC), the heart was regarded as the center of pneuma, encompassing both breath and soul. He proposed that the vital force of the body was associated with its "innate heat," which was disseminated by the heart [7]. The belief in the heart as the center of intellect likely arose from the observation that life endures while the heart beats, but ceases once its activity stops [8]. Plutarch documented that Alcmaeon expressed the idea that: "*When blood completely withdraws from the vessels, it results in the death of the individual''* [8, 9].

According to *'Ali ibn Sahl Rabbān al-Tabarī* in his book "*Firdaus ul Hikmat*," the heart is considered the center of "*Hararat-e-gariziya*" (vital heat) and life [10]. *Ibn Sīnā* also emphasizes the importance of the heart by proposing that it serves as the source of psychic and emotional activities by regulating the supply of blood or breath to every part of the body, including the brain [3].

MATERIAL AND METHODS

This study employs a qualitative historical-comparative approach, relying on literature review and textual analysis of classical Greeko-Arabic sources and secondary academic references. The methodology includes the primary classical Unani sources, including *Sharh al-Tashrīh al- Qanūn, Kitab al-Tashrīh, Al-Qanūn fī al-Tibb, Firdos-al-Hikmat, Kitāb al-Kulliyāt, Al-Moālijāt Buqrātia, Kitāb al-Umda- fī al-Jarahat, Kitāb al-Hāwi, Kāmil-al-Sanā, and Kitab-al Mukhtarāt fī al-Tibb* etc. Secondary sources include a thorough review of scholarly journals, research articles, and contemporary publications, thereby creating to establish a comprehensive framework that not only draws upon historical insights but also effectively connects them with contemporary academic discourse and emerging ideas. The extracted information was analyzed and compared to trace the evolution of cardiovascular knowledge, highlighting conceptual continuity, modifications, and advancements from the Greek to the Arab period.

Objectives

The primary objective of this research paper is to provide a comprehensive review of the anatomical descriptions and conceptual frameworks concerning blood vessels in Greeko-Arab medicine, through the analysis of classical medical texts authored between the 4th century BCE and the 13th century CE.

The secondary objectives are as follows:

1. To explore the origins and structural understanding of arteries, veins, and capillaries as described by Greek physicians such as *Buqrāt*, *Herophilūs*, *Erasistrātūs*, and *Jalinūs.*
2. To examine how Arab scholars—such as *Ibn Sīnā*, *Ibn Al-Nafīs*, *Ibn al-Quff*, and *Rabbān al-Tabarī* —adopted, modified, or challenged Greco-Roman anatomical concepts.
3. To describe the development of the concept of blood circulation prior to the discoveries made by William Harvey

LITERATURE REVIEW

Alcmaeon

According to the principles outlined in the Hippocratic work, "On the Sacred Disease," Alcmaeon is recognized as the originator of the notion that "pneuma" or vital spirit is delivered to the brain via the vessels [11]. From Alcmaeon's viewpoint, the fundamental role of all vessels was to convey this pneuma to the brain [12].

Empedocles

Empedocles, a pre-Socratic philosopher-physician, made one of the earliest recorded attempts to explain the function of blood in the human body through the lens of his cosmological theories. Although anatomical precision was absent in his time, his ideas laid philosophical groundwork for later medical thought. According to him, blood vessels distributed the "pneuma," which was absorbed through pulmonary respiration and became a part of the body's internal processes [12].

Empedocles held the belief that in all animals, there are flesh tubes devoid of blood that extend across the body's surface. These tubes have openings on the outermost layer of the skin, which are densely arranged. This arrangement hides the blood while providing unobstructed passages for the air through these openings [12, 13]. According to his idea, these tubes facilitated the

intake and release of air as the blood moved up and down within the vessels. This notion became important when the later distinction between air and blood carrying vessels (ie, arteries and veins) was made [14].

According to *Empedocles*' thoughts, the heart is the primary channel that carries the "pneuma" (spirit) and serves as the center of the circulatory system [11]. Furthermore, he regarded blood as a mixture of the four elements (earth, air, fire, and water), asserting that life processes, including nutrition and sensation, depend on their balance and interaction within the blood (Guthrie, 1962). Even though it is symbolic, this essential perspective on blood and its flow through the body demonstrates how metaphysics and physiology were first integrated in Greek thinking, opening the door for more scientific research by later scholars like *Herophilūs* and *Jalinūs* [15].

Diogenes

Influenced by *Empedocles*, *Diogenes* expanded on the concept of pneuma, asserting its movement within the vessels alongside blood. According to his beliefs, certain parts of the body, such as the empty vessels known as arteries and the vacant left ventricle of the heart, contained only air [7].

Buqrāt

Buqrāt (Hippocrates) identified two types of vessels. Firstly believed to carry air to the left ventricle, these vessels are now known to be the pulmonary veins, which transport oxygenated blood from the lungs to the heart. An additional important conduit, now known as the pulmonary artery, sent blood to the lungs and air to the right ventricle at the same time [12, 16].

Arastū

Arastū (Aristotle) observed the existence of "ducts" that connected the right and left ventricles to the lungs, carrying air or breath to the heart [12, 17]. In modern terms, these ducts closely correspond to what we now call the pulmonary artery and veins [16].

Praxāgoras

He was the pioneering Greek physician who made a significant contribution to the field of anatomy by being the first to clearly differentiate between arteries and veins, establishing a foundational understanding that would influence future medical study and practice. Instead of distinguishing them anatomically, he categorized them based on the material they were thought to contain [16]. He made a distinction between veins and arteries based on the erroneous assumption that veins carried blood and arteries transported pneuma [12, 18]. This belief was formed due to his observations of the emptiness of arteries in dissected animals, particularly those killed by strangulation [19].

Herophilūs

Herophilūs, a renowned physician, distinguished arteries from veins based on structure and function. He observed thicker, more elastic walls in arteries, while veins were thinner [20]. Despite these structural differences, he believed arteries contained pneuma (vital spirit or air) [21]. while veins carried blood [18, 21]. *Herophilūs* associated the pulse with arterial activity, contributing to early cardiology. He believed arteries had intrinsic pulsatile movement, separate from the heart's action. *Herophilūs* used direct observation through dissection to describe the vascular system, rejecting speculative theories. He also mixed understanding of vessel contents, believing veins originated from the liver and carried nutritive blood, while arteries originated from the heart and distributed pneuma (vital spirit).

Erasistrātūs

Erasistrātūs posited that arteries functioned as "pneumatic" conduits, carrying "pneuma" or air and vital spirits but devoid of blood, with veins being the exclusive vessels containing blood [16]. According to him, the major artery, vital in the circulatory system, stores the subtle spirit, symbolizing life's essence. The major vein, responsible for blood circulation, returns vital fluid to the heart, highlighting the connection between physical and metaphysical aspects [22].

Erasistrātūs made the discovery that arteries and veins undergo continual subdivision into smaller and more intricate vessels throughout the body [23]. Small vessels, known as synanastomoses or capillaries, were difficult to distinguish due to their fine points, preventing blood from crossing veins and arteries. Erasistrātūs observed these vessels consistently filled with blood [12, 23, 24].

In accordance with his teachings, it was expected that blood would be expelled from the arteries through the same passage it entered [25]. He adhered to the belief, influenced by Straton and Praxagoras, that arteries, under normal conditions, contained not blood but a refined and transformed form of air, almost like a vital, life-giving spirit crucial for an organism's existence [23, 26]. He developed a theory suggesting that the presence of synanastomoses allowed blood to flow from veins to arteries [25]. He acknowledged that, in a healthy state, the contents of veins and arteries did not mix. However, he believed that disturbances in the system could cause blood to pass from veins to arteries, leading to fever and inflammation [22].

Nevertheless, *Erasistrātūs*, drawing on his practical experience, acknowledged that when an artery was incised in a living organism, blood would forcefully spurt out. To explain this seemingly contradictory phenomenon, he proposed that upon opening an artery, all the pneuma (air or vital spirit) within it would rapidly

escape, creating a vacuum in the arterial system. The resulting suction created by the vacuum caused an immediate influx of blood from the veins through the anastomoses, which linked the fine ends of the arteries and veins. Consequently, Erasistrātūs considered the general anastomosis of the fine branches of arteries and veins as a necessary element in his physiological theory [19, 23]. In this regard, *Erasistrātūs* shared a position parallel to Cesalpinus, who, preceding Harvey, held the belief that arteries transported vital spirits to the tissues [23].

Jalinūs

In the 2nd century AD, *Jalinūs*, a physician for gladiators, conducted dissections and experiments on animals, providing evidence that arteries contained blood, contrary to the prevailing belief in the presence of air [12,27,28]. He initially adhered to the belief that arteries contained air and vital spirits were thought to circulate through the arteries, while veins were believed to transport blood continuously produced in the liver [29]. *Jalinūs* (Galen), in 'De Usu Partium Corporis Humani', argued that arteries and veins transport blood, challenging the belief that arteries only carried air and further rebutting the notion of pneuma [19, 26, 30].

Erasistrātūs believed arteries were filled with air, while *Jalinūs* (Galen) confirmed blood presence in all body arteries through experiments. He observed that arteries, visible in living animals, contained blood [31]. Jalinūs made an incision in an artery, revealing blood flow from both veins and arteries. In another experiment, he cut a small artery, demonstrating blood flow from both veins and arteries, as described in De Motu Cordis, when he stabbed the left ventricle, blood immediately spurted upon withdrawal of the blade, and the scalpel was stained with blood, regardless of how quickly it was withdrawn [19, 32, 33]. The presumed movement of blood from veins to arteries due to an incision required clarification [34]. *Jalinūs* addressed the fundamental question of whether the blood that emerges from an artery is inherently present in it or if it simply flows into the artery from another source [35].

In this context, *Jalinūs* directly challenges *Erasistrātūs*' proposition that the blood flowing from an opened artery is not naturally contained within it but enters from the veins. If this were accurate, according to Erasistrātūs, the escape of pneuma (air or vital spirit) should precede the flow of blood. Contrary to this expectation, blood immediately emerges from the incised artery. According to *Jalinūs*, if *Erasistrātūs*' hypothesis were valid, the continuous pumping of pneuma by the heart into the arteries should be sufficient to replenish any minor loss through a small incision, thus preventing any requirement for blood to fill a vacuum. Moreover, if all the pneuma could escape through a small arterial wound, it should result in a significant and widespread disturbance in the body, which, according to Jalinūs, does not occur. Therefore, he dismisses *Erasistrātūs*' idea as untenable [19].

Jalinūs observed and emphasized the qualitative difference in appearance between blood found in arteries and veins [31,35]. He classified blood into two types: spiritual blood, also known as arterial blood, found in the left heart, and venous blood, found in the right heart [19]. According to Jalinūs, arterial blood in arteries is hotter, thinner, and more spirituous compared to venous blood in veins [31]. He theorized that spiritual blood nourishes organs with light and delicate textures, such as the lungs, while venous blood nourishes organs with heavy and gross textures, like the liver [30].

Abū ʾAlī al-Ḥusayn Ibn ʿAbd Allāh ibn Sīnā

Ibn Sīnā described two primary types of blood vessels; arteries (*sharāyīn*), which carried vital, spirit-infused blood from the heart, and veins (*urūq*), which transported thicker, nutritive blood originating from the liver [20]. The heart is the source of vital heat and rooh, which is distributed throughout the body via the arteries [36, 37]. Ibn Sīnā recognized a relationship between the lungs and the heart, noting that blood moves between them for refinement [38]. He conceptualized *rūḥ* as a subtle, gaseous form derived from air that travels in the arteries to sustain life functions, aligning with oxygen in modern physiology [39].

Abū'l-Hasan 'Ali ibn Sahl Rabbān al-Tabarī

Al-Tabarī, one of the earliest Persian physicians of the Islamic Golden Age, contributed significantly to the anatomical understanding of the vascular system in the context of Greeko-Arab medicine. He highlighted the presence of *rūḥ ḥaywānī* (vital spirit) in the vessels emerging from the heart and liver, underscoring their central role in sustaining life and bodily functions. According to his interpretation, arteries (emanating from the heart) carry a higher concentration of rūḥ ḥaywānī compared to veins, which mainly contain thicker blood with less vitality [11]. This concept parallels the modern understanding, in which arteries carry oxygenated blood and veins return deoxygenated blood to the heart" [39, 40].

Ibn Al-Quff Masihi

Ibn al-Quff (1233–1286 CE), a prominent 13th-century Arab surgeon and physician, made critical contributions to the anatomical understanding of blood vessels. In his surgical treatise *Kitab al-'Umda fi al-Jiraha*, he described blood vessels not only as physical conduits but also as carriers of essential life-sustaining substances. He accurately distinguished between arteries and veins, emphasizing their structural differences—arteries being thicker and more resilient due to the pressure of blood propelled by the heart, while veins were thinner and carried blood returning to the heart [41, 42].

Moreover, Ibn al-Quff emphasized the origin of arteries from the heart and veins from the liver, aligning with Jalinūs (Galen) belief, yet he supplemented this with clinical observations. He also noted the branching patterns of vessels and their role in nourishing tissues, foreshadowing later developments in vascular physiology. His anatomical explanations were deeply influenced by Jalinūs (Galen) views but also enriched by surgical observations and rational analysis [39, 43].

Comparative Table: Historical Theories on Blood Vessels

Physician / Scholar	Period	Vessel Structure	Circulation Concept	Functional Role of Vessels	Anatomical Accuracy	Methodology	Key Contributions
Empedocles	5th c. BCE	*Poroi* (invisible channels)	No true circulation; elemental flow	Blood carries life and sensation; blood around heart is seat of thought	✗ Philosophical	Speculative philosophy	Introduced *poroi* as early concept of internal flow
Diogenes of Apollonia	5th c. BCE	Fine *poroi* for air	Air moves via channels, not blood	Vessels distribute *aēr* (air = soul/intelligence)	✗ Abstract model	Rational speculation	Unified air and vessel theory; proto-respiratory system
Buqrāt	5th–4th c. BCE	2 main vessels (*phlebes*) from head	No circulation; one-way flow	Vessels carry blood, pneuma, and waste; linked to humoral balance	Δ Functional, not structural	Clinical observation	Pulse theory; empirical treatment methods using vessels
Paraxogoras	5th c. BCE	Vessels carry mixture of *nous* (mind)	No detailed vessel theory	Vessels support mixture of mind and matter	✗ Philosophical	Abstract cosmology	Advanced early brain-based thought theory
Arastū (Aristotle)	4th c. BCE	Heart as origin of vessels	Blood moves via heart's pulsation, not in a circuit	Vessels distribute nutritive heat from heart	Δ Mixed anatomy/philosophy	Observation and dissection of animals	Distinguished arteries and veins; heart as vital center
Alcmaeon of Croton	5th c. BCE	Channels from brain to organs	No circulation; fluid flow from brain	Vessels connect brain and senses	Δ Primitive neurological insight	Animal dissection	Brain as center of thought; early concept of optic nerve
Herophilūs	4th–3rd c. BCE	Clear distinction: arteries, veins, nerves	No true circulation	Veins carry blood; arteries carry pneuma	✓ First detailed anatomy	Human dissection	First to distinguish arteries/veins/nerves; pulse origin in arteries
Erasistratūs	3rd c. BCE	Arteries, veins, tiny anastomoses	No circulation; arteries = pneuma, veins = blood	Vessels work like a pump system; heart is mechanical	✓ Accurate for time	Human dissection	Valves in heart; capillary-like theory; early physiology
Jalinūs (Galen) (Jalīnūs)	2nd c. CE	Arteries and veins; invisible pores in heart	Blood produced in liver; no circulation; cross over in heart	Arteries carry blood + pneuma; veins from liver	Δ Mixed: some correct, some flawed	Animal dissection	Dominated theory for 1400 years; venous and arterial mapping
Ibn Sīnā (Avicenna)	10th–11th c. CE	Arteries and veins mapped	Adopted Jalinūs (Galen)ic liver-heart model	Vessels distribute nutrition and vital spirit	Δ Based on Jalinūs (Galen) with refinements	Theoretical, clinical	Canon of Medicine; harmonized Greek and Islamic medicine

Ibn al-Quff	13th c. CE	Detailed arterial/venous anatomy	Galenic, but surgical accuracy	Surgical relevance: bleeding, pulse, vessel repair	✓ Highly detailed for time	Observation and surgical experience	Advanced surgical anatomy; clinical descriptions of vessels

Symbol indication:

✓ = Accurate or advanced for time

∆ = Partially accurate or conceptually valid

✗ = Speculative, inaccurate, or symbolic

DISCUSSION

The ancient Greek and Greeko-Arab scholars held diverse and evolving views on the anatomy and function of blood vessels, influenced by both observation and philosophical reasoning. The word "artery" originally meant "air carrier" in Greek, reflecting the early belief that arteries transported air or pneuma (*rūh*) rather than blood. In Unani medicine, ruh is understood as a gaseous life-sustaining substance derived from inspired air (comparable to modern oxygen), crucial for metabolism, organ vitality, and innate heat (*Harārat gharīziyah*). Thus, the concept of pneuma (*rūh*) bridges classical Greek thought and Unani physiology.

Early thinkers like *Alcmaeon, Empedocles*, and *Diogenes* theorized that vessels distributed pneuma to the brain. While not anatomically accurate, these views foreshadowed the role of oxygenated blood in brain function. Erasistrātūs and Empedocles mistakenly thought that arteries solely held air, whereas Herophilūs acknowledged that they were full of the two substances blood and pneuma, suggesting a dual functioning concept. *Praxāgoras* attempted to distinguish arteries (carrying pneuma) from veins (carrying blood), a concept partially refined in modern times with the understanding that arteries carry oxygenated blood.

Jalinūs, a physician, made a significant discovery in medical science by proving that the left ventricle of the heart and arteries are filled with blood, rather than air. This led to a deeper understanding of the circulatory system and the concept of arterial versus venous blood. *Ibn Sīnā,* a philosopher and physician, also proposed that arteries serve as conduits for intrinsic body heat, further highlighting the relationship between the cardiovascular system and bodily homeostasis. *Rabbān al-Tabarī* and *Ibn Al-Quff Masihī* further differentiated vessels based on the presence of rooh haiwani (vital spirit), conceptually similar to oxygen-rich blood, especially in major arteries like the aorta and pulmonary vessels.

CONCLUSION

The Greeko-Arab scholars laid important philosophical and observational foundations for vascular anatomy. Although early interpretations often lacked physiological accuracy (e.g., air in arteries), intellectuals like *Jalinūs* (Galen), *Ibn Sīnā*, and others progressively refined the concept of blood flow, vessel differentiation, and the vital role of oxygen (ruh). Their work greatly influenced the development of Unani medicine, and many of their anatomical insights—especially on the role of arteries in nourishment and heat regulation—are now validated by modern circulatory science. Their evolving theories ultimately paved the way for more accurate understandings of the vascular system, making them significant contributors to the historical evolution of cardiovascular physiology.

Conflict of Interest

The authors declare that there are no conflicts of interest to disclose in relation to the publication of this manuscript.

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Ethical Statement

The authors indicated that ethical approval was not necessary for this study, given its nature as a review. Nonetheless, we have taken care to ensure that all data sources employed are duly acknowledged and cited in compliance with established academic standards.

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