

# Ibn Al-Nafis - The First who described the Pulmonary Blood Circulation

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Keywords: Ibn al Nafis, Pulmonary circulation, History of medicine

## Abstract

The history of the discovery of pulmonary circulation is a complex one. Although this discovery is attributed to Servetus, Vesalius, Colombo and Harvey, the pioneering role of Ibn Al-Nafis al Quraishi, a 13<sup>th</sup> century physician and scholar deserves more attention. This article examines his contributions to the discovery of pulmonary circulation and the progress that was made a few centuries before Harvey. It also shows his contribution to description of the coronary arteries for the first time. Europe was lagging behind the Muslim world in scientific discoveries during the Medieval era and this article demonstrates that the work of scholars in post Renaissance Europe would have been impossible were it not for the discoveries of Ibn Al-Nafis.

## Introduction

Ala-al-Din Abu al-Hasan Ali Ibn Abi al-Hazm al-Qarshi al-Dimashqi (known as Ibn Al Nafis, and by his nisbah, al Qurashi) was born in 1213 CE in Damascus. He was educated at Bimaristan Al-Noori, the medical college hospital founded by Noor al-Din Al-Zingi. At the Bimaristan he was taught by the renowned physician Al Dakhwar. As well as medicine, Ibn al-Nafis studied Islamic sciences, literature and theology. He thus became an expert on hadith, the Shafi'i school of Islamic jurisprudence and as well as a reputed physician.<sup>1</sup>

In 1236, Ibn Al Nafis moved to Egypt where he worked first in Al-Nassri Hospital and then in Al-Mansouri Hospital where he became Chief Physician. He also held the role of personal physician to the sultan. When he died in 1288 CE, he left his house, library and clinic to the Mansuriya Hospital<sup>1</sup>. He was a contemporary of the polymath Ibn Abi Usaibia with whom he worked at the Mansuriya.  $^{1,2}$ 

Usaibia was a poet, biographer and physician. His work 'Uyoon al-Anbaa fi Tabaqat al-Atibbaa' was a thorough biographical account of physicians from the early Greco-Roman period to his contemporaries. Interestingly, he did not mention Ibn al Nafis in his book.<sup>3</sup>

Ibn Al Nafis lived at an interesting time in Muslim history. Referred to as the 'Islamic Golden Age', this was a time of great development in thought, particularly scientific throught, across the Muslim world. While little



is known about Western medical advancement in the period intervening the 'fathers' of medicine such as Hippocrates and Galen and renaissance physicians, advancements in the Islamic world were flourishing. In the Western world, Galen's ideas were still being propagated at Cambridge University until at least the 16th century. Damascus and Cairo, where Ibn Nafis spent much of his life, as well as Baghdad were the centres of the Golden Age. Another point of interest is that Ibn al Nafis lived during Ayyubid and Mamluk rule in Egypt, a fascinating time in Muslim history.<sup>4</sup>

Ibn al Nafis was a prolific writer and the most ambitious of his works is *Al-Shamil fi al-Tibb*. This was an ambitious project intended to be an encyclopedia of 300 volumes. Ibn Al Nafis only completed 80 before his death, of which three remain today. The manuscript is currently in Damascus. While this is his ambitious work, perhaps his most important is the commentary on Ibn Sina'sQanun fi Tibb. He called his commentary on The Canon 'SharhMujaz al Qanun'. He wrote another commentary on the anatomy in the Canon and this was named 'SharhTashrih al Qanun'. It is in the Tashrih that his description of the pulmonary circulation is found.<sup>4</sup>

He wrote extensively on both Islamic law and medicine. 'The Autodidact Theologian', a work described as a philosophical science fiction, was written in response to Ibn Tufail's 'Hayy ibn Yaqzhan'.<sup>4</sup>

As well as commenting on Ibn Sina, Ibn Nafis also wrote commentary on Hippocrates, epidemiological work 'Of the Epidemics', 'SharhKitab al Epidemia'. He could access this in Arabic, as a translation by Ibn Ishaq was available. A copy dated from the 19th century is at the Egyptian National Library and Archives. Ibn Nafis attempted to expand on Hippocrates' idea, attempting biological explanations for the causes of disease due to 'imbalances'. In terms of epidemiology, he described the exposure-outcome relationship and provided comparisons between Hippocrates examples, and cases and outbreaks Ibn Al Nafis experienced in the Damascene context. He further commented on another of Hippocrates works on epidemiology, 'Aphorisms'. Here, he again attempted to offer biological mechanisms by which external factors mentioned by Hippocrates, such as climate, could exert a role in disrupting health.<sup>5</sup>

Among his original works, two of note are Al Muhadhab fi al-Kohl, a work on ophthalmology and Kitab Al-Mukhtar Min al-Aghdiyah, on nutrition. His authorship extended into Islamic sciences. He wrote a book on principles of hadith entitled 'Al Mukhtasar fi IlmUsul al Hadith'.<sup>6</sup>

Perhaps Ibn Al Nafis' most significant contribution to medical science was his original discovery of the pulmonary circulation.

This was re-discovered by western scientists after a lapse of three centuries. He was the first to correctly describe the constitution of the lungs and gave a description of the bronchi and the interaction between the human body's vessels for air and blood. He also elaborated on the function of the coronary arteries as suppliers of blood to the cardiac musculature.



Figure 1: Ibn Nafis's Concept of Pulmonary Circulation. (7)

## Discovery of the Pulmonary Circulation

The discovery of pulmonary circulation has a complex history. It is commonly believed that this discovery was made in Europe in the sixteenth century by Servetus. It is reported he was burned at the stake as a result of this discovery, as it was in opposition to the prevailing biblical beliefs of the time. Vesalius, Colombo, and finally Harvey are all credited to various degrees with discovering the pulmonary circulation. However, subsequent to the study of ancient manuscripts, it is



proposed that the real credit for the discovery of the pulmonary circulation belongs to an eminent physician of the thirteenth century: Ibn Al Nafis.<sup>4</sup>

In 1924 an Egyptian physician, Dr. Muhyo Al-Deen Altatawi, discovered a manuscript entitled, "Commentary on the Anatomy of Canon of Avicenna" in the Prussian state library in Berlin while studying the history of Arab medicine at the medical faculty of Albert Ludwig's University in Germany<sup>4, 8, 9</sup>. In this work, Ibn AnNafis shows his aptitude as he expounds on anatomy, pathology and physiology in detail. The discovery of this manuscript revealed an incredible historic finding - this was the earliest known description of the pulmonary circulation. Max Meyrhof, an orientalist in Cairo came to know of Dr Tatawi's and took it upon himself to make translations in English, French and German.<sup>4</sup>

Prior to Ibn Nafis' discovery, the accepted contemporary understanding was that of Galen. He had theorised that the blood reaching the right side of the heart passed through invisible pores in the cardiac septum to the left side of the heart where it mixed with air to create 'spirit' and was then consequently distributed to the body. According to Galen's view, the venous system was quite separate from the arterial system, except when they came in contact through the unseen pores<sup>4, 10</sup>.

However, Ibn Al-Nafis, based his understanding of pulmonary circulation on scientific reasoning and his knowledge of anatomy. Haddad and Khairullah translate from his writings as follows:

"...The blood from the right chamber of the heart must arrive at the left chamber but there is no direct pathway between them. The thick septum of the heart is not perforated and does not have visible pores as some people thought or invisible pores as Galen thought. The blood from the right chamber must flow through the vena arteriosa (pulmonary artery) to the lungs, spread through its substances, be mingled there with air, pass through the arteria venosa (pulmonary vein) to reach the left chamber of the heart and there form the vital spirit..."<sup>1</sup>

#### Elsewhere, he states:

"The heart has only two ventricles ...and between these two there is absolutely no opening. Also dissection gives this lie to what they said, as the septum between these two cavities is much thicker than elsewhere. The benefit of this blood (that is in the right cavity) is to go up to the lungs, mix with what is in the lungs of air, then pass through the arteria venosa to the left cavity of the two cavities of the heart..." Ibn Nafis also describes the anatomy of the lungs:

"The lungs are composed of parts, one of which is the bronchi, the second the branches of the arteria venosaand the third the branches of the vena arteriosa, all of them connected by loose porous flesh." <sup>1</sup>

He then adds:

"... The need of the lungs for the vena arteriosa is to transport to it the blood that has been thinned and warmed in the heart, so that what seeps through the pores (manafidh) of the branches of this vessel into the alveoli of the lungs may mix with what there is of air therein and combine with it, the resultant composite becoming fit to be spirit when this mixing takes place in the left cavity of the heart. The mixture is carried to the left cavity by the arteria venosa." <sup>1</sup>

Ibn Nafis corrected the statements of his predecessors. A lesser known opinion of his is that he postulated that the 'nutrition' of the heart is extracted from coronary arteries:

"... Again his (Avicenna's) statement that the blood that is in the right side is to nourish the heart is not true at all, for the nourishment to the heart is from the blood that goes through the vessels that permeate the body of the heart..."<sup>1</sup>

Ibn Al-Nafis can thus be regarded as the earliest to propose the concept of coronary circulation.

## Europe's Late Awakening

These important observations were not known in Europe until 300 years later when Andrea Alpago of Belluno translated some of Ibn Al-Nafis' writings into Latin in 1547<sup>11</sup>.

Later, Michael Servetus, a Spanish theologian and anatomist, described the pulmonary circulation in his book, "ChristianismiRestitutio". He wrote, "...air mixed with blood is sent from the lungs to the heart through the arterial vein; therefore, the mixture is made in the lungs. The bright colour is given to the sanguine spirit by the lungs, not by the heart." <sup>12</sup>. Both Calvinists and Catholics considered his work a heresy and so he was consequently burnt, along with his book, at the stake in Geneva. <sup>4</sup>

Andreas Vesalius described the pulmonary circulation in his book "De Fabrica", in a manner similar to Ibn Nafis' description. An interesting observation is that in the first edition of the book (1543), Vesalius agreed with Galen



that the blood "... soaks plentifully through the septum from the right ventricle into the left..." Then in the second edition (1555), post Alpago's translation, he omitted the above statement and wrote instead..."I still do not see how even the smallest quantity of blood can be transfused through the substance of the septum from the right ventricle to the left..."<sup>11</sup>. Another similar description was given by Realdus Colombo in 1559 in his book "De re Anatomica" <sup>12</sup>.

Then in 1628, William Harvey, demonstrated by direct anatomic observation in laboratory animals the movement of blood from the right ventricle to the lung. He then observed the blood returning to the left side of the heart via the pulmonary vein and again he stated that he could not find any pores in the interventricular septum. He wrote in his monograph, 'Exercitatioanatomica de motu cordis et sanguinis in animalibus'

"I began to think there was a sort of motion as in a circle. I afterwards found true, that the blood is pushed by the beat of the left ventricle and distributed through the arteries to the whole body and back through the veins to the vena cava and then returned to the right auricle, just as it is sent to the lungs through the pulmonary artery from the right ventricle and returned from the lungs through the pulmonary vein to the left ventricle, as previously described." <sup>12</sup>

However, he did not understand the physiology of the pulmonary circulation (dissipation of carbon dioxide and replacement with oxygen), which was fully elucidated by Lavoisier in the 18th century <sup>10</sup>.

There are some remarkable coincidences among the characters within the story of the discovery of pulmonary circulation. Servetus and Vesalius were both well versed in Arabic. In Servetus' *ChristianismiRestituto*, there is a section quoted directly, but not cited, from Alpagus' translation of Ibn Nafis. Alpagus himself was a keen translator, having translated Arabic books into Latin over three decades in Syria. He taught at Padua University, the same institution where Harvey studied, and later published the famous *Exercitatioanatomica de motu cordid et sanguinis in animalibus*.<sup>13</sup>

## Views of Some Modern Historians

It may be useful to mention the views of a few modern historians who reviewed the works of Ibn Nafis. Mieli said: "We believe that henceforth it is fair to attribute the discovery of the pulmonary circulation to Ibn Nafis who was a distant precursor of the physicians of the sixteenth century Italian School and of William Harvey who, four centuries later, described the whole of the pulmonary circulation in an accurate, clear and definitive manner." <sup>14</sup>

Max Meyrholf, a distinguished scholar of Arabic historical medicine, states: "... We have seen that Ibn Nafis, three centuries before Colombo, had already noticed visible passages between the two types of pulmonary vessels." <sup>15</sup>

In the William Osler Medal Essay on the discovery of the pulmonary circulation, Edward Coppola said:

"...The theory of pulmonary circulation propounded by Ibn Nafis in the 13<sup>th</sup> century was not forgotten and that centuries after his death it may have influenced the direction of the anatomical investigations of Colombo and Valverde, who finally announced it to the Western world as a physiological fact susceptible to experimental proof."<sup>11</sup>

Responses to sharing the discovery of Ibn Al Nafis are not free of criticism. There is contention as to what credit Ibn Al Nafis deserves for his discovery. Some consider his discovery 'a lucky guess' and others argue that his theory is not so developed as to be eligible to take the title of the first description of the pulmonary circuit. In a letter to the editor from 1978, a John Forrester from Edinburgh Medical School posits:

"Dr Al-Daggagh (May 27, p. 1148) seeks to secure for Ibn Al-Nafis credit for the discovery of the pulmonary circulation. But it is difficult to establish the case...A serious claimant to a share of the discovery must have discerned some new feature of the story, or have provided some experimental evidence. On these criteria, where does Ibn Al-Nafis stand?"<sup>16</sup>

However, there are several responses to the criticism. One is that the precedence of Ibn Al Nafis' ideas by 300 years compared to those of Harvey is clearly significant. Another is the field of medical science a good three centuries later allowed for the detail provided by Harvey, conditions for which were not present in Ibn Nafis' time. <sup>17</sup>

Nahyan Fancy, in his book *Science and Religion in Mamluk Egypt: Ibn al-Nafis, Pulmonary Transit and Bodily Resurrection,* considers positioning Ibn al Nafis' understanding of pulmonary transit beyond its context as simply a development of Galen and Ibn Sina's ideas, but



as a product of Ibn Nafis's social and religious context. Fancy cautions against over-interpreting his discovery from a scientific context.

He mentions the religious discussions and debates between rationalists like Ibn Sina, mystics like Ibn Tufail and traditionalists like himself in terms of reason vs revelation.

Fancy argues that Ibn Al Nafis developed his medical ideas through his understanding of the body-soul connection which led to his understanding of a 'hylomorphic psychology' in which the soul and body are as if wired together as one unit, reducing the concept of 'chief organs' such as proposed by Galen. Instead his conception was a soul-centred one. He considered the brain as 'tempering the spirit in order to govern and issue the remaining psychic faculties.' The heart was the container of the spirit's emanated faculties and so had a crucial role in its distribution. Thus the idea of pulmonary transit was developed 'from a need to ensure the purity and fineness of the spirit and that the blood would be very fine and thoroughly mixed with air.'<sup>18, 19, 20</sup>

Fancy also dissuades those hisotrians who regard the contributions of the commentary genre as meaningful developments in historical Muslim medical thought. He explains that the purpose of commentaries was not merely the copying and disseminating of existing ideas but served to correct inaccuracies, clarify meanings, compare the views of the authors to other prevalent opinions and further critically engage with the original text.<sup>20</sup>

## Conclusion

In conclusion, Ibn al Nafis made a remarkable contribution to the discovery of the pulmonary circulation. His clear description of the pulmonary circulation, 300 years before any known Western scholar, is a product of the rich intellectual context in which he lived. Modern historians have regarded with high esteem the contributions of Ibn al Nafis and some have dedicated works to his study.

Study of key discoveries in the history of Islamic medicine is important as it leads to a greater appreciation of the contribution of the Islamic world to medical developments, and a fuller appreciation of the history of these discoveries, as their relative obscurity means they may be misattributed in mainstream literature.

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Vol 10 - No. 4 | April 2022 | www.jbima.com

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