

Historical Perspective

Michael Servetus (1511-1553) and the Discovery of Pulmonary Circulation

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Michael Servetus was the first doctor ever to challenge and scientifically argue against the theories of Galen, which predominated for 14 centuries in medical schools worldwide. Even though he was relatively correct in scientific terms, Servetus was punished because of his boldness in challenging Galen's theories and was condemned to death by the Holy Inquisition. Yet, by publicly challenging Galen's and Hippocrates' predominant and unquestionable lessons on medicine for the first time, Servetus opened the door for other doctors to challenge and correct those theories and subsequently to bring about a new view of human anatomy and physiology. This article underlines the contribution of Servetus to the description of the pulmonary circulation.

The discovery of the blood circulation cannot be attributed to a single person, nor even to a single era. In fact, many errors were in need of correction, and each and every one of those errors had to be replaced with the truth.

During the fourteen centuries that followed the death of Galen (131-201 CE), when European doctors would religiously adopt all the conclusions or theories of the Greek doctors, the structure and functions of the heart, the arteries and veins were bound to remain issues that were addressed mainly by the imagination of each doctor. Interestingly, this very same thing had happened before the recognition of Galen as an ingenious, innovating doctor, since the study of medicine was strongly attached to belief issues and all lessons taught in the medical field were considered to be beyond question.

Yet Servetus' observations were not destined to be lost; they were retained in his manuscripts, which were rescued from burning.

Who was Michael Servetus?

Servetus (Figure 1) was a French doctor of

Spanish origin. Michael Servetus (also known as Miguel Servet) was born in 1511 (or 1509, according to some sources) at Tudelle, which was located in the kingdom of Navarre, Spain. In fact, he actually gave two identities during his successive interrogations in Vienna, at Dauphiné (France), and in Geneva.¹ The Great French Inquisitor must have been unaware of Servetus' rejection of belief in the Holy Trinity, just as his accusers in Geneva must have been unacquainted with the name Michael of Ville-neuve.

His ancestors were originally from Villanueva (Villeneuve) in Aragon; his father was considered to be a "noble Spanish man and a Christian" and worked as a scrivener. As was customary at the time, the son was obedient to the family, thus taking the name Michel de Villeneuve (Villanueva).²

The occasion for his condemnation was a single book, indeed the very one that he would later pass down to us. We will not focus on the "Servetus affair", which belongs to the theologians. A large number of essays have already been devoted to two different aspects: to his "heresy", regarding his desire "to reform the ones who were already reformed" – cited in this sarcastic

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Figure 1. Michael Servetus (1511-1553), engraving by Christian Fritsch.

way in his own words—and to his dispute against the Trinitarian principle, a belief that had already twice placed his life in danger and that led to his final condemnation and execution.

It seems that, after studying Latin, Greek and Hebrew, Servetus attended some courses at the University of Saragossa, starting from age 14, and devoted himself to geography, mathematics and astronomy. In 1528, he was in Toulouse, where he studied law.³ Though still very young, he became secretary to the Franciscan Juan de Quintana, confessor of Charles V. Little by little he alienated himself from the Catholic faith and separated himself from Quintana. By the age of 19, he was in Basel, but he then moved to Alsace, where he printed two theological booklets. At this point, his correspondence with John Calvin (1509-1564) began.⁴

In order to earn a living, Servetus became editor for a printing house in Lyon, which belonged to the Trechsel brothers. In 1535, he published a new edition of the *Geography of Ptolemaeus*. His medical vocation actually dates from this point on. Because of his profession, he became involved with Symphorien

Champier (1471-1538), to whom Servetus attached himself and became his disciple. Champier was already open to all the academic disciplines: philosophy, poetry, history, medicine, surgery, pharmacy. Being a humanist and neo-platonic philosopher, Champier opposed Arab medicine, seeking to replace it with the Hippocratic and Galenic tradition. Those were precisely the guidelines that Servetus himself followed during his medical studies in Paris and subsequent practice.⁵

On October 27, 1553, Servetus was burned at the stake on the plateau of Champel, by the gates of Geneva, after being found guilty of heresy. Servetus was a big man with a small face, a pointed beard and a penetrating gaze, who was paraded at the centre of a damnatory cortege. His last words were: “Oh Jesus, son of eternal God, have pity on me.” This phrase was meant to be instantly corrected by the Reformer of Neuchâtel, who actually tried to force Servetus to say “Oh Jesus, eternal son of God,” instead of “Jesus, son of eternal God.” The condemned, Servetus, refused to do so. Having fettered Servetus with strong chains, the executioner attached to his right arm and left thigh the confiscated copies of *De Christianismi Restitutio*, the book originally responsible for his condemnation. Thousands of these manuscripts were reprinted at the time. A certain number of them were burnt in Vienna; three manuscripts survived until the present, one of which is kept in the National Library of Paris. All the remaining copies were certainly sold at the time of their initial publication and were kept in the hands of ‘Servetusists’ (i.e. Servetus’ followers) who had taken refuge in Italy, and in Padua in particular.⁶ It is probably precisely for this reason that William Harvey’s most immediate precursors and Harvey himself had knowledge of the description of the ‘small’ (i.e. the pulmonary) circulation, in the very same way that Servetus had pictured it!

The discovery of the pulmonary circulation

Three copies of Servetus’ *Christianismi Restitutio* (Figure 2) that survived reveal the strange personality of the author. The National Library of France holds one of these copies. It is difficult to imagine the tribulations the volume underwent since the day it was saved from being burnt alongside its author. It was first acquired by an English doctor, Richard Mead, who served as a doctor to King George II and as a chief of the medical staff of Théodore Tronchin (1701-1785). This copy of Servetus’ manuscript later returned to France, when its origi-

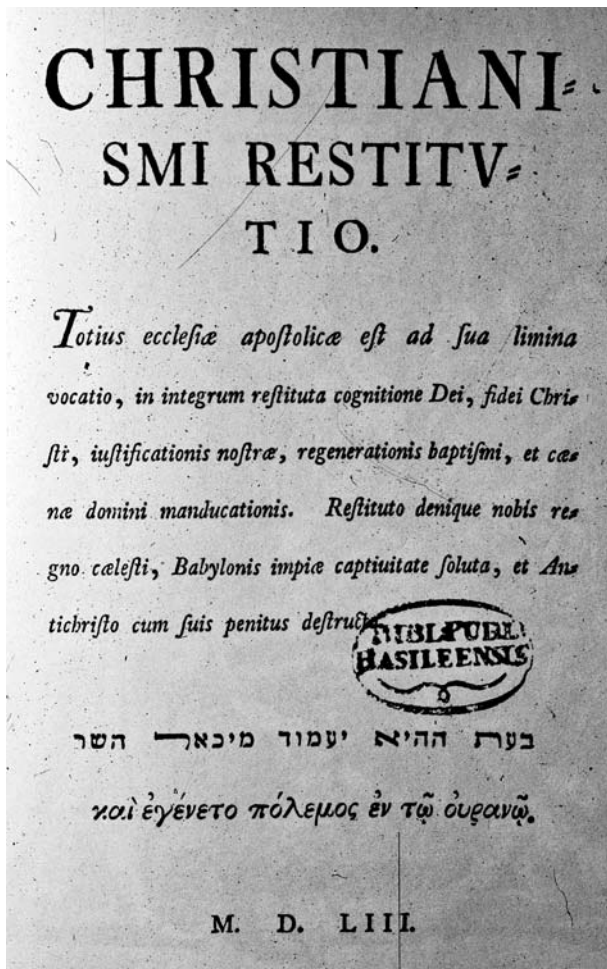


Figure 2. The first page of Servetus' Christianismi Restitutio.

nal owner donated it to a friend. Six years before the outbreak of the French Revolution (1789), the manuscript was obtained by the Royal Library.

Since 1698, the Library of the University of Edinburgh possesses the second copy of this manuscript, still surviving nowadays, from which the first 16 original pages are missing and have been replaced by handwritten copies.

The National Library of Vienna (Austria) holds the third exhibit of Servetus' original manuscript, *Christianismi Restitutio*. This copy was employed for the issue of a new edition from Christopher Gottlieb von Murr, published in 1790 in Nuremberg.⁷

Description of the pulmonary circulation

In order to better understand Servetus' scientific doctrine, without being distracted or influenced by any theological confusion, it is worth translating its first chapter:

"Reader, in order to provide you with a real and

profound knowledge of the soul and the spirit, I am going to resume herewith my philosophical thoughts and considerations; it is going to be easy for you to perceive, if you have at least some knowledge of anatomy. Let us presume that there are three spirits in us: the natural, the vital and the animal, formed by three superior elements.

"In reality, there are not three, but only two distinct spirits. The vital spirit is the one that is communicated by means of the anastomosis of the arteries to the veins; and it is exactly at this moment that it is renamed to natural spirit. Therefore, the first one is the blood, which is contained in the liver and inside the veins of the body. The second one is the vital spirit, which is sited inside the heart and the arteries of the body. The third spirit, which resembles the rays of light, is the animal spirit and resides in the brain and the nerves of the body. All three of them reflect the activity of the unique Spirit and of the light of God. The uterine formation of human beings instructs us that the natural spirit is communicated from the heart to the liver. As a matter of fact, the artery, simultaneously to the vein, passes into the umbilicus of the foetus: after birth, the artery and the vein are always united in the body. As it was originally implanted by God into Adam, the soul resides primarily inside the heart, and not inside the liver; the heart, therefore, communicates the soul to the liver. The inhalation by the mouth and the nostrils actually induces the soul: in fact, the inhaled air is directed to the heart. The heart is the *primum vivens*, the source of heat for the entire body. From the liver, blood receives the vital liquor, which resembles a material substance, and it is exactly this last that vitalises the soul. In an identical way, water brings the materials to the superior elements, and, after having received the light, it is vitalised for the growth of plants. The blood that derives from the liver constitutes the material of the soul, thanks to a marvellous elaboration, regarding which we are going to discuss now. Because of this, it is said that the soul is found inside the blood and that, the soul itself, is made out of blood or of a blood-spirit. On the contrary, it is not believed that the soul is primarily found in the walls of the heart, nor in the substance of the brain itself, not even inside the substance of the liver, yet it is believed to reside inside the blood, as God teaches us (Genesis 9, Leviticus 17, Deuteronomy 12).

"For the comprehension of these notions, it is, first of all, important to know the origin of the substance of the vital spirit itself, which finds its elements and its nourishment in the inhaled air and in the subtle blood. The vital spirit is generated in the left ventricle of the heart and is aided in its formation, to the maximum, by the lungs. It is a subtle spirit, generated by the power of

heat, of yellow colour and possessor of the power of the fire, so as to become a sort of lucid vapour of the purified blood, enclosing the elements of the water, the air and the fire. It is instantly produced inside the lungs by a mixture of inhaled air and subtle blood, while it is elaborated and communicated from the heart's right ventricle to the left one. This communication is not mediated via the median septum of the heart, as it is habitually thought; on the contrary, the subtle blood is transferred from the right ventricle, in an brilliant way, by following a long circuit through the lungs, which submits it into a transformation, in order for the blood to come out coloured yellow: the arterial vein [pulmonary artery] transports it into the venous artery [pulmonary vein]. From that moment on, the blood is mixed in that very same venous artery with the inhaled air in order to become re-purified from all fuliginous [i.e. sooty] materials, during this expiration. In this way, the entirety of this mixture is finally attracted by the left ventricle of the heart, during the diastole, to serve as a base for the vital spirit.

"Many facts prove the reality of this communication of the blood through the lungs and the very existence of this elaboration, which coincides with the junction of the arterial vein to the venous artery at the level of the lungs. A confirmation is provided by the huge width of the arterial vein. The arterial vein itself would have never been constructed this way, nor would it be so wide, and it would not be forwarding such a powerful jet of the purest of the blood from the heart to the lungs, simply in order to provide nourishment for the lungs; the heart would have never placed itself in the service of the lungs in this manner.

"Since in the foetus the lungs were used to nourish themselves in another way, these small membranes or small valves were always closed, up to the moment of birth, according to Galen. Therefore, at the moment of birth, a very large quantity of blood flows from the heart to the lungs, for a completely different purpose. On the other hand, the lungs send to the heart, via the venous artery, not simply purified air, but a mixture of air and blood; in other words, the mixing of air and blood takes place at the level of the lungs. The yellow pigmentation of the spirituous blood derives actually from the lungs and not from the heart. The heart's left ventricle does not have enough capacity to permit such an important mixing, nor to set the trend in blood's pigmentation towards yellow. Finally, this median septum, having neither vessels nor capacities, is not capable of ensuring this communication, nor this elaboration; it is, however, possible that the median septum could allow itself the transudation of a small quantity of blood. By an artifice,

similar to the one by which the passing of the blood from the portal vein to the vena cava is accomplished in the level of the liver, the transfusion of the spirit is conducted inside the lung, emerging from the arterial vein and being directed to the venous artery. He who compares these notions to those enunciated by Galen (books 6 and 7, *De usu partium*) understands perfectly the truth, even though Galen failed to see it. In this way, the vital spirit is transferred from the left ventricle to the arteries of the whole body, so that the elements retained can finally reach the superior elements. In this trend, the vital spirit is perfected, especially at the level of the plexus retiform, situated at the base of the brain (hypothetical arterial nexus). At this point, the transformation of the vital spirit into animal spirit is generated and directed to the actual locus of the reasoning soul. Right afterwards, the vital spirit becomes even more subtle, under the influence of an ardent power of the spirit; it is transformed and perfected in the vessels of an extreme fineness, resembling the capillary arteries, situated at the level of the choroid plexus and enclosing the quintessence of the spirit."⁸

After the evocation of the "nervous influx", Servetus resumed his thoughts on the pulmonary circulation (termed as "small circulation", in the original French text, in contrast to the general – "great circulation"):

"For the most part, the inhaled air is transported through the trachea artery to the lungs, in order to pass into the venous artery, after being transformed inside the lungs. Inside the venous artery, the air is mixed with the yellow, subtle blood, so that this mixture can become better elaborated. Right afterwards, this ultimately elaborated mixture is attracted by the left ventricle of the heart, during the diastole; inside the left ventricle, using the force of the highly intense and vitalising fire, which is sited there, the mixture takes its final perfect form; after having discharged, during the abovementioned procedure, a big quantity of exhaled fuliginous wastes, it turns into vital spirit. This procedure, in its entity, is, in a manner of speaking, the very substance of the soul."⁸

The paternity of the first description of pulmonary circulation

It must be mentioned that there is still great dispute among historians as to whether Servetus was actually the one who discovered the pulmonary circulation, or whether this honour should be attributed to another doctor.

In fact, for several generations, British medical historians strove to attribute to their compatriot, William

Harvey (1578-1657),⁹ all merit for the discovery of the blood circulation, a fact that can be well understood in terms of their intentions. In this way, they diminished the discovery of the pulmonary circulation made by Servetus. Furthermore, they insisted that the rediscovery of this phenomenon by Servetus was not widely and scientifically approved and established, since the vast majority of his books addressing this issue were burnt at the same time as their author, in 1553. However, in reality only a limited number of the thousand copies of his published manuscripts went up in flames. In fact, Servetus took the precaution to send one half of his published books to a bookseller at Lyon and the other half of them to a bookseller in Frankfurt. In this way, many months before and most probably many years after his execution, his treatises and, therefore, his cardiovascular discoveries, remained preserved; they were not meant to vanish from the medical community.¹⁰

Furthermore, these British historians, who were so eager to attribute the discovery of the pulmonary circulation to Harvey, forgot that Servetus was in constant communication with his colleagues in France, in Germany and in Italy and that he had probably already mentioned to them, during the twelve years that intervened between his rediscovery of this phenomenon and his death, his personal thoughts and findings regarding the pulmonary circulation.¹¹

Finally, it is difficult to accept that Harvey's British advocates were right to proclaim that all of Servetus' books were destroyed, since Servetus' works were repeatedly reprinted in France and in Germany during the same period.¹²

It appears almost certain that Realdo Colombo (1510-1559), the famous anatomist who was a contemporary of Servetus, knew about Servetus' discoveries from his own observations on this subject, long before the posthumous publications in 1559, namely six years after Servetus' death. Even Gweneth Whitteridge himself, one of the most passionate Harvey chronographers, admits that Colombo was probably aware of Servetus' anatomical discoveries; if Colombo avoided mentioning Servetus as a bibliographic source, it was most probably through fear of the Holy Inquisition.¹³ Furthermore, *De re Anatomica*,¹⁴ written by Realdo Colombo, debuted six years after Servetus's *De Christianismi Restitutio*. Colombo also gave a description of the pulmonary circulation, in which the similarities to Servetus' phrases are striking.¹⁵

It should be mentioned, too, that André Cesalpino (1519-1603) was the first one to coin the word "circulation" in the year 1569. Cesalpino, after tying up tightly

the arms of a subject, observed that the veins were being filled in underneath the ligature and not from the ligature up. He deduced the direction of the blood in the veins: "*The blood is driven to the heart through the veins, where it attains its last perfection, and, having acquired this perfection, it is brought by the arteries throughout the body*".¹⁶ Cesalpino thus founded the concept of the general circulation, but he did not dedicate much of his experiments to the pulmonary circulation.

Finally, Fabricius d'Acquapendente (1533-1619) observed the valves of the veins and their direction towards the heart. Yet, according to Fabricius, the valves served as nothing more than a means of retarding the course of the blood. This conformed to Galen's beliefs and reflected the fact that Galen was still considered to be the best doctor of all time and so could not have been mistaken. Therefore, even though Fabricius made an effort to describe the circulation, he was far from understanding its essential nature.¹⁷

Discussion

Despite these remarkable precursors and their discoveries, there was still much to be done until the final abolition of the traditional medical treatises. And it was finally Harvey who presented the determinant proofs and established the new notion of the circulatory system.

The extracts of Servetus' text that we have cited are considered to be vital, if not fundamental, in the course of revealing the existence and the function of the pulmonary circulation, and it is exactly the importance of this discovery that makes it worth pondering for a while. Servetus managed to describe the pulmonary circulation with the precision of an anatomist, given the fact that he was a pupil of Jacques Dubois (named Sylvius: 1478-1555) in Paris, as well as the assistant of Joannes Guinter (1505-1574), also in Paris. However, one question remains unanswered: how did the author manage to envision such a great, monumental piece of medicine, in an environment of total mystical confusion, when his only intention was to prove the existence of the soul inside the blood?

Conclusion

Servetus is quite an exceptional figure: the fact that he perished at the stake, punished by the Holy Inquisition, and that only three copies of his manuscripts remain to date is itself intriguing. Yet the fact remains that he was the first one ever to publicly challenge

Galen's theories on cardiac anatomy and physiology, to die on account of his opposition, and to point the way for future doctors to experiment, re-evaluate and refute all medical errors that were devoutly thought of as being correct up to that date.

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