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Review

Michael Servetus (1511–1553): Physician and heretic who described the pulmonary circulation

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ABSTRACT

The purpose of this paper is to provide an overview of the life of the physician and theologian Michael Servetus and to discuss his analysis of the pulmonary circulation. Writers have praised Servetus for his commitment to educating his colleagues about what he heralded as the truth, and criticized him for his perceived arrogance. Servetus made contributions to the fields of geography, astrology, theology, and medicine. This paper refers to the translation of a portion of Servetus' book *Christianismi Restitutio* by Charles D. O'Malley.

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Michael Servetus (Fig. 1) demonstrated a passion for learning and instruction in various academic fields, including medicine and theology [1]. However, some writers consider him to have been an arrogant man. Gilder writes: "A study of these [O'Malley's] translations confirms the view that Servetus was a difficult man in his personal relations. If ever a man may be said to have brought a violent death on himself, it was this obstinate Spaniard" [2]. Gilder argues that passages from O'Malley's translations suggest Servetus to have been a contentious and vituperative man [2]. However, Servetus is also praised for his accomplishments. Cattermole writes: "Servetus must be applauded for taking a stand against tradition" [3]; Trueta writes: "…by the example he offered in confronting human intolerance he has become even more than a martyr of the old religious quarrels — a symbol for the modern Western man" [4].

Michael Servetus was born in 1511 in Villanueva, Spain [1]. Villanueva is a small village in the area of Aragon adjoining Catalonia, and is referred to as Vilanova de Sixena in its original Catalan spelling and as Villanueva de Sigena in Spanish [4]. Cattermole gives the location and date of Servetus' birth as "Tudela, Navarre, on 20 September 1511" and site of upbringing as Villanueva [3]. However, Trueta writes Servetus said during his trials in Paris and Vienne that he had been born in Tudela, Navarre, but if he had stated Vilanova de Sigena as his place of birth, he would have been identified as Michael Servetus. Furthermore, Barrios contributed to locating Servetus' birthplace by finding in Sigena the scriptures signed by Servetus' father, who in 1511, the year of Servetus' birth, was signing as the notary of Sigena [4].

Trueta offers a brief summary of the family of Michael Servetus: "The father of Servetus, Anton Servet or Serveto, was a notary who worked at Sigena and who had married the Aragonian lady Catalina Conesa. She was the daughter of a nobleman, Don Pedro Conesa, and of Beatriu Çaporta. From this couple three sons were born — Michael the physician… Peter a notary, and John who went into the priesthood and became rector of the church of Poliñino" [4].

Cattermole writes that Servetus entered the University of Saragossa [3], but Trueta argues that no evidence of his enrollment at the University of Saragossa exists [4]. Servetus left Spain for Toulouse at the age of 14 years in 1526 to study law, but afterward began to study the Bible after becoming interested in theological discussions of the Protestant Reformation [3,4]. Trueta contends that Servetus was probably influenced by *Theologia Naturalis Liber Chreaturorum*, a work by Ramon de Sibiude (Sabonde), "a scholar born in Barcelona in the second part of the fourteenth century, who left Catalonia to teach medicine and theology at the University of Toulouse until he died in 1432" [4]. In this book, Sabonde explains how Nature reflects the rational explanation of God's revelation of Himself. Servetus would later on provide a description of the pulmonary circulation in *Christianismi Restitutio* in support of his theological beliefs concerning the Holy Spirit. Trueta contends that Sabonde's influence inspired Servetus to reinterpret Biblical scripture, thereby placing Servetus on the path toward persecution as a heretic [4].

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Fig. 1. Michael Servetus. We obtained the permission of using this picture from © BIU Santé (Paris).

In 1529, following the completion of his studies in Toulouse, Servetus returned to Barcelona, where he met the Franciscan Juan de Quintana, a Majorcan who became the Confessor of the Holy Roman Emperor Charles V; Servetus worked for Juan de Quintana as a private secretary and became a follower of the Imperial Court [3,4]. Servetus visited Italy, attended the coronation of Charles V by Pope Clement VII in Bologna, and was present at the Diet of Augsburg in 1530 [4]. Cattermole notes that "by 1530 Servetus had become disillusioned by the immortality and inefficiency of the papacy and church" and "traveled to Basel where he discussed theology with the reformer Oecolampadius", with whom he disputed the Christian doctrine of the Trinity [3]. In response to the opponents he encountered while discussing theology with Swiss Reformers, Servetus published *De Trinitatis Erroribus* in 1931 in Hagenau [4]. Servetus thus demonstrated at a young age an assertive intellect that he did not silence on occasions of disagreement with proponents of the status quo.

The circumstances of his death precipitated from his writings on Christian theology, namely *De Trinitatis Erroribus*, *Dialogorum De Trinitate libri duo* (1532), and *Christianismi Restitutio* (1553), which brought him into conflict with both the Catholic Church and John Calvin as a result of their heretical content [1–3]. Following the publication of *Dialogorum*, Servetus began a "21-year life under the pseudonym of Michael Villanovanus" [2] and "fled to Lyon where he found work as a proof-reader for the printing firm of the Trechsel brothers" [3]. The Trechsels had Servetus annotate and prepare a re-edition of Ptolemy's *Geography*, which was released in 1535 [4].

Servetus' work at the Trechsel brothers' printing firm led to his career as a scholar of medicine. Before Ptolemy's *Geography* was published, Servetus spent time in Paris and studied anatomy at the Collège de Calvi [4]. The Trechsel brothers printed works by the physician Symphorien Champier, against whose opponent, Fuchs, Servetus authored the book *In Leonardum Fuchsium Apologia* in 1536; this book was Servetus' first medical work and was expanded in 1537 in the book *Syruporum Universa Ratio. An Apology against Fuchs* demonstrated Servetus' knowledge of medical writings by Hippocrates, Galen, Dioscorides, Plinius, and Avicenna. Champier encouraged Servetus to study medicine at the University of Paris, at which Servetus enrolled on March 24, 1538 [3,4]. There is disagreement between O'Malley and Trueta on the subject of Servetus' anatomical training. O'Malley contends Servetus could not have been working in anatomy with the physician Guinter of Andernach until 1538, but Trueta argues *Syruporum Universa Ratio* and Andernach's *Institutionum Anatomicarum…libri quatuor* indicate that Servetus was acquainted with Parisian anatomists, such as Andrea Vesalius and Andernach, before the end of 1537 [4]. Indeed, others contend that Servetus was a pupil of Jacques Dubois (1478–1555), also known as Sylvius, and the assistant of Joannes Guinter (1505–1574) [5].

Servetus' experience at the University of Paris and subsequent life in Vienne evidenced his passion and contentiousness as an academic. At the University of Paris, Servetus studied mathematics and medicine. He never received a medical degree, but he became a lecturer in mathematics and astronomy. Servetus started to lecture about astrology and published *Apologetica disceptatio pro Astrologia* in 1538. The dean, Tagault, ordered him to cease giving lectures on astrology. Servetus refused, but was acquitted in civil court. He subsequently published an *Apologetic discourse in favor of astrology and against a certain physician*. Servetus was summoned to a trial on March 18, 1539; he was made to agree not to teach astrology again and to accept corrections to his book. Servetus then fled to Charlieu and practiced medicine there for three years. Pierre Palmier, the Archbishop of Vienne, who had supported Servetus as a lecturer at the University of Paris, convinced the Trechsel brothers to set up their printing press in Vienne, and Servetus joined them in Vienne, where he lived for the rest of his life [3,4]. In Vienne, he practiced as a physician attached to the household of Palmier and published an annotated Bible in 1541 and a second edition of Ptolemy's *Geography*, which he dedicated to Palmier, in 1542 [4].

During his time in Vienne, Servetus found a dangerous antagonist in John Calvin. Cattermole writes that "Servetus sough merely to inform Calvin of his faults under the pretext of learning from the master" [3]. Servetus sent Calvin an early draft of *Christianismi Restitutio* in 1546, and took offense when Calvin did not reply, thereafter "sending rude letters and copies of Calvin's *Institutes* with insulting marginalia" to Calvin. Calvin eventually came to learn that Michael Servetus and Michael Villanovanus were the same person, and on April 4, 1553, Servetus was arrested in Vienne [3]. Cattermole writes that it is uncertain whether Calvin denounced him to Catholic authorities in Vienne. Servetus was arrested in Vienne, but escaped from prison with the help of outsiders three days after his trial began. He entered Geneva on his way to southern Italy, but on August 13, 1553, he was recognized as he went to church, arrested, and prosecuted by Calvin, his trial lasting several weeks and finding him guilty of spreading heresies, leading an immoral life, and disturbing the peace [3,4]. Servetus' rejection of the Christian principle of the Trinity led to his execution [5], and he was burnt alive at the stake at Champel, a suburb of Geneva, on October 27, 1553 [2].

Thousands of copies of *Christianismi Restitutio* had been printed at the time of Servetus' execution. Many were burned in Vienna. Three copies of Servetus' *Christianismi Restitutio* survived. The National Library of France has one of these copies, which was first acquired by an English doctor named Richard Mead, who served as a doctor to King George II and as a chief of the medical staff of Théodore Tronchin (1701–1785). Six years before the start of the French Revolution in 1789, the Royal Library obtained the manuscript. Since 1698, the Library of the University of Edinburgh possesses the second copy. The National Library of Vienna (Austria) holds the third copy. This copy was used to issue a new edition from the German Unitarian scholar Cristopher Gottlieb von Murr, published in 1790 in Nuremberg [5,6].

Servetus is most famous for his discussion of the pulmonary circulation contained in *Christianismi Restitutio*. Gilder writes that the "description of the pulmonary circulation given in these pages was not the result of scientific observation and inference, but a theory developed to satisfy a theological need, the need for the dissemination of the divine spirit throughout the body" [2]. The elucidation of the pulmonary circulation, thus, was a product of theological pontification, and not the primary objective in Servetus' writings in *Christianismi Restitutio*.

Servetus studied the writings of Galen, who was a private physician to the Roman Emperor Marcus Aurelius. His analysis of Galen's writings contributed to his description of the pulmonary circulation. Galen taught that the body was the instrument of the soul, and his writings were deemed by the Church to coincide with Christian dogma. Thus, both the Church and State considered teachings contrary to Galenic doctrine heretical [6,7]. As noted earlier, Servetus' rejection of the Christian Trinity was a significant heresy in the eyes of the Catholic Church and John Calvin. Servetus' correction of Galen' teachings concerning the circulation does not seem to be the specific reason for his execution, but given the Church's support of Galenic doctrine, it certainly did not help Servetus' case.

Central to Galenic physiology were the three spirits in man: natural, vital, and animal. These spirits were contained, respectively, in the veins, arteries, and nerves, whose respective centers were the liver, heart, and brain [3]. Servetus described these spirits: "The vital spirit is that which is communicated through anastomoses from the arteries to the veins, in which it is called the natural spirit. Therefore, the natural spirit is of the blood, and its seat is in the liver and in the veins of the body. The second is the vital spirit, of which the seat is in the heart and in the arteries of the body. The third is in the animal spirit, a ray of light, as it were, of which the seat is in the brain and the nerves of the body. In all of these there resides the energy of the one spirit and of the light of God" [6].

Cattermole notes: "Servetus' concern with the 'vitalization' of the natural spirit led to the passage in *Christianismi Restitutio*" [3]. Servetus wrote: "It is not said that the divine spirit is principally in the walls of the heart, or in the body of the brain or of the liver, but in the blood, as is taught by God himself", thus arguing that the soul is located in the blood [5,7]. Servetus cites Genesis 9, Leviticus 7, and Deuteronomy 12 to support his claim that God taught the soul's location to be the blood [6]. Servetus argued that God introduces the Divine Spirit into man through inspired air, and the "substance of the created Spirit of Christ is essentially joined to the very substance of the Holy Spirit" [6]. The vital spirit is "composed of a very subtle blood nourished by the inspired air" [6].

Servetus notes: "The vital spirit has its origin in the left ventricle of the heart, and the lungs assist greatly in its generation…It is generated in the lungs from a mixture of inspired air with elaborated, subtle blood, which the right ventricle of the heart communicates to the left" [6].

Galen and Servetus proposed different solutions to the problem of how the blood moves from the right ventricle of the heart to the left ventricle. Galen argued that the blood sweats through minute openings or pores in the septum of the heart, whereas Servetus argued that the movement occurs by a long course through the lungs [7]. Servetus writes: "However, this communication is made not through the middle wall of the heart, as is commonly believed, but by a very ingenious arrangement the subtle blood is urged forward by a long course through the lungs; it is elaborated by the lungs, becomes reddish-yellow, and is poured from the pulmonary artery into the pulmonary vein. Then in the pulmonary vein it is mixed with inspired air and through expiration it is cleansed of its sooty vapors. Thus, finally the whole mixture, suitably prepared for the production of the vital spirit, is drawn onward from the left ventricle of the heart by diastole" [6]. Servetus notes that the communication among blood vessels and vitalization of the natural spirit are accomplished in the lungs by the various anastomoses, or "channels of union", between the pulmonary artery and pulmonary vein; Galen had observed anastomoses, but not in the lungs [3,6]. He argues that the size of the pulmonary artery and the lesser force of pure blood it emits from the heart suggest that the pulmonary artery does not function to solely nourish the lungs; Galen did not mention that the pulmonary artery's caliber was in excess of that required to provide only for the metabolic requirements of the lungs [3,6]. Furthermore, Servetus notes Galen's teaching that the nutrition of the lungs in the fetus are not dependent on the pulmonary arteries until the time of birth because the valves of the heart, which Servetus refers to as *membranules* and *vulvulae cordis*, do not open until the time of birth [3,6]. Servetus thus concludes that the movement of blood from the heart and into the lungs at the time of birth serves another purpose, namely the mixing of the Divine Spirit of the inspired air with the blood in the lungs for the purpose of "vitalizing" the natural spirit transported by the veins [6]. Servetus disagreed with Galen's teaching that the blood mixes with air in the heart, writing that "in the left ventricle of the heart, there is no place large enough for so great and copious a mixture, nor for that elaboration imbuing the reddish-yellow color" [3,6]. Servetus offers a physiological parallel to illustrate the process occurring in the lungs: "By the same arrangement by which a transfusion of the blood from the portal vein to the vena cava occurs in the liver, also a transfusion of the spirit from the pulmonary artery to the pulmonary vein occurs in the lung" [6].

Galen proclaimed the presence of blood in both veins and arteries, and the presence of an anastomosis between the minute branches of veins and arteries and that "they mutually receive blood and spirits from each other through invisible and extreme minute passages." Galen declared that only a small portion of the blood passes from arteries and veins in this fashion, and that the majority of the blood passes through the septum of the heart from the right ventricle to the left. Servetus' argument was the reversal of this statement, with Servetus denying the existence of communication through the septum of the heart [3,7]. Servetus concludes, "…vital spirit is then transfused from the left ventricle of the heart into the arteries of the whole body so that that which is more rarefied seeks the higher regions where it is further elaborated, especially in the retiform plexus situated under the base of the brain, and approaching the special seat of the rational soul the animal spirit begins to be formed from the vital" [6].

A source of controversy has been the question of whether another European scholar provided a written description of the pulmonary circulation prior to Servetus. Cattermole notes that an Italian anatomist named Realdo Colombo (1516–1559), who succeeded Andreas Vesalius as a professor and was also his student and co-worker, is thought by some to have made the discovery before Servetus [3]. The seventh chapter in Colombo's book *De Re Anatomica* discusses the pulmonary blood flow, with special emphasis on the presence of blood in the pulmonary vein, in contrast to Servetus' emphasis on the size of the pulmonary artery [3]. Cattermole states that this chapter was likely written after 1553, and as Servetus had sent John Calvin a copy of *Christianismi Restitutio* in 1546, Colombo did not precede Servetus in describing the pulmonary circulation [3].

Another rival of Servetus in this discussion is Juan Valverde de Hamusco, a Spaniard and former student of Colombo who provided the first widely circulated account of the pulmonary circulation in the Spanish paraphrase of Andreas Vesalius' *De humani corporis fabrica*, which was published in Rome in 1556. The preface by Valverde is dated 1554, and in it Valverde stated "nobody before me has ever said this," thus indicating his claim to primacy in providing the pulmonary circulation's accurate description [6]. J.F. Fulton refers to the book *The Spirit of Catalonia* by Joseph Trueta to address this point. Trueta argues that Valverde's description of the pulmonary circulation follows that of Servetus closely, and Valverde thus knew of Servetus' account [6]. Trueta also contends that Valverde did not refer to Servetus' work because Servetus had been violently condemned by both the Catholic Inquisition and John Calvin [6]. Thus, Valverde feared persecution were he to endorse the work of an executed heretic. Fulton notes that Trueta's position is based on the fact that Valverde does not mention the pulmonary circulation in his book

De animi et corporis sanitate, which was published in Paris in 1552, even though he discussed the heart and vascular system in that text [6].

However, Servetus is not the first person to have provided a relatively accurate description of the pulmonary circulation. The Arab physician Ibn Al-Nafis (1210–1290) argued in his book *Commentary on the Anatomy in the Canon of Ibn Sina* that the septum was too thick to allow the passage of blood through pores and that the mixing of blood with air took place in the cells of the lung, whereas Servetus argued that the mixing took place in the capillaries [3]. Servetus does not cite the work of Ibn Al-Nafis in his discussion of the pulmonary circulation. Cattermole argues: "It is possible that Al-Nafis' book was known in 16th century Europe, for Andrea Alapago returned from thirty years in Arabia to Padua in 1520 with a Latin translation of the commentary, but there is no evidence that the relevant sections were included, and even less that Servetus or Colombo knew of it" [4]. The disparity between the respective analyses provided by Servetus and Ibn Al-Nafis suggests, as Owsei Temkin argues, that Servetus had no knowledge of the discussion that Al-Nafis provided: "Ibn Al-Nafis denies the existence of pores in the septum of the heart. Servetus is silent on this point and does not exclude the possibility of blood sweating through. Ibn Al-Nafis thinks that the blood filters through the wall of the pulmonary artery, mixes with the air in the lungs, and then filters into the pulmonary vein. Servetus believes that the blood passes from the pulmonary artery into the pulmonary vein by way of intermediate vessels. If these interpretations are correct, it would mean that in two rather important anatomical details Servetus differed from Ibn Al-Nafis. This difference in its turn would give support to the belief that he had no knowledge of his Arabic predecessor" [8].

Interestingly, a few years before Servetus' description, Leonardo da Vinci (1452–1519) made discoveries on the heart, blood vessels and circulation. The anatomical works of da Vinci have been translated by O'Malley and Saunder [9]. Da Vinci noted that the heart was muscular and had four chambers and that when ventricles contract, the atria dilate. This was in fact one of the earliest examples of the departure from the Galenic doctrine of blood circulation in Europe. By attributing a muscular nature to the heart, a background was laid down with an attempt to deny the earlier ideas on the heat-generating role of the heart and to indicate a mechanistic function. Da Vinci did not discover the pulmonary circulation and his direct influence on Servetus is unknown. However his revolutionary, realistic and experimental approach to understanding anatomy and confronting traditional ideas in the Renaissance Europe was unique and could have directly or indirectly influenced the later discoveries of the blood circulation.

In conclusion, Michael Servetus was an outspoken polymath whose defiance of religious authority led to him being executed as a heretic, yet whose intellect has granted him many admirers in the realm of academe. He is certainly the first European scholar to have provided a written description of the pulmonary circulation, even though this description was the product of theological pontification and not scientific inquiry into the field of human physiology. There is some disagreement among authors regarding details of his life, but his prominence as a scholar of both the sciences and the humanities is unquestionable.

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