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500th anniversary of the birth of the precursor of modern cardiology: Josephus Struthius Polonus (1510–1568)

Andrzej Grzybowski[1, 2], Jarosław Sak[3], Jakub Pawlikowski[3]

[1]Department of Ophthalmology, Poznań City Hospital, Poznań, Poland
[2]Faculty of Medicine, University of Warmia and Mazury, Olsztyn, Poland
[3]Department of Ethics and Human Philosophy, Medical University of Lublin, Poland

Abstract

In this article, the authors take a closer look at the figure of Josephus Struthius Polonus (1510–1568), one of the most famous physicians of the European Renaissance, on the 500th anniversary of his birth. Struthius became famous for his critical analysis of Galen's works and his own research into the circulatory system. The analysis of Struthius's scientific achievements leads to a conclusion that he was one of the pioneers of modern cardiology. He was a precursor of William Harvey (1578–1657) in studying the cardiovascular system, and the first person in the history of European medicine to present the pulse in a graphic form. He also presented similar ideas to those proposed in the 19th century by the inventor of the sphygmograph Karl von Vierodt (1818–1884), and the inventor of the polygraph Sir James Mackenzie (1853–1925).
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Key words: history of cardiology, history of sphygmography, Josephus Struthius

Introduction

The year 2010 marked the 500th anniversary of the birth of the most famous physician of the Polish Renaissance, Josephus Struthius Polonus (1510–1568). Struthius (Fig. 1) owes his fame to both his scientific and teaching career (as a professor at Padua and Krakow Universities) and medical achievements, especially in the field of the diagnosis of diseases of the circulatory system. In 1555, he published the results of more than 20 years of research into heart rate variability. In his dissertation entitled 'Sphygmicae artis iam mille ducentos annos perditae et desideratae Libri V' ('Lessons about the pulse in five books') [1] (Fig. 2), for the first time in the history of European medicine, he presented the pulse in a graphic form (Fig. 3). William Harvey (1578–1657) drew on this publication while describing the functioning of the circulatory system [2]. In this work, Struthius also included his idea of detecting lies based on the pulse rate.

In addition to his medical activity, he also engaged in socio-political life. He was a physician, advisor and a member of the royal Polish, Hungarian and Turkish courts. In 1559, King Sigismund II Augustus (1520–1572) appointed Struthius his court physician, and a similar post was offered to him by King Philip II of Spain (1527–1598), one of the most powerful rulers in Europe at that time. Josephus Struthius's life was aptly characterized on the tombstone dedicated to him in the (no longer existing) Collegiate Church of St. Mary Magdalene in Poznań: "Josephus Struthius Posnaniensis, doctor of philosophy and medicine, a translator of Greek works into Latin, a former professor of medical arts in Padua, on the payroll of the Venetian senate. The

Address for correspondence: Andrzej Grzybowski, MD, PhD, MBA, Head of the Department of Ophthalmology, Poznań City Hospital, ul. Szwajcarska 3, 61–285 Poznań, Poland, e-mail: ae.grzybowski@gmail.com

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Figure 1. Portrait of Josephus Struthius (1510–1568) painted by Oleszczynski-Hofman (Olejniczak 1968).

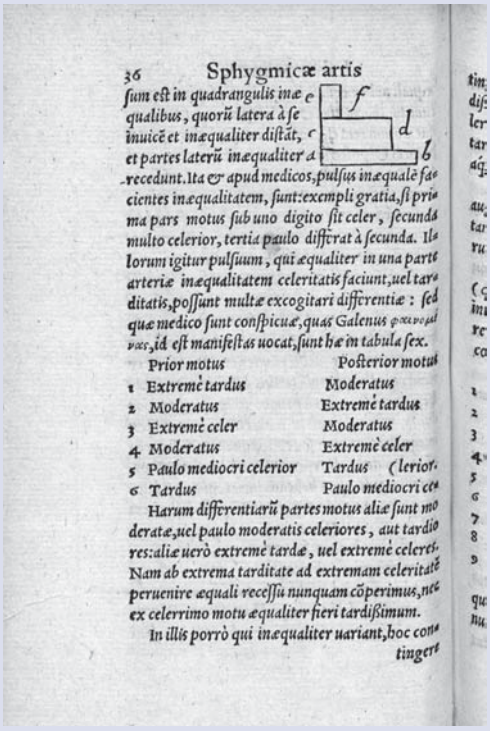

Figure 3. Graphic presentation of the pulse (Josephus Struthius 1555).

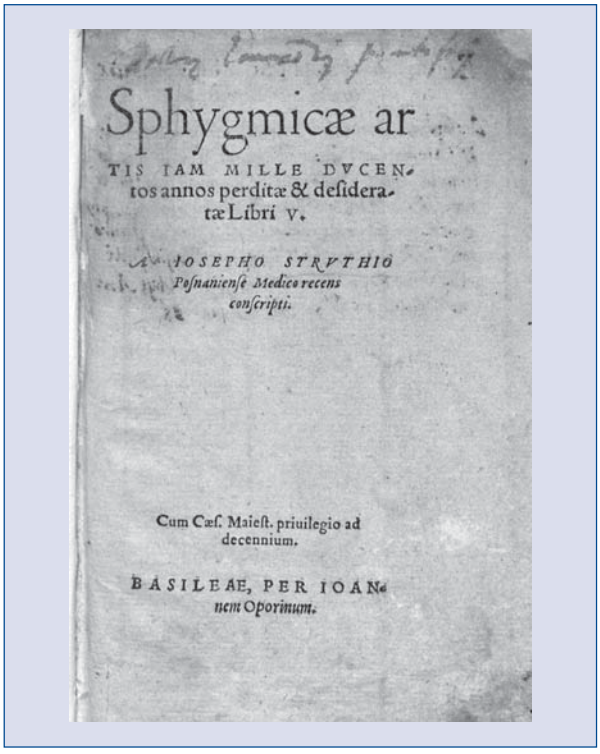

Figure 2. Title page of *Sphygmicae artis iam mille ducentos annos perditae et desideratae Libri V* (Josephus Struthius 1555).

reviver of studies on the pulse, which were forgotten by so many centuries, later a physician of King Sigismund August II of Poland. Died in the Year of Our Lord 1568, at the age of 58." [3].

Struthius and his research into heart rate variability was well remembered by the medical community in the 18th and 19th centuries [4, 5]. What contributed to this was a famous textbook on the basics of physiology and pathology written by Christian Gottfried Gruner (1744–1815) [6]. However, in the 20th century, Struthius's achievements became gradually forgotten. Even publications appearing in the Polish literature in the 1960s [7, 8] and 1970s [9–12] did not change this situation. Some of these were in connection with the 400th anniversary of his death in 1968. Although his work 'Sphygmicae artis' [1] received wide coverage in the European Renaissance, today it is completely unknown outside Poland. A sad confirmation of this fact is that no mention is made of this physician in either PubMed or Medline databases in connection with the 500th anniversary of his birth.

Struthius's achievements are such that we can call him a notable precursor of William Harvey in the studies concerning the circulatory system, and one of the founders of modern cardiology and hypertensio-

logy. In presenting the life and work of Josephus Struthius, we are trying to overcome the deficiencies identified by us in modern medical literature.

Life and work of Josephus Struthius

Josephus Struthius (Józef Struś) (Fig. 1) was born in 1510 in Poznań into a middle-class family. His parents were Mikołaj, a malt maker, and Elżbieta, a daughter of the Mayor of Poznań. In the 16th century, Poznań was one of the most important centers of the development of Renaissance ideas, and the reformation trends in central Europe were much more visible here than in any other Polish city. Struthius began his education in an urban school by the Collegiate Church of St. Mary Magdalene in Poznań. He continued his secondary education in Collegium Lubranscianum, founded in 1518 by the bishop of Poznań, Jan Lubrański (1456––1520) [5]. After graduating in 1525, he moved to Kraków, then the capital of Poland, to study at the Jagiellonian University. For the first two years there, he studied at the Faculty of Philosophy, and then between 1527 and 1531 he studied at the newly established Faculty of Medicine. King Casimir III the Great (1310–1370) had established Jagiellonian University in 1364, and initially it educated students in the fields of theology, philosophy and law. The Faculty of Medicine was established in 1525, the very same year that the young, thirsty-for-knowledge Struthius came to Kraków.

After receiving a Bachelor's degree, Struthius returned to Poznań for a short time. While in Collegium Lubrascianum, he made friends with a prominent German humanist and reformer Christopher Hegendorf (1500–1540). In Hegendorf's publications, Struthius is mentioned as one of his students [13]. Another study period in Krakow resulted in Struthius receiving a Master's Degree in 1531, and in the same year, he wrote the commentaries to the Astrology of Luciani Samosatensis [14] in the translation of Erasmus of Rotterdam. In the second half of 1532, he went to study medicine in Padua [15]. The University of Padua, which had been established in 1222, was considered the best medical university in Europe. Struthius's stay at the Department of Philosophy and Medicine at Padua coincided with the start of the greatness of this university. In the 15th century, the University had acquired patronage from the Venetian Republic and it gained a large degree of freedom concerning research. Its main motto was "Universa universis patavina libertas", ("Paduan freedom is universal for everyone"). At that time, in Padua University there had developed a habit of a critical analysis of the works of ancient and medieval physicians (e.g. Hippocrates, Galen and Avicenna). During his studies, Struthius began translating the works of Galen and Hippocrates, and among many he translated from Greek to Latin was Galen's 'Astrologia ad Aphrodisium' [16]. At the request of the professors of Padua University, Struthius's translation was published. Shortly after receiving a doctoral degree in 1535 he was appointed associate professor of theoretical medicine ('explicator extraordinarius medicinae theoricae') at the Faculty of Philosophy and Medicine in Padua [4, 5, 13]. He became the vice-rector of the University. Struthius was only 25 when he began his work as a professor. Simultaneously with didactic lectures, he began his medical practice. This enabled him to pursue not only theoretical considerations but also make practical observations on the subject of pulse variability. Later, Struthius recalled that it was in Padua where he began research on the major work of his life 'Sphygmicae artis'. Shortly after Struthius began his work as a professor, Andreas Vesalius began studying at Padua University. It is highly probable that Vesalius attended lectures given by Struthius in two consecutive academic years, 1535/36 and 1536/37. It is probable that the two famous physicians became friends [5]. In Padua, Vesalius, who is considered the creator of modern anatomy, wrote a fundamental anatomic dissertation 'Humani Corporis Fabrica Libri Septem' [17].

In 1537, Struthius returned to Poland. In the following year, he became the doctor to a famous Poznań general and magnate Andrzej Górka. He returned to Padua on several occasions, where he retained the position of professor up until 1539 or 1540 [13]. Andrzej Górka recommended him to the Polish King Sigismund I the Old (1467–1548). Struthius cured the King's daughter, Isabella Jagiellon (1519–1559), and in recognition of this, he was invited to accompany Princess Isabella, the future bride of King of Hungary John Zápolya (1487–1540) on a journey to the Hungarian royal court as her personal physician. There, he continued his studies of the diagnosis of the circulatory system. He recalled later that it was at the Hungarian court that he diagnosed a soldier with a "languid pulse" [1, 5]. He participated, together with Andrzej Górka, in the delegation of the members of Parliament to the sultan Suleiman the Magnificent (1494–1566) who was struggling with a chronic disease. Struthius cured the ruler, and for that he was handsomely rewarded. At the Turkish court in Constantinople, Struthius studied the case of a Turkish soldier who,

during fever and directly after it, had a dicrotic pulse [1, 5]. Struthius together with Andrzej Górka returned to Poland in the fall of 1541. Most frequently, he stayed in his hometown, Poznań, and continued to perform his duties as Andrzej Górka's personal physician. After the medical and diplomatic successes at the Hungarian and Turkish courts, he became very popular among the citizens of this town. After an epidemic of Black Death in Poznań, he willingly helped those in need. Unfortunately, by the middle of 1542, this epidemic had caused the death of 4,500 citizens. Despite two marriages, Struthius never had a child.

Struthius introduced his studies of pulse variability in 366 pages of his book entitled 'Sphygmicae artis iam mille ducentos annos perditae et desideratae Libri V' [1] (Fig. 2). The work, in this form, was completed in March 1555, whereupon he sent a letter informing the medical community of Padua University of his accomplishment.

The popularity and respect in which Struthius was held by the citizens of Poznań contributed to his becoming the mayor of the city twice in a row, in 1557 and 1558 [18]. Proof that his fame reached far beyond the borders of the Polish Kingdom comes in the form of the proposition he received from King Philip II of Spain to become his personal physician and medical advisor. This proposition was put forward about 1563 when the current doctor, Andreas Vesalius, the friend of Struthius from Padua days, was intending to take over the Department of Surgery at the University of Padua, vacant following the death of Gabriele Fallopio (1523–1562) [17]. Vesalius, as an excellent doctor highly thought of by King Philip II, aroused much controversy with his passion for conducting autopsies [17]. Struthius, however, preferred to remain in his home country. After resigning from the post of mayor in 1559, he decided to become the personal physician of King Sigismund II Augustus. Struthius spent more time in Poznań than at the royal court in Kraków. He continued to complete his dissertation on the subject of the pulse.

He died in 1568 in his hometown, which he did not leave despite the spreading epidemic of the Black Death [18]. He was buried in the grounds of the Collegiate Church of St. Mary Magdalene in Poznań, the same church that had sponsored the school where he had begun his education.

Josephus Struthius's contribution to cardiovascular pathophysiology

William Harvey (1578–1657), frequently considered the precursor of modern knowledge about the circulatory system, is identified as the father of modern cardiology [19–24]. Harvey, who was born ten years after Struthius's death, and who like him studied at Padua University [24], did not hide the fact that he drew inspiration from Struthius's work [2]. Unfortunately, contemporary historians of medicine often ignore this fact and the analyses of Harvey's works which mention his predecessors do not include Struthius [20, 25, 26]. Struthius's contribution to the development of cardiovascular physiology is only considered as incidental [27]. Therefore, it is beneficial to briefly analyze 'Sphygmicae artis' [1] in terms of his contribution to this development. It is worth enumerating the elements which connect 16th century medical knowledge to modern cardiology.

Struthius emphasizes the practical benefits derived from measuring patients' pulse. In modern medical practice, monitoring of the pulse (the frequency and the consistency with the action of the heart) is one of the most important aspects of obtaining information about the state of a patient's circulatory system. Struthius was the first person in the history of European medicine to present the pulse in a graphic form (Fig. 3). When more than 200 years later Henri Fouquet [28] conceived the idea of a graphic representation of the pulse, he was astonished to find that this idea had already been put into practice by Struthius [1, 5] who presented the pulse using curves similar to those which much later were demonstrated using a sphygmograph. In the thirteenth chapter of his first book, Struthius portrayed the pulse in the form of three rectangles (Fig. 3), which were to project the three phases of the pulse [1]. Struthius also expressed a similar idea to that of Karl von Vierodt (1818–1884) [29], the constructor of the sphygmograph. In the seventh chapter of his second work he stated: "Because the artery can withstand and raise bigger or smaller weights, depending on the force, it can be noticed that if in that place one puts a leaf, some skin, a piece of canvas or cloth or something similar, it will move up or down." [1]. These observations allowed Struthius an objective assessment of blood pressure [4]. In contrast to most scholars of the Renaissance, he was convinced of the presence of blood in the arteries.

Struthius enumerated five fundamental characteristics of the pulse. To make it easier for students to memorize, he applied an interesting mnemonic rule. On a diagram (Fig. 4), he assigned each of the five fingers one characteristic of the pulse, which he named "simple pulse" [1]. In each of the characteristics, he distinguished three degrees of intensity (types of the "simple pulse") which were to be symbolized by the three phalanges of each of

Figure 4. Diagram of the five fundamental features of the pulse (Josephus Struthius 1555).

the fingers. The thumb symbolized the pulse amplitude (magnus/moderatus/parvus). The index finger reflected the duration of the systolic pulse (celer/moderatus/tardus). The middle finger presented the characteristics of the frequency of the pulse (creber/moderatus/rarus). The fourth finger symbolized the pulse wave velocity (vehemens/moderatus/lanquidus), and the fifth, or the little finger, symbolised the tension of the pulse (mollis/moderatus/durus). Most of the above-mentioned features of the pulse given by Struthius, despite the passage of five centuries, are still valid. Struthius differentiated between the anacrotic pulse (pulse characterized by a transient drop in amplitude of the ascending limb) and the catacrotic pulse (a pulse in which there is an upward notch interrupting the descending limb). He could also diagnose a pulse with three pulsations where catacrotism and anacrotism coexist [30]. Struthius distinguished the tension of the pulse from the tension of the arteries. This distinction was made more than 200 years later in Laplace's law, which was to become the theoretical basis for the development of modern cardiac diagnostics and interventional cardiology. Moreover, Struthius postulated the existence of a stimuli function of the heart [30]. While giving a definition of a pulse in the second chapter of the first book, he observed: "The pulse is a proper function of first the heart and then the arteries, which due to diastole and contraction are in motion because of the vital forces […]. […] In the heart and arteries, not in the same way however, there is a vital force: in the heart, the force is inborn and implanted, and in the arteries, it is not innate, but it comes from the membranes of the heart. Similarly, light can be found in sun and in the sunbeams. Therefore, it is stated in the definition that first the heart and then the arteries." [1]. Struthius saw a close relationship between the pulse, heartbeat and the metabolism of the body. He also assumed the existence of nerves that change the tension of the vessel walls, which were much later identified as the vasomotor nerves. On the margin of these considerations, it is worth noting that 19th century physicians such as Claude Bernard (1813–1878) and Charles Edouard Brown-Sequard (1817–1894) are currently considered the discoverers of these nerves (in the years 1851–1852) [31, 32]. Nearly three hundred years earlier, Struthius in his study stated: "When the nerves are contracting, the arteries are contracting also. Thus, there is a close connection between nerves and arteries, not only because arteries receive the fibers from the nerves, but also because individual branches of the arteries and nerves are connected with each other. To each artery, from the side, from the top or from the bottom there is an adherent nerve. Therefore it is easy for the nerves to communicate their state to the arteries […]." [1].

At present, a Scottish cardiologist Sir James Mackenzie (1853–1925) is considered to have made a very significant contribution to the invention of the polygraph [33]. Frequently, Daniel Defoe is indicated as the precursor of the idea of a lie detector test [34]. In one of his essays [35] in 1730, Defoe pointed to the possibility of heart rate variability of people suspected of committing crimes when they are asked about their participation in these events. However, the main precursor of the polygraph is not Defoe but Struthius. As is apparent from his work on the pulse, not only did he postulate the exact same thing as Defoe (almost 200 years earlier), but also considered using the lie detector in practice. What is more, the following words, 455 years after the publication of Struthius's study, leave no doubt: "If you wish to find out, based on the pulse, if someone you suspect to be guilty is guilty or not, touch their arteries and by that you scare them, saying that you are certain that they are not without blame. If someone feels guilty, he will immediately fall into a spiritual disorder such as

fear, sadness or fear connected with anger. Many people try to hide these experiences; however, their pulse discovers and reveals them against their will. The pulse becomes small and frail, than irregular, than small, large, fast, slow, frequent, rare, violent, feeble, and without any order. The irregularity of the pulse and ataxia last for some time and does not stop fast." [1].

Harvey's role in overturning the erroneous Galen's physiology is often underscored. However, it must be noted that Harvey's achievements might not have been possible without the previous criticism of Galen's works. Struthius's critical sense, which had a crucial effect on further studies, is best described by the following opinion: "[…] He refers to Galen as an Arab refers to his steed with which he travels through the desert. He judges him, loves him; however, he knows how to use the bridle and say: No, this is the wrong way." [5]. This criticism is particularly evident in the rejection of many types of pulse which are distinguished by Galen and Avicenna, and which were not confirmed in Struthius's practical observations.

The study 'Sphygmicae artis' [1] should be interpreted as cardiovascular physiopathology which precedes Harvey's achievements [30]. Struthius's medical achievements indicate that his contribution to the development of knowledge about the circulatory system was significant. It can indeed be said that this progress resulted in the emergence of cardiology as an independent medical specialty [21, 23].

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