



SPECIAL ARTICLE

## A saint in the history of Cardiology

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**Abstract** Niels Stensen (1638–1686) was born in Copenhagen. He took courses in medicine at the local university under the guidance of Professor Thomas Bartholin and later at Leiden under the tutelage of Franz de la Boë (Sylvius). While in Holland, he discovered the existence of the parotid duct, which was named Stensen's duct or stenoian duct (after his Latinized name *Nicolaus Stenon*). He also described the structural and functional characteristics of peripheral muscles and myocardium. He demonstrated that muscular contraction could be elicited by appropriate nerve stimulation and by direct stimulation of the muscle itself and that during contraction the latter does not increase in volume. Toward the end of 1664, the Academic Senate of the University of Leiden awarded him the doctor in medicine title. Later, in Florence, he was admitted as a corresponding member in the Academia del Cimento (Experimental Academy) and collaborated with the Tuscan physician Francesco Redi in studies relating to viviparous development. In the Tuscan capital, he converted from Lutheranism to Catholicism and was shortly afterwards ordained in the clergy. After a few years, he was appointed apostolic vicar in northern Germany and died in the small town of Schwerin, capital of the Duchy of Mecklenburg-Schwerin on November 25, 1686. He was beatified on October 23rd, 1988.

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### PALABRAS CLAVE

Niels Stensen;  
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Corazón

### Un santo en la historia de la Cardiología

**Resumen** Niels Stensen (1638–1686) nació en Copenhague, siguió cursos de medicina en la universidad local bajo la tutoría del profesor Thomas Bartholin y, más tarde, en Leyden con Franz de la Boë (Sylvius). En Holanda descubrió la existencia del conducto parotideo, al que los catedráticos de la universidad mencionada dieron el nombre de conducto stenoiano (de su nombre latinizado: *Nicolaus Steno*). Demostró asimismo las características estructurales y funcionales de los músculos periféricos y del miocardio. Comprobó que la contracción muscular puede reproducirse no solo por estimulación del nervio correspondiente, sino también por estimulación directa del mismo músculo y que, durante la contracción, este último no aumenta de volumen. Hacia fines del año 1664, le fue otorgado el título de doctor en medicina por el Senado Académico de la Universidad de Leyden. Más tarde, en Florencia, fue admitido como miembro correspondiente en la «Accademia del Cimento» y colaboró con el médico toscano

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Francesco Redi en estudios sobre la generación de los vivíparos. En la capital toscana, se convirtió del luteranismo al catolicismo y, poco después, recibió las órdenes sacerdotales. Tras unos años, fue nombrado vicario apostólico en Alemania septentrional y falleció en la pequeña ciudad de Schwerin, capital del ducado de Mecklemburgo-Schwerin el 25 de noviembre de 1686. Fue elevado a los altares el 23 de octubre de 1988.

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## Who was Niels Stensen?

Niels Stensen (1638–1686) (Fig. 1) was born on January 10th, 1638 in the Danish capital of Copenhagen.<sup>1</sup> Stensen was educated as a Lutheran, receiving wise teachings from family friends. Having successfully completed his secondary and preparatory courses, he enrolled in the medical faculty of the local university. His professor and tutor was Thomas Bartholin, a specialist in the field of blood circulation and lymphatic function in animals and humans. At the same time, Niels frequented the Ole Borch laboratory and accompanied Bartholin on botanical excursions to the city's outskirts.

After the peace of Roskilde (1658), between Charles X Gustav, King of Sweden, and Frederic III, King of Denmark, war had sprung again between these nations. As Swedish military forces held Copenhagen under siege, local inhabitants struggled to survive. Niels Stensen served his patriotic duty as a member of a company formed by students and professors of the university. This episode constitutes a glorious precedent for the behavior of Mexican students and faculty members during the North American intervention



Figure 1 Niels Stensen (1638–1686).

(1847) and the Italians from the University of Pisa during the first independence war in their country (1848) where the acts of Curtatone and Montanara were memorable. During the night of February 10th, the civil militia and students achieved a brilliant escape from the besieged city, managing to break down enemy lines and forcing them to retreat.

## First anatomical investigations

Toward the end of the same year, Stensen left his motherland to complete and further his knowledge, learn new techniques and forge relationships with the most reputed scientists of the time. On March 20th, 1660, Stensen arrived in Amsterdam, the largest emporium of the time.<sup>2</sup> There, he visited professor Gerard Blaes (Blasius), the city's physician, with a presentation letter from Dr. Bartholin, who knew professor Blaes. Thanks to Blaes's support, Stensen was allowed to attend anatomical dissections performed in the hospital's and university's amphitheater. Stensen also had access to a small anatomic museum that was housed in his host's residence. After only three weeks of his stay, he detected the existence of a conduct between the external and internal part of a goat's mouth. A few days later, he found a similar conduct in a dog's head. He proceeded to communicate his "modest finding" to his friend James Enrique Pauli describing a salivary conduct located below the ear, which extended to the buccal cavity: the parotid duct.

Shortly after, the Danish youth left for Leiden, where he enrolled in the university on July 27th. Franz de la Boë (Sylvius) demonstrated the existence of the aforementioned duct in humans. Sylvius and van Horne showed their finding in the anatomical amphitheater of the hospital and the university and called it "stenonian duct" (after the Latinized name of Niels Stensen: *Nicolaus Steno*). In a public session presided by van Horne, anatomy professor with a doctorate from both the University of Padua and Basel, Stensen lectured on "the glands and salivary ducts that arise in the mouth and are not yet known". This dissertation, published by Elsevier, offered a radical new vision of the glandular system and was later republished in Copenhagen in 1664.<sup>3</sup>

## Researchers in the cardiovascular area

From 1662 onwards, Stensen performed studies on the hearts of different animal species. These studies allowed him to conclude that hours after death the heart can beat again if stimulated by a sharp instrument, by pressure or even a breath: the phenomenon of cardiac revival.

He had also observed that the pulsations of the superior vena cava stopped much later than the cardiac beats. When he managed to obtain a bovine heart, he decided to examine it in an unusual manner and boiled it. Afterwards, he

liberated it from the external membrane and examined it meticulously alongside the naturalist Swammerdam. In this way, both of them realized that this organ had a muscular structure with “fibers directed downwards toward the base and from there upwards”.<sup>4</sup> Thus, Stensen wrote to Bartholin: “As to the substance of the heart, I think I am able to prove that there exists nothing in the heart that is not found also in a muscle, and that there is nothing missing in the heart which one finds in a muscle. If we examine the reality closely, we find nothing but muscles”.<sup>5</sup>

## About muscles

The Danish investigator summarized and completed his observations on the heart and muscles in a book published later in Copenhagen. He proved that muscular contraction could be elicited by stimulation of the corresponding nerve and by direct stimulation of the muscle itself. He carefully analyzed the different fibers of muscular structures and concluded that muscle volume does not increase upon contraction of the muscle: a happy intuition of the contraction phenomenon.<sup>6</sup>

The concept of “Fibrillar estequiology” – which Girolamo Fabrizi d’Acquapendente, teacher of William Harvey, had applied in his incipient muscle mechanics, was successfully imposed in biology and medicine by Stensen. In his *De homine* (1662)<sup>7</sup> treatise, Descartes had elevated fibrillar composition to a basic concept in anthropology as a fundamental element of the *res extensa* (matter) of the human body and Stensen elaborated his geometrical myology based on this concept (*fibra motrice*). With the concept of *fibra motrice* as key, Giovanni Alfonso Borelli, author of the treatise *De motu animalium*<sup>8</sup> and member of the “Accademia del Cimento” would construct his iatromechanical physiology. Concomitantly, Giorgio Baglivi distinguished two types of fibers: motion fibers (*motrice*) (muscles, tendons, and bones) and the membranous fibers (viscera). Stensen and Borelli were thus the champions of the mechano-mathematical conception of muscular movement (fibers, levers, tensors). It is worth mentioning that Borelli was a disciple of Galileo and that the Danish scientist evolved, under the influence of the members of the Florentine “Accademia del Cimento”, from a Cartesian to a Galilean scientist.<sup>9</sup>

## Stensen, doctor in medicine

On December 4th, 1664, professor Sylvius presented the brilliant results of the studies performed by the “very capable young Nicolao Steno” to the Academical Senate of Leiden University, emphasizing the “noteworthy erudition shown in his publications”. For these reasons, Steno was “very worthy of the title of doctor of medicine”. Given the favorable assessment and the praise of other professors of the faculty, the University Senate, in an exceptional fashion, awarded the title of doctor in medicine *in absentia*, and decreed that the corresponding diploma be prepared and sent to him.

Stensen was then living in Paris. In the City of Lights, the doctor was a guest of Melchisedec Thévenot, a corresponding member of the “Accademia del Cimento”. By

intermission of colleagues from the Thévenot circle, Stensen was able to make himself known and was allowed to perform dissections in the Parisian hospitals: Charité, Saint-Côme, and Hôtel-Dieu. He was soon invited to perform anatomical dissections even at the Faculty of Medicine. During his brief stay in the farmhouse of his Parisian host, Stensen had the opportunity to detect a congenital cardiopathy: four malformations associated to the heart and the great arteries, known today as tetralogy of Fallot (named after Fallot, who described it in 1888 and related the anatomical defects with the clinical signs and symptoms).<sup>10</sup>

The Danish anatomist described it alongside defects of other congenital malformations in an essay written in 1665 and published in 1672.<sup>11</sup> The malformation was described after Stensen and before Fallot, by other investigators of the 18th and first half of the 19th centuries: Edward Sandifon in Leiden, John Hunter, R. Pulteney, and T.S. Peacock in England.

On his way through Montpellier, the Danish youth made the acquaintance of Martin Lister, William Croone, and the famous naturalist John Ray, English scientists who were there on visits.<sup>12</sup> Thanks to them, Stensen managed to form a relationship with the Royal Society of London. Medical members of this corporation, tried to repeat the so-called Stensen ligature. Stensen had observed that a ligature placed on the aorta stopped all voluntary movement in the lower parts of the animal with movement returning every time the ligature was loosened. This finding pointed to the importance of blood flow for muscle contraction; the Stensen ligature produced the same effect as the section of the corresponding nerves. It is also noteworthy that Stensen strongly recommended a rigorous experimental research method and collaborative team work.<sup>10</sup>

## Stensen in Italy

In February 1666, the young Danish scientist disembarked on the dock of Leghorn (Liorna) and headed to Pisa to hold an interview with Prince Leopold of Medici, the younger brother of the Grand Duke of Tuscany, Ferdinand II.

By the beginning of April, Stensen was already in Rome. At a dinner party in the Villa Ludovisi, he met the piedmontese surgeon Giovanni Guglielmo Riva of the “Santa Maria della Consolazione” hospital. Two years later, Guglielmo Riva would attempt to transfuse blood to patients suffering from tuberculosis.<sup>13</sup> Stensen interviewed with Marcello Malpighi who had already described the capillary vessels that he had observed in the lungs<sup>14</sup> and mesentery of frogs using the excellent microscopes provided by Eustachio Divini. Malpighi would be named member of the “Royal Society” of London in 1669. Back in Florence, Stensen was named corresponding member of the “Accademia del Cimento” inaugurated on June 18th, 1657, by initiative of the cultured Prince Leopoldo de Medici. The name and motto of this corporation “*Provando e riprovando*” (“trying and trying again” or “experimenting and confirming”) derived from a Dante verse (“Paradise”. III v. 3) and was established in 1660. It is important to mention that in the Platonic dialogue “*Teetetes*”, it had already been affirmed that science consists in judgment documented by proof.<sup>15</sup> Members of the

aforementioned academy met in a room of the Pitti Palace, next to the palatine library.<sup>16</sup>

Stensen renewed his studies on muscles and was able to establish the distinction between red and white muscles. He accurately determined the structure of muscular fiber as being composed "by minuscule fibers bound in parallel units" and formulated a distinction between simple and compound muscles.<sup>17</sup> Furthermore, he proved that fibers, and not tendons, participate in muscle contraction. He substantiated his thesis with many schemes and geometrical demonstrations.<sup>18</sup>

At the "Santa María Nuova" hospital, a newly renovated and enlarged building, where Leonardo da Vinci had performed anatomical dissections,<sup>19</sup> Stensen performed numerous necropsies which were frequently attended by other academics of the Experimental Academy and sometimes by foreign visitors of the Medici court. He was also known to travel with the court entourage either alone or in the company of the Tuscan physician Francesco Redi, with whom he performed studies and experiments in many places. Stensen was also an avid reader of books provided by the librarian of the grand-ducal palace, Antonio Magliabechi, who, at his death in 1714, left his personal library of 30,000 volumes to the Florentine folk to be used as a public library. This donation constitutes the foundation of the modern National Library of Florence.

## Last years

After converting to Catholicism in 1667, Niels Stensen made some trips with scientific purposes to the south of Italy (Naples) and to the north of Europe (Copenhagen). In Copenhagen, he published various scientific articles for the journal *Acta Medica et philosophica Hafniensis* (1673).

It is worth mentioning that in the same year of the publication of the great work by Harvey De *motu cordis*. (1628), the Paduan professor Giovanni Cole (1558–1631) had conceived the method and described a possible technique to perform a blood transfusion.<sup>20</sup> However, the first transfusions performed in Italy and elsewhere were so riddled by complications that civil and religious authorities banned them.<sup>21</sup> During his stay in Copenhagen (1673) he answered a question relating to blood transfusions with the following statement "it is not licit to perform blood transfusion as it exposes the patient to grave dangers as we still do not know the characteristics of the bloods we would mix". In fact, it was not until 1900 that the Austrian physician Karl Landstainer,<sup>22</sup> who also identified the Rh factor in 1937,<sup>23</sup> characterized blood groups.

In 1674, Niels Stensen received his ecclesiastical orders in Florence and in 1677 Johann Friedrich, Duke of Hannover, appointed him apostolic vicar. Stensen's missionary work commenced on November 8, 1677, in Hanover and, after many visitations to parishes and becoming an outspoken beggar for the poor, and concluded with his premature death on November 25, 1686, in the small city of Schwerin, capital of the Ducky of Mecklenburg-Schwerin. At the request and expense of Grand Duke Cosimo III de Medici of Tuscany, his old pupil and devoted friend, his body was taken to Florence. On October 13, 1687, he was buried in the crypts of the Medici tombs of San Lorenzo. Three centuries

later, on October 23rd, 1988, Stensen was beatified by Pope John Paul II.

His gigantic anatomical work was remembered synthetically by Albrecht von Haller: "He was one of the greatest anatomists of a century rich in discoveries".<sup>24</sup>

On the other hand, in the so-called prayer book left by Stensen in Schwerin<sup>25</sup> one reads "Lord, stay close to us so that all lack of love, every hatred and every word that may injure, may disappear."

## Conflict of interest

Authors have no conflict of interest to declare.

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