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REVIEW ARTICLE

Giovanni Battista Morgagni (1682–1771): father of pathologic anatomy and pioneer of modern medicine

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Abstract Giovanni Battista Morgagni (1682–1771) was an Italian anatomist who introduced the anatomo-clinical concept in medicine and established anatomy as the instrument to identify the seat and etiology of any disease. He was professor of anatomy at the prestigious University of Padua for more than 50 years. His first documented text in anatomy, *Adversaria Anatomica* was published in three volumes between 1706 and 1719. His accurate anatomical descriptions of human organs enhanced his reputation as the most famous anatomist of Europe during that period. Morgagni published the most important work of his life, the masterpiece in pathologic anatomy, *De Sedibus*, in 1761. The text is based on his pathologic observations from about 700 autopsy dissections of patients whom he had treated during their lifetime. *De Sedibus* provides the reader with a precise correlation between the anatomo-pathologic findings at post-mortem and the clinical symptoms of a disease observed during a lifetime. Morgagni's ability to integrate and synthesize information set him apart from his contemporaries, and his anatomo-clinical method was a major breakthrough in the history of medicine as it helped physicians to diagnose a disease, analyse the prognosis of that disease and prepare a management protocol for the same. His achievements led to the emergence of pathologic anatomy as an exact science and with him began modern medicine.

Keywords Anatomy · Pathology · Anatomo-clinical method · Modern medicine · *De Sedibus* · Padua

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Introduction

Italian anatomist and physician Giovanni Battista Morgagni (1682–1771) (Fig. 1) was a pioneer in the true sense. His remarkable contributions to anatomy marked the onset of a new era in the field of medical sciences and laid the foundation for the emergence of modern medicine as we now know it (Virchow 1929). He was the founder of pathologic anatomy and emphasized the correlation between empirical symptoms of a disease and the pathological findings observed at autopsy (Androutsos 2006). He described clinical symptoms as 'the cry of the suffering organs' and thus deviated from the traditional approach of his predecessors who mostly ignored the internal mechanism of human diseases and based their management on the observed symptoms (King 1963). Morgagni introduced the anatomo-clinical concept for determining the disease mechanism, and he asserted that anatomy is the instrument by which to identify the seat and the etiology of any disease (Maulitz 1987). His efforts were pivotal in shattering old school thoughts prevalent from the time of Hippocrates and Galen whereby anatomical studies and medical practice were considered to be completely different entities (Belloni 1952). His rationality led to the coherent approaches to anatomy, pathology and internal medicine that have guided the development of medical sciences over the years (King 1963).

Morgagni was able to bridge the gap between a basic science such as anatomy and clinical practice through his work. His achievements proved to be pivotal elements in the progress of pathology and internal medicine (Gairdner 1874; Belloni 1982). A biographical sketch of Morgagni is very relevant in the context of current approaches to medicine whereby teaching/learning anatomy is at crossroads with anatomists trying their best to project the relevance of pathologic anatomy in the face of ever increasing challenges posed by

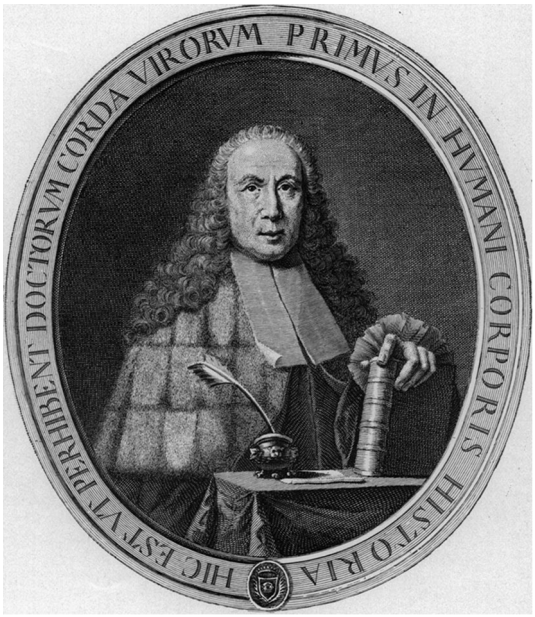

Fig. 1 A portrait of Giovanni Battista Morgagni. Image in public domain

modifications introduced into medical curriculums across the globe (Drake et al. 2009). This review was undertaken to trace the journey of this extraordinary anatomist and his academic achievements which have served mankind for centuries and could potentially inspire present and future anatomists.

Methods

An extensive literature search was undertaken, and standard search engines, such as PubMed, Scopus, Google search, Google scholar and Wikipedia, were referred to for relevant published material. The following terms were used during the literature search: "Giovanni Battista Morgagni", "Morgagni", "biography of Morgagni", "Morgagni and anatomy", "anatomy and pathology", "pathologic anatomy", "Paduan anatomists", "Morgagni and eponyms", "De Sedibus", "Pathology and medicine" and "emergence of modern medicine". Published texts by Morgagni and their translations in English were consulted from online libraries and, where applicable, these have been appropriately referenced. The images used in the text were procured from the Internet, and all figures shown are in the public domain (i.e. free from copyright issues).

Early life and anatomy training

Morgagni was born at Forli, a small town near Bologna, Italy on February 25, 1682. He completed his early studies at Forli, and his scholarly activities were evident from his teenage years as he showed interest in medicine, literature and philosophy (Ongaro 2007). In 1698, when 16 years old, he went to Bologna to further his studies and received his doctor's degrees in medicine and philosophy in 1701 (Castiglioni 1948). Once graduated, Morgagni was appointed as Prosector in anatomy under the able guidance of a noted anatomist, Antonio Maria Valsalva (1666–1723), at the Santa Maria della Morte hospital in Bologna (Ventura 2000). He worked under Valsalva for the next few years and was immensely influenced by his mentors' teachings, which is apparent from the numerous references made to Valsalva's works in his future communications (Garcia and Garcia 2006). Following Valsalva's transfer to Parma, Morgagni succeeded him as the demonstrator of anatomy in Bologna. During this period, he published his first work on anatomy, *Adversaria Anatomica Prima*, in 1706, which primarily consisted of his correspondence to the Academia Inquietorum of Bologna, of which he was elected president in the same year (Belloni 1974). At the beginning of 1707, Morgagni resigned his position of demonstrator and left Bologna to pursue postgraduate studies in anatomy at Padua and Venice. While in Venice, he conducted a number of dissections of human cadavers with Gian Domenico Santorini (1681–1737), the discoverer of the accessory pancreatic duct (Santorini's duct), who at that time was the dissector and lector in anatomy at the Venetian University (Porzionato et al. 2012). In June 1709, Morgagni returned to his native town Forli to practice medicine and very soon established himself as a successful physician (Belloni 1974).

Academic career at Padua

In September 1711, Morgagni was invited to Padua as Professor in the second chair of theoretical medicine, replacing Antonio Vallisnieri (1661–1730) who had been promoted to the first chair following the death of Domenico Guglielmini (1655–1710) (Romero-Y Huesca et al. 2007). On March 17, 1712, Morgagni delivered his inaugural lecture on theoretical medicine, entitled *Nova Institutionum Medicarum Idea*, where he presented the educational project for the "medicus perfectissimus". While outlining his teaching program, Morgagni suggested that the students be instructed first in the principles of mathematics, then chemistry, botany and zoology, followed finally by anatomy. His educational method proposed adherence to empirical data and encouraged students to search for the truth through observations and experiments (Zanchin and Panetto 2004). Very soon thereafter he established his credentials as an excellent teacher among his students and peers. In 1715, on the advice of Giovanni Maria Lancisi

(1654–1720), who himself was a famous anatomist and Papal physician, the Venetian Senate appointed Morgagni to the first chair of anatomy at Padua, following in the footsteps of illustrious predecessors such as Vesalius, Fallopius, Spigelius and Veslingius, to name only a few (Andrioli and Trincia 2004; Ghosh et al. 2014). At Padua, Morgagni enjoyed the utmost academic freedomm and he continued his tenure as professor of anatomy here with highest distinction for the rest of his life (Ongaro 2007). His reputation as a teacher spread far and wide, attracting students not only from different universities of Italy but also foreign students, particularly Germans, who attended his lectures and demonstrations at Padua. He carried himself with absolute dignity but at the same time enjoyed immense popularity among the authorities and students alike by virtue of his happy and welcoming nature and polished manner (Belloni 1974). In his lifetime, the native German students placed his statue near the anatomical theatre at Padua in 1769 (Porzionato et al. 2012). His stature as an academician can be assessed based on the number of fellowships bestowed on him from prominent scientific societies across Europe, including the Royal Society of England (1724), Academy of Sciences of Paris (1731), Imperial Academy of St. Petersberg (1735) and Academy of Berlin (1754) (Ongaro 2007). He died on December 5, 1771 due to ventricular rupture at his residence in Padua at the age of 89 and was buried in Saint Maxim Church in Padua (Belloni 1974; Zanatta et al. 2014).

Contributions as an anatomist

Morgagni was a prolific author of anatomical texts, and he started to document his findings very early in his medical career. His treatise *Adversaria Anatomica* (Fig. 2) comprises a series of research findings based on immaculate anatomical dissection. The first volume, *Adversaria Anatomica Prima*, was published in 1706 (Morgagni 1706), followed by the second volume, *Adversaria Anatomica Altera*, in 1717 (Morgagni 1717) and the final volume, *Adversaria Anatomica Omnia*, in 1719 (Morgagni 1719). These works established his reputation as a famous anatomist across Europe, which is evident from the fact that his colleagues referred to him as 'his anatomic majesty' and the 'the Prince of all European anatomists' in their correspondence (Ongaro 2007). In his texts, Morgagni first documented the anatomical details of a particular organ based on his observations and then compared his own results with those of previous authors based on his extensive reading of the literature that was available at the time. He was very particular in acknowledging the efforts of his predecessors, as shown by the references and citations of the works of illustrious anatomists, such as Harvey and Willis, among many others, at the foot of every page of his texts. He also stressed that "anatomy should be considered as the indispensable premise for the clinician" and that its proper understanding is essential to the success of a physician. His modesty is reflected in his text as he insists his readers not accept his writings blindly and never

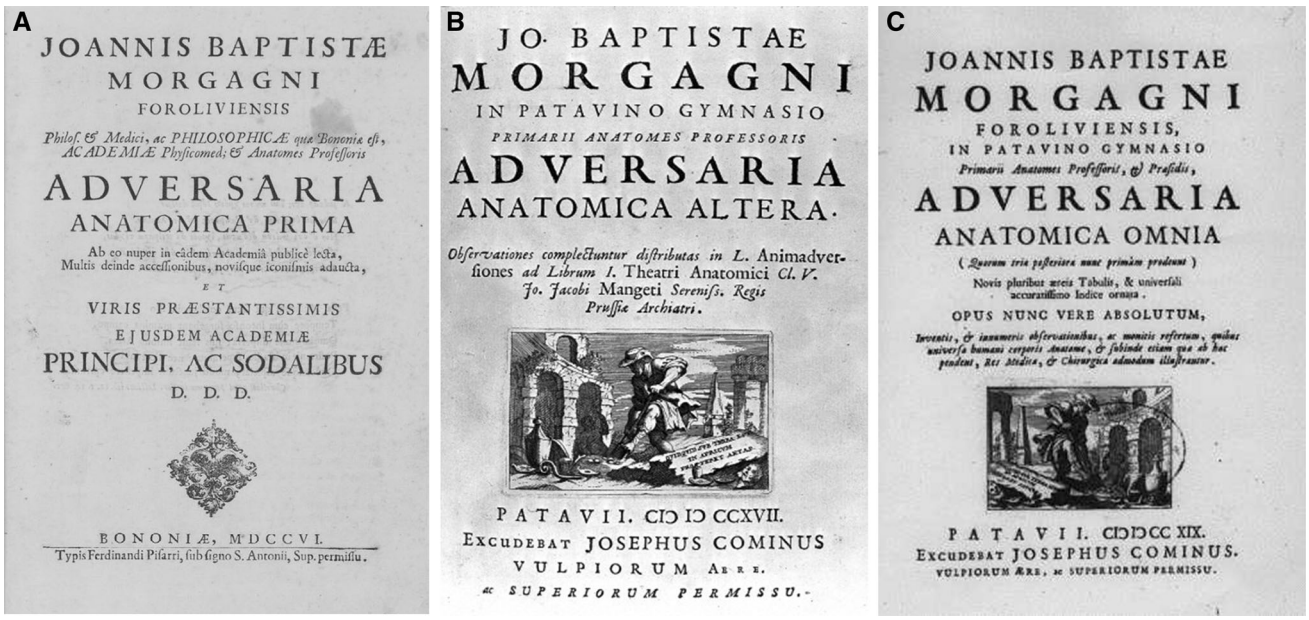

Fig. 2 Images of the cover pages of Morgagni's *Adversaria Anatomica* which was published in three volumes. **a** *Adversaria Anatomica Prima*, published in 1706, **b** *Adversaria Anatomica Altera*, published in 1717, **c** *Adversaria Anatomica Omnia*, published in 1719. All three images are in the public domain

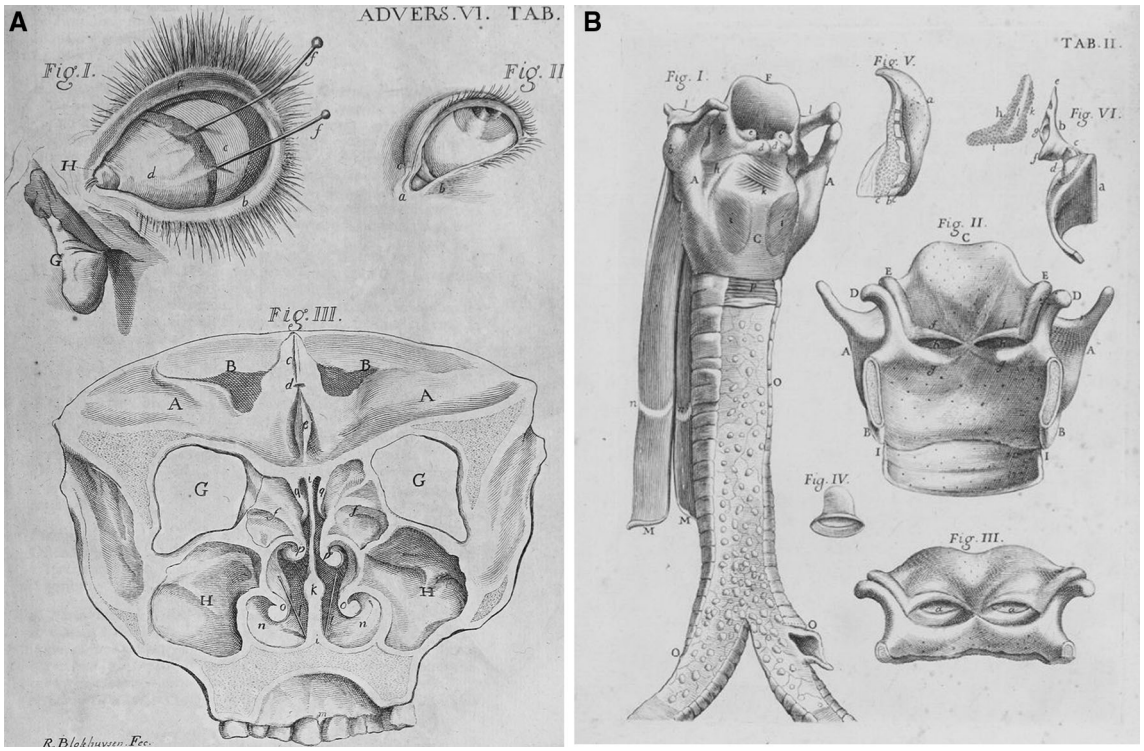

Fig. 3 Illustration plates from Morgagni's *Adversaria Anatomica* showing anatomical details. **a** Lacrimal apparatus and paranasal air sinuses, **b** different components of the larynx along with the trachea. Both images are in the public domain

believe that the last words in science have been spoken without undertaking their own experiments (Morgagni 1706, vol. I, pp 1–24). His accurate anatomical descriptions of human organs served as the platform for the emergence of pathologic anatomy as an exact science, which he himself pioneered during the later part of his life (Gairdner 1874). In addition to rectifying several errors of previous anatomists, Morgagni's findings furnished new and valuable information on various aspects of human anatomy, particularly the glands of the larynx, glottis, trachea, lacrimal apparatus, paranasal air sinuses, heart and great vessels, kidneys, male urethra and female genital organs (Bertoloni Meli 2011) (Figs. 3, 4). He described a number of anatomical structures for the first time, and some structures continue to bear his name even today as a testimony to his remarkable achievements. These include the lateral pouch in the vestibule of the larynx, referred to as Morgagni's ventricle, and the space between the base of the skull and the superior constrictor of the pharynx, referred to as the sinus of Morgagni. He is also credited with the first description of the superior nasal concha, which is known as Morgagni's concha. He was the first to describe the fissure on the right side of the diaphragm between the sterna and the costal components (trigonum sternocostale dextrum/Morgagni's foramen), and the congenital hernia (Morgagni-Larrey hernia) through this foramen is eponymous. The appendix of the testis, also known as Morgagni's hydatid, was first defined by him (Power and Sedgwick 1892). Incidentally this should not be confused with the hydatids of Morgagni which are small fluid-filled cysts commonly attached to the fimbriae of the fallopian tubes (Long 1928). Actually, Morgagni described a diverse assortment of pathological entities characterized by the formation of encysted fluid as hydatids (Watson 1902). The vertical folds in the mucous lining of the anal canal above the pectinate line are referred to as Morgagni's columns. He also documented the description of the middle prostatic lobe, also referred to as Morgagni's caruncle, and the openings of the mucous secreting glands of the urethra in males, known as Morgagni's lacunae (Power and Sedgwick 1892).

De Sedibus and birth of pathologic anatomy

Morgagni conceived his plan for a monumental work on pathologic anatomy, the first of its kind at the time, while working at Padua. He published this most important work of his life, *De Sedibus et Causis Morborum per Anatomen Indagatis Libri Quinque* (Fig. 5) or "The Seats and Causes of Disease Investigated by Anatomy in Five Books", in 1761, at the age of 79 years. This work was a compilation of his pathologic observations from about 700 autopsy dissections (Molenaar 2001). Most of the patients

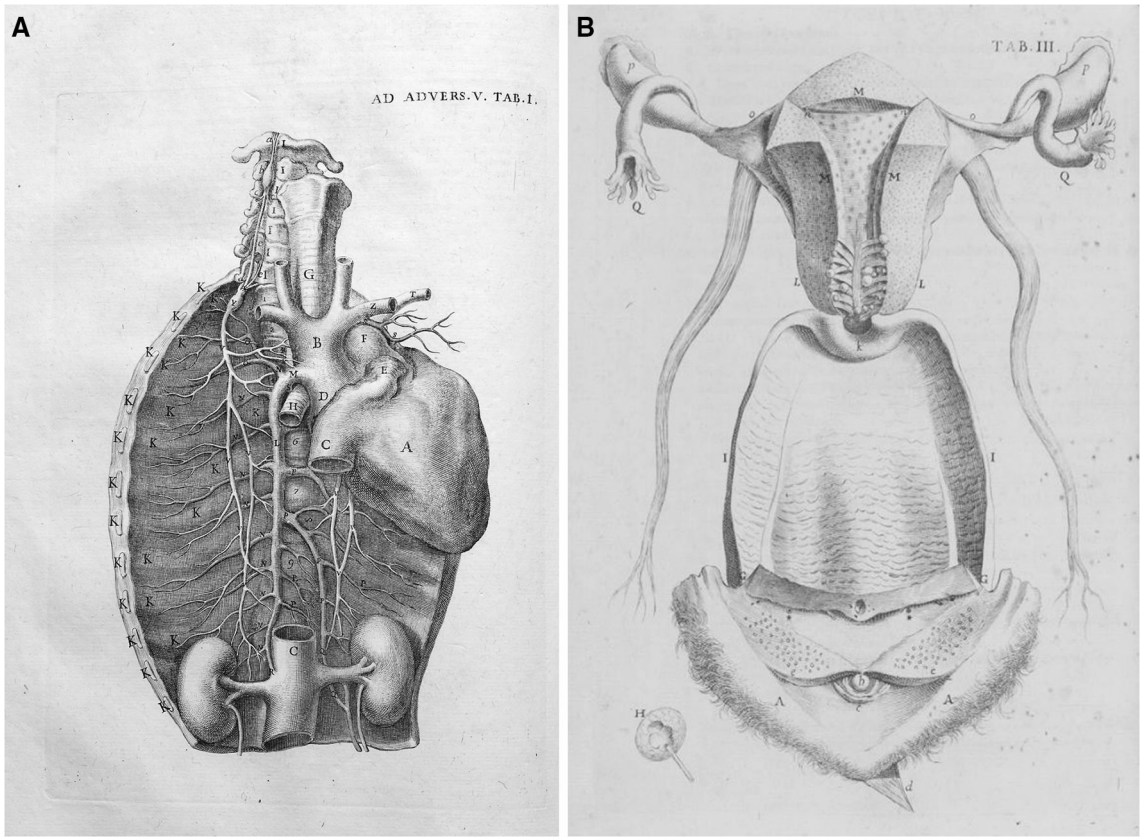

Fig. 4 Illustration plates from Morgagni's *Adversaria Anatomica* showing anatomical details. **a** Heart with great vessels, kidneys and the posterior body wall, **b** female reproductive system. Both images are in the public domain

described in his texts had been treated and ultimately dissected by himself, and the cases covered are from almost all fields of pathology (Forgazzi 1998). Each volume of *De Sedibus* describes a separate aspect, with volumes I, II and III describing diseases of the head and neck, thorax and abdomen, respectively; volume IV describing general diseases and comparing these with diseases which require surgical intervention; volume V, a supplement (*De addendis ad singulos quatuor Libros superiors*), detailing his corrections to the previous four volumes in the context of new observations and enhanced clinical experiences. His inclination towards perfection is evident from a special feature of *De Sedibus*, which comprised a series of four indexes, carefully prepared to exclude errors and referred to numerous times by Morgagni in his descriptions. The first of these is related to the subject matter of the five volumes (*Argumenta ex ordine ostendens totiusoperis*); the second one is about the disease symptoms, causes and other related matters; the third gives an account of the external and internal appearances of the cadavers (*Index Visorum in Cadaveribus*); the fourth is an index of names and other noteworthy things (*Index Nominum et Rerum Notabilium*). In *De Sedibus*, Morgagni acknowledges each of his patients whose cadaver he dissected for his observations, with the patients coming from all segments of society, including bishops, cardinals, nuns, highway men, malefactors, thieves and merchants, which is a testimonial of his range of medical practice (Morgagni 1761). The core of this anatomical masterpiece comprises about 70 letters/communications written by Morgagni in which he tries to clarify the various discrepancies that arose from a text titled *Sepulchretum Sive Anatomica Practica* published by Théophile Bonet (1620–1689) in 1679 and some other documents published earlier.

De Sedibus was possibly the first attempt ever made towards correlating ante-mortem symptoms with post-mortem findings (Long 1928; Zampieri et al. 2014). Morgagni's *De Sedibus* was, however, clearly the first time that an accurate correlation was made between pathology found post-mortem and the clinical findings. His pathologic anatomy stands apart from that of his predecessors in the precision of reasoning he applied to the subject (Molenaar 2001). *De Sedibus* constitutes the foundation stone of modern pathologic anatomy and is undoubtedly one of the most fundamentally important works in the history of medicine (Zampieri et al. 2014). Throughout the text, Morgagni follows a uniform outline which consists of initially providing the reader with a schematic description

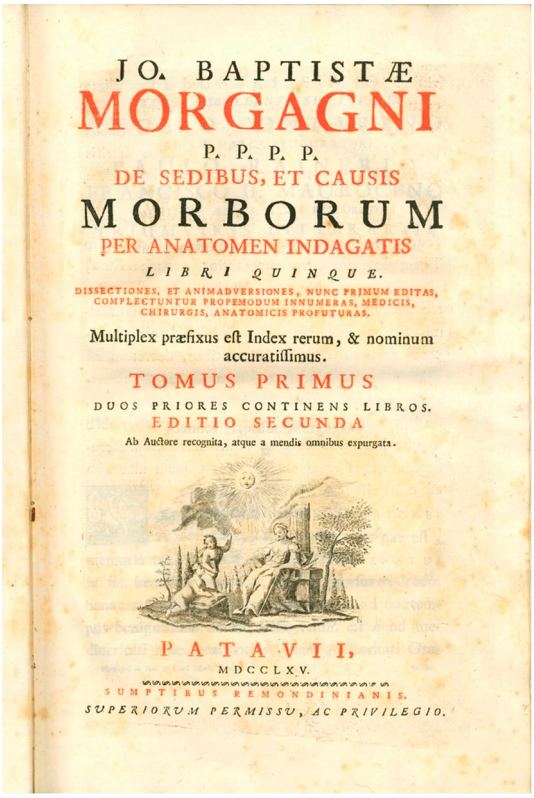
JO. BAPTISTÆ
MORGAGNI
P. P. P. P.
DE SEDIBUS, ET CAUSIS
MORBORUM
PER ANATOMEN INDAGATIS
LIBRI QUINQUE.
DISSECTIONES, ET ANIMADVERSIONES, NUNC PRIMUM EDITAS, COMPLECTUNTUR PROPEMODUM INNUMERAS, MEDICIS, CHIRURGIS, ANATOMICIS PROFUTURAS.
Multiplex præfixus est Index rerum, & nominum accuratissimus.
TOMUS PRIMUS
DUOS PRIORES CONTINENS LIBROS.
EDITIO SECUNDA
Ab Auctore recognita, atque a mendis omnibus expurgata.
PATAVII,
MDCCLXV.
SUMPTIBUS REMONDINIANIS.
SUPERIORUM PERMISSU, AC PRIVILEGIO.

Fig. 5 Image showing the cover page from Morgagni's *De Sedibus et Causis Morborum per Anatomen Indagatis Libri Quinque*. The first edition of the text was published in 1761, but the image shown here is from the second edition, which was published in 1765. Image is in the public domain

of the disease process correlated with the anatomo-pathologic findings, followed by meticulous interpretation of these findings and eventually by his perspective on the prognosis and possible management strategy (Zampieri 2013).

In *De Sedibus*, Morgagni emphasizes that physicians need to understand the disease process as this understanding would enable them to consider not only the symptoms which are apparent but also those which are absent in a patient to ensure appropriate management. He provides examples of cases where the patient suffered more at the hands of the physician rather than the disease itself simply because the physician did not have any understanding of the anatomo-clinical correlation and thereby did not know when to be inactive (Morgagni 1761, vol. I, pp 156–158). In his treatise, Morgagni accurately describes cardiac lesions, such as angina pectoris, ruptura cordis, endocarditis, myocardial degeneration, pericardial effusion and congenital cyanotic heart diseases, among others (Morgagni 1761, vol. II, pp 282–285). However, the pinnacles of his text are possibly the detailed analysis of valvular lesions of the heart (aortic stenosis and mitral stenosis) and lesions related to vessels of the heart (coronary artery block, coronary sclerosis, aortic syphilitic aneurysm and systemic vasculitis of aorta/Takayasu's arteritis?) (Long 1928; Acierno 1994; Lazzarin et al. 2005). In fact, the section on aneurysm of the aorta is one of the finest descriptions of this disorder ever documented (Long 1928). He even accurately describes the clinical disorder which subsequently came to be known as Stokes–Adams syndrome (Ventura 2000). His description of the pathology of the respiratory system, such as the hepatized lung in pneumonia, fibrinous bronchitis and pulmonary tuberculosis, remains relevant even today (Long 1928). Volume 1 of *De Sedibus* was probably the first documented text on neuropathology, where he describes clinical entities such as subarachnoid haemorrhages, cerebral air embolism, cerebral gumma and optic neuropathy, which were unheard of until then in medical practice (Öncel and Baser 2016). He gave outstanding accounts of alterations in the cerebral blood vessels and their relation to apoplexy and hemiplegia. Through his observations he was able to establish that in cerebral stroke, the lesion involved was in the cerebral hemisphere opposite to the side of paralysis (Tubbs et al. 2012). He was the first to describe familial hypertension when he detailed the history of a patient who died of edema and cardiac hypertrophy (Borsatti et al. 1994). He also provided detailed accounts of pathological conditions of the gut, such as tumors of the pylorus and lesions of the appendix (Long 1928). Morgagni worked extensively on a wide spectrum of renal abnormalities and his descriptions included variations and abnormalities in the location, contour, shape and the number of kidneys (asymmetrical kidneys, solitary kidney, horseshoe-shaped kidney), hydronephrosis, nephrolithiasis, suppuration and renal tumours (Forgazzi 1998). He was the first to document pathological conditions in paediatric patients, such as coarctation of aorta, Crohn's disease, meconium-induced peritonitis, neural tube defects (spina bifida), anterior abdominal wall defects (gastroschisis/omphalocele) and defects in the genito-urinary system (epispadias and vesico-ureteric reflux) (Zani and Cozzi 2008; Abramowsky and Berkowitz 2015). Morgagni was one of the few authors who reported cases of cancer during that period. He studied and described about 17 such cases, which included cases of osteosarcoma, carcinoma of the stomach, malignant lesions involving the larynx and pharynx, carcinoma of the pancreas, malignant ascites, ovarian cancer, cervical cancer, breast carcinoma and testicular cancer (Hajdu 2010). Hence, in *De Sedibus,* Morgagni provided a well-organized systemization of a myriad of isolated facts and discoveries, thereby underlining the scientific relation between the living and post-mortem aspects of diseases. His monumental work eventually proved to be a great service to anatomical sciences and, on a broader sense, to internal medicine.

The anatomo-clinical method and its influence on medicine

Morgagni's life and works were considerably influenced by his teacher Antonio Maria Valsalva. Both of these men tried to make anatomical dissection a medium for the progress of medicine as such and hence aimed to explore the clinical utility of anatomy during their lifetime (Andrioli and Trincia 2004). The tradition of undertaking anatomical investigation to determine the disease mechanism was initiated by Marcello Malpighi (1628–1694), who is considered to be the forefather of pathologic anatomy. Morgagni, who was a pupil of Valsalva, was his successor and continued this long-lasting legacy of following a mechanistic approach for the analysis of anatomy (King 1963). In his perspective, the human body was a machine composed of several devices (organs), each entrusted with a specific function, and there was an interrelated composite relationship between individual organs which drives the machine (human body). Hence, a defect (lesion) in one of the devices would lead to a specific mechanical problem (disease) that would in turn affect the overall performance of the machine (human body). This philosophy formed the basic architecture of his masterpiece *De Sedibus*, where Morgagni elaborated that it was the anatomical lesion in an organ (pathology) which leads to dysfunction of the anatomo-mechanical device (human body), thus resulting in the expression of disease (clinical symptoms) (Zampieri et al. 2014). He subsequently elaborated in his text that systematic post-mortem examination provided an explanation for every symptom and sign observed during life. The importance of undertaking post-mortem autopsies in medical science is appropriately reflected in Morgagni's own words, "those who have dissected or inspected many (bodies) have at least learned to doubt; when others, who are ignorant of anatomy and do not take the trouble to attend to it, are in no doubt at all" (Morgagni 1761, vol. I, pp 396). Morgagni's remarkable ability to integrate and synthesize information set him apart from his predecessors as well as contemporaries and was instrumental in compilation of his treatise *De Sedibus,* where he unveiled the anatomo-clinical method, which was a seminal event in the history of medicine (Andrioli and Trincia 2004). His concept forms the basic foundation of modern medicine that making the diagnosis, analysing the prognosis and preparing the management protocol of a disease should be based on the understanding of the pathological changes in the anatomical structures (Molenaar 2001). The value of his achievements can only be enhanced taking into consideration that the theory and practice of eighteenth century medicine was very different from that of the present era. In those days, a physician's response to illness was centered on the individual patient and the evident symptoms. The practice of medicine did not extend beyond the individual patient to the implications for society at large (Ackerknecht 1967; Jewson 2009). Morgagni's approach to anatomo-clinical correlation was the foundation for the introduction of the clinico-pathological conference at Harvard Medical School at the onset of the twentieth century, a trend which has since been adopted by medical schools worldwide. Such meetings represent the confluence of pathology, with a focus on the disease process and clinical practice and an emphasis on patient outcome, and carries forward the legacy of Morgagni (Zampieri et al. 2015). His contribution to the advancement of medical sciences is appropriately depicted in a fresco displayed at the National Institute of Cardiology, Mexico City. The mural shows Morgagni pointing his left hand towards a prominent pulsatile aortic aneurysm in the chest of a patient on his deathbed and demonstrating the morbid anatomy of the same aneurysm in the autopsy table with his right hand following dissection of the cadaver of the patient (Zampieri et al. 2013; Estañol and Delgado 2014). Such an accurate depiction of the anatomo-clinical method is a tribute to his exceptional skills, and in the light of the above discussion it may not be an overstatement to suggest that Morgagni founded modern pathology and with him began modern medicine.

Conclusion

Giovanni Battista Morgagni was a brilliant and tireless investigator who devoted his life to the systematization of morbid anatomy, which in turn led to the birth of pathologic anatomy. His experiments in correlating the clinical symptoms of a disease evident in the living with the changes observed in the normal anatomy of organs at autopsy proved to be a critical turning point in the history of medicine. Throughout his career he strived to establish the importance of knowledge of the anatomical basis of clinical practice. His footsteps continue to serve as a reliable guide in the journey for the search of excellence in the field of medical sciences. He was beyond doubt one of the most influential anatomists of the eighteenth century and by virtue of his exploits deserves a place among the greats of modern medicine.

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Compliance with ethical standards

Ethical clearance Not required.

Conflict of interest None to declare.

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