

The rise and fall of the autopsy

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Received: 15 February 2013 / Accepted: 18 February 2013 / Published online: 7 March 2013
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The history of the autopsy covers a very long period [1–3]. Autopsy derives from the Greek words *autos* (self) and *opsis* (eye), loosely translated as “seeing for oneself,” but it is impossible to recognize (abnormal) anatomical features that one can not place in the appropriate context. An understanding on “normal” anatomy and the basic mechanisms of disease causation are both prerequisites for an effective autopsy. The animistic view of the world around us in the millennia before Hippocrates (468–377 BC), explaining all events by the actions of unseen (divine) powers, precluded even the thinking of a morphological basis of disease. The subsequent naturalistic view, strongly influenced by Hippocrates’ opinion that diseases result from natural causes and not from divine or supernatural powers, opened the way for more progressive thinking. However, even then, there was no place for autopsies in the Hellenic or Roman periods or even in early medieval times when the basic knowledge necessary for understanding even gross abnormalities of organs had still to be developed

Autopsies, therefore, were necessarily preceded by thorough anatomical dissections, followed by a period of observation and correlation, leading to a gradual understanding on abnormal anatomical structures. Thus, with the exception of crude forensic investigation of the cause of “unnatural” death, “medical” autopsies were not really possible until there was also some understanding on morphological and

physiological changes occurring in the course of disease and death.

From BC to 1000 AD

The first dissections of humans were already performed within a century after Hippocrates’ death and attributed to the Alexandrian scientists Herophilos (335–280 BC) [4] and Erasistratos (304–250). Unfortunately, their writings are all lost, and we know of their work only secondhand. Herophilos is believed to be among the first to pursue anatomy as a science, while his contemporary Erasistratos was more of a physiologist than an anatomist. Although lacking sound anatomical and physiological knowledge, they nonetheless sought to explain symptoms and complaints by reference to observed morphological changes. Both these men and their followers broke with the established Hippocratic theory. However, they were unable to introduce any new doctrine in its place, and their impact was short-lived.

It is unclear if human dissections were performed during the domination of the Roman Empire. Although many paintings suggest the presence of the Roman Emperor Nero at the “autopsy” of his mother Agrippina, whom he had contrived to poison in March, 57 AD, there is no firm historical evidence that this event actually took place (Fig. 1). Later, the Church father Augustine (354–430) wrote strongly against human dissection. A tenth century manuscript from Monte Casino quotes the physician Vindician, a friend of Augustine, as saying, “It pleased the ancient anatomists to examine the viscera of the death to learn in what way they died, but for us humanitas prohibits this” [5]. This effective ban by the Church did not, however, mean that there was no increase in the understanding on disease in that period. Clear evidence of progress in medical thinking is found in the work of the Byzantine physician Aetius of Amida (who

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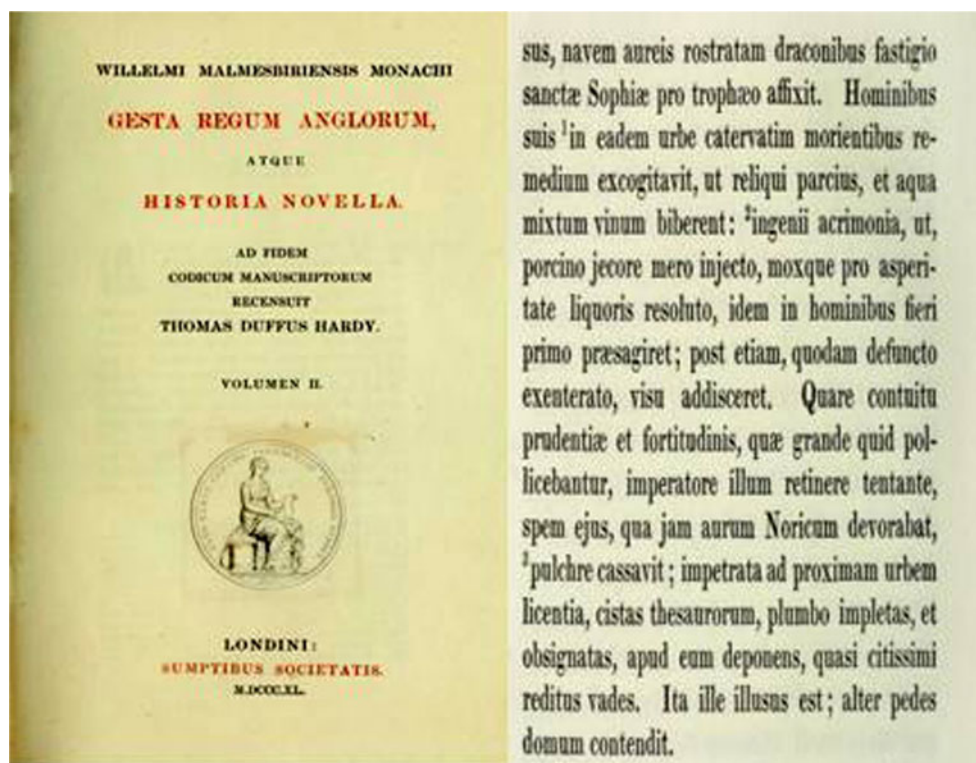
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Fig. 1 Nero witnessing the dissecting of his mother. From the Jean Sans Peur edition of “De casibus virorum illustrium” by Giovanni Boccaccio c 1410 (British Library, London, UK)

lived in the sixth century), the author of *Βιβλία Ιατρικά Εκκαίδεκα* (*Sixteen Books on Medicine*). In these books, Aetius collected his own experience and also drew upon previous medical knowledge, including that from manuscripts from the Alexandrian Library. Aetius was trying to explore the cause of disease based on “pathology” findings, at the same time as he treated patients. Especially in his

Fig. 2 Left: William of Malmesbury’s chronicle *Gesta regum Anglorum*. Right: part of the story of the dead soldiers of the Norwegian King during his stay in Constantinople [7]



book about uterine diseases, *περί των εν μήτρα παθών* (*About the Diseases of the Uterus*), he referred extensively to tumors, and he noticed that tumors are hard in consistency, “scirrhus” from the Greek word “σκίρρος” (stony hard), that they can be ulcerated or nonulcerated and are located in the portio uteri [6]. He also mentioned that cachexia is a clinical sign of uterine carcinoma. He stated that cancer is untreatable, although he performed vaginal “washes” and administered vaginal suppositories. Aetius understood the need of isolation and intensive care for a patient suffering from sepsis, and he managed to create a type of private room made of insulating material, where such patients could be isolated and treated.

From 1000–1400

It was not until the twelfth century that the first written reference to autopsies appeared. The British monk and historian William of Malmesbury reported in his chronicle *Gesta Regum Anglorum* [40] (*Deeds of the Kings of the English*, 1125 AD) (Fig. 2) that in 1111 the Norwegian King Sigmurd I Magnusson (the Crusader) on his return from Jerusalem had one of his many dead soldiers eviscerated in Constantinople to compare his liver changes with those of a pig’s liver placed in the same wine the soldier had been drinking [7]. When the wine had a harmful effect on the liver, he decided that wine must be the cause of his soldiers’

problem and that it should be diluted with water before drinking. This event was first discovered and described in 1936 by F. Grøn in a Norwegian journal. Another early reference to autopsies comes from the chronicle of the Franciscan monk Salimbene of Parma in which he mentions a physician of Cremona who opened the body of a patient who died in the pestilence of 1286 to compare the pathology of the heart with that seen in a hen suffering from the same disease [8]. Neither author displayed surprise or disapproval about the procedure.

An important breakthrough came in 1209 when pope Innocentius III declared that, in a case of unexplained death, the cause of death must be investigated by an experienced doctor. It is, thus, very likely that there was already an early history of isolated “autopsies” at that time. This conclusion is supported by the fact that the Bolognese surgeon William of Saliceto (c 1215–1280), in a treatise on surgery from 1275, described the anatomical disposition of the different organs in such a way that he must have been seen them with his own eyes. Another remarkable person in Bologna at that time was Taddeo Alderotti (1223–1303). In his works, he openly hinted at the performance of post-mortem examinations. Some of the first writers about dissections were his pupils. More cases followed in the years to come.

From 1400–1780

Many names come to mind in discussing the advent of the autopsy as a technique to study the causes of (symptoms of) disease, but four prominent physicians stand out for the major and long-lasting impact of their work. They are chronologically Antonio Benivieni (1443–1502), Théophile Bonet (1620–1689), Herman Boerhaave (1668–1738), and Giovanni Battista Morgagni (1682–1771).

Antonio Benivieni was born in 1443 in an ancient and noble Florentine family as the oldest of five sons. His youth coincided with the beginning of the Italian Renaissance and the revival of learning in the West after the fall of Constantinople in 1453 at the hands of the Ottomans. Moreover, the Gutenberg Bible was printed in 1455 when he was 12 years old. Born under this lucky star and influenced by the humanistic movement underway in Italy long before the fall of the Byzantine capital, Antonio Benivieni received the best possible education his time could offer. Under the guidance of gifted tutors, he studied, of course, Latin, Greek, and literature, the latter effectively laying the foundations for him to become also a gifted writer. Later, he had among his bestfriends poets and philosophers, and he was intimately acquainted with the Dominican monk Fra Jerónimo Savonarola, who was later (1489) condemned as heretic and schismatic, excommunicated, hanged, and burned in the Piazza della Signoria in Florence. Most of the information

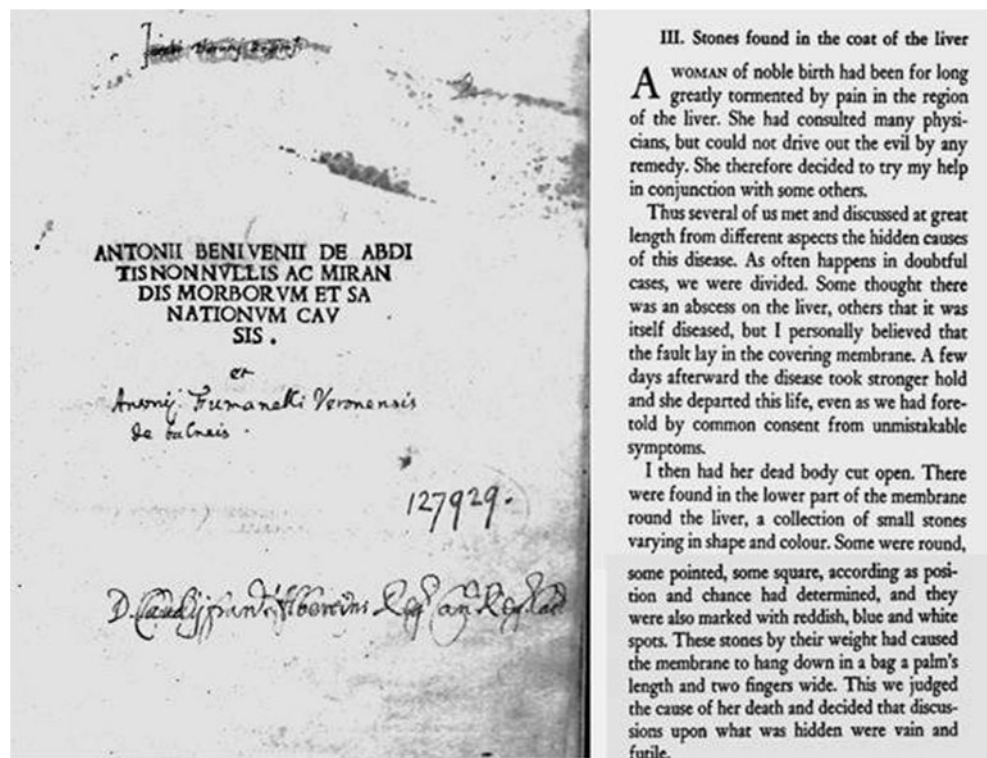
about Benivieni comes from the most important biographer of his life, the pathologist and historian Francesco Puccinotti, who published his observations in 1855 [9].

Benivieni obtained his scientific education at the universities of Pisa and Siena. There are no records of his exact training at these institutions, but we do know that both of these universities took part in the medical renaissance beginning in the thirteenth century in Italy. There also is no information about the year in which Benivieni was admitted to practice medicine in Florence, but it must be around 1470. Benivieni probably passed his whole professional life in Florence, where he was a staff physician in many large hospitals and attached to several religious houses. One of the hospitals was probably Santa Maria Nuova, although there are no records to prove this. It was in this hospital that Leonardo da Vinci (1452–1519) performed anatomical dissections. da Vinci’s own records tell about an old man who passed quietly away in his hospital bed, and Leonardo wrote, “I did an autopsy on him to see the cause of such a quiet death.” It is not unlikely that Benivieni and da Vinci met and maybe discussed their cases. From the available records, it is clear that Benivieni treated many members of the noble Florentine families.

From various records, including notes of one of Benivieni’s brothers, the poet Geronimo, it is also clear that Antonio Benivieni authored many medical manuscripts, among which is *De Pestulentia* and *Consilia contra Pestem*. In addition, he wrote several nonmedical papers, including *De Virtutibus*, *De Cometa*, and varied literature studies on classical authors. However, his most famous work is *De Abditis Nonnullis ac Mirandis Morborum et Sanationum Causis*, published in 1507 [10] (Fig. 3), 5 years after his death. His brother Geronimo discovered the manuscript “... wherein he (Antonio) had diligently and minutely set down noteworthy events and useful pieces of knowledge encountered in thirty-two years of medical experience. Struck by their novelty and variety, I felt it my duty to put together these unpolished and hurriedly written fragments.” To judge the merits of the individual 160 cases, Geronimo sought the help of his good friend, the philosopher and physician, Giovanni Rosati. Rosati made a selection of 111 cases, revised these somewhat, and returned the manuscript for publication to Geronimo. The letters of both men to each other are included in the book (Fig. 3).

The 49 cases omitted by Rosati were fortunately later found by Puccinotti when he was looking for an entirely different manuscript of Benivieni and thereby came upon the original version of *De abditis ac nonnullis...causis*. Many people who studied all of the cases think that Rosati’s selection was ill-considered. For example, he omitted a case of congenital syphilis in a child, a case of carcinoma of the stomach, and other cases with quite detailed pathological reports. Puccinotti found also that Benivieni had planned to

Fig. 3 *Left:* Original title page of Benivieni's work (Courtesy National Library of Medicine, NIH, Bethesda, USA). *Right:* translation of chapter III [11]



publish his observations in several series of one hundred (centuriae); however, his untimely death prevented this intention.

Of the 111 published cases, 16 are accompanied by an “autopsy” report. These cases determine the significance of the work, being the first book giving consideration to autopsies in the search for the causes of disease. As the first physician to describe the autopsy as a normal and accepted procedure, many regard Antonio Benivieni as one of the founders (maybe *the* founder) of pathology as a science. The fact that he died more than 140 years before the first publication of a human anatomical study (Vesalius, *De Humani Corporis Fabrica*, 1543) and long before physiology was understood, makes his achievement even more remarkable. Perforce relying heavily on Galen, it was virtually impossible for Benivieni to make correct interpretations and diagnoses, but he did what he could. Some of the most interesting cases are described in the chapters III (stones in the coat of the liver, probably the gall bladder), XXXIII (mesenteric abscess), XXXIV (severe abdominal pain, probably a colon carcinoma), XXXVI (hardening of the stomach, probably a pyloric carcinoma), and LXXXIII (heart found covered with hairs, probably fibrinous pericarditis). An English translation of this work was published in 1954 [11].

A record of the content of Benivieni's own library, dated on the 25th of December 1487, gives an idea of his wide interests. It was discovered and studied by Professor Bindo De Vecchi of the University in Florence around 1928 [12,

13]. With the exception of one printed copy (Vergil), it contains only manuscripts, 168 in number. Among them are works of Cicero, Seneca, and Sallustius, the classical works of Augustine, Flavius Josephus, and Dante, in addition to the medical works of Aristotle, Hippocrates, Pliny, Galen, Celsus, and such Arabic writers as Avicenna and Averroes, plus such later physicians as Taddeo Alderotti and Guglielmo da Saliceto. Antonio Benivieni died in Florence on November 11, 1502 at the age of 59 years. He is buried in the church of Santissima Annunciata in Florence, the city where he lived all his life. His son placed a tombstone on his grave with the simple text, “To my father, philosopher and doctor.”

In the century to follow, autopsies became more generally accepted. Many spicilegia or autopsy reports were published and studied. Among them, in 1533, was a female thoracoabdominopagus anomaly, joined from the thorax to the umbilical region [14]. The priest was uncertain as to whether one or two souls required baptism, so he baptized both. When the twins died, at 8 days an autopsy was performed to settle the question. When two sets of internal organs were found, it was concluded that there must have been two souls. The autopsy in 1556 on the founder of the Jesuit order, Ignatius of Loyola [15], provides further evidence of the acceptance of autopsies by the Church [16]. Realdo Colombo, professor of anatomy in Rome at that time, eviscerated Ignatius prior to his embalming. In his book *De re Anatomica*, published in 1559, he wrote that he extracted stones from the portal vein.

The originality of Benivieni's work is all the more striking in view of the fact that more than 150 years passed before the next book dealing with this topic saw the light. Theophile Bonet, about whom relatively little is known because of limited biographical data, wrote this voluminous work. However, good outlines of his life and career are found in the papers of Buess [17] and Irons [18]. Bonet was born in Geneva on March 5, 1620, and, following the steps of his father and grandfather, decided quite early in life to become a physician. He obtained his medical degree in 1663 in Bologna, but, before that moment, he had already extensively traveled and visited many universities throughout Europe. During these trips, he made copious notes of whatever he saw, heard, or read. He did the same while practicing medicine, first in Geneva and later in 1656 as city physician in Neufchatel, where he became the personal physician of Henry II, Duke of Longeville. Bonet's attempts to introduce regulations for the practice of medicine in that city were not appreciated by the local oligarchy and even resulted in physical attacks by health-care professionals, resulting in his return to Geneva in 1666. There he gradually lost his hearing after an accident and became deaf around his 50th year. When he had to give up his medical practice due to this handicap, his scientific output, already substantial, increased further. Bonet clearly was a scholar, knowledgeable in ancient and contemporary medical literature, with special interest in pathological anatomy.

Although the end of the seventeenth century witnessed a large number of spicilegia or autopsy reports (Fig. 4), Bonet's magnum opus *Sepulchretum sive anatomia practica ex cadaveribus morbo denatis* [19], was clearly the most important. The full title has the following addition: *Proponens historias et observationes omnium humani corporis affectuum, ipsorumque, causas reconditas relevans*. The English title is *Burial Vault/Cemetery or Anatomical Studies on Bodies Affected by Disease. An Explanation of the Histories and Observations of All Diseases Affecting the Human Body and Disclosing Their Hidden Causes*. A very challenging title, the book was truly remarkable in a time when the humoral theory of Galen still dominated medical thinking.

The original version of the book was published in 1679. A revised edition was published in Geneva in 1700, 11 years after Bonet's death, by Johannes Jacobus Mangetus (Fig. 5). The book references over 450 authors and is based on more than 3,000 post-mortem protocols with Bonet's own comments and references appended. Probably every recorded disease from the ancient Hippocratic literature up to Bonet's time was studied. Many famous physicians are included: Bartholin, Fallopius, Harvey, Malpighi, Paracelsus, Vesalius, Willis, and numerous others. The cases are collected in anatomical sections and subdivided in symptomatic sectors. Book I relates to diseases of the head [20], book II to those of the thorax, book III to abdominal diseases, and so

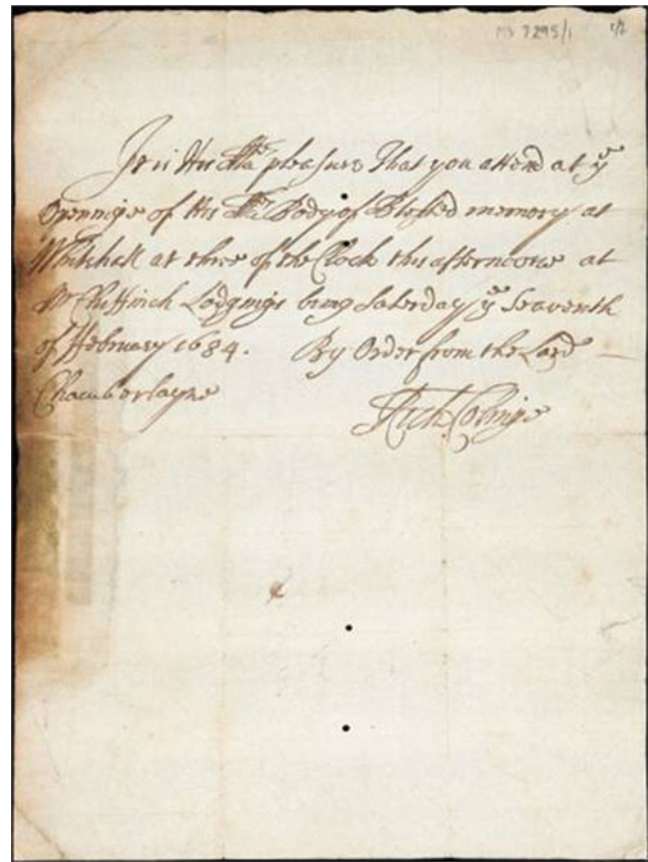


Fig. 4 Invitation from Richard Colinge (secretary to the Lord Chamberlain) to Dr. Christian Harrell F.R.C.P., inviting him to attend the opening of the body of King Charles II on Saturday the Seventh of February 1684 (Courtesy of Wellcome Library, London, UK)

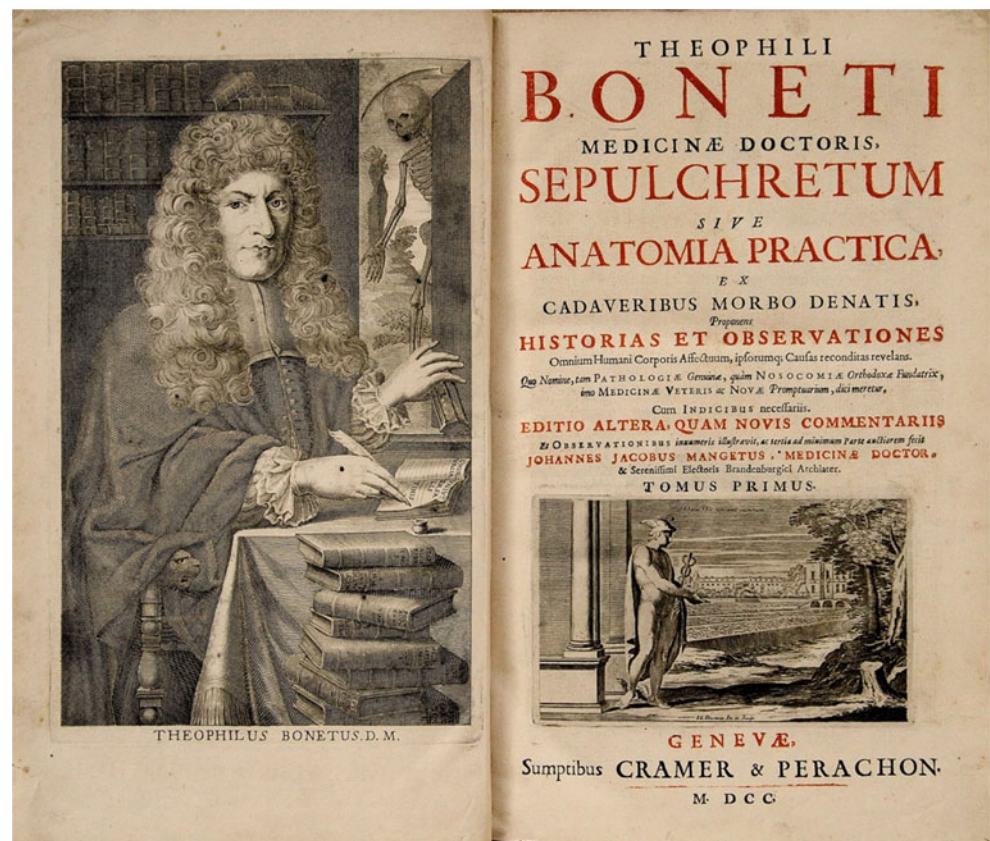
on; a monumental work. Bonet wrote in the opening of the *Sepulchretum*: “This work has cost me much more fatigue and care as the reader will draw advantage from it, but I hope I shall receive thanks for taking the first step in a career so eminently useful.”

The real merit of the book is the rediscovery and publication of the forgotten works of others. The wealth of material collected and the organization into sections based upon symptoms compels admiration. One remaining deficit, perhaps glimpsed by Bonet, but at a time in the development of medical thought that was too early for an ultimately logical conclusion, is the lack of organized correlation between abnormalities and disease.

Nevertheless, this work influenced medicine and medical knowledge for nearly a century, until in 1761 the publication of Morgagni's *De Sedibus et Causis Morborum* rendered Bonet's writings obsolete. Bonet died in his hometown Geneva, 2 days before his 68th birthday in 1689.

The first half of the eighteenth century was characterized by an increase in autopsy numbers, leading directly to a concurrent enhanced understanding on disease mechanisms. One of the leading figures in this period was the Dutch

Fig. 5 Bonet and the book that made him famous. (Edition 1700 AD, Private property)



physician Herman Boerhaave (1668–1738, Fig. 6), the author of two libelli (monographs) in which autopsies played an important role. The first of these (1724) emphasized the importance of a good clinical history, describing an admiral of the Dutch navy who presented with heavy vomiting [21]. The autopsy eventually led to the description of the “Boerhaave syndrome.” The second (1728) described in detail the clinical and anatomical findings in a young patient who suffocated from a large mediastinal tumor [22]. However, these and other detailed descriptions were somewhat anecdotal and were overshadowed by Morgagni’s opus magnum *De Sedibus et Causis Morborum*, published in 1761.

Giovanni Battista Morgagni [23] was born in 1682 in the Italian city Forlì, approximately 25 km southwest of Ravenna, on the same day as, and not far away from, the famous Italian mathematician Giulio di Fagnano, who was the first to direct attention to the theory of ecliptic integrals. In his youth, the young Morgagni proved to be a brilliant student, and at the age of 16, he went to Bologna to study both philosophy and medicine. At Bologna, he soon became a member of the famous *Accademia degli Inquieti*, rising to become the president in 1706. In 1701, he graduated with highest honors in philosophy and medicine and became the first assistant to the famous anatomist Antonio Valsalva, whom he succeeded as demonstrator in anatomy 5 years later. In the same year, he published the first volume of a series of anatomy books, his *Adversaria Anatomica*, by

means of which he became instantly a celebrated anatomist. This first volume included observations of the larynx, the lacrimal glands, and the pelvic organs in the female.

In 1707, Morgagni gave up his post in Bologna and for 2 years studied chemistry and zoology in Venice. Subsequently, he became a general practitioner in his hometown of Forlì. From there, he was called to Padua as professor of Theoretical Medicine, a position he held until his death. In his earlier years at Padua, Morgagni published (1717–1719) five more volumes of the *Adversaria Anatomica*. His strictly medical publications were few and casual, including several memoranda on medicolegal points, written at the request of the curia.

When he had been 3 years in Padua, he was also invited to occupy the Chairmanship of Anatomy in Venice, the successor of an illustrious line of scholars, including Vesalius, Fallopius, and Hieronymus Fabricius. In the following years, his fame spread around Europe, and he was invited to become a member of many national academies and societies, including the imperial German Caesareo-Leopoldina Academy, the British Royal Society, the Paris Academy of Sciences, the St. Petersburg Academy, and the Berlin Academy.

In 1740, Morgagni completed a book about his teacher Antonio Valsalva: *Epistolae anatomicae duodeviginti ad scripta pertinentes celeberrimi viri Antonii Mariae Valsalvae* [24, Fig. 7]. Following this publication, there is



Fig. 6 Title page of Morgagni's work about his teacher Antonio Valsalva. (Courtesy of the National Library of Medicine, NIH, Bethesda, USA)

a story, perhaps apocryphal, that during a walk in the Tuscan hills, he had a conversation with a (unknown) friend about Bonet's *Sepulchretum*. The more Morgagni had studied this work, the less satisfied he became because of various perceived inaccuracies, especially the frequent mistaking of normal appearances for morbid states. Despite these "inaccuracies," Morgagni wrote: "Theophile Bonet was a man who deserved the esteem of the faculty of medicine in particular and of mankind in general in account of publishing those books which are entitled the *Sepulchretum*." Finally, Morgagni decided that he should complement the *Sepulchretum* with observations of his own. The unknown friend seems to have convinced him to go on with this project, for the result was the publication of 70 letters to this friend and ultimately their publication as *De Sedibus et Causis Morborum per Anatomem Indagatis* [25] (*About the Seats and Causes of Diseases through Anatomical Investigation*) in 1761, when he was 79 years old.



Fig. 7 Herman Boerhaave (Courtesy of the National Library of Medicine, NIH, Bethesda, USA)

In the letters, Morgagni described 640 autopsies, structurally correlating the symptoms of his patients with the pathological findings at autopsy, thereby fostering the growing belief that diseases had an anatomical substrate. He divided his treatise into five books, each one dedicated to one of the academies of which he was a member. In his treatise, he follows the sequence of Bonet's observations. Book I deals with the diseases of the head, book II with those of the thorax, book III with diseases of the abdomen, book IV with surgical and universal disorders, while book V contains addenda to the first four books. Most of the autopsies were performed by Morgagni himself or (in his presence) by a few others including his mentor Valsalva. Morgagni introduces the subjects of his study as "a certain honest citizen," "a good and pious virgin," or as "a most powerful monarch." Bishops, priests, nuns, lawyers, merchants, and criminals, all are treated by him with the same respect, thereby always trying to combine the symptoms and physical findings with the morbid anatomy that he observed with his own eyes. The publication of this work led to immediate obsolescence of essentially all previous manuscripts on morbid anatomy. The work broke definitely with the Galen's humoral theory and replaced it with concept of "pathological anatomy" as the basis for disease manifestations. However, "De Sedibus" is not a pathology book in the modern sense; it is more a clinical compendium, with anatomic explanations of disease symptoms. In practical terms, Morgagni still was hampered by a lack of any meaningful integration of physiological and gross pathology

knowledge, thereby often missing the significance of his observations.

Also, Morgagni did not introduce new methods, nor did he make great discoveries, nor did he revolutionize medicine in the way that Virchow would do a hundred years later. Rather, Morgagni was the highpoint of a descriptive tradition that had progressed steadily since the sixteenth century, representing the beginning of modern medicine and pathology. It is to Morgagni's credit that from his time on, there was a growing and eventually general acceptance that diseases were organ-based processes. His different books nearly all have the same picture of him surrounded by the text "Hic est ut perhibent doctorum corda virorum primus in humani corporis historia" ("This is, as seen in the hearts of learned men, the best in the knowledge of the human body"). And so he was, even in retrospect. Morgagni died in Padua in 1772, where he was buried.

From 1780–present

The French Revolution ended in the Coup of 18 Brumaire (9 November 1799), establishing the Consulate of Napoleon. The nineteenth Century dawned with a revolution of a different kind, in the field of medicine [26], centered initially on the discovery of tissues by Marie Francois Xavier Bichat (<http://www.bium.univ-paris5.fr/histmed/medica/bichat.htm>). Born in 1771, the year that Morgagni died, Bichat witnessed and was shaped by the French Revolution as an army doctor. Bichat developed himself into the father of histology. He submitted tissues to the action of various chemicals and physical conditions, such as boiling, freezing, putrefaction, desiccation, etc. In this way, but without recourse to the microscope, he was able to distinguish 21 different tissues. In his book *Traité des membranes en général* [27], he states, "All animals are an assemblage of different organs. These are in turn made up of many textures of many kinds. Just as chemistry has its simple bodies, so anatomy has its simple tissues which make up organs." Bichat's discovery revolutionized medicine: "...we must consider disease not from the standpoint of the compound organs but from the standpoint of their different textures, which are almost always attacked separately." Diseases were no longer simply organ-based abnormalities, but they originated in a larger all-embracing concept of tissues. Bichat died young, at the age of 31, probably from tuberculous meningitis. His discoveries were pursued by his famous student, René-Théophile-Hyacinthe Laennec, a great pulmonary pathologist, who carried forward Bichat's ideas on the nature of tissues, and by another Frenchman, Gabriel Andral (1797–1876), who published in 1828 his *Précis d'Anatomie Pathologique* in two volumes, the first on general pathology and the second on special pathology.

Working concurrently but independently, Matthew Baillie (1761–1823) had published in 1793 *The Morbid Anatomy of Some of the Most Important Parts of the Human Body* [28]. This work records Baillie's observations of thousands of anatomical dissections, performed by his uncles John and William Hunter, under whom he studied, and by himself [29]. Many of these dissections were in fact conducted as "medical" autopsies, seeking clarification of the cause of disease and death. The work is organ-based, referencing extensively the "epistolae" of Morgagni, as well as Bonet's, but it is also a treatise on the changes observed in disease (inflammation, scirrhus change) and the possible causes of disease, with clinical correlations between autopsy findings and the decedent. "Some diseases consist only in morbid actions, but do not produce any change in structure of parts: these do not admit of anatomical inquiry after death. There are other diseases, however, where alterations in the structure take place, and these become the proper subjects of anatomical examination. The object of this work is to explain, more minutely than has hitherto been done, the changes arising from morbid actions in some of the most important parts of the human body" (Baillie [28], Preface First Edition,).

So as the first decennia of the eighteenth century dawned, a solid foundation had been laid for a new and definitive role of the autopsy in pathology. Understanding on the patterns of disease in different organs had increased, and there were tantalizing hints of a newer, exciting concept of tissues that extended beyond the gross organs on the anatomists or even the minute dissections of vascular and lymphatic trees. In a sense, the next step had already been taken, but tentatively and without realization of its potential, namely the use of the microscope. Morgagni gave the microscope scant attention, and Bichat formulated his concept of tissues, without its use. While John Hunter had experimented briefly with the microscope, Matthew Baillie's *Morbid Anatomy* text was essentially gross pathology. Belloni (cited by Majno and Joris [30]) quoted Galileo as having observed "flies as big as lambs," in the early 1600 s, but the microscope remained a peripheral toy for 200 years, its potential untapped.

All of that was about to change in the nineteenth century, and it is here that the contribution of Johannes Müller (1801–1858, Fig. 8), working in Berlin, was so vital, making all that followed possible. Indeed, a case can be made that Müller was the source from which both histology and cellular pathology arose. He certainly was one of the first to use the microscope for tissue analysis. As early as 1830, he had made extensive studies of different tissues, resulting in a book *Ueber den feinern Bau und die Formen der krankhaften Geschwülste* [31] (*On the Finer Structure and Form of Morbid Tumours*), which appeared in 1838. In this same year, Theodor Schwann (1810–1882), a student of



Fig. 8 Johannes Müller (Courtesy of the National Library of Medicine, NIH, Bethesda, USA)

Müller, first pointed to cellular growth as the basic principle of animal life, a thesis that established for all time the cellular character of all growth, 19 years leading naturally to Virchow's famous epigram *Omnis Cellula e cellula* [32].

Pathology, in general, and the autopsy, in particular, was just waiting for the right person to combine Morgagni's views of disease and Bichat's concepts of tissues into an integrated approach, incorporating not only clinical correlation and gross observation but also microscopic examination of normal and diseased tissues. This man was the pathologist Carl von Rokitansky (1804–1878, Fig. 9), one of the extraordinary men in the history of pathological anatomy [33, 34]. Influenced as a young man by the great French pathologists and by the anatomist/embryologist Johann Friedrich Meckel (1781–1833), Rokitansky was the first who looked at pathological changes in human organs in a systematic manner. He carefully correlated the morphology with clinical symptoms and with the pathogenesis of disease. His autopsy method preserved anatomical and physiological cohesion. Inspection during autopsy included every part of the body in each case, an approach that Virchow also would later promote. Each body was accompanied by the medical history to come to a correct clinicopathological correlation. He was the first to bring Morgagni's observations to a higher level. Rokitansky's work made him the best descriptive pathologist of his day and prompted Rudolf Virchow (1821–1902) to attribute to him the mantle as the "Linné of Pathological Anatomy," despite the fact that microscopy did not play an important role in Rokitansky's life.

Nonetheless, the pioneering work of Rokitansky established the autopsy as the primary method for



Fig. 9 Carl von Rokitansky (Courtesy of the National Library of Medicine, NIH, Bethesda, USA)

investigating the mechanisms of disease and simultaneously provided the basis for the emergence of *pathology* as a recognized specialty [35].

In succeeding years, increased attention was paid to details of autopsy techniques and to standardization of the procedures. When Virchow was appointed to assist the prosector in the Charité in 1844, he found a lack of organized procedures in the morgue. Only a few autopsies were performed by the prosector himself and then only on special request. The majority of cases were done by surgical assistants with little if any previous technical training, so that "it was a matter of difficulty to make any discoveries." In 1876, Virchow published a booklet on autopsy techniques that became widely used [36]. Also, in America, the need for standardization was felt; witness the publication in 1872 of *A Handbook of Post Mortem Examination and Morbid Anatomy* (later rewritten and enlarged into *A Handbook of Pathological Anatomy and Histology* in 1885) by Francis Delafield (1841–1915).

In the century to come, the autopsy for a while flourished, and several new manuals of technique were published, one of the most recent being the step-by-step description of Collins, Grover, and Hutchins in 2005 [37].

From the first half of the nineteenth century to well into the second half of the twentieth century, autopsies formed the base of medical progress, although they were also used for other reasons; witness the foundation of *La Société d'Autopsie Mutuelle* in Paris, in 1876, by (atheistic) members of the Society of Anthropology. The aim of the

members was to prove that souls did not exist, by performing autopsies on each other after death [38].

Since approximately 1970, we have witnessed a (steep) fall in autopsy rates. This decline is attributed to several factors, among which the predominant one is the lack of interest of clinicians, many of whom think that with modern (bio)chemical, molecular, and radiological analyses, the autopsy can add little to what is already known. Published studies tend not to support this notion and indeed show that the autopsy uncovers significant disease unknown to the clinicians prior to death in as many as 25 % of patients [39, 40]. Nonetheless, evidence notwithstanding, the decline continues. Time only will tell whether, after a period of 150 years, the medical autopsy has run its course as a useful tool for investigation of disease and death, in any context other than the medicolegal forensic modality.

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