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FROM BODY PRESERVATION TO PATHOLOGY MUSEUMS IN ITALY: CONSERVATION AND MODERN VALUE OF A HISTORICAL AND BIOLOGICAL ARCHIVE

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SUMMARY

PATHOLOGY MUSEUM IN ITALY: CONSERVATION AND MODERN VALUE

Pathology Museums in Italy are particularly relevant to cultural heritage. Most of the specimens stored in these Museums date back to the beginning of the XIX century.
The samples stored in Pathology Museums include the collections of waxwork models of dry and wet specimens.Waxwork modelling of specimens was a method of restoration and preservation.
Their importance is priceless because the methods of conservation avoided damaging the specimens, which had previously been a fundamental problem. This was especially the case in the preservation of wet specimens and their fluids. The waxwork specimens are not only of immense historical value but are also of great interest in paleopathology, shining a light on the history of many diseases which have now disappeared. The study of these significant pathological specimens using modern techniques in Pathology, such as immunohistochemistry or molecular biology, can help us understand both old and present-day illnesses and their pathomorphosis as well. Pathology Museums are, of course, of extreme importance in terms of teaching Pathology to students, but are also of value in terms of general education. For these reasons, Pathology Museums should be safeguarded and regenerated.

Key words: Pathology Museum - Paleopathology - Re-evaluation - Modern techiques - Conservation

The raising of pathological collections and the critical preservation of the human body

Ever since antiquity, there have been attempts to preserve the human body or its parts from decay following death, even if this practice had a more religious or ideological significance rather than a scientific aim.

Mummification is, of course, one of the most famous examples of body preservation, but the use of many different techniques has been common throughout the ages[1]. Historically, honey was one of the first substances used in the preservation of the human body, with Alexander the Great's corpse being a famous example treated with this method when the necessity to preserve his body was apparent in transiting the psalm from Babylon to Alexandria[2]. Another common preservation fluid was spirit, however, this did not always provide successful results. Vinegar was also used for body preservation, seen for example in the case of Friedrich I von Hohenstaufen Barbarossa, but the results were poor. As reported in Professor Vito Terribile Wiel Marin's (1939-2015) book "Cuori celebri conservate in Europa" (famous hearts preserved in Europe), as many as of 705 hearts[3] belonging to famous personalities of Europe were stored in spirit for their preservation, including that of Friedrich Chopin[4]. The preparation of these specimens needed specific medical knowledge, but there was no real medical interest in them.

The birth of Pathology Museums was directly influenced by renewed studies of pathology undertaken by Giovan Battista Morgagni (1682-1771), the first father of modern pathology. Before Morgagni's studies, the cause of diseases was embedded in Humorism Theory, which could be traced back to ancient Egyptian and Greek culture. This dominated until Morgagni's contribution "The seats and causes of diseases investigated through anatomy" (De sedibus et causis morboum per anatomen indagatis) in 1761.

The Humorism Theory stated that an excess or deficiency of the four bodily humors directly influenced health. Morgagni's modern and revolutionary idea claimed that disease was not influenced by the four humors but originated directly from organs and tissue. For this reason, the single affected organs became relevant for the study and highlighting of disease[5]. The oldest collections followed in the spirit of the Wunderkammern of the Renaissance, which was a selection of objects pertaining to the natural world: their aim was to astound the visitor and to demonstrate the power of their collector. Most cases were of monstrosities, such as fetal malformations. They were specifically collected to shock viewers and had no medical objective[6].
However, years later the Pathology Collections were used to highlight disease for medical students and thereby improve their scientific knowledge. This teaching aspect highlights the difference between the modern collections and the old Wunderkammern ones, although some artistic sense was still not lost: in fact, these old pathological preparations can still be considered artwork[7].
The first problem encountered in the collection of specimens during autopsy was the preservation of the body, avoiding the post-mortem phenomenon of decomposition. As autopsy reports in Turin University show, autopsies were generally performed at least a couple of days after death. There is no written explanation for this, but it is possible it was a way of confirming that death had in fact occurred. As was reported by the aforementioned Professor Terribile, in 1570 George Clifford Lordship of Cumberland collapsed and appeared to be dead, however, he awoke having felt the touch of the autopsy scalpel[8]. Delaying autopsy, on the other hand, also meant dealing with the start of putrefaction and subsequent lysis of the tissues. A particularly accurate description of body preparation is reported by Professor Angelo Dubini (1813-1932). He was an Italian dermatologist and one of the most relevant anatomists and clinicians of the Ospedale Maggiore of Milan. His name is associated with the

discovery of *Ancylostoma duodenale*, which he detected thanks to his intense autoptic activity. Regarding body preparation, Dubini wrote a very complete textbook on dissection and anatomical preparation[9]. In particular, he notes that if the temperature exceeds 15R (Roemer Grade, around 14°C) the preservation of a dead body can be calculated as being just six days. However, if the temperature is lower, between 10°R (4.7°C) and 0°R (-14°C) putrefaction begins between 12-15 days after death, after which time it is impossible to collect organs[10]. For this reason, Dubini suggested a number of ways of preserving the body for many months: the simplest way was to cover the body with antiseptic powders, coal, calcium chloride, natrium chloride, or treat it with ice or brine. However, he also states that these methods were useless for the anatomist since they change the structure of the body. Regarding the method applied by Ruysch using black pepper, camphor and cardamom in vinegar, via injection or immersion, he reported that while effective, the methods damaged the muscles[11]. He also mentions in his writings that the technique of injecting air into the arteries was already being applied by Galeno, and that Giacomo Berengario da Carpi had started injecting coloured water into blood vessels, being the first to do so[12]. Another extremely dangerous substance used in the preservation of the entire body was white arsenic. Dubini reports a shocking story which had occurred to a certain Doctor Poirson "At last, few will want to venture their lives with the section of a body exhaling arsenical vapors, aware of what unfortunately happened to Dr Poirson". The exact facts that occurred to Doctor Poirson are unknown but were surely tragic[13]. He also mentions health problems that the mortuary caretaker of the University of Pavia had had, having been exposed to the vapors of arsenic. Another relevant study on the preservation of the body cited in Dubini's book was "*Mémoire sur la conservation des matieres animales; par J.N.Gannal, Paris 1836*". Many different methods for cadaver preservation were described,

however, the most effective one in his experience was the use of aluminum chloride and alumina acetate, both in three-liter doses per adult body via arterial injection[14].
These methods were effective for preserving a body in its entirety, but not suitable for preserving individual organs or body parts, which was becoming increasingly of interest in terms of medical research.

Ceroplastics and the first anatomical models

The aim of preservation was to compare normal anatomy with the changes found in organs subjected to illness. Before the beginning of histology in the second half of the XIX century, organic samples were considered unnecessary; anatomic models were preferred for teaching students, this also avoided dangerous exposure to chemical substances. This was how the first wax specimens in Pathology Museums were created. The technique was called "ceroplastica" which means wax modelling, specifically beeswax modelling.
Dating back to ancient Greek and Roman times the use of beeswax can be found in examples of "*cerae pictae*" (painted wax), which were wax models made to commemorate loved ones who had passed on. This practice was also used during the Renaissance by artists such as Luca Della Robbia (1400-1452) and Michelangelo (1475-1564), who used beeswax as a material for a model of his famous David[15].
During the Renaissance, the use of beeswax in scientific study began. Leonardo Da Vinci (1452-1519) injected fused wax into the ventricles of the heart to facilitate the study of its internal structure. His experiments with wax for scientific purpose remained isolated for a long time. Wax continued to be used simply as an art material. Florence became the most important center for waxworks, known for its famous "botteghe di ceraiuoli" (wax workers shops). The best-known wax workers were the family Benintendi[16], the

most famous being Orsino Benintendi (1440 circa-1498), pupil of Verrocchio (1435-1488). He made many wax statues, that unfortunately have not survived to our day, and gypsum death masks, including that of Lorenzo de' Medici in 1492, a fact reported by Vasari (1511-1574)[17]. During this period wax was relevant in the arts, but later its use grew in science. The first waxworks that had a purely scientific aim was made by Gaetano Zumbo (1656-1701). Being an Abbott, his works were primarily religious in theme, but he later focused on the reality of death. His collection, known as "Theatres of Death", showed pestilence and death with impressive realism[18], he even included in his collection the model of a rat, evidencing the relationship between rats and the plague, years before a correlation was scientifically proven. Even though these waxworks showed realistic macabre and repellent details of bodily decay, up until the mid-20th century they were considered just a symbolic and artistic interpretation on the theme of death. Now, however, they are considered relevant historical documentation of epidemics. Zumbo's interests did not lie only in this specific use of waxworks; after he moved to Genoa, where he met the surgeon Doctor Guillaume Desnoues (1650-1735), he began making anatomical wax models for the purpose of teaching anatomy, thereby avoiding the necessity of dissection. This was a historic first. Five of these wax figures are now preserved in Museum the Specola in Florence. Other relevant wax collections of anatomical and pathological models belong to Museum the Specola and to the Pathology Museum of the University of Florence and will be discussed later. Wax models are also common in other Pathology Museums in Italy, like for example those made by Giuseppe Astorri (1785-1852) in Bologna and those of Francesco Citarelli (1790-1871) in Naples.

In conclusion, ceroplastic was useful for didactical purposes because it avoided the use of corpses. It also led to the creation of many wonderful and historically relevant models.

The first biological specimens in Museums: dry preparations

Later, chemistry development allowed for a new way to preserve real anatomical and pathological specimens: dry preparation.

Dry specimens can be made through drying or by corrosion through maceration[19]. The latter provided results that were similar to wax models. They were made through injection of fused wax and walnut oil mixed with colours, in other cases, fused metals were used; in particular for the bronchial tree. The specimen was immersed in nitric acid or muriatic acid (in proportion 3:1 with water) for up to three to four weeks. The degraded organic tissue was then removed through washing.

There was no common praxis for the preparation of dry specimens because almost every anatomist had his own technique as an artist. In general, the technique of dry preparation began immediately after dissection. Firstly the blood was removed thanks to repeated washings in fresh water. At the end of this first step, the specimen was washed with alcohol to avoid insect attack. Dubini said that Scarpa didn't perform this step and for this reason, his specimens have holes; evidence of insect attack, especially *Dermestidae*. Dubini explains that Turpentine could also be used in this step. Following these first measures, the specimen was dehydrated with chemical substances, the most common being sublimate-mercuric chloride and tannic acid. Also, sodium chloride followed by aluminum or lead acetate were used, but these substances caused an excessive hardening of the tissue. The specimens were immersed in a corrosive solution and there remained for many months. After this period the specimens were again washed in water and, with much patience, tissue surplus was removed. At this point, organs were filled with air or other substances to distend them. Finally, the specimens were dehydrated with air and the specimens were tinted with various colours to highlight different areas, for example, veins and arteries.

This method meant that specimens didn't need be subjected to further treatments and could be shown in collections without the need

for any particular environmental requirements. Dubini said that the only precaution was to avoid that specimens be exposed to direct sunlight or air pollution.

A singular case of dry specimens is that made with tannic acid. Tannic acid did not have good tissue penetration, meaning that the deepest part of the specimens could not be dehydrated. Ludovico Brunetti (1813-1899), Professor of Anatomy in Padua, discovered the so-called "*tannizzazione*" (tannization) method, which allowed for the use of tannic acid for dry preparation. After some washings of the specimens with water, he removed the fat and after this dehydrated the specimen by perfusion through the arteries. These specimens now belong to the collection of the Museum of Padua (see below).

Almost all the oldest Pathology Museums in Italy contain many dry specimens, examples being found in Turin, Pavia, Parma, Modena, Cagliari, Ferrara, Roma, Bologna, Padua, Pisa, Florence, Naples and Venice. It is remarkable that these dry specimens are so frequent in Italy, indeed in Europe examples can only be found in Paris and in Vienna[20]. The most common dry preparations are specimens of vascular pathology, especially oversized aortic aneurysms, while a case in the Pathology Museum in Turin shows even erosion of the ribs.

All these techniques of preparation of dry specimens were made to obtain specimens for teaching to medical students. However, some unusual methods of dry preparation were carried out not medical study but by independent authors as Girolamo Segato (1792-1836)[21], Paolo Gorini (1813-1881)[22] and Raimondo di Sangro Principe di Sansevero (1710-1771)[23]. This preservation had more a philosophical significance than a scientific one[24]. Anyway their collection could be considered anatomical collection of dried specimens, even the aim of the preparation was different from the collection of the medical school of anatomy and pathology.

Preparations in liquid fixative medium: wet specimens

Another method of preservation of human organs or bodies was the preservation via immersion in fluid or in other substances.

The growing interest for organ preservation between the end of XVIII and the begin of XIX century started a search for new preservation fluids.

The importance of tissue samples found its basis in the theory of Rudolf Virchow (1821-1902) which ended definitively the Humorism Theory. "Cellular Pathology" published in 1858 contains cell theory *"omnis cellula e cellula"* (all cell come from pre-existing cell), means that all the lives form are from a pre-existent cell are that every disease is represented by distinct morphological change of the tissue[25]. Modern Pathology was born.

The preservation of the real organs instead of wax models or dried and coloured specimens became more important and pathology collections consequently became be more scientific than artistic in nature.

The technique for preparation of wet specimens began after autopsy or, later, after surgical operations. The specimen was fixed and then stored immersed in a jar filled with preservative fluid.

As recorded by Dubini[26], the general proprieties of a good fluid for preservation were well known also at the beginning of the XIXth century and are still true today. He retained the ideal fluid should not change the colour of the specimen and must be transparent, it should not freeze lowing temperature and also not undergo vaporization quickly. In 1837, the fluid used were alcohol often mixed with water. However, alcohol changed the colour of the specimens and also made them harder. Other solutions were further proposed, but all presented serious drawbacks. For example, the presence of water could freeze causing the jar to break. Fixation is the process that stops putrefaction, as described in methods of the preservation of corps. The beginning of histology caused a need of better fixation, because it might preserve also the histological details and not just the macroscopic shape.

These fluids now being used for fixation and preservation were complex mixture of different chemical substances. Almost every school of anatomy and pathology had its own method. In 1940 Nello Beccari (1883-1957) wrote in his textbook "Elementi di tecnica microscopica"[27] that *"the purpose of the fixation is quickly kill the tissues (…) the reagents sperimented for this purpose are numerous and every day technicians propose new fixation formulations. Now the formulations are in their hundreds (..)"*[28].
Many of them are now forgotten and this is a real problem in modern restoration intervention.
The most common fluid for the preservation of pathology specimens in Italy was a liquid invented by Friedrich Albert von Zenker (1825-1898). The so called Zenker's fixative contained mercuric chloride ("corrosive sublimate"), potassium dichromate, sodium sulfate, water, and acetic acid[29]. This fixative, very effective, was highly toxic.
The use of ethylic alcohol 90° was not as common after the second half of XXth century, because it hardened the tissues which ruining also the exhibition itself. The use of alcohol as fixative was necessary just to perform Van Gieson's stain for elastic fiber or Niessl's stain for nervous system[30].
In 1859, Alexander Butlerov (1828-1886) was the first to synthesize formaldehyde in its gaseous form ans as polymer. In 1868 August Wilhelm von Hofmann (1818-1892) determined the molecular structure of formaldehyde and proposed a new method of producing it from methanol. A saturated water solution of 40% formaldehyde was called formalin. The first publication about the fixative use of formalin is due to Ferdinand Blum (1865-1959) in 1893. He described the property of formalin to fix tissue and also to allow Hematoxylin staining[31]. This new liquid appeared to be better than the other solution, since it was less toxic. In 2011 formaldehyde is recognized as carcinogenic substance, but at that time it was less toxic in comparison to sublimate. Carlo Ascoli, a student of University of Turin[32], described in 1894 an-

other property of formalin: it was also antiseptic as he demonstrated experimentally. But he described that it also could fixed preparer's skin by simple contact. This aspect was discovered for the first time at Schering's factory. Also there, by contact the skin became similar to leather and then became necrotic. Formalin is also volatile and this was an effective advantage for sepsis whereas its disadvantage was in specimen preservation. Indeed, if the jar wasn't hermetically closed, the level of formalin decreases over time and the specimens got dry, even if it was already fixed. The solution to the problem of dried fixed specimens is real goal in their restoration intervention.

Formalin was less effective as a fixative than other solutions, even though it was less toxic too.

At the beginning of the XXth century the most common technique for specimen preparation was the method indicated by Carl Kaiserling (1869-1942) in 1897[33]. This method provided not only one fixative fluid but a method of fixation and storage of specimens.

Kaiserling's method composes three different fluids: Kaiserling I (formalin 40%, Potassium Nitrate, Potassium Acetate and tap water) Kaiserling II (Ethil alcohol) and Kaiserling III (Glycerine, Arsenious acid 1%, Potassium Acetate and Thymol). The fixation of large specimen was generally made by injection. The common use of formalin in Italy for medical purpose began in XX century. However, possibly the use of more traditional fluids continued in museum practice, as reported in the autopsy catalogues of University of Turin. In general, it can be assumed that old pathology collections are stored in many different and often unknown fluids, whereas the more recent wet specimens are stored in formalin.

After fixation the specimen was washed just in running water or in running water and then alcohol. The specimens were not taken out of the jar also to avoid damaging it.

Some year after Kaiserling, a modified process of fixation was suggested by Pulvertaft in 1949[34]. The specimens should not be washed

before fixation since this step decreases the quality of preparation due to hemolysis. He further suggested that "*the necropsies should be performed as soon as possible after death, but in many cases, particularly in order to preserve the stomach, intestinal tract or brain, 4% formalin saline should be injected into the peritoneal cavity, the carotid arteries or stomach as soon as possible after death (…) the specimens should be washed only with saline*". This method was probably more effective for fixation than the old one and could explain the presence of necrosis in deeper tissues of older specimens. Beccari also wrote accurate indications for a further step of preservation in fluid. He suggested fixed specimens be stored in alcohol 70° and 80° if the fixation was made by Zenker or Flemming, whereas they be stored in formaldehyde 5% or 10% when fixed in formalin. Beccari said that it was important to avoid specimens putting in formalin that have been fixed in Zenker's fluid, because it dilated the tissues. The best preservation fluid for formalin fixed specimens is formalin itself[35].

In conclusion, though the variety of old fixative and preservation fluid allowed a good preservation, it represents now a real problem regarding the restoration intervention (see below).

The Pathology Museums in Italy

The Pathology Museum of Padua[36] is dedicated to the "Father of modern Pathology" Giovan Battista Morgagni (1682-1771). His activity as anatomist was famous across Europe. The Germanic nation called him the "Anatomicorum totius Europae Princeps".

The Morgagni Museum of Padua is inside the Institute of Pathology and houses more than 1500 specimens preserved by many different techniques. For example, dry specimens using Brunetti's technique, mummification and wet specimens. Morgagni collected normal and pathological specimens and he would store them in a Pathology Museum. However, this museum remained only a project until

Francesco Luigi Fanzago (1764-1836). He collected specimens and stored them in a Pathology Cabinet in 1808 in his home. In 1822, the collection was moved to Palazzo del Bo. The collection grew and Professor Francesco Cortese (1802-1883) stored it in the anti chamber of the anatomical theatre. In 1844, this location became "too small for the number of preparations". There were more than 500. The Pathology Cabinet became a Museum in 1870, thanks to the work of Lodovico Brunetti. The specimens were obtained by many different techniques, among them the most particular is "tannizzazione" (tannization), specific to Brunetti[37]. The most famous specimen of Brunetti is the "Punished suicide". She was an 18-year-old girl who had committed suicide in the river in 1863. Brunetti prepared her body keeping her original long blond hair. But the head had a big problem: the skin was damaged due to the recovery from the river using hooks. Brunetti, as a real artist, put some dried snakes biting the face of the girl and used red wax to simulate blood.

The parents of the girl were grateful to Brunetti for his work. It became a great success and won the first prize at the Universal Exposition in Paris in 1867[38].

In the Museum Morgagni, there are many wet specimens. Some of them are modern,, especially those of cardiovascular pathology. Wet specimens are stored in many different fluids. This Museum was restored some years ago and in 2018 it was opened to the public.

In Bologna, there are three relevant Museums. The Pathology Museum[39] is dedicated to Cesare Taruffi (1821-1902) who was Professor of Pathology at University of Bologna until 1902. His field of interest was Teratology and his major work was "History of teratology". He unfortunately couldn't finish it due to health problems. He understood the importance of preservation of the pathological specimen instead of wax models, which were in his opinion, only beautiful artistic representations without real scientific interest. It is interesting to note that these changes in the significance of wax-

works in scientific collections occurred in Bologna, where the "ceroplastica" was born with the work of Ercole Lelli (1702-1776)[40]. He created anatomical models for the Institutum Scientiarium et Artium founded by Luigi Ferdinando Marsili (1658-1730) in the early 1700s. The first anatomical models were dry specimens, which easily deteriorate and therefore the use of wax for didactic purposes began. The models were initially molded on real human skeletons, as a base. Later, they were made using only wax.

Initially, Lelli made anatomical wooden models such as two "skinned" ones that were placed in the Anatomical Theater. Years later, he used wax for the models of the Anatomical Museum which was established in 1742 by the will of Pope Benedict XIV. Lelli worked on this project for nine years together with Giovanni Manzolini (1700-1755). The latter became later a renowned wax expert together with his wife Anna Morandi Manzolini (1714-1774). After the premature death of her husband from tuberculosis, Anna continued her work as a wax modeler for the University Anatomy chair. Anna reached European fame by being requested by illustrious courts such as that of Catherine II of Russia, but she never left Bologna, where she died in 1774. Her most famous waxwork is a self-portrait of great realism that elegantly portrays the dissection of a brain, now preserved in the Museum of Palazzo Poggi in Bologna.

Manzolini's works were also particular for the subjects represented. Lelli preferred more classically myology and osteology, whereas they created works focused on the cardiovascular, urogenital system and on the sense organs, such as models of the ear and of the eye. They based their work on the observations made during detailed dissections carried out by themselves at their own home.

Museum Taruffi also has many precious waxworks of Giuseppe Astorri (1785-1852) who especially prepared dermatological waxworks, a collection of stones by Matteo Venturoli (1775-1860) who was a surgeon "eccelso nelle operazioni di calcoli" (excellent

in stones surgery), many bone diseases especially of the skull and many other pathological specimens. Professor Paolo Scarani was interested in wet specimens in recent years[41] as well as in their preservation. In his opinion, formalin is not a good preservation fluid because it causes a slow deterioration of the specimens. He suggested to change it with a new one.

The Museum of Anatomical Wax Luigi Cattaneo dates back to 1908 and there are many waxworks. The Museum is dedicated to Professor Luigi Cattaneo (1925-1992): thanks to his activity the old waxworks again became relevant specimens after the damage due to the II World War.

In Bologna, there is also the Museum of Palazzo Poggi. It began in 1711 as a collection of sciences. It contains the collection of the old Institute of Sciences as a real Wunderkammer. Relevant is the collection of natural history of Ulisse Aldrovandi (1522-1605) and especially his Herbarium of 7000 dried plants, but there were also Lelli's waxworks and the experimental instruments of Luigi Galvani.

In 1815 Giovanni Pietro Gallo (1785-1862) founded the Pathology Museum of Turin. He became "Conservatore delle collezioni e del Museo di Anatomia Patologica" in 1823. Some dry specimens, still stored in the Pathology Museum, probably belonged to his original collection. Specifically, the aneurisms of aorta which he described in his publication in 1836[42.] Now only 23 dry specimens remain, from the 426 recorded in 1861. The surviving specimens are in quite good preservation state and they have been recently restored. Less is known of the activity of Museum before the arrival of Professor Pio Foà (1848- 1923) who is the real founder of the Museum thanks to his collection of specimens stored in fluid. Pio Foà studied medicine in Pavia with the famous Professors Giulio Bizzozzero (1846-1901) and Giacomo Sangalli (1821-1897), then he became pathologist after a period in Strasbourg with Friedrich Daniel von Recklinghausen (1833-1910). In 1875 he became Professor of Pathology in Modena,

then in 1884 he became Professor of Pathology in Turin. His initial autopsy reports began in 1886. The majority of the wet specimens were prepared between 1896 and 1923. The original specimens are still preserved in the original jars. All have the original label and original fluid. There are 116 specimens belonging to Foà's collection according to the most recently performed inventory in 2017. In total, there are now 306 wet specimens. Ferruccio Vanzetti (1873-1942) became the next Director of the Museum. He was especially interested in cardiovascular pathology, therefore he mostly collected hearts or vascular diseases, especially tertiary syphilis[43].

His autopsy reports are much more accurate than the older ones because sometimes they were illustrated. The clinical status of the patients often appeared as well. Professor Vanzetti thought that the pathologist should help the surgeon and the clinician and for this rea-

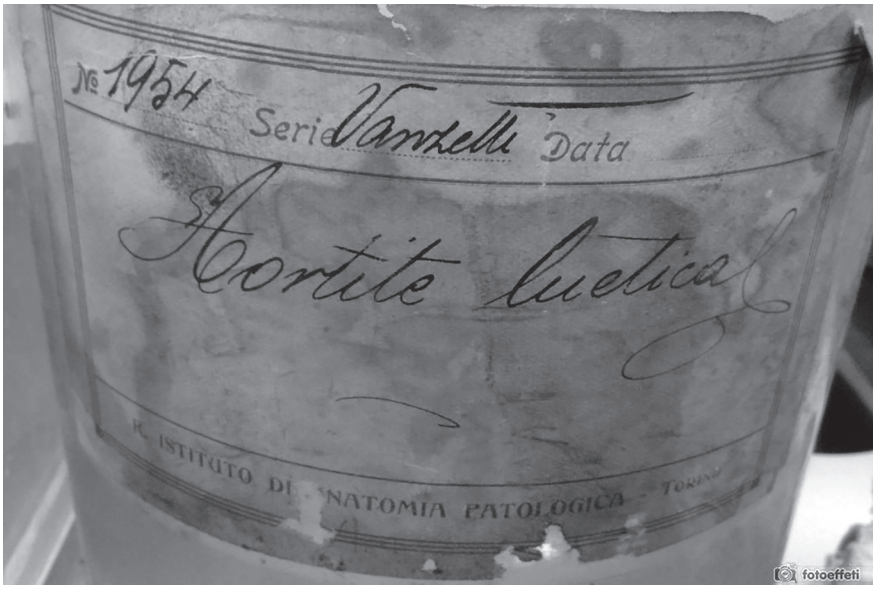

Fig. 1 A case of aortitis due to tertiary syphilis of Pathology Museum of Turin

son he moved the Pathology Institute from the old building next to Department of Human Anatomy to the new Hospital San Giovanni Battista Le Molinette. It is remarkable that in this collection there are surgical specimens as well as autopsy specimens. With the beginning of World War II, the collection stops. Fortunately the specimens were not damaged from the partial destruction of the building due to the bombs. After the end of the war, unfortunately the Museum was forgotten. This was probably due to the growing use of photography. Over the years, it was severely damaged and only recently it has been restored[44].

The Pathology Museum of the University of Florence[45] was created by the Florentine Academia Medico-Fisica, among their members were Pietro Betti (1784-1863) and Filippo Pacini (1812-1883) who described for the first time the sensorial corpuscles. In year 1824 Pietro Betti proposed to create a museum and therefore the Pathology Museum was opened on 7th April 1824. In 1839, as specified in the "Ordinamento delle Autopsie nell'Arcispedale", the clinical diagnosis and the therapy used should be compared with the autopsy findings: a real clinical-pathological approach. In 1839, autopsies started to be recorded and thanks to their accuracy they became the model for the first autopsy legislation in the Kingdom of Italy. There were 1469 autopsies performed between 1839 and 1881.

The first specimens were wax models, but later also specimens in fluid were collected, especially of those human teratology, thanks to Professor Carlo Burci (1813-1875), the first professor of the first Chair of Pathological Anatomy in Italy. The Museum moved to Careggi General Hospital in 1959 and it is still there. A collection of many wet specimens, dry specimens and 116 waxworks made by Giuseppe Ricci, Luigi Calamai (1796-1851) and Egisto Tortori (1829-1893) belong to the Pathology Museum of Florence[46].

Giuseppe Ricci belonged to the university Pathology, his ability to make gypsum and wax models was famous. Nevertheless, little is

Fig. 2 A waxwork of the Pathology Museum of Florence

known of him. In the archives, there is just one document dating back to 1851 where his dermatological waxworks (whose total number is 60) were mentioned. Other waxworks of the Museum, were made by Luigi Calamai, who became "Ordinatore delle collezioni botaniche" (officer of botanical collections) in 1830. His most famous waxwork is the so called "Leper", a model of a human body life size affected by Norwegian scabies, as recently diagnostically re-evaluated[47]. The body was probably preserved in a mercurial solution and this long exposure could be the cause of death of Luigi Calamai. His follower was Egisto Tortori, probably the last wax workers of "The Specola", who, although valid, did not reach the

artistic level of Calamai. These waxworks were recently restored because they showed crevices and discoloration (see below)[48].
The Pathology Museum of Ospedale Maggiore of Milan dated back to 1832 when Carlo Vadoni became head of the Brugna morgue[49]. He began to create a Pathology Museum on behalf of Giovan Battista Duca. In 1835, he gave his specimens to the new head Francesco Grancini. At the time there was a problem with specimen acquisition due to the priority of the Pathology Museum of Pavia. In fact, all the pathological specimens must be transferred there. In 1842, a "corpo sezionante" (staff of necroscopes) was created by Director Piantaneda. For every autopsy a report was required, which reported the clinical history as well. In the same year, Angelo Dubini visited the most famous Museums of Anatomy and Pathology in Europe to understand the European assessment of Museums, especially in Montpellier, Paris, Strasbourg; Bruxelles, Heidelberg, Munich, Vienna and London. After 1848, the pathology collection grew due to the beginning of new medical courses in Milan. In 1852, the new Director Andrea Verga reorganized the Museum, which was in very bad conditions. He asked for assistance from some young doctors expert preparers. Among them Giacomo Sangalli (1821-1897) who had experience from the Pathology School of Rokitansky in Vienna. In 1855, the Museum moved to new rooms. In the same period it received the collection of dermatological waxworks of Stanislao Tagliasecchi. After the union of Italy, the Museum grew its importance and received a new relevant specimen, the skull of Antonio Boggia, a serial killer hung in 1862. It was interesting to the development of psychiatric science and criminal anthropology. This skull was also studied by Cesare Lombroso who found and sited the findings of all the characters of the "criminal man". In 1862, Achille Visconti joined histological study to macroscopical one, following the theories of Rudolf Virchow. Unfortunately, in 1865 he had to leave his work. In the same year, the Pathology Museum had 1002

pathological specimens. Years later, Visconti became "prosettore" (head dissector) and in this time the collection grew. Furthermore, some of their specimens were presented at the International Expo in 1906. In the same year, Costanzo Zenoni became the new Director and he focused on fixative fluids, especially the new one, already used in Europe, formalin. In 1924, the fusion between the university and the hospital Pathology occurred. By 1926, the Museum had 4500 specimens. A project of a Sanitary Museum was proposed in the 30's, nevertheless the interest for the Museum descended through the years, despite the claims of Director Alberto Pepere, follower of Zenoni. In 1942, the collection was almost totally abandoned and in august 1943 an Allied bombing destroyed the collection. Only eight empty cabinets were found after the war. A general project of re-evaluation of the old collections of the Hospital started in the early 2000's and now there are 1500 historical specimens especially historical instruments. There are some pathological specimens, wax-works, teratological and osteological collection but they still have not been on display.

The Museum of Pathology in Nosocomio Civico in Trieste[50] was founded by Doctor Antonio Carlo Lorenzutti (1806-1867) around 1840. The exceptionally numerous autopsies (almost 100 to 3000 each year) were the peculiarity of the school of Pathology in Trieste, especially thanks to Doctor Enrico Ferrari and Professor Luigi Giarelli. The Museum houses 500 specimens, collected between 1873 and the beginning of World War II. Among the specimens, there are many fetal malformations (the "monsters"), infectious disease such as typhus, syphilis, an interesting case of plague of the lung in a mariner dating back to 1906 and neoplastic diseases. The latter are more than a hundred. These wet specimens are stored in Kaiserling solution, it allowed an excellent preservation. Among the neoplastic specimens, there are also some extremely rare cases such as a case of "Chloroma"[51] dating back to 1907 and

a "Sarcoma of Thyroid" dating back to 1906. It is remarkable that the chloroma was already classified as a blood disease rather than sarcoma so as Virchow himself thought. This is a sign of modern and accurate research in the pathology school of Trieste. Another interesting case is "Acute Human glanders", that was correlated to laboratory animal experiments[52]. In particular, there are four wet specimens of pathological findings from an autopsy of a 45-years-old man who died of acute human glanders in 1907. There is an ear and neck, skin of the back, muscle and lung, stored in Kaiserling's solution. Then there is a wet specimen obtained after the injection of human glanders to a guinea pig compared to a healthy guinea pig. The relevance of this case is the demonstration of the progressive historical interaction between laboratory medicine and clinical-anatomical medicine.

The Pathology Museum of Palermo[53] houses around 400 wet and dry specimens dating back to 1859. There are many wet specimens, of which the study is still ongoing. The wet specimens seem to be in original condition, even if there were probably some intervention during the years. The original fixative fluid was surely not formalin, but little is known about possible refilling. The most relevant collection of the Museum is the teratological one, almost 100 specimens. One the most interesting specimen is a case of cyclopia characterized by the presence of a single eye located in the middle of the face.

The Andrea Vesalio Museum in Venice is not a university collection but the collection of pathology of Ospedale Civile SS.Giovanni e Paolo in Venice[54]. In 1871, the first position as *"dissettore anatomico"* was created in the Hospital. The first was Luigi Paganuzzi (1843-1902). Among their tasks was the collection of pathology specimens "*a secco o in alcole*" (dry or stored in alcohol). In 1885, a new autopsy room was made where they performed around 900 autopsies each year. The pathology collection also grew during these years as

Fig.3 A case of dwarfism of the Pathology Museum of Venice.

did the number of autopsies. In 1914, their number reached 1102. The Head of Pathology Department in these years was Giovanni Cagnetto (1874-1943), who became Head of Department in 1910 and then Professor of Pathological Anatomy in Padua. He was interested especially in lung pathology and described the so called "alterazione polmonare di Cagnetto" (lung alteration of Cagnetto)[55] which is a focal anemic necrosis that is a rare consequence of acute pneumonia[56].

Nowadays, the Museum Andrea Vesalio houses 304 wet specimens, 480 preparations of bones and 4 dry specimens. A very peculiar specimen of the collection is a case of dwarfism which is the only

until now known human specimen prepared by taxidermy. After a restoration intervention, the Museum opened to the public in 2014.
The Pathology Museum of Pisa dates back to the 1870 thanks to the work of Angiolo Maffucci (1847-1903)[57]. He was an Italian pathologist, Professor of University of Pisa and Director of Pathology School. In 1881, he described as first the disease characterized by multiple enchondromas associated to multiple hemangiomas. This pathological condition is now named "Maffucci's Syndrome". The pathological specimens of the Museum were collected performing autopsies and stored in fluid. The pathology collection has not only old wet specimens but also those of work-related disease, dating back to the 60's of the XX century. Beyond the wet specimens there is also a collection of 50 bladder stones, the biggest has a diameter of 9 cm and many dry specimens. There are in total almost 1500 specimen. The collection also houses some paleopathological specimens such as old bone remains and a pre-Columbian mummy as well. Among the wet specimens of special interest, there are the "Monsters": 25 wet specimens of fetal malformations for example anencephaly and cyclopia. There are also may cases of veterinary teratology, such as a cat with two heads.
The Pathology Museum in Rome was founded by Professor Ettore Marchiafava (1847-1935)[58] at the end of XIX century in Santo Spirito Hospital. He was Professor of Pathology in Rome and a malariologist. In 1898, Ettore Marchiafava, Giovanni Battista Grassi, Amico Bignami, Giuseppe Bastianelli, Angelo Celli and Camillo Golgi demonstrated conclusively that human malaria was also transmitted by mosquitoes, in this case anophelines.
The old collection of the Pathology Museum was destroyed in March 1944 during the bombing of Allies. After the end of the war, the activity of the Museum started again thanks to Professor Antonio Ascenzi (1915-2000)[59] and now the most relevant collection is that of cardiovascular pathology, with more than 900 specimens. Almost all specimens are stored in formalin.

Tab. 1. The different specimens in Italian Pathology Museums.

Pathology Museum	**Dry specimens**	**Wet specimens**	**Waxworks**
Padova	*	*	*
Bologna	*	*	*
Torino	*	*	
Firenze	*	*	*
Milano	*	*	*
Trieste		*	
Palermo	*	*	
Venezia	*	*	
Pisa	*	*	
Roma		*	

Pathological Specimens in Anatomical or Natural History Museums in Italy

Old and historical pathological specimens belong often to anatomical collection or other collections of human specimens. These collection aren't actually "Pathology Museums", however they are still relevant for the history of pathology and modern research. In Italy there are many of these collections stored in Anatomical Museums. The recently restored Museum of Human Anatomy Luigi Rolando in Turin[60] dates back to 1739 with Professor of Anatomy Giovan Battista Bianchi, who began the project as Academic Museum. The Museum grew later, thanks to Luigi Rolando (1773-1831). His main interest was the nervous system. He was the first to describe the Rolando fissure of the brain. The Museum grew later with the activity of Lorenzo Restellini (1820-1870). He was Professor of Anatomy and also a military doctor who took part in the Italian Independence Wars. The Museum houses waxworks of Luigi Cantù and his son Giuseppe who became "ceroplasti" in the school of Florence. In

1858, according to the "*Catalogo delle preparazioni del corpo umano e d'Anatomia comparata eseguite a secco, nel alcol ed in cera*" there were 103 waxworks, 60 of them were made in Turin. There were also many dry specimens and wet specimens stored in alcohol. In 1867, Carlo Giacomini (1840-1898) became Director and the collection grew quickly. In these years, the anatomical specimens were real organs and no longer waxworks. The skeleton and the brain of Giacomini are now in the Museum. The brain was prepared using his technique.

The Obstetrical Collection in Padua dates back to 1769 thanks to Professor Luigi Calza (1736-1783)[61]. He was a student of Giovan Antonio Galli (1708-1782), the founder of Obstetrics in Bologna in 1737. He founded the first Obstetric Cabinet in Padua in 1765. The original specimens are not all present in the collection. Originally there were 60 waxworks and some models of painted crete, now there are 40 waxworks and 22 models of painted crete. Probably Luigi Calza had the collaboration of Antonio Scarpa (1752-1832). The waxworks were made by Giovan Battista Manfredini (1742-1789) from Bologna and they show the female anatomy and models of physiologic and pathological pregnancy. They were used to teach at the first Gabinetto Ostetrico of Padua University. Also the crete were models of physiological and pathological pregnancy and they were used by students during lessons. The collection contains some surgical instruments of Rodolfo Lamprecht (1781-1860) dating back to the foundation of the Obstetrical Clinic of Padua in 1819. There is an old Library as well.

The Anatomical Collection Paolo Gorini of Lodi[62] houses 166 specimens of humans and animals made by the technique of "pietrificazione" (petrification). With this process, the tissue becomes like stone. Paolo Gorini (1813-1881) was a scientist interested in geology, physics and body preservation. Probably his interest in death comes from the premature death of his father, which occurred when he was

still a boy. He was Professor of Natural Sciences at the High School in Lodi and wrote many books about geology such as "Sull'origine delle montagne e dei vulcani" (On the origin of the mountains and volcanoes). Among the preserved bodies, was the body of Giuseppe Mazzini, who died in 1872, which was preserved against the last will of Mazzini himself. But Paolo Gorini could not prepare the body of Giuseppe Mazzini using "pietrificazione" because he arrived two days after death and putrefaction was already set in. The body of Mazzini is buried in Staglieno Cemetry. Other preparations of Gorini are now collected in Lodi Hospital. In 2005, Professor Alberto Carli found the recipe of the mysterious technique of Gorini: "pietrificazione" was made by injecting into the femoral vessels a solution of bicloruro of mercury and muriatic of lime, very toxic and very effective. In the collection, there is also a preparation of an entire human body, a man who died in 1843 named Pasquale Barbieri. This was the first and most beloved specimen of Gorini, who in his last will asked to preserve the "famous Pasquale" for his historical value.

The Museum for the History of University of Pavia[63] followed the reforms thanks to Mary Therese of Austria and Joseph II. They promoted the "Piano Didattico" (didactical plan) in 1771 and "Piano Scientifico" (scientific plan) in 1773. Due to these reforms, teaching was modernized and new building were constructed such as the library and the anatomical theatre. There was a new impulse in many different fields of sciences as well, such as physics or botany and anatomy. The Pathology Museum was also created through these reforms, thanks to Professor Giovanni Pietro Frank (1745-1821). He asked and obtained by law that all the Hospitals in Lombardy must send them all of the "monster" or particular pathological specimens from surgery and especially autopsy. This collection was stored by the University near to the Anatomical Theatre. At the Hospital, there was another collection, derived from to the autopsies performed by the Medical Clinic. In 1799, the two collections were united in the

Pathology Museum. Consequently, the Museum of History of the University of Pavia dates back to the begin of XX century. In 1932, the Professor of Anatomy Antonio Pensa (1874-1970) prepared an exposition in honor of Antonio Scarpa (1752-1832) for the centenary of his death. In 1936, the Museum was opened in the location of the old "Gabinetto Anatomico" of Scarpa. During the II World War, the Museum was closed and all the specimens were carefully stored in a safe place. At the end of the war, the Museum grew thanks to Dean Fraccaro. The Museum is really rich in precious historical specimens of Medicine, such as many objects belonging to Camillo Golgi (1843-1926) among them there is his Nobel Prize certificate. There are many dry specimens and many wet specimens as well, the most particular is the head of Antonio Scarpa. There are also many manuscripts of enormous historical value such as those of Volta, Foscolo, Monti, Spallanzani, and Golgi.

The Museum of Anatomy of University of Modena and Reggio Emilia[64] was created after the reform of University of Duke Francis III of Este in 1772. In this Museum there is a collection of skulls, an osteological collection of teratology and many fetal skeletons artistically prepared. Of relevance is the collection of 300 specimens due to Professor Paolo Gaddi (1805-1871) including skulls and waxworks showing different people from different parts of the world. In the Museum, there are also three mummies of women dating back to 1841, 1834 and 1839. They were prepared by immersion in sublimate corrosive and in arsenious acid. There is also a collection of waxworks, dry specimens and some skins with tattoos all collected according to the theories of Cesare Lombroso (1835-1909) the founding father of the criminology. His main theory was that of the "uomo delinquente" (criminal man), a kind of inherited criminal tendency in consequence of some distinct morphological tracts. Despite its groundlessness, this theory influenced a lot of scientist over the years.

The Anatomical Museum of Parma[65] opened to the public in year 1920. Its origins are still under debate. It houses two waxworks of the human body dating back to the end of XVIII century thanks to Lorenzo Tenchini (1852-1906). He increased the collection with 400 skulls of psychiatric patients according to Lombroso's theory, their mummified brains, many dry specimens and 46 masks of the faces of people with their history recorded. In addition to the wet and dry specimens of the nervous system, there are anatomical models of muscles and models showing the physiopathology of the lymphatics vessels of the intestinal tract. Remarkably, there are also two wax figures from the Florentine school of Clemente Susini showing the lymphatic vascularization and superficial and deep muscles.

The Anatomical Museum Tumiati in Ferrara[66] dates back to the end of XVIII century, when Professor Giovanni Tumiati (1760-1804) started to collect the dry specimens he prepared. These specimens were stored in a "Gabinetto Anatomico" (anatomical cabinet). Later in 1831, the collection grew from 100 to 368 specimens thanks to Professor Lionello Poletti and Professor Carlo Grillenzoni and therefore the specimens were stored in "Stanze Anatomiche" (anatomical rooms). The Museum grew until 1892. In 1932, it was moved to the new Institute of Anatomy and in 1984 it was relocated. The Museum houses around 2000 specimens, among them there are wet specimens, some osteological specimens, two gypsum models, four models of an eye made by Egisto Tortori and, remarkably, waxworks of Francesco Calenzuoli (1796-1829). He had been assistant to Clemente Susini and became the Director of "The Specola" of Florence in 1819. His works are famous because he made both anatomical models and anatomical figures and botanical models as well.

In Siena, there are two relevant Museums in which anatomical and pathological specimens are stored. The Anatomy Section of Museum of Natural History Academy of Fisiocritici in Siena houses the collection of dry anatomical specimens studied by the Tuscan scientist

Paolo Mascagni (1755-1815) who was the first to demonstrate the lymphatic vessels. There are 50 specimens obtained through injection of metallic mercury in the lymphatic vessels. In addition, there are 70 "stoned" human specimens obtained by Professor Francesco Spirito (1885-1962), Director of the Academy from 1952 to 1960, using his own technique with potassium silicate.

The Anatomical Museum Leonetto Comparini dates back to 1862 and the first specimens were the dry specimens of Mascagni, now stored in the "Academy of Fisiocritici". Later the collection grew and before the end of the XIX century there were more than thousand skulls, dry specimens of the nervous system and an embryological collection stored. In 1895, the Museum was moved to the new Institute of Anatomy. Now the Museum has wet specimens, a relevant osteological collection, many fetal skeletons dating back to 1881 and also old laboratory instruments. The Museum hosts a didactic project for students and citizen[67].

In Florence there is a Museum which houses a relevant collection of waxworks named "The Specola"[68]. This Museum, before known as The Imperial-Royal Museum for Physics and Natural History, was later named "The Specola" due to the presence of an observatory. It was opened on 21st February 1775 with the aim to show the importance of the sciences. Some of these waxworks were made by Gaetano Zumbo and Ercole Lelli (see above). Thanks to Peter Leopold I, who became the second Grand Duke of Tuscany in 1765, the tradition of Florentine wax models continued. In fact, the waxworks art of the Bolognese school was later continued in Florence, where it had been brought in 1770 by Giuseppe Galletti, a doctor from the Santa Maria Novella hospital. The anatomical models proposed by Galletti and prepared by the sculptor Giuseppe Ferrini gained the attention of Felice Fontana (1730-1805), responsible for the Physics Cabinet, the first nucleus of what would later become the Museum of Natural History. Using waxworks, anatomical models could replace cadavers

during anatomical lessons. This idea pleased the Grand Duke Pietro Leopoldo, therefore he authorized the creation of a collection of wax models. Thus a group of artists and sculptors was form, among which was a very young Clemente Susini (1754-1814). He had a fortunate career and he set up over 2000 models (see below)[69]. Felice Fontana obtained from the Duke some buildings dedicated to the art of wax models: the buildings fronting to via Romana. This school of wax modelling by Fontana had a staff composed by anatomists, artist but also people who should collect the bodies for dissection. In Florentine tradition the models were created entirely in wax without using a skeletal base. One single wax model required more than one body: for instance one model of origin and insertion of muscle required 100 cadavers for partial dissection. So many bodies came from Santa Maria Nuova Hospital and a special register recorded the admission of the corps and the number of corps sent to cemetery. In 1780 the Austrian Emperor Joseph II, brother of the Grand Duke Pietro Leopoldo, visiting Florence was really impressed by the grandeur of the collection. Therefore, he commissioned a large number of waxworks to bring to Vienna. Between 1784 and 1788, Felice Fontana, Clemente Susini and the anatomical Paolo Mascagni set up 1192 models which were then carried on the back of a mule across the Alps. A considerable sum of thirty thousand florins was paid for the collection. Currently 867 anatomical models are preserved in the Josephinum Museum[70]. The waxworks from "The Specola" were also destined both to Italy so as Pavia, Cagliari and Bologna and in Europe so as Budapest, Montpellier, Uppsala and London.

This Museum still stores one of the most relevant collections of waxworks in the world. The The Specola Museum has 1400 wax specimens among them 513 of human anatomy and 65 comparative figures.

The Museum of Anatomy in Perugia dates back to the begin of the XIX century. It houses a collection of almost 500 skulls, among

them there is also the Mortara's collection of 20 Etruscan skulls, osteological specimens, dry specimens and there is a branch dedicated to criminal anthropology. As waxworks, there is a Venus and eight anatomical models commissioned to Francesco Calenzuoli of Florence (see above).

The "Museo Storico Nazionale dell'Arte Sanitaria" (National Historical Museum of Sanitary Art) in Rome is a museum of history of medicine and it is in Santo Spirito Hospital. There are some old anatomical stamps made by Antonio Serantony with Paolo Mascagni. There is a relevant collection of old specimens stored in Sala Flajani. There are dry and wet specimens of malformation and infectious disease such as syphilis. There is also a collection of wax of obstetric models made by Giovan Battista Manfredini and the anatomist Carlo Mondini.

The Museum of Anatomy "Eugenio Morelli" is located in Carlo Forlanini Hospital in Rome. It is more modern than the other museums as it started in 1941. Eugenio Morelli knew a charlatan named Grutzner who had a collection of waxworks and travelled around with it to make money. He became anatomical preparer and he died soon due to exposition to toxic chemical substances. The Museum has a collection of teratology, anatomical preparations, a wet specimen of a whole nervous system and some preparations of topographic anatomy and composed by many thin sections, like a modern CT. The Pathology Collection houses 900 specimens, especially of lung pathology and tuberculosis. There is also a branch of Radiology and Surgical Pathology, all of which are dedicated to the study of lung pathology.

The Museum of Anatomy in Naples is one of the oldest in Europe[71]. It dates back to end of the XVIIIth century. It has been recently restored and again opened to the visitors. The Museum even has a humerus prepared by Andrea Vesalio and a collection of skulls from the executed in Castel Capuano. Among the skulls, the most famous

is that of Giuditta Guastamacchia, a woman hanged in 1800 for the murder of the husband. These skulls were object of anthropological studies according to the theory of Cesare Lombroso. There is also a teratologic collection of 153 wet specimens, two dead bodies, prepared by the technique of "calcinazione" (calcination). This technique was invented by Giuseppe Albini who had to find an alternative to burial or cremation upon the request of the Interior Minister. A very particular specimen is a small table using blood, brain, liver, bile and lungs from the technique of "pietrificazione" (petrification) by Efisio Marini (1835-1900). On this table there is a hand of a woman made from the same technique.
The Museum of Anatomical Wax "Clemente Susini" in Cagliari houses 23 waxworks made by Clemente Susini[72]. The collection was created thanks to the will of Professor of Anatomy of Cagliari University Francesco Antonio Boi (1767-1855) who visited Florence. These waxworks were made by Clemente Susini between 1803 and 1805 and they were bought by Carlo Felice for the Museum of Antiquity and Natural History in Cagliari. In 1923 they moved to the Institute of Anatomy and since 1991 they are in the "Cittadella dei Musei".

Modern value and conservation of pathological specimens

The specimens of Italian Pathology Museum are all remarkably old. With a few exceptions, they date back to at least to the first half of XIX century or sometimes even much older, like those of the Pathology Museum of the University of Florence and Padua or Anatomy Museum of Naples.
Therefore, all the pathological specimens, regardless if waxworks, dry or wet specimens, are relevant to the history of medicine since they show the natural history of the diseases, not modified by modern therapies. In fact, they date back to pre-antibiotic and, often, pre-chemotherapy era. Pathology Museums often have very rare cases of old diseases, such as "Plague in a Mariner" stored

in Museum of Trieste and a case of "Leprosy" stored in Museum of Venice. Old common diseases are just as valuable because they are not comparable to the modern ones due to the changes in the habits and in nutrition. A first relevant value of these Museums is therefore a didactic one. Although now technologies offer a lot of different modern didactic possibilities, the value of the Pathology Museum is not outdated. They can be a very useful 3D teaching method for the medical or technician students, as in the past. But not only students and doctors should be interested in Pathology Museum. The understanding of pathological conditions through vision and not imagination nor reading can be useful for education of the general population. For instance, it can demonstrate the damage to the lungs due to cigarettes smoke or the damage to the liver due to excess of alcohol intake.

Besides the didactic purpose, even more relevant is the biological value of the specimens. The specimens of a Pathology Museum highlight old disease now modified. Therefore, they are relevant for paleopathology[73]. The best definition of paleopathology is that of Sir Marc Armand Ruffer (1859-1917): "*paleopathology is the science of diseases which could be demonstrated in human and animal remains of old time*". Although they are biological tissue fixed and preserved over time, they are still suitable for many different modern studies. Therefore, dry and wet specimens are a real biological archive and even a valuable fountain of old DNA[74]. The possibility of scientific research offers not only new material for paleopathology but also for modern medicine: the changes of the manifestations of the disease due to the variation of environmental conditions are relevant for understanding the pathogenesis of the disease[75]. The union between historical condition and clinical manifestation is a kind of experimental retrospective protocol. For example the study of the lungs of the "blowers of glass" in Venice could give information to the damage due to the working exposure.

The best technique to study dry specimens seems to be the resin embedding with the method appointed by Professor Ezio Fulcheri for mummified tissues. Only small samples are necessary for this technique and it can be performed without any damage to the specimen itself. In some dry specimens of the Pathology Museum of Turin, this technique allowed the histological examination of the tissue. The cyto-histological details are preserved and the different tissue such as skin or muscles are still recognizable[76]. This technique allows the re-evaluation of the pathological case of dry specimen using modern classifications.

Also wet specimens are suitable for diagnostic re-evaluation using modern pathology techniques such as special stains, immunohistochemistry and molecular biology.

These approaches have to be as conservative as possible because the exhibition of the museum specimens remains mandatory. Therefore, it is not possible to sample them by the same techniques of surgical pathology samples. An optimal sampling technique of museum specimens is fine needle aspiration or core biopsy allowing enough material for histochemical and special techniques without damage[77]. Common pathology laboratory instruments can be used making it possible to study the old museum cases just like the modern ones.

The special stains are absolutely comparable with the modern ones.

The immunohistochemistry is relevant also for paleopathological diagnostics[78] and these specimens are suitable for this special technique which helps in the differential diagnosis. Some years ago, in Pathology Museum of Turin immunohistochemistry was performed demonstrating F, Molecular biology is more important as immunohistochemistry because it allows not only a diagnostic re-evaluation but also a comparison between the molecular profile of old diseases and the modern ones. The result of these special investigations is often unpredictable, since it depends on the fluid used for storage. An excess of acidity could damage seriously the antigenicity or the nucleic acid.

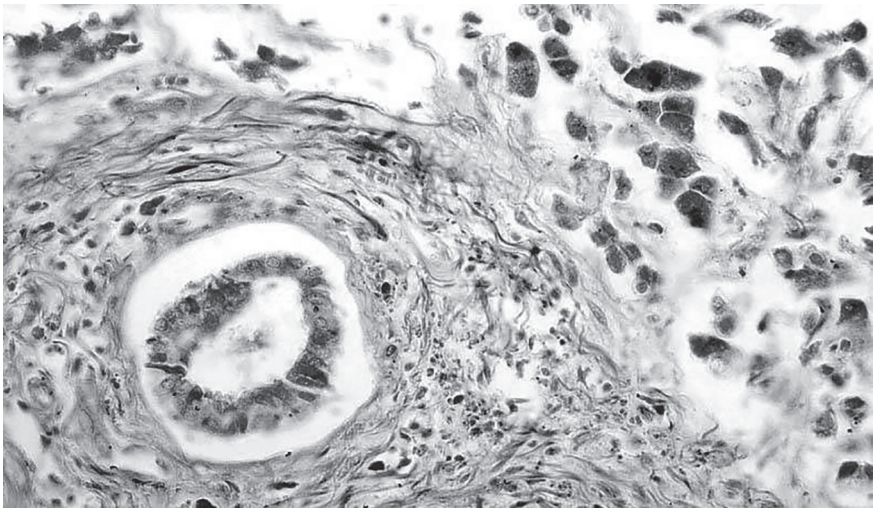

Fig. 4 The presence of new vessels in endocarditis by using immunohistochemistry (antibody Factor VIII, 200x magnification).

These new possibilities of study also change the approach of the restoration intervention of these specimens. Since their worth is now accepted to be historical and biological as well, it is necessary to preserve their biological integrity.

The main enemy of dry specimens and waxworks is air pollution if these specimens are not stored in hermetically closed spaces. Day by day the pollution covers the surfaces and damages the specimens, sometimes only superficially and sometimes also deeper. It is impossible to forecast the degree of damage because it depends on many factors such as environmental temperature or the materials of which the specimen is made. For instance, some waxworks are not real waxworks but they are made from gypsum, wood and wax. This mixture of different materials could react differently from a pure waxwork to the changes in temperature.

The waxworks are real artworks and every conservative intervention must be individual. The presence of dust on the surface could pro-

voke discoloration whereas changes of the temperature could cause fissures of the surface or other defects. The restoration intervention made by expert restorers has generally excellent results, such as the recently performed restoration of the waxworks performed by the Pathology Museum of the University of Florence (see above).
The restoration of dry specimens can be particularly challenging in some cases of vascular lesions such as aneurysms which were insufflated during the preparation. The cleaning could be made with a solution of natural soap and water, as in the experience of the Pathology Museum of Turin. These could be only operational recommendations. It is difficult, if not impossible, to have a common protocol for the restoration intervention of these specimens. After the restoration, the dry specimens of Turin appear to be in excellent condition. However, it is necessary to pay attention to the further storage to avoid a new prolonged contact with air pollution damaging these specimens again.
The main problem in the restoration of old wet specimens is the fluid of storage. In fact, it is often necessary to add or change the fluid, which has often evaporated or became turbid over the years. The chemical composition is often unknown. In the experience of the study of the Pathology Museum of Turin, chemical-physics analyses of the storage fluid were also performed to identify them and later to try to add new to the old[79]. The principle was good, but the analysis was very expensive and useless, due to the variety of possible fluids. In absence of new experimental evidence, in Turin it was decided to avoid the changes.
Nevertheless, a study of Terribile Wiel Marin[80] demonstrated that the wet specimens stored in formalin are at risk too, because if there is a contact with oxygen, the formalin is oxidized and the pH of the fluid lowers. The pH is very relevant for DNA preservation, just as the different fluids are. For instance, Bouin's fluid destroys the DNA and it makes the analysis of molecular biology useless. For this reason, in

his opinion it is necessary to change the formalin when it changes its colour, because it means that the paraformaldehyde is made.
This theory is now under discussion, because it is reasonable to think that many subsequent fixations could damage the specimen. Once it is fixed, it is fixed and fixation is a process that can happen only once. Further changes are useless and theoretically dangerous for the specimens.
A particular problem is the study of dried wet specimens. The old jars were closed by different natural materials, for instance a resin, so called rosin powder, which could become dry over time. So the lid of the jar can move and the fluid can evaporate. The oldest jars were covered by a dried pig's bladder and some accidental rupture could theoretically allow the entrance of oxygen into the jar causing oxidation. For these reasons the opening of the oldest jars should be performed only in case of particular interest and not for a general study. Even in these cases the aim of study should be evaluated very carefully, because the historical preservation of the specimen is of greater value than its histological re-evaluation. Each case should be considered individually, since up until now there isn't a common protocol for restoration intervention. Currently, the resin embedding seems to be the best solution to obtain slides suitable for histological examination.

Conclusions

Pathology Museums have many old specimens such as waxworks which are a magnificent expression of the union between art and history of medicine, dry and wet specimens which are the union between historical cultural heritage and biological archives of old diseases. Their preservation needs special attention for restoration, especially for wet specimens due to the problem of the storage fluid. A conservative approach is in any case mandatory to avoid damaging the specimens. Regardless of the subject, all the material of the Pathology Museums are useful for paleopathological studies, modern medical research,

teaching and educational purposes as well. The Pathology Museums should be saved from damage or destruction because they are the expression of the foundation of Pathology itself. Pathology Museums must be re-evaluated[81] due to their historical and scientific importance.

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