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Old anatomical models as makeshifts of measurements in medicine

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***Abstract* - In 18th century obstetrics became a special branch of medicine, with a corpus of physiological and practical knowledge sufficient to improve the outcome of childbearing. The same period also saw the emergence of new techniques and the development of instruments that would later come into widespread use, such as the forceps, as well as the first production of teaching models to provide surgery students and midwives with three-dimensional illustrations of the anatomy of the pregnant woman, the physiology of childbearing, and potential complications. Some obstetrical wax models, that can be considered makeshifts of measurements in medicine, are illustrated. They are exposed, in number of twenty-one, in the Galileo Museum of Florence and were commissioned, around 1770, by Felice Fontana, who was working on the installation of the Museum of Physics and Natural History of Florence, from the sculptor Giuseppe Ferrini and his assistant Clemente Susini. The anatomical models contributed, in a context in which the measurement was not easy to be taken in situ, to formalize medical knowledge, strictly tied, in the past, to the various communities, that had different ideas about the causes of and cures for suffering, illness and disease. As a matter of facts, instead of being based on objective parameters, medical knowledge was based often on spiritual beliefs as well as practical therapies and techniques.**

Keywords* - *anatomical models, obstetrics, history of medicine, didactics

I. Introduction

Medical knowledge of mankind is developed and passed on in many ways. Every community has opinions about the causes of and cures for suffering, illness and disease. They are often spiritual beliefs as well as practical therapies and techniques. Some traditions, or systems of medical knowledge, are tied to a part of the world, others spread widely, particularly once they become formalized in books and schools.

The anatomical models are an exceptional educational tool for studying and illustrating the internal and external structures of the human body, as well as the various functions of physiological systems [1]. Scholars interested in the medical profession, doctors, professors and health professionals can benefit greatly from model realism. A wide range of models has been developed, human musculature, bones and single joints, vertebral columns, vertebrae, skulls,

Fig. 1 – Museo Galileo, former Istituto e Museo di Storia della Scienza of Florence, Italy

life-size skeletons, miniature skeletons, human torso models, brain models, tooth models, jaw and dentition, cardiac and circulatory system, man's digestive and urinary system, models of pregnancy and childbirth, as the ones object of the paper.

Nowadays the anatomical models are particularly important for doctors, chiropractors, physiotherapists and operators in the field of nursing as a tool for patient education too. They allow the physicians to establish a relationship of trust with the patients due to the possibility to describe every single anatomical detail on a model and make easier the description of some diseases. The anatomical waxes originated in 17-18th centuries, due to the need to provide more visual information than the one provided by the available two-

dimensional illustrations and secondly in the lack of effective preservation techniques for cadavers, which made dissection of deteriorating bodies highly unpleasant [2, 3].

The old obstetrical models object of this paper, makeshifts of measurements in medicine are exposed in the Museo Galileo of Florence, whose facade is shown in Fig.1.

II. MUSEO GALILEO

The Museo Galileo, the former Istituto e Museo di Storia della Scienza (Museum of the History of Science) is located in Florence, Italy, in Piazza dei Giudici, along the River Arno and close to the Uffizi Gallery. The museum, dedicated to astronomer and scientist Galileo Galilei is housed in Palazzo Castellani, an 11th century building which was then known as the Castello d'Altafronte.

The museum owns one of the world's major collection of scientific instruments, which bears evidence of the crucial role that the Medici and Lorraine Grand Dukes attributed to science and scientists. The Museo di Storia della Scienza re-opened to the public under the new name Museo Galileo in 2010, after a two-year closure due to important redesigning and renovation works [4].

The Medici Collections exposed in the Museum are dating from the 15th century through the 18th century. The permanent exhibition includes all of Galileo's unique artifacts, among which are his only two extant telescopes and the framed objective lens from the telescope with which he discovered the Galilean moons of Jupiter; thermometers used by members of the Accademia del Cimento; and an extraordinary collection of terrestrial and celestial globes, including Santucci's Armillary Sphere, a giant armillary sphere designed and built by Antonio Santucci.

The Museum houses also instruments and experimental apparatus collected by the Lorraine dynasty (18th-19th century), which bear witness of the remarkable contribution of Tuscany and Italy to the progress of electricity, electromagnetism and chemistry. The exhibits include obstetrical wax models, object of this paper, from Santa Maria Nuova Hospital, Grand Duke Peter Leopold's chemistry cabinet and the beautiful machines made in the workshop of the Museo di Fisica e Storia Naturale to illustrate the fundamental physical laws [5].

Fig. 2 shows an overall image of the anatomical models object of this paper, recovered from the disastrous flood of November 4, 1966, that violently struck Palazzo Castellani, situated in the immediate vicinity of the river Arno. Water mixed with heating oil and mud flooded into the cellars and invaded the ground floor up to a height of four meters. The hundreds of instruments submerged in the torrent for hours were drastically damaged. Many days passed before the premises could be swept free of mud. With the help of dozens of volunteers, eminent professors and anonymous citizens, led by the indomitable Righini Bonelli, the instruments were salvaged. As they emerged from the mud and debris, they were sent to specialized laboratories and most of the artefacts were restored.

In recent years the Museo Galileo is moving from a place mainly devoted to the conservation of collections and historical research to an educational and training center where, by understanding the needs and expectations of visitors, the spreading of the history of science becomes the main goal.

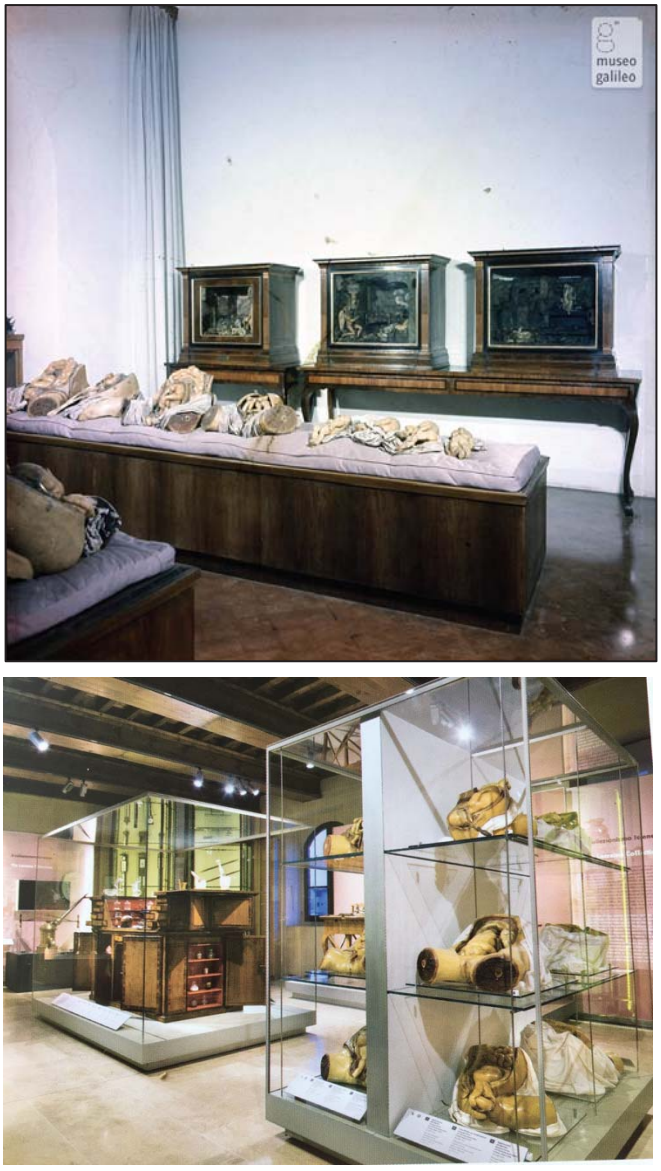

Fig. 2 – Anatomical models recovered after the flood of Arno river, that hit the Museo Galileo(up), the actual displaying conditions (down).

To make the teaching proposals increasingly interesting, it is essential to build networks and systems that work in synergy to strengthen the link between schools, museums and associations. The Museum promotes intercultural dialogue between different audiences through events, shows and theatricalizations, thus becoming a place of social exchange in which the visitors do not come exclusively to see the wonderful scientific collections, but also to meet people with whom share knowledge, opinions and new interests.

To project outwards, itinerant educational activities have been designed; the intent is to share the educational experiences of the Museum but also to listen to and receive the requests of those who do not have the opportunity to visit the museum. In this context the replicas of some artefacts exposed have been produced in order to increase the fruition of science. In the frame of these activities some polymeric replicas of the old terracotta anatomical models, below illustrated, have been made.

Fig. 3 – Drawing of 18th century of the breech presentation of the fetus that occurs when the part presented at the pelvic entrance lies caudally with respect to the iliac crests of the fetus, i.e., the buttocks and both feet (complete breech) or only the buttocks or one or more parts of the inferior limbs (incomplete breech: buttocks, knees or foot first).

III. Obstetrics in 18th century

In order to highlight the interest of these anatomical models some historical information is given. Obstetrics became, in 18th century, a special branch of medicine, with a corpus physiological and practical knowledge sufficient to improve the outcome of childbearing. As a matter of facts, until the previous century, midwives traditionally took care of pregnant women about to give birth.
Only when the procedure seemed unusually risky did the midwife summon the surgeon, who, as a rule, lacked even the rudiments of female anatomy and of the physiology of the first obstetrics childbearing, Fig. 3. In the 18th century the first maternity wards were opened in hospitals, in France and England, and schools were founded, due to progress in the knowledge of the anatomy and physiology of the uterus and childbirth.

The same period saw the emergence of new techniques and the development of instruments that would later come into widespread use, such as the forceps. In Italy, Giovanni Antonio Galli was appointed to the first chair in obstetrics, established in Bologna in 1757, meanwhile, new obstetrics schools opened in Florence and several other cities including Siena, Milan, Padua, and Rome.

The following innovations were established:

- the emergence of new techniques and the development of instruments that would later come into widespread use, such as the forceps;
- the first production of teaching models to provide surgery students and midwives with three-dimensional illustrations of the anatomy of the pregnant woman, the physiology of childbearing, and potential complications [6, 7].

By the end of the 18th century, obstetrics was distinct from general surgery and practiced by specialized faculties.

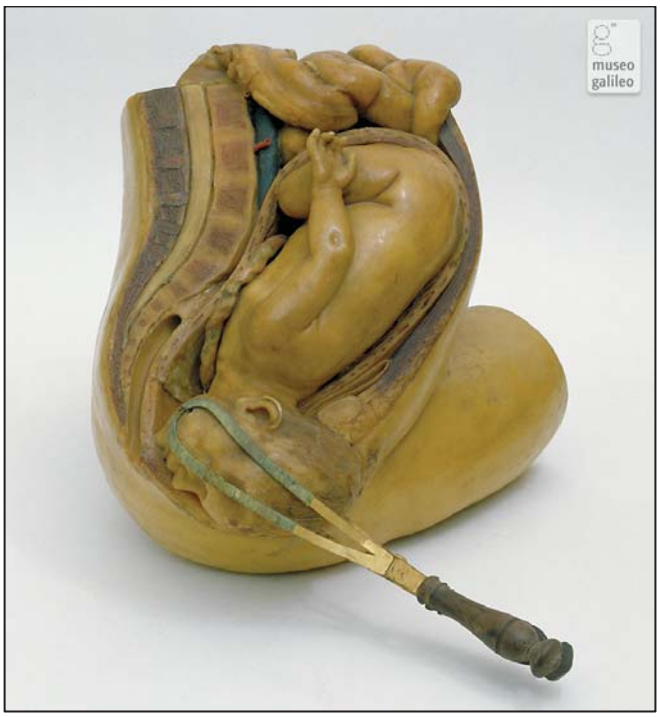

Fig. 4 – Anatomical wax model showing forceps being used to disengage the head of a foetus in cephalic presentation, produced by Giuseppe Ferrini, around 1771.

Pregnant women's right to assistance was recognized, and the high number of case histories available had made it possible to develop ever more reliable techniques.

The aim of the schools was to provide basic knowledge of basic hygiene standards and to substitute rigorous scientific ideas for the traditional prejudices that had blocked progress in the art of child delivery. In the process, the functions of the midwife were gradually separated from those of the physician. Guidelines were also drawn up for determining which cases required the help of a surgeon.

IV. Anatomical Models

The anatomical models nowadays on display in the Museo Galileo have a complex history. The twenty-one wax obstetric models were commissioned by Felice Fontana from the sculptor Giuseppe Ferrini and his assistant Clemente Susini after 1771, when Fontana was setting up the Museo di Fisica e Storia Naturale in "La Specola" in Florence.

With time, however, the opinion came to prevail that the Museum wax works should display only normal anatomical preparations. As a result, the waxes depicting pathological childbirth and monstrous fetuses were transferred in December 1817 to the Ospedale degli Innocenti, where a maternity ward and a midwife training school had opened. Meanwhile the forty terracotta obstetric models were commissioned between 1770 and 1775 by Giuseppe Galletti, who taught obstetrical practice at the Ospedale di Santa Maria Nuova. The terracotta models were based on the illustrations in the most famous obstetrical treatises of the time.

Fig. 5– Replica of the anatomical terracotta model which presents vertex presentation, produced in 18th century.

In 1785, Galletti's collection of waxes, which also included some now lost models, was purchased by the Ospedale di Santa Maria Nuova. In 1939, the obstetric waxes and terracotta models belonging to Florentine maternity wards were assembled at the Villa Blow, near the city. After the war, they were transferred to the Museo di Storia della Scienza.

The interesting wax and terracotta collection illustrates the different evolutionary steps of the foetus, the various positions that the foetus takes on during the pregnancy and also the employment of the obstetric techniques and instruments.

As an example the obstetrical wax model of Fig. 4 shows forceps being used to disengage the head of a fetus in cephalic presentation. The head is grasped transversally (above the ears) with the forceps when it has descended into the inferior strait and the occiput has rotated forward, under the pubis. The model was commissioned by Felice Fontana, who was working on the installation of the Museo di Fisica e Storia Naturale of Florence, from the sculptor Giuseppe Ferrini and his assistant Clemente Susini.

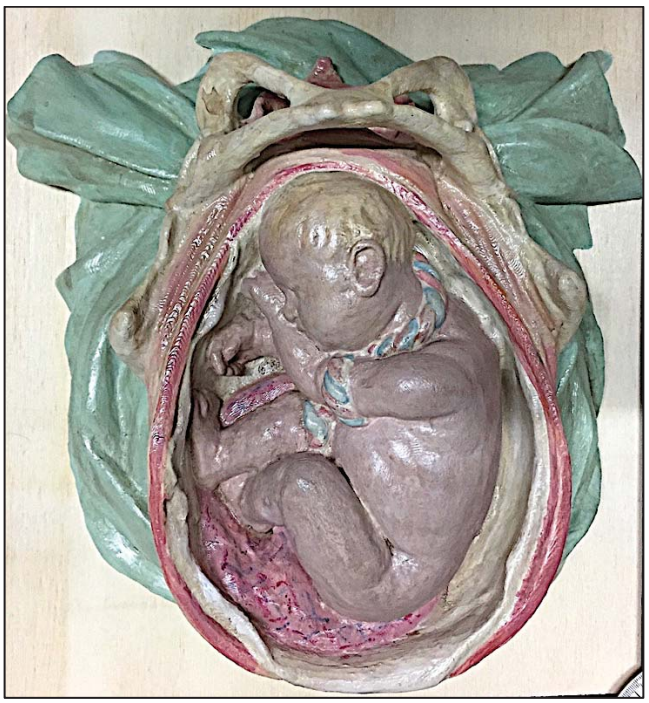

Fig. 6 – Replica of the anatomical terracotta model, representing a full term pregnancy with complications due to the umbilical cord wrapped around the neck produced in 18th century.

Forceps are used to correct an adverse position of the presented part and to enable the obstetrician to replace the expulsive force with a traction of the fetus so as to complete the delivery. Today, forceps are rarely used, because of the damage they can cause to either the mother or the child. They are replaced by Cesarean section in nearly all indications.

The replica of the obstetrical terracotta model of Fig. 5 illustrates the fetus vertex presentation: it represents the position of the head in the muscular-membranous birth canal formed by the soft parts of the pelvic floor. The occiput is now below the pubis almost up to the nape of the neck, and the back has followed the head in the rotation subsequent to engagement.
The normal but also the abnormal situations were object of the anatomical models. As a matter of facts the replicas of the obstetrical terracotta model of Fig. 6 illustrate full term pregnancy with complications due the umbilical cord not correctly positioned. As well-known an unborn baby receives oxygen-rich blood from the mother by way of the umbilical cord. Complications that cause the umbilical cord to rupture or become compressed can deprive the baby of oxygen; this is an emergency and must be treated promptly.

These anatomical models has an important role in medicine and can be considered as makeshifts of measurements in medicine for conditions in which it was difficult to quantify different parameters due to the lack of techniques as for example diagnostic imaging techniques.

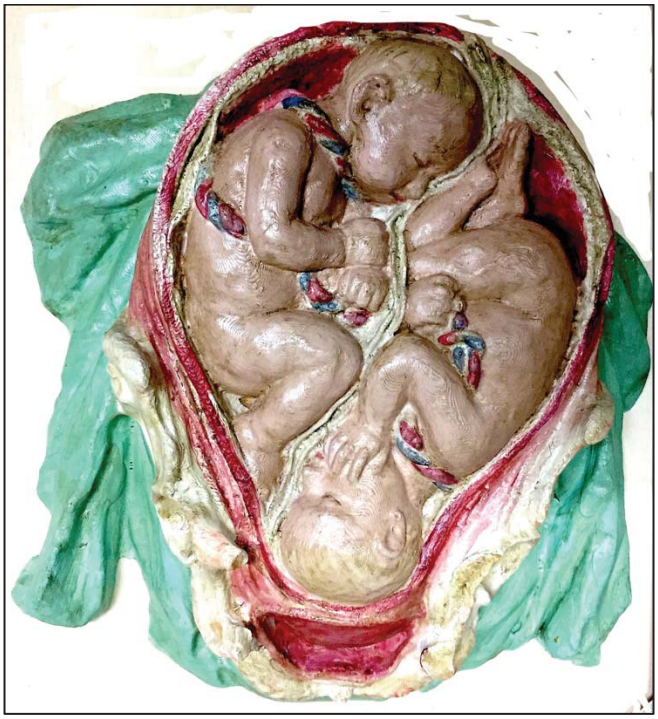

Fig. 7 – Replica of the anatomical terracotta model representing a full term pregnancy with complications due to the umbilical cord wrapped around the neck of twins, produced in 18th century

As a matter of facts important measuring instruments such as the thermometer and the barometer were developed in the 1500s and 1600s, and notwithstanding their low accuracy, some early modern doctors began to advocate the use of measurement for 'medical mathematics'. During the Enlightenment, scientists argued that numbers were more objective than qualitative descriptions. This argument had a great impact on medical research. Numbers became important both for observing individual patients and for observations on larger groups. Since the 1700s, physicians have developed ways to measure many features of the human body. The quantification of the body changed the relationship between doctors and patients. For a long time, physicians had regarded each patient's case as unique. With quantification, scientists in the 1800s began to determine 'normal' ranges for physical features such as temperature and blood pressure [8, 9].

V. Concluding Remarks

The aim of this paper is to renew interest in the tools that were used to replace the human body in medical education, particularly focusing on the anatomical models served above all medical education and whose shape, structure, and texture evolved in time.

The interest in human anatomy can be traced in the history of art definitely before the development of the science of anatomy, as witnessed by the Venus of Willendorf dating back to 24000 years BC. The science of anatomy dates back to 4th century BC, when Herophylus and Eristratus in Alexandria of Egypt managed to get the license to perform vivisections on offenders. The Arabic doctor Ibn Zuhr, around 1100 started performing vivisection of human corpse and post-mortem autopsy. The first wax models representing parts of the body, organs and part of the organs with no details and no educational purposes can still be found in catholic churches. They became very popular, the protagonist of the novel *Wilhelm Meisters Lehrjahre (*Wilhelm Meister's Apprenticeship) published in 1795 by Johann Wolfgang von Goethe says: "You can learn much more if you create rather than destroy, bringing together rather than tearing it apart, mimicking the dead rather than killing again something that has already been dead".

These old anatomical models acted as makeshifts of measurements in medicine in a period in which several technologies, as for example imaging techniques were not yet developed.

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