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Articoli/*Articles*

AN ANENCEPHALUS FOETUS PETRIFIED BY GEROLAMO SEGATO (1792-1836)

ROSALBA CIRANNI, GINO FORNACIARI, VINCENZO NARDINI[1], DAVIDE CARAMELLA[2]
Department of Oncology, Section of History of Medicine, [2]Division of Radiology, Pisa University; [1]Division of Pathology, Santa Chiara Hospital, Pisa, I.

SUMMARY

We report the case of an anencephalic foetus petrified by Gerolamo Segato in the course of his experiments on body conservation. The specimen has been studied applying non-invasive methods. Digital radiography and computed tomography (CT) alogside more advanced techniques such as three-dimensional (3-D) reconstruction and virtual endoscopy (VE) have been used to investigate anatomic morphology and to perform hypotheses about Segato's method of petrification which is still unknown.

Introduction

The problem of the preservation of human bodies has fascinated man since antiquity and followed his evolution through the ages moulding itself onto different cultures. Until the 16th century this art had a refined, esoteric significance but, in the following centuries, it became an instrument of study and anatomical research following the scientific revolution. Embalming became an obsolete process: the discovery of the circulation of the blood and the newborn chemistry made it possible to preserve the body with bactericides, cauterising and other chemical substances injected into the circulatory system[1].

Key words: Anatomical collection –Teratology - CAT, 3-D reconstruction - Virtual endoscopy – Chemistry - Minerals

This is the era of the great anatomic preparers: Régnier De Graf (1641-1673), Jan Swammerdam (1637-1680), Frederick Ruysch (1638-1731), the brothers Hunter and many others. Each of them contributes to improving our knowledge of human anatomy with his own preserving recipe, which often remains a secret as in the case of Frederick Ruysch. Some scholars developed new methods simply to satisfy general curiosity and sense of competition. Flexible, dry, flayed or petrified dead bodies travelled from one corner of Europe to the other, exhibited at the Courts and rich salons.

In the meantime – with the impetus given by the great advances in knowledge and on the wave of discovery of new lands -, aristocrats, travellers and scholars, known as "*virtuosi*", begin to collect every kind of object able to arouse amazement and wonder and to create the "Natural History cabinets", mirrors of nature. In these private collections, which are often enormous, anatomy has a privileged place: the human body is the marvel of marvels. Human and animal bodies, anatomic parts, abortions, hydrocephalics, skeletons of giants and dwarfs, enormous kidney stones and teratological foetuses, the so called "*monsters*", - side by side with exotic and supposed mythological animals, plants, shells, minerals, African tribal manufacts, Egyptian mummies and artistic objects – are exhibited without reserves. Highly precious and attractive are the teratological collections: malformed human foetuses are sought after and handsomely paid for[2].

At the end of the 18th century Segato's experience becomes part of this atmosphere in which scientific research, recreation, curiosity, desire for the rare and marvellous, social events and, not least, morbidness are mixed.

Rather than as a traveller and cartographer Gerolamo Segato is known for having developed the so-called "petrifaction method" to preserve organic material from natural decomposition.

Gerolamo Segato developed multiple preservation methods, producing three different groups of preparations[3]. The first includes anatomical specimens obtained with vascular injection and not unlike similar preparations present in any collection of the time. The second group consists in dry anatomical pieces obtained by common dehydrating procedures. The last group concerns the *"petrifaction"* procedure applied to human body parts.
One of the most interesting specimens is that of a perfectly stonified anencephalus foetus, which is the subject of the present work. In order to investigate the nature of the Segato's method, still unknown, and to perform a morphologic study, we analysed this individual using image techniques such as digital radiology and helical computed tomography (CT)[4].
The acquisition of volumetric data by CT permitted three-dimensional reconstruction (3-D CT) and virtual endoscopy (VE).

Materials and methods

The museum specimen, exhibited at the Anatomical Museum of the Florence University, belongs to a female foetus of marble consistency and very well preserved. The total length is 20 cm and gestational age is referable to 23-27 weeks (Fig. 1).
After external examination the foetus was studied using a CT equipment (HiSpeed Advantage, GEMS, Milwaukee, Wis). It was scanned with a beam collimation of 3 mm, pitch 1 (3 mm/sec of table incremental speed), 1 sec tube rotation, tube current 250 mA with 80 kVp, FOV 35 cm. All axial images were reconstructed with 180° linear interpolation at 1 mm spacing by using a standard reconstruction algorithm. Spatial resolution of slices was 512 x 512 x 12 bit (384 Kbytes of memory occupation).
From the spiral CT data sets 3-D CT reconstruction and surface rendering were performed with Navigator software (GEMS, Milwaukee, Wis)

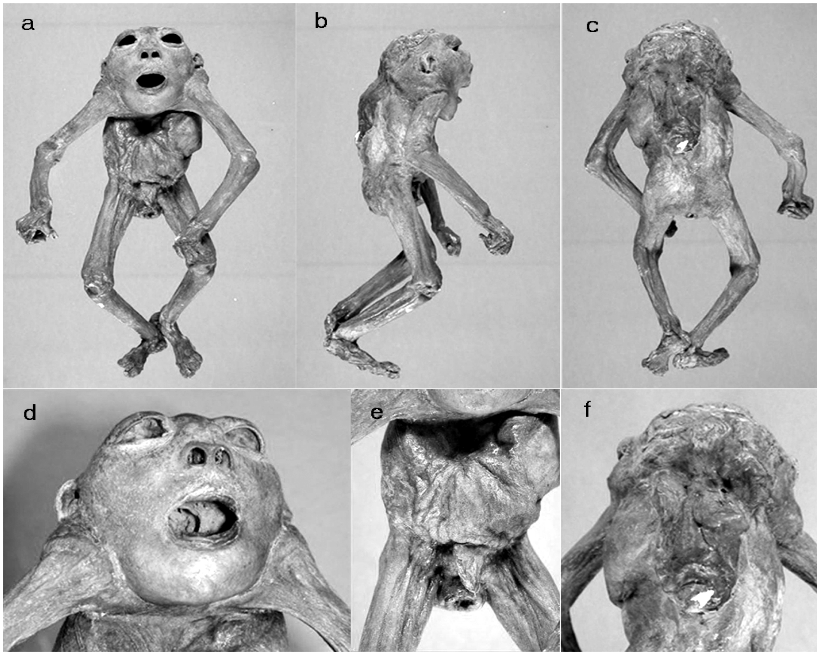

Fig. 1 - The anencephalic petrified foetus (a-c). "*Facies grottesca*" caracterized by large nose, serious exophtalmo and neurocranium agenesis (d); abdominal wall slack and wrinkled (e); total craniorrhachischisis with meningocele (f).

running on a SunSparc 20 workstation (Sun Microsystems, Mountain View, Calif).

The first step of image reconstruction was the segmentation, which was performed by means of two different thresholds: a low threshold level and a high threshold level.

After segmentation, all the voxels excluded from the selected range of Hounsfield units (HU) are considered by the system as not belonging to the object and subsequently not rendered. To generate the surface from the segmented voxels, Navigator uses the "marching cube" algorithm. In this approach, the voxels of the volume edges are transformed into a smooth surface of triangles or patches[5,6].

Morpho-radiological results

At external examination the "*facies grottesca"* - consisting in neurocranium agenesis, large nose and serious exophtalmo-, the total craniorrhachischisis with meningocele, the abdominal wall slack and wrinkled, the so called "*prune- belly*" (Fig. 1), and the arthrogryposis of the hands allowed the diagnosis of anencephaly, one of the extreme congenital malformation due to a closure defect of the neural tube[7]. Spiral three-dimensional CT images was optimized both for bone (Fig. 2) and for soft tissues (Fig. 3a); spiral three-dimensional CT coronal plane reconstruction showed the internal organs which are still recognizable and do not show macroscopic abnormalities. In particular the mediastinum above the diaphragm is well recognizable, as well as the liver and some intestinal loops into the abdomen (Fig. 3 b). The virtual CT, resulting by the computerized 3-D reconstruction of close scans, showed a large posterior palatoschisis (0,7 cm) in oral cavity (Fig. 4 a, b).

Discussion and speculations about the method

The definition of petrifaction given by the Encyclopedia Americana (1986) is the following: "*petrifaction occurs when ground water containing dissolved mineral salts infiltrates buried organic material, replacing the decaying matter with the minerals while preserving the shape and even the cellular structure of the original material*[8].

According to this definition petrifaction is a natural phenomenon of transformation of biological materials from organic into inorganic form, consequently the phenomenon can also occur in dead bodies, as forensic pathologists and anthropologists often report[9,10].

One of the earliest cases of natural human petrification reported in literature was that of Thomas Bartholinus (1616-1680), the famous Danish anatomist in 1654. He had the opportunity to study a stonified foetus with an original personal history: the foetus, of unknown

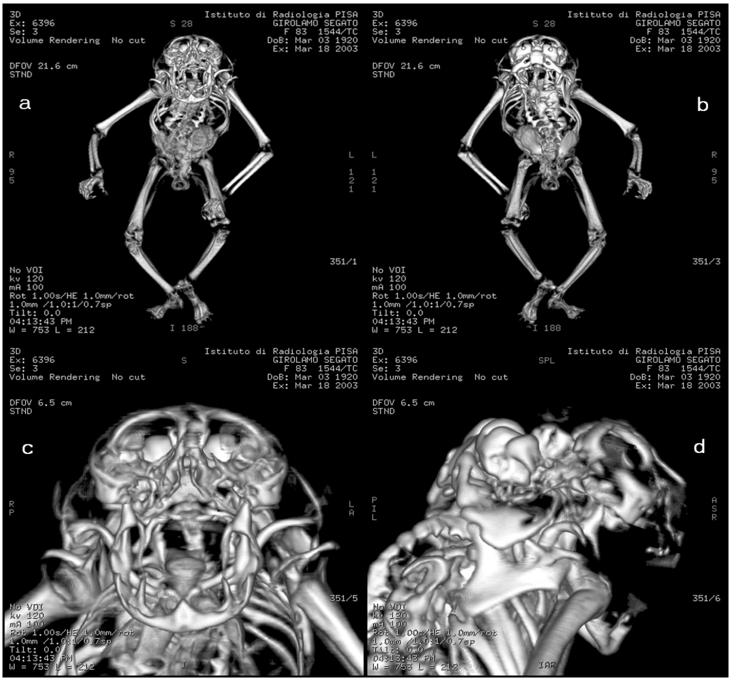

Fig. 2 – Spiral three-dimensional CT images optimized for bone. Panoramic view of the skeletal segments (a, b). Close up views of the upper portion of the body (c, d).

origin, according to Ambroise Parè was delivered after it had been in the mother' s womb for twenty-eight years. It was sent as a gift to Cardinal Richelieu. Later it became the property of a rich dealer in Paris, then of the jeweller Gilbert Vautron, who sold it in Venice. Finally it was purchased by King Frederick III of Denmark, who called Bartholinus to examine it[11].

Some years later, in 1663, the antiquarian Paolo del Sera from Venice offered Ferdinand II Grand Duke of Tuscany (1610-1670) some interesting artistic pieces belonging to a German collector and including: "*…a human petrified penis hard as marble … , a head painted by Giorgione, a book of miniatures….*". The Grand Duke bought only

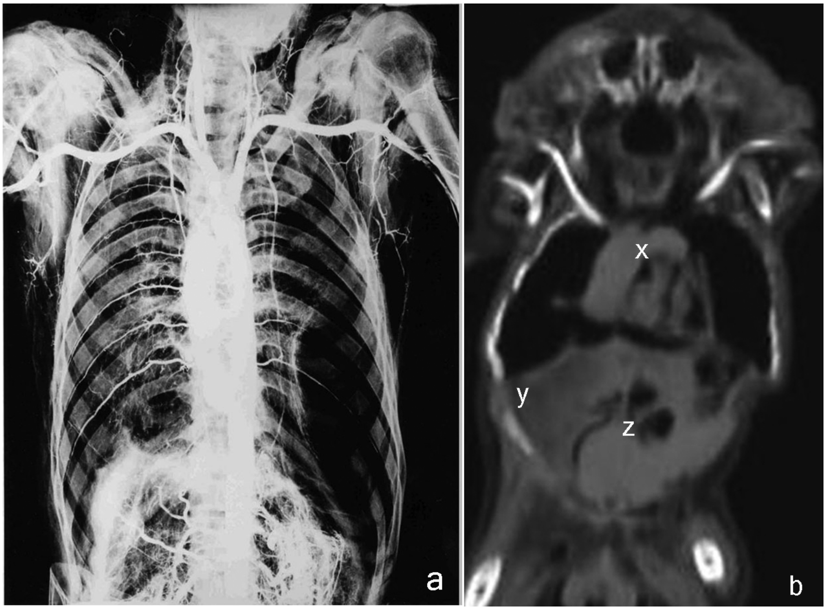

Fig. 3 - Chest of mummified body preserved by an injection of mercury and arsenic solution (Tranchina's method, 1836): the diffusion of the conserving liquid into the artery tree produces, at x-rays, an image similar to an angiography (a); Spiral three-dimensional CT images- optimized for soft tissues - shows some calcification and the lack of radio-opaque images imitating an angiography; mediastinum above the diaphragm (*x*), the liver (*y*) and some intestinal loops (*z*)in the abdomen are recognisable .

the Giorgione' s picture and rejected the petrified penis considering it "*not natural, but artificial thing*" [12]. This letter indirectly suggests the existence of procedures able to turn the organic substance into inorganic since XVII century.

The years between XVII century and the first half of the XVIII had witnessed a considerable proliferation of methods, which made the ideas of anatomist with regard to petrifaction vague and indistinct so that, in the course of the First Meeting of Italian Scientists, held in Pisa in 1834, it was necessary to establish the features of a "petrified" anatomic specimen, which must be "*hard as an hard stone, be cleaned*

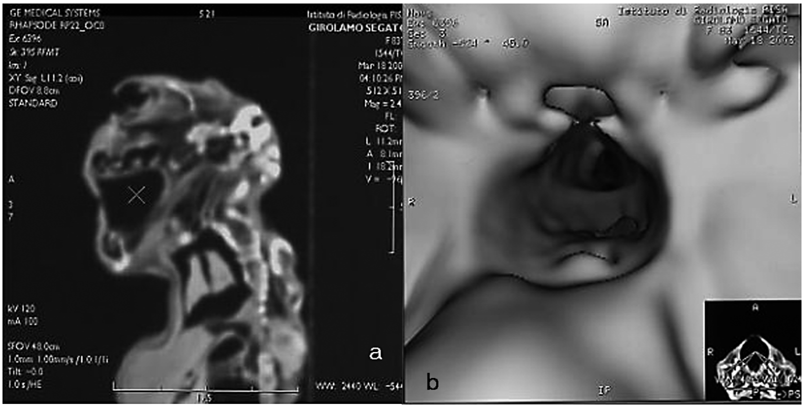

Fig. 4 - Spiral three-dimensional CT images processed with multiplanar reconstruction (a) and virtual endoscopy (b): the latter allows clear visualization of the palatoschisis (X).

using the pumice without damage, resistant to nail scratches, have a sound of stone and, finally, its weight should have increased"[13].
Segato always petrified specimens of limited size (i.e., body parts or foetuses), never whole human bodies or large animals. This might suggest that he used a method that is not applicable to large surfaces, probably a process of immersion in a chemical and/or mineral substances rather than their injection into systemic circulation. This hypothesis might be supported by the lack of radio-opaque images in the foetus after both conventional x-rays and CAT and usually due to the diffusion of the conserving liquid into the artery tree[14].
This result is opposite to that of another imaging study recently performed on a female head petrified by Segato. The authors on the basis of conventional x-rays and CT data demonstrated the injection of a radio-opaque substance into peripheral blood vessels[15]. Such different results, obtained on two items of the same collection, can be interpreted as two different moments of the research on the conservation of bodies to which Segato dedicated most of his short life and of his modest assets.

In the case of the foetus, a process of immersion seems more realistic. With regard to the substances used, we can say very little, since the preservation of the museal specimens makes mass spectrometry analyses impossible.
However, the recent reading of two 19th century documents has allowed to make a reasonable hypothesis. The Acts of the First Meeting of Italian Scientists (1839) report that Andrea Pozzi, chemist in Florence, as well as Luigi Mori, anatomo-chemist in Pisa, have obtained perfectly petrified anatomical parts using a solution of potassium silicate (K_2SiO_3)[16]. The second document reports that Segato used plaster ($CaCO_3$) to fill gaps and soaking the specimens[17]. The probable use of K_2SiO_3 and $CaCO_3$ is suggestive of a chemical reaction known as silicatization, widely used in building as consolidator since the beginning of the 19th century[18]. Such reaction occurs in two phases: by reacting with the atmospheric carbon dioxide (CO_2), K_2SiO_3 consolidates, and then hardens, bonding chemically with the support (i.e, the anatomical specimen soaked in plaster). The reaction with $CaCO_3$ forms a single highly resistant body characterized by resistense to UV rays, bacteria, moulds, fire, and having vitreous appearance[15]. The specimens petrified by Segato present the same characteristics so that the use of potassium silicate by Segato is more than a hypothesis as its use in dissection rooms was not unusual[19]. Furthermore, Segato – chemist/mineralogist living in Florence- had been dead for a year when his contemporaries Pozzi and Mori made known their discovery.

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Acknowledgements

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Correspondence should be addressed to:

Rosalba Ciranni, Department of Oncology, Medical School - Pisa University, Via Roma, 55 - 56126 Pisa- Italy Phone 1: 0039 050 2218649, Phone2: 0039 050 992994 Fax: 0039 050 992706
E-mail: r.ciranni@med.unipi.it