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RICKETS AT THE MEDICI COURT OF FLORENCE: THE CASE OF DON FILIPPINO (1577-1582)

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SUMMARY

Among the children found in the crypt of the Grand Duke Giangastone in S. Lorenzo Basilica (Florence), the skeletal remains of a 5-year-old child still wearing his fine high social status clothing were recovered. This child of the Medici family was identified as Don Filippino (1577-1582), son of the Grand Duke Francesco I (1541-1587) and Giovanna from Austria (1547-1578). The prince showed several pathological deformities of the cranial and post-cranial skeleton, including enlargement of the cranium, thinning of the cranial vault bones (craniotabes), platybasia and marked bending of femora, tibiae and fibulae. Differential diagnosis suggests that Don Filippino was affected by rickets. The occurrence of this metabolic disease related to vitamin D deficiency in a Renaissance high social class individual can be explained by the practice of very prolonged breast-feeding, up until two years of age. Maternal milk contains insufficient vitamin D ratios and retarded weaning severely exposes children to a higher risk of developing rickets, especially if dietary habits are combined with inadequate exposure

Key words: Medici – Renaissance - Vitamin D deficiency - Breast-feeding

to sunlight. Historical sources describe Don Filippino as frail and sickly, with frequent illnesses and persistent slight fevers, and it can be supposed that the child was frequently confined indoors, especially in the cold season. Integration of osteoarchaeological evidence with historical documentation suggests that bone lesions observed in the skeletal remains of Don Filippino are compatible with a diagnosis of rickets, caused by the custom of prolonged breast-feeding associated with inadequate sunlight exposure.

Introduction

In the course of exploration of the Medici burials in the Basilica of San Lorenzo in Florence, a small funerary crypt containing the tomb of the last Grand Duke, Giangastone (1671-1737), and of juvenile members of the family was discovered.[1]

Among the juvenile burials, the remains of a child, in his wooden coffin on a plank in the western corner of the crypt, appeared well preserved, still wearing his original elaborate 16th century costume. Anthropological study of this individual revealed a little boy of about 5 years, with horizontal craniotomy performed for autopsy. Some elements helped in the identification of this child. First of all, age determination suggested this child to be Don Filippino, seventh child and only son of the Grand Duke Francesco I (1541-1587) and Giovanna from Austria (1547-1578), who was born on 20 May 1577 and died on 29 March 1582, at just 5 years of age; secondly, historical accounts tell us that the young prince underwent autopsy and that the skullcap was cut and removed.[2]

Unlike other Medici children, whose life details remain unknown, archival documents provide considerable clinical information about Don Filippino. His delivery was long and difficult, as a result of his mother's pelvis dystocia, and he was immediately baptized at night because, owing to his troublesome birth, there was fear for the life of the newborn. Don Filippino grew up frail and sickly, with frequent bouts of illness and slight persistent fevers. Mental development must have been normal because by the age of five he was

already able to sign his letters. On February 6, 1582, a "catarrhal fever" occurred, and in the following weeks the little prince experienced a "tertian" (intermittent) fever, with episodes of "mal caduco" (epilepsy) and coma; the fever was continuous, starting from March 13, until death, which occurred on the morning of March 29.[3] From these reports it can be inferred that Don Filippino probably died as a consequence of an acute infectious disease, cannot be established. Examination of the skeletal remains of Don Filippino permits observation of a series of bone abnormalities involving the skull and lower limb bones. A paleopathological investigation was carried out in order to clarify the causes of these alterations; the results of this study are presented here.

Materials and methods

The presence of the clothes of Don Filippino prevented total recovery of his skeletal remains, except for the cranium, mandible, the right clavicle, the cervical vertebrae, the first two right ribs, left tibia and both fibulae, which were submitted to macroscopic and radiological examination. Remaining bones were left inside the costume, and X-ray examination was carried out *in situ* with a portable apparatus. Besides macroscopic and radiological examination, a paleonutritional study was carried out on a bone sample of Don Filippino. ^{13}C and ^{15}N isotope analysis was performed on all the members of the Medici family so far exhumed by Carmine Lubritto (Center for Isotopic Research on Cultural and Environmental Heritage (CIRCE), 2nd University of Naples) according to standard methods[4]. As is known, $\delta^{13}C$ and $\delta^{15}N$ values in the organic protein portion of bone (collagen) are directly related to dietary intake; therefore, it is possible to reconstruct and interpret human diet and subsistence patterns. Stable nitrogen isotopes can also be used to detect the timing of the weaning process by measuring isotopic values of infants and children of known age[5]. Breast-fed infants are one trophic level above their mothers in the

food chain, since they are essentially consuming their mother's tissue through the ingestion of breast milk[6]. Therefore, when an infant is breast-feeding, its $\delta^{15}N$ values are elevated by 2–3‰ compared to its mother[7]; this is the pattern one would expect in exclusively breast-fed infants. During the weaning process, the introduction of supplementary foods is signalled by a gradual decline in infant $\delta^{15}N$ values. After the cessation of breastfeeding, the infant protein $\delta^{15}N$ values reach adult values, as children are expected to consume foods that are similar to those of adult females after the weaning period[8].

Results

The study of Don Filippino's skeleton revealed some important peculiarities of both the cranial and post-cranial skeleton. In anterior view the cranium reveals increased biparietal diameter, high frontal bone and frontal bossing, while the facial skeleton has a normal morphology, with the exception of a relatively high mandibular symphysis (Fig.1a). In lateral view the vault is evenly expanded and the supraorbital ridges are weakly expressed and overhung by the frontal *squama*; the most anterior projection of the frontal *squama* in the Frankfurt horizontal plane is 3 cm above the *glabella*. A series of wormian bones is present at level of spheno-parietal, squamous and parieto-mastoid sutures (Fig.1b). In posterior view the vault is rounded superiorly, but quite flat at the sides; the left side is slightly flatter than the right and the vault tapers from the parietal eminences to the level of the mastoid processes. In superior view the cranial outline is ovoid, the vault is narrow anteriorly and maximally expanded at the parietal eminences and the coronal suture formation is relatively complete, but diastased, in particular in the *bregma* region (Fig.1c). Internally, the endocranial surface is heavily marked by sulcal and gyral impressions, especially in the region of the parietal and occipital lobes; the grooves of the branches of the middle me-

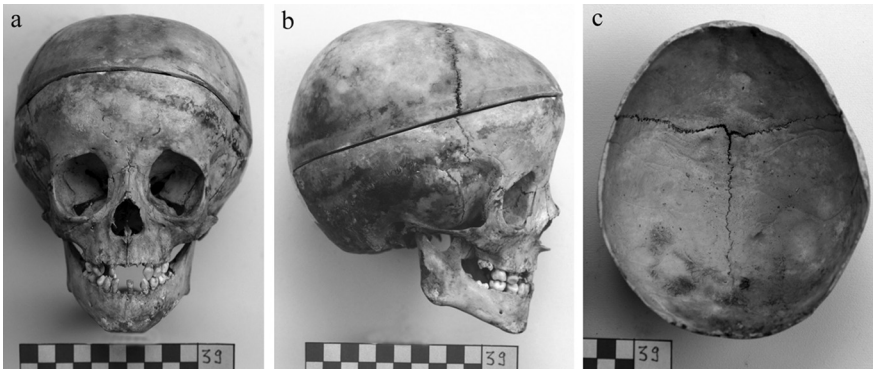

Fig. 1. The skull of Don Filippino: anterior view (a); lateral view (b); internal view (c)

ningeal vessels and nerves are abnormally deep and expanded. The parietal theca appears very thin and translucent (Fig.1c).

At X-ray examination, expansion of the neuro-cranium, severe thinning of the cranial theca at the level of parietal bones and digitated impressions are very evident in antero-posterior (Fig.2a) and latero-lateral views (Fig.2b). Computer tomography (CT) (Fig.2c) and latero-lateral standard X-ray shows marked flattening of the cranial base (*platybasia*) (Fig.2b).

In the post-cranial skeleton, the left tibia and fibulae show a marked bending of the diaphysis (Fig.3a), with diffuse porosity of metaphyseal and epiphyseal regions (Fig.3b-c). *In situ* radiographic examination of the skeleton under the clothes revealed curvature of the right tibia, and both femora (Fig.2d). Upper limb long bones show no bending.

As for paleonutritional study, Don Filippino revealed a $\delta^{13}C$ value of -17.9 ‰ and $\delta^{15}N$ of 13.9 ‰[9].

Discussion

The skeleton of Don Filippino shows an expanded cranial vault with wormian bones and digitated impressions in the endocranial

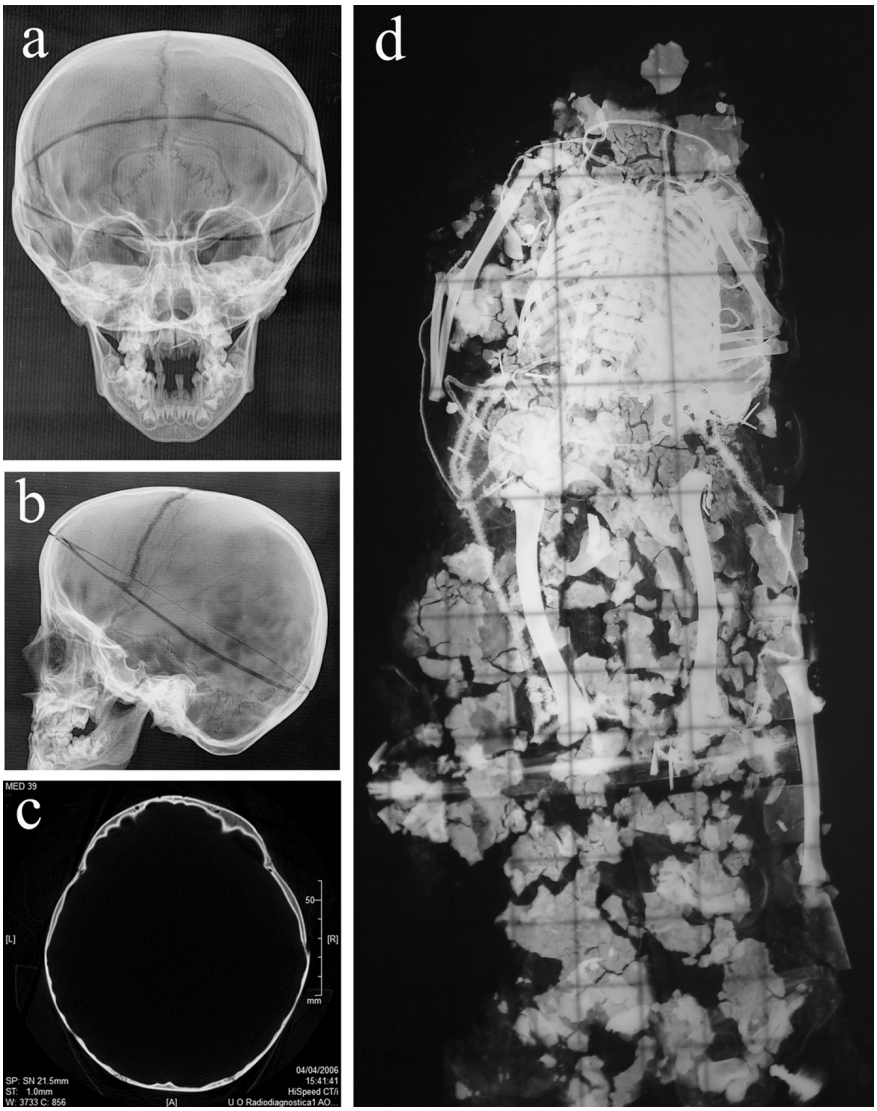

Fig. 2. Radiological examination of Don Filippino: antero-posterior X-ray projection of the skull (a); latero-lateral X-ray projection of the skull (b); high vault CT of the skull (c); in situ radiographic examination of the skeleton (d)

surface, and marked bending of the leg bones, with porosity of the metaphyseal and epiphyseal regions. Considering the differential diagnosis, various pathological conditions can be evaluated to explain these abnormalities: osteogenesis imperfecta (OI), hypophosphatasia and rickets.

Fig. 3. The left tibia and fibula of Don Filippino (a); porosity of metaphyseal and epiphyseal regions (b-c)

A deformed skull vault with temporal bulging and platybasia, wormian bones and bowed limbs are lesions described in OI, an uncommon condition caused by defects in collagen type I biosynthesis. OI comprises a heterogeneous group of diseases characterized by osteopenic bones that became susceptible to fractures in response to minor stress; recent clinical classification includes seven different types of OI[10]. OI is characterized by bone fractures, which are common in all types, most frequently in the lower limbs and usually transverse. Other characteristics, besides deformity of the cranium and long bones, are short stature, deformity of the pelvis and scoliosis; in some cases the OI is associated with dentinogenesis imperfecta[11].

In the skeletal remains of Don Filippino there was no evidence of bone fractures, the dentition was normal, and therefore the diagnosis of OI seems unlikely.

Another disease that produces a globular head and bowed limbs is hypophosphatasia, a rare inherited disorder characterized by defective bone and tooth mineralization. Six clinical forms are recog-

nized, on the basis of the age of onset[12]. In the infantile and childhood forms the disease is characterized by severe and generalized osteopenia, leading to common pathological fractures. Apart from globular head and bowed limbs, other changes include premature craniosynostosis, short stature and dental anomalies[13].
The absence of osteopenia and fractures in the skeletal remains of Don Filippino, as well as premature suture closure and dental anomalies, permits exclusion of hypophosphatasia.
The other possible diagnosis is rickets. Rickets is a disease of infancy and childhood caused by vitamin D deficiency. Prolonged lack of exposure to sunlight and/or nutritional deficit are the main causes of deficiency in vitamin D absorption[14].
The skeletal effects of rickets include deformities consequent to inadequate mineralisation of bone, developing in the acute stage of the disease and affecting a number of areas[15]. In the cranium the persistence of fontanelle, widening of cranial sutures and co-existing external hydrocephalus are common. The presence of thin and soft areas in the cranial vault, in particular in the occipital bone and posterior part of the parietal bones, produces digitated impressions due to intra-cranial pressure, and flattening of the occipital region due to pressure of the head against the supporting surface in the prone position. Frontal bossing gives the head a characteristic squared shape, with reduction of antero-posterior diameter. As for long bones, rickets is characterized by abnormal diffuse pitting, particularly on the cranium and the growth plates between metaphyses and epiphyses, where unmineralised osteoid, which does not preserve post-mortem, was present during life. The presence of cranial and post-cranial cortical porosity indicates active cases, whereas in healed individuals the defects are filled in with bone and are therefore obliterated. In prolonged rickets characteristic long bone bending develops as a consequence of weight-bearing[16].
The most likely diagnosis for the skeletal lesions observed in Don Filippino is rickets: enlargement of the head, opening of the anterior

fontanelle, areas of thinning at the level of parietal bones (craniotabes), flattening of the cranial base and marked bending of femora, tibiae and fibulae are pathognomic of this disease. Wormian bones are found in a number of different conditions, including rickets in the healing phase[17]. Hydrocephalus is confirmed also by autopsy performed on the corpse of Don Filippino: underneath the first membrane of the brain court physicians found "*the equivalent of almost a glass of water*[18]". On the other hand, a portrait of Don Filippino, painted in the same year of his death (1582), shows a head with low implant of the orbits and auricles and frontal enlargement (the so-called "olympic forehead" of cranial rickets) (Fig.4). The disease was no longer in its active phase, as the absence of porosity on the cranial surface and its presence limited to the growth plates demonstrate.

The diagnosis of a metabolic disease linked to vitamin D deficiency would seem odd for a child who grew up at the court of a Renaissance high social class family, such as that of the Medici of Florence. The analysis of historical and social background is particularly helpful in understanding the causes for the onset of such disease in this aristocratic group.

Besides information about the clinical history of Filippo that depicts the image of a unhealthy child, a remarkable starting point is represented by social customs surrounding child-rearing. If in modern medical practice exclusive breastfeeding is recommended up to 6 months of age[19], during the Renaissance a common opinion prescribed that children should not be weaned before the second year of life; for this reason, among elite classes, the wet-nursing was very diffuse. The Medici family chose the wet-nurses from the servants of the house in good health, and the princes were never weaned before the second year and, in the most cases, even some months later, although, starting from the eighth-ninth month of life, the breast milk was mixed with paps[20]. This custom is clearly attested in a letter of November 5, 1542,

Fig. 4. The portrait of Don Filippino (Allori copy (1582), Florence, Poggio Imperiale Villa)

in which Maria Salviati (1499-1543) suggested to Eleonora from Toledo (1522-1562) to wean her nephew Maria (1540-1557), who was 2 years and 8 months old[21].

With regard to Don Filippino, the exact time of weaning is not reported, but on May 16, 1578, it is said that "he sucks very well and is fine for the rest", confirming that at nearly 1 year old the child was still breast-fed[22].

Paleonutritional analysis confirms that weaning of these high social class children was made around 2 years of age, as shown in Fig. 5: the level of ^{15}N is high before the second year, due to breast-feeding, but it decreases in older children after weaning, reaching the level seen in adult subjects[23].

The ^{15}N value of Don Filippino is relatively high for a 5-year-old child, maintaining a level similar to an infant younger than 2 years of age. At this age breast-feeding can be ruled out and this result can be best explained by a rich diet, particularly abundant in red meat. Considering the fragile health status of Filippo, it is likely that the family and court doctors tried to fortify this weak child with a proper diet, forcing him to eat more and more meat, considered at that time the best source of physical strength[24].

Vitamin D sufficiency is especially critical during lactation[25]. Although human milk is the best source of nutrition for infants, it has been demonstrated that maternal milk has low levels of vitamin D, insufficient

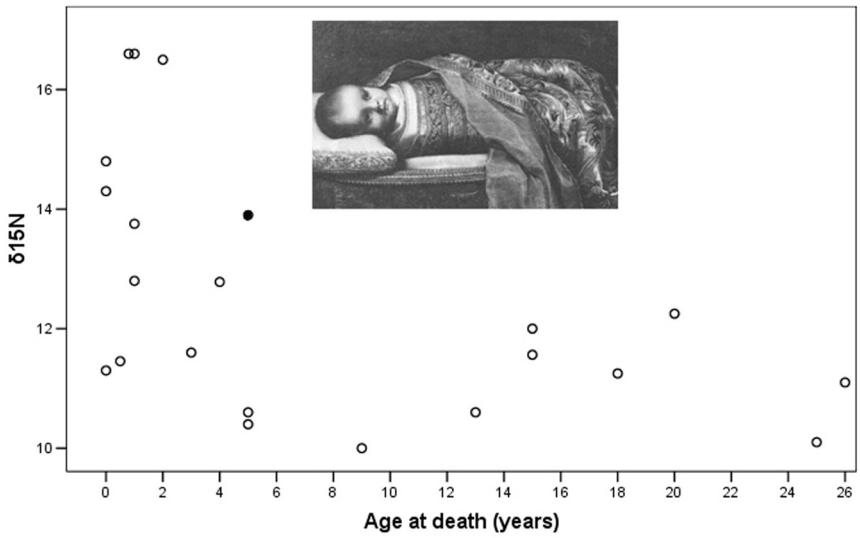

Fig. 5 Stable isotope analysis of Renaissance high social class personages (Medici and Aragonese families). Don Filippino shows a very anomalous δ15N value, resulting in an isolated position (black dot). Isotopic signals reveal a strong intake of terrestrial animal proteins.

to reach the recommended intake of 200IU/day[26] for children; modern clinical studies prescribe a supplement of vitamin D for exclusively breast-fed infants[27]. Considering that in the past such synthetic supplements were not possible, breast-fed infants were at high risk to develop rickets, in particular if the other important risk factor for developing vitamin D deficiency in early childhood, inadequate sun exposure, was present[28]. Historical sources refer to a weak and unhealthy Filippo, who suffered from recurrent episodes of illness[29], and it can be supposed that the child was frequently confined indoors, with clothing that covered most of the body surface, especially in the cold season.

In conclusion, differential diagnosis suggests that the bone alterations observed in Don Filippino were due to rickets. Historical and social documentation strongly supports osteoarchaeological evi-

dence, attesting prolonged breast-feeding that exposed the Medici children to the risk of developing rickets. Don Filippino probably suffered from vitamin D deficiency in the first years of life and recovered from the disease, as attested by the absence of diffuse bone porosity. However, he died of an acute disease before bone remodeling could hide the deformations caused by rickets.

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