A UNIQUE CASE OF HUMAN NATURALLY MUMMIFIED CEREBELLUM FROM SLOVAKIA FOUND IN TWO SKULLS IN ST. MARTIN CATHEDRAL (SPISSKA KAPITULA, EASTERN SLOVAKIA)

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Abstract

The present paper is the first report on the preservation status of a mummified brain found during anthropological analysis of human skeletal remains which were found in two skulls. So we were interested in it and we tried to discover, whether it could by mummified human cerebellum. These two samples were examined by scanning electron microscopy (SEM), energy-dispersive X-ray analysis (EDX) and CT scanning. But none of these methods withheld evident confirm of it source. The survival of brain remains when no other soft tissues are preserved is extremely rare and we could find no evidence of similar cases from Slovakia.

Key words: *Spisska Kapitula – UNESCO, human skeletal remains, mummified brain tissue, SEM, EDX, CT scan.*

Introduction

Spisska Kapitula was originally an independent village, but in 1948 it became an administrative part of the village of Spisske Podhradie. The Roman-Catholic church has had a seat there since the middle 13th century. The village was surrounded by stonewalls, built between years 1662–1665. In 1776 it became a seat of the Spis Holy See. In 1993 Spisska Kapitula (together with the Spis castle and surroundings Spisske Podhradie and the church in Žehra) was enlisted into UNESCO World Heritage List.

Archaeological research inside of St. Martin Cathedral in Spisska Kapitula was realized by The Monuments Board of the Slovak Republic in Bratislava because of prepared renovation of this church. During year 2008 the north nave of church was explored, in next year 2009 probing continue in north nave and new sondes were opened in north nave of antechapel and in south nave of cathedral.

During these researches few human skeletal remains were discovered, exhumed and now are anthropologically analyzed. These remains come from 17th – 18th century and some of them were inhumed in wooden coffins with several fittings (as wooden cross, beads, metal lockets, remains of shoes and wear). All of this finds are explore (Harčar, Uličný, 2010).

This is a unique case in which preserved human central nervous system tissue is encountered and the scarcity of available mummies from different parts of the world. The intracranial masses undoubtedly consist of brain material which must have become dried and preserved by the operation of natural processes. This study undertook an analysis of two naturally mummified human cerebellums from skulls dated to 17th – 18th Century AD. They were excavated in summer 2008 from the graves in the St. Martin Cathedral in eastern part of Slovakia during archeological research. The samples were rehydrated and processed for structural analysis by light and electron microscopy. Light microscopy of the find material wasn't possible to realize. Also CT scanning was achieved but no available results were taken.

In this study, we first tried to investigate the cerebellum masses by scanning electron microscopy (SEM) and using CT scanning methods. We describe an analysis of preserved human bones and soft matter which were discovered in year 2008 in cathedral in two individuals were found intracranial soft matter. As this finds appear to be the only one example of preserved human brain structures in Slovakia.

Methods

Skeletal remains were inhumed in anatomical position in back. Gender was estimated according to morphological characteristics on skull, pelvis and long bones (Acsádi, Nemeskéri, 1970; Černý, Komenda, 1980; Ferenbach et al., 1979; Iscan, Derrick, 1984; Loth, Hennenberg, 1996; Phenice, 1969; Brůžek, 2002; Novotný, 1986). Age of these individuals was estimated using obliteration scheme of suture closure of Olivier 1960, according to degree of abrasion of permanent dentition (Lovejoy, 1985), also morphological changes on facies symphysialis and facies auricularis were analyzed (Hanihara, Suzuki, 1978; Lovejoy et al., 1985). Osteometry according to methods of Martin and Saller (1957), Knuâmanna (1988), the stature was calculated using regression formulae by Sjřvold (1990), Telkkä (1950), Černý and Komenda (1979, 1982) and Breitinger (1937). Morphological and epigenetic features were evaluated according to Dobisíková et al. (1999), Hauser and De Stefano (1989).

Scanning electron microscopy (SEM) and energy-dispersive X-ray analysis (EDX) were realized at Institute of Histology and Embryology in Faculty of Medicine CU in Bratislava. For fixation were used 3% solution of glutar(di)aldehyde buffered by phosphate for scanning electron microscopy. Samples of human brain were dehydrated in graded acetone, subjected to critical point drying of CO2 (CPD 030, BAL-TEC, BG PRŮFZERT). Specimens were mounted on carbon stubs and coated with layer of carbon in ion sputtering apparatus (SCD 050, BALZERS, Lichtenstein). They were examined with scanning electron microscope JXA 840 A (JEOL, Japan) with the accelerating voltage of 15 kV. Simultaneous EDX analysis was performed with the aid of KEVEX 3205-1200 (Kevex, Valencia, Ca). The time period of spectrum collection was 200s with the energy range 0.160 to 8 keV.

Results

Skeletal remains

Individual from grave no. **3/2008** – adult man, age 20–39 years (adultus I–II). Probably mummified cerebellum tissue was found between fragments of the skull. The body height was calculated from the length of the long bones and was estimated with 170,82–174,87 cm. Detected pathological changes – sinusitis of cavities of maxilla and ethmoid bone, hypoplasia of canine teeth and caries on molar teeth.

Individual from grave no. **7/2008** – adult man, age 50–59 years (maturus I) – almost complete skeleton with moderate muscular relief and almost intact complete skull (Fig. 1) with intracranial mass and with persistent suture metopica. The body height was estimated with 160,46–167,71 cm. This individual suffered to pseudoarthrosis of fifth right metatarsal bone, hea-

led fracture of left ulna and left two ribs, and caries on numerous teeth.

Performed EDX analysis (energy-disperse X-ray analysis) resulted in fact that detectable elements found in this samples were predominantly calcium and tracks of magnesium (in limit of detection).No adequate results in light microscopy and scanning electron microscopy (SEM).

Unfortunately realized analyses didn't demonstrate results needed for conclusion that these two samples are mummified cerebellum. But what other it could be, because one of it was found inside the complete intact skull. And the shape of these masses (Fig. 2–4) is similar to those of fresh human cerebellum. So, this realizes let us to consider both for mummified cerebellum.

Figure 1. *Skull with defected occipital bone – grave no. 7/2008 (Photo*

Figure 2. *Intracranial mass – grave no. 7/2008 (Photo by M. Poljak)*

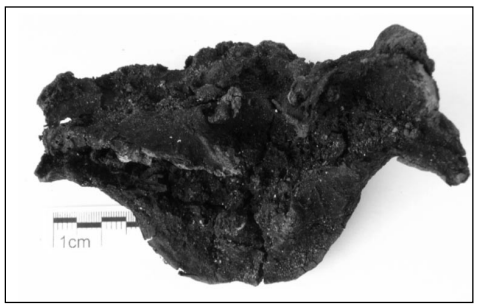

Figure 3. *Intracranial mass – grave no. 7/2008 (Photo by M. Poljak)*

Figure 4. *Intracranial mass – grave no. 7/2008 (Photo by M. Poljak)*

Discussion

Between AD 1236 and 1540 the clergy and laity of Svedborg on the Danish island of Fyn buried their dead in the cemetery adjacent to the local Franciscan monastery. Excavation of about 10% of those burials in the 1970s revealed the presence of residual brain tissue (but no other soft tissue) within the cranial cavity of 56 of 74 skulls. Their appearance varied from small, irregular, shapeless masses to about half-size but otherwise normal brains demonstrating surface convolutions. Gross, histological and electron microscopic anatomical studies showed stainable axons and clear separation of gray and white matter, but displayed "ghost" cells without nuclear or cytoplasmic structure. Preservation by adipocere formation was established chemically (Tkocz et al., 1979). Also Klohn et al. (1988) described a cerebral concretion that appears to have originated by a combination of calcium with fatty acids hydrolyzed from the brain's neutral fat to form calcium soaps, and adipocere was also the effective agent in preserving brain tissue in skulls as Tkocz et al. (1979) described.

Tissue derived from the brain was found in 30% of adult Chinchorro crania. In none of them was a mass present larger than an estimated 20% of its original size. In only one was a pattern suggestive of cerebral convolutions noted on the surface. In most bodies the brain was represented only by a dark brown, formless mass of pasty consistency without grossly recognizable anatomical structures. In several the brain had apparently liquefied after death and then subsequently dried, its solutes precipitating into minute pebbles of 1–2 mm diameter, resulting in 10–15 cubic centimeters of coarse, gray, sandlike material. The anatomist and Egyptologist Grafton Elliot Smith recognized and described all these forms of spontaneously preserved brain tissue in Egyptian bodies as early as 1920 (Aufderheide, 2003).

Aufderheide (2003) examined the victim of a summer stabbing 180 days after the murder in which several wounds had penetrated the skull. The cranial cavity was devoid of brain or meningeal tissue but was filled with teeming blowfly larvae, indicating how rapidly the brain can be not only liquefied but actually consumed after death. Yet, in spite of the brain's tendency toward rapid postmortem dissolution, examples of its unexpected preservation abound. In many of these, adipocere formation from the brain's lipid content is responsible for the preservation. In other an excessively arid environment may prevent complete cerebral dissolution, while in still others the mechanism is not at all clear.

In all probability, adipocere formation preserved the gross brain form initially and during the period that acid groundwater gradually dissolved the skull, eventually leading to mineral replacement of all the organic matter. Mineral springs have also preserved human brains by a means, probably chemical,

not yet well understood but capable of retaining gross cerebral morphology for 7000–8000 years (Royal, Clark, 1960; Doran et al., 1986) and cerebral tissue 2100 years Celtic brain (Pilleri, Schwab, 1970). Preserved human bones and soft matter were discovered in 1984–85 buried in small swampy pond in central Florida and were dated in the range of 7790 to 8290 years before present (BP). From the minimum of 40 individuals nine individuals with intracranial soft matter were recovered, in five of these, material recognizable as preserved brain tissue was present (Doran et al., 1986).

Adipocere formation was clearly the mechanism that preserved a clay-buried, 5000-year-old Swiss brain (Oakley, 1960) as well as that of a Bronze Age bog body (Powers, 1960), although in other bog bodies in which some brain tissue remained, adipocere was not described (Brothwell, 1986). Finding retained brain tissue (some cerebriform) within the cranial cavities (two intact skulls, 5 similar structures and other fragments from different regions of the human brain) of persons who died 45–50 years prior to exhumation of cranial gunshot wounds (mass grave in Bulgaria), Radanov et al. (1992) suggest that the microclimate within the cranial cavity (resulting from the crania's gunshot-induced perforation) permitted rapid evaporation of cerebral fluids and consequent brain preservation without adipocere formation.

Gerszten and Martínez (1995) examined the desiccated cerebral tissue (cerebral hemispheres, cerebellum, also dura mater and spinal cord) from 15 of the many spontaneously mummified human remains excavated from the incredible arid and rain-free climate of northern Chile's Atacama Desert results in a high rate of soft tissue preservation of biological material interred in its nitrate-rich soil. Most preserved brains were shapeless, shrunken brown masses but at least one retained its gyriform surface morphology. Aufderheide examined many mummies from this area and found the brownstained dura mater to be present very frequently when abundant soft tissue of the rest of the body was also retained. In one 4000-year-old population of 16 adults, all of whose heads were present, brain tissue was found in 8. This was usually present as an amorphous, brown mass of pasty consistency. In several, however, about one-fourth of the cranial cavity was filled with granular, pebble-like, brown material, the individual granules averaging only a millimeter or two in diameter. The taphonomic process that generated this appearance was probably initiated by liquefaction of the brain, with subsequent precipitation of the solutes as the body desiccated. In one body the particles were of sand-like quality (Aufderheide, 2003).

Kim et al. (2008) studied a mummified brain from medieval (15^{th} – 16^{th} centuries) tomb from Korea. It was well-preserved grey and white matter within well demarcated brain lobes, on which sulci and gyri could be identified. On histological examination, they found that the remaining brain tissue was composed mainly of lipids, which seems to correspond to the preserved myelin sheath.

Conclusion

The preserved structures of two analyzed samples strongly resembled human cerebellum, although they were hard in consistency and dark brown in color. In our case, histological investigation and other methods failed to bring to light any cellular elements in the cerebral tissue.

Mummification process may have occurred due to specific conditions within the cranial cavities after burial.

The phenomenon observed is believed to represent a unique case of naturally occurring preservation of human brain tissue – cerebellum found and published in Slovak republic, in the presence of complete decomposition of the other organs and soft tissues.

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Souhrn

V tomto článku prezentujeme prvý prípad nálezu zachovalého mumifikovaného mozgového tkaniva nájdeného v dvoch lebkách počas antropologickej analýzy kostrových pozostatkov. Nájdena hmota bola natoľko zaujímavá, že nás motivovala k ďalšiemu skúmaniu, pretože podľa tvaru a celkového vzhľadu by mohlo ísť o mumifikovaný mozoček. Obe vzorky boli podrobené viacerým analýzam (SEM, EDX, CT), ktoré však definitívne nepotvrdili pôvod tkaniva. Nálezy mozgového tkaniva pri celkovej absence iných mäkkých častí tela sú zriedkavé. Podobný nález zo Slovenska nebol doteraz publikovaný.

Kľúčové slová: *Spišská Kapitula – UNESCO, ľudské kostrové pozostatky, mumifikované mozgové tkanivo, SEM, EDX, CT skenovanie.*

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