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Penetrating Arrow Injury – Causing the Death of an Early Medieval Woman from the Muzla-Cenkov Locality in Slovakia (9th – 10th Century CE)

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ABSTRACT

The osteological remains of a juvenile woman, 17– 20 years, was discovered in grave number 23/88 at Muzla-Cenkov in the Nove Zamky district of Slovakia. Wound resulting from an iron arrowhead was located in her second lumbar vertebral body. Because of presence of the arrowhead in vertebral body and by the complete absence of any signs of healing processes, we conclude on perimortal injury which probably proved quickly extinguishing the life. DNA analysis was instituted for increased accuracy and reliability in establishing sex of this juvenile individual. An association with the old Hungarian troops who previously occupied this area was concluded, based on analytic evidence.

Key words: *iron arrowhead, penetrating injury, Slovakia, early medieval, old Hungarian troops*

Introduction

Evidence of interpersonal violence can be both direct, in the form of injury to the skeleton, and indirect, when reconstructed from the burial context[1]. Osteological evidence for warfare includes several classes of injuries which tend to occur in a violent context, such as embedded projectiles or scars from spears, arrows, darts, or bullets[2]. These latter weapons include bows, crossbows and slingshots which are used to propel missiles[3]. The invention of the bow and arrow occurred during the Late Paleolithic era[4,5] and it represented a major step in the evolution of effective distance weapons for hunting and war. The bow was invented at least 10,000 years ago[6–8] and it has been used almost universally since that time[9]. It proved very efficient and accurate over a long distance, and this feat had never previously been achieved by any weapon. Consequently, it is clear that hunting success was improved, and it has been estimated that more people have been killed by arrows in the history of warfare than by any other weapon, including firearms[10]. The first archaeological evidence of archery on European territory comes from the Late Paleolithic[11] and also the later part of that era[12, 13]. Ordinary bows and arrows have been known since Neolithic time, as shown by the almost modern-looking wooden bow and wooden arrows carried by the 5,000-year-old ice-man »Ö-tzi«[14]. Early European bows appear to have been shorter than an average man's height. The effective killing range has been estimated to be approximately 100 yards (90 m)[15]. The arrowhead causes a penetrating wound in whichever part of body it hits and causes immediate effects such as bleeding, paresis and immobility. Sepsis in the form of an abscess, empyema, peritonitis and tetanus can occur[16] when the individual survives. Military surgery had its origins in the treatment of wounds inflicted by arrows and spears[17]. Mays et al.[18] and Karger et al.[19] were considerably concerned with improving surgical skills in extracting arrows from the human body. Arrows have considerable penetrating capacity into the soft tissue and flat bones, and they can deeply penetrate the large body cavities and injure the heart and major vessels. Depending on the type of arrowhead, tissue elasticity can narrow the wound tract around the arrow shaft, sometimes creating a tamponade effect[20]. Arrow ballistics was described in

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Karger and associates 1998 report[21]. Injuries caused by arrows are usually less destructive than those caused by bullets due to the lower velocity and energy involved[22]. Although the effect of a projectile depends on various factors, the weight and velocity of the projectile determining its kinetic energy are the ones most often considered when the effects of bullets from firearms are discussed[23]. However, when relatively slow projectiles such as arrows are discussed, the cross-sectional area and sharpness of the projectile must also be considered[24]. These specifics are very important because the bow was such a ubiquitous primary military weapon of the past. The reflex bow fired arrows with a force of 80–85 KJ and an initial speed of up to 150 m/s. While the maximum arrow firing range is approximately 800 m[25], a living target can incur a surgical strike from a distance of 200 m.

Materials and Methods

Osteo-anthropological analysis of skeletal remains from the Muzla–Cenkov locality at the Vilmakert site in the Nove Zamky district of south-western Slovakia was dated to the 9^{th} – 10^{th} century through the inventory of grave pits and archaeological contexts. The remains of an immature female were detected there in grave No. 23/88 (Figure1) and the cause of her death was established as effects from a penetrating arrow injury, with projectile particles remaining lodged in her spine (Figures 1 and 2).

Grave No. 23/88 is in a part of the cemetery where 25 graves contained the mortal remains of some of the most important personages inhabiting the Muzla-Cenkov fortified settlement[26]. The skeletal remains therein were exhumed by standard archaeological methodology, and the immediate surrounds were surveyed. Osteological analysis was carried out in the osteo-anthropological laboratory of the Department of Zoology and Anthropology, Faculty of Natural Sciences at Constantine the Philosopher University in Nitra. Osteometric analysis was performed by standard osteological methods, and the laboratory investigations of human skeletal remains were conducted according to principles laid down in the Declaration of Helsinki. Due to the fragmentary state of the long bones, estimation of stature was calculated using four methods[27–30]. The determination of the age was based on skeletal assessment of the presence or absence of ossification centres[31,32], on the developmental changes to the pubic symphisis[33], and confirmed by observing teeth eruption, the number of permanent teeth and dental abrasion and attrition[34]. Sex diagnosis was based on skeletal bone observation according to the methods proposed by Genovés[35], Acsádi and Nemeskéri[36], Stewart[37] and Hoyme[38], Yasar Iscan[39] and Stloukal et al[40]. DNA analysis was instituted for increased accuracy and reliability in establishing the sex of this juvenile individual. Strict precautions were adhered to during each step of the sample preparation to eliminate risk of contamination by recent DNA[41]. Extractions were performed three times and the sex determination results were verified for each extraction. The examined bones were initially exposed to UV light for 15 min

Fig. 1. Grave No. 23/88, Muzla-Cenkov, Nove Zamky district, Slovakia (Photo: Hanuliak, 1988).

on each side to de-activate possible modern contaminant DNA. Bone samples were taken from compact bone of the right femur diaphysis. A minimum of 2 mm thick outer surfaces of the bone sections was removed by scraping with sterile disposable scalpels, in accordance with Bouwman et al.[42]. The samples were then reduced to fine powder using liquid nitrogen. DNA was isolated by silica matrix extraction, in accordance with Bauerova et al.[43] and Luptakova et al.[44]. To determine the sex, genetic markers on the sex-determination region Y (SRY) on the Y chromosome and the sequence on the macrosatellite DXZ4 on the X chromosome were amplified, using nested PCR. The primer pairs used for genotyping gave 91 bp (X) and 102 bp (Y) products. The applied PCR assay and primers were designed by Luptakova et al.[44] and Palmirotta et al.[45].

Results

The remains in grave No. 23/88 were poorly preserved and in a fragmentary state due to the progressive decompositional processes. Partial fragmentation of the skull and pelvis caused complications in anthropological analysis, but the intact skull and pelvic portions bore typical indications of female gender. Only the right lower extremity was reasonably preserved while the left lower extrem-

Fig. 2. Rhomboid arrowhead from grave No. 23/88 (Photo: Hanuliak, 1988).

Fig. 3. Arrowhead in lumbar vertebra (woman, juvenile individual, 17–20 years) (Photo: Kolena, 2011).

ity and most of the upper extremity bones were badly fragmented. The body height was calculated at 1.653 m. and a juvenile age category (17 – 20 years) was estimated. An individual was classified as probably female because of destruction of sexual diagnostic skeletal markers and also the juvenile age of this individual. This determination was confirmed by genetic analysis. An individual is classified as female only where the DXZ4 product is detected. Not one extraction after PCR amplification gave successful SRY sequence identification.

Description of trauma

The forensic conclusion that this trauma was due to an arrow wound caused by a reflex bow is supported by the presence of the arrowhead embedded in the second lumbar vertebra (Figure 3, Figure 4).

The arrow entered the left side of the body between the regio lumbalis and the regio infrascapularis. The wound track was directed back to front, left to right and upwards. The path of the wound led through the subcutaneous tissue, with the arrowhead causing tearing of the latissimus dorsi, iliocostalis and spinalis thoracis muscles. There was also rupture of the dorsal ramus of the spinal nerve, and superior cluneal nerve damage to L1-L3 was caused by the trajectory of the arrowhead as it penetrated more deeply into the body.

The arrowhead hit the body of the second lumbar vertebra in the lower left quadrant at an angle of 25–30°, destroying the processus costalis, superior and inferior articular facets and the spinous process and mammillary processes. It was concluded that the arrowhead penetrated the vertebral body on the left side, under the lower edge of the twelfth rib. This conclusion was reached due to the

Fig. 4. Arrowhead in lumbar vertebra (woman, juvenile individual, 17–20 years) (Photo: Kolena, 2011).

absence of traumatic changes in the surface of this rib, which was therefore lying outside the immediate trajectory path. After the arrowhead penetrated the vertebral body, the following body parts were destroyed; the vertebral arch, yellow ligaments, fat tissue in the epidural space, the internal vertebral venous plexuses, the posterior ramus of spinal nerves, posterior spinal veins and the posterior spinal artery and spinal ganglion. It was concluded from the extent of destruction of the second lumbar vertebra that the annulus fibrosus and nucleus pulposus of L1 could also have been destroyed. From the trajectory path, we can conclude that the injury occurred in the perimortal period with consequences leading to certain and relatively rapid death.

After penetrating the body, the arrowhead could have damaged the ascending lumbar vein and fragments of the vertebral body could have perforated the abdominal aorta. Because of the topographical kidney location areas, it can be assumed that the trajectory of the arrowhead pointed across the left kidney or ureter, and it could therefore also have damaged the renal/suprarenal vein and artery and ruptured the lumbar splanchnic nerves. Following the appraisal of this trajectory, we concluded that death occurred as a result of traumatic-haemorrhagic shock from damage to the major vessels located in this area. If this was indeed the case, death would have occurred within minutes to hours of the injury, depending on the extent of damage to the vessels. Given the almost certain violation of the left kidney, leading also to damage and massive bleeding, and the contamination of surrounding tissues by urine, we can conclude that death occurred in a relatively short period of several hours to days after this injury was inflicted. The death can most likely be attributed to massive internal haemorrhage because of the arrow's complete penetration of the great branches of the cardiovascular system. The arrowhead position indicates the most likely trajectory path; the attacker could have been kneeling or standing crouched behind the victim, or the victim may have been lying face down with the attacker standing over her. The depth of penetration of the iron arrowhead into the vertebra of this young woman from grave No. 23 in Muzla-Cenkov provides evidence that the arrow must have been fired from a reflex bow. Simple and reflex bows were used in the Carpathian Basin during the Middle Ages. Since the fatal injury occurred at the beginning of the 10th century and a rhomboidal arrowhead is involved, it is certainly consistent to connect this weapon with invading old Hungarian troops.

Discussion

Traumatic lesions are commonly found in archaeological skeletal samples and provide useful information on various behavioural and cultural aspects of populations[46]. It is very difficult to determine the probable cause of death in persons who lived in very early historical times by simple analysis of their skeletal remains. Therefore, when a trauma from an injury caused by an arrow leaves traces on skeletal material, it is a great challenge for anthropologists to reconstruct the final moments of an individual's life. In this special case involving the human female remains in grave No. 23/88 in the Muzla-Cenkov locality, based on the trajectory path of the arrowhead embedded in the lumbar spine, death can be assumed to be due to internal bleeding from damaged arteries and veins. This arrow must have penetrated vital viscera before striking the bone. Since there is no evidence of healing, the victim must have died at the time of the injury or shortly thereafter. We conclude that the death of this individual did not result from unintentional injuries in animal hunting, although there were no indications to directly implicate fighting in 25 graves in this part of the cemetery which contained the mortal remains of some of the most important personages from the fortified settlement of Muzla-Cenkov. Archaeological results revealed that the arrow was fired from a reflex bow, and when this is connected with the rhomboidal shaped arrowhead and the fact, that the Great Moravian fortified settlement of Muzla–Cenkov was situated on the northern Danube bank, we conclude an association with the old Hungarian troops who occupied this area on the southern Danube bank at the turn of the 10th century. From a military strategic point of view it was necessary to destroy this hill-fort and remove members of the highest stratum who lived there. The young woman whose remains were buried in grave 23 belonged to this group, and her grave was the last excavated from the burial grounds in this finding-place. Ten additional individuals most likely did not survive the attack, but their bodies were thrown into eight empty cereal storage pits and not interred in this burial place. The settlement's wooden fortifications were burned down during this military invasion.

Arrows with rhomboidal heads were also fired into the abdomen and chest of two men buried in the Great Moravian burial place in Břeclav-Pohansko[47], and an exemplary case of a rhomboidal arrowhead located in the pelvis of an adult male attacked by old Hungarian troops in the 10th century was also recorded in Brankovice, in present-day Moravia. This man's remains were found in a mass grave with three other skeletons[48]. Analogous cases of injury wounds from rhomboidal arrowheads during the old Hungarian invasions were also recorded in Baden-Württemberg and Austria[49,50]. Peri-mortal trauma with penetrating fractures most likely caused by arrows was also detected on the eastern Adriatic coast[51]. At the beginning of the 10th century, troops of the old Hungars also destroyed the hillfort of Nemětice which was located on Czech Republic territory[52].

Our findings highlight the importance of cooperation between archaeologists, anthropologists and forensic scientists in the evaluation of historical events.

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PRODORNA OZLJEDA STRELICOM – UZROK SMRTI RANOSREDNJOVJEKOVNE ŽENE IZ LOKALITETA MUZLA-CENKOV U SLOVAČKOJ (9. – 10. STOLJEĆA NE)

S A Ž E T A K

Osteološki ostaci maloljetne žene starosti 17– 20 godina su otkriveni u grobu broj 23/88 na groblju Muzla-Cenkov u okrugu Nove Zamky u Slovačkoj. Rana koja je uzrokovana željeznim vrhom strelice se nalazi u drugom lumbalnom tijelu kralješka. Zbog prisutnosti strelice u tijela kralješka i uz potpuni izostanak bilo kakvih znakova procesa zacjeljivanja, možemo zaključiti da je ova perimortalna ozljeda vrlo vjerojatno uzrokovala smrt. Napravljena je DNK analiza zbog povećanja točnosti prilikom utvrđivanja spola ovog maloljetničkog pojedinca. Na temelju analitičkih dokaza je uspostavljena je veza sa starim mađarskim vojinicima koji su u prethodno okupirali ovo područje.