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Traumas of the postcranial skeleton in medieval population in Bulgaria

N. Kondova, S. Cholakov

Institute of Experimental Morphology and Anthropology, Bulgarian Academy of Sciences, Sofia

Studies have been made of traumatic injuries and their complications in the postcranial skeletons of 3650 adults from 41 populations of Medieval Bulgaria. Most common are the fractures of the tubular bones of the upper and lower limbs, the clavicle and the ribs. About 50 per cent of the fractures had a favourable issue — no dislocations of fragments and no complications are observed. In 30 per cent of the fractures the bone fragments have healed up at an angle, with longitudinal dislocations. In 20 per cent of the traumas some traces of serious complications are observed, such as periostitis, ossifying fibrosis, post-luxational arthroso-arthritis, ankylosis, osteomyelitis, etc.

Key words: paleopathology, traumas, complications, Medieval Bulgaria.

The traces of various traumas found on the skeletal remains of people from different epochs play a distinctive role in the reconstruction of the way of life of ancient populations. Along with the group of degenerative-dystrophic lesions of the spine and the big joints of the limbs, traumatic lesions are among the most frequently observed pathological changes. Apart from common traumas related to the specific conditions of life and work, they also reflect the consequences of war engagements or heavy accidents.

The object of the present study are the traumatic injuries of the postcranial skeleton. They have been studied in 3650 adult individuals from 41 medieval necropoles on the territory of Bulgaria, dating from between the 8th and the 18th centuries.

The traces of various traumatic injuries have been studied in two directions:

1. Morphological changes, setting in due to the direct influence of the blow and in the process of healing.

2. Structural changes of the bones due to post-traumatic complications.

The excavated human osteal remains from all periods of the Middle Ages reveal distinct traces of various traumas. The peculiarities of the injured bone surfaces, as well as the localization of the lesion provide some evidence of the kind of weapon that was used, the strength of the blow, the course of the healing process, the attempted treatment and its outcome. Owing to the specific character of formation of the flat bones, the vertebrae and the tubular bones, there are differences in the way in which defects of the respective bones are manifested. The osteal traumas observed in medieval human remains can be classified, according to the type of weapon, as slashes, stabs,

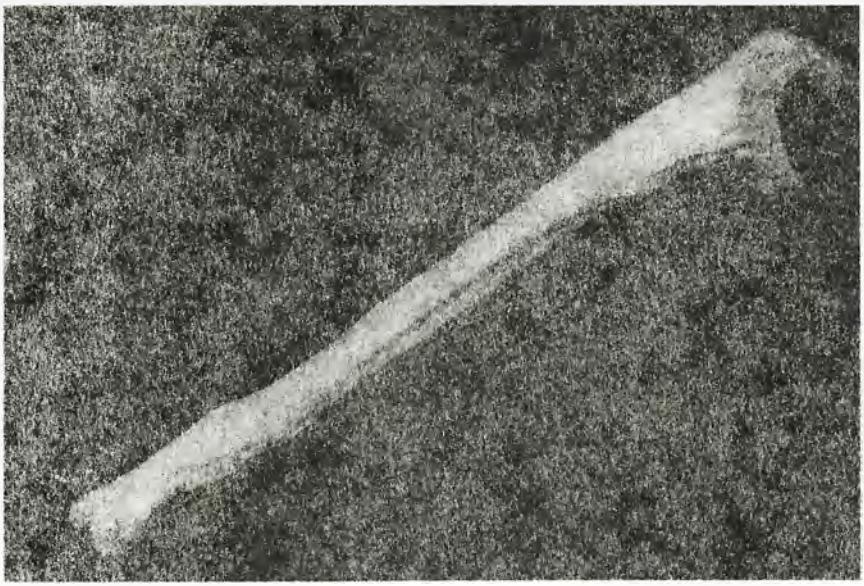

Fig. 1. Healed fracture of the distal part of the elbow, with a well formed callus

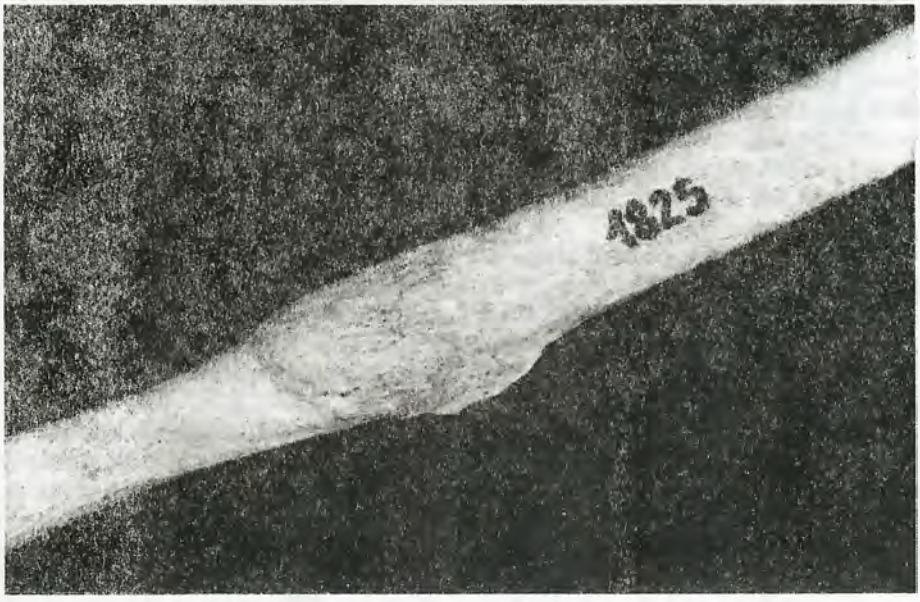

Fig. 2. Healed fracture in the middle of the elbow bone with an insignificant longitudinal dislocation of the fragments

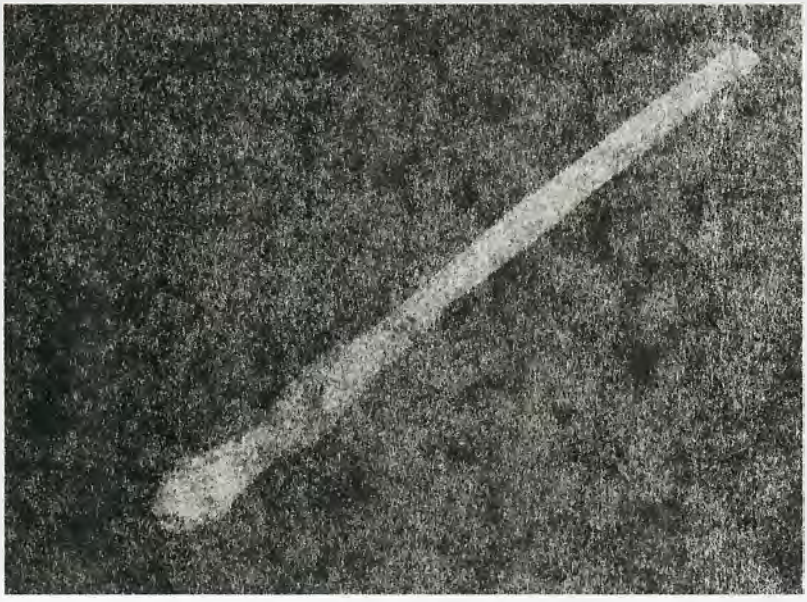

Fig. 3. Localized periostitis after a fracture of the distal part of a small leg bone

inflicted by cutting, chopping or blunt objects. Unlike cranial traumas in which the traces of slashes and stabs predominate, most frequent on postcranial skeletons are healed fractures inflicted with a blunt object. Bone lesions as a result of slash wounds are only observed in single cases, in the form of elongated defects with smooth edges, on the diaphysis of long bones.

According to their location, traumas are most frequently observed on the bones of the upper and lower limds (Fig. 1), the clavicles and the ribs. Considerably less frequent are traces from fractures of the pelvis or the vertebrae. Lesion frequency varies between 2,5 per cent and 8 per cent. A higher frequency and heavier traumas are commonly observed in the necropoles of medieval fortresses (Pernik [1], Odartsi [2], Jambol, Drustur [3], Bozhenishki Ourvich [4], Kavarna [5], Kaliakra); they can be accounted for by war engagements. In most cases the morphological changes in the structure of the affected bones testify to a favourable issue — the bone fragments have healed up with a well-formed callus and, most frequently, with insignificant, only longitudinal, dislocations (Fig. 2). This is the case with about 50 per cent of the fractures of long bones. At the same time, there is no atrophy of the affected bone, which suggests that the limb continued to function as usual. With some of those healed traumas a localized, irregular growth of the periosteum can be observed (Fig. 3). At times the healing of the bone edges was impeded, even in the absence of inflammatory complications or dislocations; in such cases the healing process has resulted in the emergence of the so-called pseudoarthrosis between the bone fragments, rather than in a callus formation. With combined fractures of the leg or the forearm, the formation of "neoarthrosis" [6] is observed between the two adjacent bones in the region of the fracture (Fig. 4). In those rare cases the movements of the newly formed joints, though extremely limited, burdened the adjacent joints and caused secondary degenerative changes. The second group of fractures consists of cases with pronounced dislocations. The bone fragments have healed up twisted, at an angle, or with a considerable longitudinal dislocation. This is the case with about 25 per cent of the

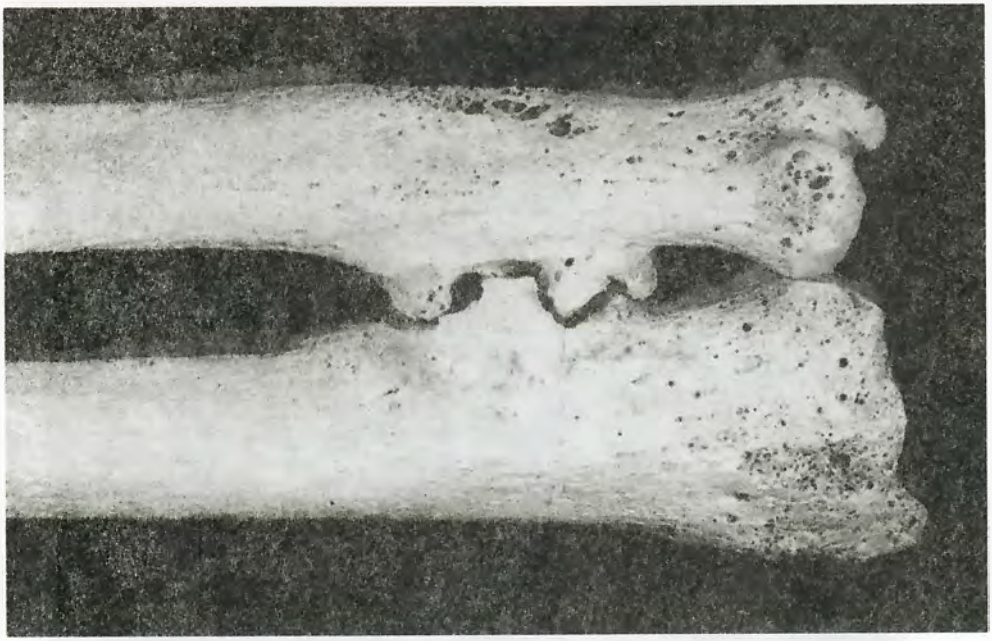

Fig. 4. "Neoarthrosis" after a trauma of the distal part of forearm bones

total number of fractures; with the majority of them the healing process went without any inflammatory complications, and the newly formed bone tissue has well enveloped the bone edges (Fig. 5). Such fractures are most frequently observed in the clavicles — the twisting and the longitudinal dislocation of fragments caused a pronounced deformation and shortening up to 3 cm. In rare cases the inexpedient treatment brought about a pronounced dislocation of the bone fragments (Fig. 6). The marked shortening and the anomalous healing impeded the functioning of the affected limb [7].

The third group of findings includes post-traumatic complications, such as periostitis, ossifying fibrosis, arthroso-arthritis, ankylosis, osteomyelitis, etc. Irrespective of the attempts to apply some treatment, in 20-25 per cent of the traumas of the postcranial skeleton some traces of slighter or more serious complications that emerged in the process of healing are observed (Fig. 7). Those were probably

Fig. 5. Fracture in the middle of a humeral bone, healed with angular dislocation of the fragments (X-ray)

Fig. 6. Deformation of the elbow bone after a fracture — a pronounced dislocation: angular, longitudinal and by twisting

open fractures with bruises and lacerations, fragmentational traumas and joint-injuries. A frequent manifestation of posttraumatic complications are the non-specific periostites (Fig. 8). An irregular growth of the periosteum is observed with combined fractures of the leg or the forearm; this sometimes leads to their knitting together. The periostites are usually localized but they can also diffuse through the bones. If there are torn muscle fibres or tendons, an ossification may set in of the layers of connective tissue in the muscles, as well as at the fastening points of the tendons. These are the so-called ossifying fibrosites.

Particularly serious post-traumatic complications are observed with fractures in the epiphyseal regions of the long bones of the limbs, accompanied by luxations or intraarthrous haemorrhages. In such cases the morphological changes usually affect both surfaces forming the joint. Among the changes observed are polishing and flattening accompanied by the formation of an additional joint-surface, as well as extensive exostosison the bone edges and heavy deformations (Fig. 9). Besides with traumas, such a morphological situation can be observed with congenital luxations of the coxo-femoral joint. Quite often the specific changes in the structure of the bone surfaces show that the degenerative changes were preceded or accompanied by inflammatory complications. Studying the numerous paleopathological findings from the Middle Ages, it should be noted that the majority of traumas affecting the joints were followed by complications of various gravity. Some of them resulted in ankyloses and caused disability. Particularly serious complications of this kind have been found among the population in the northern region of the Black Sea coast (Kavarna and Kaliakra — 15th-17th c.). In three cases, following a trauma of the knee joint, the lower limb was transformated into an immobile bone formation. With two of the traumas the ankylosation set in when the limb was in a stretched position (Fig. 10), and in the third case the bones knit at an angle. The morphological changes in the

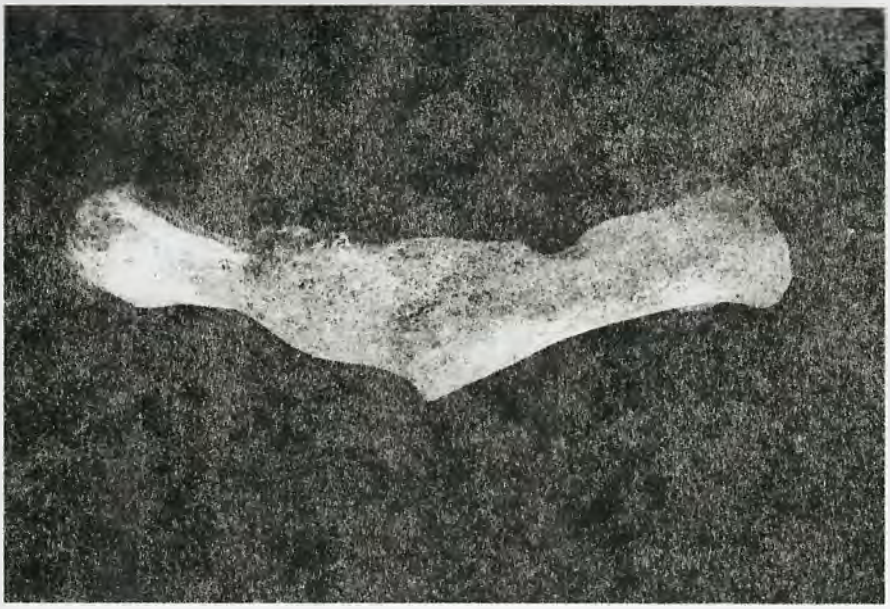

Fig. 7. Inflammatory complication after a fracture of the clavicle

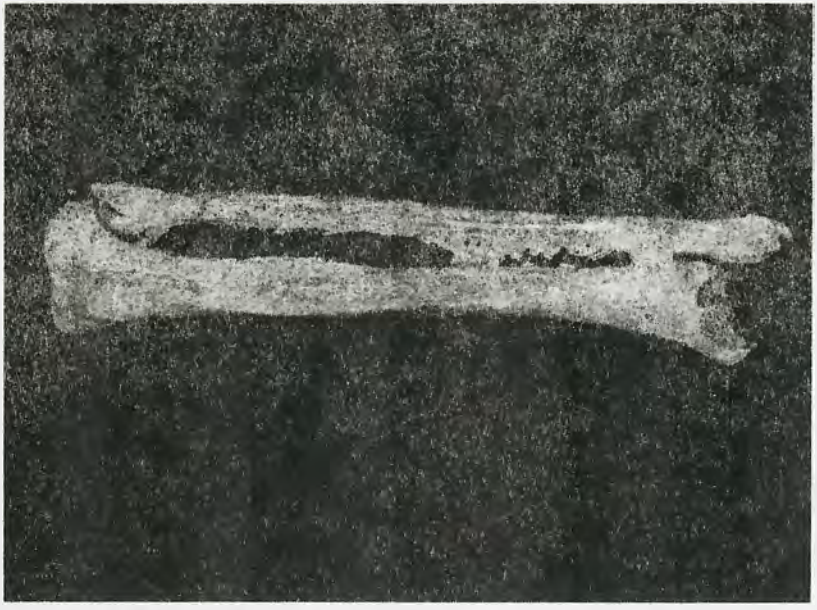

Fig. 8. Non-specific periostitis after a trauma of the leg

Fig. 9. Deforming arthroso-arthritis after a trauma of the elbow joint

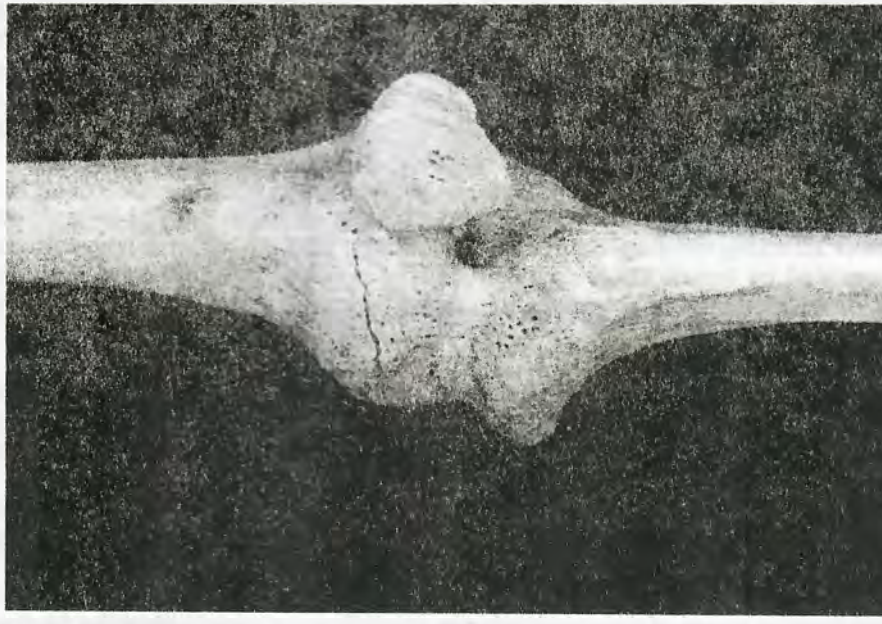

Fig. 10. Post-traumatic anchylosation of the knee joint

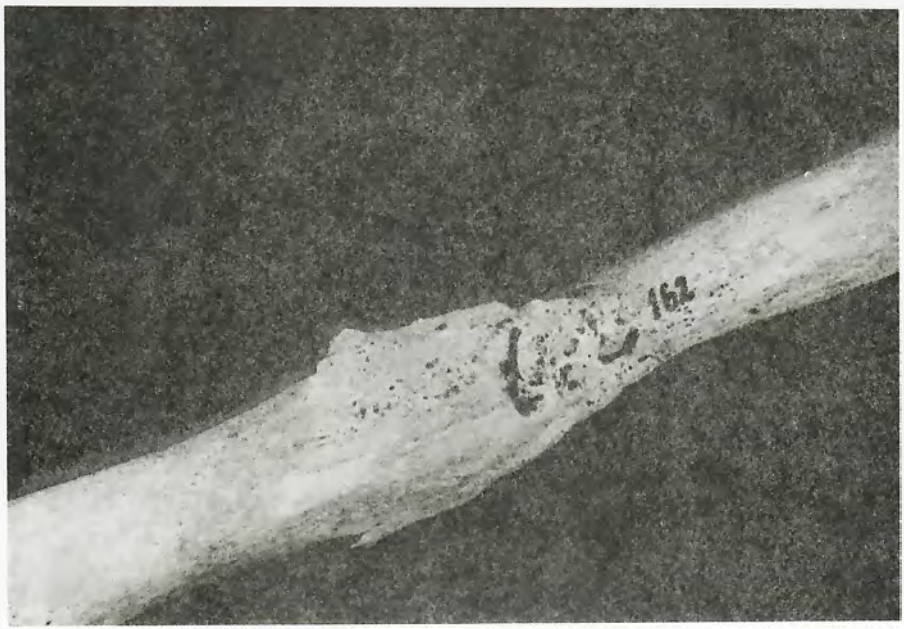

Fig. 11. Post-traumatic inflammatory process after a fracture of the femur

bone structure testify to a chronic inflammatory process, followed by secondary degenerative changes. Most probably, the frequent complications after joint-traumas were related to difficulties in the treatment of intra-arthrous haemorrhages whose impeded resorption caused injuries of the joint cartilage and the bone surface. Similar changes can occur as a result of repeated haemorrhages (usually in the knee joint) with haemophiliacs. In such cases there is no evidence of fractures or luxations. A characteristic morphological symptom is the enlarged distance between the two condyles in the distal end of the femur.

The other group of post-traumatic complications comprises the inflammatory processes affecting the diaphysis of the long bones. They occur with heavy fractures accompanied by considerable dislocations (Fig. 11) and open wounds. Sometimes the chronic inflammatory process is manifested by individual fistulisations; the typical manifestations of osteomyelitis (Fig. 12), with the formation of bone sequesters, are more rarely observed.

The traumas affecting the spine should be mentioned too. They are considerably less frequent — to some extent, owing to the more difficult preservation of affected vertebrae. Most often traces of indirect traumas can be observed — i.e. compressional fractures of vertebrae of the thoraco-lumbal section of the spine.

These are traumas that had a favourable issue but were followed by some degenerative changes in the form of osseous growths on the edges of the vertebrae (osteophytes of various sizes) and immobilisation of the affected section of the spinal column.

Summing up the results of the paleopathological study of the numerous osteal remains bearing traces of traumatic injuries, the following conclusions can be drawn:

1. In different periods of the Middle Ages the frequency of traumas affecting the postcranial skeleton varies from 2,5 % to 8 %. More numerous and morphologically more varied are the injuries of bones found in the necropoles of fortified towns; this is probably connected with frequent war engagements.

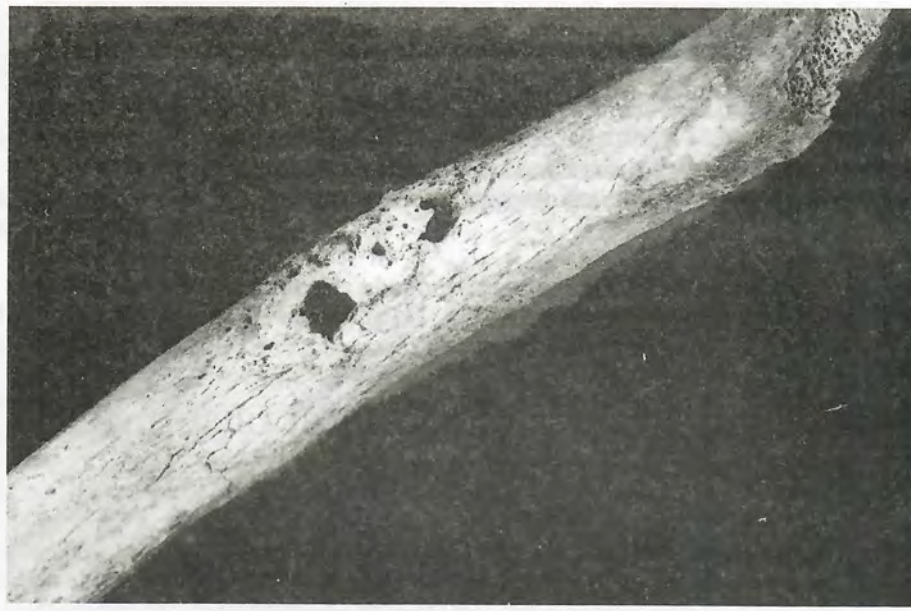

Fig. 12. Chronic osteomyelitis after a trauma of the femur

2. About 40-50 % of the fractures of long bones have a favourable issue — a well-formed callus and insignificant dislocation of fragments, which presuppose a medical help.

3. Characteristics of the epoch studied are the grave post-traumatic complication of joint-lesions.

4. The severe disability caused by some traumas and demanding prolonged care of the injured individual throws light on the social relationships in the population.

The above discussion makes it clear that the study of post-traumatic injuries traced on human skeleton of ages long past provides varied information both about the single individual and characteristic way of life of the whole population.

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Review Articles

Immunobiology of the mononuclear phagocytic system in central nervous system

D. Kadiysky, M. Svetoslavova

Institute of Experimental Morphology and Anthropology, Bulgarian Academy of Sciences, Sofia

The different central nervous system (CNS) pathology is accompanied by "gliosis" — an increase in the number of the nonneuronal cells — astroglia, microglia, exogenous macrophages. Some of these cell populations are representants of the mononuclear phagocytic system. They are perhaps the least well-characterized in the brain. The origin, the role and their relations with other cell types remains a controversial subject. The importance of the mononuclear phagocytic system in immunopathology and development is essential but its mechanisms are unexplained.

Key words: Mononuclear phagocytic system, CNS, microglia.

Introduction

The microenvironment of the central nervous system (CNS) has mechanisms of the selfprotection against injury, infection and immunologically unknown substances. The blood brain barrier makes this microenvironment partially privilege immunological region. Some of the elements of the mononuclear phagocytic system (MPS) — exogenous for the brain macrophages, perivascular cells, supraependymal cells, and different types of microglia can be easily found in the brain. Especially microglia is also one of the CNS glial cell types with controversial function, but strongly characterized as a class of MPS [13, 21, 22]. All these cells, commonly named "brain macrophages" are considered to play an active role in a variety of neurological diseases [12, 14]. Their functions in forming a network of immunocompetent cells within the CNS is supposable but not clear till now

Cell types of the mononuclear phagocytic system in the brain and its origin

Now the most important cellular forms of MPS can be defined as follows [4]:

ameboid microglia in white matter perinatally;

— ramified microglia in grey and white matter postnatally;

— activated microglia in areas of secondary reaction after nerve transection and CNS inflammation;

— reactive (phagocytic) microglia in areas of trauma, viral infection or neuronal degeneration;

— perivascular cells arround the small blood vessels and capillaries in the brain parenhyma with antigenpresenting and phagocytic functions (belonging to the resident microglia [4]);

— supraependymal cells.

The group of mononuclear phagocytic system in CNS is probably completed by ED2 — positive perivascular cells [11, 17], specialized phagocytic type with bone-marrow origin. In the same group we can include subependymal and epyplexus cells.

It's well known that the cells of the MPS in the brain are of multiple and different origin. The classical concept of del Rio Hortega (1932) [3] is in support of the cell unity of the MPS in CNS. This concept states that mesodermal elements invade the mammalian brain near the birthtime and remain scattered in the CNS throughout life, representing a source of microglia and macrophages in pathologic conditions [9]. Some authors suggest a blood-monocytic origin for ameboid microglia but the majority of resting microglial cells are of local, presumably neuroectodermal origin. Another conclusions [23] state that the normal adult CNS contains no cells belonging to the monocyte — macrophage lineage. But the majority opinions are that microglia belong to the mononuclear phagocytic system and originate from the blood monocytes-macrophages that invade the CNS in embrionic development [1, 4, 18]. Now there is agreement that microglia is a distinct class of MPS [7].

Characteristics and morphology of the MPS in the brain

Described under different terms the subpopulations of the MPS in CNS have a morphology very similar to other brain cells both in vivo and in vitro. Morphologically to make the difference is possible only between the ramified (resting, "quiescent") and the other cells of this system.

Microglia comprises between 5 and 20 % of the total glial cell in brain. Intercellular membrane contacts among microglia or between microglia and other neural cells have not been described in normal CNS [12]. Immunochemistry (monoclonal antibodies and lectins), enzyme histochemistry, metal impregnation and electron microscopy have been used to identify microglia. The resident microglia represents a major source of endogenous brain macrophages [8] and is thought to be involved in antigen presentation in vivo in CNS by virtue of the fact that they express major histocompatibility complex (MHC).

So-called "ameboid" microglia appears in the brain during the late stage of embriogenesis. These cells, with phagocytic properties disappear in postnatal period [2]. Morphologically they have been characterized by being round in shape and by exhibiting varying numbers of cytoplasmic vacuoles. They show high levels of lysosomal enzymes: acid phosphatase and non-specific esterase [5]. The "ramified" microglia appears pleomorphic, elongated or triangular with round or oval nucleus. The cells possess abundant, thin branches of cytoplasm, and contain a few primary lysosomes and varying numbers of secondary lysosomes.

In contrast to peritoneal macrophages microglia divides in culture [6]. Microglia exhibits functional characteristics common to cells of MPS: phagocytosis, Fc and CR receptors, MHC antigen expression, antigen presentation, interleukin-1 synthesis,

tumour cytotoxicity, superoxyde anion production and responsiveness to colony-stimulating factor [10]. The supraependymal cells have the phagocytic abilities of macrophages. The study of the other cell types of MPS in brain — subependymal and epyplexus cells is restricted by the absence of the procedures of their isolations.

It's clear that there are many difficulties in distinguishing all these populations — all of them possess a dendritic morphology and they are immunocompetent and phagocytic. They share features both of peritoneal macrophages and of the glial cells [6].

Cell markers and immunophenotype

For microglia the specific visualization with RCA-1 (*Ricinus communis* agglutinin 120) and GSA I-B4 (*Griffonia simplicifolia* B4 isolectin), widely used in histochemistry, are based on the presence of membrane associated glycoconjugates containing terminal α-D-galactose residues. A specific marker for ameboid microglia in vitro and ramified microglia in vivo, based on the phosphotyrosine immunoreactivity is proposed [26]. Another specific marker — OX-6 antigens, characteristic for the antigen-presenting cells in common is used for detection of activated microglia. The regional differences in the number of MHC class II antigen-presenting microglial cells in normal animals (OX-6 positive cells) correspond with the preferential sites of the eventual inflammatory infiltrates founded in EAE [27].

The OX-42 monoclonal antibody is specific for both ameboid and ramified microglia as well as for the cells of monocyte/macrophage lineage [20]. In the same time the OX-41 antibody labels only monocyte/macrophage lineage and not microglia [9]. This marker may be useful in discriminating microglia in CNS from blood-born phagocytes which invade the brain in pathologic lesions.

In tissue sections the ED1, ED2 and ED3 monoclonal antibodies label perivascular cells but not microglia. It is very interesting fact that relatively late in the course of EAE microglial cells in CNS are found to express ED1 antigen in their cytoplasm and this expression is probably a sign of phagocytic activity [10]. Common markers from this group for microglia and monocyte/macrophage cells are only ED7 and ED8. Minor differences in positive microglia markers are found between cultures derived from developing and mature central nervous tissue [10].

Discussion

As shown above it can be expected that the cells of MPS play a crucial role in the development and in the brain pathology. The experiments show a possible transformation of ameboid microglia into ramified during postnatal development. The term functional plasticity [24] refers to changes in microglial morphology, immunophenotype and functions that occur as the cells are confronted with a changing microenvironment, which will be result of pathology or normal development [25]. Microglia is implicated in wound healing, regulation of astrocytic differentiation, immune response and amyloid deposition in Alzheimer disease [20]. Whole specific cell pool of MPS in the brain plays an important role as immunological effector cells [19].

Activated microglia shows ameboidal shapes and has similar functions as monocytes-macrophages [21]. Ameboid microglia serves as principle scavenger cells during the development of CNS but during postnatal development it differentiate into ramified microglia, forming with the help of the other mononuclear phagocytes a potential immunoeffector network in adult brain [24].

Diseases where an active role for MPS has been proposed include AIDS [15], Alzheimer's disease and Multiple sclerosis [12].

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