ANGIOARCHITECTURE OF ELBOW AND KNEE JOINT CAPSULES IN A DOG

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Abstract

The purpose of this study was to examine the microcirculation section of the elbow and knee joint capsules in a dog. Two dogs' cadavers with pre-cannulated *a. subclavia* and *a. iliaca externa* were used, through which an ink-gelatin solution was introduced. The capsules were dehydrated in ascending alcohol series and enlightened in methylsalicylate. The resulting enlightened samples visualized the arterial and venous sections of the circulatory system, as well as the specific shaped capillary nets and arteriole-venular anastomoses. This method not only establishes the specific morphology of vascular formations, but also the possibility of proving regenerative, inflammatory and degenerative processes.

Key words: angioarchitecture, capillary net, elbow and knee joint, dog

Introduction. The joint capsule is of great significance to the normal function of the synovial joints. The studies of the joint capsule vascularization have shown a system of anastomosing vessels which form a nutritive unit: *Circulus vasculosus articuli et epiphyseos* [1–3]. As a part of synovial joints, the capsule is involved in all pathological conditions, such as dislocations and fractures, but also abnormalities of the capsule itself may affect the function of the joint and may predispose to other joint diseases [4]. Visualizing and clarifying the structure of the capillary bed of the elbow and stifle joint capsule of the dog will help to understand the regenerative, inflammatory and degenerative processes.

Rete articulare cubiti is a network on the caudal aspect of the elbow joint formed by branches of the brachial artery and is the main blood supply of the elbow joint capsule. The largest supply to the stifle joint is provided by the descending genicular artery and the popliteal artery. They form two networks in this region – *rete articulare genus* around the joint and *rete patelle* at the kneecap [5,6].

The intimal layer of a joint capsule is rich in blood supply. The numerous branches of the arteries and veins form vascular plexuses in the synovial membrane originating from a common main trunk [2,7,8]. Their pattern of distribution is highly organised, variable and non-uniform and functions as diffusion network to nourish the membrane [2,9,10]. This capillary bed presented by arterioles, capillaries, and venules with slight perforations or fenestrations, varies within the synovial layer in relation to the anatomical location [1,11].

Synovitis is associated with increased blood supply to the joint capsule, by vascular proliferation [12], and vascular cell death in patients with rheumatoid arthritis [11]. Many authors suggest that the early stages of rheumatoid arthritis are related to the abnormal vascular proliferation in the synovial membrane [3,12].

Clarifying the microcirculation and the specific vascular formations in the elbow and knee joint will help in understanding and managing the pathological process in the joints.

Materials and method. Two dogs' cadavers were used for the purpose of this research – one female Rottweiler and one mixed breed male dog, weighing around 30 kg. All eight limbs were included in the study. An ink-gelatin solution was prepared by VANKOV method [13] and was introduced through pre-cannulated *a. subclavia* and *a. iliaca externa*. The detached from the elbow and stifle joints capsules were first fixed in purified with calcium carbonate formaldehyde for 12 h and later dehydrated in ascending alcohol series. In the end, the capsules were enlightened in methylsalicylate and microscopic samples were prepared.

Results. The vascular plexuses are visible on the extensor and flexor surface of the elbow and stifle joint capsules. Vessel triads, where the arterioles are usually accompanied by two venules, are observed on both capsules (Fig. 1, 2). Arteriolo-venular anastomoses are common, as well as inter-venous anastomoses, such as single or multi-level communications, forming ladder-like configurations (Fig. 1, 2). Representative formations for both joints are sphincter-like branches where one arteriole is dichotomously divided into two capillaries with a double-sided pinch identified at the place of the bifurcation (Fig. 2). The capillary nets in the capsules are numerous in a variety of shapes, with loops, circumferential and polygonal nets, and clumps, resembling the renal glomeruli (Fig. 3). Typical vein and venules serpentine coils (Fig. 1, 2) and series of ampule extensions of the venules (Fig. 1, 2) are also observed. On the flexor surface of the knee joint around the femoral condyles, a very specific vascular network, defined as an arcade with a specific spatial layout and winding of both arterioles and veins and capillary nets,

Fig. 1. Extensor surface of the elbow joint capsule (A), flexor surface of the elbow joint capsule (B); 1 – triads of arteriole and two venules; 2 – ladder-like anastomoses; 3 – vein with serpentine coil; 4 – intervenular anastomoses; 5 – ampule extensions

Fig. 2. Extensor surface of the stifle joint capsule (A, B, C); 1 – triads of arteriole and two venules; 2 – ladder-like anastomoses; 3 – venule with serpentine coil; 4 – ampule extensions of the venules; ar – arteriole; sph – sphincter-like anastomosis on the level arteriole bifurcation

Fig. 3. Flexor surface of the stifle joint capsule (A, B); 1 – vessels arcade; 2 – polygonal capillary net; 3 – normal capillary net; 4 – capillary loops; 5 – glomus-like anastomoses

is visualized. Thermoregulating glomus-like anastomoses are also established on the flexor surface of the knee joint capsule (Fig. 3).

Discussion. The vascular triads are found in the knee joint of the rabbit [1,10] and hip joint capsule in a dog [14], while in the present study they are confirmed in dog's, both knee and elbow joint capsule. Literature information for the more frequent occurrence of anastomoses between arterioles and venules, compared to arteriovenous in animals and humans is also confirmed [15,16]. The ladder-like and glomus-like anastomoses are described in the epiligament connective tissue of the collateral and crossed ligaments of the stifle joints in the rabbit [10], whereas in the present research they are also observed in a dog, as the ladder-like anastomoses are identified in knee and elbow joint capsules, but the glomus only in the knee. Such glomus-like anastomoses are also described in dogs' [16] and camels' [17] pads. Sphincter-like anastomoses established by Spalteholtz method are described in the knee joint again in the rabbit [10] and the epiligament connective tissue of the cranial cruciate ligament in a dog but are visualized by scanning electron microscopy [18]. The presence of the same anastomoses is determined in our research by Spalteholtz method in examined dog capsules. The presence of a specific vascular arcade, glomerular strands, capillary nets and loops of various shapes in the joint capsule on the femoral condyles and described by LINDSTROM and BRANEMARK [1] in a rabbit, is confirmed by the authors in dogs. The venous vascular system-specific serpentine coils and ampule extensions of the vessels described in the hoof corium of the sheep and pig [19,20] are confirmed by us in the elbow and knee joint capsules in a dog, supporting the claim that they are most likely drainage devices of venous blood. Further proofs of this statement are the observed by us ampule extensions predominantly on the flexor than the extensor

surface of the capsules, on both the knee and the elbow joint. Narrowing followed by ampule extensions of the vessels are also described by KOBAYASHI et al. [18] in dogs cruciate ligament but visualized by scanning electron microscopy.

Conclusion. To our knowledge, this is the first report of the specific angioarchitecture of the elbow and knee joint capsule of the dog. This study focuses on a detailed examination of the vascular formations in these synovial membranes and on the comparison between the extensor and the flexor surface, which will contribute to the functional anatomy and physiology of blood circulation of the locomotory system of the dog.

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