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Observations on the Lymphatic Drainage of Joint Cavities.

MILLARD SMITH AND JOHN R. CAMPBELL, JR.

From the Department of Medicine, University Hospital, Ann Arbor, Mich.

The physiology of joints depends at least in part upon the mechanism for fluid exchange in these structures. Considerable attention has been given in the past to the factors which determine the formation and characteristics of intra-articular effusions, but the ways in which they can be removed are imperfectly known. From a consideration of the factors involved in the equilibrium between the capillaries beneath the synovial membrane and a joint effusion containing protein, one may conclude that absorption by way of the capillaries will cease when the filtration and osmotic pressure relations within the capillaries and within the joint space are in equilibrium. Furthermore, such equilibrium relations can become established with fairly large amounts of effusion fluid remaining within the joint. It may be pointed out also that absorption by way of the blood capillaries would be slow even under ideal conditions.

It is the purpose of this communication to direct attention to the lymphatic system as the most important factor concerned in the drainage of joints under both normal and pathological conditions. This is not a new or original concept but it has not received the emphasis in the past which it demands. It is known that the synovial membrane is abundantly supplied with lymphatic capillaries, but we have been unable to find any specific statement about the lymphatic trunks which drain these capillaries.

Utilizing the knee joints of cats we have determined by injections of solutions containing methylene blue that the lymphatic capillaries of the synovial membrane unite in the popliteal space, with a lymphatic trunk coming from the foot and running up Hunter's canal and then into the pelvis, where it ends in a deep subinguinal lymph node situated at the brim of the pelvis just lateral to the mid line. So far as we were able to determine, this trunk drains only the joint structures. The popliteal lymph nodes drain only the skin and soft structures of the lower leg. The same relations obtain in the dog. These observations suggest the possibility of similar findings in the human.

Using Berlin Blue solutions as injection material we found that the lymphatics were not filled until intra-articular pressure was so elevated that the capsule of the joint was greatly distended. Since Berlin Blue is a non-diffusible colloidal dye, this observation contra-

dicts previous ideas about lymphatic connection with the joint space by means of stomata within the synovial membrane. That the lymphatic capillaries finally did fill with the dye when the latter was injected under considerable pressure indicates that the synovial membrane and the lymphatic capillary membrane are somewhat permeable to colloidal substances. We have also noted a definite difference in the rapidity of drainage from the joint space between isotonic and hypertonic NaCl solutions, and at the same time demonstrated that they were drained by way of the lymphatics by adding to the solution enough methylene blue to color the solution.

Since the lymphatic trunk draining the joint had its course along Hunter's canal it seemed improbable that muscular action ("the milking of lymphatic trunks") could account for lymph flow from the joint. We performed a series of experiments to demonstrate that joint motion was responsible for lymph filtration through the synovial membrane and flow along the lymphatic trunk. Chart 1 illustrates the changing pressure relations within the joint during

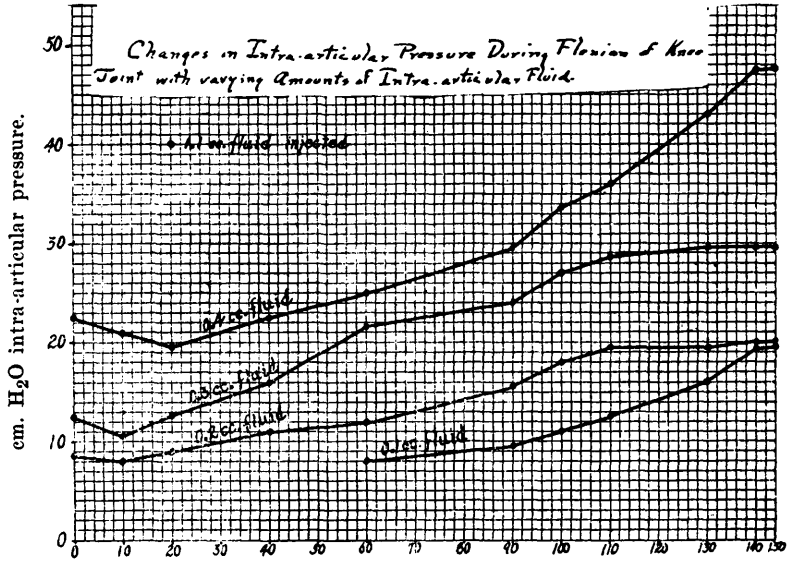

FIG. 1.

Each curve was obtained by means of a water manometer connected to a Luer needle inserted through the patella of the knee joint of a cat. The points on a given curve represent the pressure within the knee joint in terms of centimeters of water pressure at the angle of flexion indicated on the abscissae. In each curve a constant amount of fluid was kept within the joint space and the amount of this fluid is indicated in cubic centimeters on the curve. Flexion was measured by the angle between the limb distal to the knee joint and the line of full extension of the limb.

full range of motion with different amounts of fluid within the joint. The point of least pressure corresponds closely with the position maintained by a limb containing a palpable effusion. By means of a hypertonic saline solution containing methylene blue we demonstrated that drainage was dependent upon joint movement.

These observations indicate that fluids poor in, or, free from colloidal materials will be drained rapidly from the joint space by way of the lymphatics when joint motion occurs. Fluids containing colloidal material which exerts an osmotic pressure may be concentrated until the osmotic pressure of the fluid equals the highest intra-articular pressure attainable by joint motion. Our observations suggest that even colloidal material may filter through the lymphatic capillary membrane when high intra-articular pressures are produced, but it is well known from clinical experience that the absorption of joint effusions is slow when the protein content is appreciably elevated.

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Hemorrhagic Glomerular Lesions Produced by Filtrates of Streptococcus Viridans Cultures.

ARNOLD R. RICH, JOHN H. BUMSTEAD AND MARTIN FROBISHER, JR.

From the Department of Pathology and Bacteriology, Johns Hopkins Medical School.

It is well known that hemorrhagic, glomerulo-nephritis occurs with great frequency in association with *Streptococcus viridans* endocarditis. The glomerular changes are generally regarded as a direct result of damage caused by minute emboli from the vegetations on the heart valves. The following considerations led us to question the assumed embolic nature of the nephritis: (1) If the nephritis associated with *Streptococcus viridans* endocarditis is merely the result of emboli, one might reasonably expect to encounter a similar nephritis quite as commonly in every form of endocarditis characterized by profuse, friable vegetations, regardless of the etiology. This, however, is not the case. (2) There is no relation between the size of the valvular vegetations and the occurrence or degree of nephritis. (3) We have observed florid hemorrhagic nephritis in association with gonococcal endocarditis, in which the vegetations were confined to the right side of the heart, and in which therefore,