THE LYMPHATICS OF THE SYNOVIAL MEMBRANE

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Although the existence of lymphatic vessels and plexuses in the synovial membrane has been recognized for a considerable time, these structures are still inadequately described and figured. In many cases investigations have not been controlled by histological sections to verify the nature of the injected vessels.

The earliest work on the synovial lymphatics was that of Heuter (1886). He and most other investigators of the last century (such as von Mosengeil, 1876; Hagen-Torn, 1882; Tillmanns, 1876) were concerned primarily with the nature of the synovial cavity in particular relationship to the lymphatic system, and with the much-discussed problem of possible direct communications (stomata) from the joint cavity into the lymphatic vessels. Evidence for the existence of such stomata has been based mainly on silver preparations and is in general inconclusive. The present consensus of opinion is probably against the existence of such stomata, although the ease with which colloidal matter enters the lymph stream from the joint cavity is a feature upon which all workers agree.

Subsequent investigators were concerned chiefly with the pathways and lymph nodes draining particular joints rather than with the configuration of the lymphatic vessels in and around the synovial membrane. Amongst these investigators are Baum (1911, 1927), Mouchet (1911 *a*, *b*), Oschkaderow (1929) and Schdanow (1930).

Chief amongst observations of the synovial lymph vessels and their arrangements are those of Tillmanns (1876) and Magnus (1923). There appears to be some disagreement as to whether the terminal vessels and plexuses can be demonstrated following injection of various colloidal particles and injection masses directly into the joint cavity with subsequent movement of the joint for periods up to half an hour. Tillmanns failed to achieve any success by this method. Baum (1911) was of the opinion that Tillmanns had failed to observe or had wrongly interpreted the vessels which he himself believed must have been injected by this method. More recently Kuhns (1933) wrongly quoted Tillmanns as having succeeded by this method and believed it to be adequate for the demonstration of synovial lymphatics. There seems little doubt that colloidal particles can reach the regional lymph glands following injection of the joint cavity immediately post-mortem, but, as will be seen later, there is a good reason why injection should fail to be an adequate method for the demonstration of the synovial vessels and their plexuses. Furthermore, substances injected directly into the joint cavity become deposited on the surface of the synovial membrane, particularly among its folds, and render subsequent interpretation difficult.

MATERIAL AND METHODS

Injections were made into the metatarsophalangeal and metacarpophalangeal joints of cattle within 1 hr. of slaughtering. In the earlier experiments the injection was made directly into the joint cavity, in some cases to the point of its distension. The joint was then alternately flexed and extended slowly over a period of $\frac{1}{2}$–1 hr. It was afterwards opened and the synovial membrane examined for lymphatics. In later experiments the joint was opened first and stab injections were made under a low head of pressure directly into various regions of the synovial membrane. The specimen was immersed whole in 10 % formalin for 24 hr. and then examined directly for lymphatic vessels. Portions of synovial membrane and periosteum were removed, and after a further period of fixation in formalin were cleared and again examined with a binocular microscope and in section after light staining with haematoxylin and eosin.

Most of the injections were made with a 50 % dilution of Winsor and Newton's Mandarin Black ink in tap water, using a record syringe and a 20-gauge needle. Other injection masses such as Prussian blue and Berlin blue were also tried but as these seemed to possess no advantage over Mandarin Black they were discarded. In a few cases the lymphatics were successfully injected (after previous delineation of the vascular tree) with carmine gelatine.

RESULTS

Injections directly into the joint cavity followed by movement failed to delineate the lymph vessels in the synovial membrane, although the injected material was generally found in the larger collecting lymphatic trunks. The explanation of this became obvious when stab injections were made into the synovial membrane. In the latter case movements of the part led to a rapid emptying of the smaller synovial lymphatics. It is known that movement is an important factor in promoting drainage from the joint cavity in the living animal (Adkins & Davies, 1940), as, possibly, is pressure also.

Stab injections into the synovial membrane are

successful in delineating its lymphatic channels in most cases. Over most parts of the synovial membrane the large lymphatics are arranged in the form of a wide-meshed, freely anastomosing, polygonal pattern within which are numerous, blindly ending, smaller tributaries, frequently showing terminal lacuniform enlargements (Pl. 1, figs. 1, 2). The meshes of the lymphatic plexus measure from 2 to 3 mm. across. This plexus in the synovial membrane corresponds to the superficial lymphatic plexus of Tillmanns. Over the more fibrous areas of the synovial membrane, and towards the cartilaginous articular margins, the plexus becomes attenuated; its vessels become finer and fewer, and their anastomoses become less frequent. Unlike the blood capillaries, these fine lymph vessels terminate blindly at some distance from the articular margin.

From the network of lymphatics in the synovial membrane the collecting trunks pass in groups of two, three, or more, along the main blood vessels, generally towards the flexor aspect of the limb. They pass deeply on to the surface of the periosteum and communicate freely with the lymphatic vessels thereof, both where it underlies the synovial membrane and on the shaft of the metatarsal or metacarpal bone (Pl. 1, figs. 3, 4). These lymph vessels on the periosteum are almost invariably injected, and they constitute in the region of the joint the deep lymphatic plexus of Tillmanns.

Where the articular synovial membrane passes over tendons or ligaments in the ox, its lymphatics communicate with those in the areolar tissue which separates and surrounds the tendon or fibrous tissue-bundles (Pl. 2, fig. 5).

Over the intra-articular pads of fat, the lymphatic plexus is poorly marked. Here the vessels are few in number and very wide in calibre; they drain with few anastomoses almost directly into the lymphatics on the periosteum (Pl. 2, fig. 6). Baum's statement that the lymph vessels are particularly numerous over the fat pads cannot be substantiated.

No lymphatic vessels are visible in the villi of the synovial membrane, nor in the cord-like bridges which are sometimes seen at the reflexions of the membrane. This agrees with Tillmanns's observations. It would appear that any activities which the villi might have in the drainage of the joint cavity are achieved through their rich blood capillary bed or their free phagocytic cells.

Passive movement of the joint following injection of the lymphatics is found to empty the synovial plexus quickly and completely. Its effects on the larger collecting trunks, particularly those on the periosteum, are not so marked. This explains the failure to outline the synovial lymphatics by the method of direct injection into the joint cavity followed by movement. Hence it is advisable to fix the joint in formalin for 24 hr. after injection without further manipulation, for thereby the fine lymphatic vessels of the synovial membrane remain injected.

The synovial lymphatic plexus is generally easier to display in the younger animal. In adult joints the collecting trunks are generally injected, but frequently little or none of the synovial plexus shows. The vessels injected in adult joints are generally fewer and finer than in the young animal, in conformity with the general atrophy which overtakes the whole lymphatic system with age.

In histological section the anastomosing lymph vessels of the synovial membrane lie close to the larger blood vessels and are numerous and large (Pl. 2, fig. 7). The smaller blindly ending tributaries generally take a course parallel with the synovial surface, a few, however, passing inwards towards the cavity of the joint (Pl. 2, fig. 7). The synovial lymph channels are neither as numerous nor as superficial as the blood capillaries. They lie in a plane superficial to the elastic lamina which the author has described in the synovial membrane (Davies, 1945), the collecting trunks passing deeply through this lamina on to the surface of the periosteum. The rapidity with which colloidal particles introduced into the joint cavity arrive in the lymphatic trunks and nodes is still a matter for surprise. Very few valves are seen in the synovial lymphatics: they are much more frequent in the accompanying venous channels and in the larger lymphatic trunks on the periosteum with which the synovial lymphatics communicate.

In several cases the injected material was found in the blood vessels of the synovial membrane, with or without an injection of the corresponding lymphatics. These cases were generally identified at the time of injection by the richness and pattern of the vascular net. In some, the circulus articuli vasculosus was completely injected, whilst in others the injection had passed along the veins (perforating veins) in the vascular canal traversing the lower end of the metacarpal bone and thus into the venous sinuses in the bone marrow (Pl. 2, fig. 8). Baum suggested that some of the synovial lymphatics may drain directly into the regional veins. The author could see nothing in the histological sections that was even suggestive of this, although some were cut and mounted in series. It is, however, a possibility that is difficult to confirm or refute. In view of the vascularity of the synovial membrane it is more probable that these injections were made directly into the blood vessels. Surprisingly they did not occur more frequently.

SUMMARY

The lymphatic vessels of the synovial membrane were studied in the metacarpophalangeal and metatarsophalangeal joints of recently slaughtered cattle,

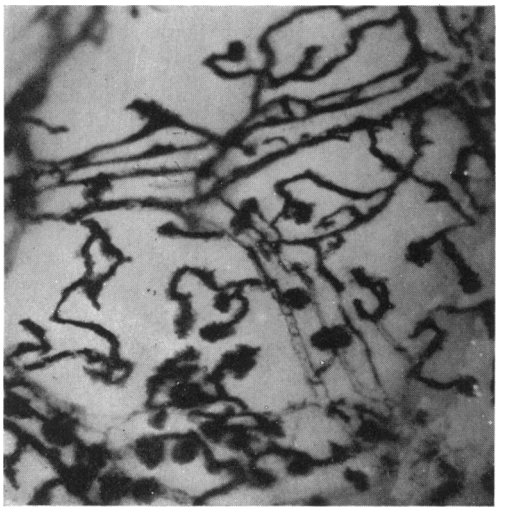

Fig. 2

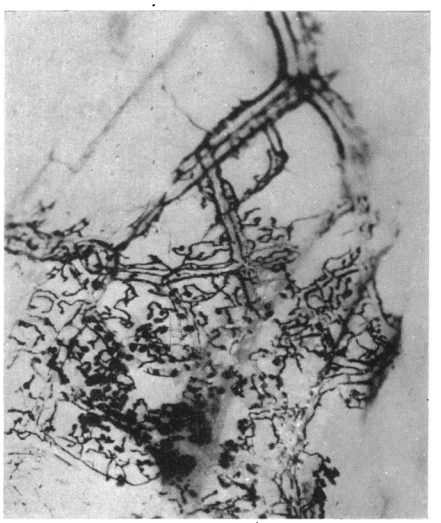

Fig. 1

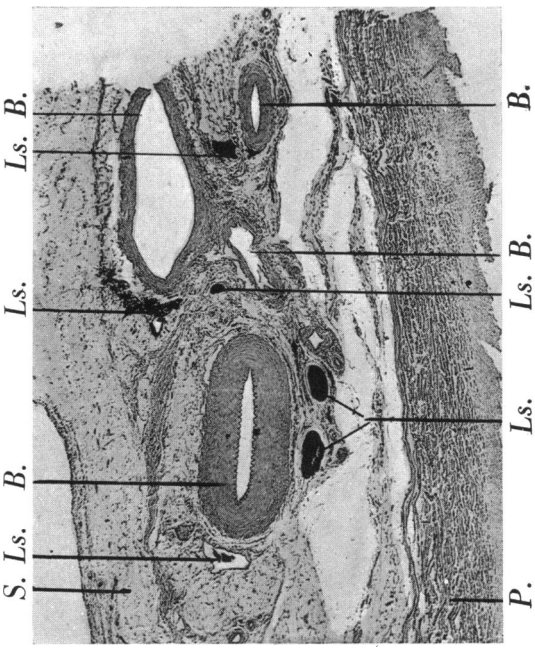

Fig. 3

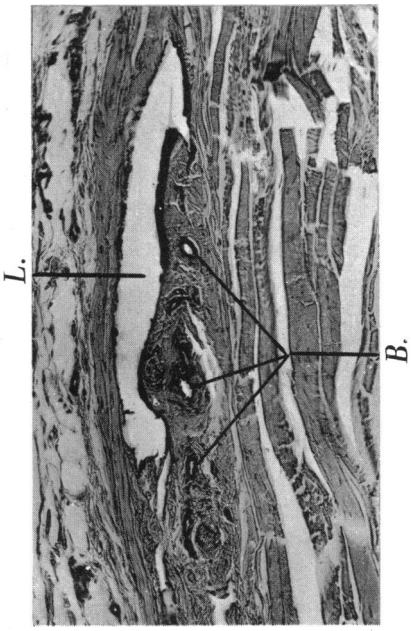

Fig. 4

Fig. 6

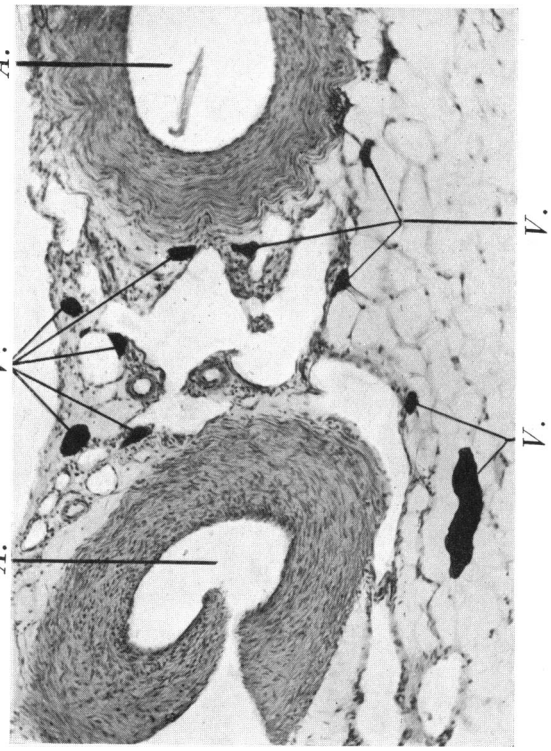

Fig. 8

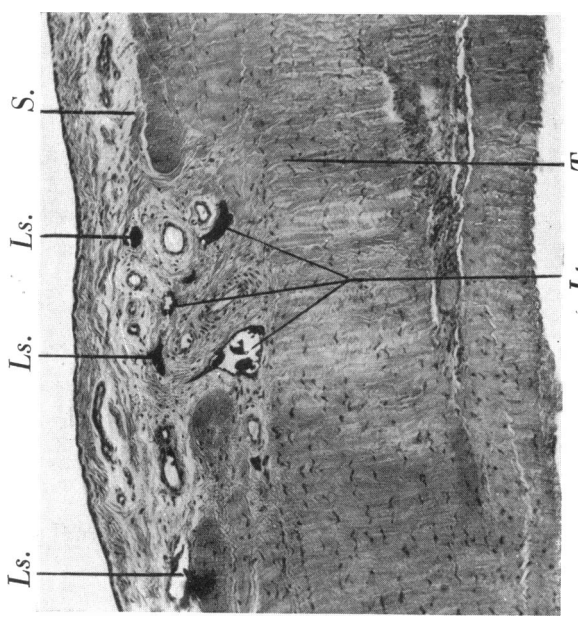

Fig. 5

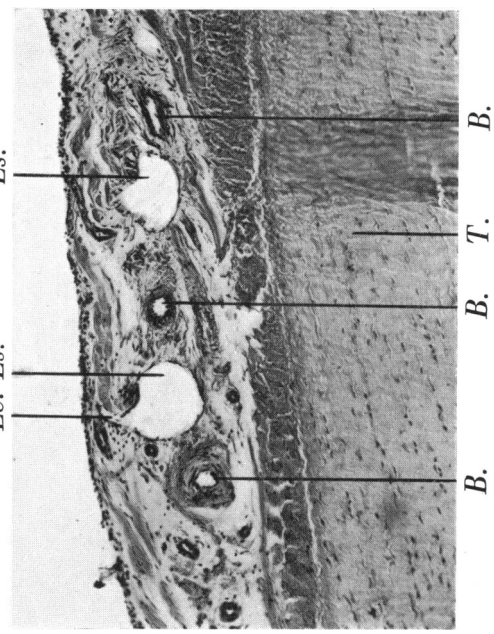

Fig. 7

using 50 % Mandarin Black ink as a medium. To demonstrate the synovial lymphatics, injections directly into the joint cavity followed by movement proved unsuccessful: an explanation is suggested for this. The stab technique proved successful. The synovial lymphatic plexus is described, together with its extra-articular connexions. In some experiments the blood vessels were injected, but no evidence was seen of drainage of the synovial lymphatics directly into the neighbouring veins. All injections were confirmed histologically.

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EXPLANATION OF PLATES

PLATE 1

Fig. 1. Lymphatic plexus in the synovial membrane of the metatarsophalangeal joint of an ox. Injected with Mandarin Black ink. ×4·7.

Fig. 2. High-power view of an area from the previous specimen. ×21.

Fig. 3. Section of the synovial membrane and underlying periosteum from the metatarsophalangeal joint of an ox. The large lymphatic vessels on the surface of the periosteum have been injected with Mandarin Black ink from the synovial lymphatic plexus. Stained with haematoxylin and eosin. ×22·5.

Fig. 4. Section of the periosteum from the posterior surface of the metacarpal bone of an ox, some distance proximal to the metacarpophalangeal joint. The lymph vessels on the periosteum contain Mandarin Black ink from the synovial lymphatic plexus. Stained with haematoxylin and eosin. ×84.

PLATE 2

Fig. 5. Section of the synovial membrane and underlying deep flexor tendon from the metatarsophalangeal joint of an ox, showing the lymphatic vessels of the synovial membrane passing deeply to communicate with those in the tendon. The lymph vessels have been injected with Mandarin Black ink. Stained with haematoxylin and eosin. ×84.

Fig. 6. Lymphatic vessels in the synovial membrane overlying a fat pad in the metacarpophalangeal joint of an ox, for comparison with fig. 2. The lymphatic vessels are injected with Mandarin Black ink and are shown at the same magnification as in fig. 2. ×21.

Fig. 7. Section of the synovial membrane from the metacarpophalangeal joint of an ox, showing two large lymphatic channels injected with Mandarin Black ink. A small blindly ending tributary from the more superficial part of the synovial membrane is seen entering one of these large vessels. Stained with haematoxylin and eosin. ×84.

Fig. 8. Section of the bone marrow from the metacarpal of an ox, showing some of the venous sinuses injected with Mandarin Black ink which was injected into the synovial membrane of the corresponding metacarpophalangeal joint. Stained with haematoxylin and eosin. ×84.

KEY TO LETTERING. *A.* arteries; *B.* blood vessels; *L.* lymphatic; *Lc.* lymphatic tributary; *Ls.* synovial lymphatics; *Lt.* tendon lymphatics; *P.* periosteum; *S.* synovial membrane; *T.* tendon; *V.* venous sinuses.