STUDIES ON HEMAL NODES. VIII

THE ABSENCE OF HEMAL NODES IN THE DOMESTIC PIG

ARTHUR WILLIAM MEYER

From the Division of Anatomy of the Stanford Medical School

SEVEN FIGURES

If a hemal node is merely a lymphatic node in the parenchyma or the sinuses of which blood-cells are contained in more than the usual number, then every animal that has lymph nodes may undoubtedly also have hemal nodes. I am not prepared to state what the usual number of blood-cells in the lymph current is, nor do I think that the number is constant. From the varying color of the thoracic duct alone we know that the cellular content of the main lymph stream varies greatly and the changes in color of the mesenteric lymph nodes can only be explained by vasomotor changes or by a greater ingress of blood-cells into the intranodal lymph current or the parenchyma, or by both. This conclusion does not depend on the macroscopic appearances of the nodes, but upon blood counts made on the thoracic duct and upon histological examination of nodes.

Another source of evidence showing that any lymph node may in the above sense become a hemal, that is a red node, lies in the differences between the appearances of the afferent and efferent vessels frequently seen in the mesenteric nodes of the pig. It is not uncommon to find the latter distended with a blood-colored fluid, although the former are scarcely visible. The finest examples of this were found in the mesorectum of a young pig. That the nodes in question were lymph nodes and that the vessels concerned were lymph and not blood-vessels, was easily demonstrated by subsequent injections made directly into the rectal wall and then into the nodes themselves. This observa-

tion may be new for the pig, but Helly ('02) says that Herbst ('44) noticed that the efferent lymphatics may be more or less red even when the afferent vessels are pale or almost colorless. Under these circumstances, the blood must have entered the lymph current within the lymph node itself. It must do this wholly regardless of the question whether erythrocytes are formed within lymph nodes, as Retterer holds, and subsequently enter the lymph current directly, or whether erythrocytes pass from the vascular into the lymph current through the parenchyma. Moreover, upon injecting such reddened nodes in the pig, with granular suspensions from the intestinal wall, one would expect the veins which drain the nodes also to become filled with injection mass if the vascular and the lymphatic circulations had common sinuses within the node; that is, if the nodes in question were mixed, neither lymph nor hemal, in type. Were this the case one would also expect the blood-vessels within the node to become injected. However, this never occurred. From these considerations alone I think it must be clear that a lymph node the lymph sinuses of which contain blood-colored lymph remains as truly a lymph node as the thoracic duct remains what it was even after being filled with blood-colored lymph.

Von Schumacher ('12) explained the occurrence of reddened lymph nodes in the retroperitoneal tissues of sheep fetuses and young lambs by the presence of extravasations in these tissues. These extravasations which von Schumacher associated with the presence of small degenerating arteries were regarded by him as the undoubted fonts of the erythrocytes found in the lymph nodes. The frequent presence of focal hemorrhages in the subcutaneous and other tissues of fetuses, must be familiar to everyone who has handled large numbers of embryos and fetuses. That such of these extravasations as are antemortem may cause reddening of the neighboring or even of the more distant lymph nodes one cannot doubt. But the reddening of the lymph nodes of hogs cannot be explained in this way. The mere fact that the node and efferent vessels often are intensely red while the afferent vessels are barely visible, is alone sufficient proof of this statement. Besides, I have never seen a sufficiently large number

of small hemorrhages to account for the general reddening of all or most of all the lymph nodes in the pig. Furthermore, von Schumacher emphasizes that the lymph sinuses of the nodes of the pig usually contain no erythrocytes. Hence, whatever their origin, it would seem that the latter could not have come into the node through the afferent lymphatics, but must have gained entrance to the lymph within the node itself.

I have never observed transition forms of circulation by the use of injection methods. That, after all, is the crucial test. The hemal node has no intranodal lymph current and its parenchyma stands in essentially the same relation to the vascular stream as the parenchyma of the lymph node does to the lymph stream. However, the relations of the vascular trunks to the hemal node as a whole also differ from that of the lymph vessels to the lymph node, for the artery and vein usually enter a hemal just as they enter a lymph node. Even within the hemal node the course of the artery is very similar to that of the artery in the lymph node, but, as shown in several previous publications, the relation of the vein to the parenchyma of the hemal node is a wholly different one from that of the vein to the parenchyma of the lymph node. Other minor differences in the structure of hemal and lymph nodes have also been spoken of elsewhere.

In re-emphasizing the difference between hemal and lymph nodes I am not merely insisting upon a personal preference. I can see no possible purpose in retaining the use of the word hemolymph if it simply is to designate reddened lymph nodes. For one and the same node may change from red to gray and from gray to red in very short periods of time and for very many different reasons. Consequently, when so applied the term hemolymph node loses its meaning, for all manner of transition color stages must necessarily prevail as a node changes from red to gray and then back again from gray to red.

From the appearance of carcasses of hogs in the slaughter house and also from my knowledge of the literature, I had assumed that hemal nodes occur in the pig. Their presence had been noted by Clarkson ('91), who thought that these and other 'hemal glands' form erythrocytes. They were described by Meek ('10),

who thought that leucocytes as well as erythrocytes were formed in the hemal nodes of the pig. However, Vincent and Harrison ('97) and von Schumacher ('12) found no hemal nodes in the pig, nor did Richter ('02) or Baum and Hille ('08) mention them in their examination of the lymph nodes of the horse, bovines, the pig and the dog. Gutig ('07), on the other hand, described 'hemolymph' glands in the pig and also thought that they occasionally form lymph nodes. Sabin ('05, '07, and '11-'12) distinguished two kinds of nodes, lymph and hemolymph, and also represented developing hemolymph nodes, in the pig. The writer ('15), under the subhead 'Depleted hemal nodes,' reported three apparently similar specimens of hemal nodes, one each from a lamb, a newborn colt and from the pig. The latter taken from the paraparotid region was a very interesting specimen which I owe to the courtesy of Professor Sabin. Nodes similar to the latter were apparently also found in the pig by Meek.

There is, of course, no doubt that pink nodes are very common in the pig. In fact, it is often difficult to find ordinary gray nodes in the abdominal or thoracic regions of carcasses of hogs as they hang in the abattoirs. I had often been impressed by this and also by the fact that these pink nodes were much larger than the abdominal hemal nodes in the sheep and bovines and that they were rather mottled in color. This had been noted in hundreds of carcasses of pigs examined more or less casually in abattoirs in various parts of the country during the past decade.

I had always hesitated to try puncture injections on carcasses of the pig in abattoirs because the nodes usually are imbedded so deeply in fat that it is difficult to see just what is happening. However, about a year ago, I happened to be present while a fine lot of young hogs were being slaughtered. Since these young animals were not so fat and also since they were available immediately after evisceration, I injected some of the reddest and largest nodes lying along the iliac vessels, the abdominal aorta, and in the thorax. I was quite surprised to find that in every instance the India ink could plainly be seen to enter the large lymph trunks. In many instances in which the thoracic duct

had not been severed peripherally the ink ran out of its cut end in the thorax. Pink node after node, both large and small, was injected with the same result. There could, to be sure, be only one conclusion, and that was that there were no hemal nodes in these pigs. But in order to test this conclusion further two pigs four weeks old, which were in excellent condition and belonged to the same litter, were carefully examined by inspection. Some of the nodes were also examined microscopically and others were injected.

Both these pigs were fine, healthy young animals and neither was fat. The first one which was somewhat better fed and heavier was killed with illuminating gas about twelve hours after a light feeding. Injections were made into the feet and into the peripheral nodes after these had been examined. All the peripheral nodes had the usual appearance and all were easily injected. Upon opening the abdomen practically all the abdominal nodes were seen to be quite pink. However, none of them had the appearance or form which I had learned to know as peculiar of typical hemal nodes. Some spheroid nodes in the mesorectum which were redder than the rest were peculiar in that vessels apparently distended with blood ran centrally from them. The efferent vessels were related to the node much as the afferent lymphatics are related to lymph nodes except that the afferent vessels were never more than visible as fine opalescent lines in the mesorectum. Upon injecting the lymphatics from the rectum the latter were easily filled, the reddened nodes became black and the India ink soon found its way into the blood-colored efferent vessels. The latter then also became filled with ink which finally entered the main lymph trunks. By repeated puncture injections it was also an easy matter to inject any pink abdominal node which might be selected and so establish its connection with the lymphatic system. Not infrequently one node was injected from another before the central lymphatic connections could be established, but veins were never injected.

Since von Schumacher concluded that the presence of a marginal sinus within the sheep's node, wholly regardless of whether it contained blood or lymph, alone is sufficient evidence of the

fact that such a node was once in connection with the lymphatics, it is difficult to understand why the absence of such a sinus in many of the nodes of the pig does not necessarily imply that they are devoid of such connections. That they are so related can be established very easily by injections. Indeed, in some such nodes the injection mass penetrated the parenchyma in all directions, even surrounding the individual cells.

Weidenreich regarded the reddened lymph nodes of the pig as transition forms, but according to Helly the latter always lie very close to large lymph vessels with which they are in connection by the finest branches only which are said to end blindly at the capsule or communicate with the subcapsular sinus. I am unable to confirm this statement of Weidenreich or von Schumacher's conclusion that blood is never found in the lymph sinuses of the nodes of the pig. However, the erythrocytes are scattered about in the parenchyma as they state and my observations are wholly confirmatory of von Schumacher's conclusion that 'hemolymph glands' do not occur in the pig and that with some few rare exceptions, perhaps, the reddened lymph nodes are always in connection with afferent and efferent lymph vessels.

Similar results as above were obtained from injections of the nodes in the thorax and neck the color and location of which were quite characteristic of the normal lymph nodes. However, one small flat, reddish cyst-like node about $2 \times 1.5 \times 0.5$ mm. in size looked quite like a hemal node. This specimen lay directly on the aorta and not far from similar small nodes. The latter were all injected either from the surrounding tissue or from each other, but all attempts to inject the node in question failed. Hence the specimen was excised and examined microscopically. Although my attempts to inject this small bleb-like node were unsuccessful, its true nature need not remain a matter of conjecture. Upon microscopical examination it was found to be a practically depleted node such as I had sometimes found before in the sheep, horse, and bovines. As shown in figure 1 made from a section cut about 15 microns thick, the parenchyma was depleted extraordinarily and the derangement of the intranodal

circulation resulting from this depletion may, in part at least, be responsible for failure to inject it. Upon studying the serial sections it is found that a number of vessels which beyond all question are lymph vessels enter the node at one extremity. The continuations of these vessels are shown to the top in the figure where they still seem to lie within the widened capsule itself. They contain a finely granular coagulum which reminds one of lymph and which is also found in the empty portion of the node. It is well to remember, however, that a similar coagulum could probably be found wherever blood plasma or any serous fluid was contained, although in this case there can be no question regarding its true nature. Besides the finely granular coagulum, this node contains a remnant of the lymphatic parenchyma and very few free erythrocytes and little intravascular blood, but quite a large number of very large phagocytes which are filled mainly with erythrocytes. One of these is shown at (*a*) in figure 2. Transitional forms of these phagocytes are shown at *b* to *g* in the same figure. These cells were drawn approximately to scale and all transition stages between the largest of these which was engorged with scores of erythrocytes and the ordinary lymphocyte characteristic of the germinal center can easily be found. The cellular content of this node has dispelled the slight doubt which I still had regarding the possible phagocytic activity of the prelymphocyte. Some of these phagocytes, both large and small, contain two nuclei which sometimes lie at somewhat different levels in the larger cells. These nuclei are usually quite regular in form with the chromatin scattered about in fine granules. The cytoplasm of the smaller cells usually takes an oxyphile stain and the cells of all sizes not infrequently contain some pigment granules and smaller inclusions as shown in the figures.

In figure 3 a portion of the remaining parenchyma of this node is shown as seen with the oil-immersion lens. Phagocytic cells are evident everywhere and one of them is engorged with erythrocytes. This drawing which was made from a thin section shows very well how depleted the parenchyma of this node really is and how completely the architecture of the node, even

the reticulum itself was disturbed. Only isolated erythrocytes are found in the parenchyma and polymorphonuclear leucocytes are very much rarer.

Here and there larger and smaller masses of partly fused leucocytes as shown in figure 4 are also seen. These cells are very evidently degenerating. Some of them contain vacuoles and most of them also numerous pigment granules. Sometimes only two quite well-preserved parenchyma cells can be seen to fuse and in other cases fusion of several cells has formed a multinucleated mass which could easily be taken for a polykaryocyte.

It is not difficult to see that if such an empty node as this were filled with blood with the latter also filling the lymph vessels connected with the node, it would probably be impossible to positively determine its exact nature histologically. The finding of this specimen also suggests a plausible explanation for the occurrence of such specimens as previously recorded (Meyer, '15) in the pig, horse, and calf. The causes that lead to such a complete depletion of the parenchyma of a lymph node are obscure, but the process would undoubtedly begin as soon as cell proliferation within the node did not equal the removal of lymphocytes from the node or their destruction within it. This does not, however, imply that once begun, the process of depletion necessarily must proceed without halting until the node is empty. That the process may often be intermittent seems indicated in many specimens.

I am wholly at a loss to know why all the markedly depleted specimens which I have seen are small nodes, unless perhaps that nodes become smaller and smaller as they are being depleted. There is abundant evidence that this may be the case, but as long as it is not possible to watch an individual node during the process of transformation one cannot be certain. It is also evident that it may be difficult to determine from microscopic examination alone whether such a depleted node is in reality a lymph node, unless some of the afferent and efferent vessels joining the node have been preserved.

In addition to the redness and the large size many of the red-den lymph nodes of the pig are further distinguished by the

exceeding thinness of their capsules and by the presence of a fatty transformation. In portions of some nodes one can really not speak of the presence of a definite capsule at all for there seems to be no line of demarcation whatever between the node and the surrounding fatty tissue. This is especially true if fatty transformation of the node has occurred, for then the fatty tissue without the node may be directly continuous with that within it. Since hogs are usually well fed and often very fat indeed, the presence of a fatty transformation of the lymph nodes need not surprise one. This transformation does seem to begin extremely early in life, however, and may become exceedingly complete. It would almost seem as though the lymph nodes of the pig played a far more subsidiary rôle, at least in postnatal life; than they do in other mammals.

Sometimes the intranodal fat is confined to a row of cells immediately under the capsule, as shown in figure 5. Von Schumacher also found such specimens. This arrangement of the fat cells could be explained by the statement of Baum ('11) that fatty degeneration or infiltration always begins from the capsule and proceeds inward, causing a pressure atrophy of the lymphocytes. However, since this fatty degeneration or infiltration of the node is, according to Baum, supposed to proceed from the reticulum, it is difficult to understand why it should necessarily begin at the capsule. Moreover, in some cases fat cells are scattered throughout the node, as shown in figure 6. In other cases areas of fatty tissue are found only in the interior of the lymph node and then again the entire mid-portion may be transformed, as in the specimen from a guinea-pig shown in figure 7.

This process of fatty transformation is an exceedingly interesting one and decidedly erratic in nature, but the appearances in the pig do not suggest that it always begins at the hilum, as observed by Rubens, Duval et Fage ('09), although a complete fatty regression as found in man may be present in the pig also. I have not been able to find any very good reasons why fatty transformation should be correlated with the accumulation of erythrocytes within the parenchyma of the node, but what I have seen in the carcasses of hogs and also in some very

fat guinea-pigs has caused me to believe that there is some relation between the two. It does not seem unlikely to me that the advent of fat within a node and the gradual substitution of adipose tissue for the parenchyma might well cause obstruction of the lymph stream. Indeed, it seems that it must of necessity do so. But stagnation of the lymph current would result in an accumulation of erythrocytes within the parenchyma of the node. This has been abundantly demonstrated, especially by the experiments of Retterer ('01) and by Retterer et Lelievre ('10). Since the presence of fat is far less common in the lymph nodes of young bovines, sheep, and goats of an age corresponding to that of these hogs, we may find in this a reason for the fact that the lymph nodes of these animals are less frequently reddened.

A number of the very pink injected lymph nodes of the pig, which were cut serially showed a distribution of the ink characteristic of lymph nodes. In most of them the ink was contained in the large subcapsular sinuses and in the lymph sinuses surrounding the trabeculae. In others the ink although injected under optimum conditions had completely penetrated the parenchyma of the node, even surrounding the individual lymphocytes and penetrating the germinal centers.

Although no very representative series of nodes from the pig was cut, it may be permissible to add that the trabeculae were few and large, the sinuses were very evident, the follicles few and the erythrocytes were intermixed quite uniformly, as mentioned by Weidenreich and von Schumacher, within the parenchyma so as to cause the cross-section to look like a portion of the spleen. Von Schumacher, too, found but few germinal centers and surmised that the proliferation of lymphocytes was not an active one. The nodes examined contained very little pigment and very little evidence of phagocytosis except in the case of the depleted node shown above.

A perusal of Gutig's cytological study of the nodes of the pig shows that he regarded any reddened lymph node as a hemolymph node. Gutig also emphasized that in most pigs examined the only difference between lymph and hemolymph nodes lay in the

fact that the hemolymph nodes contained many more erythrocytes and far greater evidences of degeneration of the latter. Meek, on the other hand, saw few evidences of blood destruction in the pig. Uninucleated eosinophiles and mast cells were found more common in hemolymph than in lymph nodes, undoubted germinative centers for the formation of erythrocytes and granular neutrophiles were also found, and Gutig specifically declared that one must regard all nodes as hemolymph nodes, "larger and smaller areas of which appear dark red on cross section." Since the entire inadequacy of such a criterion must be clear to anyone at all acquainted with the subject, it is unnecessary to justify a refusal to regard Gutig's conclusions regarding the occurrence of hemolymph (hemal) nodes in the pig as valid. Gutig also believed that a lymph node may become a hemolymph node and then again become a lymph node and stated that in most cases he found only quantitative differences between the two kinds of nodes which, to be sure, is tantamount to saying that there is only one kind of node in the pig, namely, a lymph node.

LITERATURE CITED

- BAUM AND HILLE 1908 Die Keimzentren in den Lymphknoten von Rind, Schwein, Pferd und Hund und ihre Abhängigkeit vom Lebensalter der Tiere. *Anat. Anz.*, Bd. 32.
- BAUM 1911 Der Zirkulationsapparat. *Handbuch der vergleichenden mikroskopischen Anatomie der Haustiere*, Bd. 2.
- CLARKSON, ARTHUR 1891 Report on haemal glands. *Brit. Med. Jr.*, vol. 2.
- GUTIG, KARL 1907 Zur Morphologie des Schweinblutes. *Arch. mikr. Anat. u. Entw.*, Bd. 70.
- HELLY, KONRAD 1902 Haemolymphdrüsen. *Ergebn. Anat. u. Entwicklgsch.* Bd. 12.
- HERBST 1844 Das Lymphgefäßsystem und seine verrichtung. (Cited after Helly.)
- MEEK, W. O. 1910 Some morbid histological changes met with in the lymph glands, especially with the formation of hemolymph glands. *Quart. Jr. Med.*, Oxford, vol. 3.
- MEYER, A. W. 1915 *Spolia Anatomica Addenda I*. *Anat. Rec.*, vol. 9.
- RETTGER, ED. 1901 Recherches expérimentales sur les ganglions lymphatiques pour montrer qu'ils fabriquent outre le plasma et les globules blanc, des globules rouges qui sont emportés par le courant lymphatique. *Comptes Rend. Ass. Anat. Troisième session, Lyon*.

- RETTERER, ED., ET LELIEVRE 1910 Précède simple pour voir que le ganglion lymphatique possede des hematies. *Comptes Rend. Soc. Biol.*, T. 68.
- RICHTER, JOHANNES 1902 Vergleichende Untersuchungen über den mikroskopischen Bau der Lymphdrüsen von Pferd, Rind, Schwein und Hund. *Arch. mikr. Anat. Bd.* 60.
- RUBENS, H. DUVAL, ET FAGE 1909 La regression du ganglion lymphatique. *Comp. Rend. Biol.*, T. 67.
- SABIN, FLORENCE 1907 The lymphatics. Morris' Human Anatomy, Fourth edition. Philadelphia.
- 1905 The development of the lymphatic nodes in the pig and their relation to the lymph hearts. *Am. Jour. Anat.*, vol. 4.
- 1911-12 The development of the lymphatic system. Human Embryology, Keibel and Mall, vol. 2. Philadelphia.
- VINCENT AND HARRISON 1897 On the hemolymph glands of some vertebrates. *Jr. Anat. Phys.*, Lond., vol. 31.
- VON SCHUMACHER, S. 1912 Bau, Entwicklung und systematische Stellung der Blutlymphdrüsen. *Arch. f. mikr. Anat. Bd.* 81.
- WEIDENREICH, FRANZ 1902 Die Blutlymphdrüsen und ihre Beziehung zu Milz und Lymphdrüsen. *Verh. anat. Gesellsch.*

PLATE 1

EXPLANATION OF FIGURES

- 1 Cross-section of an empty node from the thoracic region of the pig. $\times 79$.
- 2 Phagocytic cells from the same node. $\times 750$.

PLATE 2

EXPLANATION OF FIGURES

- 3 A small portion of the same node taken from the undepleted portion.
× 410.
- 4 Fusing, pigmented, degenerating leucocytes from the same node. × 515.
- 5 Fat cells in the periphery of a lymph node from the pig, the parenchyma
of which contains many erythrocytes. × 320.

PLATE 3

EXPLANATION OF FIGURES

- 6 Fat cells distributed at random throughout a lymph node of the sheep.
× 72.
- 7 Fatty transformation of the midportion of a lymph node from the guinea-
pig. × 42.