LYMPHATICO-VENOUS COMMUNICATIONS IN THE ALBINO RAT

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There has long been disagreement as to whether lymphatico-venous communications —exclusive of the subclavian connexions—are a normal occurrence. Bartels (1909) definitely denies their existence and disputes the claims of earlier investigators who had recorded such anastomoses. Baum (1911, 1912) considered that he had found lymphatico-venous communications several times in the thorax and abdomen of cattle, but he admits that it is often difficult to prove that the dye has been injected into a lymph vessel and not into a vein. There are some reports which indicate that the situation may vary from species to species or group to group. In New World monkeys Silvester (1912) found that the main opening of the mesenteric and lower limb lymphatics was into the inferior vena cava near the renal vein, but in the Old World monkeys no indications of these communications could be found. In the common wild rat, the frequency and localization of lymphatico-venous communications was investigated by Job (1918). In 48% of the rats injected through, or caudal to, the lumbar nodes lymphatic communication with the inferior vena cava just cranial to these nodes was found and 8% showed renal vein communications. In cats, however, Carlsten & Olin (1952) found that the only route for any appreciable amount of intestinal lymph to reach the blood stream was the thoracic duct.

It is of the utmost importance for the evaluation of a number of physiological investigations concerning the lymphatic system and for an understanding of the spread of cancer by this system to determine the occurrence and frequency of lymphatico-venous anastomoses. The literature contains no reports of such investigations in the common laboratory rat, and Job's findings have not been confirmed. This problem has, therefore, been investigated, and by a method different from that previously employed.

MATERIAL AND METHODS

The material included twenty-two rats of the laboratory's hooded strain, bred as a closed population for many years, and five wild rats (*Rattus norvegicus*).

The lymphatics were visualized by injecting metallic mercury into the lymph vessels or nodes. Their course can then be determined both roentgenologically and by dissection (Engeset, 1959). Job (1918) states that lymphatico-venous anastomoses were found most readily in healthy animals which were active just before sacrificing and which were injected immediately after death. He found more anastomoses in animals killed with illuminating gas than in animals killed with chloroform or ether. 'Pregnant females, within a few days of delivery, always showed two or more venous connexions besides the thoracic duct taps.' These points were borne in mind and every effort was made to afford optimal conditions for the demonstration

of lymphatico-venous anastomoses by using healthy rats, pregnant within a few days of delivery. The animals were killed with carbon monoxide after running in a drum for 1–2 min. They were laparotomized immediately after killing, and mercury was injected into the lumbar nodes.

The injection was made with an automatic syringe which delivered 0·01 ml./min. First 0·04 ml. was injected into the right lumbar node and the mercury usually went to the saccus lymphaticus and the thoracic duct, or it could be milked up into the duct. To force the filling of lymphatico-venous anastomoses in the abdomen, the thoracic duct was then ligated in the middle of the thorax, and 0·08 ml. mercury was then injected in the left lumbar node. The animals were X-rayed and the findings were controlled by dissection under magnification.

RESULTS

Series 1 consisted of the twenty-two rats of the laboratory strain. In all of them the roentgenograms showed mercury in a number of lymph vessels and nodes in the abdomen. The saccus lymphaticus was distended with mercury, and in most of the animals was a considerable amount of retrograde filling in the chylus vessels (Pl. 1, figs. 1 and 2).

In fifteen of the animals neither the roentgenograms nor the dissection afforded any evidence of lymphatico-venous connexions in the abdomen.

In seven of the animals drops of mercury could be identified in the large abdominal veins. In none of these, on dissection, however, were the lymphatics observed to empty into the veins. In three of them it was established that the mercury had entered the venous system through small veins in the wall of the left lumbar node, and in one through veins in the wall of the right lumbar node (Pl. 1, fig. 4). In two of the animals the passage was, respectively, through veins in the wall of the right and the left renal node (Pl. 1, fig. 3). In one animal the site of the communication was not found. In this specimen the mercury was seen as a column in the vena cava between the two lumbar nodes. Ventral to the vein there was an abundant network of small, mercury-filled vessels which were connected with the lumbar nodes. In an attempt to follow one of these vessels towards the dorsal side of the vena cava the vein was ruptured and the dissection was spoiled.

Series 2. Five wild rats were investigated in this series. They were pregnant and, like those in Series 1, they were killed with carbon monoxide and the thoracic duct was ligated.

In none of these wild rats were lymphatics observed to empty into abdominal veins. In two animals, however, mercury had entered the vena cava through small veins in the wall of the left lumbar node. In a third rat which showed drops of mercury in abdominal blood vessels, it was not possible to find the connexion between the lymphatic and venous system. In this animal the mercury injection had not been completely successful. Several punctures had been made in the left lumbar node, and it is possible that a small amount of mercury may have been directly deposited in a vein.

DISCUSSION

Metallic mercury was injected in the lumbar nodes of twenty-two tame and five wild rats to investigate the frequency of lymphatico-venous communications. The topography of the efferent lymphatics was determined roentgenologically and by dissection. In no case was it found that the lymph vessels from the nodes emptied into abdominal veins. This is in contradiction to Job's findings in wild rats: under optimal conditions—which have also been applied in the present investigation—he found lymphatico-venous communications in the abdomen in practically all of the animals he examined. According to Job the lymphatic system of wild rats is much better developed than in captive white specimens. This may explain why the results are so different, but it is surprising that no anastomoses were found in any of the five wild rats examined. Job injected a Berlin blue gelatin mass and indian ink. If the anastomoses to the venous system are of a very fine calibre, this may make a difference, as indian ink would presumably flow more readily through the lymph vessels than mercury. But it is not reported that the lymphatico-venous communications, which have also been demonstrated in other animals, are particularly thin. Moreover, it is known that mercury flows readily in vessels of ordinary calibre.

It is our opinion that mercury affords a more reliable basis for the study of this problem than the injection of various dyes. The mercury does not mix intimately with blood or lymph. For this reason it is relatively easy to determine whether the injection has entered a small blood or lymph vessel. In the cases where the mercury passed into veins in the wall of a node, drops of blood were found between the drops of mercury, and there were side branches which contained pure blood. Further, the passage occurred through veins which ordinarily lead from the node and the topography of which is familiar from numerous injections and dissections (Pl. 1, fig. 4). After injection of mercury the course of the lymphatics can be accurately determined roentgenologically, and even the smallest passage of mercury to the venous system can be visualized. Thus lymphatico-venous communications which allow the passage of mercury will not be overlooked, and it may easily be determined whether a lymph vessel which appears to end in the wall of a vein has emptied into the vein or not. In such cases it is also an advantage that the mercury can be 'milked' forward in the lymph vessels. This has been done several times when the mercury filled a lymph vessel which appeared to end in the wall of the vena cava. By palpation of the end point of the vessel and 'milking' of the mercury, it was possible to follow the further course of the lymph vessel, usually over to the lymphatics on the other side.

Investigation by this method affords such a high degree of accuracy that it is possible to draw the conclusion that lymphatico-venous communications in the abdomen must be very rare in the laboratory strain examined, or they must be of such fine calibre that they do not allow the passage of mercury, even under the optimal conditions provided. In several of the rats the mercury entered the large veins through small veins in the wall of a lymph node. This may possibly be due to the puncture of the node or to lesions resulting from the high pressure used for the injection. Whether it can be due to lymphatico-venous anastomoses in the lymph node itself has not been investigated or considered.

ENGESET—LYMPHATICO-VENOUS COMMUNICATIONS IN THE ALBINO RAT

(*Facing p.* 383)

The observations made can hardly be confined to the strain of rats employed in investigation. After injection of mercury in the knee node and in lymph vessels on the hind-leg of fifty-six rats from another laboratory, not a single case was observed in which lymph vessels emptied into abdominal veins.

SUMMARY

In order to examine the frequency of lymphatico-venous communications in the abdomen, metallic mercury was injected in the lumbar nodes of twenty-two tame and five wild rats. The injections were made under conditions which should afford optimal possibilities for the demonstration of such anastomoses. The topography of the vessels was determined roentgenologically and by dissection. In none of the specimens were the lymphatics from the lumbar nodes observed to empty into abdominal veins. In some of the rats, probably owing to injection artefact, mercury entered the vena cava inferior through small veins in the wall of the lymph nodes.

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EXPLANATION OF PLATE

Fig. 1. Rat. Mercury injected in lumbar nodes, both sides. Thoracic duct ligated. Saccus lymphaticus distended with mercury. Anastomoses between lymph vessels. No mercury outside the lymphatic system.

Fig. 2. Rat. Mercury injected in lumbar nodes, both sides. Thoracic duct ligated. Note the retrograde filling in the chylus vessels. No mercury outside the lymphatic system.

Fig. 3. Rat. Mercury injected in lumbar nodes, both sides. Thoracic duct ligated. Note mercury outside the lymphatic system in a vein proximally in abdomen.

Fig. 4. Radiogram of the right lumbar node magnified. Most of the node with efferent and afferent lymph vessels filled with mercury. Note that large amounts of mercury have entered vena cava inferior and vena iliaca com. An arrow points to small veins through which the mercury entered the vena cava.