Topographical Anatomy of the Internal Mammary Lymphatics in the Superior Mediastinum and Anterior Mediastinal Lymph Nodes

By

Masashi FUJII, Gen MURAKAMI*, Toshiyuki YAMAGATA, Kazuyuki SHIMADA**, Hajime HOSHI* and Takashi TANAKA

Department of Surgery and Department of Anatomy, Nihon University School of Medicine, Tokyo, Japan
Department of Anatomy**, Showa University School of Medicine, Tokyo, Japan

—Received for Publication, April 19, 1994—

Key Words: Internal mammary lymphatics, Mammary gland, Superior mediastinum, Anterior mediastinal lymph nodes, Human gross anatomy

Summary: The lymphatics lying along the internal thoracic artery and vein, which are termed the “internal mammary lymphatics” (IML), were minutely dissected in 134 adult cadavers (80 males and 54 females, aged 27–94 years) in order to clarify the configuration of IML in the superior mediastinum.

On the right side, IML frequently terminated at the brachiocephalic angle (BA) nodes and often at the nodes situated at an intermediate position between the internal thoracic artery and vein. By way of these nodes, IML communicated with regional lymphatics of the lung and esophagus. Moreover, IML joined the right superficial bronchomediastinal trunks. On the left side, IML consistently terminated at a superficial group of aortic arch nodes, termed the “superior phrenic nodes”, lying along the left phrenic nerve and lying medially to the internal thoracic vein and inferiorly to the left brachiocephalic vein. At and around these nodes, IML joined drainage routes from the so-called Botallo’s nodes, which received the left lung lymphatics. The efferents of the superior phrenic nodes formed the left superior bronchomediastinal trunks, and passed deeply to the left brachiocephalic vein and on the subclavian artery toward the left venous angle region. Consequently, IML formed common drainage routes with the drainage routes from the lung and esophagus in the superior mediastinum.

A transverse communicating route of IMLs via the retromanubrial nodes, lying inferior to or along the left brachiocephalic vein, was often observed. On the right side, the communicating route terminated at the BA nodes or the nodes situated at an intermediate position between the internal thoracic artery and vein. On the left side, the route consistently terminated at the superior phrenic nodes. In addition to the communicating route described above, we identified (1) a direct and superficial transverse communicating route, and (2) a deep transverse communicating route. The former route was composed of fasciculated large collecting vessels directly connecting the BA nodes to the left venous angle region, lying superficial to the left brachiocephalic vein. The latter route was composed of several large collecting vessels, crossing the brachiocephalic and left common carotid arteries superficially, and merging into the left phrenic nodes directly or occasionally via the pretracheal nodes. These results suggested that IMLs of both sides can closely communicate with each other in the superior mediastinum.

The internal mammary (or thoracic) lymphatics (IML) have been well known as a lymphatic node chain situated along the internal thoracic artery and vein (Williams and Warwick, 1980). From the surgical point of view (Haagensen et al. 1972; Japan Breast Cancer Society, 1989), the IML are composed of two parts: (1) the parasternal node chain draining into the venous angle region along the internal thoracic artery and vein, and (2) a transverse communication between the superior portion of the node chain via the retromanubrial nodes (Plate 1). This overly simplistic interpretation seems to be based on previous anatomical investigations of IML that were concentrated on its anterior mediastinal portion (Stibb, 1918; Nishida, 1938; Kaneko, 1989). In contrast, few anatomical studies have been performed on its superior mediastinal portion (Hiraki, 1958). Hiraki (1958) considered that IML mainly empty into the brachiocephalic angle nodes (BA nodes: defined by Bartels, 1909) on the right side and into the superior group of the aortic arch nodes on the left side, and that the transverse communication via the retromanubrial nodes connects these nodes to each other. However, the aortic arch nodes are

Address correspondence to Dr. Gen Murakami, Department of Anatomy, Nihon University, School of Medicine, 30 Ohyaguchi-Kamimachi, Itabashi-ku, Tokyo 173, Japan

99
considered to be situated at the anterior surface of the aortic arch, the position of which seems to be away from (deep to) IML. Moreover, Murakami et al. (1990) suggested that the terminal portion of IML, in other words, the last intercalated nodes of IML, varies in location according to the configuration of other drainage routes from the thoracic viscera, involving the possibility of the internal mammary trunk (Jossifow, 1930). Murakami et al. (1990) also reported the existence of the superficial communicating vessels between the venous angles which run transversely in close relation to the BA nodes. Thus, it has been expected that another configuration of the transverse communication would be found, in addition to the "classical" transverse communication. The aim of this study was to clarify the topographical anatomy of IML in the superior mediastinum, relating to the arrangement of the "anterior" mediastinal nodes (which are located mainly in the "superior" mediastinum; reviewed by Sato and Sakamoto, 1992), in order to clarify such points as those mentioned above (Plate 2).

Materials and Methods

The lymphatics lying along the internal thoracic artery and vein, and those around the large vessels in the superior mediastinum were minutely dissected macroscopically in 134 adult cadavers (80 males and 54 females, aged 27–94 years) without neoplasms in the region at the clinical level before donation. After cutting the internal thoracic artery and vein at the most distal (inferior) portions possible, the anterior thoracic wall was removed. The dissection was performed on the removed thoracic wall as well as on the superior mediastinum. Special attention was paid to the transverse communicating routes of IMLs of both sides and to the relationship between IML and the bronchomediastinal lymphatic trunks, the latter of which was defined in our previous study (Murakami et al. 1990). After the gross observation described above, large collecting vessels were removed with the related lymph nodes. The lymph vessels were immersed in water and dissected under a stereomicroscope (x10–20), in order to observe their valves and the portions connecting to the lymph nodes. During the stereomicroscopic observation, we verified a large lymph vessel that was sometimes quite similar to a vein, since the lymph vessels terminated at or communicated with the marginal or medullary sinuses of the nodes (Hoshi, 1987). In addition, in cases of long collecting vessels, such as the direct and superficial transverse communicating vessels (see Results), fine intercalated nodes along the vessels were examined using the clearing method with methylsalicylate (Murakami et al. 1994b). There appeared to be no difference between the configuration of IMLs of males and females, as suggested by previous studies (Murakami et al. 1990, 1994c).

Results

A. Right side

The internal mammary lymphatics (IML) frequently (in 90 of the 134 cases) terminated at the brachiocephalic angle (BA) nodes situated at an angle between the right and left brachiocephalic veins (Plates 3 and 7). The BA nodes often extended deeply to the right paratracheal node chain, so that these two node groups were continuous with each other. The BA nodes also communicated with the pretracheal nodes through the large collecting vessels superficially crossing the brachiocephalic artery (i.e. the right half of the deep transverse communicating route; see below). Relating to the different and independent courses of the internal thoracic artery and vein (Herniquez-Pino et al. 1993), IML often (23 cases) terminated at the nodes situated at an intermediate position between the internal thoracic artery and vein (Plate 4), irrespective of whether or not IML also terminated at BA. The nodes lying at the intermediate position did not closely communicate with the right paratracheal node chain. However, the nodes at the intermediate position closely communicated with the right phrenic node chain (Caplan, 1990) along the phrenic nerve, so that the nodes might be called the superior phrenic nodes, as proposed on the left side (see below). During the more proximal course of the draining route between these nodes described above and the right venous angle region, IML formed common trunks (the right superficial bronchomediastinal trunks; Murakami et al. 1990) lying on the anterior surface of the right brachiocephalic vein together with other drainage routes from the mediastinum, in particular, those from the right paratracheal node chain. However, IML sometimes (6 cases) terminated at the nodes lying close to the origin of the internal thoracic artery. In this case, the draining vessel passed deeply to the subclavian artery and joined the right deep bronchomediastinal trunks (Murakami et al. 1990). Moreover, in 5 cases, the draining vessel originated from the parasternal nodes at the level of the second or third intercostal space in the anterior mediastinum and directly merged into the right venous angle region (i.e. the right internal mammary trunk; see Introduction). The right internal mammary trunk co-existed with other collecting vessels of IML which terminated at the BA nodes and/or the nodes lying at an intermediate position between the internal
Internal Mammary Lymphatics in the Superior Mediastinum

B. Left side

In 105 of the 134 cases, IML terminated at a group of the aortic arch nodes. In the other 29 cases, the left IML in the superior mediastinum was not observed clearly. The group of aortic arch nodes was located along or superficial to the left phrenic nerve as well as medially to the internal thoracic vein and inferiorly to the left brachiocephalic vein. These nodes were situated in front of the aortic arch, but did not attach to the aortic arch, in contrast to the other aortic arch nodes. Thus, the nodes should be identified as the “superior” group or aortic arch nodes, not as the superior group as classified by Kutsuna (1968). We named the nodes the “left superior phrenic nodes” after the “superior phrenic node chain” of Caplan (1990) and as a modification of “the phrenic nodes” of Murakami et al. (1990). The superior phrenic nodes were sometimes well developed and fused with other aortic arch nodes lying at the anterior surface of the aortic arch, so that the phrenic nerve as well as the internal thoracic artery and vein, and occasionally the vagus nerve also, passed through the large mass of nodes. The superior phrenic nodes consistently received the drainage routes from the so-called Botallo’s nodes (Nishi et al. 1990), lying close to the anterior aspect of Botallo’s ligament (Lig. arteriosum), and also received those from nodes lying on the anterior aspect of the left pulmonary artery. Thus, at the superior phrenic nodes, the left IML formed a common drainage route along with other mediastinal lymphatics. The common route was composed of 2–3 large collecting vessels (Plate 5). The collecting vessels corresponded to the left superior bronchomediastinal trunks (Murakami et al. 1990). The large collecting vessels from the superior phrenic nodes passed deeply to the left brachiocephalic vein and on the subclavian artery, and merged into the left venous angle region or into the thoracic duct. Along their course, the left common drainage route often joined collecting vessels from the left paratracheal node chain. A collecting vessel from the parasternal nodes in the anterior mediastinum coexisted with the common route and drained directly into the right venous angle region in 7 cases (i.e. left internal mammary trunk; see Introduction).

In the cases of left IML that terminated at the superior phrenic nodes, large collecting vessels from the parasternal nodes sometimes emptied into small nodes lying close to the left brachiocephalic vein (9 cases) (Plates 3 and 4). Moreover, in another 5 cases of superior phrenic nodes, the collecting vessels drained into the nodes lying close to the origin of the internal thoracic artery. In the former 9 cases, the efferent vessels of the small nodes joined the collecting vessels from the pretracheal nodes and/or communicated with the common drainage route of the superior phrenic nodes, then merged into the left venous angle region. In the latter 5 cases, the efferents passed superiorly and between the subclavian artery and vein, and emptied into the venous angle region, with or without joining other large collecting vessels along their courses.

Table 1 summarizes these observations of the last intercalated nodes along IMLs before the formation of the common drainage route.

C. Transverse communicating route

1) The transverse communicating route between the left and right IMLs via the retromanubrial nodes (the “classical” communicating route, Plate 1) was often observed along or inferior to the left brachiocephalic vein (in 86 of the 134 cases). The classical communication was composed of a node chain (Plate 6) or a few nodes and large interconnecting vessels (Plate 4). The right terminal of the communicating route was situated at the BA nodes (56 of the 86 cases) or the nodes situated at an intermediate position between the internal thoracic artery and vein (28 cases, Table 2). In the other 2 cases, the classical communicating route, lying inferior to and away from the left brachiocephalic vein, originated from the parasternal nodes at the level of the second intercostal space in the anterior mediastinum. In contrast, the left terminal was consistently identified at the superior phrenic nodes, except for 9 cases in which the communicating route terminated at the

Table 1. Configuration of the terminal portion of IML in the superior mediastinum

<table>
<thead>
<tr>
<th>Right last-intercalated nodes</th>
<th>90*</th>
<th>23</th>
<th>6</th>
<th>5</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Brachiocephalic angle nodes</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2. Node at an intermediate position between the internal thoracic artery and vein</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>3. Node lying close to the origin of the internal thoracic artery</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>4. Parasternal node in the anterior mediastinum (right internal mammary trunk)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Left last-intercalated nodes</td>
<td>105*</td>
<td>9</td>
<td>5</td>
<td>7</td>
</tr>
<tr>
<td>1. Superior phrenic node**</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2. Node lying close to the left brachiocephalic vein</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>3. Node lying close to the origin of the internal thoracic artery</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>4. Parasternal node in the anterior mediastinum (left internal mammary trunk)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

* In 134 cases examined, except for cases in which IML was not identified clearly in the superior mediastinum. Each of these 4 types co-existed with other types of drainage.

** The nodes was defined in the present study (see Results).
Table 2. Configuration of the classical transverse communicating route

<table>
<thead>
<tr>
<th>Right terminal nodes</th>
<th>Brachiocephalic angle nodes</th>
<th>56*</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Node at an intermediate position between the internal thoracic artery and vein</td>
<td>28</td>
</tr>
<tr>
<td></td>
<td>Nodes at the right paratracheal nodes in the anterior mediastinum</td>
<td>2</td>
</tr>
<tr>
<td>Left terminal nodes</td>
<td>Superior phrenic nodes**</td>
<td>77*</td>
</tr>
<tr>
<td></td>
<td>Node lying close to the left brachiocephalic vein</td>
<td>9</td>
</tr>
<tr>
<td>Number of the retromanubrial nodes:</td>
<td>1–2</td>
<td>13***</td>
</tr>
<tr>
<td></td>
<td>3–4</td>
<td>56</td>
</tr>
<tr>
<td></td>
<td>more than 5</td>
<td>17</td>
</tr>
</tbody>
</table>

* The classical transverse communication was observed in 86 of 134 cases examined (see also Table 2).
** defined in the present study (See Discussion section).
*** In total 86 cases of the classical communicating routes.

small nodes, lying on the left brachiocephalic vein (Plate 4). The small nodes also communicated with the superior phrenic nodes. The retromanubrial nodes varied in number (Table 2), but numbered 3–4 in most cases. By way of the retromanubrial nodes, the classical transverse route often communicated with the pretracheal nodes and the right paratracheal node chain, and sometimes to the aortic arch nodes lying at the base of the left common carotid artery. The classical communicating route also received fine vessels from the fatty body of the thymus remnant. The valves of the interconnecting vessels along the classical communicating route suggested that the lymph flow was along the route directed to the left side (Plate 4B).

In addition to the classical communicating route, two other transverse communicating routes were identified and co-existed (Table 3).

2) The large collecting vessels originated from the BA nodes and emptied into the left venous angle region or the thoracic duct, lying superficial to the left brachiocephalic vein (25 cases, Plate 7A). In the 25 cases, fine intercalated nodes were not found along the entire course from the BA to the left venous angle region, even in the cleared specimens (Plate 8). We named this second communicating route the “direct and superficial transverse communicating route.” The direct and superficial communicating route did not co-exist with the classical route, but co-existed with the third communicating route described below. The direct and superficial communicating route was composed of 1–6 large collecting vessels, which were fasciculated or lay in parallel, varying case by case and depending on the location along the course. These vessels sometimes joined the draining vessels at the midportion of the entire course along the left brachiocephalic vein. Also, at the terminal portion of the vessels, the second communicating route often joined other collecting vessels from the mediastinum. The valves of the direct and superficial communicating vessels suggested that the lymph flowed along the route directed to the left side (Plate 7B). Moreover, the superficial transverse communicating vessel (Murakami et al. 1990) was observed in 2 of the 134 cases examined (Plate 9). This special communication was composed of a long and large collecting vessel, similar to the second communicating route of IMLs. However, the vessels connected directly between the venous angle regions of both sides, passing in the pretracheal region. The very low incidence contrasted to that in our previous study (Murakami et al. 1990). In these 2 cases, the superficial transverse communicating vessel did not communicate with IMLs and did not co-exist with the second communicating route, but communicated only with the pretracheal nodes.

3) The collecting vessel connected the BA nodes to the left superior phrenic nodes, crossing behind large veins and the inferior thyroid veins, and crossing the brachiocephalic and the left common carotid arteries superficially (41 cases, Plate 10A). We named the route the “deep transverse communicating route.” The deep communicating route was composed of 1–6 large collecting vessels. The large vessels often communicated with the pretracheal nodes, and occasionally were intercalated by the nodes in front of the base of the left common carotid artery. Other large collecting vessels, crossing before or behind the left common carotid artery, sometimes connected the deep communicating route to the left venous angle region or the thoracic duct. Moreover, the large collecting vessels, which seemed to correspond to the right half of the deep communicating route, frequently (72 of the 134 cases examined, including the 41 cases of deep communication) connected between the BA nodes and the pretracheal nodes.

Table 3. Various configurations of the transverse communicating route of IMLs of both sides

<table>
<thead>
<tr>
<th></th>
<th>Classical retromanubrial communication*</th>
<th>86**</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Direct and superficial communication</td>
<td>25</td>
</tr>
<tr>
<td></td>
<td>Deep communication</td>
<td>41</td>
</tr>
</tbody>
</table>

* The configuration of the classical communicating route was described in the Introduction section. The other 2 communicating routes were defined in the present study (see Results).
** In 134 cases examined, except for cases in which IML was not identified clearly in the superior mediastinum, these 3 types of transverse communication sometimes co-existed with other types.
(Plate 7A). The valves were not clearly observed or showed irregular arrangement along the large collecting vessels crossing the brachiocephalic artery (Plate 10B).

In view of the fascial arrangement, these transverse communicating routes described above, including the superficial transverse communicating vessel (Murakami et al. 1990; see above), were located in the loose vascular sheath (Sato et al. 1984) around the large vessels in the superior mediastinum. The vascular sheath existed deeply to the thyro-pericardiac fascia (lame thyro-pericardique in Perlemutter and Waligora, 1984). The thyro-pericardiac fascia connects the capsule of the thyroid gland and the fibrous pericardium, and extends deeply to the fatty tissue of the thymus remnant. Moreover, the superior and lateral portion of IML, i.e. that along the phrenic nerve and/or the proximal portion of the internal thoracic artery, often attached to the parietal pleura.

The present observations of the configuration of IML in the superior mediastinum are summarized in Plate 11.

Discussion

Until 1980, many surgeons had considered that breast cancer surgery should be radical and that en mass resection of IML after opening of the sternum was necessary (Urban and Baker, 1952; Handley and Thackray, 1954; Hultborn et al. 1955). Recently, however, there has been an increasingly strong tendency toward reduced resection without removal of IML, and IML has seemingly been excluded from the target of lymphatic resection (Veronesi et al. 1985). Nevertheless, the anatomy of IML has become clinically important again, since diagnostic procedures have been much improved in order to find occult metastases along IML using ultrasonography or lymphscintigraphy (Kaplan, 1983; Scatarige et al. 1989).

The present study demonstrated the configuration of IML in the superior mediastinum, relating to the arrangement of the anterior mediastinal nodes. This large group of mediastinal nodes has been roughly classified into 3 subgroups: BA nodes on the right side, aortic arch nodes on the left side and the intermediate group (Rouvière, 1932; Schaeffer, 1953; Sato and Sakamoto, 1992). The BA nodes, which closely communicate with the regional lymphatics of the lung and esophagus (Riquet et al. 1991, 1993, Riquet, 1993; Murakami et al. 1990), have been considered a critical terminal point of both IML and the classical communicating route (Hiraki, 1958; Kutsuna, 1968). However, in the present study, the IML often terminated at nodes other than the BA nodes on the right side. Moreover, the BA nodes are not located along the major lymphatic pathway via the right recurrent nerve nodes (Nishi, 1990) from the lung and esophagus on the right side (i.e. the right deep and the right superior-most broncho-mediastinal trunks by Murakami et al. 1990). In contrast, on the left side, IML consistently terminated at the superior phrenic nodes, which were separated from the other nodes lying on the aortic arch. At and around the superior phrenic nodes, IML joined the drainage route from Botallo’s nodes. Botallo’s nodes are situated at a critical position along the drainage route from the left lung (Nishi et al. 1990; Riquet et al. 1993b). Therefore, IML seemed to exhibit a closer relationship with the drainage routes from the lung and esophagus on the left side than that on the right side. In contrast to the close relationship with the other lymphatics discussed above, Jossifow (1930) described that IML formed the internal mammary trunk, which was independent of the other regional lymphatics. However, we believed that a common drainage route and the internal mammary trunk co-existed, since the controversial point seemed to originate from the difference in definition of a “lymph trunk” (Murakami et al. 1990). We considered that the internal mammary trunk was a collateral pathway of IML in the superior mediastinum, which was similar to other collateral lymphatic configurations as often seen at various regions (Murakami et al. 1994a).

We identified three transverse communicating routes of IMLs. Occasionally, these routes were well developed and composed of very large collecting vessels. Our observations suggested that metastases of breast cancer as well as lung and esophageal cancers are easily carried contra-laterally along the communicating routes. However, studies using lymphscintigraphy (Vendrell-Torne et al. 1972; Ege, 1976) demonstrated the presence of only the “retromanubrial nodes” along the classical transverse communicating routes. Further, these clinical investigations did not reveal the close relationship of IML with other regional lymphatics. Moreover, in the physician’s view, the retromanubrial nodes may be considered the nodes behind the sternal manubrium. However, other anterior mediastinal nodes, particularly the BA nodes, were also located behind the skeletal shield of the superior mediastinum (Plate 11). Because of this confusion, if present, and the simplistic interpretation of IML (see Introduction), it seems likely that positive observations supporting our present results might have been considered either an artifact or a rare variation during previous clinical investigations.
Acknowledgement

We wish to thank Prof. Tooru Sato and Associate Prof. Iwao Sato (Department of Anatomy, Nippon Dental University, Tokyo) for their encouragement. We also wish to thank Prof. Tatsuo Sato, Tokyo Medical and Dental University, for his excellent guidance at the beginning of our study.

References

7) Hiraki S. Anatomical study as to whether there are the bronchomediastinal trunks and their common trunk or not in Japanese embryos. Kumamoto Med J 1958;32:812-841.
9) Hultborn KA, Larson LG. and Ragnhult I. The lymph drainage from the breast to the axillary and parasternal lymph nodes, studied with the aid of colloidal Au198. Acta Radiol 1955; 43:52–64.

Common abbreviations

AO: aortic arch; BA: brachiocephalic angle nodes; BCA: brachiocephalic artery; CC: (left) common carotid artery; IH: infrahyoid muscles; IT: internal thoracic artery and/or vein; LBC: left brachiocephalic vein; P: phrenic nerve; PS: parasternal nodes; PT: pretracheal nodes; RBC: right brachiocephalic vein; RM: retromanubrial nodes; SC: subclavian vein; SVC: superior vena cava; TD: thoracic duct; THY: thyroid gland; TR: trachea; VA: venous angle region; X: vagus nerve.

Explanation of Figures

Plate I

Schematic representation of the configuration of IML from the surgical point of view.

The IML was composed of two parts: (1) the PS node chain, lying along the IT artery and vein, draining into the VA, and (2) a transverse communication (arrowhead), lying in front of large vessels of the superior mediastinum, between the superior portion of the node chains via the RM nodes.
Schematic representation indicating unclear points in the configuration of IML in the superior mediastinum.

The BA nodes are well known as a consistent node group lying at an angle between the LBC and RBC veins. The R and L nodes indicate the last intercalated nodes, which are situated immediately before IML joining other drainage routes. Kutsuna (1968) identified the BA nodes as the R nodes and also identified the superior group of the aortic arch nodes as the L nodes. However, the topographical anatomy of the R and L nodes and their draining routes have remained unclear. Moreover, the direct draining vessels (the internal mammary trunk: IMT) may originate from the PS nodes in the anterior mediastinum. The drainage routes from the thoracic viscera (curved open arrows) seem to join IML at the BA nodes as well as at other portions of IML, including the R and L nodes. In addition to the classical transverse communicating route (arrowheads) of IMLs via the RM nodes, other communicating routes (asterisk) seem to exist in the superior mediastinum. Moreover, it is also unclear which nodes terminate the classical communicating route.
Plate III

Photograph showing the entire configuration of IML in the anterior mediastinum. Ventral view after removal of the anterior thoracic wall.

The IML in the anterior mediastinum, lying along the IT artery and vein, is composed of several PS nodes and large interconnecting vessels (black arrowheads). The classical transverse communicating route passed via the BA nodes and RM nodes to the small nodes (white star), situated close to the LBC and IT veins. The superior portion of this figure is shown in Plate 4. The wide white arrow indicates a large anthracomatous node lying at the intermediate position between the IT artery and vein. This node extends deeply to the anterior surface of the SVC. The number (1–5) indicates the location of each rib that has been removed. Numerous arrowheads indicate the lymph nodes and large collecting vessels.
Plate IV

Photograph showing the IML in the superior mediastinum of the same specimen as in Plate 3.

A. The common trunks formed by the IMLs (black arrowhead) with other regional lymphatics, running along the RBC and LBC veins, drain into the VA. Along the left common trunk, two intercalated nodes (black open stars) are present. The SC veins have been cut, reflected ventrally and fixed to the IH muscles by two green pins. The transverse communicating route (black arrows) communicated via the BA node and RM nodes between a large anthracomatous node (wide white arrow) at an intermediate position between the IT artery and vein and small nodes (white star) situated close to the LBC vein. The BA node communicated with a deep node (black asterisk) lying between the RBC vein and BCA artery. The trachea is not observed behind the IH muscles in this case. P: A root of the right P nerve superficially crossing the subclavian vein.

B. Internal aspect of the large interconnecting vessel along the transverse communicating route at a portion indicated by the white dotted line in A. The configuration of valves (small arrows) suggests that the lymph flow was directed to the left side (large arrow). Scale: 1 mm.
Plate V

Photograph showing the terminal portion of the left IML.

The superior phrenic nodes (white star) are prominently developed in this case and occupy a large space in front of the AO. As a result, the nodes are located close to the so-called Botallo’s nodes (BL) and to Botallo’s ligament (white and black arrows). Large collecting vessels originate from the superior phrenic nodes. These vessels run superiorly, in front of the left SC artery and deeply to the LBC vein (reflected to the left side), along the left X and P nerves, terminating at the left VA. The left IT artery is slightly removed to the left side. The P nerve has been moved to the left side. R: The origin of the left recurrent nerve.
Plate VI

Photograph showing the classical transverse communicating route via the retromanubrial nodes.

The transverse communicating route in this case is composed of a complicated node chain (large arrows), including the RM nodes. A node (wide white arrow), lying in front of the SVC and at the intermediate position between the IT artery and vein, is identified at the right terminal of the transverse communication. The IT vein has been cut, reflected superiorly and fixed to the BCA artery by a pin. The left terminal of the communication is identified as consisting of the superior phrenic nodes (white star), lying in front of the AO and medially to the IT artery and vein. The BA nodes are not observed in this case at an angle between the RBC and LBC veins (white arrowhead). Several large collecting vessels (small black arrows) originate from the node at the right terminal of the transverse communication and from the right paratracheal nodes, and run superiorly to the right VA on the anterior surface of the RBC vein. The parietal pleura has been removed from the right lung (L).
Plate VII

Photograph showing the direct and superficial transverse communicating route of IMLs.

A. Fasciculated large collecting vessels (black arrow), running transversely along the LBC vein, connect the BA nodes to the left VA. Another two large collecting vessels, crossing the BCA artery superficially, connect the BA nodes to the PT nodes. A node group (wide white arrow) is developed well in front of the SVC and continues to the BA nodes. The superior phrenic nodes (white star) do not clearly communicate with BA or the direct and superficial communicating route.

B. Internal aspect of the large collecting vessels along the direct and superficial communicating route at a portion enclosed by the white dotted line in A. The configuration of valves (small arrows) suggests that the lymph flow was directed to the left side (large arrow).
Plate VIII

Cleared specimen of large collecting vessels in the superior mediastinum.

The direct and superficial communicating vessels (arrows) originate from the BA nodes and merge into the TD. No lymph nodes are observed along the vessels. The BA nodes have been dissected and separated from each other. A large collecting vessel from the superior phrenic nodes (SP) and a vessel from the left paratracheal node chain (asterisk) join together, and merge into the TD. The so-called Virchow's node (V) is observed at the terminal portion of the TD and other trunks. SCT: subclavian trunk; CT: cervical trunk; IDC: inferior deep cervical nodes.
Plate IX

Photograph showing a rare case of the superficial transverse communicating vessel (Murakami et al. 1990).

A long, large collecting vessel (white and black arrows), crossing superficially to the BCA and CC arteries, communicated between the VAs of both sides. In the pretracheal region, a short collecting vessel (arrowheads) connects the superficial communicating vessel to the PT nodes. The superficial communicating vessel did not connect the inferior thyroid veins (IV). Other large collecting vessels from the PT nodes cross the BCA superficially. Tracheostomy had been performed before donation (TR). Large arteries and veins have been cut and slightly moved or partly removed. SM: sternocleidomastoideus muscle; SCA: left subclavian artery; asterisk: a large collecting vessel connecting the superficial transverse communicating vessel and the deep cervical nodes (DC).
Photograph showing the deep transverse communicating route of IMLs.

Large collecting vessels (black and white arrows) superficially cross the BCA and CC arteries. The collecting vessels connect the BA nodes to the superior phrenic nodes (white star). A major part of the superior phrenic nodes has been removed. The large collecting vessels that compose the deep communication vary in number at each portion: 2 vessels on the BCA, 1 on the CC and 6 on the AO. These large collecting vessels communicated with the PT nodes. The LBC vein has been cut and reflected to the left side. Other large collecting vessels (small black arrows) running on the anterior surface of the RBC vein, connect the BA nodes to the right VA. The left drainage route of the PT nodes is also observed (arrowheads).

B. Internal aspect of a large collecting vessel along the deep transverse communication. A portion located on the BCA. The valves (arrows) are arranged irregularly and do not suggest a consistent direction of lymph flow.
Plate XI

Diagram summarizing the present observations. The drainage routes of IML and related anterior mediastinal nodes.

The IML terminated at several groups of anterior mediastinal nodes: the BA nodes and/or nodes lying at an intermediate position between the IT artery and vein (open star) on the right side, the superior phrenic nodes (SP) and/or nodes lying close to the left brachiocephalic vein (black star) on the left side. The IMLs rarely terminated at nodes lying close to the origin of the IT artery (asterisks). A collecting vessel, directly connecting the VAs and PS nodes in the anterior mediastinum (internal mammary trunks), also rarely co-existed with other drainage routes. In addition to the classical transverse communicating route (lines made by black stars) via the RM nodes, the direct and superficial communicating route (line made by open triangles) and the deep transverse communicating route (lines made by asterisks) are observed. Dotted lines indicate some of the major lymphatic pathways in the mediastinum, particularly those from the lung. a: Aortic arch nodes lying at an angle between the BCA and CC arteries; B: Botallo’s nodes; PR: right paratracheal node chain; R: right recurrent nerve nodes (the right superior-most mediastinal nodes); PA: node lying on the left pulmonary artery.