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# CUTANEOUS AND SUBCUTANEOUS LYMPHATIC DRAINAGE OF THE BREAST

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*ABSTRACT*

*The aim of this study was to topographically map the superficial lymphatic drainage of the breast. The study was performed on 24 female cadavers. Patent blue dye was administered intradermally and subcutaneously. After visualization and dissection of the lymphatics, a schematic record of their routes was made on a transparency folio of the breast map. Afterwards, a summation was performed of all schematic records, and a map of the lymphatic vessels of the breast was derived. The natural dominant drainage for the outflow of lymph from the superficial areas of the breast is to the axillary nodes. This pathway plays a primary role in the initial stages of breast cancer. This observation does not exclude other pathways of lymph drainage, which probably play a secondary role except in cases where flow is limited in the primary lymphatic pathway. Although each quadrant is dominantly drained by one or two of its own collectors, it is also interconnected via the subareolar plexus with the other quadrants of the breast, and lymph collectors of the upper medial quadrant pass to the lower medial quadrant and vice versa. Lymphatic collectors from the medial quadrants followed the medial, cranial and caudal margins of the breast and afterwards ran into the axilla. The common interconnections of the individual quadrants of the breast with one or two collectors, which circumscribe the breast, but run outside the subareolar plexus, further increase the risk of developing locoregional recurrences. In some cases, the marginal lymphatic collectors of the breast may even run beyond the anatomical boundaries of the breast–particularly apparent in the submammary region.*

In the last 10 years, mapping of the lymphatic drainage of human organs has come to the forefront of clinical interest in oncologic surgery. The aim of modern surgical treatment of breast cancer is to limit the radicality of the surgical procedure in the axilla and minimize possible consequences and complications of radical lymphadenectomy. This can be accomplished by finding the sentinel node (SN – the first node that drains the tumor) for histological examination. In the case that the SN is negative, it is assumed that the other nodes in the axilla will also be without metastases, and axillary lymphadenectomy will not be performed. Gradually, biopsy of the sentinel node has become the method of choice in the surgical treatment of the initial stages of breast cancer because of its low postoperative morbidity and high predictive value regarding the status of the axillary nodes and thus also the staging of patients with breast cancer.

The current anatomical pattern of the lymphatic drainage of the breast is the result

of several studies that have been published during 2 centuries. During this time, anatomical findings have been gradually supplemented by the topography of the lymphatics of the breast and its regional nodes on the basis of injecting the lymphatics using classic methods such as visualizing the vessels with mercury, Indian ink, and Gerota mass. In the last 30 years, lymphatic vessels have been clinically visualized with contrast oil lymphography, lymphoscintigraphy, and intravital dyes (Blue dye).

The development of anatomic findings of the lymphatic drainage of the breast has taken place over the last ~215 years. In 1789, Cruiskshank and Mascagni described the lymphatics of the areola and superficial part of the breast, which ran laterally to the pectoral nodes and then to the axillary nodes. From the posterior part of the gland, the lymphatics emerged and connected to the lymphatic vessels and nodes along internal thoracic artery over the surface of the pectoralis major muscle. They also described the lymphatic vessels of the breast that connected to the intercostal and epigastric nodes and lymphatics (1). In an 1876 textbook of anatomy, Sappey graphically demonstrated and described a rich superficial subareolar plexus of thin lymphatic vessels that is connected with the lymphatics of the deeper parts of the gland. In the deeper part of the gland, the fine lymphatics run into thicker lymphatic vessels along the lactiferous ducts into the lymphatics of the subareolar plexus. The plexus is connected to the lymphatics of the skin lying above it (2). In 1953, Grant et al graphically demonstrated this centripetal lymphatic flow (3). The hypothesis, that the skin of the breast together with the mammary gland create a unit which has common lymphatic drainage, is explained by Borgstein with the common ectodermal origin of both tissues (4). From these findings, some authors demonstrate that the periareolar course of the lymphatics shows the same routes for tumor spread as peritumoral injections of labeled colloids independently of the location of the tumor in the breast (4-7). Relying on the lymphatic interconnections with the surrounding lymphatic routes, subareolar injection of labeled colloids is considered an appropriate marker of sentinel routes and the sentinel node (8). However, not all authors accept this view. In addition, following intradermal and periareolar injection, the routes to the mammary nodes are not visualized (9). But application of contrast intraparenchymally leads to simultaneous visualization of extra-axillary lymphatics in 10-19% (3,10-12). Up to the present, it is not completely clear to what extent the cutaneous lymphatics communicate with the deeper parenchymal lymphatics (9). Many years ago (13-15) the possibility was demonstrated of tumor spread from the deeper part of the breast through the lymphatic vessels that perforate the retroglandular adipose tissue, pectoralis major muscle (especially its sternal part) and sometimes also pectoralis minor muscle and connection to the interpectoral and subpectoral nodes. These transmuscular lymphatic connections are difficult to demonstrate with anatomical injection techniques. Rouvier (15), using Sappeys findings, described two main collectors arising from the subareolar plexus, one for the lateral part of the breast and the other for the medial part. The lymphatic collectors are connected to various groups of axillary nodes (15). In 1959, Turner-Warwick and later Haagensen regarded lymphatics of the deeper part of the breast as primary in comparison to the subareolar lymphatic vessels (16,17). On the other hand, the mammary (parasternal) lymph nodes which receive lymphatic connections from the breast across the intercostal spaces are considered secondary in importance, after axillary nodes, as the site for metastasis of breast cancer (18-22).

Most of the authors cited here and several others describe still other accessory lymphatic vessels which connect the lymphatics of the breast with the lymphatics of the intercostal, supraclavicular, and

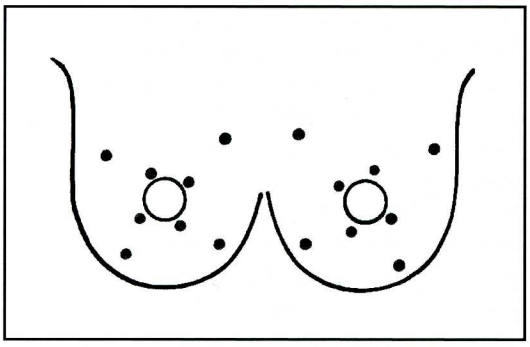

*Diagram 1: Locations of intradermal and subcutaneous injection of blue dye in the breast.*

epigastric nodes (23-27). On the basis of these morphological studies, several anatomic routes were discovered through which lymph can drain from the breast and through which tumor cells can spread. Nevertheless, the opinions regarding the preferred route of tumor spread are still not unified. Most authors declare tumor spread from the medial and lateral quadrants of the breast via the lymphatics to the ipsilateral axillary nodes including the sentinel node (28,29). Another group of authors declares the spread of metastases to the axillary nodes in ~90% as well as in 1-6% (30), 12% (31), 17% (32) or up to 56% (33) to the parasternal mammary nodes. Metastases to the mammary nodes were found from all quadrants of the breast, but percentage-wise they differed from quadrant to quadrant. Simultaneously, metastases were also found in 13% in the supraclavicular nodes and in 12% in the interpectoral nodes (33).

The method of lymphatic mapping and biopsy of the sentinel node in breast cancer is still not fully standardized. In clinical mapping of the SN, a combination of administering labeled colloids and patent blue (Blue dye) is most often used. The mode (time interval before the operation) and site of administration (peritumoral, subareolar, parenchymal, subcutaneous) of these substances varies greatly in different clinics. Despite the fact that many studies have been published regarding SN biopsy, some questions remain controversial (i.e., site of contrast administration, location of the sentinel node outside the axilla, etc.) (34). The published studies are based on perioperational lymphatic mapping in patients with breast cancer. The contrast material is usually administered only to the surroundings of the tumor and then the draining SN is dissected, without even visualizing the lymphatics.

The aim of our study was to topographically map the superficial lymphatic drainage (including accessory routes) of the breast under non-tumorous physiologic conditions in an attempt to define possible sites of metastases.

## *MATERIAL AND METHODS*

The study was performed on 24 female cadavers with a mean age of 65 years, within 12 hours of death from internal diseases with a negative history for malignancies. The breast was divided into 4 quadrants (upper medial - UM and upper lateral - UL, lower medial - LM and lower lateral - LL) and the region of the areola. After local warming of the anterior part of the chest to a temperature of 37 degrees Celsius, gradually and slowly patent blue dye was administered intradermally and subcutaneously periareolarly, on the boundary of breast quadrants and into the individual breast quadrants and around the circumference of the base *(Diagram 1)*. In two cases Gerota Mass – Berlin blau (Ferrum Feroxyanide in oil was utilized (18,35). To increase the transport of contrast material, we performed non-specific massage of the breast. After visualization and careful dissection of the lymphatic vessels and nodes, a schematic record of their routes and location was made on a transparency folio of the breast map. Afterwards, a summation was performed of all schematic records, and a map of the lymphatic vessels of the breast was derived from the summation.

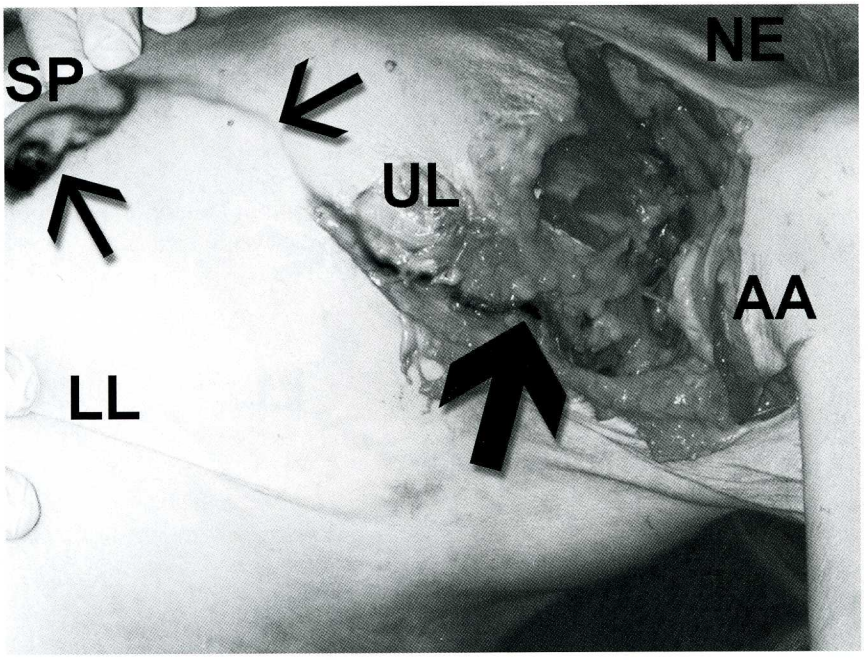


*Fig. 1: Lymphatic collector passing from subareolar plexus (SP) to upper medial quadrant and then cross upper lateral quadrant towards to axilla (left breast). Thick arrow – sentinel node , thin arrow – lymphatic collector, NE – neck, UL – upper lateral quadrant, LL- lower lateral quadrant.*

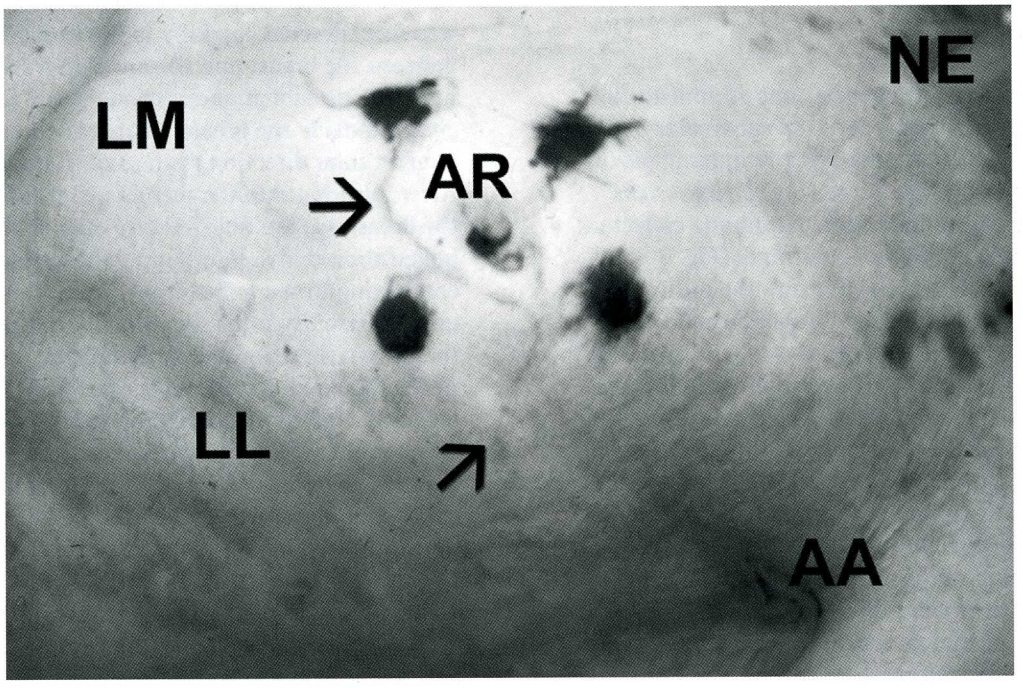


*Fig. 2: Periareolar plexus (left breast). Arrows – lymphatic vessels, AA – axilla, AR – areola, NE – neck, LL- lower lateral quadrant, LM – lower medial quadrant.*

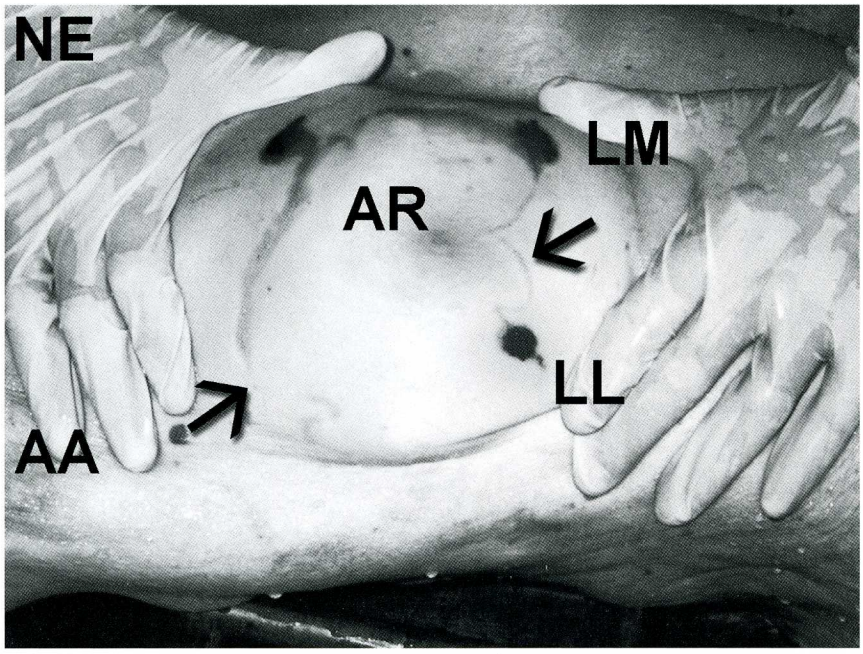


*Fig. 3: Lymphatics encircle the breast (right breast). Arrows – lymphatic vessels, AA – axilla, AR – areola, NE – neck, UL – upper lateral quadrant, LL- lower lateral quadrant, UM – upper medial quadrant, LM – lower medial quadrant.*

*RESULTS*

Following subcutaneous administration of patent blue dye into the subareolar region and areola, the subareolar lymphatic plexus was reliably visualized (*Fig. 1*), its vessels connected to individual lymphatic collectors from the individual quadrants (*Fig. 2-4*). Administering blue dye into the individual quadrants visualized lymphatic collectors from all quadrants (*Figs. 4-6*), and from the lateral quadrants, they ran directly into the axilla (*Figs. 5-7*). Administering dye into the upper medial quadrant highlighted vessels leading to the lower medial quadrant and vice versa. Lymphatic collectors from the medial quadrants followed the medial, cranial and caudal margins of the breast (*Fig. 3*) and afterwards ran into the axilla. In 2 cases, the lower medial quadrant drained directly into the axilla (*Fig. 4*).

In 4 cases, the route of the lymphatic collectors from the lower medial quadrant was first directed caudally to the transition between the breast and the lower thoracic wall (sulcus submamarius) and after a short course outside the breast, turned in the laterocranial direction to the axilla (*Fig. 8*). After injection into the medial quadrants of the breast, we did not find any case of penetration of dye into lymphatic vessels connecting to the parasternal nodes. Despite great variability in the lymphatic drainage of the breast, these individual lymphatic vessels in the region of the lateral border of the pectoralis major muscle connected to one or two lymphatic collectors, which entered the axilla in the upper lateral quadrant and connected to the lymph node in the lower part of the axilla. We considered this node to be the sentinel node. The node was located ventrally from the axis of the axilla (in the center between the anterior and posterior axillary line) at the level of the 3rd and 4th ribs (*Figs. 1,5-8*). Only one collector emerged from the SN, which led to a higher level of

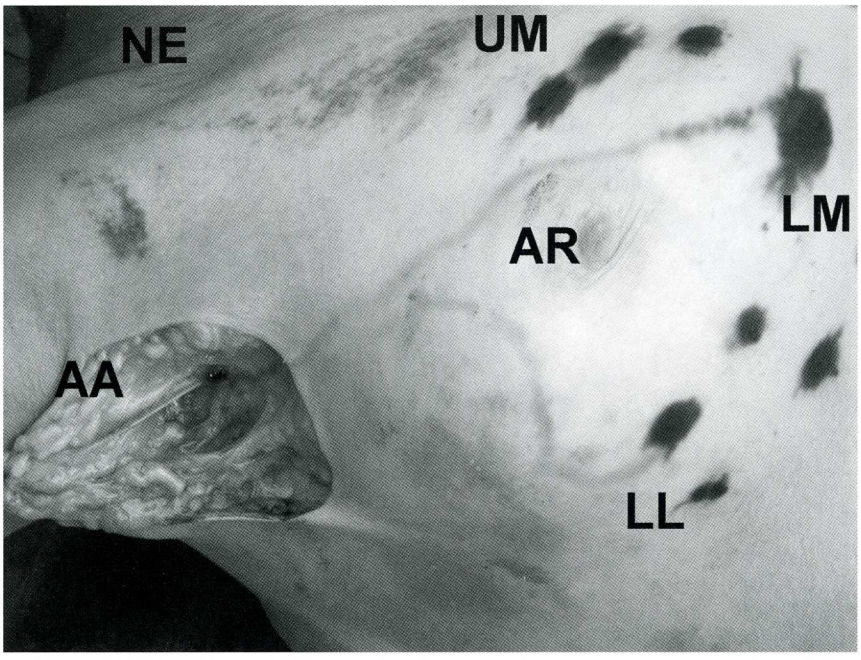


*Fig. 4: Lymphatic running from lower medial quadrant, passing areola towards upper lateral quadrant and axilla. Lymphatic from lower lateral crosses upper lateral quadrant and runs to axilla (right breast). AA – axilla, AR – areola, NE – neck, LL- lower lateral quadrant, UM – upper medial quadrant, LM – lower medial quadrant.*

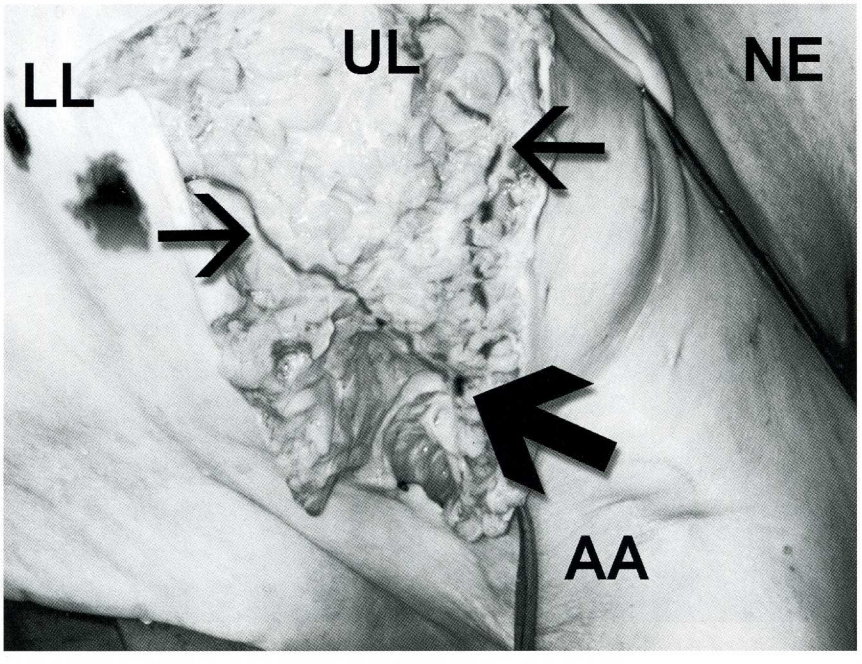


*Fig. 5: Lymphatic collectors run from lower lateral and upper lateral quadrant (left breast). Thick arrow – sentinel node, thin arrow – lymphatic vessels, AA – axilla, NE – neck, UL – upper lateral quadrant.*

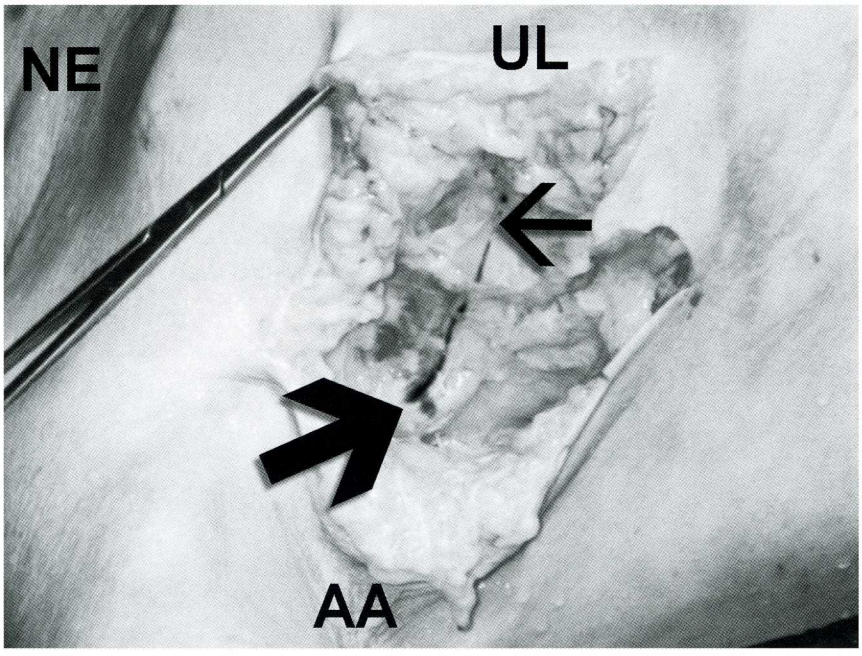


*Fig. 6: Lymphatic from upper lateral quadrant (right breast). Thick arrow – sentinel node , thin arrow – lymphatic vessels, AA – axilla, NE – neck, UL – upper lateral quadrant.*

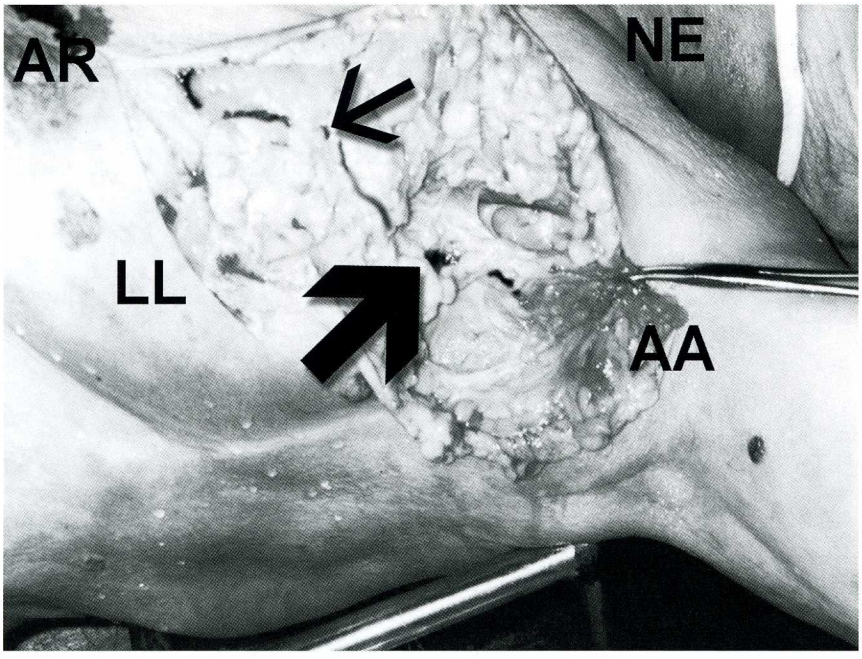


*Fig. 7: Only one collector emerges from the SN, which leads to a higher level of axillary nodes (left breast). Thick arrow – sentinel node , thin arrow – lymphatic vessels, AA – axilla, AR – areola, NE – neck, LL- lower lateral quadrant.*

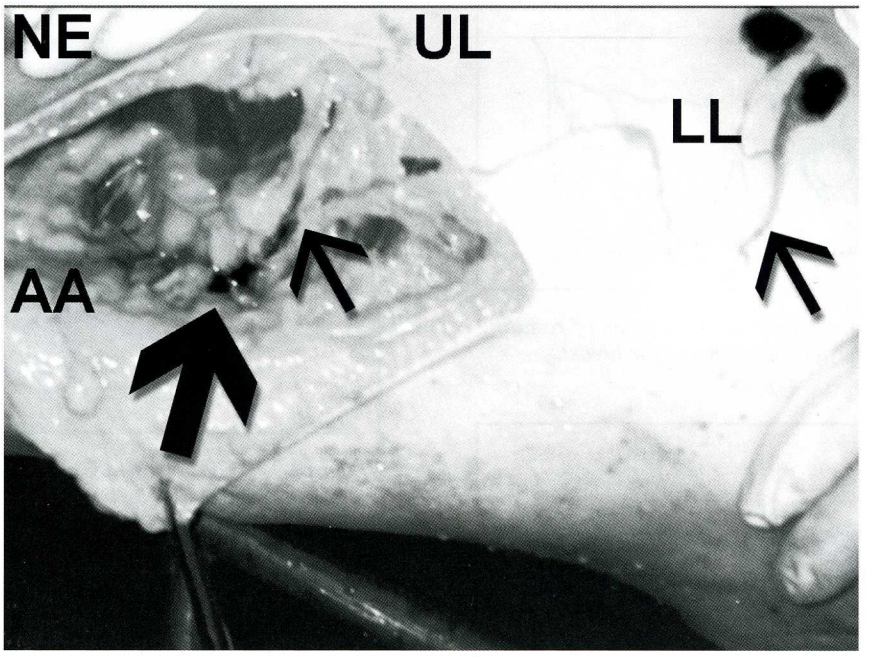


*Fig. 8: Lymphatics start from lower lateral quadrant, partly run behind the base of the breast in submammary region (right breast). Thick arrow – sentinel node , thin arrow – lymphatic vessels, AA – axilla, NE – neck, UL – upper lateral quadrant, LL- lower lateral quadrant.*

axillary nodes (*Fig. 7*). The site of administration of the patent blue dye did not change this result. The locations of blue dye injections and an example of the scheme of the drainage of the breast is pictured on *Diagrams 1 and 2*. Summation of all drainage schemes is shown in *Diagram 3* and the resulting model of superficial lymphatic drainage of the breast is depicted in *Diagram 4*.

*DISCUSSION*

Our study describes the superficial lymphatic drainage of the breast in women under physiologic conditions without malignant disease of the breast. The results clearly show that the skin and subcutaneous tissue of the breast is primarily drained into the axilla. A group of authors (2,3,4,6) describe lymphatic vessels that run in the parenchyme of the mammary gland along the lactiferous ducts and that lymph flows through them centripetally, toward the areola, where it empties into the rich Sappey subareolar plexus. In the plexus, the lymph from the entire breast intermixes and flows further via two large superficial lymphatic vessels into the axilla. In this way, the lymphatic system of the breast is unique in the human body (3). The reason for this arrangement is probably the necessity of ensuring outflow of several times larger amount of lymph during lactation (4). The key role here is played by the subareolar plexus. This theory is supported not only by the results of our study but also on the basis of clinical studies (5-7). From this it follows that the parenchyme of the mammary gland and its skin covering have the same lymphatic system, which creates a common functional unit with dominant lymph drainage into the axillary nodes. This is probably the result of their common embryonic origin from the ectoderm (4). The direction of spread of contrast material described by us demonstrates communication

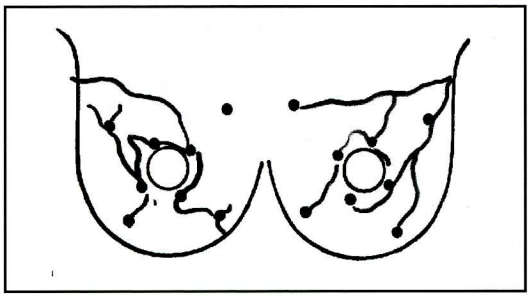

*Diagram 2: An example of the scheme of resulting pattern of superficial drainage of the breast.*

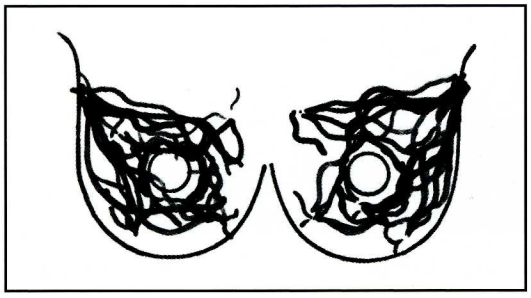

*Diagram 3: Summation overlay drainage pattern of schemes from all subjects.*

of the subareolar plexus with the breast quadrants and possibly the passage of lymph collectors through several breast quadrants simultaneously (*Figs. 1,8*). Assuming that the tumor cells can spread in the same way as the patent blue dye, there is a great probability of tumor recurrence anywhere in the breast. This also explains the significant increase in local recurrences among patients treated with quadrantectomy without radiotherapy (9%) compared with patients treated with radiotherapy (0.3%) (36). Our results confirm that this path of lymph outflow is natural under physiologic conditions and that it plays a primary role in the initial stages of breast cancer. This observation does not exclude other pathways of lymph drainage, which most likely play a secondary role when there is limited flow through the primary lymphatic pathway (i.e., large tumor size or metastatic involvement of the axillary nodes) (37-40).

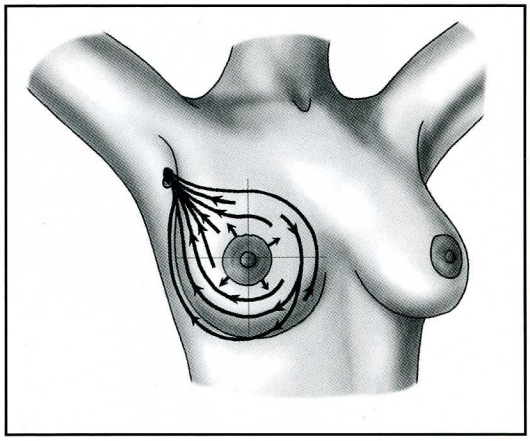

*Diagram 4: The resulting model of superficial lymphatic drainage of the breast.*

In the past, but also relatively recently, great significance has been placed on the alternative routes of lymphatic drainage of the breast, especially to the mediastinal nodes (internal mammary nodes) (14,16,22). Currently, several studies have been published with the finding of the SN outside the axilla (40-42). The demonstration of these nodes is dependent on the site of administration of the labeled colloid. In peritumoral administration, these nodes are detectable in 35% (43-45). For better detection of the SN, some authors propose primary injection subareolarly and in the case of uncertain results to supplement with a peritumoral injection (46,47). Recently published papers on the technique of sentinel lymphadenectomy show that the majority of the breast tissue must drain to a limited number of SNs located in the axilla (47,48). Several trials confirmed similar diagnostic accuracy rates for intraparenchymal, intradermal and subareolar injection. (47,49,50).

From the pathways of the lymphatic vessels it is apparent that the breast cannot be divided into functionally separate segments and that the primary role in the development of locoregional metastases in breast cancer is played by the lymphatic drainage of the breast rather than the location of the tumor. The common interconnections of the

lymphatic system of all quadrants of the breast give rise to the possibility of developing metastases anywhere in the breast and support the significant role of radiotherapy after breast-conserving surgical procedures.

From the literature, it follows that lymph outflow from the breast is complex, and there is no unified scheme and 100% certainty where and to how many locations (sentinel nodes) the cancer cells will spread. Our observations focused on the possible anatomic variations of the pathways of the superficial lymphatic vessels of the breast under physiologic conditions and do not resolve the complex conditions and causes of variable spread of breast cancer.

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