# Lymphoscintigraphy in High-Risk Melanoma of the Trunk: Predicting Draining Node Groups, Defining Lymphatic Channels and Locating the Sentinel Node

Roger F. Uren, Robert B. Howman-Giles, Helen M. Shaw, John F. Thompson and William H. McCarthy

*Nuclear Medicine and Diagnostic Ultrasound, Camperdown and Sydney Melanoma Unit, Royal Prince Alfred Hospital, Sydney, New South Wales, Australia*

Lymphoscintigraphy was performed in 209 patients with high-risk melanoma of the trunk referred to the Sydney Melanoma Unit and considered for lymph node dissection. Lymphoscintigraphy accurately defined the draining lymph node groups and was 94% sensitive in detecting draining sites that contained metastases. When combined with the clinical finding of palpable lymph nodes, the sensitivity rose to 98%. Most patients showed lymph drainage to one or two node groups and only 22 patients showed drainage to 3 or more node groups. The major lymph channels could also be marked on the skin prior to incontinuity dissection. Most patients had multiple draining lymph channels and these often diverged significantly from each other in the path to the draining node group. The number and location of interval nodes could be determined and marked on the skin. These and the major lymph channels could thus be excised at the time of surgery. Unusual drainage patterns were sometimes seen; for example, three patients displayed a new lymph pathway with direct drainage from the back anteriorly to the para-aortic nodes. The location of the sentinel nodes in each draining lymph-node group could also be marked on the skin prior to surgery, enabling quick and accurate identification of this node, using the blue-dye technique if biopsy were to be performed. These findings lead us to recommend lymphoscintigraphy prior to wide local excision in patients with truncal melanoma who are candidates for surgery. Lymphoscintigraphy results will help plan surgery and lead to minimum surgical intervention, consistent with effective surgical management.

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In patients with clinically impalpable lymph nodes and melanomas thicker than 1.5 mm, micrometastases are detected in nodes excised during elective lymph node dissection in up to 37% of patients (*1*). Consequently, prognosis of high-risk melanoma of intermediate thickness is improved by early lymph node dissection (ND) performed at the same time as wide local excision (WLE) (*2–5*).

The difficulty with trunk melanomas is determining which lymph node groups are potential sites of micrometastases and candidates for surgical removal. Many studies using lymphoscintigraphy (LS) have shown the lymphatic watershed concept based on Sappey's work (*6*) to be incorrect in approximately half the patients (*7–9*). Clinical judgment based on this concept is thus of no practical use in an individual patient when a node dissection or biopsy is contemplated. LS has itself been used to define which node groups drain a cutaneous lesion, and surgical correlation in some patients has validated this approach (*7*). The number of patients in such studies has always been small.

The aims of our study were to (1) use LS prospectively prior to WLE and ND in order to define the draining lymph node groups in a large number of patients with truncal melanoma; (2) determine its accuracy in predicting the location of melanoma metastases to lymph nodes; (3) define the number and distribution of the major lymph channels involved in each patient; (4) document the degree of divergence from each other and the expected path to the draining node group; (5) define the number and location of any interval nodes and (6) determine if LS could be used to locate the sentinel node or nodes in each of the draining lymph node groups. The sentinel node is the first to accept and retain the tracer in each draining lymph node group.

## METHODS AND MATERIALS

From October 1986 to July 1992, cutaneous LS was performed on 209 patients—159 males and 50 females. Technetium-99m-antimony sulphide colloid ($^{99m}$Tc-Sb2S3) was prepared on site for each patient, using kits supplied by the Royal Adelaide Hospital radiopharmacy. Technetium-99m was supplied daily by Australian Radioisotopes and produced in the nuclear reactor at Lucas Heights in Sydney. Particle size varied from 3 to 12 μm (*10,11*). Multiple, small-volume (0.1 ml) intradermal injections were used to surround the biopsy excision site or, in some patients, the primary lesion. All studies were performed prior to wide local excision, which is essential to a good quality study. Specific

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For correspondence or reprints contact: Dr. Roger Uren, Missenden Medical Centre, 54-60 Briggs Street, Camperdown, NSW 2050, Australia.

activity of the dose varied from 50–70 MBq/ml, so that each injection contained 5–7 MBq. Between 4 and 14 injections were used, although most patients received 6–8 injections. This delivered a radiation dose of 0.2–0.5 Sv to the injection site. This injection site was completely excised as part of the WLE in all patients within one week.

Careful technique was required to ensure accurate intradermal injections and avoid contamination of the rest of the skin, which greatly complicates interpretation, especially in the definition of interval nodes. A large, waterproof incontinence sheet was used to cover the patient's trunk and a small window cut in the sheet to expose the lesion. Gloves were essential. In addition, because the intradermal injection was under pressure, swabs were placed over the area before the needle was withdrawn to prevent spraying the radionuclide over the patient and provider.

All scans were performed using a large, rectangular field-of-view digital gamma camera (Toshiba 90B) with a low-energy, high-resolution collimator. Each scan view was collected over 10 min. Scanning was commenced immediately and the major lymph channels defined at this stage. The digital camera was important so that the computer image could be enhanced to reveal even the faintest channels, which were drawn on the skin using an indelible marker after the channel had been followed with a radioactive source. We used a drop of $^{99m}$Tc in the tip of a needle cap.

Calibrated rulers were provided surgeons so patient measurements could be checked directly with patient scans at the time of surgery. Delayed scans were performed at 2.5 hr and anterior views of the axillary and inguinal areas obtained. If a lesion was high on the back, a posterior view was obtained to check drainage to posterior triangle nodes. Lateral or oblique views were done, if necessary, to define the anterior or posterior position of a node or clarify unusual drainage patterns. Computer enhancement of the image was important, and any discernible activity above background in recognized node group was regarded as a positive finding on delayed scans. Interval nodes were said to be present if focal uptake along one of the lymph channels in early scans was seen as a persisting focal area of uptake in the same spot on delayed scans.

In the last 6 mo of the study, the skin overlying the sentinel node or nodes was marked with an indelible pen for each node group receiving lymph flow from a lesion site. The sentinel node was the first draining lymph node to accumulate the tracer; in delayed images it was the node with the most activity because of significant hold up of colloid particles in the lymph nodes. The more proximal nodes showed less and less activity compared with the sentinel node. Accurate marking of the sentinel node required considerable care and imaging at several angles to avoid parallax error. The marking procedure must be performed with the patient in the normal position for surgery. In the case of axillary nodes, this is supine with the arm at right angles to the body. If this varies, the skin mark will not overlie the node. At surgery, patent blue is injected intradermally at the lesion site (*1*) and a small incision made at the site of the marked sentinel node, identified with the aid of blue dye.

One of us reported the scans at the time of the study. To test reproducibility of the reporting method for determining drainage sites, the first 51 patients, sorted in alphabetic order, were re-read by two of us separately, without knowledge of the clinical history, physical findings, original report or the other physician's new report.

Wide local excision with or without split-skin grafting was performed on all patients; ND also was performed, unless LS revealed flow to three or more node groups, or the patients refused such surgery or some other contraindication to surgery existed. Lymph nodes excised surgically were examined histologically by hematoxylin and eosin staining to determine the presence of metastatic melanoma.

Patients were followed at regular intervals at the Sydney Melanoma Unit and further resection with histology performed if palpable nodes developed.

**TABLE 1**
Lymph Drainage

| Node groups | Patients |
|---|---|
| 1 | 88 (42%) |
| 2 | 99 (47.5%) |
| 3 | 19 (9%) |
| 4 | 2 (1%) |
| 5 | 1 (0.5%) |

## RESULTS

### Lymphoscintigraphy Reproducibility

The reproducibility study showed 84 positive lymph node groups in 51 patients. Both physician readers agreed on 83 of the 84 node groups. In one patient with a lesion high on the back in the mid-line at the nape of the neck, both agreed there was flow to the supraclavicular node groups but disagreed about a small node in the posterior triangle close to the lesion site.

## PATIENT STUDIES

### Node Groups

Lymph drainage patterns in the 209 patients are summarized in Table 1. One hundred and eighty-seven patients (89%) had drainage to one or two node groups and were potential candidates for ND.

Drainage to the different node groups is described in Table 2. One hundred and twenty patients had drainage to one axilla; 73 had drainage to both axillary node groups. Flow to at least one axilla thus occurred in 193 patients (92%). Three patients, all of whom had lesions in the loin, displayed an unusual drainage pattern. These patients

**TABLE 2**
Draining Node Groups

| Site | Patients |
|---|---|
| Right axilla | 126 (60%) |
| Left axilla | 141 (67%) |
| Right supraclavicular | 16 (8%) |
| Left supraclavicular | 21 (10%) |
| Right inguinal | 11 (5%) |
| Left inguinal | 17 (8%) |
| Right posterior triangle | 5 (2.5%) |
| Left posterior triangle | 7 (3%) |
| Para-aortic | 3 (1.5%) |
| Right cervical | 3 (1.5%) |
| Left cervical | 4 (2%) |
| Submental | 1 (0.5%) |
| Internal mammary | 1 (0.5%) |

showed drainage to the axilla or groin as well as a dominant channel passing posteriorly, medially and superiorly to the midline until, at the level of the upper abdomen or the inferior mediastinum, the lymph channel passed anteriorly to the para-aortic area. Activity then passed superiorly and tracer was seen in the thoracic duct on delayed scans (Fig. 1). Another patient with an umbilical lesion showed drainage to the left axilla and the right internal mammary chain (Fig. 2).

**Lymph Channels**

A total of 592 major lymph channels were seen draining the lesion site in the 209 patients with an average of 2.8 channels per patient. The number of channels varied from 1 to 7, and only 33 patients (16%) had one lymph channel draining to the regional node group. The remaining 176 patients averaged 3.2 channels per patient. Only 40 patients (19%) had channels that passed straight to the draining node group along the expected path; 23 of these had only one major lymph channel. Thus, only 16 of 176 patients (9%) with multiple lymph channels showed straightforward drainage to a relevant node group. One hundred and sixty patients with multiple lymph channels showed some divergence of channels on their way to the lymph node group. Ten patients with only one channel showed divergence from the expected pathway up to a maximum of 4 cm. In patients with multiple channels, 88 showed a divergence of 5 cm or greater, 22 a divergence of 10 cm or greater and 3 a divergence of 15 cm. The path to draining node groups varied greatly from patient to patient, as did the number of channels draining what appeared to be identical sites on the skin in different patients (Fig. 3).

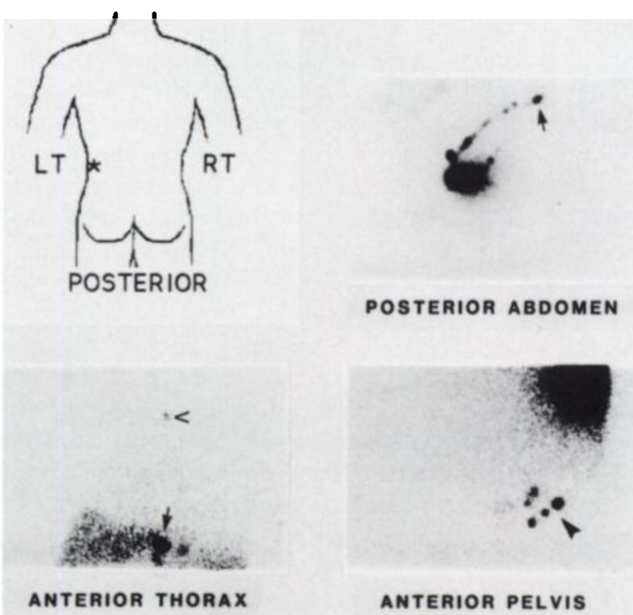


**FIGURE 1.** Patient with left loin lesion has lymph drainage to left inguinal nodes and para-aortic nodes. The early study posteriorly over the abdomen shows two dominant channels passing superiorly toward midline. Activity was seen in the para-aortic area at this time and on the delayed Anterior view of the thorax (small arrow). Activity was also seen in upper thorax just to the left of midline (open arrowhead) in the thoracic duct region. Delayed scans over the pelvis anteriorly show drainage to the left inguinal nodes (small arrowhead). Three patients showed such para-aortic drainage.

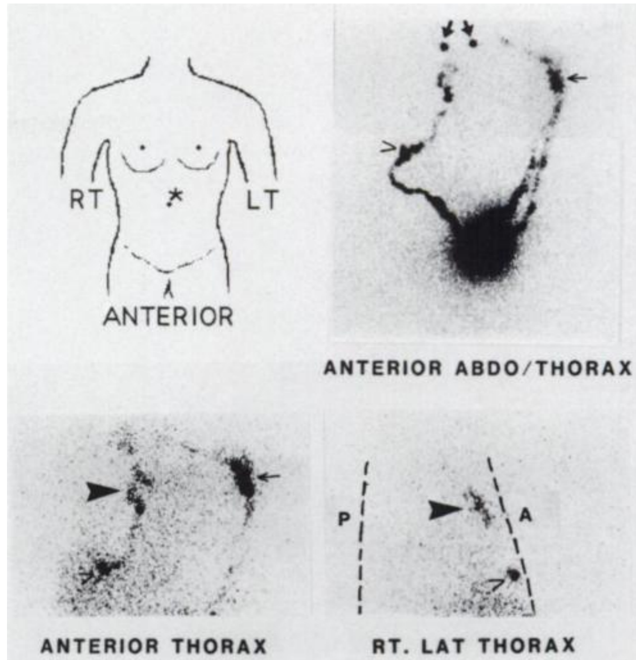


**FIGURE 2.** Patient with lesion just above and to the left of the umbilicus and with lymph drainage to the right internal mammary chain and the left axilla. Early dynamic phase of the study performed anteriorly over the abdomen and thorax shows dominant channels passing superiorly to the left axilla (small arrow) but also a dominant channel passing superiorly to the right before it turns once more to the left and meets an interval node (open arrowhead). The channel then enters the right internal mammary chain and continues superiorly. Internal mammary lymph nodes can be seen in the anterior and right lateral view of the thorax (large arrowhead). Two small bold arrows on the anterior view of the abdomen and thorax superiorly point to markers for manubrioclavicular joints.

**Interval Nodes**

Seventy-seven interval nodes were detected in 45 of 209 patients with an average of 1.7 nodes per patient and from 1 to 7 interval nodes in each patient. Twenty-nine patients had only one interval node. Of the remaining 16, an average of 3 nodes per patient was detected.

**Sentinel Nodes**

Over the last 6 mo of the study, nodes were marked in 18 patients, involving 29 separate draining node groups with one sentinel node.

**Initial Surgery**

In 22 of 209 patients, lymph drainage to 3 or more node groups was identified (Table 1), and 20 of these patients had WLE only. Forty-eight patients refused node dissection or had some other contraindication, and had WLE only. The remaining 141 patients had WLE and ND within one week of LS. In 30 patients there were 34 draining node groups that showed metastases.

Lymphoscintigraphy correctly predicted lymphatic

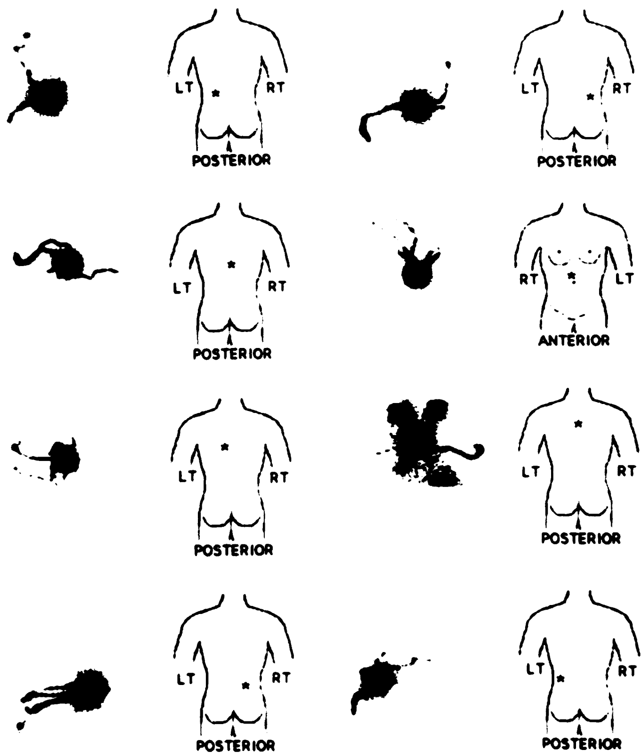


**FIGURE 3.** Figure illustrates the large variation in the pattern and number of draining lymph node channels. The early phase image is on the left in each case, with the position of the lesion marked on the corresponding torso to the right. Lesions in similar sites in different patients have dramatically different lymphatic drainage, which the study consistently reinforced. If an incontinuity dissection is performed with the intent to remove major lymph channels and interval nodes, LS information would appear essential.

drainage to 32 of the 34 sites. Of the two incorrect cases, the first patient had a lesion in the low back just to the left of midline and palpable nodes in the right inguinal area. The early LS showed a dominant channel passing to the left. Despite activity in the right and left inguinal areas on delayed scans (left more than right), the scan was misinterpreted and drainage diagnosed to the left inguinal area only. In view of clinical findings, the surgeons ignored scan results and performed a node dissection on the right groin at the site of the clinically palpable nodes and found metastases to multiple nodes in the groin, which might explain less uptake in the right inguinal nodes than in the left. Both physicians correctly reported bilateral inguinal drainage in a subsequent re-read as part of the reproducibility study.

The second patient had a lesion in the right loin posteriorly and laterally. LS showed drainage to the right axilla only. Nodes were clinically palpable in the left axilla and contained metastases at surgery. Even in retrospect no activity could be seen in the left axilla on the LS study.

Among 18 patients with marked sentinel nodes one patient's sentinel node contained a tumor; the other 13 nodes were normal. Sentinel nodes in the remaining 17 patients were normal.

### Subsequent Follow-up

In 14 patients, 17 node groups subsequently developed metastases. Sixteen sites originally were predicted on LS to be potential sites of micrometastases. One patient with a lesion on the upper back to the right of midline showed dominant channels passing to the right axilla, with a small truncated channel passing superiorly and to the left for 3–4 cm. Delayed scans showed activity in the right axilla only. In retrospect, there may have been a faint trace of activity in the left axilla on the anterior view. At the time of the study, there were no palpable nodes in either axilla and, because of age, the patient received a WLE only. The course of disease was extremely rapid: Metastases developed in both axillary node groups within 5 mo and the patient died with bone metastases 18 mo after WLE.

## DISCUSSION

The reproducibility study shows that interpretation of LS studies is reproducible to an acceptable degree with 99% agreement. It is reasonable to expect a similar accuracy among other nuclear medicine physicians; detecting the presence of activity as a positive finding is much easier than detecting decreased activity as a positive finding. The most difficult area for interpretation is around the neck; lateral and superior oblique views may be required here.

### Axillary Drainage

We have shown that most patients (92%) with truncal melanoma have drainage to at least one axilla. Slightly more than half (58%) have more than one draining node group, although only 10.5% have drainage to three or more node groups. Our study reemphasizes the extreme variability of lymphatic drainage in individuals, which makes general rules inappropriate when predicting draining groups clinically (Fig. 3). Many patients showed surprising drainage across the midline, even when the lesion site was quite lateral. Lesions do not have to be near the midline, Sappey's line or the shoulder to have ambiguous drainage.

We also described a small group of patients who displayed unusual drainage patterns. Three included para-aortic drainage (*12*), which has not previously been described. Since completing the study, we have seen two more patients with this drainage pattern. We also have seen a patient with internal mammary drainage. Norman et al. (*8*) recently attempted to redefine lymph drainage patterns and enlarge the ambiguous drainage zone in which they advise LS. However, our experience favors LS in any patient with truncal melanoma considered for ND, regardless of the site of the lesion.

### Sensitivity of Lymphoscintigraph

The sensitivity of LS in detecting drainage sites that may contain metastases is 94%, or 96% if the one obvious misinterpretation is removed. The two remaining false-negative cases indicate that some node groups do not accumulate sufficient tracer to be detected with this technique, although they are potential drainage sites. If LS were combined with clinical findings of palpable lymph nodes, there would have been 98% sensitivity. This overall degree of sensitivity means that LS can reliably be used prospectively to guide surgical intervention in patients with truncal melanoma. It removes the uncertainty associated with clinical judgment regarding node groups that contain micrometastases, thus limiting surgical resection to only those node groups that are potential sites of spread.

It has been postulated that melanoma metastases can block the lymph channels and replace the lymph nodes (*8*), causing nonvisualization of potential drainage sites on LS. This was not a significant problem in this study; in fact, good channels were sometimes seen despite clinically obvious, in-transit metastases in the lymph channels (Fig. 4).

### Mapping Drainage Channels

We mapped the major lymph drainage channels by drawing the path of the channels on the patient's skin. This dramatically demonstrates great variation in the distribution of the draining lymph channels from patient to patient even when the lesion site is almost identical (Fig. 3). Early in the study, it was obvious that lymph channels often took a tortuous path to the draining lymph node group, indicating that an incontinuity dissection to the node group along the usual path would frequently miss much of the channel. If an incontinuity dissection is to be performed with intent to remove the major lymph channels and any interval nodes, it would be important to define the exact location of these structures. Drawing the major lymph channels on the skin demonstrates the practicality of performing an effective incontinuity dissection. In patients with a single dominant channel only, one can excise a thin strip containing the lymph channel, with primary closure. In patients with multiple divergent channels, a much wider resection, possibly with grafting, may be necessary. Figure 5 illustrates this point well. It was this case that led us to change from simply supplying the surgeon with LS films and a calibrated ruler, to actually drawing the path of the major lymph channels on the patient's skin with an indelible pen.

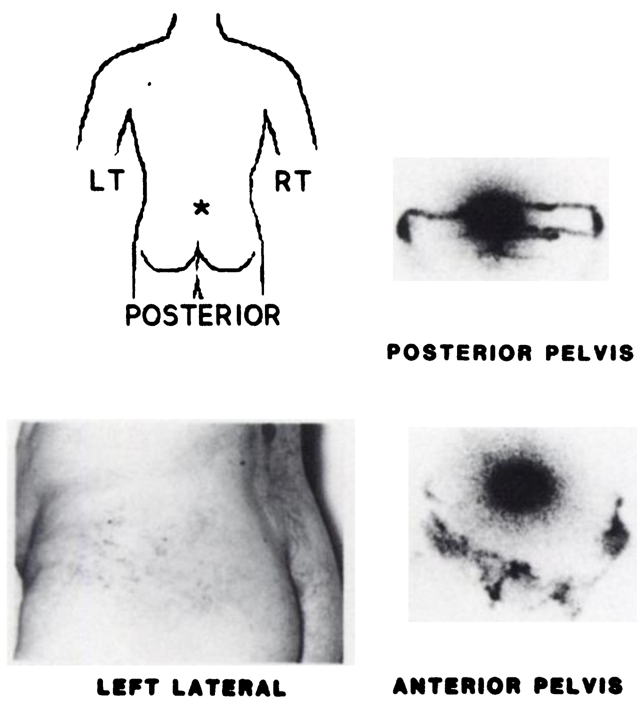


**FIGURE 4.** Patient with visually obvious metastases in major lymph channels passing from low back in midline to inguinal regions bilaterally (left lateral photograph). The major lymph channels, despite presence of intransit metastases, were clearly visualized on LS in the early dynamic phase performed posteriorly over the pelvis. On the delayed image anteriorly over the pelvis, little activity was seen in the inguinal nodes and most of the tracer remained in the lymph channels, suggesting that the rate of lymph flow was reduced by the metastases.

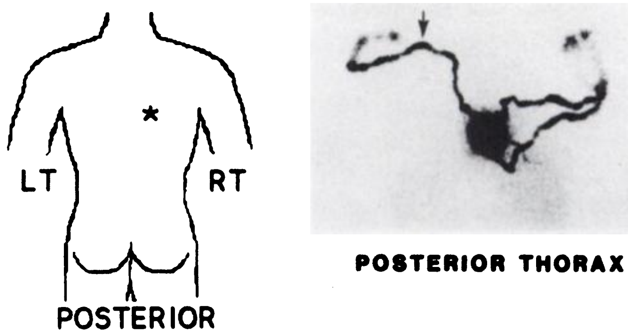


**FIGURE 5.** Patient with lesion on the mid back to the right of midline. Early dynamic phase performed posteriorly over the thorax shows two dominant channels passing to the right axilla and a tortuous single dominant channel passing to the left. The channel takes a superior path before turning toward the left axilla. An incontinuity dissection was performed on the left without exact correlation with the LS findings and a narrow strip of tissue removed followed by primary closure. The strip was below the actual path of the channel on the left; an intransit metastasis developed later at the site of the original high channel on the left (arrow).

### Locating the Sentinel Node

During the last 6 mo of the study we marked the sentinel node in each draining node group. This has proved to be one of the most useful aspects of LS; in the 6 mo since completion of the study, we performed sentinel node marking in another 100 patients. Locating and examining the sentinel node makes sense: If the sentinel node is normal, the likelihood that other nodes will contain metastases is low. A more radical node dissection can be avoided, with little chance that micrometastases will be missed.

LS speeds up the location of the sentinel node using the dye technique and identifies patients with interval nodes between the lesion site and the draining lymph node group. This approach is less technically demanding than dissecting the lymph channels (*1*).

Using LS to locate the sentinel node is also relevant for melanoma on the upper and lower limbs. Screening the node group by removing only the sentinel node should markedly decrease the incidence of lymphedema if the node is negative and a radical dissection can be avoided. Surgical resection was generally not done if there were drainage to more than two node groups. With the ability to mark the sentinel node, multiple sentinel node biopsies can be performed in different node groups, with radical dissection confined to groups with metastases in the sentinel node. The approach makes surgery available to more patients.

Great care should be taken in marking the sentinel node or nodes: The LS technique and multiple-orthogonal views must be used to avoid parallax error when marking the node site on the skin. The patient must also be in the same position as that used for surgery.

## CONCLUSION

This study demonstrates that LS makes available considerable information to assist surgical management of patients with melanoma of the trunk. It can accurately define node groups draining the lesion site and identify sites of potential micrometastases in patients who do not have palpable lymph nodes. The number of node groups draining the lesion site may determine if surgery is practical. The number and actual path of the draining lymphatic channels can be defined and marked on the patient's skin prior to surgery; incontinuity dissection includes all of the major lymph channels and any interval nodes.

The sentinel node in each draining lymph node group can be marked on the skin, allowing rapid location of the sentinel node during surgery using the blue-dye technique. Patients who have a negative sentinel node may be spared a radical-node dissection and will have only a small incision over the sentinel node itself. We have confirmed previous studies that demonstrate great variability of lymph drainage in individuals and have also shown a new drainage pathway from the back to the para-aortic nodes. These findings lead us to conclude that LS is indicated in any patient with melanoma of the trunk who is being considered for surgical resection of the lymphatics and lymph nodes.


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