TECHNICAL NOTE

The Application of Internal Mammary Lymphoscintigraphy to Planning of Radiation Therapy

Elaine N. Dufresne, William D. Kaplan, Robert E. Zimmerman, and Christopher M. Rose

Sidney Farber Cancer Institute, Harvard Medical School, Boston, Massachusetts

A technique is described for the anterior and lateral imaging of the thorax during internal mammary lymphoscintigraphy. It permits reliable estimates of lymph-node location to within 3 mm of the actual location. Use of the results from these measurements can be directly applied to radiation portal planning.

J Nucl Med 21: 697–699, 1980

In patients with carcinoma of the breast for whom radiation therapy is indicated, radionuclide lymphoscintigraphy has been used as a noninvasive tracer technique for the location of the internal mammary lymph nodes (*1*). The rationale for this diagnostic test is to disclose the medial drainage pathway of the breast lymphatics to the internal mammary nodes, which are said to lie in the intercostal spaces, deep to the sternum and 3 cm lateral to it (*2, 3*). Recent information accumulated from our lymphoscintiscans suggests that node position can be quite variable, and many are located at a considerable distance from this anticipated location (*4*). Precise knowledge of node location, particularly the depth, is essential if tangential-beam irradiation is to ensure adequate treatment. This study describes an imaging technique that allows for the location of lymph-node position; the information is directly applicable to the planning of radiation therapy portals.

MATERIALS AND METHODS

Injection technique. The site of injection is important, to provide adequate lymphatic uptake of activity and subsequent visualization of the nodes. The technique as described by Ege indicates the need for a subcostal injection approximately 3 cm inferior to the xiphoid process and 1-2 cm medial to the midclavicular line (*1*). With the patient in the supine position, 0.5-1.0 mCi of technetium-99m antimony trisulfide (Tc-99m Sb_2S_3)* in a volume of approximately 0.25 ml is deposited anterior to the posterior rectus sheath. The syringe (1.0 cc tuberculin) is held at an angle approximately 45° from the horizontal, with the needle (22 gauge, 1½ in.) directed toward the axilla of the side to be examined. The depth of injection is controlled by applying tension to the skin surface with the opposite hand.

Assessment of injection. Within a few minutes after adminis-

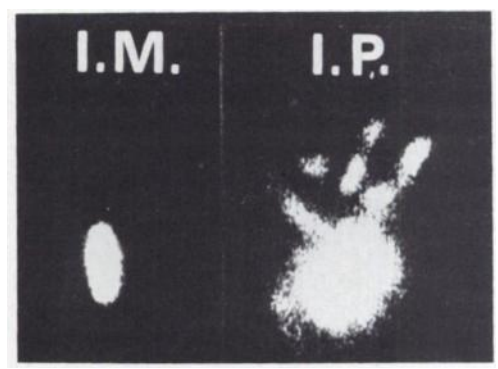

FIG. 1. Two patterns of injection observed at 5 min. IM injection (left) provides maximal opportunity for visualization of nodes.

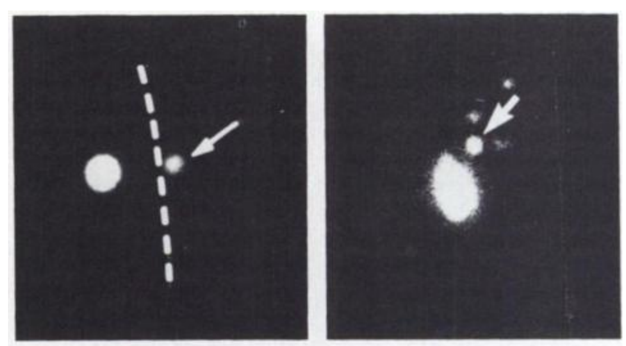

FIG. 2. (left) Cross-table lateral view, with skin surface defined by radioactive marker (arrow), will indicate depth of injected material. Adequate IM injection will show separation between injectate and skin surface.

FIG. 3. (right) Xiphisternal diaphragmatic node (arrow), visualized 3 hr after injection, is evidence that adequate IM injection has been achieved (anterior projection).

Received March 15, 1979; revision accepted Feb. 4, 1980.

For reprints contact: William D. Kaplan, MD, Div. of Nuclear Medicine, Sidney Farber Cancer Institute, 44 Binney St., Boston, MA 02115.

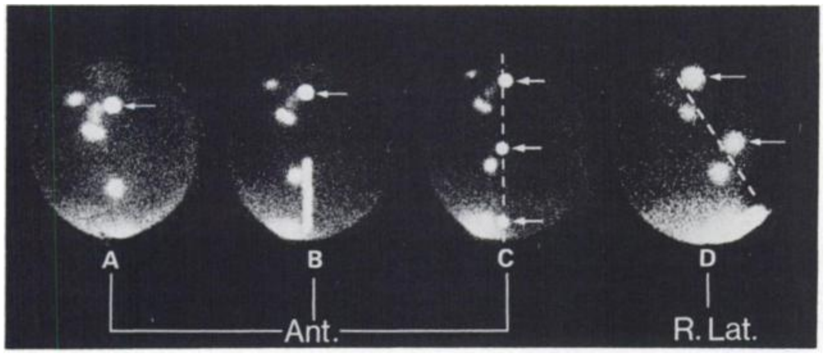

FIG. 4. Scintiphotos from which estimates are made. (A) anterior view with sternal notch marker (arrow). (B) same, with added 10-cm Co-57 string. (C) three Co-57 markers (arrows) in position for the anterior projection. (D) right lateral view of same (arrows), with lines constructed for measurement.

tration of the radiocolloid, the patients are imaged to verify configuration of the injectate. Two injection patterns have been observed (Fig. 1). When the radiocolloid is deposited just posterior to the rectus abdominis muscle (IM) the injectate will appear as a focal area of activity; this is the ideal configuration. Intraperitoneal injections show as a region of dispersed activity (IP). In general, a well localized elliptical focus of activity has been associated with optimal visualization of nodes, whereas the IP pattern of injection has been associated with delayed nodal visualization at 3 hr.

Further assurance of the proper depth of the radiocolloid deposition can be achieved by imaging the supine patient in a cross-table lateral projection while defining the skin surface with a radioactive source. This view will demonstrate a noticeable separation between the skin marker and the injectate when the tracer has been deposited anterior to the posterior rectus sheath (Fig. 2). If the radioactive marker and the injected material overlap, a subcutaneous injection must be suspected.

In an obese patient, it is well to check the placement of the radiocolloid by acquiring an additional lateral view with the patient lying on the nonoperated side. With correct, deep injection, this will increase the spacing in the image between the skin marker and the tracer, whereas with subcutaneous injection the two will move together, retaining about the same spacing in the image. Identification of an inadequate injection allows for an immediate reinjection, thereby ensuring the best opportunity for visualization of the nodes at the time of imaging.

Imaging. At approximately 3 hr, the injection site is again imaged to verify visualization of the xiphisternal-diaphragmatic nodes (*1*). Scintigraphic identification of these nodes indicates that a technically adequate injection has been achieved (Fig. 3). Nonvisualization of nodes above those at the diaphragm may indicate disease or postsurgical debris within the lymphatics.

Scintiphotos are obtained using a standard-field camera with a parallel-hole, low-energy, all-purpose collimator (Fig. 4). With the sternal notch identified by a Co-57 spot marker, the patient in the supine position, and the injection site excluded from the field of view, a 100,000-count anterior scintiphoto is collected over the thorax (A). A second anterior image is obtained after placing a Co-57 string on the sternum with the inferior end of the string placed at the xiphoid (B). This 10-cm marker serves as the standard for subsequent measurement. With three cobalt markers (arrows) identifying the sternal notch, xiphoid, and the midpoint between both, a third anterior image is obtained (C). A cross-table lateral view with the three cobalt markers in place (D) allows identification of the skin surface and subsequent precise definition as to the depth of the nodes from the anterior chest wall.

In obtaining a lateral view of the side of interest, the mode of image acquisition is critically important. The image must be obtained in a true cross-table lateral view with the patient lying supine and the arm extended upward to allow the thorax to come in close proximity to the camera (Fig. 5).

Quantitation. On the anterior view (Fig. 6) a node's distance from the midline, A, is determined by measuring from the center of each node medially to a line that connects the three cobalt markers. The distance of a node from the sternal notch, B, is obtained by measuring from the center of the SN marker to the center of each node along a plane parallel to the midline.

The depth of a node is found from the lateral view by measuring from the center of the node tangentially to a line running just inside the posterior edges of the skin markers (C, Fig. 6). Measurements are made directly from the Polaroid film using the 10-cm Co-57 string as a standard.

Verification. The validity of distance estimates by this technique was verified using the Alderson-Rando tissue-equivalent phantom.† Gelatin capsules containing trace amounts of Tc-99m were

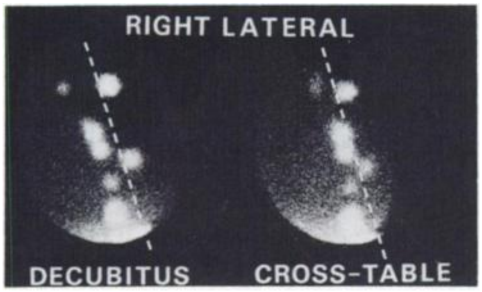

FIG. 5. Two lateral views for comparison. View on left falsely increases apparent depth of lymph nodes. Cross-table lateral image on right provides true representation of nodal depth.

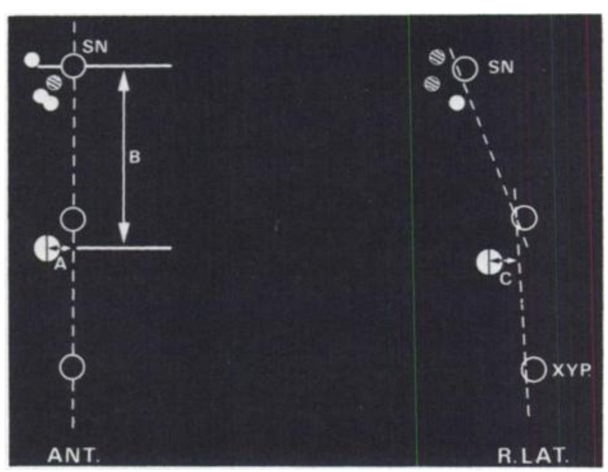

FIG. 6. Placement of lines connecting Co-57 markers. A indicates distance of node from midline; B gives distance from sternal notch. C shows depth beneath skin surface.

TABLE 1. A COMPARISON OF ESTIMATES WITH ACTUAL RADIOACTIVE POINT-SOURCE LOCATIONS USING THE ALDERSON-RANDO PHANTOM

Node	Below SN*		From Midline*		Depth	
	Estimated	Actual	Estimated	Actual	Estimated	Actual
A	0.8	1.0	2.0	2.3	1.4	1.5
B	4.0	4.0	2.3	2.2	3.2	3.0
C	8.7	8.7	5.5	5.4	3.0	2.8
D	9.0	9.0	2.5	2.7	5.0	4.8
E	12.0	12.0	5.0	5.2	6.0	6.2
F	8.7	8.6	2.6	2.4	1.8	1.8
G	14.0	14.0	2.4	2.4	3.0	3.0
Maximum deviation	0.2		0.2		0.2	
Average deviation	0.04		0.13		0.1	

* Distance in centimeters.

inserted into holes drilled within phantom slices at various levels and locations. Anterior and lateral scintiphotos of the small sources within the phantom's thorax were obtained. The actual locations of the capsules, as measured from the phantom, were compared with the scintigraphically determined estimates derived from the Polaroid film. Table 1 gives the results. The inferred locations in relation to the sternal notch, midline, and depth showed a maximum deviation of 3 mm from the true positions.

DISCUSSION

The standard treatment plans for breast cancer, including the lymph nodes from the second through the fifth intercostal spaces, were examined for 68 patients (*4*). At our institution, a line 3 cm deep and 3 cm lateral to the midsternal line has been used to indicate the presumed location of the internal mammary lymph nodes. However, scintigraphic data for interspaces two through five show that 29 of 230 nodes (13%) would have been inadequately treated.

A retrospective analysis of the adequacy of the standard tangential portal technique was performed in 15 patients using the scintigraphically determined location of the internal mammary lymph nodes. Nodes that could be located in three dimensions were placed on the central axis isodose contour. The dose received by each node was determined using the isodose contours generated by the standard technique. Treatment portals were scored as adequate if all visualized lymph nodes were contained within 3 mm of the 100% isodose line. Using this criterion of assessment, six of 15 patient plans (40%) were judged to be inadequate.

Fifty-three consecutive patients who had scintigrams and then underwent treatment planning were analyzed for the consequences of the addition of radionuclide lymph node imaging to the tangential technique. In 16 patients (30%) there was a 1- to 3-cm increase in the length of the tangential separation between the medial and lateral beams. In four of these patients (8%), the concomitant increase in volumes of heart and lung irradiated led to the use of *en face* portals to the internal mammary region for a portion of the treatment. The lymphoscintigram allowed a decrease in the volume of irradiated tissue in 15 patients (28%).

Use of radionuclide lymphoscintigraphy for either tangential beam or *en face* radiation therapy will, by more precisely defining the positions of internal mammary lymph nodes, allow individual radiation therapy portals to be better tailored to patient anatomy. This technique will not only ensure that a lymphatic chain is included in the portal, but in many instances allow a reduction in portal size, thereby sparing normal tissue.

FOOTNOTES

* Union Carbide, Tuxedo, NY.

† Alderson Research Labs. Inc., Stamford, CT.

ACKNOWLEDGMENTS

The authors extend their appreciation to Christopher Black for his technical assistance, Deborah Hansen and John Buckley for their art work, and Barbara Connolly for her assistance in the preparation of the manuscript.

REFERENCES

1. EGE GN: Internal mammary lymphoscintigraphy. *Radiology* 118:101–107, 1976
2. HULTBORN KA, LARSSON LG, RAGNHULT I: The lymph drainage from the breast to the axillary and parasternal lymph nodes, studied with the aid of colloidal Au^{198} *Acta Radiol* 43:52–64, 1955
3. TURNER-WARWICK RT: The lymphatics of the breast. *Br J Surg* 46:574–582, 1959
4. ROSE CM, KAPLAN WD, MARCK A, et al: Parasternal lymphoscintigraphy: Implications for the treatment planning of internal mammary lymph nodes in breast cancer. *Int J Radiat Oncol Biol Phys* 5:1849–1853, 1979