LYMPHOSCINTIGRAPHIC DRAINAGE PATTERNS OF THE AURICLE IN HEALTHY SUBJECTS

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Abstract: Background. In lymphoscintigraphies of the head and neck, multiple injections around a tumor result in variable drainage to multiple nodal basins. We undertook this study in healthy subjects to test whether single injections at specified points in the auricle display single predictable pathways and predict visualization of parotid sentinel lymph nodes (SLNs).

Methods. Twenty-five healthy subjects were classified according to their injection points in the auricle. Each was injected bilaterally with 99mTc nanocolloid. Parotid and extraparotid lymph nodes were topographically differentiated. The procedure was repeated 1 week later.

Results. Lymphoscintigraphy was reproducible. Each injection revealed a single SLN. Injection site predicted parotid SLN visualization. Two lymphatic territories with parotid or extraparotid drainage were identified.

Conclusions. Lymphatic territories in the auricle coincide with the vascular territories and branchial origins. Our findings contradict the notion that lymphatic drainage of the head and neck is unpredictable and variably involves multiple nodal basins. © 2005 Wiley Periodicals, Inc. Head Neck 27: 893–900, 2005

Keywords: auricle; lymphoscintigraphy; sentinel lymph node

Sentinel lymph node (SLN) biopsy is potentially applicable in all N0 cutaneous malignancies spreading initially by the lymphatic route1–5 and almost a standard approach in the treatment of malignant melanoma.

Lymphoscintigraphy is considered essential before SLN biopsy for the primary tumors in all regions.6 It was found to be reliable on the basis of nodal recurrence in basins of negative scan.7,8 With the use of lymphoscintigraphy, the typical malignant melanoma of the head and neck has been shown to have an individually variable lymphatic drainage to multiple nodal basins ranging from one to five6,9 and to unpredictable sites in 34% to 84% of the patients.9–14

Mostly on the basis these data, the head and neck region has been said to be “hallmarked by interlacing, watershed cutaneous lymphatic drainage patterns that are impossible to predict on clinical grounds.”9,8 We speculate that in lymphoscintigraphies for malignant melanomas
of the head and neck, each of the multiple injections around the lesion or biopsy site has its own specific lymphatic drainage pattern that may come up with SLN appearances in multiple basins, and the lymphoscintigraphy with a single injection at a specified point would reveal a single SLN on a predictable pathway.

On the basis of this idea, we hypothesize that when the radiotracer is injected at specified points in the auricle, lymphoscintigraphic demonstration of critically located parotid SLNs is determined by the location of the injection site. “Critically located” means that the risk of facial nerve injury necessitates a facelift incision for retrieval of SLNs. This corresponds to the entire parotid except for a portion of the tail that is included in neck dissection. To test the preceding hypothesis, we designed a study of healthy subjects in which the estimated SLN locations were correlated with single injection sites in the auricle. As a sample of a head and neck cutaneous area, the auricle was chosen for its lymphatic drainage through parotid and extraparotid pathways, its easily described tiny features, and the improbability of contralateral drainage. The aim of this study was to determine the predictive value of an injection site within a small area like the auricle for the necessity of a challenging SLN retrieval from the parotid.

**MATERIALS AND METHODS**

Twenty-five healthy subjects (13 women and 12 men; age, 21–69 years [mean, 32 years]) were recruited through a bulletin board. Written informed consent was required from each subject. The study was approved by the institutional review and ethical boards.

**Study Design.** Nine points were specified in the auricle for the injections as follows: helical tubercle, confluence of superior and inferior antihelical crus, tip of helical foot, helix–scalp junction, tip of tragus, tip of antitragus, medial skin side of the helical foot, helix at the end of superior antihelical crus, and lowermost lobule (Figure 1). Each injection site was studied in two or three subjects. Considering the improbability of lymphatic flow to the other side, symmetric injections were made bilaterally, and SLNs from both ears were simultaneously visualized for the same injection site. In addition to providing duplicated data, this enabled an assessment of symmetry. For the assessment of reproducibility, the experiment was repeated on the same subject at least 1 week apart.

**Scintigraphic Procedure.** A single injection of $^{99m}$Tc-labeled nanocolloid (Lymphoscint, Bristol-Myers Squib, Belgium) containing 8 to 15 MBq in a 0.2 mL volume, was made intradermally for each site with a 27-gauge needle on a tuberculin syringe. Wheals of 3 to 5 mm were produced. Injection sites were covered with malleable lead leaves to diminish the signals that may obscure the nearby lymph node basins. Dynamic images (128 x 128 matrix size and a frame every 30 seconds) were obtained immediately after the injections over a period of 20 minutes, and static planar images (256 x 256 matrix size and each image acquisition lasting 300 seconds) were acquired after injection at 30 minutes and 2 hours. Posteroanterior and left lateral views were obtained simultaneously during the dynamic phase. Right and left lateral static images were taken successively, accompanied by posteroanterior views. The subjects remained in a standard supine position during the scan. The images were obtained using a double-head gamma camera system (E-Cam dual-head variable-angle system; Siemens, Chicago, IL) equipped with high-resolution collimators for low energy. The photopack was centered at 140 keV with a 20% window. A

![Figure 1. Nine injection sites in the auricle: 1, helical tubercle; 2, confluence of antihelical crus; 3, tip of helical foot; 4, medial skin side of the helical foot; 5, tip of antitragus; 6, tip of tragus; 7, helix at the end of superior antihelical crus; 8, scalp-helix junction; 9, lowermost lobule. The auricle is divided into two territories according to the lymphatic drainage pattern of these injection sites. The borderline denotes the watershed zone. The anterior and posterior parts drain to parotid and extraparotid sentinel lymph nodes, respectively.](image-url)
hot spot separate from or protruding out of the outline of injection site was considered to represent a lymph node. It was considered to be an SLN if it was the first one seen in a sequential pattern, if it was the only one visualized, or if the trace of afferent lymphatic channels arising from the injection site was seen. If a lymph node appeared at an interval after the visualization of the SLN and a trace of lymphatic channels was seen arising from the SLN, it was accepted to be a nonsentinel lymph node (NSLN). Because of the symmetric locations of SLNs, they were frequently superposed in lateral views. Projections from the other side in lateral views were easily delineated with their dull appearances and their locations in posteroanterior and contralateral views.

**Topographic Localization.** On the lateral static images obtained from both sides 2 hours after injection, three reference points were highlighted with a Co-57 pen-point marker: mastoid tip (M), tragus (T), and mandibular angle or gonion (G) (Figure 2A). The locations of lymph nodes were defined with sides and corners of the triangle formed by these points (Figure 2B, C). When activity of the lymph nodes was seen right anterior to the tragus, or posterior to the mandibular angle, or overlying the mastoid tip, the locations were expressed with these corners. From these positions, a location was expressed with the sides of the triangle. The SLNs localized as M should correspond to the mastoid or postauricular lymph nodes. M–G and G nodes may be the superficial and deep cervical lymph nodes as well as the tail of parotid, which is amenable to excision during neck dissection without a formal parotidectomy approach. T, T–G, and T–M nodes were accepted as the critically located parotid nodes.

**RESULTS**

SLN signals with ear lobule injections were frequently obscured by the adjacent injection site activity. Therefore, the lobule data were excluded from the analysis and interpreted at the end in accordance with general trend of the data.

Lymphoscintigraphy for SLN localization was found to be 100% reproducible in repeated scans of 44 ears. All the SLNs were within the territory of described triangle (Table 1). Only one SLN location was identified for each injection. More than 50% of the SLN visualizations (46 of 90) occurred within the first minute. Nearly one third (29 of 90) were visualized in a 1- to 5-minute period. Two SLNs from each of tragus and scalp–helix junction groups did not appear until the activity level at the injection sites decreased enough to let the SLNs appear at the 2-hour static images. Tragus and helix–scalp junction always drained to parotid SLNs. Antitragus, helical tubercle, confluence of superior and inferior antihelical cruses, helical foot, and medial skin side of the helical foot always drained to extraparotid SLNs. Helix at the end of superior antihelical crus had diverse drainage patterns with either parotid or extraparotid SLNs in different ears. SLN locations for an injection site may vary within the limits of these drainage patterns. The SLNs were symmetrically located with superposed appearances in lateral views in 65% (15 of 23) of the subjects. All additional hot spots were evaluated as NSLNs (Table 1). Thirty-one percent (11 of 34) of the NSLN visualizations occurred after injection in 5 minutes, and the rest occurred by 2 hours. The numbers of NSLNs visualized were 18 and 16 in the first and second sets of scans, respectively. Twelve NSLNs were repeatedly observed in repeated scans, and 22 ears did not reveal any NSLNs in either of two the scans (Table 2). This points to a significant association between the two sets of scintigraphies for the visualization status of NSLNs (Fisher exact test, \( p < .05 \)). The NSLNs were marked scintigraphically as M–G (\( n = 21 \)), M (\( n = 4 \)), and G (\( n = 3 \)) in decreasing order of frequency.

SLN visualizations were totally irreproducible after lobule injections. This was because the injections too proximate to the draining lymph nodes resulted in nonvisualization of lymph nodes and discordance in repeated scans. For example, M and T–M marked SLNs in the latter scans are missed in the former ones, and the G and M–G marked lymph nodes taken to be SLNs in the former scans are interpreted to be NSLNs on the basis of the second scans (Table 1). Nevertheless, both parotid and extraparotid SLNs were visualized with lobule injections. Two lymphatic territories were delineated in the auricle according to whether a parotid or extraparotid SLN drains an injection point (Figure 1).

**DISCUSSION**

Single intracutaneous injections at nine specified points in the auricle always resulted in single SLN appearances. All SLNs were visualized
within a triangle formed by the tragus, mastoid tip, and mandibular angle in lateral views. The SLNs were always identified at the same location in the repeated injections of an ear, demonstrating 100% reproducibility of lymphoscintigraphy for SLN visualization. The NSLN visualizations were significantly reproducible in the repeated scintographies. The lowermost lobule and helix at the end of the superior antihelical crus were found to drain variably in different ears to parotid or extraparotid SLNs. The other injection points drained consistently to SLNs in either parotid or extraparotid locations. However, the SLN locations were variable within these drainage patterns. Our hypothesis that injection site in the auricle predicts drainage to a critically located parotid SLN was confirmed.

As can be seen in Figure 1, division of the auricle according to lymphatic drainage patterns of the injection sites can be closely correlated with the vascular territories of the auricle (Figure 3). The injection sites within the territory of the superficial temporal artery invariably drained along the superficial temporal vein to parotid SLNs. The sites within the territory of posterior auricular artery invariably drained along the
The two points that were demonstrated to drain in both patterns are located in the watersheds of these vascular territories. The information gathered from various minor auricular fusion anomalies suggests that the division of the auricle according to the embryonic origins matches well with the vascular territories (Figure 3). The auricular parts derived from the mandibular and hyoid arches correspond to the vascular territories of superficial temporal and posterior auricular vessels, respectively.15,16 Embryonic development of the lymphatic system begins later than blood vessels as outgrowths of veins.17 Therefore, the concept of two lymphatic drainage patterns in the auricle having parallel relationships with the two vascular territories and two branchial arch origins is plausible.

The SLNs localized to the parotid region deserve special consideration whether they are posterior auricular vein to extraparotid SLNs. The two points that were demonstrated to drain in both patterns are located in the watersheds of these vascular territories. The information gathered from various minor auricular fusion anomalies suggests that the division of the auricle according to the embryonic origins matches well with the vascular territories (Figure 3). The auricular parts derived from the mandibular and hyoid arches correspond to the vascular territories of superficial temporal and posterior auricular vessels, respectively.15,16 Embryonic development of the lymphatic system begins later than blood vessels as outgrowths of veins.17 Therefore, the concept of two lymphatic drainage patterns in the auricle having parallel relationships with the two vascular territories and two branchial arch origins is plausible.

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### Table 1. SLN and NSLN locations bilaterally visualized for each injection site.

<table>
<thead>
<tr>
<th>Injection site</th>
<th>Subject</th>
<th>Left</th>
<th>Right</th>
<th>Left</th>
<th>Right</th>
</tr>
</thead>
<tbody>
<tr>
<td>Helical tubercle</td>
<td>1</td>
<td>M-G</td>
<td>M</td>
<td>M-G</td>
<td>M</td>
</tr>
<tr>
<td></td>
<td>2</td>
<td>M</td>
<td>G</td>
<td>M</td>
<td>M-G</td>
</tr>
<tr>
<td></td>
<td>3</td>
<td>G</td>
<td>M</td>
<td>M</td>
<td>M-G</td>
</tr>
<tr>
<td>Confluence of antihelical cruses</td>
<td>1</td>
<td>M-G</td>
<td>M</td>
<td>M-G</td>
<td>G</td>
</tr>
<tr>
<td></td>
<td>2</td>
<td>M</td>
<td>M</td>
<td>M</td>
<td>MG</td>
</tr>
<tr>
<td></td>
<td>3</td>
<td>M-G</td>
<td>M</td>
<td>M</td>
<td>M-G</td>
</tr>
<tr>
<td>Helical foot</td>
<td>1</td>
<td>M</td>
<td>M</td>
<td>M</td>
<td>M</td>
</tr>
<tr>
<td></td>
<td>2</td>
<td>M</td>
<td>M</td>
<td>M</td>
<td>M</td>
</tr>
<tr>
<td></td>
<td>3</td>
<td>M</td>
<td>M</td>
<td>M</td>
<td>M</td>
</tr>
<tr>
<td>Tip of antitragus</td>
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<td>M</td>
<td>M</td>
<td>M</td>
<td>M</td>
</tr>
<tr>
<td></td>
<td>2</td>
<td>M</td>
<td>M</td>
<td>M</td>
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<tr>
<td></td>
<td>3</td>
<td>M</td>
<td>M</td>
<td>M</td>
<td>M</td>
</tr>
<tr>
<td>Medial skin side of helical foot</td>
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<td>M-G</td>
<td>M-G</td>
<td>M-G</td>
<td>M-G</td>
</tr>
<tr>
<td></td>
<td>2</td>
<td>M-G</td>
<td>M</td>
<td>M</td>
<td>M</td>
</tr>
<tr>
<td></td>
<td>3</td>
<td>M-G</td>
<td>M</td>
<td>M</td>
<td>M</td>
</tr>
<tr>
<td>Helix–scalp junction</td>
<td>1</td>
<td>T</td>
<td>T</td>
<td>T</td>
<td>T</td>
</tr>
<tr>
<td></td>
<td>2</td>
<td>T-G</td>
<td>M</td>
<td>T-G</td>
<td>M-G</td>
</tr>
<tr>
<td></td>
<td>3</td>
<td>T-G</td>
<td>T</td>
<td>T</td>
<td>T</td>
</tr>
<tr>
<td>Helix at the end of superior antihelical crus</td>
<td>1</td>
<td>T</td>
<td>M-G</td>
<td>M</td>
<td>M-G</td>
</tr>
<tr>
<td></td>
<td>2</td>
<td>M</td>
<td>M</td>
<td>M</td>
<td>M</td>
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<td>3</td>
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<td>M</td>
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<tr>
<td>Tip of tragus</td>
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<tr>
<td></td>
<td>2</td>
<td>T-M</td>
<td>T-M</td>
<td>T-M</td>
<td>T-M</td>
</tr>
<tr>
<td></td>
<td>3</td>
<td>T-M</td>
<td>T-M</td>
<td>M</td>
<td>M</td>
</tr>
<tr>
<td>Lowermost lobule</td>
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<td>M</td>
<td>G</td>
<td>M</td>
<td>MG</td>
</tr>
<tr>
<td></td>
<td>2</td>
<td>M-G</td>
<td>M</td>
<td>M</td>
<td>M</td>
</tr>
</tbody>
</table>

**Abbreviations:** SLN, sentinel lymph node; NSLN, nonsentinel lymph node; M, mastoid tip; G, gonion; T, tragus. Note. The upper and lower rows corresponding to each subject are the data from first and second scintigraphies, respectively. Note 100% reproducibility for SLN location when the lobule data were excluded.

### Table 2. NSLN visualization in repeated scintigraphies of 44 auricles.

<table>
<thead>
<tr>
<th>NSLN visualization</th>
<th>Second scintigraphy</th>
</tr>
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<tbody>
<tr>
<td>Yes</td>
<td>12</td>
</tr>
<tr>
<td>No</td>
<td>4</td>
</tr>
</tbody>
</table>

**Abbreviation:** NSLN, nonsentinel lymph node. Note. A significant association between repeated scintigraphies is present for NSLN visualization (Fisher exact test, p < .05).

### FIGURE 3. Vascular territories and embryonic origins of the auricle according to Park and Roh.15,16 The hillocks numbered 1, 2, and 3 come from the mandibular arch; 4, 5, and 6 come from the hyoid arch. STA, superficial temporal artery; PAA, posterior auricular artery. Reprinted with permission, Park C, Lower auricular malformations: their representation, correction, and embryologic correlation, Plast Reconstr Surg 1999;104(1):29–40.
Lymphoscintigraphic Drainage Patterns of the Auricle

Although they did not address the lymph node basins in association with location of the lesion in the auricle, some helical lesions should have drained to the parotid lymph nodes for the parotid to be the most frequent SLN location. Narayan and Ariyan reported a lesion of the helix that was demonstrated to drain to the preauricular nodes. The locations of the lesions in the Cole et al ear melanoma series were helix (47%), lobule (21%), ear–scalp junction (10.5%), posterior ear (10.5%), concha (5%), and tragus (5%). They found 24 SLNs in 19 patients. The SLN locations could be summarized as follows: level II cervical nodes, tail of parotid, and superficial cervical lymph nodes (n = 10); mastoid (n = 1); parotid (n = 6); lower jugular chain (n = 2); supravacular (n = 1); and nonspecified neck (n = 4). With their findings, the authors concluded that their study was in line with the notion that the lymphatic drainage of the ear was highly variable and unpredictable. Lower jugular chain and supravacular SLNs were unpredictable in their study. Jansen et al reported four patients with malignant melanoma of the ear. The lymph node basins involved were level II neck (n = 4), parotid (n = 3), retroauricular (n = 1), and level V neck (n = 1). Eicher et al reported three cases of malignant melanoma of the ear with unpredictable SLN locations at level IV in two cases and supravacular in another. The overall rate of SLNs in nonadjacent lymph node basins was 42%. Pathak et al reviewed metastatic melanoma of the head and neck cases at the Sydney Melanoma Unit. They compared anatomic distribution of the pathologically involved nodes with the clinically predicted patterns of lymphatic spread. The malignant melanoma of the ear had been predicted to spread to the parotid and levels I to V neck nodes; on the basis of this prediction, modified radical neck dissection with parotidectomy had been recommended. All the metastases in ear cases were within the limits of their prediction, with no unusual, isolated metastases. Despite the previous report of 34% discordance between scintigraphy and clinically predicted lymphatic spread from the same unit, metastases conformed to the clinical predictions in 92.3% of the patients. The most common cause of discordance in lymphoscintigraphy was the postauricular lymph nodes. One third in their series skipped the nearest nodes and involved nodes at a more distant site.

Our findings suggest that the helix posterior to the end of the superior antihelical crus does not
drain to the parotid SLNs. Depending on where a lesion is located on the helix, multiple injections around it or the excision scar can extend the area of interest to the watershed zones or beyond and may result in multiple drainage patterns toward extraparotid and parotid lymph node basins. Thompson et al reported a scintigraphic demonstration of lymphatic drainage from the tragus directly to a submental node and to the contralateral upper cervical chain. Again, the injections around the lesion might have extended the area of interest out of the tragus to the cheek or even beyond for such an unexpected lymphatic drainage pattern to occur.

As mentioned previously, the level IV and V neck node basins are not infrequently reported to harbor SLNs that drain ear melanomas. No SLNs were visualized below the level of the mandibular angle in our study. Because of the weaker activity at the injection site, the chance of visualization for the adjacent lymph node basins could be higher in our study than the routine lymphoscintigraphies for malignant melanoma. Impairment of adjacent node function because of tumor in malignant melanoma may also explain the SLNs in nonadjacent basins, whereas we did not find any in our study.

In a study of reproducibility in the repeated lymphoscintigraphies, the images were identical for number and location of nodes in 88% of the patients with malignant melanoma. Because of the more consistent nature of single injections in our study, the reproducibility rate was 100% when the lobule was excluded.

The weaknesses of this study partially stem from the weaknesses of lymphoscintigraphy in the head and neck region. First, precise location of the lymph nodes with external markings is a very difficult task in the head and neck, where the lymph node fields are so concentrated. The radioactive signal from the injection site may obscure the signal from a nearby SLN in 47% of the cases. Even with early dynamic images, it is usually difficult to distinguish SLNs from NSLNs, because the tracer travels fast in the head and neck. Because the gamma cameras are not successful in identifying multiple SLNs in a basin separately, we were interested solely in the lymphatic basins involved, not the number of SLNs in each basin. The lack of surgical confirmation for the lymphatic anatomy implied by external markings is an important weakness of the study.

The common notion based on lymphoscintigraphies of patients with malignant melanoma considers lymphatic drainage of the head and neck totally unpredictable. The lymphoscintigraphies performed on healthy subjects with single injections to specific points demonstrate that the external ear can be divided into two territories with different lymphatic drainage patterns. These territories were described according to their parallel relations with the embryonic origin and vascular supply. Depending on the location of the lesion, a lymphatic territory and/or a watershed may be involved. It is valuable to know the lymphatic zones in a particular region both for doing injections and for judging lymphoscintigraphies more consciously. Radiotracer injections should be done intracutaneously in small volumes knowing that the head and neck skin area is composed of very small lymphatic territories, and thus the radiotracer can easily intrude on a neighboring lymphatic zone. More importantly, this study proposes that lymphoscintigraphic SLN locations should be associated with the injection sites rather than with the lesion site. The biopsy, even with a negligible safety margin, and the resulting scar may broaden the involved area. Moreover, the radiotracer injections may extend the area of interest further enough to capture multiple lymphatic territories. Therefore, we recommend that lymphoscintigraphies should be performed before excisional biopsy if the diagnosis of malignant melanoma is likely. After histopathologic confirmation of the diagnosis, the radiotracer may secondarily be injected for intraoperative radiolocalization of SLNs in the lymphoscintigraphically involved basins.

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the controversies in the N0 neck? Head Neck 2004;26:603–611.