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How Many Sentinel Lymph Nodes Are Enough During Sentinel Lymph Node Dissection for Breast Cancer?

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Abstract

BACKGROUND—It remains unclear how many sentinel lymph nodes (SLNs) must be removed to accurately predict lymph node status during SLN dissection in breast cancer. The objective of this study was to determine how many SLNs need to be removed for accurate lymph node staging and which patient and tumor characteristics influence this number.

METHODS—The authors reviewed data for all patients in their prospective database with clinical tumor, lymph node, metastasis (TNM) T1 through T3, N0, M0 breast cancer who underwent lymphatic mapping at their institution during the years 1994 through 2006. There were 777 patients who had at least 1 SLN that was positive for cancer. Simple and multiple quantile regression analyses were used to determine which patient and tumor characteristics were associated with the number of positive SLNs. The baseline number of SLNs that needed to be dissected for detection of 99% of positive SLNs in the total group of patients also was determined.

RESULTS—The mean number of SLNs removed in the 777 lymph node-positive patients was 2.9 (range, 1-13 SLNs). Greater than 99% of positive SLNs were identified in the first 5 lymph nodes removed. On univariate analysis, tumor histology, patient race, tumor location, and tumor size significantly affected the number of SLNs that needed to be removed to identify 99% of all positive SLNs. On multivariate analysis, mixed ductal and lobular histology, Caucasian race, inner quadrant tumor location, and T1 tumor classification significantly increased the number of SLNs that needed to be removed to achieve 99% recovery of all positive SLNs.

CONCLUSIONS—In general, the removal of a maximum of 5 SLNs at surgery allowed for the recovery of >99% of positive SLNs in patients with breast cancer. The current findings indicated that tumor histology, patient race, and tumor size and location may influence this number.

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Keywords

sentinel lymph node dissection; breast cancer; sentinel lymph node metastasis

Sentinel lymph node (SLN) dissection (SLND), which was used first by Morton et al.[1] for lymph node staging in patients with clinically lymph node-negative melanoma, also has become a widely accepted method of staging lymph nodes for patients with breast cancer. SLND, compared with complete axillary lymph node dissection (ALND), limits the extent of axillary surgery, because fewer lymph nodes are removed, thereby reducing the morbidity associated with the surgery.[2–4]

An SLN is defined best as any lymph node that receives direct lymphatic drainage from a primary tumor site. During SLND, the number of SLNs removed is variable, perhaps because of the specific technique used, the surgeon's experience, the type of agents used for lymphatic mapping, or individual anatomic variation. The mean number of SLNs removed at surgery in breast cancer patients ranges from 1.2 to 3.4 SLNs, and the total number from 1 to 15 SLNs.[5,6] Because of the multiple factors involved in SLND, the number of SLNs that should be removed to accurately predict lymph node status remains controversial. Some researchers have proposed that all lymph nodes that are dyed blue or are "hot" should be removed. Others suggest that all lymph nodes above a predefined threshold percentage of the ex vivo count of the "hottest" SLN should be removed. Still others argue that the procedure can be stopped after a certain predefined number of lymph nodes have been removed.[5,7] The objective of the current study was to determine the number of SLNs that must be removed for accurate lymph node staging in patients with breast cancer and the patient and tumor characteristics that influence this number.

MATERIALS AND METHODS

After receiving Institutional Review Board approval, we queried the University of Texas M. D. Anderson Cancer Center's prospective surgical oncology breast cancer database for patients with clinical tumor, lymph node, metastasis (TNM) T1 through T3, N0, M0 breast cancer who had undergone lymphatic mapping at our institution from March 1, 1994 through March 31, 2006. We reviewed the records of 3580 patients who were identified from this database for clinical and pathologic variables.

From those 3580 patients, we specifically identified those who had an SLN that was positive for metastatic carcinoma and evaluated the patient, tumor, and SLN characteristics to determine whether they influenced the number of SLNs that needed to be removed. We examined patient characteristics (age, sex, race, and body mass index [BMI]), tumor characteristics (location, multicentricity, tumor stage, histologic type, final margin status, lymphovascular invasion [LVI], modified Black nuclear grade [BNG], estrogen receptor [ER] status, progesterone receptor [PgR] status, and HER-2/*neu* status), treatment characteristics (prior biopsy type, use of neoadjuvant chemotherapy, and procedure performed at the time of SLND), and SLN characteristics (drainage observed on lymphoscintigraphy, mapping agent[s] used, day of radiocolloid injection, and ordinal position of the first positive SLN removed).

Clinicopathologic data were tabulated for each patient. Simple and multiple quantile regression analyses were used to model the joint contributions of explanatory variables to the number of SLNs that needed to be removed to retrieve 99% of the positive SLNs (that is, the equivalent of an additional 1% in the false-negative rate for SLND, attributable to removal of an insufficient number of lymph nodes). Stata statistical software (SE 9; StataCorp LP, College Station, Tex) was used for statistical analysis. All *P* values were 2-tailed, and a value ≤.05 was considered significant.

The patients had also undergone SLND using a standard technique, as described previously.[8] Briefly, SLND was guided by filtered, technetium 99m (^{99m}Tc)-labeled sulfur colloid alone; 1% isosulfan blue dye alone; or a combination of the 2 agents. Patients had received injections of either 0.5 mCi^{99m}Tc-labeled sulfur colloid on the day of surgery or 2.5 mCi ^{99m}Tc-labeled sulfur colloid on the day before surgery by means of a peritumoral, subareolar, or subdermal injection. The 1% isosulfan blue dye was injected at the time of surgery by means of a peritumoral or subareolar injection. A lymph node was judged to be an SLN if it had stained blue, if it had gamma counts ≥10 times those of background radioactivity in vivo, or both.

The lymph nodes were numbered in the order in which they were removed by surgeons. When blue dye was used, after the axillary incision was made, a blue channel was identified and followed to the axilla, and the first blue lymph node (which was not always the bluest or hottest lymph node) observed in the lymphatic drainage of the tumor was regarded as the first SLN, the second lymph node observed in the lymphatic drainage was regarded and removed as the second SLN, and so on. When colloid alone was used, the surgeon placed the incision in the axilla over the hottest area identified with the use of the handheld probe. After opening the axillary fascia, the surgeon used the probe to find the hottest area of radioactivity. The lymph node at this spot was removed and checked for radioactive counts ex vivo. If the lymph node had evidence of radioactive counts ex vivo, then it was regarded as the first SLN. The surgeon then rechecked the axilla for residual counts and identified the hottest area of radioactive counts. This lymph node was then removed and checked for radioactive counts. If the lymph node had evidence of radioactive counts ex vivo, then it was regarded as the second SLN, and so on.

Touch-preparation cytology was performed intraoperatively in most patients after all SLNs were removed. When intraoperative evaluation of the SLNs revealed malignant cells, a complete ALND was performed.

Then, all SLNs were submitted for histologic analysis with serial sectioning and immunohisto-chemical (IHC) staining for cytokeratin. A positive SLN was defined as any SLN that contained a metastasis >0.2 mm in greatest dimension on frozen-section analysis, standard hematoxylin and eosin staining, or IHC analysis. Patients with isolated tumor cells (<0.2 mm) were excluded from this study.

RESULTS

Of the 3580 patients who were identified as having undergone a SLND, 3478 patients (97.2%) had at least 1 SLN identified at surgery. Pathologic evaluation revealed that 777 of those 3478 patients (22.3%) had metastasis to at least 1 SLN.

Patient and Tumor Characteristics for Patients With SLNs

Among the 3478 patients who had SLNs identified, the median age was 56 years (range, 22-92 years). There were 2637 Caucasian patients (75.8%) and 841 non-Caucasian patients (24.2%). Invasive ductal carcinoma (IDC) was the most common histologic tumor type (75.8%). The clinical tumor classification (T) at presentation included 2478 patients (71.3%) with T1 tumors, 894 patients (25.7%) with T2 tumors, and 106 patients (3%) with T3 tumors. The number of SLNs identified at the time of surgery ranged from 1 to 13 (mean ± standard deviation [SD]: 2.7 ± 1.5 SLNs).

Patient and Tumor Characteristics for Patients With Positive SLNs

The patient, tumor, treatment, and SLN characteristics for the 777 patients who had SLNs that were positive for cancer are summarized in Table 1. The median age of these patients (54 years; range, 22-91 years) was slightly younger than that of the larger group in which SLNs were negative. There were 284 patients (36.6%) aged <50 years and 493 patients (63.4%) aged ≥50 years. The race distribution of patients with positive SLNs was similar to that of the whole group: 601 Caucasian patients (77.4%) and 176 non-Caucasian patients (22.7%). Among the 176 non-Caucasian patients, there were 58 African Americans and 75 Hispanics (133/176, 76%). Most diagnoses (547; 70.4%), were made either by core-needle biopsy or by fine-needle aspiration biopsy, and the remaining diagnoses (230; 29.6%) were made by excisional biopsy. There were 370 patients (47.6%) with single tumors located in the outer half of the breast and 132 patients (17%) with single tumors located in the inner half of the breast; the other 275 patients (35.4%) had tumors that were either centrally located or multicentric. The majority of patients (436; 56.1%) underwent total mastectomy with SLND. Significantly different from the overall group, in the SLN-positive group, more invasive lobular carcinoma (ILC) (12.1% vs 7.1%), more mixed ductal and lobular carcinoma (10.8% vs 4.3%), but less carcinoma of other histologic types (3.5% vs 12.1%) were observed. Among 27 patients with other histologic types, there were 3 mucinous neoplasms, 9 micropapillary neoplasms, 4 tubular neoplasms, 6 metaplastic neoplasms, and 5 inflammatory tumors. The patients with positive SLNs, as expected, had more advanced disease than the overall group, with the following clinical T classifications at presentation: 435 patients (56%) had T1 tumors, 290 patients (37.3%) had T2 tumors, and 52 patients (6.7%) had T3 tumors. Of the 633 tumors with information about LVI available, 218 tumors (28.1%) were positive. Receptor status was as follows: 650 tumors (83.7%) were positive for ER, 510 tumors (65.6%) were positive for PR, and 119 tumors (15.3%) were positive for HER-2/*neu*.

Sentinel Lymph Node Dissection Technique and Tissue Processing in Patients With Positive SLNs

The majority of SLNDs (549; 70.7%) were performed with both radiocolloid and blue dye, whereas just 228 SLNDs (29.3%) were performed with only a single agent. In total, 391 patients (51.6%) had radiocolloid injected the day before undergoing SLND, 312 patients (41.2%) had radiocolloid injected on the day of SLND, and 55 patients (7.3%) had radiocolloid injected on both days because there was no obvious drainage on lymphoscintigraphy on the day before surgery, and the surgeon injected a second, smaller dose on the day of surgery. Lymphoscintigraphy was performed in 602 of 777 patients (77.5%) before SLND. Of those 602 patients, 556 patients (92.4%) had evidence of drainage to the regional lymph node basins, whereas 46 patients (7.6%) had no evidence of such drainage.

Twenty-nine patients had positive SLNs detected by IHC for cytokeratin only. Intraoperative touch preparation cytology was performed in 400 of 777 patients (51.5%). Of all 777 patients who had a positive lymph node, 176 patients (22.7%) underwent immediate completion ALND, 372 (47.9%) patients underwent delayed completion ALND, and 229 patients (38.1%) did not undergo completion ALND either because the patient declined the procedure or because the treating physician believed that the risk of additional nonsentinel involvement was relatively low. In 376 of 548 patients (68.6%) who underwent a completion ALND, no additional axillary lymph nodes were identified that contained metastatic disease. The remaining 172 patients (31.4%) had positive non-SLNs in addition to the positive SLNs.

Characteristics of Positive SLNs

The number of SLNs identified at the time of surgery ranged from 1 to 13 (mean ± SD, 2.9 ± 1.7 SLNs identified). Table 2 summarizes the number of SLNs removed and the corresponding number of patients in each group: One hundred fifty-six patients (20%) had 1 SLN removed, 217 patients (27.9%) had 2 SLNs removed, 199 patients (25.6%) had 3 SLNs removed, and 103 patients (13.3%) had 4 SLNs removed. Greater than 90% of patients had ≤5 SLNs removed, whereas <10% of patients had >5 SLNs removed. In 572 patients (73.6%), there was only 1 positive lymph node. In 405 patients (70.3%), the first SLN turned out to be positive. In 399 of those 405 patients (70.25%), the first SLN was the only positive lymph node. In all, micrometastases were identified in 270 patients (34.8%).

The number of positive SLNs ranged from 1 to 9 (mean ± SD, 1.4 ± 0.8 positive SLNs). Most patients had only 1 (73.6%) or 2 (20%) positive SLNs; only 47 patients (6%) had ≥3 positive SLNs.

Among the 777 patients who had positive SLNs, the “hottest” SLN was the first positive lymph node in 533 patients (69.0%). We also identified the ordinal position of the first positive lymph node among all SLNs removed (Table 3). In 579 patients (74.5%), the first SLN removed was the one that contained metastatic disease. With each successive SLN removed, the probability that it would contain metastatic disease decreased (Table 3). Greater than 99% of patients had the first positive SLN identified in the first 5 lymph nodes

removed. In only 7 patients (0.9%) was the first positive SLN identified by removing >5 lymph nodes; and, in 4 of those patients, the metastasis measured <2 mm (ie, micrometastasis). There were 29 patients who had their first positive lymph node identified after ≥4 lymph nodes. The first positive lymph node was blue and hottest in 3 of those 29 patients, it was blue and not hot in 1 patient, and it was blue and had counts >10% of the counts in the hottest SLN in 7 patients. Among the remaining 18 patients who had lymph nodes that were hot but not blue, the first positive lymph node was hottest in 2 patients and had counts >10% of the counts in the hottest SLN in 16 patients.

Univariate Analysis and Multivariate Analysis

Univariate analysis revealed that patient age and race; tumor location, size, and histologic type; and ER and PR status significantly affected the number of SLNs that needed to be removed to identify 99% of positive SLNs (Table 4). However, BMI, receipt of neoadjuvant chemotherapy, prior biopsy type, surgery type, mapping agent used, detection of drainage on lymphoscintigraphy, LVI, HER-2 status, final margin status, BNG, multicentricity, and time of radiocolloid injection had no significant effect on the number of SLNs that needed to be removed. The most significant factors were patient race, tumor location, and tumor histologic type. Identifying 99% of positive SLNs required the removal of 2 more SLNs in Caucasian patients than in non-Caucasian patients (6 SLNs vs 4 SLNs; $P < .001$), the removal of 3 more SLNs in patients with inner hemisphere tumors than in patients with outer hemisphere tumors (8 SLNs vs 5 SLNs; $P < .001$), and the removal of 2 more SLNs in patients with mixed ductal and lobular carcinoma than in patients with IDC or ILC only (7 SLNs vs 5 SLNs; $P < .001$).

Multivariate analysis revealed that Caucasian race, tumor located in the inner half of the breast, clinical T1 tumors, and mixed ductal and lobular histology significantly increased the number of SLNs that needed to be removed to identify 99% of positive SLNs (Table 5). As in the multivariate analysis, patients with tumor histologic types as mixed ductal and lobular would need to have 1 more SLN removed than patients with IDC or ILC alone; patients with tumor histologic types other than IDC, ILC, or mixed ductal and lobular carcinoma would need to have 2 less SLNs removed than patients with IDC or ILC alone; and patients with inner hemisphere tumors would need to have 3 more SLNs removed than patients with outer hemisphere tumors. Patients with T3 tumors would need to have 1 less SLN removed than patients with T1 tumors. Non-Caucasian patients would need to have 1 less SLN removed than Caucasian patients. By using these different patient and tumor characteristics, it is possible to estimate how many SLNs should be removed to identify 99% of positive SLNs. By multivariate modeling, the number of SLNs that need to be removed ranges from 2 to 10 SLNs based on different patient and tumor characteristics. For example, for Caucasian patients with T1 IDC tumors located in the outer half of the breast, 99% of positive SLNs would be identified in the first 6 lymph nodes removed. Conversely, non-Caucasian patients with large (>5 cm), non-IDC, non-ILC, and nonmixed IDC and ILC tumors located in the outer half of the breast would need to have only 2 SLNs removed to identify 99% of positive SLNs.

DISCUSSION

The current results indicate that removal of a maximum of 5 SLNs at surgery allows for recovery of >99% of all positive SLNs in patients with breast cancer. However, this number can range from 2 to 10, depending on patient and tumor characteristics.

The concept of the SLN was reported first in 1977 by Cabanas,[9] who described its role in the management of penile cancer. The SLN is defined as the first lymph node in a regional lymphatic basin to accept drainage from the primary tumor.[1,9,10] In the management of breast cancer, most surgeons will identify >1 SLN regardless of which SLND technique they use (blue dye, isotope, or a combination of both).[11] Several studies have reported that the average number of SLNs removed at the time of SLND is 3 (range, 1-15 SLNs removed).[4,5,11–13] In our study, almost 80% of patients had >1 SLN removed (mean, 2.9 SLNs removed; range, 1-13 SLNs removed). The identification of >1 SLN is not unique to breast cancer or to the axilla. The detection of multiple SLNs may reflect migration of dye or isotope from the "true" SLN into secondary echelon lymph nodes or simply a normal anatomic variation in which the lymphatics of a given site in the breast drain simultaneously into >1 SLN.[14,15]

The number of SLNs that need to be removed for accurate lymph node staging is debated. A surgeon must weigh the risk of missing a pathologically positive lymph node against the risks of SLND so extensive that the number of dissected lymph nodes essentially would equal that of a completion ALND, thereby negating the potential benefits of SLND. Some studies have suggested that removal of multiple SLNs provides for optimal detection of metastatic lymph node disease.[5,6,14–17] In our study, >99% of positive SLNs were identified in 1 of the first 5 lymph nodes removed. Our results are consistent with those reported previously. Woznick et al.,[17] in their study of 172 breast cancer patients, reported a mean number of 4.4 SLNs removed per surgery. They demonstrated that, by using both dye and radiolabeled colloid for mapping, almost 99% of positive SLNs were identified in the first 4 lymph nodes removed, and >99% of positive SLNs were identified in the first 5 lymph nodes removed. Those authors concluded that removing only 1 or 2 lymph nodes or removing only the hottest lymph node may not complete the SLND. In a study of 449 lymph node-positive patients, McCarter et al.[6] demonstrated that, by using a combination of blue dye and radiocolloid, 99% of positive SLNs were identified in the first 4 lymph nodes removed in their study, in which they removed a mean of 2.3 SLNs per surgery. However, those authors concluded that, to be certain a metastasis is not missed, there should be no upper limit for the number of SLNs removed, and that all SLNs identified should be removed. Although our data, which were based on a larger group of patients, support the previous findings, we have tried to identify patient and tumor features that also may help limit the extent of SLND and, thus, its attendant risks.

To the best of our knowledge, no previously published studies have explored which patient and tumor characteristics would influence the number of SLNs that should be removed to retrieve 99% of all positive SLNs. In our study, we used simple and multivariate quantile regression to model the joint contributions of these factors and observed that factors that had a significant effect on the number of SLNs that should be removed were patient race, tumor

size, tumor location, and tumor histologic type. Patient age, BMI, the receipt of neoadjuvant chemotherapy, prior biopsy type, surgery type, ER or PR status, mapping agent used, presence or absence of drainage on lymphoscintigraphy, time of radiocolloid injection, and BNG had no significant effect. Patients with large tumors (>5 cm); tumors located in the outer half of the breast; tumor histologic types other than IDC, ILC, or mixed ductal and lobular carcinoma; or non-Caucasian race needed fewer SLNs removed to identify 99% of positive SLNs than patients with the opposite features.

Patient race appears to be an important factor in deciding how many SLNs should be removed. Our finding that non-Caucasian patients would need to have fewer SLNs removed than Caucasian patients agrees with the report of Gann et al.,[18] who reported a 35% to 40% increased risk of lymph node metastasis in African-American and Hispanic women compared with Caucasian women and corroborated studies suggesting that women in these racial/ethnic groups develop more biologically aggressive breast carcinomas for reasons not yet identified. In our study, most non-Caucasians (76%) were African Americans and Hispanics. Because it has been noted that African-American and Hispanic patients have a higher incidence of lymph node positivity, this may explain why these groups of patients needed 1 less SLN removed compared with Caucasian patients.

It is well established that larger tumors have a higher prevalence of axillary metastases.[18,19] Published data indicate that there is a direct relation between the size of the primary tumor and the likelihood of axillary lymph node metastases for cancers that measure up to 5 cm in greatest dimension.[20] Tumor size is the most important factor contributing to the likelihood of a positive SLN.[21] Weaver et al.[21] reported that, with increasing tumor size, both the frequency of a positive SLN and the number of positive SLNs increased. In our study, patients with large tumors (>5 cm) needed 1 less SLN removed compared with patients who had smaller tumors (≤5 cm). Patients with larger tumors needed fewer SLNs removed before the first positive SLN was detected, most likely because the burden of disease was greater and the size of the metastatic lesions was larger in those lymph nodes.

Our finding that tumors in the inner half of the breast tended to require more SLNs removed than tumors in the outer half is consistent with previous data showing that the incidence of axillary metastasis was more likely when primary tumors were located in the outer half of the breast.[22,23] Gann et al. also observed that patients who had tumors located in the upper-inner or lower-inner quadrants were 30% to 50% less likely to be lymph node positive than patients with upper-outer quadrant tumors.[18] All of these findings appear to be consistent with the anatomy of lymphatic drainage in the breast: Tumors in the inner hemisphere are more likely than tumors in the outer hemisphere to have alternative drainage to the internal mammary chain.

Invasive ductal carcinoma (IDC), which was identified in 568 of our patients (73.1), is the most common histologic type of breast cancer. The propensity of IDC and ILC to metastasize to lymph nodes is very similar.[20] In our study, the numbers of SLNs that needed to be removed to identify 99% of all positive SLNs was the same in the IDC group and the ILC group. Mixed IDC and ILC may be classified better as tubulolobular carcinoma in some patients. These histologies reportedly are less aggressive than pure IDC not otherwise

specified and pure ILC. This may explain the need to remove more SLNs to identify a positive lymph node among patients with this unusual histology. Patients who had tumors of other histologic types (most [74%] were micropapillary, metaplastic neoplasm, or inflammatory tumors, which reportedly are more aggressive than pure IDC and pure ILC) needed fewer SLNs removed than the IDC and ILC groups to identify a positive lymph node.

In this analysis, the techniques of SLND (ie, the time from injection of radioactive colloid to SLND and the mapping agents used) were not associated with the number of SLNs that needed to be removed. The drainage pattern observed on lymphoscintigraphy also was not associated with the number of SLNs that needed to be removed. Our study had a few limitations, including those inherent to any single-institutional, retrospective study. Notwithstanding, we believe that the results of this study can be valuable to other institutions with respect to their own recommendations on the use of SLND in patients with invasive breast cancer. Because our group performed this type of analysis opens the subject to critical analysis and debate among other cancer experts and may be useful in the design of prospective trials addressing this issue. In general, we have adopted the approach that, in the case of multiple hotspots in the axillary lymph node basin, the surgeon can stop the dissection after recovering 5 SLNs. Depending on the tumor histology, patient race, and tumor size and location, the surgeon may consider removing additional SLNs. In addition, the relation between the site of colloid or blue dye injection and the number of SLNs that should be removed was not tested in this study but may be important.[24]

In conclusion, we observed that removing up to 5 SLNs was sufficient to identify metastatic carcinoma in >99% of patients. There are several patient and tumor characteristics that may influence the number of SLNs that need to be removed, such as tumors located in the inner half of the breast, T1 tumors, and Caucasian race. In addition, if additional blue or hot SLNs are present after the removal of 5 SLNs, then the removal of more lymph nodes may be necessary.

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TABLE 1

Patient, Tumor, and Treatment Characteristics for 777 Patients With Positive Sentinel Lymph Nodes

Characteristic	No. of patients	%
Age, y		
<50	284	36.6
≥50	493	63.4
Race		
Caucasian	601	77.4
Other	176	22.7
Body mass index, kg/m^2		
<30	517	66.5
≥30	260	33.5
Modified Black nuclear grade		
I	100	12.9
II	414	53.3
III	263	33.8
Tumor location		
Outer half	370	47.6
Inner half	132	17
Central/multicentric	275	35.4
Multicentric		
No	720	92.7
Yes	57	7.3
Lymphovascular invasion		
Yes	218	28.1
No	415	53.4
Unknown	144	18.5
Tumor stage		
T1	435	56
T2	290	37.3
T3	52	6.7
Histologic type		
Invasive ductal carcinoma	572	73.6
Invasive lobular carcinoma	94	12.1
Mixed ductal and lobular	84	10.8
Other	27	3.5
Estrogen receptor status		
Positive	650	83.7
Negative	111	14.3
Unknown	16	2.1
Progesterone receptor status		
Positive	510	65.6

Characteristic	No. of patients	%
Negative	247	31.8
Unknown	20	2.6
HER-2/*neu* status		
Positive	119	15.3
Negative	580	74.7
Unknown	78	10
Prior biopsy		
Core biopsy/fine-needle aspiration	547	70.4
Excisional	230	29.6
Drainage seen on lymphoscintigraphy		
Yes	556	71.6
No	46	5.9
Not done	175	22.5
Mapping agent		
Radiocolloid/ blue dye only	228	29.3
Combination	549	70.7
Day of radiocolloid injection		
Same d as SLND	312	41.2
One d before SLND	391	51.6
Both	55	7.3
Neoadjuvant chemotherapy		
No	669	86.1
Yes	108	13.9
Surgery type		
Segmental mastectomy	341	43.9
Total mastectomy	436	56.1

SLND indicates sentinel lymph node dissection.

TABLE 2

Number of Sentinel Lymph Nodes Removed per Surgery and Percentage of Total Patients With That Number of Sentinel Lymph Nodes (N=777)

No. of SLNs removed	No. of patients	%	Cumulative %
1	156	20.1	20.1
2	217	27.9	48
3	199	25.6	73.6
4	103	13.3	86.9
5	46	5.9	92.8
6	29	3.7	96.5
7	12	1.5	98.1
8	8	1	99.1
9	2	0.3	99.4
10	2	0.3	99.6
11	1	0.1	99.7
12	1	0.1	99.9
13	1	0.1	100

SLN indicates sentinel lymph node.

TABLE 3

Sentinel Lymph Nodes That Contained the First Metastasis and the Corresponding Percentage of Patients on the Basis of the Order of Sentinel Lymph Node Removal (N=777)

SLN with first metastasis	No. of patients	%	Cumulative %
1	579	74.5	74.5
2	128	16.5	91
3	41	5.3	96.3
4	13	1.7	97.9
5	9	1.2	99.1
6	2	0.3	99.4
7	2	0.3	99.6
8	2	0.3	99.9
9	1	0.1	100

SLN indicates sentinel lymph node.

TABLE 4

Univariate Analysis for the Characteristics Associated With the 99% Quantile for the First Pathologically Positive Sentinel Lymph Node

Characteristic	Coefficient*	*P*
Age, y		
<50	7	
≥50	5	.007
Race		
Caucasian	6	
Other	4	<.001
Histology type		
Invasive ductal carcinoma	5	
Invasive lobular carcinoma	5	1
Mixed ductal and lobular	7	<.001
Other	3	<.001
Estrogen receptor status		
Positive	5	
Negative	8	.009
Unknown	3	<.001
Tumor location		
Outer half	5	
Inner half	8	<.001
Central/multicentric	6	.15
Tumor stage		
T1	5	
T2	7	.026
T3	5	1
Unknown	6	.4
Progesterone receptor status		
Positive	5	
Negative	7	.015
Unknown	3	<.001

SLN indicates sentinel lymph node.

* The number of SLNs that needed to be removed to identify 99% of positive SLNs.

TABLE 5

Multivariate Analysis for the Characteristics Associated With the 99% Quantile for First Pathologically Positive Sentinel Lymph Node

Characteristic	Coefficient*	SEM	*P*	95% CI
Tumor location				
Inner half	3	0.12	0	2.77-3.23
Central/multicentric	1	0.42	.019	0.17-1.83
Race, non-Caucasian	−1	0.24	0	−1.47 to −0.53
Tumor stage				
T2	0	0.23	1	−0.46 to 0.46
T3	−1	0.26	0	−1.51 to −0.49
Histology				
Invasive lobular carcinoma	0	0.23	1	−0.45 to 0.45
Mixed ductal and lobular	1	0.23	0	0.55-1.45
Other	−2	0.29	0	−2.57 to −1.43
Intercept	5	0.21	0	4.58-5.42

SEM indicate standard error of the mean.

*Represents changes relative to the intercept (5) in the predicted number of sentinel lymph nodes that should be removed. Positive numbers indicate an increase, and negative numbers indicate a decrease, in the number of additional lymph nodes to remove.