Axillary Lymph Node Dissection (ALND) has been part of breast cancer surgery since the description of the radical mastectomy. ALND reliably identifies nodal metastases and maintains regional control, but the contribution of local therapy to breast cancer survival is controversial. The Early Breast Cancer Trialists’ Collaborative Group synthesized findings from 78 randomized controlled trials, concluding that local control of breast cancer was associated with improved disease-specific survival.

ALND, as a means for achieving local disease control, carries an indisputable and often unacceptable risk of complications such as seroma, infection, and lymphedema. Sentinel lymph node dissection (SLND) was therefore developed to accurately stage tumor-draining axillary nodes with less morbidity than ALND. SLND alone is the accepted management for patients whose sentinel lymph node dissection (SLND) accurately identifies nodal metastasis of early breast cancer, but it is not clear whether further nodal dissection affects survival.

To determine the effects of complete axillary lymph node dissection (ALND) on survival of patients with sentinel lymph node (SLN) metastasis of breast cancer.

The American College of Surgeons Oncology Group Z0011 trial, a phase 3 noninferiority trial conducted at 115 sites and enrolling patients from May 1999 to December 2004. Patients were women with clinical T1-T2 invasive breast cancer, no palpable adenopathy, and 1 to 2 SLNs containing metastases identified by frozen section, touch preparation, or hematoxylin-eosin staining on permanent section. Targeted enrollment was 1900 women with final analysis after 500 deaths, but the trial closed early because mortality rate was lower than expected.

All patients underwent lumpectomy and tangential whole-breast irradiation. Those with SLN metastases identified by SLN were randomized to undergo ALND or no further axillary treatment. Those randomized to ALND underwent dissection of 10 or more nodes. Systemic therapy was at the discretion of the treating physician.

Overall survival was the primary end point, with a non-inferiority margin of a 1-sided hazard ratio of less than 1.3 indicating that SLND alone is noninferior to ALND. Disease-free survival was a secondary end point.

Clinical and tumor characteristics were similar between 445 patients randomized to ALND and 446 randomized to SLND alone. However, the median number of nodes removed was 17 with ALND and 2 with SLND alone. At a median follow-up of 6.3 years (last follow-up, March 4, 2010), 5-year overall survival was 91.8% (95% confidence interval [CI], 89.1%-94.5%) with ALND and 92.5% (95% CI, 90.0%-95.1%) with SLND alone; 5-year disease-free survival was 82.2% (95% CI, 78.3%-86.3%) with ALND and 83.9% (95% CI, 80.2%-87.9%) with SLND alone. The hazard ratio for treatment-related overall survival was 0.79 (95% CI, 0.56-1.11) without adjustment and 0.87 (95% CI, 0.62-1.23) after adjusting for age and adjuvant therapy.

Among patients with limited SLN metastatic breast cancer treated with breast conservation and systemic therapy, the use of SLND alone compared with ALND did not result in inferior survival.

Trial Registration clinicaltrials.gov Identifier: NCT00003855

For editorial comment see p 606.
sentinel lymph nodes (SLNs) are histologically free of tumor, while ALND remains the standard of care for patients whose SLNs contain metastases.11

Cancer biology is much better understood now than it was when ALND was introduced. Biological factors may affect the predilection of some malignant cells to selectively invade lymph nodes rather than visceral organs, just as certain tumor types metastasize to certain organs and not others.12 Recognition of the complexity of tumor biology has changed cancer treatment, with more liberal use of systemic therapy to treat occult cancer cells wherever they may be in the body. Consequently, the decision to administer systemic therapy is influenced by a variety of patient- and tumor-related factors, with lymph node tumor status influencing13,14 but not necessarily dictating the use of chemotherapy.15-18 Other factors, such as early cancer detection by screening mammography, have led to earlier intervention in breast cancer, reducing the incidence of nodal metastases and even the number of tumor-involved lymph nodes.19

These evolving concepts have called into question the need for ALND.20,21 A variety of algorithms have been developed to help clinicians decide which patients would benefit from ALND.22-24 Review of Surveillance, Epidemiology, and End Results data has shown that the use of ALND for SLN metastases has decreased in recent years.25 No study has conclusively demonstrated a survival benefit or detriment for omitting ALND when metastatic breast cancer is identified by SLND. In the late 1990s, the American College of Surgeons Oncology Group designed and began the multicenter Z0011 trial. The primary aim of this study was to determine the effects of ALND on overall survival in patients with SLN metastases treated in the contemporary era with lumpectomy, adjuvant systemic therapy, and tangential-field radiation therapy.

METHODS

Patient Characteristics

This multicenter, randomized phase 3 trial was registered with the National Cancer Institute and approved by the institutional review boards of participating centers. All patients provided written informed consent. Adult women with histologically confirmed invasive breast carcinoma clinically 5 cm or less, no palpable adenopathy, and an SLN containing metastatic breast cancer documented by frozen section, touch preparation, or hematoxylin-eosin staining on permanent section were eligible for participation. Patients with metastases identified initially or solely with immunohistochemical staining were ineligible. Treatment with lumpectomy to negative margins (no tumor at ink) was required. Women were ineligible if they had 3 or more positive SLNs, matted nodes, or gross extranodal disease, or if they had received neoadjuvant hormonal therapy or chemotherapy.

Study Design and Treatment

Before randomization, all women underwent SLND and were stratified according to age ($\leq 50$ and $>50$ years), estrogen-receptor status, and tumor size ($\leq 1$ cm, $>1$ cm and $\leq 2$ cm, or $>2$ cm). Eligible women were randomly assigned to ALND or no further axillary-specific intervention—specifically, no third-field nodal irradiation. ALND was defined as an anatomical level I and II dissection including at least 10 nodes. All women were to receive whole-breast opposing tangential-field radiation therapy. The use of adjuvant systemic therapy was determined by the treating physician and was not specified in the protocol.

Patients most commonly entered the study post-SLND following identification of metastases on final pathology report. However, of the 891 registered patients, 287 were registered pre-SLND and assigned to treatment after intraoperative documentation of SLN metastases. Patients in this group subsequently found to have 3 or more tumor-involved lymph nodes were included in the analysis. Patients were assessed for disease recurrence according to standard clinical practice. History and physical examination were performed every 6 months for the first 36 months and yearly thereafter. Annual mammography was required; other testing was based on symptoms and investigator preference.

Study End Points

The primary end point was overall survival, defined as the time from randomization until death from any cause. A short-term primary end point was occurrence of surgical morbidities. The study plan was to report surgical morbidities following the completion of accrual and prior to overall survival reporting after receiving permission from the data and safety monitoring committee. These morbidities have been reported.10

A secondary end point was disease-free survival, defined as the time from...
randomization to death or first documented recurrence of breast cancer. Breast cancer recurrence was categorized as locoregional disease (tumor in the breast or ipsilateral supraclavicular, subclavicular, internal mammary, or axillary nodes) or distant metastases. Disease-free survival and its components (locoregional disease and distant metastases) are reported instead of the protocol-specified secondary end point (eg, distant disease–free survival) to facilitate comparison with other studies.

**Statistical Analysis**

The primary end point was overall survival as a measure of noninferiority of no further axillary specified interventions (SLND-alone group) compared with the ALND group. Based on the literature at the time of study design, we hypothesized that overall survival was 80% at 5 years for optimally treated women with positive nodes. Clinical noninferiority was defined as the SLND-alone group having a 5-year survival of not less than 75% of that observed in the ALND group. Noninferiority of the SLND-alone treatment was also considered if the hazard ratio (HR) for mortality was less than 1.3 when compared with ALND. An estimated 500 deaths were needed for the study to have 90% power to confirm noninferiority of SLND alone compared with ALND, with the use of a 2-sided 90% confidence interval (CI) for the HR from a Cox regression model. Specifically, if the 90% CI for the HR was below 1.3, noninferiority was considered to be established in the ALND group. Noninferiority P values are reported. As a secondary analysis, known prognostic factors including adjuvant treatment were included in the Cox regression model to generate an adjusted HR for overall survival (with a 90% CI and noninferiority P values). Disease-free survival was analyzed using Kaplan-Meier curves and univariable and multivariable Cox regression analyses with 95% CIs. The fact that there were only 94 deaths limited the number of variables that could be used in a multivariable model without affecting model stability. We created a base model that included the treatment group (SLND alone vs ALND), age (≤50 vs >50 years), and whether the patient received adjuvant therapy (yes vs no) and added prognostic variables to this model individually. Only variables obtained on 90% or more of the patients were included in the multivariable analysis. Locoregional recurrence rates were compared with the Fisher exact test. Each analysis, other than analysis for the primary end point of overall survival, was performed with 2-sided P values, 5% significance, and a 95% CI; all analyses were performed using SAS release 9.1 (SAS Institute Inc, Cary, North Carolina).

**RESULTS**

**Patient Characteristics**

The first patient was enrolled in May 1999, and accrual closed in December 2004 based on a recommendation of the independent data and safety monitoring committee because of concerns regarding the extremely low mortality rate. Even if the trial had accrued the targeted 1900 patients, it would have taken more than 20 years of follow-up to observe 500 deaths at the realized event rate. At the time of the decision to terminate the study there had been no formal analysis comparing the survival experience between the 2 groups; the decision was based solely on the ob-
erved mortality rate for pooled data from the 2 groups. The date of last follow-up for this analysis was March 4, 2010.

Patients were enrolled from 115 institutions, which included affiliates of the Cancer Trials Support Unit and the North Central Cancer Treatment Group. Of 891 patients, 445 were randomly assigned to the ALND group and 446 to the SLND-alone group (Figure 1). Thirty-five patients were excluded after withdrawing consent prior to surgery. The 103 ineligible patients were included in the analyses reported here. Because this was a noninferiority trial, a more conservative analysis was performed on the treatment-received sample (n=813 patients); 32 patients in the ALND group did not have ALND, and 11 patients in the SLND-alone group had ALND. No qualitative differences were observed between treatment-received sample and intent-to-treat sample analyses, so only intent-to-treat results are reported. Disease characteristics at baseline were well balanced between the 2 groups (Table 1).

**Treatment Results**

There was an expected difference between ALND and SLND-alone treatment groups in total number of removed lymph nodes and total number of tumor-involved nodes; the median total number of nodes removed was 17 (interquartile range [IQR], 13-22) in the ALND group and 2 (IQR, 1-4) in the SLND-alone group. The median total number of nodes with histologically demonstrated tumor involvement (including SLNs) in the ALND group and SLND-alone group was equal (1 [IQR, 1-2] for both groups). Hematoxylin-eosin–stained tumor deposits no larger than 2 mm were defined as micrometastases and were identified in SLNs of 137 of 365 patients (37.5%) in the ALND group compared with 164 of 366 (44.8%) in the SLND-alone group (P=.05). In the ALND group, 97 of 355 patients (27.3%) had additional metastasis in lymph nodes removed by ALND, including 10% of patients with SLN micrometastasis who had macroscopically involved non-SLNs removed. Total nodal involvement is summarized in Table 1; 21.0% of patients undergoing ALND had 3 or more involved nodes compared with 3.7% undergoing SLND alone. Four or more involved nodes were seen in 13.7% of patients receiving ALND and 1.0% of those receiving SLND alone.

Adjuvant systemic therapy was delivered to 403 women (96.0%) in the ALND group and 423 women (97.0%) in the SLND-alone group. No differences in the proportion of women receiving endocrine therapy, chemotherapy, or both were observed. The type of chemotherapy administered was similar in the 2 groups; anthracycline- and taxane-based combination regimens were the most common. The majority of the women (n=605) received whole-breast radiation therapy: 263 of 296 (88.9%) in the ALND group and 277 of 309 (89.6%) in the SLND-alone group.

**Overall Survival**

At a median follow-up of 6.3 years (IQR, 5.2-7.7), there were 94 deaths (SLND-alone group, 42; ALND group, 52). The use of SLND alone compared with ALND did not appear to result in statistically inferior survival (Figure 2) (P=.008 for noninferiority). The unadjusted HR comparing overall survival between the SLND-alone group and the ALND group was 0.79 (90% CI, 0.56-1.10), which did not cross the specified boundary of 1.3 (Figure 3). The 5-year overall survival rates were 92.5% (95% CI, 90.0%-95.1%) in the SLND-alone group and 91.8% (95% CI, 89.1%-94.5%) in the ALND group. This was substantially greater than the 80% anticipated at protocol design. The HR for overall survival adjusting for adjuvant therapy (chemotherapy, endocrine therapy, and/or radiation therapy) and age for the SLND-alone group compared with the ALND group was 0.87 (90% CI, 0.62-1.23). The adjusted HRs comparing the SLND-alone group with the ALND group in the other multivariable models ranged from 0.86 to 0.92 (Table 2), all similar to the unadjusted rate of 0.79. An exploratory analysis revealed that treatment with ALND vs SLND alone produced no statistically significant difference in outcome among patients grouped by receptor status of the primary tumor (ER+/PR+ or ER-/PR-).

**Disease-Free Survival**

Disease-free survival (Figure 2) did not differ significantly between treatment groups. The 5-year disease-free survival was 83.9% (95% CI, 80.2%-87.9%) for the SLND-alone group and 82.2% (95% CI, 78.3%-86.3%) for the ALND group (P=.14). The unadjusted HR comparing the SLND-alone group with the ALND group was 0.82 (95% CI, 0.58-1.17), and the HR adjusted for adjuvant treatment and age was 0.88 (95% CI, 0.62-1.25) (Table 3). The adjusted HRs comparing the SLND-alone group with the ALND group in the other multivari-
able models ranged from 0.84 to 0.89 (Table 3), all similar to the unadjusted rate of 0.82. Locoregional recurrence and its correlates have been previously reported. The 5-year rates of local recurrence were 1.6% (95% CI, 0.7%-3.3%) in the SLND-alone group and 3.1% (95% CI, 1.7%-5.2%) in the ALND group (P = .11). Locoregional recurrence-free survival at 5 years was 96.7% (95% CI, 94.7%-98.6%) in the SLND-alone group and 95.7% (95% CI, 93.6%-97.9%) in the ALND group.

**Surgical Morbidities**

Paresthesias, shoulder pain, weakness, lymphedema, and axillary web syndrome are recognized morbidities of ALND. As previously reported, the rate of wound infections, axillary seromas, and paresthesias among patients in the Z0011 trial was higher for the ALND group than for the SLND-alone group (70% vs 25%, P < .001). Lymphedema in the ALND group was significantly more common by subjective report (P < .001) and also tended to be higher by objective assessment of arm circumference. These findings are in accordance with other randomized comparisons of SLND with vs without ALND.

**COMMENT**

In the American College of Surgeons Oncology Group Z0011 randomized trial, ALND did not significantly affect overall or disease-free survival of patients with clinical T1-T2 breast cancer and a positive SLN who were treated with lumpectomy, adjuvant systemic therapy, and tangential-field whole-breast radiation therapy. These survival findings are consistent with those of the National Surgical Adjuvant Breast and Bowel Project B04 trial, in which women with clinically negative nodes were randomized to treatment by radical mastectomy, total mastectomy plus nodal irradiation, or total mastectomy with delayed ALND if nodal recurrence was observed. Initially and at each interim analysis for up to 25 years of follow-up, no statistically significant survival differences were observed between any of the groups. For patients treated in the modern era, the relevance of the B04 study, which included patients with larger tumors undergoing mastectomy without adjuvant systemic therapy, is uncertain, because an axillary recurrence after SLND in patients with a lower risk of death from distant disease might negatively affect survival. The findings from Z0011 document the high rate of locoregional control achieved with modern multimodality therapy, even without ALND. In contrast to B04, in which about 40% of patients in the radical mastectomy group were node-positive and the same number in the total mastectomy group were assumed to be node-positive and 5-year overall survival was only about 60%, 100% of patients in Z0011 had nodal involvement; yet the 5-year over-

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Table 2. Adjusted Hazard Ratios for Overall Survival Comparing SLND-Alone vs ALND Groups

<table>
<thead>
<tr>
<th>Model Variables</th>
<th>No.</th>
<th>Adjusted HR (90% CI)</th>
<th>Noninferiority P Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Treatment group (SLND alone vs ALND), age (=50 vs &gt;50 y), adjuvantly treated (yes vs no)</td>
<td>839</td>
<td>0.87 (0.62-1.23)</td>
<td>.03</td>
</tr>
<tr>
<td>Variables in row 1 + primary tumor size (per 1 cm, continuous)</td>
<td>818</td>
<td>0.89 (0.62-1.25)</td>
<td>.03</td>
</tr>
<tr>
<td>Variables in row 1 + estrogen receptor status (negative vs positive)</td>
<td>778</td>
<td>0.92 (0.64-1.30)</td>
<td>.05</td>
</tr>
<tr>
<td>Variables in row 1 + modified Bloom-Richardson score (1 vs 2 vs 3)</td>
<td>839</td>
<td>0.86 (0.61-1.21)</td>
<td>.02</td>
</tr>
<tr>
<td>Variables in row 1 + tumor type (ductal vs lobular vs other)</td>
<td>839</td>
<td>0.88 (0.63-1.25)</td>
<td>.03</td>
</tr>
</tbody>
</table>

Abbreviations: ALND, axillary lymph node dissection; CI, confidence interval; HR, hazard ratio; SLND, sentinel lymph node dissection.

Table 3. Adjusted Hazard Ratios for Disease-Free Survival Comparing SLND-Alone vs ALND Groups

<table>
<thead>
<tr>
<th>Model Variables</th>
<th>No.</th>
<th>Adjusted HR (95% CI)</th>
<th>P Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Treatment group (SLND alone vs ALND), age (=50 vs &gt;50 y), adjuvantly treated (yes vs no)</td>
<td>839</td>
<td>0.88 (0.62-1.25)</td>
<td>.47</td>
</tr>
<tr>
<td>Variables in row 1 + primary tumor size (per 1 cm, continuous)</td>
<td>818</td>
<td>0.86 (0.60-1.22)</td>
<td>.40</td>
</tr>
<tr>
<td>Variables in row 1 + estrogen receptor status (negative vs positive)</td>
<td>778</td>
<td>0.87 (0.58-1.29)</td>
<td>.33</td>
</tr>
<tr>
<td>Variables in row 1 + modified Bloom-Richardson score (1 vs 2 vs 3)</td>
<td>839</td>
<td>0.87 (0.61-1.23)</td>
<td>.43</td>
</tr>
<tr>
<td>Variables in row 1 + tumor type (ductal vs lobular vs other)</td>
<td>839</td>
<td>0.89 (0.62-1.27)</td>
<td>.52</td>
</tr>
</tbody>
</table>

Abbreviations: ALND, axillary lymph node dissection; CI, confidence interval; HR, hazard ratio; SLND, sentinel lymph node dissection.
all survival was more than 90%. Furthermore, a 19% rate of axillary first failure was observed in B04, whereas the axillary nodal recurrence rate was only 0.9% in the SLND-alone group in Z0011. The excellent local and distant outcomes in this study highlight the effects of multiple changes in breast cancer management during the interval between the 2 studies. These changes, which include improved imaging, more detailed pathological evaluation, improved planning of surgical and radiation approaches, and more effective systemic therapy, emphasize the need for ongoing reevaluation of “standard” local therapy.

The well-documented morbidity from ALND has led other investigators to explore alternative methods of axillary treatment in patients with clinically negative nodes, including radiation, systemic therapy, and axillary observation. These have consistently demonstrated low axillary failure rates, with no significant differences in survival.35,36 The International Breast Cancer Study Group trial of ALND vs observation is noteworthy because more than half of the patients did not receive breast or axillary radiotherapy. In women 60 years and older receiving adjuvant tamoxifen but no axillary treatment, the rate of axillary recurrence was only 3%, and overall survival was 73% at a median follow-up of 6.6 years.35

The low rates of locoregional recurrence at 5 years and the nearly identical overall and disease-free survival between treatment groups in Z0011 would suggest that differences in survival between study groups are unlikely to emerge with longer follow-up, because ALND would only affect survival by virtue of improved locoregional control. In the Early Breast Cancer Trialists’ Collaborative Group overview, statistically significant survival differences between treatments at 15 years were seen only when differences in locoregional recurrence between treatments were greater than 10% at 5 years.6 Axillary recurrence is usually an early event, occurring at a median of 14.8 months in B04; in that trial, only 7 of 68 axillary recurrences occurred more than 5 years after study entry.6 Greco et al37 reported that median time to axillary recurrence was 30.6 months for 401 patients who underwent breast-conserving procedures and radiation therapy with no axillary surgery. Recent reports of long-term follow-up in randomized trials confirm these findings.38,39 Because the total locoregional recurrence rate in the Z0011 SLND-alone group at 5 years is only 2.5% compared with 3.6% in the ALND group, it is unlikely that further follow-up would result in enough additional recurrences to generate a clinically meaningful survival difference between groups. The absolute difference in 5-year overall survival between the treatment groups in Z0011 is 0.7%, numerically favoring the SLND-alone group. The HR for overall survival comparing the SLND-alone group with the ALND group was 0.79 (90% CI, 0.56-1.10). The worst HR (1.10) is less than 1.3, which was hypothesized as the inferiority margin threshold. In essence, this means that the 5-year overall survival for the SLND-alone group might be as low as 90.3% if the true 5-year overall survival for the ALND group was 91.8% and the HR as high as 1.10. Most importantly, there is no suggestion that rates of locoregional recurrence, the mechanism by which variations in local therapy result in survival differences, differ between groups to the extent needed to produce survival differences or are likely to do so in the future. Taken together, this suggests that contemporary women may sustain the morbidity of ALND without any meaningful improvement in survival rates. Limitations of the study, such as failure to achieve target accrual and possible randomization imbalance favoring the SLND-alone group, must be considered. However, even in high-risk women (ER/PR−) in Z0011, preliminary analysis suggests no effect of elimination of ALND on survival.

Despite limitations of the Z0011 trial, its findings could have important implications for clinical practice. Examination of the regional nodes with SLND can identify hematoxylin-eosin–detected metastases that would indicate a higher risk for systemic disease and the need for systemic therapy to reduce that risk. Results from Z0011 indicate that women with a positive SLN and clinical T1-T2 tumors undergoing lumpectomy with radiation therapy followed by systemic therapy do not benefit from the addition of ALND in terms of local control, disease-free survival, or overall survival. The only additional information gained from ALND is the number of nodes containing metastases. This prognostic information is unlikely to change systemic therapy decisions and is obtained at the cost of a significant increase in morbidity.10 The only rationale for ALND in these patients would be if the finding of additional nodal metastases would result in changes in systemic therapy. Because current guidelines do not support differences in adjuvant systemic therapy based on the number of positive lymph nodes, except in some uncommon select subgroups,40 ALND does not appear to be warranted in this patient population.

The Z0011 trial did not include patients undergoing mastectomy, those undergoing lumpectomy without radiotherapy, those treated with partial-breast irradiation, those receiving neo-adjuvant therapy, and those receiving whole-breast irradiation in the prone position, in which the low axilla is not treated. In those patients, ALND remains standard practice when SLND identifies a positive SLN. However, ALND may no longer be justified for women who have clinical T1-T2 breast cancer and hematoxylin-eosin–detected metastasis in the SLN and who are treated with breast-conserving surgery, whole-breast irradiation, and adjuvant systemic therapy. Implementation of this practice change would improve clinical outcomes in thousands of women each year by reducing the complications associated with ALND and improving quality of life with no diminution in survival.

Author Contributions: Dr Giuliano had full access to all of the data in the study and takes responsibility for the integrity of the data and the accuracy of the data analysis. Study concept and design: Giuliano.
SENTINEL NODE DISSECTION IN INVASIVE BREAST CANCER

Acquisition of data: Giuliano, Beitsch, Whitworth, Blumencranz, Leitch, Saha, Morrow. Analysis and interpretation of data: Giuliano, Hunt, Ballman, Whitworth, Leitch, McCall, Morrow. Drafting of the manuscript: Giuliano, Ballman, Beitsch, Whitworth, Morrow. Critical revision of the manuscript for important intellectual content: Giuliano, Hunt, Ballman, Beitsch, Whitworth, Blumencranz, Leitch, Saha, McCall, Morrow. Statistical analysis: Ballman, McCall. Administrative, technical, or material support: Giuliano, Hunt, Whitworth, Leitch. Study supervision: Giuliano, Whitworth.

Conflict of Interest Disclosures: All authors have completed and submitted the ICMJE Form for Disclosure of Potential Conflicts of Interest and none were reported.

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Additional Contributions: We thank the ACOSOG staff, in particular the leadership of Heidi Nelson, MD (Medical Director, Rochester, Minnesota), David Ota, MD (Duke University, Durham, North Carolina), and Samuel A. Wells Jr, MD (National Cancer Institute, Bethesda, Maryland). All 3 of these individuals contributed to study design, manuscript review, or both; none received compensation for their contributions. We also thank all of the investigators and their site research teams. Lastly, we wish to thank the brave patients with breast cancer who participated in this study and their caregivers.

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