Ann Surg Oncol (2019) 26:3305–3311
https://doi.org/10.1245/s10434-019-07540-3

Annals of
SURGICAL ONCOLOGY
OFFICIAL JOURNAL OF THE SOCIETY OF SURGICAL ONCOLOGY

ORIGINAL ARTICLE – BREAST ONCOLOGY

Patterns in the Use of Axillary Operations for Patients with Node-Positive Breast Cancer After Neoadjuvant Chemotherapy: A National Cancer Database (NCDB) Analysis

Marissa K. Srour, MD[1], Joshua Tseng, MD[1], Michael Luu, MPH[2], Rodrigo F. Alban, MD[1], Armando E. Giuliano, MD[1], and Alice Chung, MD[1]

[1]Division of Surgical Oncology, Department of Surgery, Cedars-Sinai Medical Center, Los Angeles, CA; [2]Department of Biostatistics and Bioinformatics, Cedars-Sinai Medical Center, Los Angeles, CA

ABSTRACT

Background. The American College of Surgeons Oncology Group (ACOSOG) Z1071 and Sentinel Neoadjuvant (SENTINA) trials of sentinel node biopsy for node-positive breast cancer treated with neoadjuvant chemotherapy (NAC) demonstrated false-negative rates that varied on the basis of surgical technique. This study evaluated trends in axillary operations before and after publication of these trials.

Methods. This study analyzed patients from National Cancer Database (NCDB) with clinical T0 through T4, N1 and N2, M0 breast cancer who received NAC from 1 January 2012 to 31 December 2015 and sentinel lymph node biopsy (SNB) or axillary lymph node dissection (ALND). The patients were divided into the following groups: SNB, ALND, and (SNB + ALND).

Results. Of the 32,036 evaluable patients identified in this study. 5565 had SNB, 19,930 had ALND, and 6541 had SNB + ALND. Compared with the ALND group, the SNB group was younger, had more invasive ductal cancers, and had lower clinical T- and N-stage disease ($p < 0.001$). The patients in the SNB group had a higher rate of estrogen receptor-positive and triple-negative breast cancers, but a lower rate of human epidermal growth factor receptor 2 (HER2)-positive cancer ($p < 0.001$). The nodal pathologic complete response (PCR) rate, defined as no residual invasive cancer, was 66.5% in the SNB group and 33.1% in the ALND group. Since 2013, the rate of ALND has decreased from 88.7 to 77.1% in both community and academic institutions ($p < 0.001$).

Conclusion. Since publication of the ACOSOG Z1071 and SENTINA trials, the national rates of ALND in node positive breast cancer treated with NAC have decreased despite reported false-negative SNB rates and lack of prospective outcome data regarding the oncologic safety of ALND omission.

The standard of care for the management of the axilla after neoadjuvant chemotherapy (NAC) is axillary lymph node dissection (ALND). Given the interest in minimizing the morbidity of axillary surgery, the feasibility of sentinel lymph node biopsy (SNB) after NAC has been evaluated via clinical trials including the American College of Surgeons Oncology Group (ACOSOG) Z1071 trial and the Sentinel Neoadjuvant (SENTINA) trial published in 2013. The aforementioned trials demonstrated false-negative rates that vary based on surgical technique. Thus, controversy exists about whether SNB is appropriate for this population. The rates of SNB after NAC by both community and academic centers have not been analyzed to date.

This study aimed to evaluate trends in ALND and SNB before and after publication of the ACOSOG Z1071 and SENTINA trials. Specifically, the study examined the rates of SNB and ALND in both community and academic settings.

Presented at the 20th Annual Meeting for The American Society of Breast Surgeons, May, 2019, Dallas, TX, USA.

First Received: 4 April 2019;
Published Online: 24 July 2019

A. Chung, MD
e-mail: alice.chung@cshs.org

METHODS

After Institutional Review Board (IRB) approval was obtained, patients from the National Cancer Database (NCDB) with clinical T0 through T4, N1 and N2, M0 breast cancer who received NAC and had an SNB or ALND from 1 January 2012 to 31 December 2015 were identified. The patients were divided into three groups based on type of axillary operation as follows: SNB alone, ALND, or SNB + ALND.

The patient variables collected included age, histology, clinical T stage and N stage at presentation, hormone receptor status, human epidermal growth factor receptor 2 (HER2) receptor status, type of operation, radiation, chemotherapy, pathologic yN stage, nodal pathologic complete response (PCR), number of nodes examined, number of positive nodes, rates of ALND by year from 2012 to 2015, and facility type.

Nodal PCR was defined as grade ypN0 cancer with no residual invasive disease in the node. Facility type was categorized as community cancer program (CCP), comprehensive community cancer program (CCCP), academic/research program, or Integrated Network Cancer Program (INCP). The primary outcome measures included rates of ALND per year according to facility type.

Data are presented as frequency (%) for categorical variables and median (interquartile range [IQR]) for numeric variables. Univariate associations between variables were examined with the Kruskal–Wallis test, Chi square test, or Fisher's exact test where appropriate. Post hoc pairwise comparisons using the Bonferroni correction with adjustment for inflation due to multiple comparisons were further performed where significant associations were found ($p < 0.05$).

To compare the rate of ALND decrease by facility type, a logistic regression model of facility types adjusted for year was performed, and the estimates are interpreted as odds of the difference between each facility type. Points in Fig. 1 are raw estimates of ALND, and lines are model estimates of the trends from 2012 to 2015. All statistical analyses were performed using SAS 9.4 (SAS Institute, Inc., Cary, NC, USA) and R version 3.5.1 (R Foundation, Vienna, Austria) with two-sided tests and a significance level of 0.05.

RESULTS

The study identified 32,036 patients with clinical T0 through T4, N1 and N2, M0 breast cancer who underwent axillary operations after NAC. Of these patients, 5565 (17.4%) had SNB alone, 19,930 (62.2%) had ALND, and 6541 (20.4%) had SNB + ALND. The median age was 54 ± 13 years.

The patients were younger in the SNB group (53 years) and SNB + ALND group (53 years) than in the ALND group (54 years) ($p < 0.001$) and more often had invasive ductal cancer (SNB, 86.7%; ALND, 81.0%; SNB + ALND, 81.3%; $p < 0.001$).

At presentation, compared with the ALND and SNB + ALND groups, the SNB group had a lower clinical T stage (T1–T2 stage: SNB, 72.5%; ALND, 57%; SNB + ALND, 66.9%; $p < 0.001$) and a lower clinical N stage (N1 stage: SNB, 92.1%; ALND, 82.3%; SNB + ALND, 88.3%; $p < 0.001$). Compared with the other groups, the patients in the SNB group had a higher rate of estrogen receptor-positive cancer (SNB, 51.3%; ALND, 41.9%; SNB + ALND, 36.8%; $p < 0.001$) and a lower rate of HER2-positive cancer (SNB, 72.4%; ALND, 74.8%; SNB + ALND, 77.2%; $p < 0.001$), but a higher rate of triple-negative breast cancer (SNB, 31.7%; ALND, 26.3%; SNB + ALND, 23.5%; $p < 0.001$). The patients in the SNB group had a higher rate of partial mastectomy (SNB, 47.8%; ALND, 24.2%; SNB + ALND, 31.5%; $p < 0.001$).

All the patients received neoadjuvant chemotherapy, and the patients in the SNB biopsy group had the lowest rate for additional reception of subsequent adjuvant chemotherapy (neoadjuvant + adjuvant treatment: SNB, 36.9%; ALND, 42.7%; SNB + ALND, 45.3%; $p < 0.001$). The patients in the SNB group had a lower rate of beam radiation (SNB, 73.2%; ALND, 77.4%; SNB + ALND, 76.4%; $p < 0.001$) (Table 1).

For the patients with N1 and N2 disease at presentation whose operative report was available, 5157 (17.1%) had SNB, 18,787 (62.3%) had ALND, and 6229 (20.6%) had SNB + ALND. The nodal PCR rate was 66.5% in the SNB group compared with 33.1% in the ALND group and 30.7% in the SNB + ALND group ($p < 0.001$). The median number of nodes examined was 3 in the SNB group (IQR, 2–6), 13 in the ALND group (IQR, 8–19), and 11 in the SNB + ALND group (IQR, 6–17). The median number of positive nodes was 1 in the SNB group (IQR, 0–2), 2 in the ALND group (IQR, 1–7), and 2 in the SNB + ALND group (IQR, 1–5) (Table 2).

For the 23,047 patients in the ALND and SNB + ALND groups, information regarding facility type was available. Of these patients, 2084 patients were treated at a CCP, 9974 at a CCCP, 7986 at an academic/research program, and 3003 at an INCP. Overall, the rate of ALND was 88.7% in 2012, 85.7% in 2013, 80.9% in 2014, and 77.1% in 2015. The rate of ALND decreased over time among all facility types: CCP, from 86.5% in 2012 to 76.8% in 2015; CCCP, from 87.2% in 2012 to 76.9% in 2015; academic/research program, from 91.2% in 2012 to 78.7% in 2015; and INCP, from 87.8% in 2012 to 74.1% in 2015 (Table 3).

TABLE 1 Demographics and clinical detail

	All patients (n = 32,036) 100.0% n (%)	SNB (n = 5565) 17.4% n (%)	ALND (n = 19,930) 62.2% n (%)	Both (SNB + ALND) (n = 6541) 20.4% n (%)	p Value
Mean age (years)	54 ± 13	53 ± 12	54 ± 13	53 ± 12	< 0.001[a,b]
Age (years)					
18–39	4232 (13.2)	808 (14.5)	2480 (12.4)	944 (14.4)	< 0.001[a,b]
40–49	7797 (24.3)	1439 (25.9)	4662 (23.4)	1696 (25.9)	
50–59	9492 (29.6)	1671 (30.0)	5915 (29.7)	1906 (29.1)	
60–69	7131 (22.3)	1137 (20.4)	4590 (23.0)	1404 (21.5)	
> 70	3384 (10.6)	510 (9.2)	2283 (11.5)	591 (9.0)	
Histology					
Ductal	26,280 (82.0)	4827 (86.7)	16,134 (81.0)	5319 (81.3)	<0.001[a,b,c]
Lobular	1966 (6.1)	235 (4.2)	1210 (6.1)	521 (8.0)	
Mixed	1977 (6.2)	272 (4.9)	1274 (6.4)	431 (6.6)	
Other	1813 (5.7)	231 (4.2)	1312 (6.6)	270 (4.1)	
Clinical T stage					
0	13 (0.0)	2 (0.0)	9 (0.0)	2 (0.0)	< 0.001[a,b,c]
1	4654 (14.8)	917 (16.7)	2652 (13.6)	1085 (16.8)	
2	14,736 (46.9)	3067 (55.8)	8438 (43.4)	3231 (50.1)	
3	7306 (23.3)	1154 (21.0)	4630 (23.8)	1522 (23.6)	
4	4695 (15.0)	360 (6.5)	3723 (19.1)	612 (9.5)	
Clinical N stage					
1	27,300 (85.2)	5128 (92.1)	16,398 (82.3)	5774 (88.3)	< 0.001[a,b,c]
2	4736 (14.8)	437 (7.9)	3532 (17.7)	767 (11.7)	
Estrogen receptor					
Positive	13,528 (42.5)	2838 (51.3)	8291 (41.9)	2399 (36.8)	< 0.001[a,b,c]
Negative	18,305 (57.5)	2688 (48.6)	11,505 (58.1)	4112 (63.1)	
Unknown	14 (0.0)	5 (0.1)	5 (0.0)	4 (0.1)	
Progesterone receptor					
Positive	16,729 (52.6)	3314 (60.0)	10,328 (52.2)	3087 (47.4)	< 0.001[a,b,c]
Negative	15,056 (47.3)	2209 (40.0)	9427 (47.7)	3420 (52.5)	
Unknown	33 (0.1)	4 (0.1)	26 (0.1)	3 (0.0)	
HER2 receptor					
Positive	23,689 (74.9)	3977 (72.4)	14,708 (74.8)	5004 (77.2)	< 0.001[a,b,c]
Negative	7319 (23.1)	1431 (26.0)	4549 (23.1)	1339 (20.7)	
Unknown	635 (2.0)	87 (1.6)	411 (2.1)	137 (2.1)	
Triple-negative breast cancer	8242 (26.7)	1710 (31.7)	5045 (26.3)	1487 (23.5)	< 0.001[a,b,c]
Type of operation					
Partial mastectomy	9510 (29.8)	2651 (47.8)	4804 (24.2)	2055 (31.5)	< 0.001[a,b,c]
Mastectomy	22,377 (70.2)	2897 (52.2)	15,010 (75.8)	4470 (68.5)	
Radiation					
None	7190 (22.4)	1438 (25.8)	4273 (21.4)	1479 (22.6)	< 0.001[a,c]
Beam radiation	24,502 (76.5)	4072 (73.2)	15,432 (77.4)	4998 (76.4)	
Radioactive implants	13 (0.0)	3 (0.1)	7 (0.0)	3 (0.0)	
Combination of beam radiation with radioactive implants	29 (0.1)	4 (0.1)	18 (0.1)	7 (0.1)	
Radiation therapy (NOS)	198 (0.6)	28 (0.5)	135 (0.7)	35 (0.5)	
Unknown	104 (0.3)	20 (0.4)	65 (0.3)	19 (0.3)	

TABLE 1 continued

	All patients (n = 32,036) 100.0% n (%)	SNB (n = 5565) 17.4% n (%)	ALND (n = 19,930) 62.2% n (%)	Both (SNB + ALND) (n = 6541) 20.4% n (%)	p Value
Chemotherapy					
Neoadjuvant alone	18,512 (57.8)	3511 (63.1)	11,422 (57.3)	3579 (54.7)	< 0.001[a,b,c]
Neoadjuvant + adjuvant	13,524 (42.2)	2054 (36.9)	8508 (42.7)	2962 (45.3)	

SNB sentinal lymph node biopsy; *ALND* axillary lymph node dissection; *HER2* human epidermal growth factor receptor 2; *NOS* not otherwise specified

[a]Post hoc testing using Bonferroni correction identified significance between the SNB and ALND groups

[b]Post hoc testing using Bonferroni correction identified significance between the ALND and SNB + ALND groups

[c]Post hoc testing using Bonferroni correction identified significance between the SNB and SNB + ALND groups

Model estimates of the trends for ALND from 2012 to 2015 by facility type showed a decrease in the rate of ALND over time among all facility types. A logistic regression model of the facility types adjusted for year showed significantly fewer ALNDs performed at CCCP facilities compared with acdemic/research facilities (odds ratio [OR], 0.839; 95% confidence interval [CI], 0.763–0.923; $p < 0.001$), at INCP facilities compared with academic/research facilities (OR, 0.778; CI, 0.683–0.887; $p < 0.001$), and at INCP facilities compared with CCP facilities (OR, 0.836; 95% CI, 0.702–0.996; $p = 0.043$) (Fig. 1).

Comparison of the rates for ALND by facility type showed that 5978 patients were treated before the Z1071/SENTINA trial, and 17,069 patients were treated after the Z1071/SENTINA trial. In the CCP setting, the rate of ALND was 86.5% before the trial and decreased to 82.6% after the trial ($p = 0.037$). In the CCCP setting, the rate of ALND was 87.2% before the trial and decreased to 80.4% after the trial ($p < 0.001$). In the academic/research setting, the rate of ALND was 91.2% before the trial and decreased to 82.3% after the trial ($p < 0.001$). In the INCP setting, the rate of ALND was 87.8% before the trial and decreased to 78.8% after the trial ($p < 0.001$) (Table 4).

DISCUSSION

Publication of the ACOSOG Z1071 and SENTINA trials raised concern regarding the accuracy of sentinel node mapping for patients with node-positive disease who responded to NAC. However, the findings from our study demonstrated that the national rates of ALND in this patient population have decreased over time among both community and academic settings despite the lack of prospective data regarding oncologic safety of ALND omission.

After publication of the ACOSOG Z0011 trial, Boughey et al.[1] conducted the ACOSOG Z1071 trial, which included 756 women with clinical T0 through T4, N1 and N2, M0 breast cancer who received NAC. All the patients underwent SNB with subsequent ALND. Boughey et al.[1] reported an SNB false-negative rate of 12.6%, which was higher than their expected rate of 10% for patients undergoing SNB with two or more sentinel nodes evaluated and presenting with clinical N1–N2 disease that converted to N0 after NAC. Further analysis showed that when the dual-tracer technique was used with both radiolabeled colloid and blue dye, the false-negative rate decreased to 10.8%.[2]

Subsequent analysis of the ACOSOG Z1071 trial showed that when a clip was placed at the diagnosis of node-positive disease with resection of the clipped node and confirmation of the node as a sentinel lymph node, the false-negative rate decreased to 6.8%.[3] Long-term follow-up evaluation in the ACOSOG Z1071 trial, with a median follow-up period of 4.1 years, showed the highest breast cancer-specific and overall survival rate for the patients who achieved a pathologic complete response and the lowest survival rates for the patients with triple-negative breast cancer.[4]

In 2013, Kuehn et al.[5] published the SENTINA trial, which included 1737 patients in Germany and Austria with clinical N1 disease who converted to node-negative disease (ycN0) after NAC and showed an SNB false-negative rate of 14.2%. In 2015, Boileau et al.[6] published the Sentinel Node Biopsy Following Neoadjuvant Chemotherapy (SN-FNAC) trial, which included 153 patients with biopsy-proven node-positive breast cancer (T0–T3, N1–N2) treated with NAC and showed an 8.4% SNB false-negative rate. The false-negative rates ranged from 6.8 to 14.2% among the trials. This wide range was likely due to differences in technique, with variation in the number of

TABLE 2 Pathologic ypN stage and lymph node results

	All patients (n = 30,173) n (%)	SNB (n = 5157) n (%)	ALND (n = 18,787) n (%)	Both (SNB + ALND) (n = 6229) n (%)	p value
Pathologic ypN stage					
0	11,566 (38.3)	3429 (66.5)	6226 (33.1)	1911 (30.7)	< 0.001[a,b,c]
1	11,215 (37.2)	1563 (30.3)	6895 (36.7)	2757 (44.3)	
2	5325 (17.6)	142 (2.8)	4016 (21.4)	1168 (18.8)	
3	2066 (6.8)	23 (0.4)	1650 (8.8)	393 (6.3)	
Nodes examined: n (IQR)	11 (5–18)	3 (2–6)	13 (8–19)	11 (6–17)	–
Nodes positive: n (IQR)	2 (1–5)	1 (0–2)	2 (1–7)	2 (1–5)	–

SNB sentinel lymph node biopsy; *ALND* axillary lymph node dissection; *IQR* interquartile range

[a]Post-hoc testing using Bonferroni correction identified significance between SNB and ALND group

[b]Post-hoc testing using Bonferroni correction identified significance between ALND and SNB + ALND groups

[c]Post-hoc testing using Bonferroni correction identified significance between SNB and SNB + ALND groups

TABLE 3 Rates of axillary lymph node dissection by year before and after the Z1071/SENTINA trials by type of program

	All patients (n = 23,047) n (%)	CCP (n = 2084) n (%)	CCCP (n = 9974) n (%)	Academic/research program (n = 7986) n (%)	INCP (n = 3003) n (%)	p value
2012 (pre-trial)	5978 (88.7)	444 (86.5)	2524 (87.2)	2162 (91.2)	848 (87.8)	< 0.001[a]
2013 (post-trial)	5598 (85.7)	573 (87.2)	2392 (84.8)	1932 (87.5)	701 (82.9)	
2014	5678 (80.9)	548 (83.9)	2495 (80.3)	1895 (81.3)	740 (80.0)	
2015	5793 (77.1)	519 (76.8)	2563 (76.9)	1997 (78.7)	714 (74.1)	

CCP community cancer program; *CCCP* comprehensive community cancer program; *INCP* integrated network cancer program

[a]Post hoc testing using Bonferroni correction identified significance between CCP and CCCP groups, CCP and academic/research groups, CCP and INCP groups, and CCCP and INCP groups. The adjusted p values for the CCP group vs the academic/research group (p = 0.0530) and the academic/research group versus the INCP group (p = 0.2796) were not significant

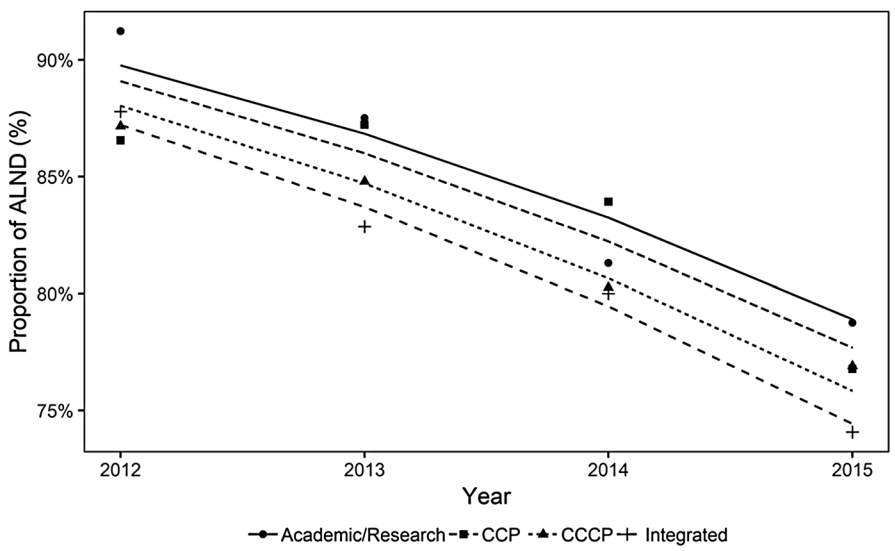

FIG. 1 Model estimates in trends of ALND from 2012 to 2015 by facility type

TABLE 4 Rates of axillary lymph node dissection by year before and after the Z1071/SENTINA trial

	Pre-trial (n = 5978) n (%)	Post-trial (n = 17,069) n (%)	p value
CCP	444 (86.5)	1640 (82.6)	0.037
CCCP	2524 (87.2)	7450 (80.4)	< 0.001
Academic/research	2162 (91.2)	5824 (82.3)	< 0.001
INCP	848 (87.8)	2155 (78.8)	< 0.001

CCP community cancer program; *CCCP* comprehensive community cancer program; *INCP* integrated network cancer program

sentinel nodes excised, types of tracer used, and placement of a biopsy clip in the lymph node before initiation of NAC followed by localization and removal of the clipped node.

In 2017, Caudle et al.[7] surveyed 642 members from the American Society of Breast Surgeons, and 86% of the respondents indicated knowledge of the Z1071 trial, 57% indicated knowledge of the SENTINA trial, and 39% indicated knowledge of the SN-FNAC trial. Of the 556 respondents who reported knowledge of at least one trial, 56% offered SLND to more than 50% of their patients, 31% offered SLND to less than 50% of their patients, and 13% routinely performed ALND. Our NCDB study showed that the rate of ALND decreased over time among community, academic, and integrated facilities, similar to the trend seen in the Caudle et al.[7] survey.

In 2018, Palmer et al.[8] examined 130 patients at a single-institution, of which 74 were treated before Z1071 (before the 5 December 2012 presentation at the San Antonio Breast Cancer Symposium), and 41 were treated after Z1071 (after 5 December 2012). They showed a decrease in ALND frequency, from a rate of 99% (n = 73/74) before the trial to 27% (n = 15/56) after the trial, exhibiting a rapid adaptation of the trial into clinical practice at their institution. Our NCDB study differed from this single-institution study in that the rate of ALND decreased at a slower rate in frequency, from 88.7% before Z1071 to 77.1% after Z1071, which likely is more representative of practices across the nation.

A limitation of the NCDB study was that accurate coding for axillary surgery did not exist before 2012. However, a full year of data before publication of these trials is included in the analysis. A further decrease in ALND over time may be observed as more recent data are released from the NCDB. Another limitation of the NCDB is the lack of reliable data on recurrence, survival, and long-term follow-up evaluation. Finally, the NCDB has no data on the technique of sentinel lymph node mapping, but robust published literature supports the use of dual-tracer mapping in the neoadjuvant setting.[2]

The ACOSOG Z1071 trial showed that SNB in node-positive breast cancer after NAC did not meet the 10% false-negative rate threshold to support the use of sentinel lymph node surgery in this patient population. Currently, outcome data on oncologic safety of ALND omission are limited. Despite this, trends in ALND have decreased. This may be due to results of subsequent analyses showing that excision of three or more sentinel lymph nodes, use of the dual-tracer technique, and localization with removal of a clip in the lymph node at the time of SNB reduce the false-negative rate to less than 10%.

It may not be appropriate for surgeons to extrapolate the results of these analyses due to the lack of prospective outcome data regarding the oncologic safety of ALND omission. In the current study, more than one-third of the SNB group had residual nodal disease and did not go on to have an ALND. Although some of these patients may have been enrolled in clinical trials, the NCDB does not provide this information. Use of SNB alone in this setting is not the current standard of care unless performed in the setting of a clinical trial.

The Alliance A011202 trial is a randomized phase 3 trial evaluating the role of ALND for patients with clinical T1–T3, N1 breast cancer who have metastatic disease in the sentinel lymph node after NAC, which randomizes patients with a positive SNB on intraoperative frozen and final pathology to ALND with radiation or nodal radiation alone.

The National Surgical Adjuvant Breast and Bowel Project (NSABP) B-51/RTOG 1304 study is a randomized phase 3 trial evaluating whether the addition of chest wall and regional nodal radiation after mastectomy or breast-conserving surgery will significantly reduce the rate of events during the invasive breast cancer recurrence-free interval for patients who present with histologically positive axillary nodes but convert to histologically negative axillary nodes after NAC. These trials will help to further define locoregional management of the axilla in this patient population.

CONCLUSION

Since publication of the results from the ACOSOG Z1071 and SENTINA trials, the national rates of ALND in node-positive breast cancer treated with NAC have decreased despite reported false-negative SNB rates and lack of prospective outcome data regarding the oncologic safety of ALND omission.

ACKNOWLEDGMENT The authors thank the Fashion Footwear Charitable Foundation of New York, Inc.; The Margie and Robert E. Petersen Foundation Associates for Breast and Prostate Cancer Studies; and Linda and Jim Lippman for their contributions to this study.

DISCLOSURE There are no conflicts of interest.

REFERENCES

1. Boughey JC, Suman VJ, Mittendorf EA, et al. Sentinel lymph node surgery after neoadjuvant chemotherapy in patients with node-positive breast cancer—The ACOSOG Z1071 (Alliance) clinical trial. *JAMA*. 2013;310(14):1455–61.
2. Mittendorf EA, Caudle AS, Yang W, et al. Implementation of the American College of Surgeons Oncology Group Z1071 trial data in clinical practice: Is there a way forward for sentinel lymph node dissection in clinically node-posiitve breast cancer patients treated with neoadjuvant chemotherapy? *Ann Surg Oncol*. 2014;21:2468–73.
3. Boughey JC, Ballman KV, Le-Petross HT, et al. Identification and resection of clipped node decreases the false-negative rate of sentinel lymph node surgery in patients presenting with node-positive breast cancer (T0–T4, N1–N2) who receive neoadjuvant chemotherapy: results from ACOSOG Z1071 (Alliance). *Ann Surg Oncol*. 2016;263:802–7.
4. Boughey JC, Ballman KV, McCall LM, et al. Tumor biology and response to chemotherapy impact breast cancer-specific survival in node-positive breast cancer patients treated with neoadjuvant chemotherapy: long-term follow-up from ACOSOG Z1071 (Alliance). *Ann Surg Oncol*. 2017;266:667–76.
5. Kuehn T, Bauerfeind I, Fehm T, et al. Sentinel-lymph node biopsy in patients with breast cancer before and after neoadjuvant chemotherapy (SENTINA): a prospective, multicenter cohort study. *Lancet Oncol*. 2013;14:609–18.
6. Boileau JF, Boirier B, Basik M, et al. Sentinel node biopsy after neoadjuvant chemotherapy in biopsy-proven node-posiitve breast cancer: the SN FNAC study. *J Clin Oncol*. 2015;33:258–64.
7. Caudle AS, Bedrosian I, Milton DR, DeSnyder SM, Kuerer HM, Hunt KK, Mittendorf EA. Use of sentinal lymph node dissection after neoadjuvant chemotherapy in patients with node-positive breast cancer at diagnosis: practice patterns of American Society of Breast Surgeons members. *Ann Surg Oncol*. 2017;24:2925–34.
8. Palmer JAV, Flippo-Morton T, Walsh KK, Gusic LH, Sarantou T, Robinson MM, White RL Jr. Application of ACOSOG Z1071: effect of results on patient care and surgical decision making. *Clin Breast Cancer*. 2018;18:270–5.