Original Article

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Sentinel Lymph Node Biopsy for Breast Cancer in North Africa: A Retrospective Analysis of Feasibility, Safety, and Morbidity Reduction in a Real-World Setting

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ABSTRACT

Objective: Conventional axillary lymph node dissection (ALND) carries significant morbidity in breast cancer surgery. Sentinel lymph node biopsy (SLNB) offers a less invasive alternative but lacks validation in resource-constrained environments. To compare postoperative morbidity between SLNB and ALND in breast cancer and assess SLNB feasibility.

Materials and Methods: A retrospective study was conducted at the Mother-Child Department of Bizerte, Tunisia (January 2022-August 2024). Patients with early-stage breast cancer undergoing SLNB or ALND were included. Primary outcomes were: lymphedema, lymphocele, pain [visual analog scale (VAS)], hemoglobin drop, and length of hospital stay. Statistical analyses were performed using SPSS v26.0. The Student's t-test was used for normally distributed quantitative variables, the Mann-Whitney U test for non-normally distributed variables, and Fisher's exact test for categorical variables with small sample sizes. Normality was assessed using the Shapiro-Wilk test.

Results: Among the 64 included patients, SLNB (n = 26) significantly reduced lymphedema (3.8% *vs.* 23%, p = 0.039), early postoperative pain (mean VAS: 3.92 *vs.* 4.7, p = 0.025), and length of hospital stay (5.69 *vs.* 7.71 days, p = 0.001) compared with ALND (n = 38). Lymphocele incidence was lower but not statistically significant (4% *vs.* 11; p = 0.640). The SLNB detection rate was 89%.

Conclusion: SLNB significantly reduces postoperative morbidity compared with ALND and is feasible in this resource-limited North African setting. Our findings support its integration into routine breast cancer surgery as a safe and effective alternative to axillary dissection.

Keywords: Sentinel lymph node biopsy; lymphedema; postoperative morbidity; breast cancer; axillary lymphadenectomy; feasibility

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Key Points

- Sentinel lymph node (SLN) biopsy is feasible and safe in a resource-limited North African setting when performed using a dual-tracer technique (technetium-99m and methylene blue).
- Compared with axillary dissection, SLN biopsy significantly reduces postoperative morbidity while preserving arm mobility.
- This study provides a real-world model for implementing SLN biopsy in low- and middle-income countries, contributing to the modernization of breast cancer surgical care.

Introduction

Breast cancer is the most commonly diagnosed cancer in women worldwide, with over 2.3 million new cases reported in 2022, accounting for approximately one in four female cancers (1). Despite advances in systemic therapies, surgery remains a cornerstone of treatment, particularly for axillary staging. Traditionally, axillary lymph node dissection (ALND) has been used to assess nodal involvement, but it is associated with significant morbidity, including lymphedema, shoulder dysfunction, and postoperative pain (2, 3).

Sentinel lymph node (SLN) biopsy has emerged as a less invasive alternative that enables accurate nodal staging while minimizing complications (4). The SLN is defined as the first LN to receive drainage from a tumor, and its pathological status reflects the likelihood of metastasis to the remaining axillary basin (5). In many low- and

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middle-income countries, the adoption of SLN biopsy has been limited by the availability of nuclear medicine services and necessary surgical equipment. Nevertheless, several centers have demonstrated that with adequate team training and basic infrastructure, SLN biopsy can be implemented even in constrained environments.

This study aimed to evaluate the implementation and clinical outcomes of SLN biopsy for early-stage breast cancer at the Maternity Center of Bizerte, Tunisia. Specifically, we compared SLN biopsy with ALND for detection rate, feasibility, and postoperative morbidity, including lymphedema, hemoglobin loss, hospital stay lengh, pain, and arm mobility.

Methods

Study Design and Setting

We conducted a retrospective, single-center, descriptive study in the Department of Gynecology and Obstetrics at the Bizerte University Hospital, Tunisia. SLN biopsy was introduced in our unit in January 2022. Data were collected from January 1, 2022, to August 31, 2024. During the study period, 80 patients with breast cancer were screened for eligibility; 64 met the inclusion criteria and were retained for the final analysis, while 16 were excluded (Figure 1).

This study was approved by the Ethics Committee of Bougatfa Hospital (approval no: 13/2022, date: 20.12.2022). Information regarding the committee name and approval number has been provided as required. In accordance with the journal's guidelines, we will provide our data for independent analysis by a team selected by the Editorial Team for additional analyses or to support the reproducibility of this study at other centers, if requested.

Population

We included patients with histologically confirmed early-stage breast cancer (T1-T3, N0-N1, M0) who underwent either SLN biopsy or ALND.

Inclusion criteria included patients undergoing mastectomy, lumpectomy, or wide local excision, and patients receiving neoadjuvant chemotherapy (NAC) for tumor downstaging or for triple-negative or human epidermal growth factor receptor 2 (HER2)-positive disease.

Exclusion criteria included patients with bilateral cancer; patients with advanced (T4d or metastatic) tumors; patients operated at other institutions; patients who did not undergo surgery or who were receiving palliative care; pregnant or breastfeeding patients; and those whose medical records were incomplete or missing.

SLN Procedure

SLN biopsy was performed using a dual-tracer approach combining technetium-99m radiolabeled human albumin nanocolloid (99mTc-HANC; Nanocoll®) and methylene blue.

• Radiotracer Injection

99mTc-HANC was injected according to the standard two-day protocol (preoperative day 1: tracer injection and imaging; day 2: surgery with or without imaging) at the Nuclear Medicine Department of the Salah Azaïez Institute in Tunis. The nuclear medicine physician administred 4 periareolar intradermal injections each delivering 9–13.7 MBq (0.1–0.3 mL) per site (total activity of 37–55 MBq). Local massage was used to enhance lymphatic drainage. Initial lymphoscintigraphy (LS) was performed, using a gamma camera, 30 minutes to 2 hours post-injection. If no lymphatic drainage was observed during this phase, delayed imaging was acquired for up to 18 h.

• Intraoperative Detection

On the day of surgery, 15 minutes before the skin incision, methylene blue dye was injected in the periareolar region at the same sites as those used for 99mTc-HANC. Detection was achieved via both visual identification of stained nodes and radio-guided localization using a single-photon gamma probe.

SLNs were sent for frozen section (extemporaneous) analysis. In the case of positive results or failed detection, ALND was performed.

Data Collection and Primary Outcomes

Data were collected from patient records, histopathology reports, surgical logs, and follow-up consultations. Supplemental information was obtained through telephone interviews when required. A single surgical team managed all patients and performed all procedures to ensure procedural consistency.

The primary outcomes were: SLN detection rate, hemoglobin loss (pre- and postoperative delta), postoperative lymphedema, lymphocele incidence, pain presence and intensity (using EVA scale) at postoperative day 1, 6 months, and 1 year), length of hospital stay, arm mobility limitation

Statistical Analysis

Data analysis was performed using SPSS v26.0. Quantitative variables were expressed as means, medians, and standard deviations. Qualitative variables were presented as frequencies and percentages. Normally distributed quantitative variables were compared using Student's t-test; non-normally distributed variables were analyzed using the Mann-Whitney U test. Comparisons between the SLNB and ALND groups

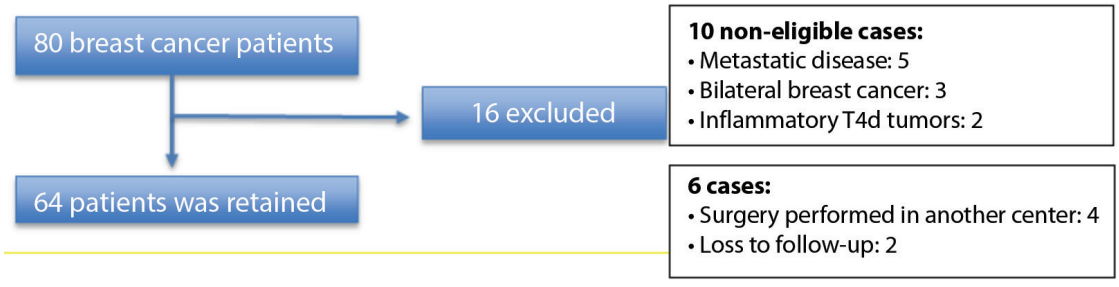


Figure 1. Flowchart of patient selection for the study

for categorical variables were assessed using Pearson's chi-square test or Fisher's exact test, as applicable based on sample sizes. Normality was verified using the Shapiro-Wilk test. A p-value <0.05 was considered statistically significant.

Results

During the study period, a total of 80 breast cancer patients were screened for eligibility; 64 met the inclusion criteria and were retained for the final analysis, while 16 were excluded. Among the 64 retained patients, 27 underwent mastectomy, 25 underwent lumpectomy, and 12 underwent wide local excision. NAC was administered to 14 patients: 6 for tumor downstaging, 5 with triple-negative disease, and 3 with HER2-positive tumors.

SLN biopsy was successfully performed in 89% of the cohort. The 11% failure rate was attributed to intraoperative non-visualization of the LN (n = 4) or weak preoperative radiotracer uptake on LS (n = 2), which necessitated immediate conversion to ALND. Intraoperative frozen-section analysis of the SLN revealed no metastatic involvement in 79% of patients, whereas a positive SLN in 18% of patients led to immediate ALND during the same surgical session. Postoperative outcomes demonstrated a clear benefit of SLNB over ALND in terms of morbidity. The mean hospital stay was significantly shorter in the SLNB group than in the ALND group (5.7 *vs.* 7.7 days, p = 0.001), and perioperative blood loss, as reflected by the mean hemoglobin drop, was markedly reduced (0.71 g/dL *vs.* 1.57 g/dL, p = 0.02). Lymphedema occurred in 3.8% of SLNB patients compared with 23% of ALND patients (p = 0.039). Although lymphocele rates were less frequent in the SLNB group (4% *vs.* 11%), this difference was not statistically significant (p = 0.64). Pain assessment using VAS showed significantly lower scores in SLNB group both on postoperative day 1 (3.92 *vs.* 4.7, p = 0.025) and at 6 months (1.27 *vs.* 2.08, p = 0.002), whereas the difference was not statistically significant at 1 year (p = 0.079). Functional outcomes were also superior in the SLNB group: all patients retained full arm mobility, whereas 43% (n = 16) of patients in the ALND group reported persistent movement restriction (p = 0.001) (Table 1).

Discussion and Conclusion

Our study reinforces the clinical relevance and practicality of SLN biopsy in breast cancer surgery within a resource-limited North African healthcare system. Despite restricted access to advanced nuclear imaging modalities and hybrid tracers, we successfully implemented SLN biopsy at our institution, demonstrating significant advantages in terms of postoperative outcomes and patient quality of life. These results are in line with the growing international consensus supporting SLN biopsy as the standard of care for axillary staging in early-stage breast cancer.

Compared with axillary dissection, SLN biopsy was associated with substantially lower postoperative morbidity. We observed shorter hospital stays, a smaller hemoglobin drop, and less postoperative pain, with statistically significant differences maintained at both early and intermediate follow-up assessments. Importantly, all patients in the SLN group preserved full arm mobility, whereas nearly half of those who underwent axillary dissection developed functional limitations.

A better understanding of tumor biology and the availability of new systemic therapies have reshaped breast cancer management, shifting the surgical approach toward less invasive procedures. Within this evolving paradigm, our findings highlight that SLN biopsy represents not only a safe and effective alternative to axillary dissection but also a cornerstone of modern, patient-centered surgical strategies (6).

The incidence of lymphedema was also markedly reduced, from 23% to 3.8%, a finding consistent with international meta-analyses (2, 3, 7). These benefits underscore the value of SLN biopsy not only for accurate staging but also for safeguarding postoperative quality of life. Given the chronic and disabling impact of axillary morbidity, particularly lymphedema and reduced mobility, SLN biopsy represents a major advance for breast cancer patients, especially those treated conservatively. Moreover, it reduces demand for rehabilitation services and long-term follow-up clinics, which are often overburdened in public health systems (2, 3, 7-10).

The introduction of SLN biopsy in our hospital was achieved by adapting international protocols to local realities. While high-income centers commonly employ radiotracer–fluorescent dye combinations

Table 1. Summary of clinical outcomes

Primary outcomes	**SLNB (n = 26)**	**ALND (n =38)**	**Statistic test**	***p*-value**
Lymphedema (%)	1 (3.8%)	9 (23%)	Chi²/Fischer exact test	0.039
Arm mobility impairment	0 (0%)	16 (43%)	Chi²/Fischer exact test	0.001
Lymphocele (%)	1 (4%)	4 (11%)	Chi²/Fischer exact test	0.64
	SLNB (n = 26)	ALND (n = 38)	Statistic test	*p*-value
Postoperative day 1: mean visual analog scale	3.92%	4.7%	Student's t-test	0.025
	SLNB (n = 26)	ALND (n = 38)	Statistic test	*p*-value
Hospital stay lengh (days)	5.69 Standard deviation: 1.61	7.71 Standard deviation: 2.27	Student's t-test	0.001
	SLNB (n = 26)	ALND (n = 38)	Statistic test	*p*-value
Hemoglobin drop (g/dL)	0.71 Standard deviation: 0.71	1.57 Standard deviation: 1.57	Student's t-test	0.02

SLNB: Sentinel lymph node biopsy; ALND: Axillary lymph node dissection

and intraoperative gamma probes with real-time imaging, we used to technetium-99m-label human albumin nanocolloids in combination with methylene blue, an approach that remains accessible and cost-effective (11, 12). Our detection rate reached 89%, which is comparable to published reports during the early phases of SLN program implementation. Most identification failures were related to limited tracer migration or technical difficulties during intraoperative localization. Nevertheless, the dual technique we used was adequate for reliably mapping axillary drainage and enabled the safe avoidance of unnecessary axillary dissection in N0 patients. This demonstrates that SLN biopsy can be successfully integrated into practice even without near-infrared cameras or intraoperative single photon emission computerized tomography-computed tomography, provided that minimal nuclear medicine infrastructure and adequate surgical training are available (7, 13).

A particularly promising innovation in SLN mapping is the use of indocyanine green (ICG), a near-infrared fluorescent tracer that provides real-time visualization of lymphatic drainage with high sensitivity. Several studies have shown that ICG achieves detection rates equal to or exceeding those of radiotracers, including patients with altered lymphatic anatomy or prior surgery (14, 15). In our setting, ICG holds great potential, as it eliminates the need for radiotracers and allows SLN mapping entirely within the operating theater. However, its adoption remains constrained by two main challenges:

1. The high cost and limited availability of near-infrared imaging systems,

2. The absence of structured training and accreditation pathways in fluorescence-guided surgery.

To overcome these barriers, phased implementation strategies could be considered, starting with pilot programs in high-volume centers, supported by national initiatives or international collaborations. Regional training workshops and knowledge-sharing with centers already experienced in ICG use would further facilitate dissemination.

It is also important to address the role of SLN biopsy following NAC, which remains the subject of ongoing debate (16). Evidence from multiple studies indicates acceptable false-negative rates (<10%) in carefully selected T1-T2 patients. Systematic reviews and meta-analyses have supported the overall feasibility and accuracy of SLNB post-NAC. Tan et al. (17) and Kelly et al. (18) both concluded that SLNB after NAC can be performed reliably, particularly when combined with adjuncts such as immunohistochemistry or dual tracer mapping. These conclusions were further validated by Kuehn et al. (19) in the SENTINA trial, a large prospective multicenter study, which standardized the timing and technical approach to SLNB in this context. Our protocol followed these evolving guidelines, but long-term oncological outcomes require ongoing monitoring.

Study Limitations

This study does, however, present certain limitations. It is retrospective and has a modest sample size, which restricts generalizability. In addition, long-term oncological outcomes, such as recurrence and disease-free survival, were not assessed, as the focus was limited to perioperative parameters. Finally, the unavailability of ICG or hybrid tracers may limit detection sensitivity in anatomically complex cases.

Nonetheless, our findings provide strong real-world evidence that SLN biopsy can be safely and effectively implemented in public hospitals operating under resource constraints. This model could be replicated in other low- and middle-income countries aiming to modernize breast cancer surgical management without imposing unsustainable costs.

Our experience demonstrates that SLNB is a feasible, safe, and effective approach to axillary staging in early-stage breast cancer, even in a resource-limited setting. The technique significantly reduces postoperative morbidity—particularly lymphedema, pain, and impaired arm mobility—while maintaining acceptable detection rates and oncologic validity. With proper protocol adaptation, interdepartmental collaboration, and apprenticeship-based training, SLNB can and should be integrated into routine breast cancer surgery across low- and middle-income countries.

Ethics

Ethics Committee Approval: This study was approved by the Ethics Committee of Bougatfa Hospital (approval no: 13/2022, date: 20.12.2022).

Informed Consent: Retrospective study.

Footnotes

Authorship Contributions

Surgical and Medical Practices: C.B.S.; Concept: A.B., N.K.; Design: Y.C., M.Mab.; Data Collection or Processing: L.Z., A.M.; Analysis or Interpretation: W.J., M.Mo.; Literature Search: M.M., Writing: M.B.

Conflict of Interest: No conflict of interest was declared by the authors.

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