Original Article

# Targeted Axillary Lymph Node Dissection after Neoadjuvant Treatment of Breast Cancer Using Indocyanine Green Compared to Patent Blue V Dye

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## ABSTRACT

**Background:** For patients with breast cancer, targeted axillary lymph node dissection (TAD) after neoadjuvant therapy is an essential surgery for precise axillary staging. TAD with sentinel lymph node (SLN) detection may be enhanced by using indocyanine green (ICG), a promising substitute for conventional dyes. The effectiveness of ICG and patent blue V dye (PBVD) in identifying targeted axillary LNs and SLNs during axillary dissection in patients with breast cancer following neoadjuvant treatment is being compared in this prospective randomized controlled experiment. As a result, there will be less need for a full axillary LN dissection and fewer side effects.

**Patients and Methods:** This study was conducted at Ain Shams University Hospitals between October 2022 and March 2024. A total of 60 breast cancer patients received neoadjuvant therapy and were prepared for surgery of TAD. They were randomized in a 1:1 ratio using randomization software (random.org) into two groups: group A underwent TAD using ICG dye and group B underwent TAD using PBVD. The primary endpoint was the targeted LN, as well as the SLNs removed detection rate, number, and accuracy.

**Results:** The study examined variations in the two groups' SLN detection rates, the quantity of SLNs found, and their adverse consequences. In comparison to PBVD, ICG is said to have shown better SLN detection and identification, as well as fewer problems and adverse effects.

**Conclusion:** The purpose of this experiment is to determine if ICG provides a more accurate and dependable technique for both targeted LN and SLN detection in patients with breast cancer who have received neoadjuvant treatment. By increasing nodal staging accuracy and lowering the possibility of missing sentinel nodes, the data could validate ICG as the preferred tracer for TAD.

**Key Words:** Indocyanine green, Neoadjuvant therapy, Patent Blue V Dye, Sentinel lymph node, Targeted axillary lymph node dissection.

**Received:** 16 December 2024, **Accepted:** 25 December 2024, **Published:** 1 July 2025

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**ISSN:** 1110-1121, July 2025, Vol. 44, No. 3: 908-916, © The Egyptian Journal of Surgery

## INTRODUCTION

With an expected 2.3 million new cases, or 11.7% of all cancer cases, female breast cancer is the most diagnosed malignancy in 2020, according to a recent Globocan 2020 analysis. With 685,000 deaths–or 6.9% of all cancer deaths–it ranks as the seventh most common cause of cancer mortality globally. Following liver cancer, breast cancer is the second most common cause of cancer-related fatalities in Egypt[1].

Neoadjuvant systemic treatment (NAST) has gained significant therapeutic and prognostic importance during the past 10 years, and it has been expanded to encompass patients with operable node-positive breast cancer. In many centers worldwide, axillary lymph node (LN) dissection (ALND) is still the gold standard for axillary staging once NAST is finished. According to studies, neoadjuvant therapy can result in a pathological complete response in 40% of patients with axillary LNs positive[2,3].

Therefore, in order to appropriately stage the axilla, it might not be required to commit all node-positive patients to ALND[4]. AS the most significant predictor of outcome and prognosis in breast cancer is axillary nodal status, an effective diagnostic method and a trustworthy predictor of the axilla's metastatic state is the sentinel lymph node (SLN)[5].

*DOI: 10.21608/EJSUR.2024.344921.1317*

The first LNs to get lymphatic drainage from the main tumor are known as SLNs. According to Zahoor *et al*.[6], patients with negative sentinel lymph node biopsy (SLNB) who did not have ALND had a 5-year overall survival rate that was comparable to that of individuals who did ALND[6].

To guarantee the outcome of NAST at the time of final surgery, the National Comprehensive Cancer Network currently recommends inserting a clip in the positive node before chemotherapy[7].

Targeted axillary dissection (TAD) is a technique where clinically node-positive breast cancer patients have the biopsy-positive node marked before NAST with a clip, dye, or radioactive iodine seed[8].

In clinically node-positive patients, TAD is a viable method and could be a more precise way to stage the axilla following NAST, regardless of the method utilized for LN labeling and localization. Additionally, it is a more restricted approach to the axilla with a lower risk of arm lymphoedema and less morbidity than ALND[9]. Additionally, sentinel node biopsy must be done after removing the clipped LN in TAD for proper staging of the axilla[10].

The first tracer used to map the SLN was radioisotope technetium-99m (RI) in (1993)[11]. Followed by blue dye (BD) in (1994)[12]. Combining BD with RI is the gold standard for lymphatic mapping[13]. A popular BD, patent blue V dye (PBVD), is inexpensive, easy to use, and has a lower detection rate and a greater false-negative rate when used alone. It is also invisible through fatty tissues and skin. It might also result in skin tattooing that might not go away after a few months and, in rare instances, allergic responses that can even lead to anaphylaxis[14].

Only big volume centers with nuclear medicine and accessible infrastructure can use RI. According to Stratmann *et al*.,[15], it also exposes the personnel and patients to radiation. The drawbacks of both conventional tracers have prompted the creation of substitute contrast agents for SLNB, including micro-bubble contrast agent, indocyanine green (ICG) optical imaging, and super-paramagnetic iron oxide-guided SLNB, which have shown promising outcomes in cases of early breast cancer[16].

The US Food and Drug Administration has authorized ICG, a low molecular weight water-soluble green dye with near-infrared (NIR) fluorescence characteristics, for use in assessing ocular perfusion, hepatic clearance, and cardiac output. With optical imaging using the NIR fluorescence lymphatic tracer ICG, SLN mapping can be performed intraoperatively after injection of ICG, depending on its ability to bind with plasma proteins in the lymphatic system[17]. This technique combines the visible green light emitted from ICG with the use of specialized cameras to record the fluorescence[18].

## PATIENTS AND METHODS:

### Patient eligibility

Between October 2022 and March 2024, a total of 60 clinically confirmed node-positive breast cancer patients, confirmed clinically or radiologically before neoadjuvant therapy, then became node negative after neoadjuvant treatment they received, were recruited to this study. They were scheduled to undergo TAD as their targeted LNs were clipped before neoadjuvant. The study was conducted at Ain Shams University Hospitals and aimed to compare the efficacy of ICG fluorescence with PBVD in targeted LN identification and SLNs. All surgeries were performed by a dedicated surgical team experienced in SLNB and TAD.

### Study population

***Inclusion criteria***

1. Patients aged up to 65 years.
2. Breast cancer patients were diagnosed pathologically by core needle biopsy.
3. Clinically and/or radiologically with node positive (N1), and placing a clip at the positive node before NAST.
4. The patient received NAST and became node negative as a result.
5. Patients willing to undergo TAD after NAST.

***Exclusion criteria***

1. Patients with more than three abnormal nodes (N2).
2. Metastatic breast cancer (M1).
3. Upfront surgery, did not receive NAST.
4. History of radiation therapy at the breast or axilla.
5. History of breast or axillary surgery or excisional biopsy.
6. History of allergy to ICG, isosulfan blue, or radioisotopes.

### Ethical considerations

Approval obtained from the ethical committee of the Department of General Surgery, Faculty of Medicine, Ain Shams University.

**Study design**

A randomized controlled trial with an open prospective design was used. intended to compare the effectiveness of PBVD and ICG fluorescence in locating specific axillary LNs following neoadjuvant therapy. Sixty patients received TAD then were divided into two equal groups: 30 patients in group A; underwent TAD using ICG for targeted and SLN mapping, and 30 patients in group B received TAD using PBVD for the same purposes. Based on its appearance as fluorescent (green or blue) in ICG or becoming blue in PBVD, each sentinel or targeted LN was recognized and documented. When compared to blue dye, the main result was how sensitive ICG was in detecting SLNs and targeted nodes. Any nodes identified solely by palpation without dye were documented as well.

**Study procedures**

***Preoperative***

1. Clinical and radiological assessment (before and after NAST), tissue diagnosis, metastatic workup, preoperative preparation of TAD surgery (laboratory tests, ECG, and anesthesia consultation) and discussion by multidisciplinary team done for all patients before surgery.

2. Preoperative wire localization of the clipped node.

3. Signing up for informed consent after explaining the operative procedure and expected complications of TAD surgery and the dye used intraoperatively.

***Study interventions***

1. General anesthesia and patient positioning in the supine position with abducted arm, then prepping and draping of the patient.

2. Operative details related to each patient in group A underwent TAD using ICG:

a. One hour before the surgery, one vial of ICG–containing 25mg of lyophilized sterile powder–was dissolved in 10ml sterile distilled water to a concentration of 2.5mg/ml.

b. After sterilization, 2ml of ICG was injected retroareolar and periareolar, with gentle massaging of breast for 5min to enhance dye uptake.

c. Exposure of the axilla, either from the mastectomy incision or a separate transverse skin incision.

d. In all cases, at that time the operating room lights were turned off, and the system used was the IMAGEL ST camera system, HOPKINS NIR/ICG scope, and D-LIGHT P light source, Karl Storz Endoskope, Tuttlingen, Germany.

e. A laparoscope with a 30° field of view and a 10mm diameter that is fitted with a particular filter for the best detection of NIR fluorescence and white light, with manual switching for imaging. The imaging is produced by a top-tier full HD camera system.

f. Switching the camera from normal to NIR mode to allow visualization of both anatomy and fluorescence signals, which was controlled by the surgeon by means of a pedal (Figure 1).

g. Removing the LN marked with a clip and wire localization and confirmation by instant radiograph imaging. Also, assessment is done using both camera modes (normal and NIR) (Figure 2).

h. Removal of SLNs identified by ICG using NIR mode with assessment after removal in both modes (normal and NIR). (Figure 3).

i. All harvested LNs from the targeted and sentinel were sent for frozen section.

3. Operative details related to each patient in group B underwent TAD using PBVD:

a. After sterilization; retroareolar injection of 3ml (in concentration of 3mg/ml) of PB solution (Patent Blue V, S.A.L.F. S.p.A. Laboratorio Farmacologico, Cenate Sotto, Italy). Followed by gentle massaging of the breast for 5–15 min to enhance dye uptake.

b. Exposure of the axilla, either from the mastectomy incision or a separate transverse skin incision.

c. Identification of tissue staining by blue dye in the axilla.

d. Removing of LNs marked with clip and wire localization, then confirmation by instant radiograph imaging, also assessment of staining with PBV (Figure 4).

e. Removal of SLNs stained by PB and sent for frozen section (Figure 5).

f. All blue-stained LNs and targeted LNs were harvested and sent for frozen section.

4. After results of frozen section: complete axillary dissection was only done in positive targeted LN and SLN proven by frozen.

5. Wound closure with application of a drain and covering, then recovery of the patient from anesthesia.

6. Postoperative: all specimens were sent for histopathological examination through paraffin-embedded section.

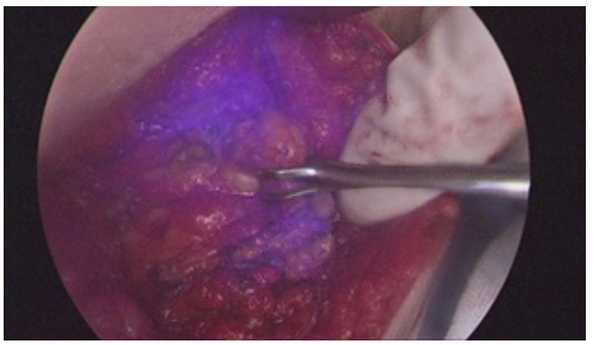

**Figure 1:** NIR camera view of the axilla with identification of ICG dye staining. ICG, indocyanine green.

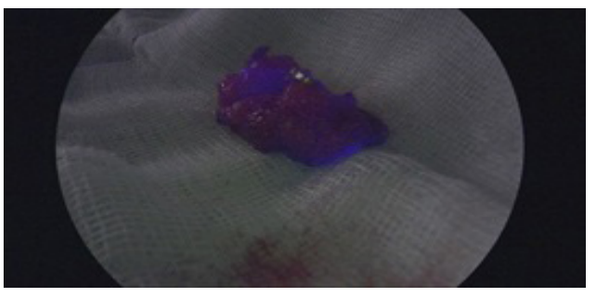

**Figure 2:** Visualization of the targeted LN by NIR camera mode.

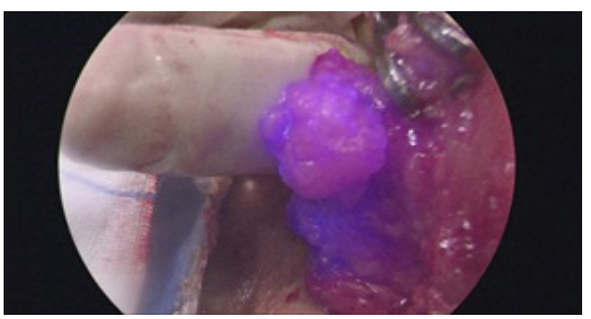

**Figure 3:** Removal of sentinel LN with ICG staining in NIR mode. ICG, indocyanine green.

### Safety and follow-up

After ICG and blue dye were administered, all patients were thoroughly watched for any acute toxicity. Close monitoring during surgery and after in the hospital stay period, in addition to follow-up sessions (2 weeks after hospital stay period), any negative outcomes associated with the dye injections, such as allergic responses or local site irritation, were documented and managed. Patients gave their informed agreement to participate in the trial, which was authorized by the local Ethics Committee.

### Statistical analysis

Excel 365, developed by Microsoft Corporation in the United States, was used to capture, tabulate, and code the gathered data. The Statistical Package for Social Sciences, IBM SPSS Statistics, version 28.0, IBM Corporation, Chicago, Illinois, USA, was then used to statistically analyze the data.

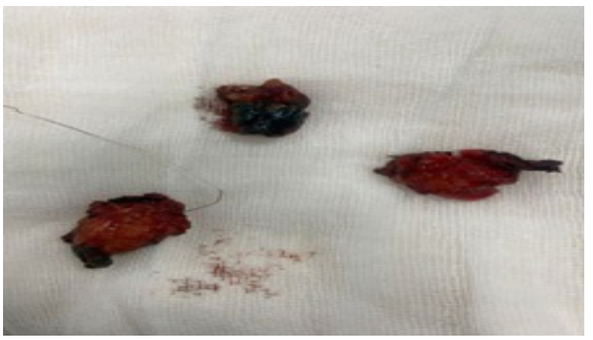

**Figure 4:** Marked or targeted LNs removed.

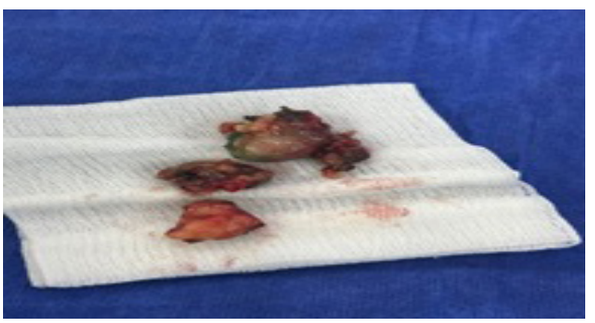

**Figure 5:** Removal of sentinel LNs stained by blue dye.

## RESULTS:

### Patients' characteristics

Regarding patients' data, 60 patients with breast cancer who had marked LN with clipping and positive before NAST, turned LN negative both clinically and radiologically following neoadjuvant treatment. Table (1) provides a summary of the primary attributes of the patients and their tumors. In general, the patients in group A and group B had similar demographic traits and medical histories. Given that they ranged in age from 30 to 60, the mean age of group B was somewhat higher (43.97 years) than that of group A (40.30 years), although this difference was not statistically significant ($P$= 0.078). There were no discernible variations in the distribution of BMI categories between the two groups ($P$= 0.916). 86.7% of patients in group A and 90.0% of patients in group B were married, and there was no discernible difference in their marital status ($P$= 1.000). The majority of patients had no comorbidities, and the prevalence of comorbid conditions, such as diabetes, hypertension, and a combination of the two, was similar among the groups ($P$= 0.942). Furthermore, there was no discernible difference between the two groups' family histories of breast cancer, which were primarily negative ($P$= 1.000).

**Intraoperative procedure details among study groups**

The intraoperative procedure details, as shown in Table (2), reveal significant differences between group A and group B. Group A had a significantly faster estimated time for dye to reach the axilla (mean 3.57±1.09min) compared to group B (mean 15.47±2.66min), with *P* value less than 0.001. Additionally, while a higher percentage of targeted LNs were stained by ICG in group A (96.7%) compared to group B (76.7%) with PB, this difference was not statistically significant (*P*= 0.058). The number of SLNs stained by ICG was slightly higher in group A (mean 4.20±0.92) than in group B (mean 3.57±1.19) with PB, this difference approaching statistical significance (*P*= 0.054).

**Table 1:** Demographic data and medical history of study groups:

| | | Group A | Group B | Test Result |
|---|---|---|---|---|
| | | *n*= 30 | *n*= 30 | |
| Age (years) | Mean±SD | 40.30±7.72 | 43.97±8.40 | *t*: 1.767, *p*= 0.078 |
| | Median (Min-Max) | 37.50(30.00-60.00) | 45.50(30.00-59.00) | |
| BMI (kg/m$^2$) | Average | 11(36.7%) | 11(36.7%) | |
| | Overweight (25-30) | 16(53.3%) | 15(50.0%) | $X^2$: 0.175, *p*= 0.916 |
| | Obese (>30) | 3(10.0%) | 4(13.3%) | |
| Marital status | Married | 26(86.7%) | 27(90.0%) | $X^2$: 0.000, *p*= 1.000 |
| | Single | 4(13.3%) | 3(10.0%) | |
| Comorbidities | DM | 2(6.7%) | 3(10.0%) | |
| | HTN | 5(16.7%) | 6(20.0%) | $X^2$: 0.391, *p*= 0.942 |
| | HTN/DM | 2(6.7%) | 2(6.7%) | |
| | No comorbidities | 21(70.0%) | 19(63.3%) | |
| Family history of breast cancer | Negative | 22(73.3%) | 23(76.7%) | $X^2$: 0.000, *p*= 1.000 |
| | Positive | 8(26.7%) | 7(23.3%) | |

Table 2: Intraoperative procedure details among study groups:

| | | Group A | Group B | Test Result |
|---|---|---|---|---|
| | | *n*= 30 | *n*= 30 | |
| Estimated time for dye to reach axilla (min) | Mean±SD | 3.57±1.09 | 15.47±2.66 | *t*: 22.665, *p*< 0.001* |
| | Median (Min-Max) | 3.75(1.50-5.50) | 16.00(11.00-20.00) | |
| Targeted LN or marked LN stained by dye | No | 1(3.3%) | 7(23.3%) | $X^2$: 3.606, *p*= 0.058 |
| | Yes | 29(96.7%) | 23(76.7%) | |
| No. of sentinel LNs seen stained by dye intraoperative | Mean±SD | 4.20±0.92 | 3.57±1.19 | *Z*: 1.855, *p*= 0.054 |
| | Median (Min-Max) | 4.00(2.00-6.00) | 4.00(1.00-5.00) | |

*t*: Student *t* test; $\chi^2$: $\chi^2$ test; *Z*: Mann–Whitney test;*: Significant *P* value (<0.05).

**Intraoperative (frozen section)**

Regarding data in Table (3), group A and group B's intraoperative (frozen section) findings show some significant variations. The mean number of total SLNs excised was substantially larger in group A (5.20±1.06) than in group B (4.13±0.68), and the difference was statistically significant (*P*< 0.001). In group A 17(56.7%) of cases were found to be with positive LNs, while 13(43.3%) were negative. On the other hand in group B 13(43.3%) were positive and 17(56.7%) were negative, which was not statistically significant difference (*P*= 0.439), but the number of cases affected by axillary clearance. With a mean of 1.00±1.36 in group A and 0.87±1.33 in group B (*P*= 0.483), there was no statistically significant difference between the two groups in terms of the total number of positive SLNs. However, the status of the target or marked LN (whether positive or negative) did not show a significant difference between the groups, with 56.7% of group A and 43.3% of group B having positive LNs (*P*= 0.439). Furthermore, if a patient had a positive targeted LN or SLN as a result of treatment failure, full axillary clearance was performed. Group A data revealed that 17(56.7%) patients underwent axillary clearance, whereas 13(43.3%) patients did not. In group B 13(43.3%) underwent axillary clearance due to positive LN, but 17(56.7%) did not due to negative LNs. However, this difference was not statistically significant (*P*= 0.439).

**Postoperative final histopathological**

There was no discernible difference between group A and group B in terms of postoperative final histological diagnosis Table 4, as evidenced by the total number of positive LNs (*P*= 0.593). However, group A had a

considerably larger total number of excised LNs in the material than group B ($P< 0.001$). There was no discernible change in the distribution of marked or clipped LNs, whether they were positive or negative. The incidence of invasive ductal carcinoma and intramammary carcinoma, among other final histological findings, did not substantially differ between the two groups.

**Table 3:** Intraoperative (frozen section) results in study groups:

| | | Group A | Group B | Test Result |
|---|---|---|---|---|
| | | ***n*= 30** | ***n*= 30** | |
| Total number of removed sentinel LN | Mean±SD | 5.20±1.06 | 4.13±0.68 | *Z*: 4.317, *p*< 0.001* |
| | Median (Min-Max) | 5.00(3.00-9.00) | 4.00(3.00-6.00) | |
| Total number of positive sentinel LN | Mean±SD | 1.00±1.36 | 0.87±1.33 | *Z*: 0.651, *p*= 0.483 |
| | Median (Min-Max) | 1.00(0.00-5.00) | 0.00(0.00-4.00) | |
| Removed sentinel LN | Negative | 13(43.3%) | 17(56.7%) | $X^2$: 0.600, *p*= 0.439 |
| | Positive | 17(56.7%) | 13(43.3%) | |
| Target LN or marked LN | Negative | 13(43.3%) | 17(56.7%) | $X^2$: 0.600, *p*= 0.439 |
| | Positive | 17(56.7%) | 13(43.3%) | |
| Complete axillary clearance | Done | 17(56.7%) | 13(43.3%) | $X^2$: 0.600, *p*= 0.439 |
| | Not done | 13(43.3%) | 17(56.7%) | |

$\chi^2$: $\chi^2$ test; Z: Mann–Whitney test; *: Significant *P* value (<0.05).

**Table 4:** Postoperative final histopathological (final paraffin section) results among study groups:

| | | Group A | Group B | Test Result |
|---|---|---|---|---|
| | | ***n*= 30** | ***n*= 30** | |
| Total number of removed LN in specimen | Mean±SD | 6.40±2.24 | 6.40±3.79 | *Z*: 3.814, *p*< 0.001* |
| | Median (Min-Max) | 6.00(5.00-15.00) | 5.00 (4.00-17.00) | |
| Marked LN or clipped LN | Negative | 13(43.3%) | 17(56.7%) | $X^2$: 0.600, *p*= 0.439 |
| | Positive | 17(56.7%) | 13(43.3%) | |
| Total number of positive LN | Mean±SD | 1.20±1.67 | 1.40±2.27 | *Z*: 0.503, *p*= 0.593 |
| | Median (Min-Max) | 1.00(0.00-7.00) | 0.00(0.00-8.00) | |
| Final histopathology | Intrammary carcinoma | 4(13.3%) | 7(23.3%) | $X^2$: 0.445, *p*= 0.505 |
| | IDC | 26(86.7%) | 23(76.7%) | |

$\chi^2$: $\chi^2$ test; IDC: Invasive Ductal Carcinoma; *Z*: Mann–Whitney test; *: Significant *P* value (<0.05).

## DISCUSSION

A viable substitute for conventional blue dye and radioisotope techniques is ICG. ICG, a fluorescent dye, provides a more straightforward and economical way to see the lymphatic system and find SLNs. Its application has been linked to high detection rates that are on par with those attained using the blue dye and radioisotope combination approach. ICG has not been consistently incorporated into clinical practice despite these developments, especially in European contexts where blue dye is still more common[19].

The use of TAD following neoadjuvant therapy has drawn interest recently as a novel strategy. By evaluating SLNs after neoadjuvant chemotherapy, this technique may help direct more accurate surgical procedures. In this perspective, comparing ICG to PBVD provides a useful chance to assess these tracers' efficacy and dependability in a contemporary surgical environment[20].

In patients receiving neoadjuvant therapy for breast cancer who are prepared for TAD, this research intends to evaluate the effectiveness of TAD using ICG in comparison to PBVD. By assessing the detection rates of SLNs and targeted LNs, the results of surgery, and the related advantages. The goal of this study is to support the continuous attempts to optimize and standardize axillary staging methods in the treatment of breast cancer.

Group A had a greater percentage of targeted LNs stained by dye (96.7%) than group B (76.7%), however, this difference was not statistically significant

(*P*= 0.058). The higher staining rate in group A, in spite of the nonsignificant *P* value, implies that ICG could be more likely than blue dye to detect LNs. The results of previous investigations showing a greater staining rate with ICG are in line with this trend[21].

The average number of SLNs stained by dye was slightly higher in group A (mean 4.20±0.92) compared to group B (mean 3.57±1.19), approaching statistical significance (*P*= 0.054). This indicates that ICG might be more effective in identifying a larger number of SLNs, which could potentially enhance the accuracy of staging and treatment planning[22].

The detection rate of blue dye in our study (97.5%) aligns closely with the detection rates reported in large cohort studies using blue dye, which typically range from 70% to over 95%. The results are also comparable to the detection rate obtained with combination methods involving radioisotope tracers (97.2%) reported in the NSABP B-32 study Krag *et al*.,[23]. These findings support the high effectiveness of blue dye, though the detection rate varies across different studies.

The high detection rates reported with ICG, ranging between 95 and 100% in various studies, highlight its reliability. Additionally, the use of ICG provides the advantage of real-time visualization on a screen during surgery, which is a significant pedagogical tool and enhances precision. This visualization aids in avoiding blind exploration and helps in preserving the anatomy of the vascular and nervous systems, potentially leading to reduced surgical site injury. Our study reinforces the effectiveness of ICG in SLN mapping, demonstrating its efficiency and high detection rate. The results are consistent with previous studies and meta-analyses, confirming ICG as a reliable and effective alternative to blue dye for SLN identification[24].

The intraoperative (frozen section) results provide insight into the differences in SLN evaluation between group A and group B.

The significant difference in the total number of SLNs removed highlights the potential advantage of ICG in improving the visualization and identification of sentinel nodes. However, the lack of significant differences in the number of positive SLNs and the status of target or marked LNs indicates that both methods are similarly effective in detecting nodal involvement. The findings support the use of ICG for its potential to enhance the number of nodes evaluated while maintaining comparable detection of positive nodes. The decision to perform complete axillary clearance appears to be influenced by additional factors beyond the dye used for sentinel node mapping, such as any targeted LN or SLN found to be positive must go for clearance, as it indicates failure of NAST[25].

These results, consistent with Coibion *et al*.,[26], underscore the utility of ICG in SLN mapping, particularly in increasing the number of nodes that can be evaluated, which may contribute to more accurate staging and treatment planning. Further studies could explore the clinical implications of these findings and investigate whether the increased number of nodes removed with ICG impacts long-term patient outcomes or treatment strategies.

94.1% of patients in group A (using ICG) had positive targeted LNs stained by dye, compared to 69.2% in group B (using blue dye). Although group A showed a higher rate of successful staining, the difference between the two groups was not statistically significant (*P*= 0.187). This indicates that while ICG may offer a higher rate of staining for positive LNs, the difference in clinical significance between the two dyes is not substantial enough to reach statistical significance. This suggests that both methods are relatively effective in staining positive nodes, but ICG might have a slight edge in detecting more nodes. This result is consistent with Coibion *et al*.,[26].

The results indicate that while ICG may provide a higher rate of staining for positive targeted LNs and facilitate the removal of a greater number of LNs, these differences do not translate into significant variations in the final histopathological outcomes. The similar rates of positive LNs and the incidence of invasive ductal carcinoma between the groups suggest that both ICG and blue dye are effective for sentinel node mapping, with ICG potentially offering some practical advantages in terms of visualization and node removal[27]. These findings support the continued use of ICG for its enhanced imaging capabilities, though the choice of dye method should also consider other factors such as availability, cost, and surgeon preference. Further research could explore the long-term implications of these findings on patient outcomes and overall surgical success.

## CONCLUSION

TAD with ICG enhances SLNB in clinically node-negative breast cancer patients who received NAST. Compared to PBVD, ICG offers superior visualization and accuracy by increasing staining rates and SLN identification. However, it does not significantly affect the detection of positive nodes or complete axillary clearance rates. Cost and availability should be taken into account while selecting a dye. ICG is anticipated to further enhance axillary staging in breast cancer with increased expertise and better methods.

## ACKNOWLEDGMENTS

The author thanks all the staff at Ain Shams University Breast Cancer Unit.

*Data Availability Statement:* The datasets used or analyzed during the current study are available from the corresponding author on reasonable request.

## CONFLICT OF INTEREST

There are no conflicts of interest.

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