

# Single-Port Endoscopic Sentinel Lymph Node Biopsy Combined with Indocyanine Green and Carbon Nanoparticles in Breast Cancer: A Retrospective Cohort Study

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**Clinical trial**

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# Abstract

## Purpose

Indocyanine green (ICG) is an efficient tracer method used in sentinel lymph node biopsy (SLNB). The application of single-port endoscopic-assisted technology in the field of breast cancer is widely accepted. In order to explore the surgical safety of single-port endoscopic-SLNB (SPE-SLNB) and the reliability of axillary staging, we combined it with ICG that was excited by near-infrared fluorescence endoscopy and carbon nanoparticles (CN) as a tracer and compared this method to conventional open SLNB (C-SLNB).

## Methods

Sixty patients with early breast cancer were recruited and divided into three groups. Twenty patients who underwent SPE-SLNB combined with ICG and CNs were placed in group A. Twenty patients who underwent SPE-SLNB with CNs only were placed in group B. Twenty patients who underwent C-SLNB with ICG and CNs were placed in group C.

## Results

The detection rate of SLNs was 100% in group A, 100% in group B, and 95% in group C. In total, 97 SLNs were detected in group A, 65 SLNs were detected in group B, and 98 SLNs were detected in group C.

## Conclusion

The novel technique of combining ICG and CNs with SPE-SLNB and the utilization of the endoscopic fluorescence imaging system achieved the same detection rate and mean number of SLNs as C-SLNB. Therefore, for patients who meet the indications, SPE-SLNB is as safe and reliable as C-SLNB.

## Introduction

In the late 20th century, one of the greatest advances in clinical surgery was the gradual maturity of the theory of minimally invasive surgery, and then the rapid development of endoscopic surgery to make that theory a reality. Endoscopic technology is precise, minimally invasive, and can protect the function of the surgical area (*e.g.* upper extremity function is protected during endoscopic lymph node biopsy). As an important female sexual organ, breast surgery has benefitted from the development of minimally invasive surgery because of the cosmetic effect and postoperative quality of life of patients [1–3].

Single-port laparoscopic surgery technology has several advantages in breast surgery including being less invasive and having a small, hidden surgical incision, which achieves a beneficial postoperative aesthetic effect. In recent years, the application of single-port endoscopic-assisted technology in the field of breast cancer has become more and more extensive. A number of studies have shown that the clinical efficacy and safety of single-port endoscopic subcutaneous mastectomy, single-port endoscopic breast

reconstruction, and single-port laparoscopic breast-conserving surgery are equivalent to traditional open surgery [4–6].

When performing single-port laparoscopic breast surgery in breast cancer, single-port endoscopic sentinel lymph node biopsy (SPE-SLNB) implemented simultaneously is very important for axillary lymph node staging. If SPE-SLNB can accurately predict axillary lymph node status, then the patients could avoid axillary lymph node dissection when the sentinel lymph node (SLN) metastases fulfill the Z0011 criteria [7]. At present, few studies have shown whether SPE-SLNB and conventional SLNB (C-SLNB) have the same reliability in the detection rate and number of SLNs. In order to explore the surgical safety of SPE-SLNB and its reliability in axillary staging, our center created a novel technique of combining indocyanine green (ICG) and carbon nanoparticles (CN) as a tracer and utilized an endoscopic fluorescence imaging system through a single port. We then compared this novel SPE-SLNB method to C-SLNB.

## Materials And Methods

### Ethics Statement

This study was approved by the Ethics Committee of the Beijing Friendship Hospital, Capital Medical University (2019-P2-058-02). Written informed consent was obtained from all patients before surgery.

### Patients

Procedures were performed on breast cancer patients ( $N=60$ ) between March 2019 and May 2020 at the Beijing Friendship Hospital. Patients with early invasive breast cancer (stage I and II) as confirmed by core needle biopsy and with clinically negative axilla were enrolled in the present study. Patients with tumors  $>5$  cm, clinically or radiologically suspicious lymph nodes, inflammatory breast cancer, distant metastatic tumor, previous axillary surgery, or hypersensitivity to iodine or ICG were excluded from the study.

After recruitment, patients were divided into three groups. Twenty patients who underwent SPE-SLNB combined with ICG and CNs were placed in group A. Another 20 patients who underwent SPE-SLNB using CNs only were placed in group B. The remaining 20 patients who underwent C-SLNB using ICG and CNs were placed in group C.

### Surgical technique

#### Group A (SPE-SLNB combined with ICG and CNs)

The patient was in a supine position with a high shoulder cushion on the affected side. The upper limb was wrapped in a sterile towel and placed at a  $90^\circ$  abduction. ICG (25 mg, Yichuang Pharmaceutical LLC, Dandong, China) was dissolved in 10 mL sterilized distilled water before use, and the mass concentration was 2.5 mg/mL after dissolving. Then the ICG was further diluted to 0.5 mg/mL in 1 mL of sterilized distilled water for use. Intradermal injection of 0.3 mg/mL of ICG and 0.2 mL of CNs (Chongqing LUMMY

Pharmaceutical, Chongqing, China) were injected at the outer and lower margins of the areola. Tumescence solution was injected into the axilla to facilitate liposuction. The formula of the tumescence solution was 1 mg adrenaline and 20 mL of 2% lidocaine mixed with 250 mL of 0.9% sodium chloride and 250 mL of sterilized distilled water. A total of 100 mL of tumescence solution was injected into the SLN region with a blunt lipolysis needle at the top. After 15 minutes, we performed liposuction in this area.

A small single-port incision about 2.5 cm in length was created with the single-port insufflation kit (HTKD- Hang T Port, China) (Fig. 1) at the axillary midline flush with the nipple and filled with CO<sub>2</sub> gas. The pressure was maintained at 8 mmHg (1 mmHg = 0.133 kPa), and the gas flow rate was kept at 8 L/min. This established adequate working space for the operation. Then, endoscopic surgical instruments and the near-infrared fluorescence endoscopy of FloNavi™ Endoscopic Fluorescence Imaging System (Optomedic Technique Inc., Guangdong, China) (Fig. 2) were implanted through the single-port insufflation kit. The endoscopic fluorescence imaging system emits an excitation light at 760 nm, which produces the fluorescence of ICG that is displayed by computer processing. The near-infrared fluorescence endoscopy also magnifies the area to easily detect the fluorescence of the ICG in the SLNs and the lymphatic vessels connected to it (Fig. 3). The lymphatic vessels surrounding the SLNs were clipped, and the SLNs visible with fluorescent lymph nodes (ICG +) and/or black-stained lymph nodes (CN +) were removed (Fig. 4). The SLN specimens were removed through the single-port insufflation kit and sent for intraoperative frozen pathology. Patients who did not conform to the Z0011 criteria continued to receive endoscopic axillary lymph node dissection through the single-port incision. On the contrary, if a patient met the Z0011 criteria, then the surgical field was washed with physiological saline, and a silicone drainage tube was placed to connect the negative pressure suction. The drainage tube was removed three days after operation. Patients receiving single-port endoscopic subcutaneous mastectomy, breast-conserving surgery, or implanted breast reconstruction were performed through the same single-port incision to complete the follow-up single-port endoscopic surgery. Specific procedures and techniques of single-port endoscopic breast surgery was described previously [6].

### **Group B (SPE-SLNB with CNs only)**

CNs (0.5 mL) were injected into the outer and lower edge of the areola. The placement of the patient's posture, liposuction, and the establishment of surgical space were the same as in group A. The endoscopic instruments and laparoscope were implanted through the single-port insufflation kit. Then, we separated the fibrous connective tissue in front of the lens, identified the black-stained SLN and its connected lymphatic vessels, clipped the lymphatic vessels around the SLN, and removed all lymph nodes stained with CNs. The extraction, treatment, and other surgical procedures of the specimens were the same as in group A.

### **Group C (C-SLNB combined with ICG and CNs)**

Intradermal injection of 0.3 mg/mL of ICG and 0.2 mL of CNs were injected at the outer and lower margins of the areola, respectively. Then, ICG fluorescence was excited and detected by an *in vitro* hand-held fluorescence detector (Optomedic Technique Inc., Guangdong, China), and lymphatic drainage was tracked in real time on the monitor. The incision was made 1 cm away from the disappearance of the fluorescence. The fluorescent lymph nodes (ICG +) and/or black-stained lymph nodes (CN +) were detected under direct vision, and the C-SLNB was completed. Once the SLN specimens were removed, they were sent for intraoperative frozen pathology. The removal of specimens and the treatment of the axilla were the same as group A. Finally, the breast surgery was performed through traditional open surgery.

If the fluorescent lymphography was undetected, then we made a routine incision in the axilla of the patient. When the skin and subdermal fat were incised, the black-stained lymph nodes were resected.

## **Evaluation of SLNs and arm function**

The detection rate of SLNs, mean number of SLNs, and the physical function of the upper limbs were evaluated. In order to evaluate the physical function of the upper limbs, clinicians performed sensory evaluation at one month and six months after surgery. The patients were contacted by telephone for follow-up. The upper arm pain score (PS) was measured by the visual analogue scale. If PS = 0, then it was reported as no pain; if PS = 1–3, then it was reported as mild pain; if PS  $\geq$  4, then it was reported as moderate to severe pain. The degree of sensory loss at the upper arm was also measured by the visual analogue scale. The scale ranged from 0 (no change in sensation) to 10 (complete loss of sensation).

## **Statistical analysis**

Variables between the three surgical techniques were compared using the chi-squared test and independent sample t-test. All statistical analyses were performed using IBM SPSS Statistics ver. 26.0 (IBM Co., Armonk, NY, USA) software, and a *p*-value < 0.05 represented statistical significance.

## **Results**

### **Patient and tumor characteristics**

Detailed information about patient characteristics and tumors was shown in Table 1. There were no differences in mean age, body mass index, histological classification, menopause status, or tumor localization between the patients in the three groups. There were statistical differences in tumor size and laterality.

Table 1  
Patient and tumor characteristics

Characteristic	Group A (n = 20)	Group B (n = 20)	Group C (n = 20)	p-value
Age (yr)				0.153
≤ 50	6	10	12	
> 50	14	10	8	
Body mass index (kg/m <sup>2</sup> )				0.540
≤ 18.4	0	1	0	
18.5–23.9	12	11	10	
24.0-27.9	8	7	9	
≥ 28	0	1	1	
Histologic type				0.729
Invasive ductal	17	18	17	
Invasive lobular	1	1	0	
Ductal carcinoma in situ	2	1	3	
Other types	0	0	0	
Tumor size (cm)				0.002
< 2.0	15	17	7	
2–5	5	3	13	
Menopause				0.215
Pre	5	6	10	
Post	15	14	10	
Laterality				0.007
Left	12	5	3	
Right	8	15	17	
Tumor localization				0.283
Upper outer	11	7	9	

Group A: Single-port endoscopic sentinel lymph node biopsy combined with indocyanine green and carbon nanoparticles; Group B: Single-port endoscopic sentinel lymph node biopsy combined carbon nanoparticles; Group C: Conventional sentinel lymph node biopsy combined with indocyanine green and carbon nanoparticles.

Characteristic	Group A (n = 20)	Group B (n = 20)	Group C (n = 20)	p-value
Lower outer	6	8	8	
Upper medial	2	0	2	
Lower medial	1	2	1	
Central	0	3	0	
Estrogen receptor status				0.065
Positive	5	3	1	
Negative	15	17	19	

Group A: Single-port endoscopic sentinel lymph node biopsy combined with indocyanine green and carbon nanoparticles; Group B: Single-port endoscopic sentinel lymph node biopsy combined carbon nanoparticles; Group C: Conventional sentinel lymph node biopsy combined with indocyanine green and carbon nanoparticles.

## SLN detection

The SLN detection rates for group A, group B, and group C were 100%, 100%, and 95%, respectively. SLNs were detected successfully in group A and group B. The SLN in one patient in group C was not detected. The detection rates of group A and group C and of group B and group C were compared separately, and there were no statistical differences ( $p > 0.05$ ).

Fluorescent lymphography was visible in group A and group C. In group A, the fluorescent lymphangiography and fluorescent SLN was detected in 20 patients. Transcutaneous fluorescent lymphography or black-stained lymph nodes were visible in 19 patients in group C.

In group A, group B, and group C, the total number of SLNs detected was 97 (68 were ICG+/CN+, 27 were ICG+/CN-, and 2 were ICG-/ CN+), 65 (CN+), and 98 (68 were ICG+/CN+, 30 were ICG+/CN-, and 0 were ICG-/ CN+), respectively. In addition, there was a significant difference in the mean number of SLNs between group A ( $4.85 \pm 2.28$ , range: 1–9) and group B ( $3.25 \pm 1.77$ , range: 0–6) ( $p < 0.05$ ), and there was a significant difference in the mean number of SLNs between group B and group C ( $4.90 \pm 2.27$ , range: 1–9) ( $p < 0.05$ ). There was no statistical difference between group A and group C.

## Metastasis rate of SLNs

In group A, three tumor-positive patients were detected with seven metastatic SLNs in the paraffin pathology (five were ICG+/CN+, two were ICG+/CN-, and zero were ICG-/CN+). In group B, there was one positive patient with two metastatic SLNs. In group C, there were two positive patients with six metastatic SLNs (three were ICG+/CN+, three were ICG+/CN-, and zero were ICG-/CN+).

## The physical function of the upper limbs

The average pain scores of group A, group B, and group C at one month after surgery were  $2.65 \pm 0.93$ ,  $2.35 \pm 1.03$ , and  $3.20 \pm 0.70$ , respectively. The average pain scores of group A, group B, and group C at six months after surgery were  $0.95 \pm 0.69$ ,  $1.15 \pm 0.81$ ,  $1.50 \pm 0.76$ , respectively. The average sensory loss scores of group A, group B, and group C at one month after surgery were  $5.40 \pm 0.88$ ,  $5.35 \pm 1.08$ , and  $5.50 \pm 0.89$ , respectively. The average sensory loss scores of group A, group B, and group C at six months after surgery were  $4.70 \pm 0.92$ ,  $4.40 \pm 1.35$ , and  $4.65 \pm 1.09$ , respectively. There were no statistical differences between the three groups in average pain scores and average sensory loss scores (Table 2).

Table 2  
Pain and sensory loss scores at one month and six months after surgery

	Group A	Group B	Group C	<i>p</i> -value <sup>#</sup>
Average pain score at one month	$2.65 \pm 0.93$	$2.35 \pm 1.03$	$3.20 \pm 0.70$	0.081
Average pain score at six months	$0.95 \pm 0.69$	$1.15 \pm 0.81$	$1.50 \pm 0.76$	0.075
Average sensory loss score at one month	$5.40 \pm 0.88$	$5.35 \pm 1.08$	$5.50 \pm 0.89$	0.881
Average sensory loss score at six months	$4.70 \pm 0.92$	$4.40 \pm 1.35$	$4.65 \pm 1.09$	0.672

#: The ANOVA test was used to evaluate differences between the three groups. Group A: Single-port endoscopic sentinel lymph node biopsy combined with indocyanine green and carbon nanoparticles; Group B: Single-port endoscopic sentinel lymph node biopsy combined carbon nanoparticles; Group C: Conventional sentinel lymph node biopsy combined with indocyanine green and carbon nanoparticles.

## Discussion

SLNs are the first lymph nodes that cancer cells are most likely to spread to from the primary tumor. The accurate and complete visualization of the lymphatic vessels and sentinel lymph nodes is crucial for detecting metastasis and accurately staging the cancer. ICG-enhanced fluorescence was introduced to improve the detection of SLNs in early breast cancer during conventional open surgery and was found to be safe and effective [8, 9]. However, in C-SNLB the location of the lymph node is judged by the position of the disappearance of the lymphatic vessel and cannot be accurately detected before creating an incision. Therefore, our center uses SPE-SLNB combined with an endoscopic fluorescence imaging system that magnifies and directly excites the ICG to overcome this disadvantage. However, few studies have shown if SPE-SLNB has similar detection rates and is as safe as C-SLNB. In this study, our center tested a novel method of using ICG as a tracer while performing SPE-SLNB.

There was no significant difference in the SLN detection rates between the three groups. This result indicates that SPE-SLNB combined with ICG and CNs is just as reliable at detecting SLNs as C-SLNB. It should be noted that in group C, detection of the SLNs through the skin failed in one patient. This is due to the limitation of approximating the position of the SLN by the disappearance of the fluorescent lymphatic vessels. Kitai *et al* [10] reported a similar observation in which one patient out of eighteen who received C-SLNB failed to detect the fluorescence of ICG. Similarly, Guo *et al* [11], who used ICG combined

with a methylene blue tracer, found that 16/200 cases of C-SLNB failed to detect fluorescent SLNs through the skin. In traditional surgery, only the fluorescence excited by the superficial lymphatic vessels could be detected after the injection of ICG. However, the fluorescence of SLNs that are further from the body surface cannot be directly detected by conventional methods before creating an incision. To overcome this challenge, our center established the use of ICG-enhanced fluorescence imaging with a near-infrared fluorescence endoscopy while performing SPE-SLNB. The near-infrared fluorescence endoscopy placed deep in the axillary enlarges the SLNs and directly visualizes the SLNs that emit strong fluorescence. This avoids the inability of detecting SLNs that can be hidden deep within skin and subcutaneous tissue during C-SLNB. Moreover, when performing other single-port endoscopic breast surgery, such as single-port endoscopic breast-conserving surgery, single-port endoscopic subcutaneous mastectomy, and single-port endoscopic breast reconstruction, it is advantageous to perform the SLNB through the single-port incision. By combining ICG and SPE-SLNB, we are able to reliably accomplish the axillary lymph node staging with the same single-port incision.

The mean number of SLNs detected in group A and group C (which were traced by ICG + CNs) was significantly more than that of group B (which was traced by CNs alone) ( $p < 0.05$ ). The mean number of SLNs detected between group A and group C was not statistically significant ( $p = 0.944$ ). This result shows that SPE-SLNB can detect as many SLNs as C-SLNB, indicating the reliability of this technique. According to previous studies [12–14], increasing the number of SLNs removed will lead to improved accuracy and a decreased false negative rate. When the detection number of SLNs reaches 3–4, the accuracy rate is stable at 95%, and the false negative rate is below 5%.

When comparing group A with group B, the result suggested that the use of ICG significantly increased the mean number of SLNs detected. This is likely due to the novel use of the near-infrared fluorescence endoscopy. The use of this tool allows the surgeon to directly visualize the SLN that is emitting the fluorescence. It is also important to note that ICG has a stronger affinity for the lymphatic system than CNs due to the molecular structure and diameter of ICG [15]. Another reason may be that the detection of CNs is *via* the naked eye, and interference caused by electric knife eschar and intraoperative bleeding would affect identification of CN-traced SLNs. In contrast, ICG is excited *via* the endoscopic fluorescence imaging system, which allows for the fluorescence to be easily detected. Moreover, in group A, five of the seven metastatic SLNs were ICG+/CN+, and 0 were ICG-/CN+. In group C, three of the six metastatic SLNs were ICG+/CN+, and 0 were ICG-/CN+. This indicates that ICG is a reliable tracer for metastatic SLNB. Importantly, two metastatic SLNs were ICG+/CN- in group A, and three metastatic SLNs were ICG+/CN- in group C. If ICG had not detected these metastatic SLNs, then the patients would have received false negative results.

Patients who receive axillary surgery may suffer from nerve injury and shoulder dysfunction as a result [16]. We observed that there were no statistically significant differences in pain or sensory loss between the three surgical groups at both timepoints. Another study reported that patients who received endoscopic-SLNB had less upper limb pain and anesthesia after surgery than patients who received conventional open SLNB [17]. This discrepancy may be due to the small sample size of this study.

However, this observation shows that SPE-SLNB and C-SLNB affect the upper limb in a similar way and thus displays the safety of this surgical technique.

## Conclusion

The novel combination of the single-port, the use of ICG, and the introduction of the near-infrared fluorescence endoscopy can achieve a satisfactory SLN detection rate while performing other endoscopic breast surgeries. We observed that the application of SPE-SLNB combined with ICG and CNs is as safe and efficacious as C-SLNB with the added benefit of reducing the number of missed SLNs and the subsequent false negative rate. Because this study was not a randomized study, some of the patient characteristics, such as the tumor size and laterality, were not even between the three groups. A randomized controlled trial with a larger sample size is needed to further confirm the benefits of SPE-SLNB combined with ICG and CN observed in this study.

## Abbreviations

CN

Carbon nanoparticles

C-SLNB

Conventional sentinel lymph node biopsy

ICG

Indocyanine green

PS

Pain score

SLN

Sentinel lymph node

SPE-SLNB

Single-port endoscopic sentinel lymph node biopsy

## Declarations

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**Conflicts of interest/Competing interests:** The authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

**Ethics approval:** This study was approved by the Ethics Committee of the Beijing Friendship Hospital, Capital Medical University (2019-P2-058-02) and were performed in line with the principles of the

Declaration of Helsinki.

**Consent to participate:** Written informed consent was obtained from all patients before surgery.

**Consent for publication:** Consent to publish was included in the informed consent details that was obtained from all patients before surgery.

**Availability of data and material:** Not applicable

**Code availability:** Not applicable

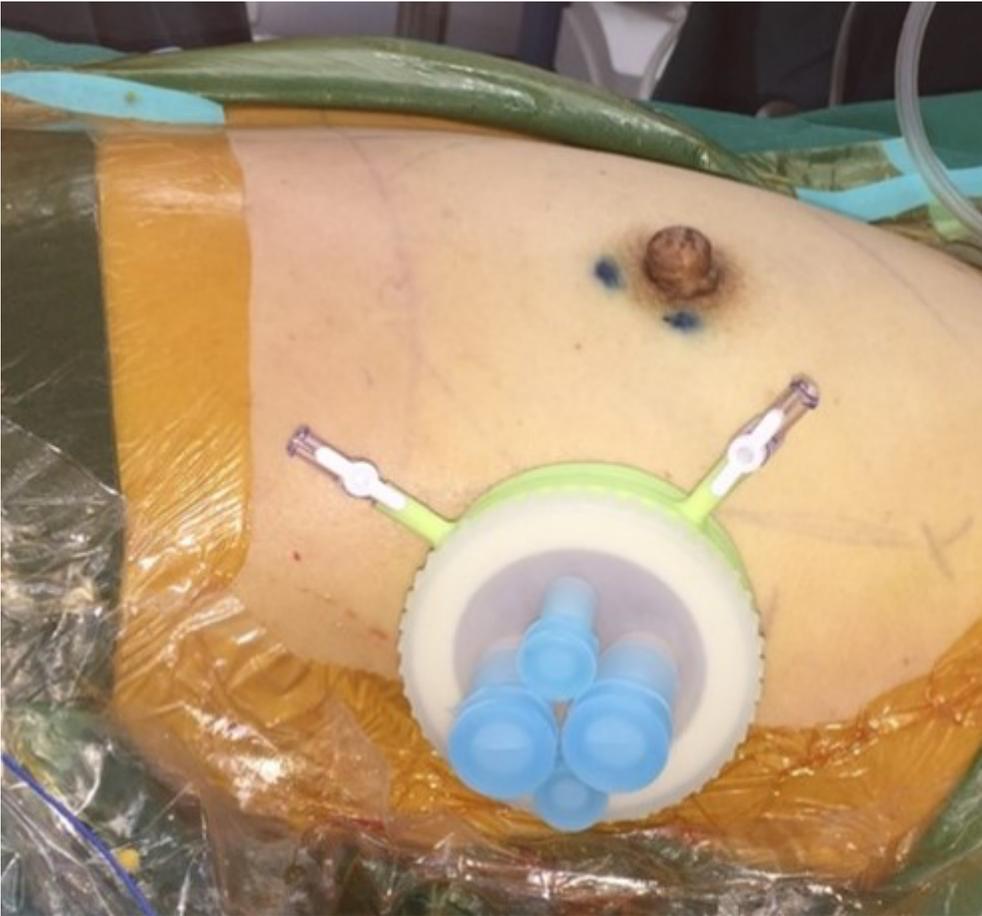
**Authors' contributions:** Zi-Han Wang and Tian-Ran Gang were responsible for manuscript writing. Xiang Qu and Zhong-Tao Zhang were responsible for concept and protocol development. Shan-Shan Wu was responsible for statistical analysis. Can Lu was responsible for the evaluation of arm function. Guo-Xuan Gao, Wei Xu, and Guo-Qian Ding were responsible for recruitment of study patients. All authors were responsible for final approval of the manuscript and are accountable for all aspects of the work.

## References

1. Jaroszewski DE, Ewais MM, Pockaj BA (2015) Thoracoscopy for Internal Mammary Node Dissection of Metastatic Breast Cancer. *J Laparoendosc Adv Surg Tech* 25:135–138. <https://doi.org/10.1089/lap.2014.0563>
2. Gringeri E, Boetto R, Bassi D et al (2014) Totally Laparoscopic Caudate Lobe Resection: Technical Aspects and Literature Review. *Surgical Laparoscopy Endoscopy Percutaneous Techniques* 1. <https://doi.org/10.1097/01.sle.0000442525.26905.6d>
3. Takahashi H, Fujii T, Nakagawa S et al (2014) Usefulness of endoscopic breast-conserving surgery for breast cancer. *Surg Today* 44:2037–2044. <https://doi.org/10.1007/s00595-013-0767-2>
4. Wang Z-H, Qu X, Teng C-S et al (2016) Preliminary results for treatment of early stage breast cancer with endoscopic subcutaneous mastectomy combined with endoscopic sentinel lymph node biopsy in China: E-SM + E-SLNB for Stage I/II Breast Cancer. *J Surg Oncol* 113:616–620. <https://doi.org/10.1002/jso.24199>
5. Zhang P, Luo Y, Deng J et al (2015) Endoscopic axillary lymphadenectomy combined with laparoscopically harvested pedicled omentum for immediate breast reconstruction. *Surg Endosc* 29:1376–1383. <https://doi.org/10.1007/s00464-014-3808-z>
6. Wang Z-H, Ng H-I, Teng C-S et al (2019) Outcomes of single-port gasless laparoscopic breast-conserving surgery for breast cancer: An observational study. *Breast J* 25:461–464. <https://doi.org/10.1111/tbj.13249>
7. Chung A, Gangi A, Mirocha J, Giuliano A (2015) Applicability of the ACOSOG Z0011 Criteria in Women with High-Risk Node-Positive Breast Cancer Undergoing Breast Conserving Surgery. *Ann Surg*

- Oncol 22:1128–1132. <https://doi.org/10.1245/s10434-014-4090-y>
8. Wishart GC, Loh S-W, Jones L, Benson JR (2012) A feasibility study (ICG-10) of indocyanine green (ICG) fluorescence mapping for sentinel lymph node detection in early breast cancer. *Eur J Surg Oncol* 38:651–656. <https://doi.org/10.1016/j.ejso.2012.05.007>
  9. Aoyama K, Kamio T, Ohchi T et al (2011) Sentinel lymph node biopsy for breast cancer patients using fluorescence navigation with indocyanine green. *World J Surg Onc* 9:157. <https://doi.org/10.1186/1477-7819-9-157>
  10. Kitai T, Inomoto T, Miwa M, Shikayama T (2005) Fluorescence navigation with indocyanine green for detecting sentinel lymph nodes in breast cancer. *Breast Cancer* 12:211–215. <https://doi.org/10.2325/jbcs.12.211>
  11. Guo J, Yang H, Wang S et al (2017) Comparison of sentinel lymph node biopsy guided by indocyanine green, blue dye, and their combination in breast cancer patients: a prospective cohort study. *World J Surg Onc* 15:196. <https://doi.org/10.1186/s12957-017-1264-7>
  12. Ban EJ, Lee JS, Koo JS et al (2011) How Many Sentinel Lymph Nodes Are Enough for Accurate Axillary Staging in T1-2 Breast Cancer? *J Breast Cancer* 14:296. <https://doi.org/10.4048/jbc.2011.14.4.296>
  13. Yi M, Meric-Bernstam F, Ross MI et al (2008) How many sentinel lymph nodes are enough during sentinel lymph node dissection for breast cancer? *Cancer* 113:30–37. <https://doi.org/10.1002/cncr.23514>
  14. Yang B, Zheng G, Zuo W et al (2013) [Analysis of clinicopathological factors associated with false-negative rate of sentinel lymph node biopsy in breast cancer patients: experience of a single center]. *Zhonghua Zhong Liu Za Zhi* 35:389–393. <https://doi.org/10.3760/cma.j.issn.0253-3766.2013.05.015>
  15. Hutteman M, Mieog JSD, van der Vorst JR et al (2011) Randomized, double-blind comparison of indocyanine green with or without albumin premixing for near-infrared fluorescence imaging of sentinel lymph nodes in breast cancer patients. *Breast Cancer Res Treat* 127:163–170. <https://doi.org/10.1007/s10549-011-1419-0>
  16. Manca G, Rubello D, Tardelli E et al (2016) Sentinel Lymph Node Biopsy in Breast Cancer: Indications, Contraindications, and Controversies. *Clin Nucl Med* 41:126–133. <https://doi.org/10.1097/RLU.0000000000000985>
  17. Bhandari A, Xia E, Wang Y et al (2019) Laparoscopy-assisted sentinel lymph node dissection in breast cancer patients. *Breast J* 25:172–174. <https://doi.org/10.1111/tbj.13172>

## Figures

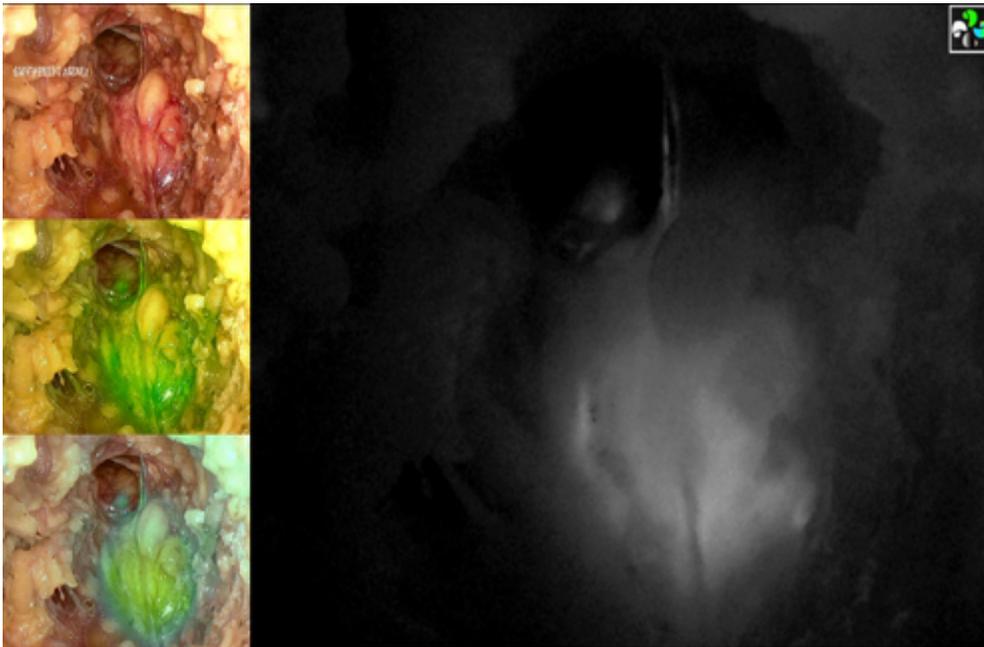


**Figure 1**

The single-port incision was created with the single-port insufflation kit. Indocyanine green and carbon nanoparticles were injected at the out and lower margins of the areola



**Figure 2**



**Figure 3**

Example of parallel display mode. The near-infrared fluorescence endoscopy can easily detect the fluorescence of the indocyanine green in the sentinel lymph nodes and the lymphatic vessels connected to them



**Figure 4**

The left and right lymph nodes were stained with both indocyanine green (fluorescence) and carbon nanoparticles (black stain). The middle lymph node was only stained with carbon nanoparticles