



Implication of indocyanine green angiography for chest wall perforator flap reconstruction in breast-conserving surgery

Sarun Thongvitokomarn[^], Sikrit Denariyakoon

Queen Sirikit Centre for Breast Cancer, King Chulalongkorn Memorial Hospital, Thai Red Cross Society, Faculty of Medicine, Chulalongkorn University, Bangkok, Thailand

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Correspondence to: Sarun Thongvitokomarn, MD. Queen Sirikit Centre for Breast Cancer, King Chulalongkorn Memorial Hospital, Thai Red Cross Society, Faculty of Medicine, Chulalongkorn University, 1873 Rama IV Rd., Pathum Wan, Bangkok, Thailand. Email: toph@hotmail.com.

Background: Volume replacement after breast-conserving surgery (BCS) can help achieve a good cosmetic outcome, especially in patients with small breast size, where volume displacement is limited. Latissimus dorsi myocutaneous flaps, which are widely used, require a longer hospital stay and have a risk of donor site morbidity. Chest wall perforator flap (CWPF) could be used as an alternative option. Although this has the advantage of a shorter hospital stay and muscle preservation, the dissection of perforator vessels is required. Using indocyanine green (ICG) intraoperatively can help the surgeon to visualize the perforators and assess the flap perfusion. Our study aimed to examine the roles of these techniques for CWPF reconstruction in BCS.

Methods: We retrospectively reviewed 22 patients who underwent CWPF reconstruction at the Queen Sirikit Centre for Breast Cancer, King Chulalongkorn Memorial Hospital from January 2023 to October 2024. Patients' baseline characteristics, types of CWPF, number of perforators identified by ICG and by direct visualization, complications, and perfusion time of ICG were reviewed.

Results: Eight patients had anterior intercostal artery perforator (AICAP) flap reconstruction. Thirteen patients had lateral intercostal arterial perforator (LICAP) flap reconstruction with or without lateral thoracic arterial perforator (LTAP) flap reconstruction. One patient had thoracodorsal arterial perforator (TDAP) reconstruction. The ICG was used in 21 flaps. ICG perfusion was completed within 2 minutes (range, 20–110 seconds). Most of the patients had two perforators identified by ICG. In 88% of cases, ICG perfusion of the perforator flap and adjacent normal tissue was visualized simultaneously. There was a difference in ICG perfusion onset time between flaps with one versus multiple perforators.

Conclusions: ICG angiography can be used intraoperatively for flap assessment with helpful information. A perfusion time of less than 2 minutes was correlated with a good clinical outcome. Intraoperative ICG angiography can guide surgeons in evaluating flap perfusion, which can help address both immediate and long-term morbidity concerns.

Keywords: Indocyanine green (ICG); oncoplastic; breast cancer; chest wall perforator flap (CWPF)

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[^] ORCID: 0000-0002-3519-3290.

Introduction

Breast cancer surgery is the main treatment for breast cancer patients with the disease localized to the breast without distant organ metastasis. Due to intensive screening mammography, the proportion of early-stage breast cancer has increased in recent years. (1-7). The main local treatment could be either breast-conserving surgery (BCS) or total mastectomy with the option of reconstruction. However, many studies have shown the benefits of BCS in many aspects (8,9). For patients with small breast size, it can be difficult in some circumstances to achieve a good cosmetic outcome from standard BCS. Oncoplastic surgery can play an important role in these cases. The current National Comprehensive Cancer Network (NCCN) guideline allows the use of oncoplastic surgery, including local flap reconstruction (10). This can extend BCS options and reduce the mastectomy rate. Additionally, using oncoplastic breast surgery (OPBS) techniques can allow wider local excisions while still achieving negative margins (11).

Chest wall perforator flap (CWPF) reconstruction is one of the options for volume replacement after BCS. This procedure is commonly considered when conventional BCS is not feasible, especially in patients with small or non-ptotic breasts. Results are very promising, with one study showing

that 92% of patients who underwent CWPF felt that the decision not to have a mastectomy was correct (12). A large prospective database review and one systematic review demonstrated that CWPF was safe, provided very good patient satisfaction, and had low complication rates (13,14). Recent data from the ANTHEM study also demonstrated the benefit of oncoplastic surgery in avoiding mastectomy, with a high patient satisfaction rate (15).

The details of the operation have been previously described in many studies (12,13,16-18). CWPFs can be used either as a single-stage procedure with wide local excision or as a delayed second-stage procedure. One study showed no differences in complication rates, aesthetic outcomes, or patient satisfaction (19). The delayed reconstruction technique can be applied to patients whose margin assessment is uncertain and requires thorough pathological review—especially those with lobular cancer, ductal carcinoma in situ (DCIS), multifocality, or post-neoadjuvant chemotherapy (20).

Vascular dissection and familiarity with vascular anatomy are key steps in this procedure. Due to the complexity of the technique, one study showed that 11% (5/45) of patients required reoperation due to surgical morbidity (21). In addition to perforator identification, intraoperative flap-perfusion imaging can visualize the tissue perfusion area and may help predict post-operative morbidity (22). Indocyanine green (ICG) angiography is one of the commonly used techniques in this setting, where perfusion duration and angiographic patterns have been studied in various types of flap reconstruction (23-28). However, no study has demonstrated the perfusion time of ICG or the outcomes related to ICG perfusion in CWPF. This study aimed to demonstrate the role of ICG angiography in CWPF for breast-conserving procedures. We present this article in accordance with the STROBE reporting checklist (available at <https://gs.amegroups.com/article/view/10.21037/gs-2025-160/rc>).

Methods

A retrospective study of CWPF reconstruction was conducted at the Queen Sirikit Centre for Breast Cancer, King Chulalongkorn Memorial Hospital, Bangkok, Thailand. All CWPF reconstructions performed between January 2023 and October 2024 were included, based on data from the operative record database. The study was approved by the institutional review board of the

Highlight box

Key findings

- An indocyanine green (ICG) angiography duration of less than 2 minutes correlates with favourable clinical outcomes, indicating its potential as a reliable intraoperative assessment tool.

What is known and what is new?

- Chest wall perforator flap (CWPF) reconstruction is one of the reconstructive options to increase the breast-conserving surgery rate, with good oncological outcomes and low postoperative complications. This procedure requires detailed surgical planning, including preoperative marking, precise tissue dissection, and understanding of perforator anatomy.
- ICG angiography—including start time, completion time, and the number of perforators—can be used intraoperatively for flap assessment, providing valuable information, especially for surgeons who are beginning to perform these procedures.

What is the implication, and what should change now?

- Information from ICG angiography in this study can be implemented in clinical practice as a marker for flap outcomes.
- Incorporating ICG angiography into CWPF procedures can enhance surgical precision and predict patient outcomes, and its use should be encouraged in clinical practice.

Faculty of Medicine, Chulalongkorn University, Bangkok, Thailand (No. 0902/67) and individual consent for this retrospective analysis was waived. This study was conducted in accordance with the Declaration of Helsinki and its subsequent amendments.

ICG angiography was performed after the flaps and perforators were dissected. A dose of 7.5 mg ICG (3 mL) was injected intravenously, and ICG angiography was recorded immediately after the injection. The dose of 7.5 mg ICG was based on previously reported studies in the literature (29,30). We used the FLUOBEAM® LM system for near-infrared (NIR) imaging. The video recording included the area of the flap, adjacent undissected tissues, and all perforators to determine the area of perfusion, number of perforators, and perfusion time. The video was recorded for at least 3 minutes in all cases. All recordings were reviewed by two surgeons, and data were documented in case record forms.

Statistical analysis

Patients' characteristics—including age, symptomatic/asymptomatic presentation, clinicopathological features, tumor focality, pre- and post-operative tumor size, size of the resection specimen, breast cancer subtypes, and types of systemic treatment—were reviewed and recorded.

Regarding CWPF reconstruction, data on the number of perforators, flap complications, ICG use for flap assessment, perforator type, and ICG perfusion time were collected. Surgical outcomes and complications were also recorded. Statistical analysis included mean, median, and range, as reported in tables. For comparisons between the two groups, Fisher's exact test and the *t*-test were analyzed using STATA software.

For sample size calculation, the aim of this study was to provide descriptive data on ICG perfusion time without hypothesis testing as the primary outcome. The sample size was limited due to the specificity of the surgical intervention. All participants included in this study were from a single centre. Based on a systematic review and meta-analysis, most studies recruited between 20 and 25 participants (28).

Results

Patients' characteristics

Twenty-two patients were identified and reviewed. One had bilateral CWPF. Of these, twenty presented with

symptomatic breast cancer, one had asymptomatic cancer, and one underwent surgery for correction of a deformity following BCS. Age ranged from 27 to 57 years. Four patients received neoadjuvant chemotherapy. Six patients had multifocal tumors. Resection specimen sizes (medial-lateral × superior-inferior) ranged from 38 mm × 30 mm to 70 mm × 130 mm. All four subtypes of breast cancer were included: 12 patients with estrogen receptor (ER)⁺/human epidermal growth factor receptor 2 (HER2)⁻, two with ER⁺/HER2⁺, two with ER⁻/HER2⁺, and four with ER⁻/HER2⁻. Seven patients underwent CWPF as a second-stage procedure. All patient characteristics are reported in *Table 1*.

Operative details and outcomes

Preoperatively, Doppler ultrasound was used to mark the perforators in all patients. The lateral CWPF was designed with the patient lying on their side. Tumors or resection margins were located using either skin marking or wire-guided techniques. If sentinel node biopsy was required, a dual technique (ICG and blue dye) was performed.

Intraoperatively, the patient was positioned on their side for lateral intercostal arterial perforator (LICAP)/lateral thoracic arterial perforator (LTAP) or thoracodorsal arterial perforator (TDAP) reconstruction, and in the supine position for anterior intercostal artery perforator (AICAP) flap reconstruction. For CWPF dissection, the perforators were identified by direct visualization without the use of ICG (*Figure 1*). Then, 7.5 mg of ICG was injected intravenously. The number of perforators identified with ICG was counted and recorded using the NIR imaging system. Additionally, the time from ICG injection to the first visible ICG perfusion in the flap was recorded as the start time (*Figure 2*). We recorded ICG perfusion for 3 minutes, following techniques described in previous studies (22). However, if perfusion was delayed, recording continued until full perfusion was observed or until 5 minutes had elapsed. The time at which full perfusion was achieved was recorded as the completion time.

ICG perfusion and flap assessment

Regarding ICG perfusion and CWPF reconstruction (*Table 2*), eight patients underwent AICAP flap reconstruction. Another thirteen patients had LICAP flap reconstruction (including one patient with bilateral LICAPs), and one had a TDAP flap reconstruction. ICG was used in 21 flaps (20 patients). None had postoperative complications

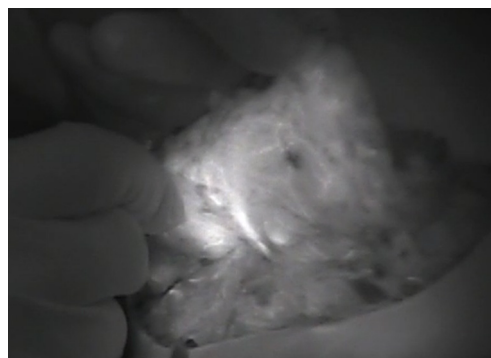
Table 1 Patients' characteristics

Characteristics	Values
All patients	22 patients (23 breasts)
Age (years)	27–57
Presentation	
Symptomatic	20
Asymptomatic	1
Correction deformity	1
Pre-operative diagnosis	
Invasive cancer	19
DCIS/ <i>in-situ</i> lesion	1
Lymphoma	1
Benign	1
Systemic treatment	
Neoadjuvant treatment	4
Tumor foci	
Single	15
Multiple	6
Tumor size (mm)	
Preoperative	14–90
Postoperative	15–83
Resection specimen (mm × mm)	38×30–70×130
Subtype	
ER ⁺ /HER2 ⁻	12
ER ⁺ /HER2 ⁺	2
ER ⁻ /HER2 ⁺	2
ER ⁻ /HER2 ⁻	4
Two-stage approach	7

Values are presented as number or range. DCIS, ductal carcinoma in situ; ER, estrogen receptor; HER2, human epidermal growth factor receptor 2.

requiring further surgery. ICG perfusion of all flaps was completed within 20 to 110 seconds. Most patients had two perforators identified by ICG.

Among seventeen patients whose video clips of ICG perfusion were reviewed, the mean start and completion times were 37 and 69 seconds, respectively. There was a significant difference in start time between the single perforator group and the multiple perforator group

**Figure 1** Perforator identified intraoperatively.**Figure 2** Perforator identified from ICG. ICG, indocyanine green.

($P=0.01$). A significant difference was also observed in completion time ($P=0.008$) (Table 3).

We also reviewed the perfusion of the flap compared to the adjacent tissue. In fifteen out of seventeen flaps, ICG perfusion in the flap and the adjacent undissected normal tissue began at the same time. The concordance rate for simultaneous ICG perfusion onset in the flap and adjacent undissected tissue was 88%. No statistical difference was observed between the single perforator group and the multiple perforator group ($P>0.99$) (Figure 3, Table 3).

Discussion

The intraoperative flap assessment is one of the important steps in CWPF reconstruction (28). Among experienced surgeons, direct visual inspection remains the primary method of evaluation; however, radiological tools have

been developed to aid in perforator visualization. Doppler ultrasound is one of the convenient methods for identifying perforators preoperatively, but intraoperative assessment is very limited due to the magnitude of flap dimension and the sensitivity of flow detectors (31). Intraoperative angiography has been used for decades, but contrast media and radiation exposure are the limitations. These disadvantages can be overcome with the use of ICG angiography. Two systematic reviews demonstrated the popularity and the benefit of this technique (28,32).

ICG perfusion time has been reported in many studies

Table 2 Perforators of CWPF reconstruction

Characteristics	Values
ICG use for flap assessment	21 flaps
Number of perforators identified	1–3 (mode 2)
1 perforator	2
2 perforators	18
3 perforators	1
Flap complication	0
Perforator type	
AICAP	8
LICAP/LTAP	13
TDAP	1
Perfusion time (s)	20–110
Start time after injection	37 [17–79]
Completed time	69 [35–130]

Values are presented as number, range, or mean [range]. AICAP, anterior intercostal artery perforator; CWPF, chest wall perforator flap; ICG, indocyanine green; LICAP, lateral intercostal arterial perforator; LTAP, lateral thoracic arterial perforator; TDAP, thoracodorsal arterial perforator.

Table 3 Comparison between one perforator and multiple perforators group

Characteristics	All	Single perforator	Multiple perforator	P value
Start time (s) [†] , mean [SD]	37 [19]	22 [2]	39 [19]	0.01
Completed time (s) [†] , mean [SD]	69 [30]	47 [17]	72 [31]	0.008
Concordance/discordance [‡] , n [%]				>0.99
Concordance	15 [88]	2 [100]	13 [87]	
Discordance	2 [12]	0 [0]	2 [13]	

[†], t-test; [‡], Fisher's exact test. n, number of flaps; SD, standard deviation.

assessing various types of flaps and procedures, such as mastectomy flaps, deep inferior epigastric perforator flap, and transverse rectus abdominis muscle (TRAM) flaps. However, none of these studies specifically reported perfusion times in CWPF (23–28). One study demonstrated that the perfused area less than 33% could be a factor of flap necrosis (33). Regarding the CWPF procedure, one study included patients underwent ICG angiography for flap assessment (21). Another recent study demonstrated safe outcome using ICG for flap assessment in 200 patients who received CWPF reconstruction (34). However, neither study reported ICG perfusion time in CWPFs. To the best of our knowledge, our study is the first to report perfusion times in CWPF reconstruction.

In this study, we used a single shot of ICG angiography to identify the number of pedicles and examine tissue perfusion time. This procedure was simple and compatible for use with ICG in sentinel node biopsy as a consecutive procedure (34). Among the patients who had ICG perfusion time recorded, all the perfusions were completed within



Figure 3 An early ICG perfusion of the flap (red arrow) and adjacent normal tissue (white arrow). ICG, indocyanine green.

2 minutes. We also monitored the perfusion of the flap in comparison with the adjacent undissected normal tissue. The perfusion of the flap and normal tissue mostly began at the same time. We believe that if perfusion occurs in this manner and is completed within 2 minutes, the flap is well perfused and viable. ICG angiography could assist less experienced surgeons in performing this CWPF flap and aid in planning for postoperative management.

The specimen sizes in this study were relatively large, ranging from 38 mm × 30 mm to 70 mm × 130 mm. This suggests that most patients were borderline candidates between OPBS and mastectomy. Eight patients underwent CWPF as a second-stage surgery, allowing for margin assessment prior to the second operation. Although mastectomy with reconstruction could have been a viable alternative for this group, BCS offers benefits beyond cosmetic outcomes. Increasing evidence demonstrates a survival benefit of BCS over mastectomy (35-37). Regarding post-operative outcome, one study compared outcomes between volume replacement using CWPF, volume displacement, and total mastectomy with reconstruction. It showed that the mean tumor size in the volume replacement group was not significantly different from that in the mastectomy group. However, the volume replacement group had significantly lower morbidity compared to the mastectomy with reconstruction group (18).

There were limitations in this study. First, the descriptive design of the study did not directly correlate with the surgical outcome. Further trials using ICG as the intervention are needed to emphasize the benefits of ICG angiography. Secondly, the perfusion times in ICG angiography were based on the surgeons' direct observation. Using ICG angiography did not directly affect the surgical outcome. Preoperative planning and intraoperative meticulous surgical skills are still the most important factors determining the success of this surgical procedure.

Conclusions

ICG angiography can be used intraoperatively to assess CWPFs, providing valuable information such as perfusion start time, completion time, and the number of perforators. A completed perfusion time within 2 minutes has been correlated with good clinical outcomes. Delayed perfusion may alert surgeons to potential concerns and raise clinical suspicion.

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Footnote

Reporting Checklist: The authors have completed the STROBE reporting checklist. Available at <https://gs.amegroups.com/article/view/10.21037/gc-2025-160/rc>

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Ethical Statement: The authors are accountable for all aspects of the work in ensuring that questions related to the accuracy or integrity of any part of the work are appropriately investigated and resolved. The study was approved by the institutional review board of the Faculty of Medicine, Chulalongkorn University, Bangkok, Thailand (No. 0902/67) and individual consent for this retrospective analysis was waived. This study was conducted in accordance with the Declaration of Helsinki and its subsequent amendments.

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