

Standardized Skin Flap Warming Effectively Improves Flap Survival without Obstructing Temperature Monitoring after DIEP

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Objective: This study aimed to determine whether skin flap warming after an operation interferes with temperature monitoring. The postoperative nursing workflow of subabdominal deep inferior epigastric artery perforator (DIEP) flap breast reconstruction was optimized.

Methods: A retrospective analysis involving 69 patients who received one-stage breast reconstruction at the Huashan Hospital from July 2017 to December 2019 was performed. The postoperative physical care of patients, including flap temperature monitoring and flap warming, was reviewed.

Results: All patients had successful operations. After surgery, all flaps were warmed following the standard protocol. Abnormal temperature and compromised circulation of flaps were observed in three of the patients. These patients received re-exploration surgery and all three flaps survived. A postoperative follow-up shows a high level of patient satisfaction in most cases.

Conclusions: The appropriate warming of transplanted flaps did not interfere with temperature monitoring. This helped determine whether there was compromised circulation, leading to increased skin flap survival and improved patient satisfaction. (*Plast Reconstr Surg Glob Open* 2022;10:e4153; doi: [10.1097/GOX.0000000000004153](https://doi.org/10.1097/GOX.0000000000004153); Published online 28 February 2022.)

INTRODUCTION

Breast cancer, a common malignant tumor in women, has an incidence rate of 7%–10% and accounts for the highest cancer incidence in Chinese women.^{1,2} Breast cancer treatments include surgery, chemotherapy, radiation, and hormonal therapies.³ With the development of novel medical technology, the survival of breast cancer patients has significantly increased. Besides long-term survival, patients also require a better quality of life, including breast reconstruction to remedy surgical imperfections.⁴ Therefore, immediate breast reconstruction is now the most cutting-edge surgical treatment for

breast surgery.⁵ Compared with other immediate breast reconstruction procedures, such as prosthesis implantation and autologous transplantation, a subabdominal deep inferior epigastric artery perforator (DIEP) flap results in less damage to the donor site, better conceals scars,⁶ exhibits greater tissue similarity, and results in a higher survival rate, making it a first choice in breast reconstruction surgery.^{7–9} However, this procedure faces technical challenges, such as flap anastomosis. It is important to closely monitor the circulation of the flap after the operation to prevent reconstruction operation failure caused by poor circulation related to necrosis.¹⁰ Temperature monitoring is used to check flap circulation.^{11,12} At the same time, appropriate warming care is needed to prevent vasospasm-induced compromised circulation. However, there is no consensus on whether warm protection affects flap temperature readings and interferes with temperature monitoring. In this study, we proposed a standard workflow, placing emphasis on temperature monitoring and warm protection of the skin flap after a DIEP operation. This was shown to effectively improve flap survival rate and patient satisfaction.

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MATERIALS AND METHODS

Temperature Measurements

An infrared electronic thermometer (Cofee, HTD8818D, Hunan, China) was used to take temperature measurements. This thermometer was routinely calibrated before use and adopted to its body temperature mode to avoid possible system errors. For each measurement, the thermometer was held at a vertical distance of 1 cm from the measured object, and measurements were taken three times for an average value. The initial temperature of transplanted flaps and the normal breast were recorded as soon as patients who received breast reconstruction surgery were returned to the ward. In the first 24 hours after surgery, temperature was measured every hour. Monitoring intervals were extended to 2 hours after 24 hours. After 72 hours, the temperature record was updated every 12 hours.

Flap Warming

The warming lamp used in this study is a homemade warming tool shown in [Figure 1](#). The main body contained a 40-watt incandescent lamp with a reflector, and the outer circle was shielded with two layers of blue nonwoven fabric to reduce external light emission and enhance local warmth. The warming lamp vertically irradiates 40 cm from the flap. In the early stage of patient recovery, the warming lamp temporarily stops working only for 5 minutes before measuring the temperature.

Patient Data

A retrospective analysis of 69 patients who received immediate breast reconstruction after a mastectomy



Fig. 1. Warming lamp.

Takeaways

Question: Postoperative nursing for improving the survival rate of skin flaps after DIEP.

Findings: Clinical practice, combined with verification experiments, confirmed that the use of postoperative warming lamps can effectively prevent vasospasm and improve the survival rate of skin flaps.

Meaning: An affordable and feasible method had been proposed to help the transplanted flap recovery after the operation. This method can prevent anastomotic vasospasm, thereby avoiding flap necrosis caused by blood flow disorder without hindering temperature monitoring.

combined with a deep inferior artery perforating flap (DIEP) was conducted. These surgeries were performed at our center from July 2017 to December 2019. Detailed information for these patients is listed in [Table 1](#). All patients were women between the ages of 24 and 66 years (median age = 43 years). Preoperative biopsies confirmed invasive breast carcinoma or ductal carcinoma in situ. These cases were either not suitable for breast conserving surgery or refused surgery. All patients had a strong desire to accept autologous breast reconstruction, and their physical conditions and donor areas met surgery requirements. The internal mammary artery or internal mammary artery perforator were isolated as recipient vessels.^{13,14} Surgery in the abdomen was performed according to routine DIEP breast reconstruction surgery methods.¹⁵ Informed consent, follow-up data, and clinical data were obtained. Temperature monitoring and flap warming started when patients returned to the ward after surgery.

Volunteer Information

The volunteer group included 10 healthy women with a median age of 42 years (ranging from 28 to 60 years). No breast-related diseases were reported in these volunteers before they were enrolled. All subjects denied sensitive skin or a history of mastitis. Left side of each volunteer's breast was selected for the experimental group. The special warming lamp was used for partial flap warming. The temperature of bilateral breasts was recorded in different situations, and temperature differences were noted. Temperatures were measured every hour, resulting

Table 1. Patient Information

	Overall
Total no. patients	69
Age, mean (SD)	42.4 (6.7)
Median	43
Range	24–66
BMI, mean (SD)	23.5 (2.3)
Smoking	5 (7.2%)
Anticoagulant drugs	0 (0%)
Previous breast surgery	2 (2.9%)
Diabetes	4 (5.8%)
Hypertension	8 (11.6%)
Chemotherapy per patient	41 (59.4%)
Preoperative	8 (11.6%)
Postoperative	33 (47.8%)

All values are n (%) unless otherwise specified.

in a total of six measurements. These experiments were approved by the ethics committee of Huashan Hospital (approval number: HS-KY-2019-1222).

Simulation of the In Vitro Flap and Heating Preservation

Six same-sized pieces of swine abdominal skin flaps were placed at room temperature (22°C), and the warming lamp was used to simulate the heating preservation process. Temperature was measured every hour.

RESULTS

Flap Warming Effectively Improved the Survival Rate of DIEP Flaps

This study retrospectively analyzed clinical data for 69 breast cancer patients who received DIEP breast reconstruction from 2017 to 2019. Flap temperature monitoring and warm up procedures began as soon as patients returned to the ward after surgery. The warming lamp was placed at the surgical side near the bed. Next, skin temperatures of each patient's bilateral breasts were recorded as the starting point. Then, the warming lamp was turned on and maintained at a vertical distance of 40 cm from the skin flap for irradiation and heat preservation. The flap warming measurements continued for 7 days after surgery. It is worth noting that the warming lamp should be turned off for 5 minutes before temperature recordings to avoid reading errors. Among 69 breast reconstruction patients, three patients developed compromised circulation during hospitalization. Seven hours after surgery, the skin temperature of one patient was observed to decline 4°C. The skin flap was pale in color and exhibited poor capillary filling. Another patient showed vascular complications 18 hours postoperation. The temperature of the skin flap dropped to 31.2°C. The third case showed dropped temperature 4 days after the operation, where the skin temperature dropped to 32°C and the color of the flap appeared purple-red when the patient left her bed without medical permission. The skin temperature of the transplanted flaps measured 2°C lower than the healthy side for all three cases where complications were observed. Timely surgeries were performed as soon as abnormal temperature drops were reported. Finally, the transplanted skin flaps in the three patients who initially experienced complications were successfully saved. The remaining 66 patients recovered smoothly after surgery, where the temperature curve of the skin flap was normal, there was no redness, swelling, fever, or pain, and the skin appeared normal and soft. At 1–3 years of follow-up, all flaps survived and showed good aesthetic effects. All patients were highly satisfied. This result showed that our self-made warming lamp effectively kept skin flaps warm after surgery and prevented postoperative small blood vessel spasms, thus maximizing the survival of the skin flaps. On the other hand, the timely discovery of the three patients with blood flow disorders confirmed that our warming measures did not hinder temperature monitoring. The temperature of the flaps that have compromised circulation do not rise to normal levels even though they

are continuously being warmed. Therefore, standardized heat preservation measures are conducive to promoting the vascular circulation of transplanted skin flaps and the recovery of patients who receive breast reconstruction surgery.

Warming Lamps Did Not Damage the Skin

Ten healthy volunteers were enrolled for breast flap warming experiments to see if the warming lamp burned the skin. For each volunteer, the left breast was chosen to simulate the DIEP flap, whereas the right breast was used as the control. The vertical irradiation range was surrounded by the clavicle and costal arch, and the horizontal range was surrounded by the midline of the sternum and the anterior axillary line. The initial temperatures of the breast skin on the left side and the right side of the volunteers were (35.3±0.5)°C and (35.5±0.6)°C, respectively. Subsequently, the warming lamp was used to keep the left breast warm for 4 hours. The warming lamp was set at a vertical distance of 40 cm from the skin. During this period, the flap temperature was monitored every hour. Irradiation was paused for 5 minutes before recording the temperature. All volunteers completed the experiment and did not show redness, swelling, itching, or breaks in the skin at the irradiated portion of the flap. Flap temperature records are shown in Figure 2. These results indicated that the warming lamp effectively kept the breast warm without causing skin damage to the irradiated area.

Simulation of Isolated Flaps Confirmed that the Warming Lamp Did Not Heat Necrotic Flaps

Fresh isolated swine abdominal flaps were used to simulate the necrosis process of the flap. Six equal-sized swine abdominal skin flaps were randomly divided into two groups. Both groups were placed at room temperature (22°C). The experimental group was continuously irradiated with warming lamps for 4 hours, whereas no special treatment was performed for the control group. The purpose of the experiment was to determine whether the warming lamp heated the skin flap that already lost blood. The temperature curves are shown in Figure 3. Results showed that the isolated skin flap had a short-term rise in temperature during the warming lamp process. The highest temperature achieved was 20.4°C, which was still far

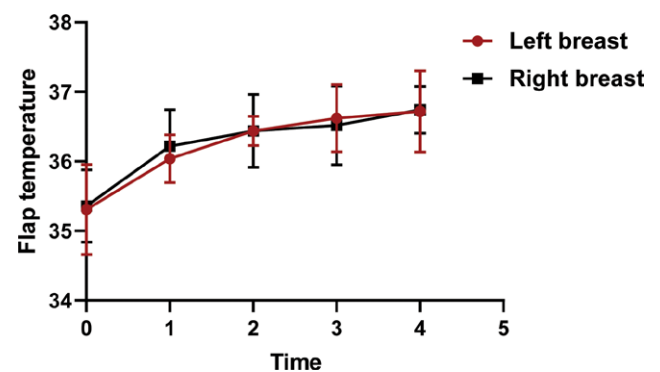


Fig. 2. Volunteers' breast flap temperature.

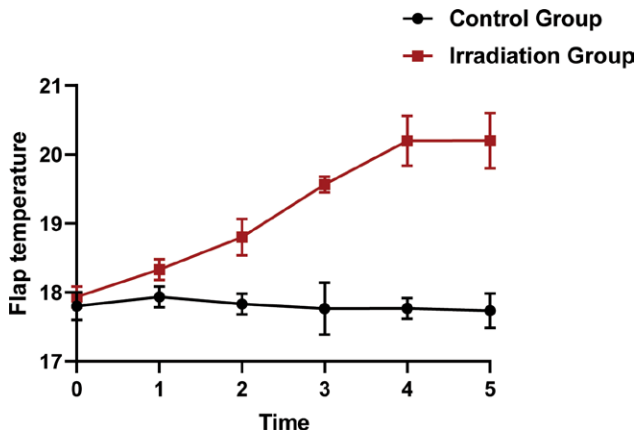


Fig. 3. Simulated in vitro flap temperature.

from the monitored body temperature range. Thus, we concluded that the local heat preservation by the warming lamp did not interfere with temperature monitoring and will not affect the interpretation of skin temperature changes caused by vascular crisis.

DISCUSSION

DIEP breast reconstruction has proven to be both safe and reliable. The shape and texture of the flaps are close to real breast tissue and the operation protects the abdominal donor area. These unique advantages make DIEP breast reconstruction more favorable by both doctors and patients. This procedure is also the first choice for breast reconstruction surgery at our center. This successful operation shows an accurate preoperative assessment, delicate intraoperative operation, and careful postoperative care. Necrosis of the transplanted skin flap is one of the most serious complications of DIEP breast reconstruction surgery.¹⁶ Partial necrosis of the skin flap may lead to local inflammation of the breast, unsightly appearance, and palpable lumps.¹⁷ The reported fat necrosis rate of the DIEP flap is 12%–45%,¹⁸ and the blood circulation of the flap is a key factor for its survival. This not only depends on accurate suturing of blood vessels during operation, but also depends on careful flap nursing after operation.

In this study, we used the modified warming lamp to prevent compromised circulation of the postoperative reconstruction area. Only three of the 69 patients showed vascular disorders, with an incidence of only 4.3%, which was lower than reported in other studies. The strict temperature-monitoring program presented here was able to quickly detect abnormalities of the transplanted flaps and allow for appropriate symptomatic treatment to successfully rescue the flaps. This resulted in a 100% flap survival rate in our study. These results suggest that scientific and standardized skin flap warming effectively prevents vasospasms. This also reflects that our heat preservation measures will not interfere with temperature monitoring, and the temperatures of skin flaps that lost blood supply will no longer increase despite continued heating by the warming lamp.

Since the DIEP operation was proposed, the perioperative nursing measures have also been improving. However, there is still no consensus on a standard workflow. Over the past few decades, many groups developed optimal methodology to monitor and protect transplanted flaps.^{19,20} The laser Doppler and laser speckle imaging techniques noninvasively map perfusion dynamics.^{21,22} Disadvantages, such as their large size and pricing, make it difficult to use these technologies. Thus, measuring skin flap temperature is still a basic protocol used after DIEP surgeries due to affordable pricing, convenience, and timeliness. Before this study, some used a hot water bag to keep the local transplanted flaps warm, but this method has a risk of causing burns and compression. Since transplanted DIEP flaps do not have peripheral nerves compared with normal skin,²³ the cold and warm sensations were lost.²⁴ During this period, the hot water bag may cause local skin burns that can become severe since patients cannot feel the heat. On the other hand, the weight of the hot water bag will locally pressurize the skin flap, causing a risk of poor circulation. The warming lamp irradiation method avoids these risks. Experiments analyzing healthy volunteers confirmed that standard warming lamp radiation does not damage irradiated skin, providing a theoretical basis for clinical practice.

CONCLUSIONS

Here, we proposed an affordable and feasible method that helps the recovery of a transplanted flap after DIEP breast reconstruction surgery. We also uncovered the paradox between flap warming and temperature checking, proving that this method prevents anastomotic vasospasm and thereby avoiding flap necrosis caused by blood flow disorders without hindering the monitoring of temperature.

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