European Journal of Plastic Surgery (2019) 42:29–32
https://doi.org/10.1007/s00238-018-1456-6

ORIGINAL PAPER

Decision between contralateral and ipsilateral DIEP flap harvesting for unilateral breast reconstruction

Albert L. Niepel[1] · Schauer Dominik[2] · Magdalena Lewicki[1] · Sokullu Fuat[1] · Kreuzwirt Gerhard[1] · Primas Helga[1] · Hellekes Dirk[1] · Fercan Kömürcü[1]

Received: 28 March 2018 / Accepted: 15 August 2018 / Published online: 27 August 2018

Abstract

Background Deep inferior epigastric artery perforator flap (DIEP/DIEAP) procedure is a common method for breast reconstruction after mastectomy. For unilateral breast reconstruction, harvesting of the flap can be done contralaterally or ipsilaterally. The aim of this study is to demonstrate a possible side difference in quality of abdominal skin perfusion from left to right and its causes, which could have implications on our selection of flap harvesting side, operating time, and flap design itself.

Methods We performed thermographic imaging after induced hypothermia of the abdominal skin in 17 females to evaluate the quality of blood supply to each side of the abdominal wall. Additionally, we examined the diameter of the deep inferior epigastric artery, whether there is a difference in size correlating to the quality of blood supply of each side. Evaluation of our pre-operative thermographic imaging method was performed in four patients which underwent unilateral DIEP flap reconstruction regarding reduction of surgery time and assessment of overall outcome.

Results Every subject showed a dominant side of perfusion (greater area of perfusion after set time). Furthermore, we discovered a side difference between left and right diameter of the deep inferior epigastric artery in each patient (0.2-mm mean difference; $p = 0.0002$). The rewarming process of the abdominal skin was faster (16 out of 17 subjects; 94.1%) (greater area of rewarming after set time) on the side with the greater diameter deep inferior epigastric artery. In our DIEP patients using thermographic imaging of the abdominal skin, we only performed perforator dissection on the preferable side. The consequence was a reduction in operating time of 25 minutes compared to careful dissection of both sides. None of our patients showed complications such as wound-healing disorders.

Conclusions Thermographic assessment of the abdominal skin after hypothermia is easy to conduct and gives reproducible information about different areas of skin perfusion quality. The difference in rewarming speed from left to right is thought to be due to a larger diameter deep inferior epigastric artery, which translates into a superior perfusion, but does not necessarily correlate with the size of the perforators itself. The presented technique offers the potential to improve outcome, especially by lowering perfusion-related complications and reducing operation time by fast dissection of the non-dominant side while carefully dissecting the area of interest with fast thermographic rewarming results, and must therefore be investigated in future studies by measuring objective outcome results.

Level of Evidence: Level III, risk/prognostic

Keywords DIEP · Perforators · Flap · Breast · Reconstruction

Introduction

Deep inferior epigastric artery perforator flap (DIEP) procedure is a common method for breast reconstruction after mastectomy. Its blood supply to the DIEP flap is well known to arise from the perforating vessels of the deep inferior epigastric artery through the rectus muscle. A single large-diameter perforator is sufficient to supply the whole flap [1]. For unilateral breast reconstruction, harvesting of the flap can be done contralaterally or ipsilaterally. There are several considerations

✉ Albert L. Niepel
albertlaurenz.niepel@gmail.com

[1] Department for Plastic and Reconstructive Surgery, Rudolf Foundation Hospital, Vienna, Austria

[2] Departement for Radiology, Rudolf Foundation Hospital, Vienna, Austria

which can influence the choice of harvesting side like flap design, presence of scars from previous operations, surgeon's personal preference of technique, or evaluation of perforator quality pre- or intra-operatively. The overall goal for a successful procedure is to ensure the best possible blood supply and perfusion to the flap to decrease complications like partial flap necrosis [2]. One of the most important parts is pre-operative planning with imaging of the perforating vessels. Additional knowledge of the quality of skin perfusion through its supplying perforating vessels could change the design from ipsilateral to contralateral or the other way around.

In the last decade, several new hardware and especially software applications like perforator computed tomography angiography (P-CTA) (in combination with software like Osirix (Pixmeo, Geneva, Switzerland) and Siemens Syngo InSpace 4D (Siemens, Erlangen, Germany)) or laser-assisted indocyanine green fluorescence angiography help to get more precise imaging of perforating vessels [3–9].

Dynamic infrared thermography (DIRT) offers a comparatively cheap and effortless way to display the quality of blood supply to the abdominal skin [10–12]. Cameras, such as the FLIR ONE (FLIR, USA) infrared camera, can be purchased at low cost (purchase price for this study 250 USD) and be operated with nearly every modern smart phone of today (Android or iOS based). De Weerd et al. showed the benefit of using a DIRT perforator mapping prior to DIEP flap surgery [13]. It can be used for pre-operative planning, intra-operative perfusion evaluation, and post-operative flap monitoring [11]. Additionally, with prior induced hypothermia (e.g., coolpack), the rewarming process of reperfusion can be displayed (Fig. 1).

Most pre-operative methods aim to find the perforator with the largest diameter, which is usually chosen for flap harvesting. What is less considered is the quality of subcutaneous and cutaneous plexus which distribute the blood flow to every angle of the flap. The authors believe that the best possible perforator is a perforator large in diameter in combination with a high-quality network of vessels inside the flap itself. Since

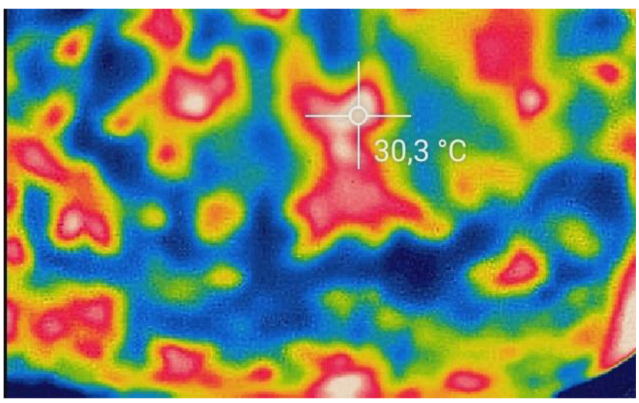

Fig. 1 Thermographic imaging of the emerging hot spots after removing the cooling medium from abdominal wall

DIEP flap harvesting for unilateral breast reconstruction can be done ipsilateral or contralateral, side differences in perfusion quality should be considered. Burns-Brown et al. demonstrated a side difference in diameter of the inferior epigastric artery which had implications on the harvesting side for coronary artery bypass grafting [14]. This anatomical variance in diameter could be responsible for a superior blood supply to the abdominal skin either on the right or the left side of the patient. Identifying the superior side regarding overall blood supply in combination with identifying areas with optimal and low perfusion quality (perforasomes) could help choosing the highest-quality perforator with a superior network of small vessels and therefore decreasing perfusion-based complications.

The aim of this study is to demonstrate a possible side difference in quality of abdominal skin perfusion from left to right which we hypothesize could have implications on preselecting of perforator dissection side and therefore reduce operating time and improve overall outcome like partial flap necrosis rate.

Methods and materials

We assessed the quality of blood supply to the abdominal skin through thermographic imaging after induced hypothermia in 17 healthy female subjects ranging from 18 to 60 years of age. Additional ultrasonographic assessment of the deep inferior epigastric artery was performed to correlate anatomical variances to differences in quality of blood supply from left to right. All subjects were enrolled into study through public invitation to participate. Due to limited availability of the sonographic device, we could only include 17 subjects.

For induced hypothermia, a 21 × 38-cm coolpack (Alerion, Essen, Germany), kept at 4 °C for > 24 h, was applied for 10 seconds to the lower abdominal region. The room temperature during examination was being kept constant at 22 °C for every subject. Immediately next to removing the cooling medium, thermographic imaging was done using the FLIR ONE camera (Software version for Android 2.1.27, FLIR® Systems, Inc., Oregon, USA) attached to a Samsung Galaxy S6 Smartphone, used as output monitor (Samsung, Seoul, South Korea). The overall process of rewarming was documented by taking still pictures with the thermographic camera every 5 seconds. Reevaluation of the rewarming process for each site of the abdominal wall was done after examination to address any differences in rewarming speed (more rapid temperature change).

After thermographic imaging, ultrasonographic examination of the abdominal wall was performed to assess the inner diameter (mm) of both deep inferior epigastric arteries at the point of first dorsal alignment to the rectus muscle using a 18L6HD 18-MHz high-frequency probe (Siemens, Berlin,

Germany). The inner diameter was measured in a longitudinal section plane. Mean values were averaged from three consecutive measurements.

Statistics were done using SPSS (©IBM, Armonk, USA) using paired t tests (two tailed, $p = 0.05$) and descriptive statistics.

After the conduction of our 17 test subjects, we evaluated our method with four patients enrolling into unilateral DIEP flap reconstruction. Intra-operative surgery time was evaluated and compared to our previous surgery times without our pre-operative thermographic imaging. Patient follow-up was done over a period of 6 months to record possible complications like wound-healing disorders.

This study was approved by the local ethics committee (EK-17-148-0817).

Results

Our 17 test subjects had a mean age of 33.5 years. To limit the impact of bias, we only included healthy, non-smoking subjects, with no history of daily medication, diseases, or prior abdominal surgery.

Every subject showed a dominant side of perfusion (greater area of perfusion after set time). Areas of lower blood perfusion were easy to differentiate (blue) from areas with superior perfusion (red; fast rewarming) (Fig. 2).

Furthermore, we discovered a side difference between left and right diameter of the deep inferior epigastric artery in each patient (0.2-mm mean difference; $p = 0.0002$). Mean diameter of the deep inferior epigastric artery was 2.1 mm with a minimum of 1.3 mm and the largest one with 2.8 mm (Fig. 3).

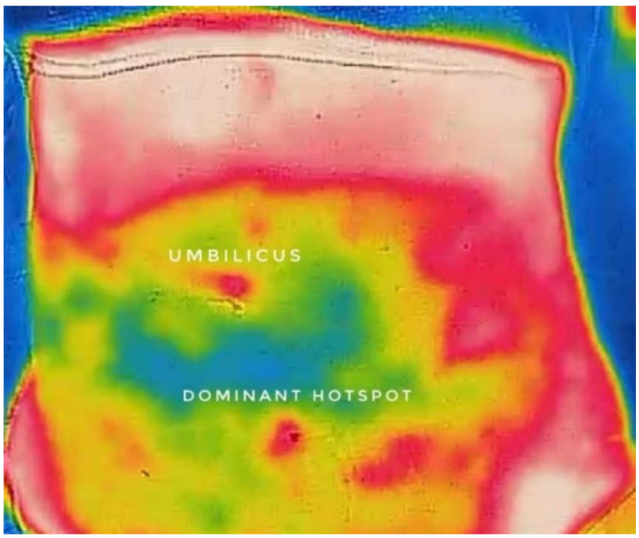

Fig. 2 Rewarming process 30 seconds after removing the cooling medium. A clear hot spot emerges over the left rectus muscle, whereas the blood supply to the right side is remarkable weaker. The image belongs to a DIEP patient which underwent complication-free DIEP flap breast reconstruction with two strong perforators in the nearby area of the hot spot

The rewarming process of the abdominal skin was faster (16 out of 17 subjects; 94.1%) (greater area of rewarming after set time) on the side with the greater diameter deep inferior epigastric artery.

In our four patients undergoing DIEP flap reconstruction, surgery time could be lowered by 25 minutes compared to normative data from previous DIEP flap procedures. This could be achieved through reduction of perforator dissection time, which was only carefully done on the thermographic pre-selected side of the abdomen. Each patient showed a large perforator suitable for a single-perforator design. All patients had complication free recovery. These four patients had a mean age of 52.1 years, and a mean BMI of 26.8, were non-smokers and had no previous record of abdominal surgery. Two of the patients had known elevated blood pressure with antihypertensive daily medication.

Discussion

Thermographic assessment of the abdominal skin after hypothermia is easy to conduct and gives reproducible information about different areas of skin perfusion quality. The difference in rewarming speed from left to right can either be affiliated with a difference in perfusion quality (greater diameter and volume flow) of the deep inferior epigastric artery and its perforators, a supreme network of vessels for blood flow distribution in the subcutaneous and cutaneous plexus, and collaterals or a combination of both [15].

The size of the deep inferior epigastric artery does not necessarily correlate with the size of the perforators, but it seems that the larger-diameter pedicle translates into a superior perfusion of the skin.

The rewarming process itself was noted to arise from the territorial vascular supply of the lateral abdominal wall as well as from the rectus perforating vessels (see Fig. 3). We aimed to distinguish between these two rewarming processes to only give credit to the rewarming process arising from the rectus perforators.

Areas with a very slow rewarming process could possibly be discarded from flap design to diminish complications like wound-healing disorders such as partial flap necrosis.

One of the downsides of dynamic infrared thermography is the lack of method standardization. Theoretically measuring the exact area of rewarming after induced hypothermia would be possible through smart software, but particularly challenging. Overlapping perforasomes and rewarming from different blood supply sources make it difficult to objectify results. Nevertheless, it offers an elegant way for future studies to investigate the model of perforasomes in different body areas [13].

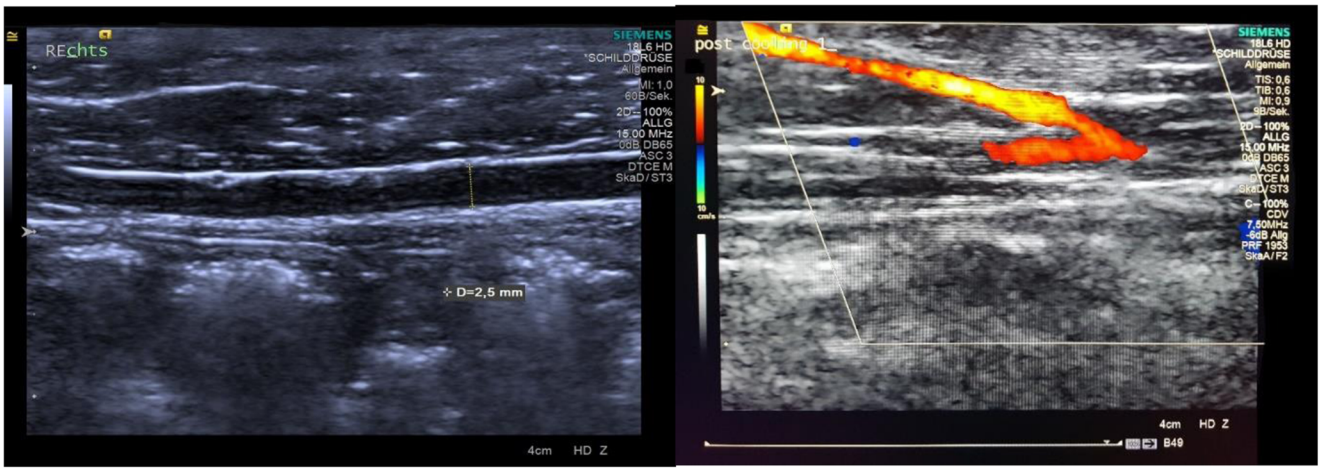

Fig. 3 Sample pictures of diameter assessment of the deep inferior epigastric artery and arising of a large perforator

The presented technique offers the potential to improve outcome, especially by lowering perfusion-related complications and reducing operation time by fast dissection of the non-dominant side while carefully dissecting the area of interest with fast thermographic rewarming results, and must therefore be investigated in future studies by measuring objective outcome results.

Compliance with ethical standards

Financial disclosure statement None of the authors has a financial interest in any of the products, devices, or drugs mentioned in this manuscript. Additionally, there is no conflict of interest in affiliation with the outcome of this study.

Conflict of interest Niepel A., Schauer D., Lewicki M., Hellekes D., Sokullu F., Kreuzwirt G., Primas H., and Kömürcü F., declare that they have no conflict of interest.

Ethical statement All procedures performed in studies involving human participants were in accordance with the ethical standards of the institutional and/or national research committee and with the 1964 Helsinki declaration and its later amendments or comparable ethical standards (EK-17-148-0817).

Informed consent was obtained from all individual participants included in the study.

References

1. Mohan AT, Zhu L, Wang Z, Vijayasekaran A, Saint-Cyr M (2016) Techniques and perforator selection in single, dominant DIEP flap breast reconstruction: algorithmic approach to maximize efficiency and safety. Plast Reconstr Surg 138(5):790e–803e
2. Kelly JA, Pacifico MD (2014) Lateralising paraumbilical medial row perforators: dangers and pitfalls in DIEP FLAP planning: a systematic review of 1116 DIEP flaps. J Plast Reconstr Aesthet Surg 67(3):383–388
3. Chae MP, Hunter-Smith DJ, Rozen WM (2016) Comparative study of software techniques for 3D mapping of perforators in deep inferior epigastric artery perforator flap planning. Gland Surg 5(2):99–106
4. Weum S, Mercer JB, de Weerd L (2016) Evaluation of dynamic infrared thermography as an alternative to CT angiography for perforator mapping in breast reconstruction: a clinical study. BMC Med Imaging 16(1):43
5. Ono S, Hayashi H, Ohi H, Ogawa R (2017) Imaging studies for preoperative planning of perforator flaps: an overview. Clin Plast Surg 44(1):21–30
6. Yang SF, Wang CM, Ono S, Xu W, Xu KY, Pu LL (2016) The value of multidetector row computed tomography angiography for preoperative planning of freestyle Pedicled perforator flaps. Ann Plast Surg 77(6):669–673
7. Battaglia S, Maiolo V, Savastio G, Zompatori M, Contedini F, Antoniazzi E, Cipriani R, Marchetti C, Tarsitano A (2017) Osteomyocutaneous fibular flap harvesting: computer-assisted planning of perforator vessels using computed tomographic angiography scan and cutting guide. J Craniomaxillofac Surg 45(10):1681–1686
8. Wu C, Kim S, Halvorson EG (2013) Laser-assisted indocyanine green angiography: a critical appraisal. Ann Plast Surg 70(5):613–619
9. Newman MI, Samson MC (2009) The application of laser-assisted indocyanine green fluorescent dye angiography in microsurgical breast reconstruction. J Reconstr Microsurg 25(1):21–26
10. de Weerd L, Mercer JB, Setsa LB (2006) Intraoperative dynamic infrared thermography and free-flap surgery. Ann Plast Surg 57(3):279–284
11. de Weerd L, Miland AO, Mercer JB (2009) Perfusion dynamics of free DIEP and SIEA flaps during the first postoperative week monitored with dynamic infrared thermography. Ann Plast Surg 62(1):42–47
12. de Weerd L, Mercer JB, Weum S (2011) Dynamic infrared thermography. Clin Plast Surg 38(2):277–292
13. de Weerd L, Weum S, Mercer JB (2009) The value of dynamic infrared thermography (DIRT) in perforatorselection and planning of free DIEP flaps. Ann Plast Surg 63(3):274–279
14. Burns-Brown R, Marshall WG Jr, McHenry G, Tan WS, Kish GF (1993) Duplex scanning of the inferior epigastric artery. J Vasc Surg 17(3):559–562
15. Saint-Cyr M, Wong C, Schaverien M, Mojallal A, Rohrich RJ (2009) The perforasome theory: vascular anatomy and clinical implications. Plast Reconstr Surg 124(5):1529–1544