Salvage of Intraoperative Deep Inferior Epigastric Perforator Flap Venous Congestion with Augmentation of Venous Outflow: Flap Morbidity and Review of the Literature

Oscar Ochoa, MD
Steven Pisano, MD
Minas Chrysopoulo, MD
Peter Ledoux, MD
Gary Arishita, MD
Chet Nastala, MD, FACS

Background: Breast reconstruction with deep inferior epigastric perforator (DIEP) flaps has gained considerable popularity due to reduced donor-site morbidity. Previous studies have identified the superficial venous system as the dominant outflow to DIEP flaps. DIEP flap venous congestion occurs if superficial venous outflow via the deep venous system is insufficient for effective flap drainage. Although augmentation of venous outflow through a second venous anastomosis may relieve venous congestion, effects on flap morbidity remain ill defined.

Methods: A retrospective analysis of 1616 patients who underwent 2618 DIEP flap breast reconstructions between March 2005 and January 2012 was performed. Patients with intraoperative venous congestion underwent a second venous anastomosis. Preoperative demographic data and methods used to relieve venous congestion were recorded. Incidence of flap morbidity was calculated and compared with a group of 418 controls having 639 DIEP flap breast reconstructions with no venous congestion.

Results: Venous augmentation was required to relieve venous congestion in 87 (3.3%) DIEP flaps on 81 patients. The superficial inferior epigastric vein or accompanying deep inferior epigastric venae comitantes was used to augment venous outflow. Preoperative comorbidities were similar between both groups. Patients requiring a second venous anastomosis had a longer operative time and length of hospital stay. Overall, flap morbidity, delayed wound healing, fat necrosis, and flap loss were similar to controls.

Conclusions: Arterial and venous anatomies play unique roles in flap reliability. DIEP flap venous congestion must be treated expeditiously with venous augmentation to relieve venous congestion and mitigate flap morbidity. (Plast Reconstr Surg Glob Open 2013;1:e52; doi:10.1097/GOX.0b013e3182aa8736; Published online 18 October 2013.)

From the PRMA Plastic Surgery, San Antonio, Tex.
Received for publication March 11, 2013; accepted August 28, 2013.
Copyright © 2013 The Authors. Published by Lippincott Williams & Wilkins on behalf of The American Society of Plastic Surgeons. PRS Global Open is a publication of the American Society of Plastic Surgeons. This is an open-access article distributed under the terms of the Creative Commons Attribution-NonCommercial-NoDerivatives 3.0 License, where it is permissible to download and share the work provided it is properly cited. The work cannot be changed in any way or used commercially.
DOI: 10.1097/GOX.0b013e3182aa8736

Abdominal-based reconstruction is considered by many the standard of care in autologous breast reconstruction due to natural-appearing and long-lasting results. The deep inferior epigastric perforator (DIEP) flap has gained considerable popularity due to reduced abdominal morbidity.1-5 While limiting the number of vascular

Disclosure: The authors have no financial interest to declare in relation to the content of this article. The Article Processing Charge was paid for by the authors.
perforators used for DIEP flap elevation has enabled rectus muscle and fascial sparing, it has also generated concerns regarding flap reliability.2,6,7

Arterial perfusion of the inframamillary abdomen has been studied extensively8-15 since first described by Hartrampf et al.15 Alternatively, venous anatomy has received less attention but remains a critical component of flap viability. While arterial perfusion to the inframamillary abdomen is primarily dependent on the deep inferior epigastric system, venous outflow is preferentially channeled through the superficial venous system.15-17 During flap dissection, venous outflow is redirected from the (dominant) superficial venous system to venous perforators of the deep inferior epigastric system through a network of linking veins.17-19 Because of suboptimal venous outflow through the deep venous system, venous congestion may occur at various stages of flap dissection or after flap transfer. If venous insufficiency is not recognized and addressed expeditiously, venous congestion will lead to increased flap complications and potential flap failure.

The reported incidence of venous congestion in DIEP flaps is 2-8%.7,18-22 To minimize the incidence of DIEP flap venous congestion, previous investigators have recommended utilization of multiple perforators23 or inclusion of rectus muscle during flap elevation.7,19 Once present, DIEP flap venous congestion may be relieved with augmentation of venous outflow through additional venous anastomoses. The purpose of this study is to determine the incidence of flap morbidity following augmentation of venous outflow among intraoperatively congested DIEP flaps and suggest potential alleviating interventions.

METHODS

A retrospective review was conducted after institutional review board approval among 1616 consecutive patients who underwent 2618 DIEP flap breast reconstructions from March 2005 to January 2012 by a single group practice. Flap elevation was conducted in a consistent stepwise manner in all patients. The ipsilateral superficial inferior epigastric vein (SIEV) was preserved and dissected when present, regardless of size, at the caudal edge of the abdominal flap. Identification and skeletonization of perforators was performed under high-powered magnification to prevent inadvertent injury. Focal areas of flap venous congestion were debrided in situ before flap transfer. A single, hand-sewn, arterial and venous anastomosis was routinely performed between the deep inferior epigastric and internal mammary vessels after flap transfer.

Patients with clinically diffuse intraoperative flap venous congestion in situ, or after transfer without primary venous anastomotic complications, underwent an additional venous anastomosis (double vein group). Data regarding patient demographics, medical comorbidities, abdominal surgical history, body mass index (BMI), active tobacco use (≤6wk before reconstruction), and neoadjuvant therapies were collected preoperatively. Methods used for venous augmentation, flap perforator number, ischemia time, time for reconstruction, and length of hospital stay were recorded. Primary outcomes defined as postoperative flap complications were recorded. A group of consecutive patients undergoing DIEP flap breast reconstruction without venous congestion from January 2006 to March 2008 were selected as controls for comparison.

Associations involving categorical variables were assessed using Pearson’s chi-square test or Fisher’s exact test, as appropriate. The Kruskal-Wallis test was used to assess associations involving continuously distributed variables. Associations involving flap complications and reconstruction timing were assessed using a logistic model with binary response adjusted for correlations introduced by bilateral reconstructions. Logistic regression was used to identify independent risk factors associated with double vein procedures. A propensity score was derived using a logistic regression model of demonstrated intraoperative venous congestion requiring a second venous anastomosis in terms of medical comorbidities, patient characteristics, flap characteristics, and adjuvant therapy. All flap complication results were adjusted for the propensity score. All statistical analyses were performed using a significance level of 5% and SAS Version 9.3 (SAS Institute, Cary, N.C.).

RESULTS

During the study period, 81 (5.0%) patients undergoing 87 (3.3%) DIEP flaps demonstrated intraoperative venous congestion requiring a second venous anastomosis. Based on the availability of data, 418 consecutive patients undergoing 639 DIEP flaps were designated as controls for comparison. There were no selection biases or exclusions and no decisions to include or exclude patients based on good or bad outcomes, ultimately resulting in 499 patients and 726 flaps for statistical analysis.

The SIEV was used as the source of additional venous outflow in 67.8% of cases. The most frequently used recipient vessel was a second internal mammary vein (57.5%) or a second/third intercostal perforating vein (27.6%) (Table 1). Interposition vein grafts were required in 15 (17.2%) cases.
The mean age of patients requiring a second venous anastomosis was 51.5 years (range, 32–72 y). The mean age of the control group was similar (∼P = 0.37) at 50.4 years (range, 24–74 y). Average BMI was 29.1 in the double vein group compared with 28.3 in the control group (∼P = 0.32). A trend toward a lower mean number of abdominal surgeries was seen in the double vein group (1.0) compared with controls (1.3) (∼P = 0.09) (Table 2). Individual medical comorbidities were similar between both groups (Table 3).

Distribution of patients in relation to BMI was similar (∼P = 0.27) for both study groups. The most prevalent subset of patients in both the double vein and control groups was classified as overweight (BMI, 25–29.9). The majority of remaining patients in both study groups had a BMI ≥ 30, with normal weight (BMI ≤ 24.9) patients representing less than one quarter of the total population of each study group (Table 4).

Administration of neoadjuvant chemotherapy or radiation was equivalent in both study groups. Patients in the double vein group underwent a higher proportion of delayed reconstructions (35.6%) compared with control group patients (22.5%) (∼P = 0.05). The proportion of unilateral versus bilateral reconstructions (47.1 vs 52.9%) was nearly equal in the control group population. By contrast, patients requiring a second venous anastomosis underwent a significantly (∼P = 0.004) higher rate of bilateral (70.4%) versus unilateral (29.6%) reconstructions compared with controls (Table 5).

Flap ischemia time was nearly identical for both groups. Number of perforators dissected during flap elevation was greater for both left-sided (∼P = 0.07) and right-sided (∼P < 0.05) flaps in the double vein group compared with controls (Table 6).

Operative times were longer for patients requiring a second venous anastomosis compared with control patients overall (∼P < 0.01) and when unilateral (314 vs 253 min) and bilateral (434 vs 413 min) reconstructions were considered separately (Table 7). When patients in the double vein group were further subdivided into those with or without vein grafts, a similar correlation was maintained compared with controls (Fig. 1). Mean length of stay was significantly (∼P < 0.01) different between all groups. For control patients, mean length of stay was 4.0 days. Double vein patients without vein grafts had a mean length of stay of 4.7 days, whereas the longest length of hospital stay (6.6 d) was reported in patients requiring vein grafts (Fig. 2).

Comparison of flap morbidity between the double vein and control groups demonstrated similar (21.8 vs 23.8%, ∼P = 0.37) overall flap complications. Soft-tissue infection was more commonly reported in the control group (5.4%) compared with patients requiring a second venous anastomosis (1.2%). All other individual flap complications, including fat

---

**Table 1. Double Vein Group Procedures**

| Variable                      | N  | %       |
|-------------------------------|----|---------|
| Double vein group             | 87 | 3.3     |
| Second vein donor             |    |         |
| SIEV                          | 59 | 67.8    |
| DIEVC                         | 28 | 32.2    |
| Second vein recipient         |    |         |
| IMV                           | 50 | 67.8    |
| IC                            | 24 | 27.6    |
| DIEVC                         | 6  | 6.9     |
| LSTV                          | 5  | 5.7     |
| TD                            | 2  | 2.3     |
| Vein graft                    | 15 | 17.2    |

DIEVC, deep inferior epigastric veins; IC, intercostal perforating vein; IMV, internal mammary vein; LSTV, lateral superficial thoracic vein; TD, thoracodorsal vein.

**Table 2. Mean Preoperative Characteristics of 499 DIEP Patients**

| Variable, Mean (SD) | Double Vein (N = 81) | Control (N = 418) | P   |
|---------------------|----------------------|-------------------|-----|
| Age                 | 51.5 (9.3)           | 50.4 (9.1)        | 0.37|
| BMI                 | 29.1 (5.8)           | 28.3 (4.9)        | 0.32|
| Abdominal surgery   |                      |                   |     |
| Laparoscopic        | 0.4 (0.6)            | 0.5 (0.6)         | 0.3 |
| Open               | 0.7 (0.9)            | 0.9 (1.1)         | 0.28|
| Total              | 1 (1.1)              | 1.3 (1.3)         | 0.09|

**Table 3. Prevalence of Medical Comorbidities in 499 DIEP Patients**

| Variable                    | Double Vein (%) (N = 81) | Control (%) (N = 418) | P   |
|-----------------------------|--------------------------|-----------------------|-----|
| Hypertension                | 25.9                     | 25.8                  | 1   |
| Diabetes mellitus           | 9.9                      | 5.0                   | 0.11|
| Cardiac disease             | 2.5                      | 6.7                   | 0.2 |
| Pulmonary disease           | 2.5                      | 4.5                   | 0.55|
| Peripheral vascular disease | 0.0                      | 0.2                   | 1   |
| Autoimmune disease          | 2.5                      | 5.5                   | 0.4 |
| Coagulopathy                | 3.7                      | 2.6                   | 0.48|
| Tobacco                     | 4.9                      | 8.1                   | 0.49|

**Table 4. Distribution of Body Mass Index in 499 DIEP Patients**

| Variable              | Double Vein (%) (N = 81) | Control (%) (N = 418) | P   |
|-----------------------|--------------------------|-----------------------|-----|
| Body mass index       |                          |                       |     |
| Normal (≤24.9)        | 23.5                     | 23.9                  |     |
| Overweight (25–29.9)  | 34.6                     | 36.6                  |     |
| Obese (30–34.9)       | 21                       | 27                    |     |
| Severely obese        | 17.3                     | 10.8                  |     |
| (35–39.9)             | 3.7                      | 1.7                   |     |
necrosis and flap failure, were similar between both groups (Table 8).

In a multivariate logistic regression model, flaps based on a greater number of perforators were significantly ($P < 0.01$) associated with an increased risk of venous congestion requiring a second venous anastomosis. On the other hand, previous abdominal surgery was significantly ($P = 0.03$) associated with a decreased risk of requiring a second venous anastomosis. No other recorded variables were found to be independent risk factors for DIEP flap venous congestion including BMI (Table 9).

**DISCUSSION**

**Background**

Promoted by landmark studies by Hartrampf et al\textsuperscript{11} and Holm et al,\textsuperscript{9} perfusion to the infraumbilical abdomen has received considerable interest in an attempt to improve abdominal flap reliability. A more thorough understanding of the abdominal wall microcirculation has facilitated the evolution of abdominal-based reconstruction from myocutaneous (ie, transverse rectus abdominis myocutaneous) to perforator (ie, DIEP) flaps. With elimination of muscle harvest, DIEP flaps rely solely on a limited number of vascular perforators for perfusion and venous outflow. Recent studies have further delineated unique flap perfusion characteristics based on perforators from the medial or lateral branches of the deep inferior epigastric vessels.\textsuperscript{11,12} In addition to perforator location, perforator caliber may also represent a significant determinant of flap perfusion and secondarily venous outflow.\textsuperscript{13} Although perfusion via small (<5 mm) perforators is limited to the subscarpal adipose layer, large arterial perforators (>5 mm) have a direct course into the subdermal plexus optimizing flap perfusion. Moreover, some large perforators (>5 mm) are associated with venae comitantes draining the subdermal plexus,\textsuperscript{13} making selection of perforators critical not only for flap perfusion but also for venous outflow.

The venous anatomy of the infraumbilical abdominal wall contains unique characteristics of critical importance for successful DIEP flap elevation. For instance, while the dominant arterial source of the infraumbilical abdominal wall is the deep inferior epigastric artery, venous drainage is preferentially channeled through the superficial venous system.\textsuperscript{15–17} The superficial and deep venous systems are, in turn, joined by a variable number\textsuperscript{16} of valve-less linking veins that allow redirection of venous outflow into the deep venous system if superficial channels are disrupted such as during flap dissection. Communication between the superficial and deep venous systems via linking veins thus becomes a critical component of adequate venous drainage and contributes to a full spectrum of venous outflow ranging in varying degrees from superficial to deep venous dominance.\textsuperscript{24}

**Venous Congestion and Outflow Augmentation**

Diffuse flap venous congestion is ultimately a result of insufficient superficial venous outflow via the deep venous system (Fig. 3). It may arise subtly in the form of brisk capillary refill, cutaneous discoloration that improves promptly with release of venous blood through the SIEV, or predominant venous bleeding with peripheral flap incisions. The specific etiology may include an intrinsic underdevelopment of veins linking the superficial and deep venous systems, inadequate perforator selection, or suboptimal deep venous drainage through a single venous anastomosis. In our clinical experience, the temporal relationship between venous congestion occurrence and stage of flap dissection and transfer may suggest an etiology and guide treatment options. An algorithm
is proposed outlining a stepwise approach for flap dissection facilitating diagnosis of flap congestion and suggested treatment options (Fig. 4).

In our experience, proper perforator selection is a crucial component of prevention of venous congestion. Perforators should be selected based on the
quality (caliber, palpable pulse, and venous component) as opposed to the absolute number. Schaverien et al. demonstrated the critical relationship between linking vein anatomy and venous congestion. In a retrospective study of 54 DIEP flaps with preoperative MRI, 7 flaps developed diffuse venous congestion. None of the congested DIEP flaps demonstrated direct connections between the perforator used for flap elevation and the superficial venous system, while 46 out of the 47 noncongested flaps demonstrated direct connections between the deep and superficial venous system by MRI. To optimize drainage of the superficial venous system through deep perforators, some authors have recommended increasing the number of perforators or conversion of a DIEP to a free TRAM flap if venous perforators are of small caliber or inadequate for flap drainage. By including a greater number of perforators when diameter is less than 1.5 mm, similar rates of venous congestion, fat necrosis, and flap loss have been reported among DIEP and muscle-sparing TRAM flaps.

If congestion is recognized, prompt intervention with augmentation of venous outflow is required. Various effective techniques to augment venous outflow have previously been described (Table 10). In the current study, patients underwent venous augmentation through anastomosis of the ipsilateral SIEV or second deep inferior epigastric venae comitantes to increase venous outflow (Fig. 5). As outlined in the proposed algorithm (Fig. 4), use of the second deep inferior epigastric venae comitantes for venous augmentation is effective only in a subset of flaps that exhibit persistent venous congestion only after primary anastomosis. In these flaps, the deep venous system is sufficient for venous drainage based on the cumulative cross-sectional area of both patent deep venae comitantes in situ before flap transfer. After flap transfer and anastomosis, the cross-sectional area of a single deep venous anastomosis is insufficient for adequate flap drainage. Cutaneous venous congestion in these flaps is a result of transduced venous hypertension from the deep to superficial system through valve-less linking veins within a flap. Through a second deep venous anastomosis, venous outflow is significantly increased effectively off-loading both deep and superficial systems alleviating venous congestion.

Patient Characteristics

Age, BMI, preoperative medical comorbidities, tobacco history, surgical history, and neoadjuvant therapies were similar between both groups. Patients in the double vein group underwent a higher proportion of bilateral reconstructions negating the possible effect of extended unilateral flaps on venous congestion. Not surprisingly, patients requiring additional venous outflow procedures had a longer operative time than control patients even when those who required vein grafts were separated. A longer operative time associated with double vein patients was not only due to additional time required for identification and isolation of a recipient vein and time for an additional venous anastomosis but also due to dissection of a greater number of perforators during flap elevation. Compared with the control group, double vein patients had DIEP flaps based on a greater number of perforators. A higher perforator number was, therefore, not preventative of venous congestion in this study. Similar findings have been reported pre-

Table 8. Incidence of Flap Morbidity in 729 DIEP Flaps

| Variable                  | Double Vein (%) | Control (%)  | P  |
|---------------------------|-----------------|--------------|----|
| Infection                 | 1.2             | 5.4          | 0.02 |
| Hematoma                  | 1.2             | 1.9          | 0.6 |
| Seroma                    | 0.8             | 0.8          | NA  |
| Fat necrosis              | 12.8            | 10.4         | 0.53 |
| Delayed wound healing     | 10.5            | 6.3          | 0.62 |
| Vessel thrombosis         | 0               | 0.6          | NA  |
| Flap failure              | 0               | 1            | NA  |
| Total                     | 21.8            | 23.8         | 0.37 |

*Adjusted for propensity score. NA, not available.

Table 9. Independent Risk Factors for Requiring a Second Venous Anastomosis among 726 DIEP Flaps

| Variable                  | Odds Ratio | 95% CI       | P  |
|---------------------------|------------|--------------|----|
| Number of perforators     | 1.46       | 1.17–1.83    | 0.004 |
| Previous abdominal surgery| 0.8        | 0.66–0.99    | 0.03 |
| Body mass index           | 1.04       | 0.99–1.10    | 0.14 |

Fig. 3. Intraoperative appearance of congested right hemi-abdominal DIEP flap with deep inferior epigastric pedicle in continuity. Right SIEV dissected and temporarily occluded with temporary vascular clamp (yellow arrow).
Fig. 4. Stepwise approach for DIEP flap elevation. Venous congestion may occur at various points during dissec-
tion suggesting a likely etiology and effective interventions. (A) Type 1 venous congestion—Intrinsic malforma-
tion of linking vein network where superficial and deep venous systems are discontinuous. (B) Type 2 venous con-
gestion—Improper perforator selection. (C) Type 3 venous congestion—Focal areas of flap venous congestion. (D) Type 4 venous congestion—Incomplete venous outflow through a patent single deep venous anastomosis.
Previously, where the number of perforators was unrelated to the development of venous congestion. Moreover, logistic regression analysis identified a positive correlation between a greater number of perforators and development of intraoperative venous congestion requiring a second venous anastomosis. The explanation behind this correlation is that flaps without a dominant perforator(s) required a greater number of lesser quality perforators included with the dissection. Although the cumulative effect of a greater number of lesser quality perforators was able to provide sufficient inflow, venous outflow was suboptimal due to the small venous component within those perforators. Longer hospital stays among patients in the double vein group is attributed to an extended course of postoperative anticoagulation routinely used in this patient population.

An inverse correlation was identified between previous abdominal surgery and venous congestion requiring an additional venous anastomosis. The etiology behind this finding is unclear. However, based on the principle of superficial to deep venous system shunting through linking veins, we speculate that patients who have undergone previous abdominal surgery are more likely to have disturbed the natural venous drainage of the superficial venous system through incisions on the abdominal wall promoting gradual conditioning of venous outflow through the deep venous system. In the current study, no other variables were correlated with the development of DIEP flap venous congestion requiring an additional venous anastomosis including patient BMI.

**Flap Morbidity**

Intraoperative DIEP flap venous congestion was identified in 87 (3.3%) flaps performed in the current study. Incidence of venous congestion in DIEP flaps reported in the literature range between 2% and 8%, with one study reporting rates as high as 15%. Augmentation of venous outflow was necessary to relieve venous congestion to minimize flap morbidity and almost assured flap loss.

Expansion of venous stasis caused by venous congestion increases interstitial edema reducing the caliber of oscillating linking veins. This, in turn, exacerbates the disconnection between the superficial and deep venous systems causing a disturbance in local microcirculation and tissue ischemia, which may proceed to complete flap loss. In a study by Ali et al., congested DIEP flaps that underwent no additional surgical intervention (observation) and those treated with additional venous outflow

---

**Fig. 5. Deep inferior epigastric perforator flap anastomosis.** Primary DIEP flap anastomosis to the internal mammary artery and lateral IMV (elevated by Gerald forceps). Second venous anastomosis from the SIEV to the medial IMV (yellow arrow).

---

**Table 10. Techniques for Venous Drainage of Abdominal-based Flaps**

| Author                | Technique                                                                 | Journal               |
|-----------------------|---------------------------------------------------------------------------|-----------------------|
| Barnett et al         | Interposition vein grafts between SIEV and IMV                           | *PRS*, 1996           |
| Blondeel et al        | SIEV to thoracodorsal, lateral thoracic vein, IC                         | *PRS*, 2000           |
| Wechselberger et al   | SIEV to cephalic vein as outflow channel                                 | *PRS*, 2001           |
| Niranjani et al       | Contralateral SIEV to cephalic vein (using vein graft)                   | *BJPS*, 2001          |
| Tutor et al           | DIEV comitantes to IC                                                   | *J Reconstr Microsurg*, 2002 |
| Mehrara et al         | DIEV to external jugular or cephalic vein                                | *PRS*, 2003           |
| Rohde and Keller      | SIEV to proximal cut end of second DIEV venae comitantes                 | *Ann Plast Surg*, 2005 |
| Cohn and Walton       | SIEV to thoracodorsal vein as outflow                                    | *J Reconstr Microsurg*, 2006 |
| Liu et al             | SIEV to DIEV venae comitantes                                           | *Ann Plast Surg*, 2007 |
| Guzzetti and Thione   | SIEV to basal vein as outflow                                            | *Microsurgery*, 2008  |
| Shamsian et al        | SIEV to DIEV end-to-end anastomosis (reverse flow)                       | *J Reconstr Microsurg*, 2002 |
| Stasch et al          | Venesection of superficial epigastric vein                              | *Ann Plast Surg*, 2009 |
| Kerr-Valentic et al   | Use of retrograde IMV for outflow                                        | *PRS*, 2009           |
| Enajat et al          | SIEV to cephalic vein for outflow                                        | *Microsurgery*, 2010  |
| Cheng and Nguyen      | SIEV to DIEV comitantes in end-to-end or end-to-side anastomosis         | *PRS*, 2010           |
| Sojitra et al         | Contralateral SIEV to proximal DIEV or SIEV to branch from DIEV        | *PRS*, 2010           |
| Eom et al             | SIEV to lateral thoracic, thoracoacromial, IC                           | *Ann Plast Surg*, 2011 |
| Sbitany et al         | SIEV to proximal cut end of second DIEV venae comitantes                | *PRS*, 2012           |

IC, intercostal perforating vein; IMV, internal mammary vein.
procedures at take-back (postoperative salvage) had rates of total flap loss of 9.1% and 14.3%, respectively. By contrast, no flap losses were reported in non-congested (normal) flaps or flaps that underwent additional venous outflow procedures initially (intraoperative salvage). Similarly, no flap losses or vessel thromboses requiring reoperation were reported in the current study among patients undergoing venous outflow augmentation.

The results of the current study suggest that early recognition of venous congestion and intervention is crucial in minimizing flap morbidity. Initially, compromised DIEP flaps were restored or salvaged to normal conditions with augmentation of venous outflow; overall flap morbidity was similar compared with our control group and previous studies.41–43 Regarding rates of individual flap complications, reported rates of fat necrosis following DIEP flap reconstruction have ranged between 1.8% and 29%,2,6,17,41–47 Moreover, impaired venous outflow has been associated with increased rates of fat necrosis in DIEP flaps.2 In the current study, clinical fat necrosis was mitigated to 12.8% by using a second venous anastomosis. If venous outflow pathways are delayed, a 4-fold increase in fat necrosis has been reported compared with intraoperative salvage.40 With the exception of soft-tissue infection, all remaining individual flap complications were reduced by venous outflow augmentation to rates equivalent to controls.

CONCLUSIONS

DIEP flaps have proven to be a valuable option for autologous breast reconstruction with limited donor-site morbidity. The arterial and venous anatomies of the anterior abdominal wall play unique roles in flap reliability. Successful DIEP flap elevation is based not only on adequate arterial inflow but also on sufficient venous outflow. Venous outflow insufficiency may result from multiple etiologies along the venous outflow pathway. Once recognized, effective treatment of venous congestion is based on the inciting etiology. Venous outflow augmentation with an additional venous anastomosis is effective in salvaging compromised DIEP flaps.

Oscar Ochoa, MD.
PRMA Plastic Surgery
9635 Huebner Road
San Antonio
TX 78240
E-mail: dr.ochoa@prmaplasticsurgery.com

REFERENCES
1. Blondeel N, Vanderstraeten GG, Monstrey SJ, et al. The donor site morbidity of free DIEP flaps and free TRAM flaps for breast reconstruction. Br J Plast Surg. 1997;50:922–330.
2. Kroll SS. Fat necrosis in free transverse rectus abdominis myocutaneous and deep inferior epigastric perforator flaps. Plast Reconstr Surg. 2000;106:576–583.
3. Bonde CT, Christensen DE, Elberg JJ. ‘Ten years’ experience of free flaps for breast reconstruction in a Danish microsurgical centre: an audit. scand j plast reconstr Surg Hand Surg. 2006;40:8–12.
4. Scheer AS, Novak CB, Neligan PC, et al. Complications associated with breast reconstruction using a perforator flap compared with a free TRAM flap. Ann Plast Surg. 2006;56:355–358.
5. Man LX, Selber JC, Serletti JM. Abdominal wall following free TRAM or DIEP flap reconstruction: a meta-analysis and critical review. Plast Reconstr Surg. 2009;124:752–764.
6. Nahabedian MY, Dooley W, Singh N, et al. Contour abnormalities of the abdomen after breast reconstruction with abdominal flaps: the role of muscle preservation. Plast Reconstr Surg. 2002;109:91–101.
7. Nahabedian MY, Tsangaris T, Momen B. Breast reconstruction with the DIEP flap or the muscle-sparing (MS-2) free TRAM flap: is there a difference? Plast Reconstr Surg. 2005;115:436–444; discussion 445–446.
8. Dinner MI, Dowden RV, Schefflan M. Refinements in the use of the transverse abdominal island flap for postmastectomy reconstruction. Ann Plast Surg. 1983;11:362–372.
9. Holm G, Mayr M, Höfter E, et al. Perforasomes of the DIEP flap revisited: a clinical study. Plast Reconstr Surg. 2006;117:37–43.
10. Keller A. Perfusion zones of the DIEP flap revisited: a clinical study. Plast Reconstr Surg. 2006;118:1076–1077; author reply 1077.
11. Wong C, Saint-Cyr M, Mojallal A, et al. Perforasomes of the DIEP flap: vascular anatomy of the lateral versus medial row perforators and clinical implications. Plast Reconstr Surg. 2010;125:772–782.
12. Schaverien M, Saint-Cyr M, Arbiique G, et al. Arterial and venous anatomies of the deep inferior epigastric perforator and superficial inferior epigastric artery flaps. Plast Reconstr Surg. 2008;121:1909–1919.
13. Elmotaby HI, Milner RH. The vascular anatomy of the lower anterior abdominal wall: a microdissection study on the deep inferior epigastric vessels and the perforator branches. Plast Reconstr Surg. 2002;109:539–543; discussion 544–547.
14. Hartrampf CR, Schefflan M, Black PW. Breast reconstruction with a transverse abdominal island flap. Plast Reconstr Surg. 1982;69:216–225.
15. Carramenzia e Costa MA, Carriquiry G, Vasconez LO, et al. An anatomic study of the venous drainage of the transverse rectus abdominis musculocutaneous flap. Plast Reconstr Surg. 1987;79:208–213.
16. Rozen WM, Pan WR, Le Roux CM, et al. The venous anatomy of the anterior abdominal wall: an anatomical and clinical study. Plast Reconstr Surg. 2009;124:848–853.
17. Imanishi N, Nakajima H, Minabe T, et al. Anatomical relationship between arteries and veins in the paraumbilical region. Br J Plast Surg. 2003;56:552–556.
18. Wechselberger G, Schoeller T, Bauer T, et al. Venous superdrainage in deep inferior epigastric perforator flap breast reconstruction. Plast Reconstr Surg. 2001;108:162–166.
19. Blondeel PN, Arnstein M, Verstraete K, et al. Venous congestion and blood flow in free transverse rectus abdominis myocutaneous and deep inferior epigastric perforator flaps. Plast Reconstr Surg. 2000;106:1295–1299.
20. Schaverien MV, Ludman CN, Neil-Dwyer J, et al. Relationship between venous congestion and intraflap venous anatomy in DIEP flaps using contrast-enhanced magnetic resonance angiography. Plast Reconstr Surg. 2010;126:385–392.

21. Enajat M, Rozen WM, Whitaker IS, et al. A single center comparison of one versus two venous anastomoses in 564 consecutive DIEP flaps: investigating the effect on venous congestion and flap survival. Microsurgery 2010;30:185–191.

22. Eom JS, Sun SH, Lee TJ. Selection of the recipient veins for additional anastomosis of the superficial inferior epigastric vein in breast reconstruction with free transverse rectus abdominis musculocutaneous or deep inferior epigastric vein: an aid in free TRAM flap breast reconstruction. Br J Plast Surg. 1996;49:289–294.

23. Niranjan NS, Khandwala AR, Mackenzie DM. Venous augmentation of the free TRAM flap. Br J Plast Surg. 2001;54:335–337.

24. Cheng MH, Nguyen A. Invited discussion: a case of intraoperative venous congestion of the entire DIEP flap: a novel salvage technique and review of the literature. Microsurgery 2010;30:447–448.

25. Barnett GR, Carlisle IR, Gianoutsos MP. The cephalic vein: an aid in free TRAM flap breast reconstruction. Br J Plast Surg. 1996;49:71–76; discussion 77–78.

26. Sojitra NM, Vandevoort M, Ghali S, et al. Two new techniques for correcting venous congestion in the free DIEP flap for breast reconstruction: an analysis of venous augmentation in 581 DIEP flaps. Plast Reconstr Surg. 2010;125:72e–74e.

27. Keller A. The deep inferior epigastric perforator free flap for breast reconstruction. Plast Reconstr Surg. 2001;108:241e–242e.

28. Mehrara BJ, Santoro T, Smith A, et al. Alternative venous outflow vessels in microvascular breast reconstruction. Plast Reconstr Surg. 2003;112:448–455.

29. Rohde C, Keller A. Novel technique for venous augmentation in a free deep inferior epigastric perforator flap. Ann Plast Surg. 2005;55:298–303.

30. Cohn AB, Walton RL. Immediate autologous breast reconstruction using muscle-sparing TRAM flaps with superficial epigastric system turbocharging: a salvage option. J Reconstr Microsurg. 2006;22:153–156.

31. Liu TS, Ashjian P, Festekjian J. Salvage of congested deep inferior epigastric perforator flap with a reverse flow superficial epigastric system. Ann Plast Surg. 2007;59:214–217.

32. Guzzetti T, Thione A. The basilic vein: an alternative drainage of DIEP flap in severe venous congestion. Microsurgery 2008;28:555–558.

33. Shamsian N, Sassoon E, Haywood R. Salvage of a congested DIEP flap: a new technique. Plast Reconstr Surg. 2008;122:41e–42e.

34. Stasch T, Goon PK, Haywood RM, et al. DIEP flap rescue by venesection of the superficial epigastric vein. Ann Plast Surg. 2009:62:372–373.

35. Kerr-Valentic MA, Gottlieb LJ, Agarwal JP. The retrograde limb of the internal mammary vein: an additional outflow option in DIEP flap breast reconstruction. Plast Reconstr Surg. 2009;124:717–721.

36. Sojitra NM, Vandevoort M, Ghali S, et al. Two new techniques for correcting venous congestion in the free DIEP flap for breast reconstruction: an analysis of venous augmentation in 581 DIEP flaps. Plast Reconstr Surg. 2010;125:72e–74e.

37. Sbitany H, Mirzabeigi MN, Kovach SJ, et al. Strategies for recognizing and managing intraoperative venous congestion in abdominally based autologous breast reconstruction. Plast Reconstr Surg. 2012;129:809–815.

38. Rubino C, Ramakrishnan V, Figus A, et al. Flap size/flow rate relationship in perforator flaps and its importance in DIEAP flap drainage. J Plast Reconstr Aesthet Surg. 2009;62:1666–1670.

39. Tran NV, Buchel FW, Convery PA. Microvascular complications of DIEP flaps. Plast Reconstr Surg. 2007;119:1397–1405; discussion 1406–1408.

40. Ali R, Bernier C, Lin YT, et al. Surgical strategies to salvage the venous compromised deep inferior epigastric perforator flap. Ann Plast Surg. 2010;65:398–406.

41. Gill PS, Hunt JP, Guerra AB, et al. A 10-year retrospective review of 758 DIEP flaps for breast reconstruction. Plast Reconstr Surg. 2004;113:1153–1160.

42. Drazan L, Vesely J, Hyza P, et al. Bilateral breast reconstruction with DIEP flaps: 4 years’ experience. J Plast Reconstr Aesthet Surg. 2008;61:1309–1315.

43. Selber JC, Serletti JM. The deep inferior epigastric perforator flap: myth and reality. Plast Reconstr Surg. 2010;125:50–58.

44. Chen CM, Halvorson EG, Disa JJ, et al. Immediate postoperative complications in DIEP versus free/muscle-sparing TRAM flaps. Plast Reconstr Surg. 2007;120:1477–1482.

45. Garvey PB, Buchel EW, Pockaj BA, et al. DIEP and pedicled TRAM flaps: a comparison of outcomes. Plast Reconstr Surg. 2006;117:1711–1719; discussion 1720–1721.

46. Parrett BM, Caterson SA, Tobias AM, et al. DIEP flaps in women with abdominal scars: are complication rates affected? Plast Reconstr Surg. 2008;121:1527–1531.