# Integrating the DIEP and Muscle-Sparing (MS-2) Free TRAM Techniques Optimizes Surgical Outcomes: Presentation of an Algorithm for Microsurgical Breast Reconstruction Based on Perforator Anatomy

John T. Lindsey, M.D.

*Metairie, La.*

**Background:** Optimal surgical outcomes in autogenous breast reconstruction require a balance between the reliability of older transverse rectus abdominis musculocutaneous (TRAM) flap techniques and the decreased donor-site morbidity of the newer deep inferior epigastric perforator (DIEP) flap techniques. This article presents an approach to autogenous breast reconstruction that uses principles of both techniques.

**Methods:** One hundred twenty patients receiving 140 breast reconstructions (100 unilateral and 20 bilateral) using the DIEP or the muscle-sparing (MS-2) free TRAM techniques were retrospectively reviewed over a 5-year period. All patients before January of 2004 (group 1, $n = 107$ flaps) received the DIEP flap. Patients after January of 2004 (group 2, $n = 33$ flaps) were approached using an integrated technique and received either the DIEP or the muscle-sparing (MS-2) free TRAM based on the perforator anatomy identified at the time of surgery.

**Results:** Average follow-up was 27 months for group 1 (range, 5.2 to 43 months) and 8 months for group 2 (range, 3 to 18 months). By applying the surgical technique according to the algorithm presented, the success rate has been increased to 100 percent (33 of 33 flaps, $p = 0.0425$, group 2) over the past 18 months without increasing donor-site morbidity. This compares with a success rate of only 92 percent (98 of 107 flaps, group 1) when the DIEP was attempted nonselectively in every case.

**Conclusion:** By integrating DIEP and MS-2 surgical techniques and selectively applying the surgical technique according to the perforator anatomy, microsurgical breast reconstruction can be more reliably offered to patients while still minimizing donor-site morbidity. (*Plast. Reconstr. Surg.* 119: 18, 2007.)

Although many recent publications attest to the utility and effectiveness of deep inferior epigastric perforator (DIEP) free flap breast reconstruction, success rates remain variable.[1–5] When basing all flap reconstructions on skeletonized deep inferior epigastric perforators, even when the perforators were of diminutive size, our success rate was only 92 percent (98 of 107 flaps). After January of 2004, we modified our approach to breast reconstruction by selecting the surgical technique, DIEP or muscle-sparing (MS-2) free transverse rectus abdominis musculocutaneous (TRAM), based on the perforator anatomy identified at the time of surgery. By applying the algorithm shown in Figure 1, we dramatically improved our success rate to 100 percent (33 of 33 flaps, $p = 0.0425$, group 2) without incurring donor-site morbidity.

It is important to take an anatomical inventory during DIEP flap reconstruction, as perforators that are diminutive in size (<1.5 mm in external diameter) were encountered in 12 percent of our cases in group 2. Skeletonization of perforators in this situation is risky and contributes to a

*Received for publication May 31, 2005; accepted August 31, 2005.*

*Presented at the Annual Meeting of the Southeastern Society of Plastic and Reconstructive Surgeons, in Atlantis Resort, Bahamas, June 4 through 8, 2005.*



DOI: 10.1097/01.prs.0000244743.90178.89

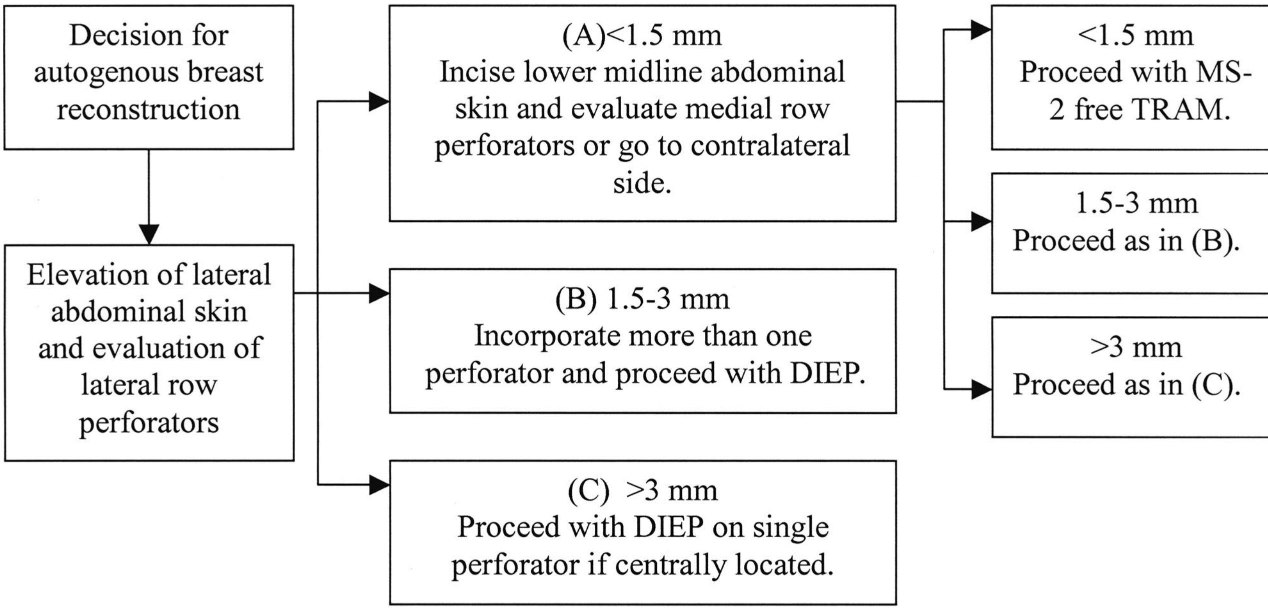


**Fig. 1.** Algorithm for microsurgical breast reconstruction based on perforator anatomy.

high failure rate. When diminutive perforators are encountered, we favor an MS-2 free TRAM technique that is based on perforator anatomy.

## SURGICAL ALGORITHM

Accurate (Fig. 1) assessment of perforator size and location requires dissection on the surface of the adventitial layer of the vessel and release of the fascial collar as the perforator penetrates the rectus fascia. This allows the vessels to plump up and further allows accurate assessment of the location of muscular penetration. At this time, the external diameters of the perforating artery and vein are measured, and the sagittally oriented intramuscular septum in which the perforating vessels travel is defined.[6]

When small perforators (<1.5 mm) are encountered during lateral row perforator dissection, the medial row should be explored. If the medial row perforators are also smaller than 1.5 mm, further perforator dissection and the DIEP technique should be abandoned. An MS-2 free TRAM flap based on the location of the perforators should then be undertaken. The MS-2 free TRAM flap discussed in this article incorporates all of the medial and lateral row perforating vessels, with the small intervening segment of rectus muscle. For cases where perforators measure between 1.5 and 3.0 mm, more than one perforator should be incorporated into the DIEP flap. For cases where a centrally located perforator greater than 3 mm in diameter can be found, DIEP reconstruction is straightforward and can be reliably based on a single perforator.

## PATIENTS AND METHODS

One hundred twenty patients who underwent 140 microsurgical breast reconstructions with the DIEP or the MS-2 free TRAM technique were retrospectively reviewed over 5 years. All patients before January of 2004 (group 1, $n = 107$ flaps) received the DIEP flap. All patients after January of 2004 (group 2, $n = 33$ flaps) were approached using an integrated technique and received either the DIEP or the MS-2 free TRAM flap according to the surgical algorithm. For these patients, the external diameters of the perforating artery and vein were prospectively measured under loupe magnification at the level of anterior rectus fascial penetration.

All patients were referred by their respective general surgeons for breast reconstruction following mastectomy, either immediate or delayed. Patient demographics and comorbidities are shown in Table 1. A two-sample test of proportions was conducted to compare the outcomes and risk factors between groups 1 and 2; $p$ values were obtained to demonstrate statistically significant differences between the two groups.

### DIEP Surgical Techniques

A standard DIEP approach was used for all patients and has been well described previously.[7–11]

**Table 1. Patient Demographics and Comorbidities**

| | Group 1 ($n$ = 91 patients) (%) | Group 2 ($n$ = 29 patients) (%) |
|---|---|---|
| Age, years | | |
| Mean | 52 | 48 |
| Range | 30–73 | 28–66 |
| Mean BMI, kg/m$^2$ | 28 | 28 |
| BMI (kg/m$^2$) >30 (obesity) | 10% | 8% |
| Smoker | 6 (6.6) | 2 (6.9) |
| Hypertension | 25 (27)* | 3 (10)* |
| Diabetes | 6 (6.6) | 1 (3) |
| Asthma | 3 (3) | 0 |
| Lupus | 1 (1) | 0 |
| Psoriasis | 1 (1) | 0 |
| CAD, PVD | 3 (3) | 3 (10) |
| MVP | 2 (2) | 0 |
| Sarcoidosis | 1 (1) | 0 |
| Crohn's disease | 1 (1) | 0 |
| Hypothyroidism | 3 (3) | 1 (3) |
| Rheumatoid arthritis | 1 (1) | 1 (3) |
| ESRD | 1 (1) | 0 |
| Epilepsy | 1 (1) | 0 |

BMI, body mass index; CAD, coronary artery disease; PVD, peripheral vascular disease; MVP, mitral valve prolapse; ESRD, end-stage renal disease.
*$p$ = 0.0288.

Several aspects of surgical technique merit emphasis.

### Finding the Perforators

As the flap is elevated from lateral to medial, arborization of the perforators becomes visible in the subcutaneous fat as it is dissected off of the underlying abdominal wall fascia. These vessels, which are generally less than 1 mm, are easily followed using 3× loupe magnification and generally converge on the parent perforating vessels emerging through the anterior rectus fascia (Fig. 2).

Once the perforators are identified, the fascial collar around each vessel is released. This allows the perforating vessels to plump up and expand. At this time, the perforating vessels are assessed for size and flow, and a decision is made to either proceed with a DIEP flap or further explore for better perforating vessels.

The anterior rectus fascia is further split sagittally at the site of perforator fascial penetration, and dissection proceeds directly on the vessels through the rectus abdominis muscle to the underlying deep inferior epigastric vascular pedicle. Multiple small muscular branches are electrocoagulated using bipolar cautery. The vascular pedicle is followed into the groin (Fig. 3).

### Palpating the Pulse

Once skeletonization of the vascular anatomy is complete, the pulsations in the perforators should be palpable and assessable by means of Doppler probe both before and after microvascular transfer. If the pulses in the perforators are not both palpable and assessable by means of Doppler probe, the flap should be discarded and the contralateral flap harvested. Patency and flow at the level of the microvascular anastomoses should also be confirmed using standard microsurgical techniques.[12]

Venous microvascular anastomoses have been facilitated by vascular couplers (Medical Companies Alliance, Inc., Bessemer, Ala.). Our recipient vessels of choice are the internal mammary vessels, as has been previously recommended.[13,14]

### Using the Internal Doppler Probe

Internal Doppler probes (Cook Vascular, Inc., Leechburg, Pa.) are applied to the arterial and venous limbs of the pedicle distal to the microvascular anastomoses. Any change or diminution of the arterial or venous signals during flap inset or in the postoperative period mandates immediate investigation. Clinically, the flap should be pink, should have capillary refill of approximately 1.5 seconds, and should show bright red bleeding from the subdermal plexus both before and after microsurgical transfer. Doppler monitoring of both the venous and arterial signals is particularly useful during flap inset; however, Doppler technology is not a substitute for routine clinical postoperative monitoring.

### Using Adjacent Zones (II and III) Conservatively

Most of the ipsilateral triangular tip of the flap (zone III; Fig. 4) and most of zones II and IV are discarded, depending on flap requirements and intraoperative assessment of flap perfusion.

### Anchoring the Flap

For thicker flaps (subcutaneous tissue >1.5 inches), the deep surface fat should be anchored to the pectoral fascia. This is done with two to three 3-0 Vicryl sutures (Ethicon, Inc., Somerville, N.J.) to protect the microvascular anastomoses from translational motion of the subsurface fat.

### Repairing Muscle and Fascia

The rectus abdominis muscle is repaired with a running 2-0 Vicryl suture (Ethicon), and the anterior rectus fascia is repaired with a running no. 1 Prolene suture (Ethicon).

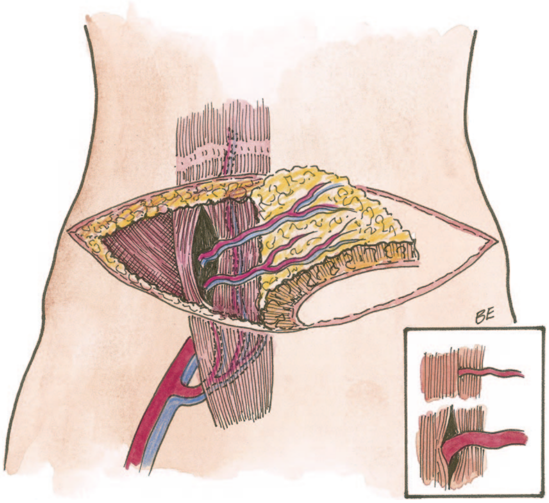

**Fig. 2.** Perforating vessel dissection during flap mobilization. (*Inset*) Perforating vessels plump up after release of the anterior rectus fascial collar.

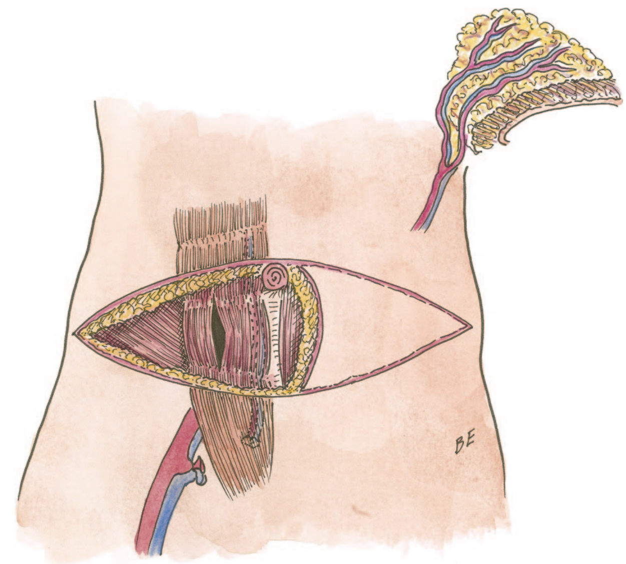

**Fig. 3.** Harvest of the DIEP Flap. The perforating vessels are followed through the rectus abdominis muscle to the underlying parent vessels and then into the groin.

### MS-2 Free TRAM Flap

The MS-2 free TRAM flap that is presented in this article preserves rectus abdominis muscle continuity both medially and laterally, but is similar to the standard free TRAM flap in that both medial and lateral row perforators are included in the flap.[15–17] The extent of muscle harvest in the MS-2 technique is further defined here and is based on the perforator anatomy identified intraoperatively. Elevation of the flap proceeds from lateral to medial as with the DIEP flap. If the lateral row perforators are diminutive (<1.5 mm), dissection stops. The flap is divided in the midline and the medial row perforators are identified. If these are also diminutive, the contralateral side can be explored, or an MS-2 free TRAM flap can be undertaken as outlined in the algorithm.

### Defining the Limits of Muscle Dissection

The anterior rectus fascia is sagittally divided at the level of penetration of the medial and lateral row perforators, respectively. The areas of perforator penetration into the rectus abdominis muscle define the medial, lateral, superior, and inferior extent of muscle and fascia harvest. The minimal amount of muscle required to incorporate the medial and lateral perforators is harvested (Fig. 5). In most cases, this involves the central third of the rectus abdominis muscle, extending from just below the level of the umbilicus caudally for a distance of approximately 2 inches (Fig. 6). All muscle dissection is performed with bipolar cautery, as this limits local muscle damage. Recommendations for palpating the pulse, using the internal Doppler, using adjacent zones conservatively, anchoring the flap, and repairing muscle and fascia are the same as with the DIEP flap.

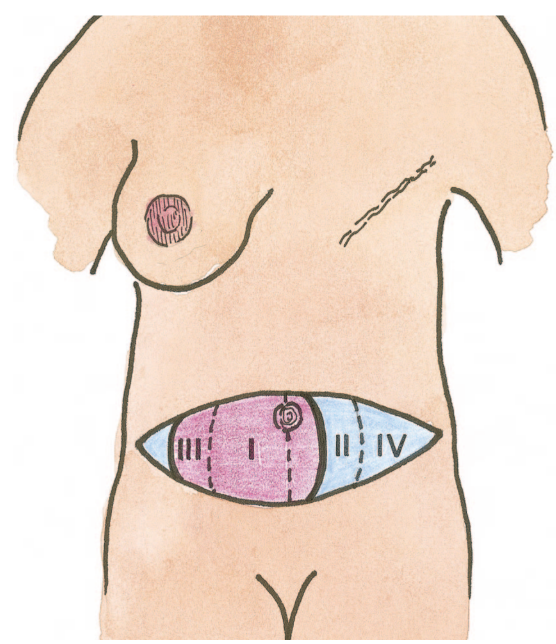


**Fig. 4.** Conservative use of adjacent zones (II and III) during harvest of the DIEP or MS-2 free TRAM flap. This is similar to the guidelines for the classic unipedicled TRAM flap.

## RESULTS

All 120 patients undergoing microsurgical breast reconstruction were available for follow-up.

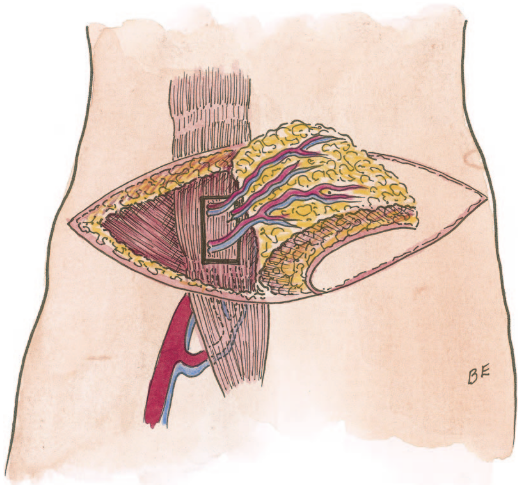


**Fig. 5.** Defining the limits of MS-2 muscle harvest based on the medial and lateral row perforating vessels.

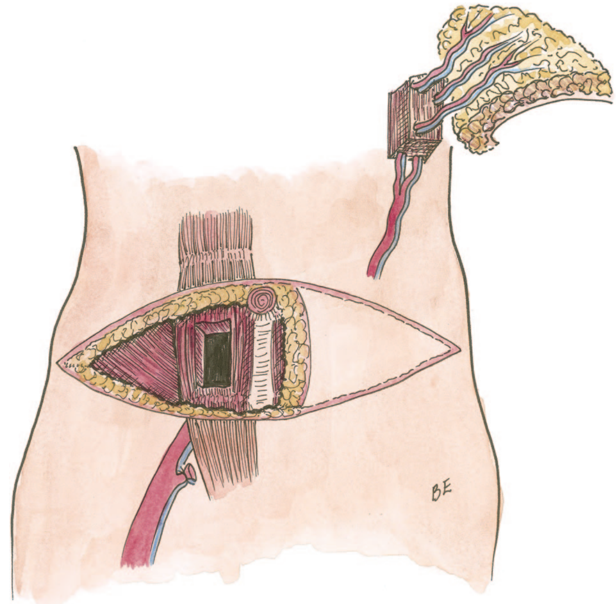


**Fig. 6.** Harvest of the MS-2 flap. The medial and lateral row perforating vessels and the small intervening segment of rectus muscle are incorporated into the flap.

Average follow-up was 27 months (range, 5.2 to 43 months) for group 1 and 8 months for group 2 (range, 3 to 18 months). There were no statistically significant differences between groups 1 and 2 with respect to demographics or comorbidities except for a higher incidence of hypertension (27 percent versus 10 percent, $p = 0.028$) in group 1 (Table 1). There were no statistically significant differences when the seven patients experiencing nine flap failures in group 1 were compared with group 1 as a whole with respect to the same parameters, except for a higher incidence of smokers among the patients experiencing flap failure (29 percent versus 6.6 percent, $p = 0.0407$).

There were eight take-backs in the immediate postoperative period in group 1 (7.4 percent). There were no take-backs in group 2. Five were attributable to venous congestion, and three were attributable to loss of the arterial signal. Translational motion of subsurface fat was a contributing factor in three of the five flaps experiencing venous congestion and in one of the three flaps experiencing arterial thrombosis. Four of the five flaps experiencing venous congestion could not be salvaged and were removed. Two of the three flaps with arterial thrombosis were salvaged. Ultimately, five of the eight (63 percent) take-backs failed and required removal. One of the flaps experiencing arterial thrombosis partially necrosed but ultimately was successful after debridement. Leeches were not used in this study.

The other four flap failures occurred in two patients undergoing bilateral DIEP reconstruction. In these two patients, the vessels were too small to allow perforator flap reconstruction, and perforator flap reconstruction was abandoned intraoperatively. The weight of these patients was 105 and 117 pounds, respectively. An analysis of the nine flap failures is provided in Table 2.

There were two instances of fat necrosis in this study (Table 3). The case in group 1 involved a 3-cm area of firmness, and the case in group 2 involved a 2-cm area of firmness. In neither of these cases was there a history of vascular compromise, venous congestion, or soft-tissue loss. These areas were removed in both patients during subsequent flap revision and completion, at which time the pathologic findings were confirmed. The distribution of flap failures over time is shown in Figure 7. Typical results for immediate DIEP and delayed MS-2 free TRAM flap reconstructions are shown in Figure 8.

The surgical algorithm was successfully applied to 29 patients receiving 33 microsurgical breast reconstructions (group 2). There were no flap failures, either partial or total (zero of 33, $p = 0.0425$), and no instances of abdominal herniation or contour deformities. All complications in group 2 were managed on an outpatient basis in an office setting. Overall complication rates were 21 percent for group 2 and 30 percent for group 1. A summary of complications for groups 1 and 2 is shown in Table 3.

Among the 33 flaps in group 2, 24 had perforators measuring between 1.5 and 3.0 mm; 21 of

**Table 2. Analysis of the Nine Flap Failures**

| No. of Flaps | Reason for Failure | Immediate Take-Back to Operating Room | Age (yr) | Timing of Reconstruction | No. of Perforators | Previous Irradiation | Smoker |
|---|---|---|---|---|---|---|---|
| 4 | Perforators too small and flap abandoned intraoperatively | NA | 42, 52 | Immediate | NA | 0 | 0 |
| 4 | Venous thrombosis | Yes | 39, 46, 52, 61 | 1 immediate, 3 delayed | 2 each flap | 3 | 2* |
| 1 | Arterial thrombosis | Yes | 47 | Delayed | 2 | 0 | 0 |

NA, not applicable.
*$p$ = 0.0407.

**Table 3. Complication Summary for Groups 1 and 2**

| | Group 1 ($n$ = 91 patients) (%) | Group 2 ($n$ = 29 patients) (%) |
|---|---|---|
| Flap failure | 9 (10) | 0* |
| Fat necrosis† | 1 (1) | 1 (3) |
| Partial flap necrosis‡ | 1 (1) | 0 |
| Abdominal contour deformity | 0 | 0 |
| Abdominal hernia | 0 | 0 |
| Major abdominal wound dehiscence (requiring return to OR) | 1 (1) | 0 |
| Major wound infection (requiring admission) | 1 (1) | 0 |
| Skin cellulitis/minor wound infection | 2 (2) | 2 (7) |
| Seroma (all managed with serial office needle aspirations) | 4 (4) | 1 (3) |
| Minor wound-healing problems of breast or abdomen (all healed without return to the OR) | 7 (8) | 2 (7) |
| Keloid requiring intralesional steroids | 1 (1) | 0 |

OR, operating room.
*$p$ = 0.0425.
†Development of a localized area of firmness in the absence of soft-tissue loss or wound-healing problems
‡Subtotal flap loss that responded to debridement and revision and still allowed satisfactory breast reconstruction.

these flaps were based on two perforators and three were based on three perforators. Five of the 33 flaps (15 percent) had a single perforator that measured more than 3 mm; four of the 33 (12 percent) were found to have perforators less than 1.5 mm and received the MS-2 free TRAM flap.

The internal mammary vessels were used in 138 of the 140 flaps in this study. Early in this study, the thoracodorsal vessels were used in two immediate reconstructions. Both of these cases were take-backs for venous congestion, and one failed. Exposure of the internal mammary vessels was achieved through the second or third intercostal space, depending on vessel size match. Seventy-eight percent of the reconstructions in group 1 were immediate, and 83 percent of the reconstructions in group 2 were immediate. Eight of the 24 delayed reconstructions (33 percent) in group 1 had previous irradiation. Of the eight delayed reconstructions having previous irradiation, three failed. Although this demonstrated a trend toward statistical significance, it was not statistically sig-

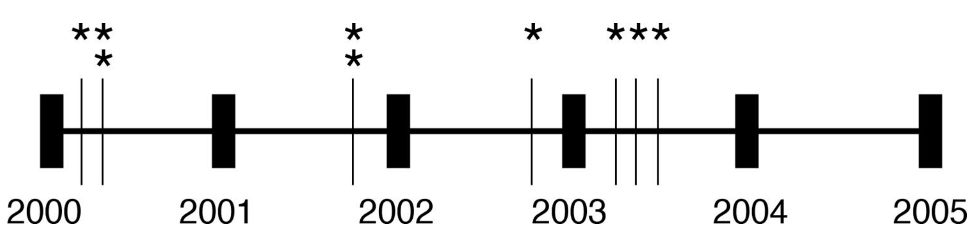

**Fig. 7.** Distribution of flap failures. Frequency of flap failure in group 1. *Single flap failure; **bilateral flap failure.

**Fig. 8.** Typical results for immediate DIEP (*above*) and delayed MS-2 free TRAM flap (*below*) reconstructions.

nificant. Three of the six delayed reconstructions in group 2 had previous irradiation, and all were successful. One of these three reconstructions was an MS-2 free TRAM flap.

## DISCUSSION

This study further defines the surgical technique of muscle-sparing free TRAM flap reconstruction and its role as a backup to the DIEP flap.[18] Although there have been numerous descriptions of muscle-sparing TRAM procedures, this description emphasizes the intraoperative identification and assessment of the medial and lateral row perforating vessels. Proper assessment of these vessels can only be done after release of the fascial collar at the site of perforator penetration. The medial and lateral perforating vessels are incorporated into this type of muscle-sparing free TRAM flap and define the limits of rectus abdominis muscle harvest, which is minimal. This technique of muscle harvest integrates the well-known principles of free TRAM flap breast reconstruction with the more recently developed principles of DIEP flap breast reconstruction. The integration of surgical techniques and the use of the proposed algorithm optimize surgical outcomes by using skeletonized perforators when they are of good quality and size and by incorporating minimal amounts of rectus muscle and fascia when the perforator anatomy is unfavorable.

This article is in agreement with and amplifies the recommendations of Nahabedian et al., who favor the DIEP flap when large perforators (1.5 to 3 mm) are visualized and a muscle-sparing free TRAM flap when perforator size is less than 1.5 mm.[1] In that study, the DIEP failure rate was reduced to 1.7 percent, with no reported partial flap necrosis or fat necrosis. This compares with a failure rate of 0 percent, no partial flap necrosis, and a 3 percent incidence of mild (<2 cm) fat necrosis in this study when the surgical algorithm was applied (group 2).

The importance of perforator quality, palpability, and caliber has been emphasized previously.[2]

Kroll reported a 17.4 percent incidence of fat necrosis and an 8.7 percent incidence of partial flap loss when selectively using the DIEP flap. Criteria for selecting the DIEP technique in that study included perforating vessels greater than 1 mm with a palpable pulse. Arnez et al. state that the DIEP flap must be based on vessels of "suitable size"; however, there is no specified lower acceptable limit.[19] They do, however, specify that the superficial inferior epigastric artery flap must be based on vessels 1.5 mm or larger. Munhoz et al. emphasize the importance of the lateral row perforators in DIEP flap harvest.[20] They conclude that the clinical appearance of the perforators, especially the arterial and venous caliber, is the major selection criterion for their flaps. They do not, however, comment on a minimal acceptable size. In a recent review by Chevray, the minimal required perforator diameter was increased from 1.2 mm to 1.5 mm during that study to decrease perfusion-related flap morbidity.[21]

Gill et al., in a recent review of 758 DIEP free flaps, noted an overall 12.9 percent incidence of fat necrosis and further noted an increasing incidence of fat necrosis related to an increasing number of perforators used for each flap.[22] Twenty-two percent of flaps using four perforators and 29 percent of flaps using five perforators were noted to have fat necrosis. This phenomenon was explained by the apparent inadequacy of flap perfusion by multiple diminutive-sized perforators; however, there was no lower limit of acceptable perforator size in that study, and all flaps were based on the DIEP technique.

The algorithm proposed in this article is consistent with the evolving philosophy that less muscle and fascia harvest directly benefits patients by decreasing abdominal donor-site morbidity.[18,23] Accordingly, by following this algorithm, the vast majority of patients should receive the DIEP flap, where no muscle or fascia is harvested. For the minority of patients who have unfavorable perforator anatomy, a minimal amount of muscle and fascia is harvested by using the MS-2 free TRAM flap technique.

Neither an MS-1 free TRAM nor an MS-0 free TRAM flap was required or used in this study. Incorporating increasing amounts of rectus muscle beyond that which is confined between the medial and lateral row perforators (MS-2 free TRAM flap) does not increase flap vascularity or reliability but does contribute to an increasing incidence of abdominal contour deformities and possibly herniation. Perforating vessels were present and isolated in all 140 flaps in this series, making either the DIEP or MS-2 free TRAM flap techniques viable alternatives for each case. The pedicled TRAM flap is still indicated when recipient vessels are not available; however, this clinical scenario did not occur in this series.

One of the most important concepts in reconstructive plastic surgery is to have a lifeboat, or backup plan, in the event that difficulties are encountered with the primary plan. Experience with this series of 120 patients has shown that perforator anatomy can be variable and occasionally unfavorable and that an alternate technique of reconstruction in these cases should be planned in advance to minimize flap morbidity. The MS-2 free TRAM flap is a reliable alterative to the DIEP flap when perforator size is diminutive. My success rate has dramatically improved by eliminating risky dissections when the perforator size is less than 1.5 mm.

The superficial inferior epigastric artery flap has also been suggested as an intraoperative alternative to the DIEP flap; however, in a recent study by Chevray, the superficial inferior epigastric vessels were found to be present in only 30 percent of cases.[21] In addition, the relatively high skin paddle position required to incorporate the periumbilical perforators of the DIEP flap usually captures branches of the superficial inferior epigastric vessels after they have arborized. This makes the superficial inferior epigastric pedicle difficult to reliably isolate, even when it exists. Stated alternately, to maximize chances for successful superficial inferior epigastric artery flap reconstruction, the skin paddle needs to be designed lower on the abdominal wall, as illustrated by previous authors.[24] This lower skin paddle position, however, is not desirable for DIEP flap harvest.

The benefits of the DIEP flap have become increasingly clear and have included decreased abdominal wall morbidity, decreased pain, shorter hospital stay, and possibly decreased cost when compared with more conventional techniques of autogenous breast reconstruction.[18–21,25–31] These benefits are somewhat offset by a variable incidence of total flap loss, partial flap loss, and fat necrosis.[1,3,31,32] These complications are related to a diminutive perforator blood supply that is inadequate for good flap perfusion. The low incidence of partial flap loss and fat necrosis in this study can also be explained based on the conservative use of skin paddle in zones II and III. These recommendations for conservative skin paddle use are similar to the recommendations for the classic single-pedicle TRAM flap.[33] This study is also in agreement with Garvey el al., who show that the DIEP flap technique can be applied to a large range of body types, including obese patients.[34] The largest patient in this study weighed 291 pounds and underwent an uncomplicated unilateral DIEP flap reconstruction.

## CONCLUSIONS

The unfavorable clinical situation of diminutive perforator blood supply occurs in the minority of cases but should be recognized intraoperatively. I believe that the failure to recognize this clinical situation partly explains the low but consistent frequency of flap failure in group 1 (Fig. 8). I think that the statistically significantly increased success in group 2 was not learning curve related from increased experience with perforator dissection but was directly related to my ability to recognize unfavorable perforator anatomy. Surgical outcomes can be optimized and perfusion-related flap complications can be minimized by taking an anatomical inventory at the time of flap elevation and then following the algorithm for microsurgical breast reconstruction. This requires an integration of DIEP and free TRAM flap surgical techniques, relying on the former technique for perforators greater than 1.5 mm diameter and a modification of the latter technique when perforator anatomy is diminutive.

***John T. Lindsey, M.D.***
4228 Houma Boulevard, Suite 500
Metairie, La. 70006
jlindseyplassurg@aol.com

### ACKNOWLEDGMENT

*The author acknowledges the East Jefferson General Hospital's Department of Quality Assurance for assistance with data collection and statistical analysis.*

### DISCLOSURE

*The author has no financial interest in any product or device mentioned in this article.*

### REFERENCES

1. Nahabedian, M. Y., Momen, B., Galdino, G., and Manson, P. N. Breast reconstruction with the free TRAM or DIEP flap: Patient selection, choice of flap, and outcome. *Plast. Reconstr. Surg.* 110: 466, 2002.
2. Kroll, S. S. Fat necrosis in free transverse rectus abdominus myocutaneous and deep inferior epigastric perforator flaps. *Plast. Reconstr. Surg.* 106: 576, 2000.
3. Blondeel, P. N., Arnstein, M., Verstraete, K., et al. Venous congestion and blood flow in free transverse rectus abdominus myocutaneous and deep inferior epigastric perforator flaps. *Plast. Reconstr. Surg.* 106: 1295, 2000.
4. Namnoum, J. D. Breast reconstruction with the free TRAM or DIEP flap: Patient selection, choice of flap, and outcome (Discussion). *Plast. Reconstr. Surg.* 110: 476, 2002.
5. Allen, R. J. DIEP versus free TRAM for breast reconstruction (Letter). *Plast. Reconstr. Surg.* 111: 2478, 2003.
6. Chang, D. W. Breast reconstruction with the DIEP flap or the muscle-sparing (MS-2) free TRAM flap: Is there a difference (Discussion). *Plast. Reconstr. Surg.* 115: 445, 2005.
7. Feller, A. M., and Galla, T. J. The deep inferior epigastric artery perforator flap. *Clin. Plast. Surg.* 25: 197, 1998.
8. Allen, R. J., and Treece, P. Deep inferior epigastric perforator flap for breast reconstruction. *Ann. Plast. Surg.* 32: 32, 1994.
9. Garcia-Tutor, E., and Murillo, J. The ideal patient for the first breast reconstruction using a DIEP flap. *Plast. Reconstr. Surg.* 111: 947, 2003.
10. Heitmann, C., Felmerer, C., Durmus, C., Matejic, B., and Ingianni, G. Anatomical features of perforator blood vessels in the deep inferior epigastric perforator flap. *Br. J. Plast. Surg.* 53: 205, 2000.
11. Hamdi, M., Weiler-Mithoff, E. M., and Webster, M. H. C. Deep inferior epigastric perforator flap in breast reconstruction: Experience with the first 50 flaps. *Plast. Reconstr. Surg.* 103: 86, 1999.
12. English, J. M., and Tittle, B. J. Microsurgery: Free tissue transfer and replantation. *Sel. Read. Plast. Surg.* 7: 8, 1997.
13. Dupin, C. L., Allen, R. J., Glass, C. A., and Bunch, R. The internal mammary artery and vein as a recipient site for free flap breast reconstruction: A report of 110 consecutive cases. *Plast. Reconstr. Surg.* 98: 685, 1996.
14. Ninkovic, M. M., Schwabegger, H. A., and Andevi, H. Internal mammary vessels as a recipient site. *Clin. Plast. Surg.* 25: 213, 1998.
15. Grotting, J. C. Immediate breast reconstruction using the free TRAM. *Clin. Plast. Surg.* 21: 207, 1994.
16. Jones, G. E., Nahai, F., and Bostwick, J. Microsurgical techniques. In J. Bostwick (Ed.), *Plastic and Reconstructive Breast Surgery* , 2nd Ed. St. Louis: Quality Medical Publishing, 2000. P. 1147.
17. Schusterman, M. A. The free TRAM flap. *Clin. Plast. Surg.* 25: 191, 1998.
18. Nahabedian, M. Y., Tsangaris, T., and Momen, B. Breast reconstruction with the DIEP flap or the muscle-sparing (MS-2) free TRAM flap: Is there a difference? *Plast. Reconstr. Surg.* 115: 436, 2005.
19. Arnez, Z. M., Khan, U., Pogorelee, D., and Planisck, F. Rational selection of flaps from the abdomen in breast reconstruction to reduce donor site morbidity. *Br. J. Plast. Surg.* 52: 351, 1999.
20. Munhoz, A. M., Ishida, L. H., Sturtz, G. P., et al. Importance of lateral row perforator vessels in deep inferior epigastric perforator flap harvesting. *Plast. Reconstr. Surg.* 113: 517, 2004.
21. Chevray, P. M. Breast reconstruction with superficial inferior epigastric artery flaps: A prospective comparison with TRAM and DIEP flaps. *Plast. Reconstr. Surg.* 114: 1077, 2004.
22. Gill, P. S., Hunt, J. P., Guerra, A. B., et al. A 10 year retrospective review of 758 DIEP flaps for breast reconstruction. *Plast. Reconstr. Surg.* 113: 1153, 2004.
23. Nahabedian, M. Y., Dooley, W., Singh, N., and Manson, P. M. Contour abnormalities of the abdomen following breast reconstruction with abdominal flaps: The role of muscle preservation. *Plast. Reconstr. Surg.* 109: 91, 2002.
24. Allen, R. J. Autogenous augmentation mammoplasty with microsurgical tissue transfer. *Plast. Reconstr. Surg.* 112: 97, 2003.
25. Feller, A. M. Free TRAM: Results and abdominal wall function. *Clin. Plast. Surg.* 21: 223, 1994.
26. Kroll, S. S., Gherardini, G., Martin, J. E., et al. Fat necrosis in free and pedicled TRAM flaps. *Plast. Reconstr. Surg.* 102: 1502, 1998.
27. Kroll, S. S., and Marchi, M. Comparison of strategies for preventing abdominal wall weakness after TRAM flap breast reconstruction. *Plast. Reconstr. Surg.* 89: 1045, 1992.

28. Grotting, J. C., Urist, M. M., Maddox, W. A., and Vasconez, L. O. Conventional TRAM versus free microsurgical TRAM for immediate breast reconstruction. *Plast. Reconstr. Surg.* 83: 828, 1989.
29. Thoma, A., Veltri, K., Khuthaila, D., et al. Comparison of the deep inferior epigastric perforator flap and free transverse rectus abdominus myocutaneous flap in post mastectomy reconstruction: A cost-effective analysis. *Plast. Reconstr. Surg.* 113: 1650, 2004.
30. Kaplan, J. L., and Allen, R. J. Cost-based comparison between perforator flaps and TRAM flaps for breast reconstruction. *Plast. Reconstr. Surg.* 105: 943, 2000.
31. Blondeel, P. N. One hundred free DIEP flap breast reconstructions: A personal experience. *Br. J. Plast. Surg.* 52: 104, 1999.
32. Nahabedian, M. Y., Momen, B., and Manson, P. N. Factors associated with anastomotic failure after microvascular reconstruction of the breast. *Plast. Reconstr. Surg.* 114: 74, 2004.
33. Shestak, K. C. Breast reconstruction with a pedicled TRAM flap. *Clin. Plast. Surg.* 25: 167, 1998.
34. Garvey, P. B., Buchel, E. W., Pockaj, B. A., Gray, R. J., and Samson, T. D. The deep inferior epigastric perforator flap for breast reconstruction in overweight and obese patients. *Plast. Reconstr. Surg.* 115: 447, 2005.