BANKING A HEMI-ABDOMINAL DIEP FLAP: A PILOT REPORT OF INDICATIONS, TECHNIQUE, AND UTILITY

SACHIN M. SHRIDHARANI, M.D., NAVIN K. SINGH, M.D., JESSE A. TAYLOR, M.D., and GEDGE D. ROSSON, M.D.*

We present a pilot report of 'banking' the contralateral hemi-abdominal deep inferior epigastric perforator (DIEP) flap under the abdominal closure in patients undergoing unilateral autologous breast reconstruction when a hemi-abdominal flap suffices. Four patients undergoing unilateral autologous breast reconstruction with a hemi-abdominal DIEP or superficial inferior epigastric artery flap had their contralateral hemi-abdominal flap left in position, or 'banked,' under their abdominal closure to be used in case of failure. This novel method may be of assistance when a free microvascular hemi-abdominal flap is felt to be threatened or suspect. It provides a life-boat for the younger and experienced surgeon alike, and most importantly, for the breast cancer survivor. Economic analysis of the technique reveals that the contralateral hemi-abdominal flap should be banked more often than intuition alone would suggest. © 2009 Wiley-Liss, Inc. Microsurgery 29:265–269, 2009.

The deep inferior epigastric artery perforator (DIEP) flap and the superficial inferior epigastric artery (SIEA) flap have become outstanding options in breast reconstruction after mastectomy for breast cancer or prophylaxis. The popularity has arisen because they eliminate much of the significant morbidity to the abdominal wall and rectus musculature associated with the traditional transverse rectus abdominis myocutaneous (TRAM) flap.[1–3] However, these perforator flaps are complex and challenging due to the high variability and unpredictability in perforator anatomy and microsurgical skill required for success. Furthermore, perforator-based flaps do not have the same blood supply that the pedicled and free TRAM flaps have.[4] Free TRAM flaps and DIEP flaps share similar source arterial blood supply and venous drainage; however, normal and abnormal anatomic variation can exist.[5] Some studies show higher rates of partial flap necrosis and fat necrosis in DIEP flaps than those in free TRAM flaps.[4,6]

We postulate that better preoperative patient selection and intraoperative conversion to a different reconstruction method based on intraoperative findings are some ways to reduce flap necrosis due to inadequate blood supply. Intraoperative identification of a flap with potential questionable blood supply is always a stressful situation for the surgeon. Therefore, we believe there is a great deal of interest in disseminating novel management options for the patient who is in need of a salvage procedure due to possible compromise.

In our institution, preoperative evaluation with CT scan angiography is conducted to see if patients are candidates for DIEP flap reconstruction.[7,8] History of abdominoplasty is an absolute contraindication secondary to previous ligation or destruction of the perforating vessel of interest.[9] Excessive adipose tissue, heavy smoking history or active smoker, and extensive peripheral vascular disease are a few of the relative contraindications for breast reconstruction by way of DIEP flap.

We present the idea of ''banking'' the contralateral hemi-abdominal adipocuteneous flap under the abdominal closure in patients undergoing unilateral autologous breast reconstruction when a hemi-abdominal flap suffices for volume. We sought to evaluate the use of banking a hemi-abdominal adipocutaneous flap in patients when an index DIEP or SIEA flap seemed potentially compromised or when the recipient reconstruction site had severe radiation changes. In these cases, the intra-operative concern was that the patient may potentially require the contralateral, banked flap as the salvage maneuver for reconstruction. Despite a relatively high volume of microsurgical perforator flap breast reconstructions and a low flap failure rate (~2%) at our institution, we encountered a few rare cases where banking the contralateral hemi-abdomen seemed warranted.

METHODS

We conducted a retrospective analysis of the Johns Hopkins Avon Foundation Breast Center patients pertaining to breast reconstruction with a DIEP or SIEA flap for all patients over the past 3 years. The Johns Hopkins Medicine Institutional Review Board approved this study. No patients were excluded. Only patients who had their contralateral hemi-abdomen left in place after microvas-

Division of Plastic, Reconstructive and Maxillofacial Surgery, The Johns Hopkins University School of Medicine, Baltimore, MD

This article was a poster presentation at the 9th International Course on Perforator Flaps, Clinica Planas, Barcelona, Spain, October 5–9, 2005.

This article was a podium presentation at the American Society for Reconstructive Microsurgery Annual Meeting, Loews Ventana Canyon Resort in Tucson, Arizona, January 14–17, 2006.

*Correspondence to: Gedge D. Rosson, M.D., Division of Plastic, Reconstructive and Maxillofacial Surgery, Johns Hopkins Outpatient Center, McElderry 8161, 601 North Caroline Street, Baltimore, MD 21287.
E-mail: gedge@jhmi.edu

Received 15 July 2008; Accepted 5 November 2008

Published online 9 March 2009 in Wiley InterScience (www.interscience.wiley.com). DOI 10.1002/micr.20611

Figure 1. Contralateral DIEP flap remains attached to fascia during temporary closure. [Color figure can be viewed in the online issue, which is available at www.interscience.wiley.com.]

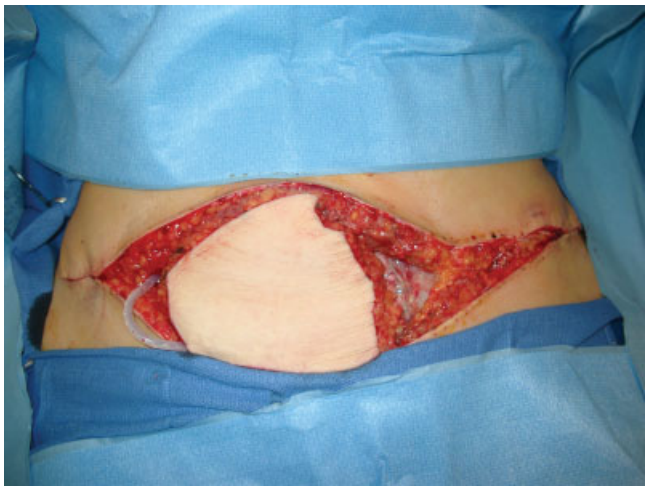

Figure 2. Contralateral DIEP flap 5 days after it was 'banked.' [Color figure can be viewed in the online issue, which is available at www.interscience.wiley.com.]

cular transfer of their index flap were evaluated and considered for this study.

During this study period, 510 DIEP or SIEA flaps in 384 patients were performed. Clearly this technique could neither be performed in any bilateral DIEP flap patient nor any patient in whom the volume requirement clearly exceeded a hemi-abdominal flap. Overall, four patients required "banking" of the contralateral hemi-abdominal DIEP flap, representing less than 1% of the total DIEP or SIEA flaps performed. All patients were women with an average age of 54 (range 46–71, SD 11.4) and with an average BMI of 28 (range 23–30, SD 5.0). These demographics were not statistically different from the historic values of our DIEP or SIEA flap patients. Complications such as surgical site infections, dehiscences, hematomas, seromas, thromboembolic events, and abdominal bulges were evaluated.

Operative Technique

After microvascular transfer of the index hemiabdominal flap as a microvascular free tissue transfer, the contralateral hemi-abdominal adipocutaneous flap is kept attached by all its major perforators, and the abdominal skin is closed (see Fig. 1). The skin closure requires the standard superior dissection of the upper abdominal adipocutanous tissues toward the xiphoid and the costal margins, as would any standard abdominal donor site closure for a typical TRAM or DIEP flap surgery. It would be fair to say that a subtle increase in the superior extent of the dissection may be required for accommodation of the added bulk of the "banked" flap. The patient is then flexed at the waist, and the upper abdominal flap is inset to the lower abdominal skin edge, over the retained hemi-abdominal flap, which is now buried underneath the adipocutaneous tissues. Because of the fact that the "banked" hemi-abdominal flap is still attached to all its major rectus abdominus perforators, there is no need to monitor this flap. The skin incisions are closed with deep dermal buried 3-0 polyglycolic acid sutures and stainless steel surgical skin staples. The skin staples and the incisions are then covered with Xeroform gauze. This skin closure allows ease and rapidity of opening the abdominal tissues to access the buried flap when the patient is brought to the operating room at a later date. On return to the operating room, the temporary staples are removed, and the flap seems pristine and healthy (see Fig. 2).

Statistical Analysis

Because of the nature of a retrospective chart review, much of the analysis was descriptive. Whenever comparative data were obtained, we applied the following analysis: A chi-square statistic was used when the characteristic or outcome was categorical, and a Student t test was used when the variable of interest was continuous. All testing was two sided at the 0.05 alpha level.

Economic Analysis

Various economic assumptions are made and coupled with standard economic modeling equations to generate a cost-utility model. The specifics of the assumptions and equations are detailed in Discussion section.

RESULTS

In one case, the appearance of the flap at the completion of the microsurgical anastomoses was worrisome, but a technical problem could not be discerned. The patient was noted to have a history of dermatographia (which her biologic son also had). Dermatographia is defined as

"a condition in which pressure or friction on the skin gives rise to a transient raised usually reddish mark so that a line traced on the skin becomes visible."[10] Although the patient had no obvious sign of vascular perfusion compromise, it was difficult to discern between venous congestion and erythema from her previous pathologic diagnosis. Although unwilling to discard the viable (albeit concerning) flap, we were loathe to discard the intact contralateral hemi-abdominal tissues.

In two cases, it was obvious from the extreme post radiation changes to the recipient site that the patient would not tolerate reconstruction with an implant. Because only autologous tissue would suffice as the reconstruction option, and as the hemi-abdomen had sufficient volume, it was felt necessary to preserve the contralateral hemi-abdomen until the team was fully convinced that the compromised donor site would support the current DIEP flap. If problems were to occur and the current flaps were not to survive because of vessel mismatch or other anatomical and pathologic issues, at least there would be a contralateral TRAM or DIEP flap available to utilize as a pedicle flap or repeat free flap. In these cases, there was no evidence of flap compromise during the operation and when leaving the operating room. Fortunately, in the three aforementioned patients, index flap survival was 100% and the patient only required the subsequent procedure of removing the banked tissue.

The fourth patient in our retrospective review underwent breast reconstruction with a SIEA flap. This patient had a BMI of 30 and it was noted intraoperatively that the patient would have a fair amount of redundant abdominal tissue for reconstruction if the full harvest for a DIEP flap was to be performed. As the quality and caliber of her SIEA were in good condition, the surgery proceeded by utilizing the SIEA flap. No overt complications were noted in the operating room, however, given her history of radiation, extensive amount of postradiation scarring, body habitus, and need for autologous tissue for reconstruction, the patient's contralateral hemi-abdomen was banked. The operating surgeon felt the dermal bleeding from the skin edges was not as robust as usual, but did not wish to completely discard the index flap. On postoperative day 6, the patient was noted to have a warm tissue island; however, the skin edges of the flap had minimal bleeding and skin blistering was noted. We were concerned that this flap would develop significant fat necrosis to an unacceptable degree. At this time, the patient returned to the operating room for exploration. Although no anatomical or technical problem could be identified, and the vascular pedicle was patent, dermal bleeding was weak and not present at all edges. Therefore, the index flap was resected and discarded. The previously banked contralateral hemi-abdomen was then mobilized and utilized as a pedicle TRAM flap. The patient tolerated the procedure well and had her TRAM flap as her definitive breast reconstruction.

The timing of the reconstructions are as follows: three patients had delayed free flap breast reconstructions several months to years after mastectomy and radiation; one patient had a planned staged autologous breast reconstruction with immediate placement of tissue expander at the time of mastectomy to save the skin envelope, followed by abdominal autologous tissue flap 4 months later.

The average ischemia time was 54 min (range 34–62, SD 13.4), which was not statistically different from our control DIEP flap patients. The average number of days elapsed between the index free flap and the return to surgery for removal of contralateral "banked" hemi-abdominal flap (three patients) or the pedicled TRAM surgery (one patient) was 3.8 days (range 2–6, SD 2.1). Details of the four patients are given in Table 1. Of note, the patients suffered no ill-effects from the banked flaps-no increased surgical site infections, dehiscences, hematomas, seromas, thromboembolic events, blood transfusions, or abdominal bulges.

DISCUSSION

We present a pilot report of "banking" the contralateral hemi-DIEP flap under the abdominal closure in patients undergoing unilateral autologous breast reconstruction when the volume of a hemi-abdominal flap suffices. The banked flap can be left intact on its perforators and buried under the abdominoplasty closure to be 1) harvested and used in the event of free flap failure, or 2) excised in the event of a successful primary free tissue transfer. We recommend transferring the ipsilateral hemi-DIEP preferentially if the internal mammary vessels are the recipient vessels so that the option of a contralateral pedicled flap remains. If the thoracodorsal system receives the index free tissue transfer, it would appear that either hemi-abdomen could be used as the index flap. However, the ipsilateral hemi-abdomen would still be preferred to allow for the option of a pedicled technique for breast reconstruction salvage. This may also be an acceptable alternative in special circumstances in which a solo microsurgeon attempts a bilateral DIEP flap and can only safely perform one flap on a given day; the second flap perhaps could be "banked" and transferred 4 or 5 days later.

At first glance, the idea of banking a flap in case of failure seems radical in terms of economic cost. Whenever a new or unconventional approach is tried, one has to ask about its cost-effectiveness. We have developed an analysis modeling the costs of repeat surgery, costs of salvage of an operation, and the frequency with which flap re-exploration is required. Although the details of the

Table 1. Details of Our Four 'Banked' DIEP Flap Patients

Patient	Age	HPI	Staged vs. delayed	Ht/wt/ BMI	Surgery	Misc
1	71	Mastectomy, chemo and Xrt 1 ypts	Delayed	5′3″ 160 cm 130 lb 59 kg BMI: 23	Right DIEP to RIMA Hemi flap resected POD 2	Prereconstr xrt 62 min ischemia
2	49	Mastectomy, Xrt 3 ypts	Delayed	5′3″ 160 cm 190 lb 86 kg BMI: 33.7	Left DIEP to LIMA Hemi flap resected POD 2	Prior failed implant Prereconstr xrt 60 min ischemia
3	51	Mastectomy w/tissue expander 4 mpts	Staged	5′6″ 168 cm 150 lb 68 kg BMI: 24.2	Left DIEP to LIMA Hemi flap resected POD 5	Planned staged reconstr No xrt 34 min ischemia
4	46	Mastectomy 14 mpts chemo 9 mpts Xrt 7 mpts	Delayed	5′4″ 163 cm 175 lb 80 kg BMI: 30	Left SIEA to LIMA *Failure Reconstr with Right banked TRAM flap POD 6	Prereconstr xrt 60 min ischemia
Mean	54			BMI: 28	POD: 3.8	Min ischemia: 54
Range	46–71			BMI: 23–33.7	POD: 2–6	Min ischemia: 34–62
Standard deviation	11.4			BMI: 5.0	POD: 2.1	Min ischemia: 13.4

BMI, Body Mass Index; Chemo, chemotherapy; Etoh, alcohol use; min, minutes; mpts, month(s) prior to surgery; POD, postoperative day; Tob, tobacco exposure; XRT, radiation therapy; ypts, year(s) prior to surgery.

equations are omitted here for the sake of brevity, it becomes apparent that even though flaps need to be re-explored only a rare minority of time (from 1 to 9%), given the high costs associated with salvage attempts (because of repeat OR, blood transfusions, antibiotics, and anticoagulants), banking a flap is not as uneconomic as it sounds. We performed a sensitivity analysis across a range of costs and a range of rates of flap complication, and from this analysis, banking a hemi-abdominal flap can be helpful without increasing the costs of care for breast reconstruction in many clinical scenarios. This type of sensitivity analyses have helped in decision-making clinical guidelines in instances such as in the distribution of vaccines, screening mammograms, and other diagnostic and therapeutic interventions, and are germane to intraoperative decision making in breast reconstruction as well.

This mathematical analysis demonstrates that banking a hemi-DIEP flap is more economically sound than intuition alone would suggest. Add in the emotional overlay, sense of disappointment of a failed reconstruction, medico-legal implications of flap failure, and patient satisfaction from knowing that there is a safety net, it is even more desirable than our simple economic analysis indicates. In short, "banking" a hemi-DIEP flap changes the patient experience from one of therapeutic failure to a simple change in plan. On the other hand, the patient may be worried that she is only a small segment of the overall patient base that needs a second surgery, or that they might get a pedicled TRAM. All of these scenarios would have to be discussed in detail with the patient prior to the second stage surgery if she had such a banking procedure.

Cost-utility analysis of free tissue transfer for breast reconstruction has been favorable.[11,12] Using conservative economic assumptions we found that if the probability of free-flap loss is felt to be greater than 10%, then the remaining hemi-abdomen could be banked for later use as a pedicled or free tissue transfer for breast reconstruction.

One of the clear limitations of this technique and this report is that the patients were not preoperatively informed of the possibility. Because of the fact that the surgeons made the decision to "bank" the contralateral hemi-abdominal tissues based on an intraoperative decision, the patients were not specifically informed of this option preoperatively. This could be more easily addressed moving forward prospectively, now that we are all more aware of this technique as an option.

We report this as a novel method that may be of assistance when a flap is felt to be threatened by a microvascular microcirculation problem rather than an anastomotic problem and when chance of success remains good. For example, it can be clinically difficult to distinguish reperfusion reactive hyperemia from mild intrinsic venous congestion of the flap. This concept of "banking" the contralateral hemi-abdominal flap may also be indicated clinically in situations when the patient has very severe radiation damage and absolutely cannot have an implant-based reconstruction. These patients truly require autologous tissue. The volume of the hemi-abdominal

flap must be sufficient for esthetic reconstruction of the breast. This technique is not meant to become a routine fall-back for low-volume centers; rather it should be reserved for the strict, rare indications described earlier. The disadvantages are clear. Most importantly, an obligatory return trip to the operating room, even if the index flap succeeds. This very obvious disadvantage must always be weighed against the potential benefit of the ease of salvage of the breast reconstruction with the "banked" flap should the index flap fail.

This is not a remedy for a truly deteriorating flap. Remember, it would be inappropriate to remove a patient with a failing flap from the operating room; everything possible should be done to salvage a dying flap while it is still viable. If nonflap factors are a concern, such as brittle irradiated recipient vessels, then a repeat contralateral flap would have less chance of success, and a pedicled flap from the contralateral side should be utilized.

Banking the contralateral hemi-DIEP flap provides a life-boat for the younger and veteran surgeon alike, and most importantly, for the breast cancer survivor. Our review of the English literature via PubMed Medline, since the first report of the TRAM flap[13] has not demonstrated a prior report of this method. The idea of banking a free flap is not new,[14] but this particular strategy for a banked flap we feel is novel.

REFERENCES

1. Nahabedian MY, Momen B, Galdino G, Manson PN. Breast reconstruction with the free TRAM or DIEP flap: Patient selection, choice of flap, and outcome. Plast Reconstr Surg 2002;110:466–475; discussion 476–467.
2. Vyas RM, Dickinson BP, Fastekjian JH, Watson JP, Dalio AL, Crisera CA. Risk factors for abdominal donor-site morbidity in free flap breast reconstruction. Plast Reconstr Surg 2008;121:1519–1526.
3. Wu LC, Bajaj A, Chang DW, Chevray PM. Comparison of donor-site morbidity of SIEA, DIEP, and muscle-sparing TRAM flaps for breast reconstruction. Plast Reconstr Surg 2008;122:702–709.
4. Lipa JE. Breast reconstruction with free flaps from the abdominal donor site: TRAM, DIEAP, and SIEA flaps. Clin Plast Surg 2007; 34:105–121; abstract vii.
5. Rozen WM, Ashton MW, Pan WR, Taylor GI. Raising perforator flaps for breast reconstruction: The intramuscular anatomy of the deep inferior epigastric artery. Plast Reconstr Surg 2007;120:1443–1449.
6. Scheer AS, Novak CB, Neligan PC, Lipa JE. Complications associated with breast reconstruction using a perforator flap compared with a free TRAM flap. Ann Plast Surg 2006;56:355–358.
7. Rosson GD, Williams CG, Fishman EK, Singh NK. 3D CT angiography of abdominal wall vascular perforators to plan DIEAP flaps. Microsurgery 2007;27:641–646.
8. Masia J, Clavero JA, Larranaga JR, Alomar X, Pons G, Serret P. Multidetector-row computed tomography in the planning of abdominal perforator flaps. J Plast Reconstr Aesthet Surg 2006;59:594–599.
9. Granzow JW, Levine JL, Chiu ES, Allen RJ. Breast reconstruction using perforator flaps. J Surg Oncol 2006;94:441–454.
10. Merriam-Webster Online. http://medical.merriam-webster.com/cgi-bin/medical?book=Medical&va=dermographism. Accessed September 15, 2008.
11. Thoma A, Khuthaila D, Rockwell G, Veltri K. Cost-utility analysis comparing free and pedicled TRAM flap for breast reconstruction. Microsurgery 2003;23:287–295.
12. Kroll SS, Reece GP, Miller MJ, Robb GL, Langstein HN, Butler CE, Chang DW. Comparison of cost for DIEP and free TRAM flap breast reconstructions. Plast Reconstr Surg 2001;107:1413–1416; discussion 1417–1418.
13. Hartrampf CR, Scheflan M, Black PW. Breast reconstruction with a transverse abdominal island flap. Plast Reconstr Surg 1982;69:216–225.
14. Sadove RC, Powell LA. Simultaneous maxillary and mandibular reconstruction with one free osteocutaneous flap. Plast Reconstr Surg 1993;92:141–146.