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Breast Reconstruction with Microvascularly Augmented TRAM Flap

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ABSTRACT

Modern trends in breast reconstruction with TRAM flap have promoted adequate blood supply to the flap while minimizing the donor site defect in the anterior abdominal wall. To improve the blood supply of the pedicled flap we have performed an additional microvascular augmentation to this type of breast reconstruction procedure since 1998. Twenty supercharged TRAM flaps were performed for breast reconstruction after modified radical mastectomy. There were 19 immediate and one delayed reconstruction. The contralateral deep inferior epigastric pedicle was anastomosed to the thoracodorsal vein and artery. Reinforcing polypropylene mesh was applied routinely for abdominal closure. For the arterial anastomoses this technique proved to be feasible in all patients. For the venous anastomoses only in 3 of 20 patients the anastomoses failed. There is no single case of total or partial flap loss. Fat necrosis was observed in 10% of cases. The incidence of abdominal bulge or hernia was zero percent. The supercharged TRAM flap produces an improvement in vascularity that permits use of all four zones of the flap. It minimizes the risk of total flap loss. The main disadvantage is less freedom in positioning the flap due to the presence of the superior muscular pedicle.

Key Words: *Breast reconstruction - TRAM flap.*

INTRODUCTION

During the past 15 years, the TRAM flap has firmly established itself as the standard for autogenous tissue breast reconstruction worldwide [**1**]. It provides the reconstructive surgeon with the ability to simulate a breast almost of any size and shape, while simultaneously improving the contour of the lower abdominal flap donor area. It was initially described as a unipedicle island flap by Hartrampf in 1982 [**16**]. One of the main disadvantages of the procedure, however, is the unpredictable occurrence of fat necrosis and skin loss complicating the healing in a relatively high percentage (13-36%) of patients [**38**]. Fewer complications may be encountered by selecting patients and by modifying the operative technique to improve circulation in the flap.

Maneuvers to increase the circulation of the flap include:

1- A more proximal, periumbilical (mid abdominal) flap [**36**].

2- A delay procedure [**5**].

3- The use of double superior pedicle [**6**].

4- Application of a turbocharge (bypassing) the midline choke arteries by connecting both inferior pedicles [**33**].

5- Application of a supercharge "connecting an inferior pedicle to vessels in the recipient area" [**14**].

6- Omission of the superior pedicle and use of the (dominant) inferior pedicle as a free flap [**13**].

The drawback unique to the mid abdominal TRAM flap is an aesthetic one. The mid abdominal scar is neither as attractive nor as unobtrusive as the suprapubic scar left by harvesting a lower abdominal skin island. Another problem is the more limited opportunity for improvement of the lower abdominal contour. Also, due to the shorter pedicle length, the flap mobility and excursion is significantly limited [**22**]. The major disadvantage of a preoperative delay with TRAM flaps is the necessity for a preliminary operation. Associated with this surgery is the local discomfort at the delay sites and requirements of wound and dressing care. The second disadvantage is that the potential for additional abdominal scar if the site of the flap delay cannot be incorporated into the incision for harvesting the TRAM flap [**1**]. The use of a double pedicle impairs the integrity of the

abdominal wall too much. Patients do show a decrease in absolute truncal flexion force generation capability. The incidence of lower abdominal hernia or bulging has been high. Significant contour defect from the muscle at the xiphoid has been found which may necessitate second revisional surgery using suction assisted lipectomy of the subcutaneous fatty tissues in this region [23]. Turbo charging the flap by connecting both inferior pedicles improves the circulation in the contralateral skin flap by bypassing the barrier of the midline choke arteries, but does not improve any impaired inflow through the nondominant superior pedicle [22]. The main disadvantages of the free TRAM flap are an increased risk of total flap loss, increased operative time and increased need for blood transfusion [9].

The supercharged TRAM flap has been presented as a method where the single superiorly based pedicle can be augmented by additional flow by means of the microvascular anastomosis of the deep inferior epigastric artery and vein to recipient vessels in the axillae [14]. The deep inferior epigastric artery has been demonstrated to be the dominant artery to the lower abdominal region [24]. The preferred recipient vessels for the supercharged flap as well as the free TRAM flap include the axillary branches and the thoracodorsal artery and its divisions. The internal mammary system also has been utilized successfully [2,26]. In this paper we tried to evaluate the effect of supercharging the TRAM flap for breast reconstruction as regards flap site complication and donor site morbidity.

PATIENTS AND METHODS

Between July 1998 and June 2000, 20 TRAM flap reconstructions were performed at NCI, Cairo University. Of this group 19 patients were scheduled preoperatively for immediate supercharged TRAM flap breast reconstruction using the thoracodorsal vessel as the recipient vessel for the flap. Only one patient was scheduled for delayed reconstruction 3 years after the modified radical mastectomy.

Eligibility requirements:

1- Pathologically documented breast cancer either by FNAC or frozen section.

2- Disease stage T_2-T_3-N_0-N_1 M_0 breast cancer according to TNM classification.

3- Age less than 60 years.

4- Karnofisky performance status > 70.

5- Preoperative metastatic work up including CXR, abdominopelvic ultrasonography and bone scan should be negative for metastases.

Exclusion criteria:

1- Patients age more than 60 years.

2- Poor liver or kidney function.

3- Poor performance status.

4- Presence of metastatic disease.

5- Multiple abdominal scars especially bilateral Kocher incisions, colostomies, previous abdominoplasty or suction lipectomy.

Technique:

The operation is performed by two surgeons either simultaneously or sequentially. One surgeon starts with modified radical mastectomy, then dissects a contralateral superiorly based TRAM flap. The TRAM flap is raised in a standard way except in that we include the umbilicus in the flap to be used later for nipple reconstruction. After the development of the skin flap and the proximal muscular pedicle, the inferior vascular pedicle is dissected to its origin from the external iliac vessels, as is done in a free flap procedure. After that the inferior end of the muscle is divided and the flap tunneled to the recipient area. During flap elevation, the second surgeon starts to prepare the recipient thoracodorsal vessels under loupe (power x 5) magnification. Small branches are ligated or clipped. The length of the vessels disclosed in this way measures 7-10 cm. After positioning the flap with a few temporarily placed stitches, the deep inferior epigastric vessels are anastomosed end to end to the thoracodorsal vessels using loupe magnification. We preferred to use the thoracodorsal trunk proximal to the takeoff of the crossing vessel to the serratus, since the vessels are larger proximal to this division and blood supply will be assured to the remaining latissimus dorsi muscle through the collateral serratus circulation. The arterial microanastomoses are done using ethilon 8/0 continuous suture. The venous anastomoses are performed using ethilon 9/0 interrupted suture. If there are two epigastric veins present in the pedicle the largest one is used for the anastomosis. After revascularization, the distal end of the muscle is positioned in such a way that kinking of the vessels is prevented. Then the flap is shaped and su-

tured in layers after insertion of suction drains. Purse string suture using 2/0 prolene is applied at the umbilical base to construct the new nipple. We routinely plicate the opposite anterior rectus sheath so as to balance the abdominal wall closure. Synthetic prolene mesh is routinely used to repair the abdominal wall defect. All skin wounds are sutured subcutaneously using 3/0 prolene. Prophylactic subcutaneous heparin are given routinely during the postoperative period. Postoperative adjuvant radiotherapy and/or chemotherapy are given as indicated.

RESULTS

Patients age ranged from 25 to 60 years with an average 44.2 years. Average operating time was 6.9 hours including the mastectomy (range from 5-9 hours). All but two patients required blood transfusion; an average of 2 units of blood was transfused per patient. In no single patient was the thoracodorsal artery judged to be insufficient as a recipient artery. In all flaps the thoracodorsal artery was of an appropriate calibre and length to make an end to end anastomosis, even without significant discrepancies in diameter (Fig. 1). In three patients the thoracodorsal-inferior epigastric vein anastomoses could not be performed. In one patient the inferior epigastric vein was present as two equal sized small veins which made venous anastomosis impossible. In another patient the thoracodorsal vein was too short and precluded venous anastomosis. Thoraco-acromial vein was used to complete the microanastomosis. In the third case (where delayed reconstruction was intended) the thoraco-dorsal vein was injured during dissection and there was no other available nearby vein. The average hospital stay was 12 days (range 7-15 days). The average follow-up period was 15 months, ranging from 3 months to 2 years. Postoperative radiotherapy had been given in 15 patients and all patients received postoperative adjuvant chemotherapy. In one patient a haematoma developed under the upper breast flap which needed evacuation and repeated dressing. Donor site complications such as abdominal hernia or bulge were not recognized in any patient Fig. (2,3,4). There is no single case of partial or total flap loss Fig. (5,6). Fat necrosis was documented pathologically in two patients at the medial end of the flap. In four patients an assessment was made of the blood flow through the anastomosed vessels using duplex sonography 6 months postoperatively (Fig. 2). Adequate arterial flow could be demonstrated in all four patients, with flow velocity ranging from 15 cm/sec to 45cm/sec. Venous flow was detected in three patients, with velocity ranging from 12 to 25 cm/sec.

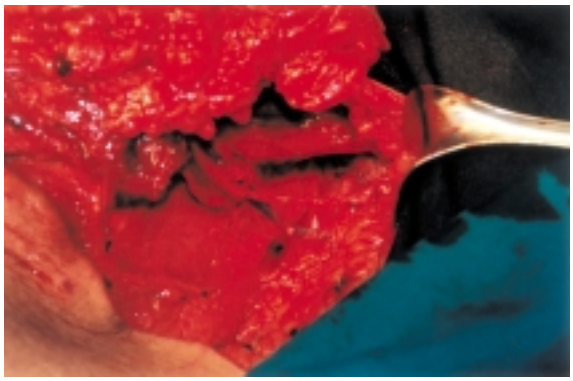


Fig. (1): Showing completed microvascular anastomosis between thoracodorsal artery and vein and deep inferior epigastric artery and vein in the axilla.

Fig. (2): 3 Months postoperatively showing no abdominal sequallae.

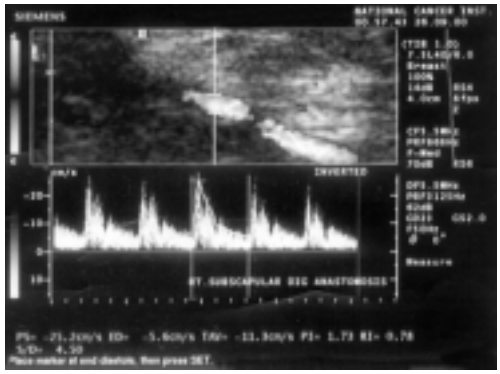
Fig. (3): 18 Months postoperatively showing no evidence of abdominal hernia or bulge inspite of huge volume of tissue transfer.

Fig. (4): One year postoperatively showing excellent abdominal wall integrity.

Fig. (5): Early postoperative period showing no evidence of ischaemia.

Fig. (6): Late postoperative period without any ischaeic manifestation.

(A)



(B)

Fig. (7): Duplex sonography of the micro anastomosis showing good flow across both arterial and venous anastomoses.

DISCUSSION

Since the initial reports of use TRAM flap for breast reconstruction in the early 1980s [16], the TRAM flap has been evolved as the most widely accepted technique for autogenous breast reconstruction. The clinical results of the unilateral pedicled TRAM flap in breast reconstruction demonstrate that transfer of a myocutaneous flap with a large skin paddle on its non-dominant muscular pedicle is not ideal. It is a common observation during this operative procedure that large areas of the skin flap and the underlying subcutaneous tissue are not well perfused due to an insufficiency of inflow or outflow of blood. Potential problems can occur with the poorly vascularized contralateral portion of the flap (zone IV) including fat necrosis and skin loss [14,31].

The deep inferior epigastric artery in fact, has been demonstrated to be the dominant artery to the lower abdominal region [12]. The free TRAM flap exploits this principle and has evolved as a popular and reliable choice in breast reconstruction [3]. Marck et al. [22] noted that if the dominant deep inferior epigastric pedicle is not ligated, a decreased pressure in the artery and an increased pressure in the veins occurs. This is in conformity with the findings of Harris et al. [15], who measured the blood pressure in the deep epigastric arterial system after cutting this artery, but before tunneling to the thorax. The arterial pressure decreased by 54% (with a surprising range of 35-87%). The deleterious haemodynamic effect of the tunneling procedure has been clarified by Codner et al. [5]. They noted that the perfusion pressure before tunneling was 26.2 mmHg and decreased to 13.3 mmHg due to a significant increase in venous pressure. Thus it may be stated conclusively that in a pedicled TRAM flap blood enters the flap with difficulty and leaves it with even more difficulty. So, a rational approach to this problem is restoration of blood flow through the dominant inferior pedicle. This can be obtained in two ways: with a free flap or with a supercharge procedure. This strategy is validated both by clinical results and haemodynamic studies. In many series of free and microvascularly augmented TRAM flap reconstruction a lower incidence of complications due to ischaemia is reported.

Yamamoto et al. [39] reported 14.3% incidence of total flap loss and zero % partial flap loss in their 7 patients who underwent free TRAM flap. In their 29 patients who underwent microvascular augmented TRAM flap the incidence of partial flap loss was 2% and total flap loss was zero %. They reported 15.8% fat necrosis in microvascular augmented flap versus 28.6% in patients who underwent free TRAM flap. Marck et al. [22] performed 20 supercharged TRAM flap using the internal mammary vessels with no incidence of total flap loss. Partial flap loss occurred in one patient. Three patients developed abdominal hernia with no significant fat necrosis. This is in accordance with the results in this study as we have no single case of partial or total flap loss among the studied patients. In different series [1,9,25,32] the incidence of partial flap loss after the conventional flap ranged from 0-17% versus 0-4% after the free TRAM flap breast reconstruction. However, the incidence of total flap loss was more common after free TRAM flap breast reconstruction 1-10% than after the conventional TRAM 0-1%.

Fat necrosis and abdominal sequallae are the most common late complications in TRAM flap breast reconstruction affecting 12-35% of patients [1].

Fat necrosis is a symptom of inadequate circulation as stated by Arenz et al. [1]. In this study the incidence of documented pathologically proven fat necrosis was 10% (2 patients) [17,18,21,32,38]. In other series the bipedicled or the microvascularly augmented TRAM flaps were associated with much lower incidence of fat necrosis (0-10%) than the conventional TRAM (10-35%).

Watterson et al. [38] found that the risk factors associated with increased incidence of complications included: smoking, history of chest wall irradiation, significant abdominal scar. Their conclusion was that patient selection is a fundamental determinant of successful TRAM flap breast reconstruction. Among patients with multiple risk factors, the risk of tissue loss in the reconstructed breast may be diminished by use of a bipedicled TRAM flap.

Edsander-Nord et al. [8] found that the use of a pedicled or free TRAM flap did not influence postoperative abdominal strength per se and the difference between the procedures is relatively small compared with individual variations, indi-

cating that there are more important factors than the kind of surgery influencing the restoration of muscle strength. We agree with Edsander, as we have zero percent incidence of abdominal hernia and 95% of our patient can do sit-up performance without using their hands. Kroll et al. [21] found an incidence of an abdominal bulge 3.8% and hernia 2.6% after 268 TRAM flap breast reconstruction. Synthetic mesh was required for reinforcement of donor site closure twice as often in the conventional TRAM patients versus the free TRAM patients. The ability to perform sit-ups was 63% for the free TRAM group versus 57.1% after the conventional TRAM. They concluded that the incidence of abdominal bulge or hernia is relatively independent of the type of TRAM flap used.

Immediate breast reconstruction has been shown to be safe and well tolerated in patients with early beast cancer who must undergo mastectomy [19]. Patients reconstructed with the free or supercharged TRAM flap have had lower incidence of partial flap necrosis and less of a delay in receiving adjuvant therapy. Grotting et al. [13] pointed out several advantages of using free TRAM or microvascular augmented TRAM flap in the immediate setting. (1) This approach avoids concerns regarding thoracodorsal vessel injury as a result of repeated surgery and potential vessel ligation from previous axillary lymph node dissection. (2) Perivascular fibrosis and the potential effect of prior radiation therapy are eliminated. (3) The frequency of non usable axillary vessels as recipient vessels in the delayed breast reconstruction setting has been reported at 15% with 6% incidence of flap loss (Ferg) [10]. Elliott et al. [9] added that immediate reconstruction has the benefit of a single anaesthetic event and decreased overall costs. Also, skin sparing mastectomy incisions can add a more natural appearance to the final result because the skin is not scarred down to the chest wall as in the delayed reconstruction. The psychological issues have been emphasized by others [27,30].

The axilla can provide multiple options for both recipient artery and vein. If the thoracodorsal vessels were not available, the subscapular circumflex, lateral thoracic and even the axillary vessels could be considered (Shaw) [35]. In addition the inferior epigastric vein may present as two equal sized smaller veins. They can be anastomosed both to independent recipient veins so as to provide the most ideal venous drainage for the flap. The variety of options in the axilla permits revision of the anastomosis if thrombosis has occurred (Serletti et al.) [34].

Thoracodorsal vessels have been the most frequently used recipient vessels for immediate free and supercharged TRAM flap breast reconstruction. The mastectomy flaps allow access to the axilla for lymphadenectomy. This access has allowed easy approach for performing microanastomosis in the axilla. Thoracodorsal vessels have usually been exposed as a result of lymphadenectomy and have typically required little additional operative time for preparation as recipient vessels [28]. These vessels have had consistent anatomy, have provided adequate vessel diameters, have had a good size match for the majority of inferior epigastric vessels and have proven success record of free flap success [29].

There is growing support in the literature for the use of internal mammary vessels as the first choice, especially in delayed free TRAM or microvascularly augmented reconstruction, in the light of recent anatomic studies that have shown the internal mammary vein to be consistently adequate above the level of the 4th intercostal space [4,7,10,26]. This approach avoids surgery in the previously operated or irradiated axilla, requires a shorter pedicle length and allows for more medial placement of the TRAM tissue. However, Ninkovic et al. [26] mentioned that the thin and fragile wall of the vein may preclude its use. In addition harvesting of the vessels is carried out by rib resection or minithoracotomy a step that adds to the morbidity of such an operation (Kaddoura et al.) [20]. Other disadvantages include difficulties in microanastomosis because of a limited field, respiratory movements [26]. In addition the operation for dealing with anatomic variations within the inferior epigastric vessels and for dealing with thrombosis occurrence are much more limited at the internal mammary site [4,12,35].

In this study, the results of postoperative blood flow measurements, demonstrating a high flow in both artery and vein, confirm the haemodynamic importance of the anastomosed inferior pedicle. This flow is sustained during follow-up. Our arterial flow velocity ranging from 15 cm/sec to 45 cm/sec. Whereas venous flow velocity ranging from 12-25 cm/sec. Mark et al.

[22] flow measurements in the immediate post-operative period of internal mammary vessels supercharged TRAM flap have demonstrated adequate flow. Their arterial flow velocity ranging from 7-16 cm/sec; while venous flow was ranging from 4-10 cm/sec. These measurements are far less than the thoracodorsal vessels supercharged TRAM.

A major criticism of the microvascular procedures has been the operative time involved. Our average time of 6.9 hours is no longer than that reported by Arenz et al. **[1]** 5.6 hours, Grotting et al. **[13]** 8.42 and Elliot et al., 6.5 hours **[9]**. Hospital stay of an average 12 days in this series are significantly longer than of Hartrampf's **[16]** series (7 days). There is no apparent surgical reason for this and the difference may be due to social, economic and cultural variations.

The question of whether the free flap or the supercharged procedure should be preferred deserves a balanced answer. Technically the procedures do not differ significantly. Theoretically the supercharge procedure may produce more donor site damage and sometimes a slight restraint in the positioning of the flap due to the presence of the muscular pedicle. The advantage of the supercharge procedure is that the risk of complete loss of the flap almost eliminated, in contrast to the free flap procedure. Preference depends on economic, personal and institutional factors. Further improvement of the operative technique may be obtained by supercharging zone 4 by harvesting the inferior vascular pedicle at the contra-lateral side of the muscular pedicle with muscle splitting technique, thus maintaining abdominal integrity as much as possible.

Conclusion:

From this study it seems that supercharging a pedicled TRAM flap on the thoracodorsal vessels is suitable in almost all patient. The supercharge procedure is comparable to the free flap procedure in operation time, technical difficulty and hemodynamic consequences. The disadvantages compared with a free flap are the possibility of increased in donor site damage and a slightly more difficult positioning and shaping of the flap due to the presence of the superior muscular pedicle. The main advantage is that the risk of complete flap loss is eliminated. Further improvement may be obtained by supercharging the contra-lateral perforators of the flap with muscle splitting technique. We also recommend consideration of polypropylene mesh use for improved strength and aesthetic quality of the donor-site closure following TRAM flap breast reconstruction.

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