Monopedicled TRAM Flap

42

Andrea Manconi

The transverse rectus abdominis myocutaneous (TRAM) flap revolutionized breast reconstruction, allowing surgeons to create a breast that is soft, warm, and with good and long-lasting result [1]. Despite advances in free flap breast reconstruction, pedicled TRAM flap breast reconstruction remains an excellent option for unilateral breast reconstructions. Unlike microsurgical breast reconstruction, the pedicled TRAM flap does not require sophisticated postoperative monitoring and can be performed efficiently in any hospital setting.

42.1 History

Robbins [2] described the use of a vertical rectus abdominis flap for breast reconstruction in 1979. Drever [3], Dinner [4], and Sakai [5] refined variations on the use of vertical rectus abdominis myocutaneous flaps for breast reconstruction, but initially Hartrampf observed during abdominoplasty procedures that the lower abdomen could survive as an island of tissue as long as the attachments to the rectus muscle were kept intact. Hartrampf and colleagues [6–8] took the bold step of changing the skin island orientation to a transverse one across the midabdomen, making a larger volume of tissue available for breast reconstruction with a cosmetically desirable donor site describing in 1982 the TRAM flap as the use of the excess skin and subcutaneous fat that is routinely discarded in an aesthetic abdominoplasty for breast reconstruction. From these beginnings, the TRAM flap was destined to become the gold standard procedure for breast reconstruction, and nowadays, it remains a very good surgical option. Subsequently, several free flap options have developed as refinements of the original pedicled technique, including the free TRAM, the muscle-sparing free TRAM, and the perforator flaps.

42.2 Anatomy

The skin and fat of the lower abdomen are supplied by five major sources:

- Superior epigastric vessels arising from the termination of the internal mammary vessels
- Deep inferior epigastric vessels
- Superficial inferior epigastric vessels
- Intercostal segmental vessels
- The superficial and deep circumflex iliac vessels

The predominant blood supply of these areas is from the deep inferior epigastric system [9–11]. The vessels from both epigastric systems perforate the rectus muscles on their deep surfaces and travel as single or duplicated vessels up and down the flap arising to the skin in two rows, a medial one and a lateral one (Fig. 42.1). This system is cranially connected with the superior epigastric vessels, which represents the unique vascular pedicle used when raising a pedicled TRAM flap, even if the eighth intercostal vessels can be incorporated into the pedicle to augment blood supply if necessary.

Rectus muscles can be vascularized by three different patterns:

Type I: single superior and inferior arterial supply (29%)

Type II: double-branched system from each source artery (57%)

Type III: has a triple-branched system from each vessel (14%)

Symmetrical vascular pattern symmetry was described in only 2% of patients.

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Fig. 42.1 Corpse dissection of a TRAM flap: scissors are collocated behind superior pedicle, and flap is rotated toward the chest. It is clearly visible the inferior pedicle running posteriorly to the rectus muscle

Millory found that only 40–50% of patients have macroscopic communication between the two systems, while 60% of patients have choke vessels of microscopic caliber [12]. The superior vessels pass into the muscle from the deep aspect of the costal margin and run inferiorly. The distal supply enters the posterolateral aspect of the muscle below the arcuate line and passes up to anastomose with the superior vessels in the periumbilical area. Major vascular supply is provided by the deep inferior vessel with venous drainage system supported by two large venae comitantes into the iliac vein. The inferior and the superior venous systems create an anastomotic web at the umbilical level. When a pedicled TRAM flap is raised, distal venous flow has to reverse and follow the drainage pattern of the superior veins, overcoming the venous valves within the choke system described by Taylor and colleagues [11]. Arterial perforators arise in two rows aside the linea alba. The lateral row lies 2–3 cm within the lateral border of the rectus sheath, while the medial row lies 1–2 cm from the linea alba. These vessels vary significantly in both size and number; their caliber may vary up to several millimeters in diameter.

The anterior rectus sheath is tightly adherent to the muscle at the tendinous inscriptions. It is formed by two layers provided by external and internal oblique muscles in the lower rectus muscle and by a single layer in upper rectus muscles. During flap elevation, it is possible to harvest a gentle strip of fascia within the muscle in order to keep it more resistant to tractions or to spare as much fascia as possible in order to provide a more stable closure of the door site [13]. A muscle-sparing technique can be used to leave strips of the muscle laterally and medially to assist in maintaining abdominal wall strength, but it has been demonstrated that any left muscular segment loses neurovascular inputs [14, 15]. For these reasons nowadays, muscle-sparing pedicle TRAM flap can be considered obsolete. Two major vascular classifications exist for TRAM flap blood supply. The most classical description was introduced by Hartrampf (Fig. 42.2a), who divided the supply into four zones:

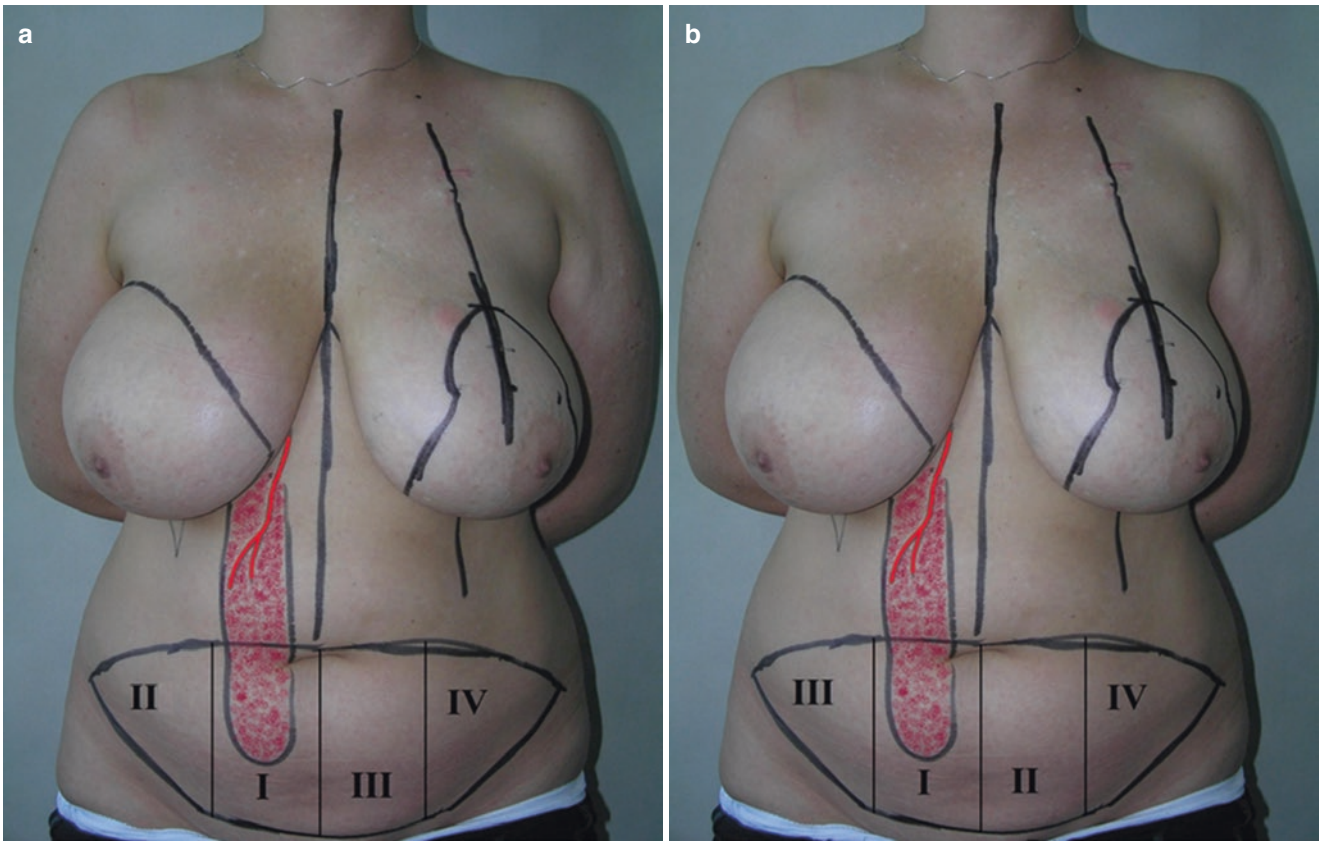
- Zone I: overlying the muscle pedicle
- Zone II: lying across the midline, immediately adjacent to zone I
- Zone III: lying lateral to zone I on the ipsilateral side
- Zone IV: lying lateral to zone II on the contralateral side from the pedicle

Zone I has been found to be the most reliable portion of the flap. The medial portion of zone III is the next most reliable portion of the flap, but it decreases in blood supply close to the ipsilateral tip. The medial portion of zone II is also usually reliable, but the lateral part is less predictable. Finally zone IV should be always considered not vascularized and discarded routinely. Holm and colleagues [16] demonstrated that while zone I remains the most reliably perfused portion of the flap, any flow across the midline is more precarious than ipsilateral flow. So the classification proposes that Hartrampf's zone III should be renamed zone II, while Hartrampf's zone II should be renamed zone III (Fig. 42.2b) .

Moon and Taylor [11] recommend surgical delay of the TRAM flap 1 week before definitive elevation. The procedure focuses on ligation of the superficial and deep inferior epigastric systems in an outpatient setting. It increases arterial supply, but TRAM flap partial necrosis is often related to venous congestion rather than arterial inadequacy. Bigger flap can be raised with a bipedicled approach or as a free flap.

42.3 Surgical Technique

Appropriate patient selection is the key to achieving predictable results. Candidates for TRAM flap breast reconstruction must have sufficient lower abdominal tissue to achieve a successful reconstruction. Clinically, this can be evaluated by estimating the amount of superficial fat in the lower abdomen



Figs. 42.2 (**a**, **b**) TRAM flap vascular zone classification by Hartrampf on the right and by Holm on the left

by squeezing the tissue between one's index finger and thumb (i.e., the "pinch test"). Patients with prior abdominal surgery should be carefully selected before undergoing to TRAM flap reconstruction. Pfannestiel and McBurney incision can be considered safe. Surgical technique for flap harvesting can be considerate similar in immediate or delayed reconstruction. Preoperative markings consist in midline drawing (very effective in donor site closure to achieve a good symmetry and result) and cutaneous palette drawing. This is obtained marking a sovrapubic transverse straight or arcuate line from one inguinal fold to the other. Laterally it continues upward in the inguinal fold or parallel to it up to the superior transverse mark. This line is drawn 1 or 2 cm above the navel, and laterally it creates an angle aside the anterior superior iliac spine. Markings are variable in function of the amount of the skin and fat available in the lower abdomen. Also inframammary folds are marked. Preoperative Doppler is useful in order to find perforators, but it isn't mandatory. Recipient site markings are different in case of immediate or delayed reconstruction. In immediate breast reconstruction, the breast ongoing to mastectomy is marked on oncological patterns such as Patey mastectomy, skin-sparing mastectomy, or nipple-sparing mastectomy.

In case of delayed breast reconstruction, it is suggested to mark inframammary fold in the contralateral breast and to recreate the opposite one with the same footprint but 2 cm above: it will be lowered during the donor site closure by donor site suture tension. The skin between this marking and mastectomy scar should be removed in order to recreate a natural new inframammary fold, but the surrounding skin should be excised if radiodystrophic. Tight mastectomy scar can also be cut in a Z-style incision if releasing skin tension is needed.

Perioperative assessment consists in heparin prophylaxis associated with pneumatic leg pumps. Blood transfusions can be required but should be prevented. Patient is positioned on a folding surgical bed.

Surgery starts undermining the epigastric flap in a suprafascial plane. The skin is incised to the sheath with an upward 45° inclination in order to include as many perforators as possible and also in order to face donor site skin flap with similar thickness (Fig. 42.3).

Rectus abdominis muscles are both individuated up to the rib arc and xiphoid. Rectus muscles and external oblique muscles are dissected on a suprafascial plane keeping a very thin layer of fat on the fascia in order to respect suprafascial vascularization as much as possible (Fig. 42.4).

After that, a tunnel is undermined to the breast. Tunnel should be large enough to let surgeon fist pass. Before continuing dissection, it is helpful to tilt the patient in order to check donor site closure (Fig. 42.5).

Fig. 42.3 Elevating the epigastric skin flap. A 45° initial incision can obtain several improvements such as better skin vascularization and better donor site close with nice aesthetic result

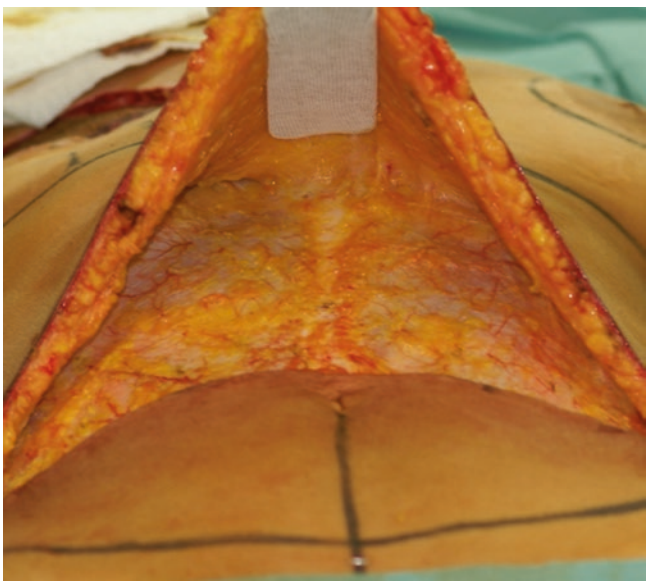


Fig. 42.4 Epigastric skin flap is elevated: rectus muscles are both individuated up to the rib arc

Fig. 42.5 A tunnel is undermined to let transpose the flap to the chest. It should be large enough, but it is suggested that dissection should not exceed midline in order to respect the inframammary fold

Before continuing the flap dissection, it is suggested that donor site closure should be checked (Fig. 42.6). In case of excessive skin tension, it is possible to modify preoperative lower markings.

Flap dissection continues with sovrafascial dissection of the TRAM flap skin island from lateral to medial identifying perforators (Fig. 42.7). The choice of an ipsilateral or a contralateral pedicle can be based on the availability of good perforators. If possible it is suggested to harvest an ipsilateral pedicle because it has been described to have a better perfusion [17] and also a better arch of rotation. Also ipsilateral pedicle avoids to have a muscle bulge in xiphoid after flap rotation.

Once the side to be dissected is decided, rectus sheet is incised all along its length medially the lateral border and few millimeters laterally the perforators. Fascia is also incised 1 cm lateral to the medial border of the muscle down to skin palette (Fig. 42.8).

The muscle is dissected from the fascia and intercostal segmental vessels, and nerves are ligated (Fig. 42.9). Main vessels run just beneath the muscle, so it is suggested that posterior fascia should be dissected by fat surrounding main vessels.

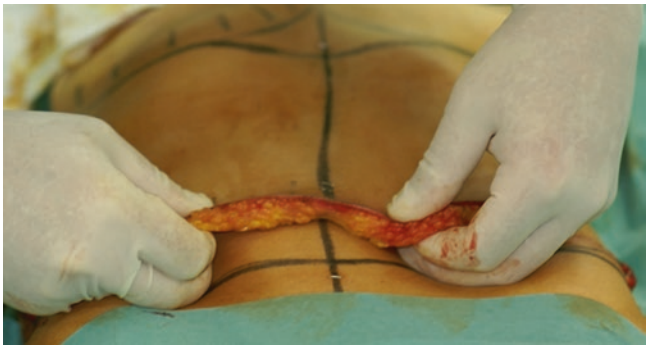


Fig. 42.6 Checking donor site closure. Patient can be moved to a slightly sitting position, but skin tension should be avoided

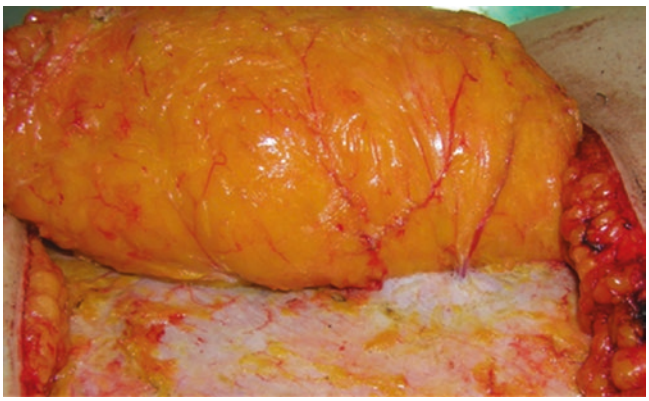


Fig. 42.7 Lateral view of the skin island after dissection. Perforators are usually identified on a row

Fig. 42.8 Fascial dissection exposes the rectus muscle

Then inferior pedicle is ligated and the muscle divided downward the pedicle insertion in the muscle, if possible upward the Douglas arcade (Fig. 42.10).

Rectus sheath can be now incised from the inner, few millimeters aside the linea alba, in order to spare as much sheet as possible, so to repair the fascial defect more easily. After that it is suggested that muscle perfusion should be checked: in case of bad perfusion, it will be still possible to harvest a bipedicled TRAM flap. In case of good muscular perfusion, the navel is isolated and cutaneous palette is dissected. Once the flap is harvested, it can look congested but soon after it achieve a well-perfused looking (Fig. 42.11).

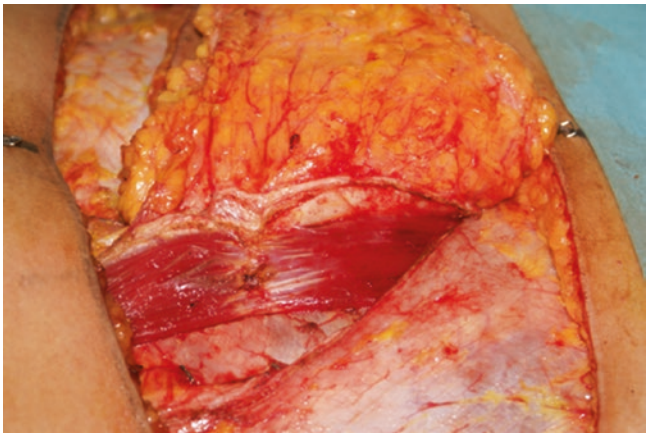


Fig. 42.9 Rectus muscle is exposed by surrounding aponeurosis

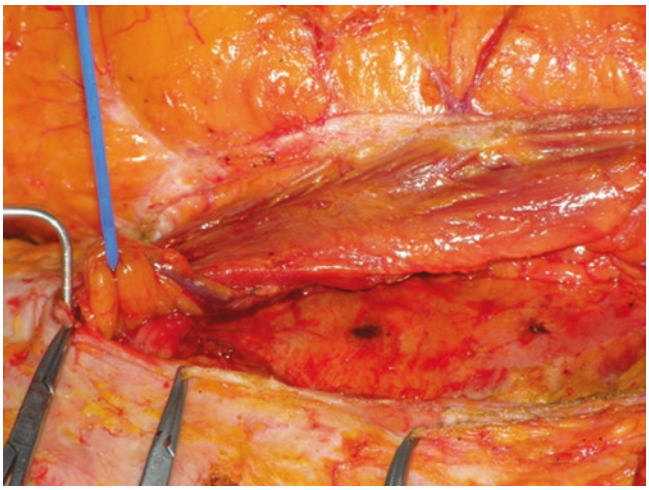


Fig. 42.10 Inferior pedicle is identified (by blue loop) and ligated before cutting the rectus muscle inferiorly

Fig. 42.11 TRAM flap skin island is congested after dissection. Skin color can be reddish or bluish, and it is possible to identify superficial vein net

Fig. 42.12 TRAM flap extremities are less perfused, so it'd better to be excised. It is clearly visible a venous bleeding

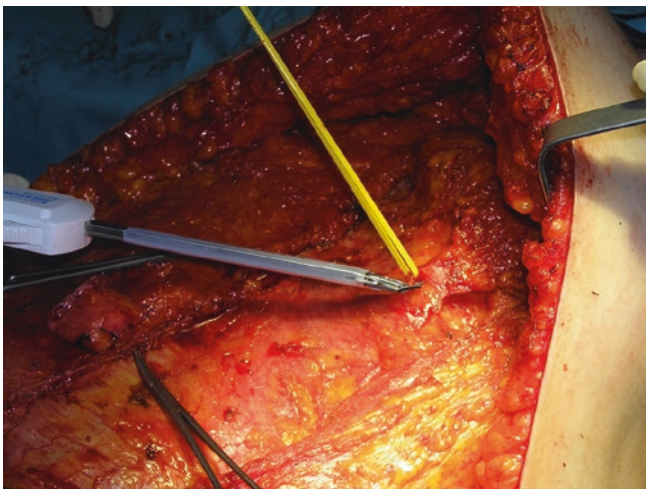


Fig. 42.13 Eighth intercostal nerve is isolated on the rib edge

It is a normal phenomenon, due to the gradual opening of choke vessels that improves venous drain. Zone IV and partially zones II and III are resected, and the flap is now ready to be transferred (Fig. 42.12).

It is essential to denervate the eighth intercostal nerve at the costal margin in order to avoid unpleasant muscle contraction after reconstruction (Fig. 42.13).

42.4 Donor Site Repair and Closing

Competent rectus sheath closure is an essential procedure in any TRAM flap surgery as far as it should prevent the risks of hernia formation. It is essential to incorporate both the internal and external oblique aponeuroses into the sheath closure [18]. We suggest to incorporate a Mersilene mesh or an acellular matrix [19] in the closure, but some surgeons prefer not to use it, if not necessary, because of the risk of infection [20]. First mesh is sutured to the medial edge of the remaining rectus fascia, and then it is sutured laterally with single stitches transfixing external oblique muscle (Fig. 42.14). After that the lateral edge of the remaining rectus fascia is sutured above the mesh in order to reinforce the closure (Fig. 42.15) .

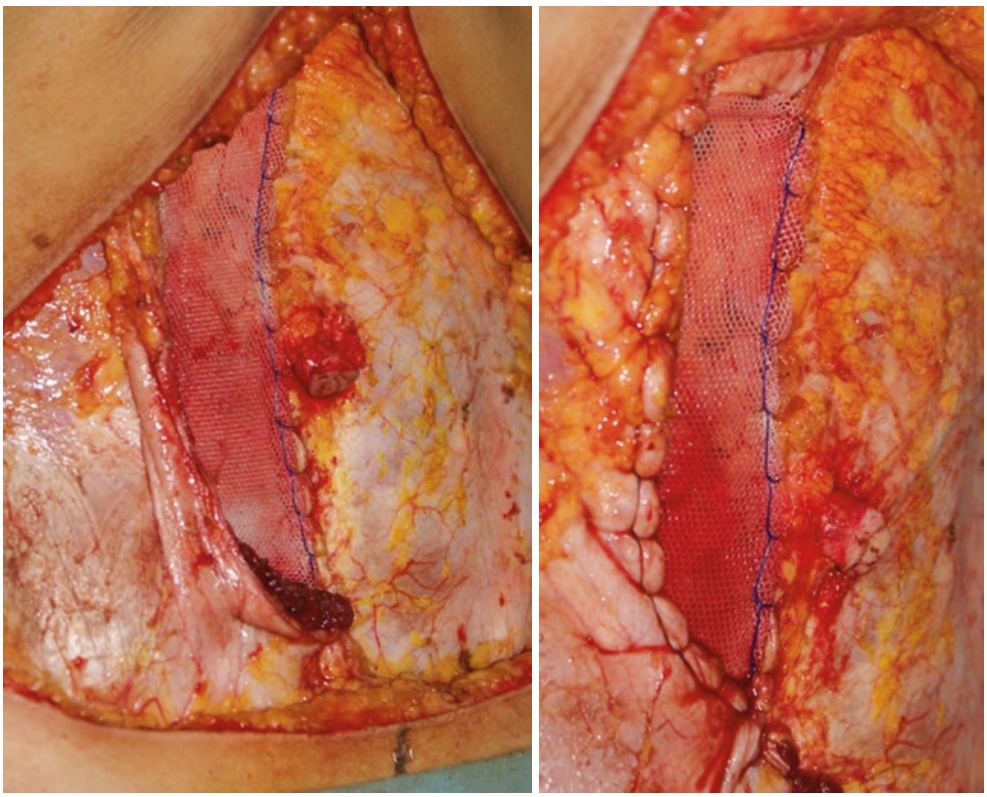
Before closing, the navel is repositioned in the midline, at the level of ankle crease, defatting the epigastric flap. Quilting suture can avoid postoperative seroma formation and also prevents tension in the abdominal triple-layer suture. Prineo is an automatic system of closure that can be effective and time-sparing (Fig. 42.16). Please notice that donor site closure should be considered a very important phase of the procedure as abdominal results are very important in demanding patients.

42.5 Flap Remodeling

Once the flap is harvested and transposed to the chest, the job isn't yet completed: the following steps are probably the most important for patient satisfaction. We can distinguish different approaches in delayed or immediate reconstruction. In delayed reconstruction, scar should be excised and the skin undermined in the whole breast footprint. It is important first of all to determine the new inframammary fold. It is possible to compare the contralateral side after donor site closure or to draw it in a line that will lay 1 or 2 cm upper the contralateral inframammary fold (that is because of the skin tension after donor site closure). Mastectomy scar can represent a challenge because it can push the flap down to the chest wall with a retracted appearance. Most of the times, the solution is to excise completely the retracted scar and also most of the inferior mastectomy skin flap. Skin paddle can be orientated in different ways, but the principal two suggestions are 180° or 90°. First the skin paddle is fixed to the new inframammary fold, and then flap is put under mastectomy skin flaps after checking a good bleeding all along the skin and fat margins. In case of poor or venous bleeding, it is suggested to excise less perfused area in order to avoid partial skin necrosis as much as possible. Contralateral symmetrization is often required. Volume should be compared to the contralateral breast. Also Wagner and colleagues [21] devised a formula to calculate flap volume:

$L \times W \times T \times 0.81 = V$ where L is weight, W is width, and T is thickness of the TRAM flap, and V is flap volume.

Once the symmetry is achieved, undermined flap skin is deepithelized and flap can be sutured.



Figs. 42.14 and 42.15 Donor site repair with mesh. It is essential to fix the mesh to the surrounding muscle compartment and then to suture the rectus sheath edges to the mesh in a dual-layer approach

Fig. 42.16 Donor site closure with Prineo

In case of immediate breast reconstruction, breast reshaping is somewhat similar, but it is easier in case of nipple-sparing or skin-sparing mastectomies, whereas TRAM flap skin paddle is completely or almost totally deepithelized and then sutured to the chest wall, allowing an easy remodeling like putting the jelly in the mold. It is suggested to spare the original inframammary fold in order to keep the original ptotic appearance of the breast, obtaining a symmetrical result.

42.6 TRAM Flap and Implant?

Somebody can identify a breast implant beneath a TRAM flap as an adulteration of one of a pure autologous reconstruction, but it represents a very good indication in selected cases. First of all it is indicated in case like the following:

- Breast augmentation demanding patient without possibility to harvest a latissimus dorsi flap
- Patient refusing contralateral breast reduction
- Very large mastectomy or delayed breast reconstruction in patients presenting wide radiodystrophic area to be excised
- Bad perfused flap

The last one represents a revolutionary way to manage bad perfused flap. In fact, if a bad blood supply is identified during dissection, it is suggested to harvest a bipedicled TRAM flap, but, if the flap looks poorly perfused after transposition, the idea is to excise as much skin as needed. It doesn't matter how much volume you can lose because it can be replaced by an implant or an expander. In our series of patients with TRAM flap associated with implants, at European Institute of Oncology, they have very good outcomes in most of cases. Delayed volume augmentation is still possible with implant or fat grafting (Figs. 42.17, 42.18, and 42.19).

42.7 Complications

The major complications of delayed TRAM flap reconstruction include scarring, skin and fat necrosis, flap loss, hernia formation, deep venous thrombosis, asymmetry, abdominal tightness, and the psychosexual issues associated with breast reconstruction. Some degree of fat necrosis is common in

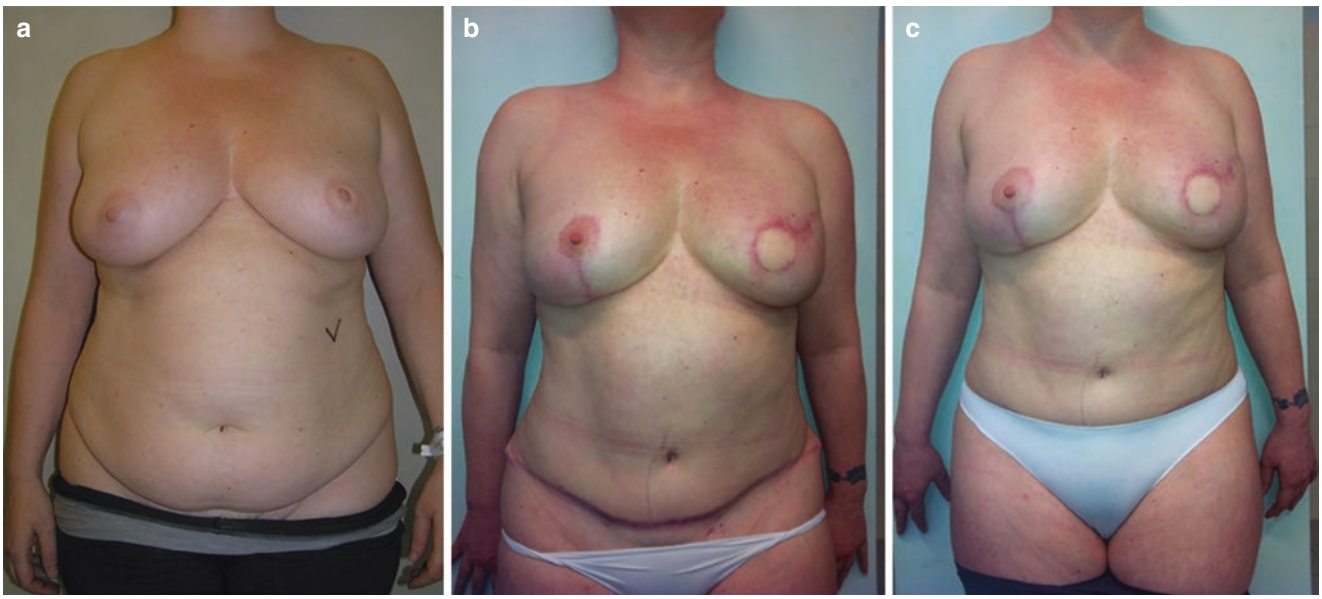


Fig. 42.17 (**a**–**c**) Immediate left breast reconstruction with ipsilateral pedicle TRAM flap after skin-sparing mastectomy, preoperative and postoperative views. Please notice that abdominal scar can be easily hidden by pants

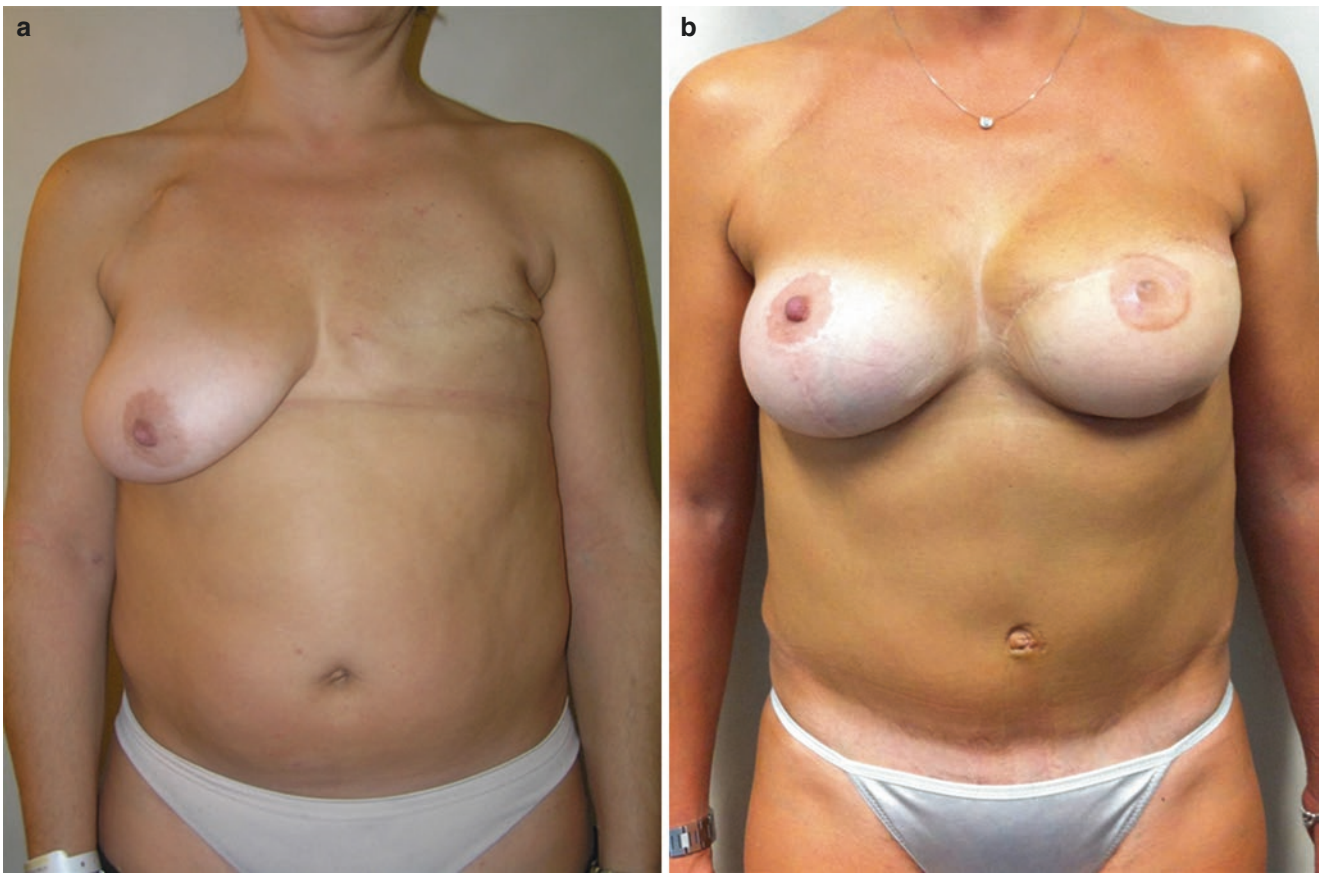


Fig. 42.18 (**a**, **b**) Delayed left breast reconstruction with ipsilateral TRAM flap, preoperative and postoperative views. Please notice a good symmetry but a lateral deviation of the navel and a little bulge aside of it

Fig. 42.19 Immediate breast reconstruction with TRAM flap and implant: preoperative and postoperative view

Table 42.1 TRAM flap necrotic complication, EIO series 1994–2007

	Ipsilateral TRAM flap	Contralateral TRAM flap	Bipedicled TRAM flap	TRAM flap and implant
Partial necrosis	12.22%	14%	3.26%	7.89%

any TRAM flap reconstruction whether free or pedicled. In our series, we observed different rates of partial necrosis (requiring surgical debridement). Also very rare total flap necrosis has been observed (Table 42.1).

42.8 TRAM Flap and Pregnancy

Despite the loss of muscle function after pedicled TRAM flap harvest, it is still possible for patients to conceive and carry a pregnancy to term as well as to achieve normal vaginal delivery [21]. Johnson and colleagues [22] described the successful vaginal delivery of monozygotic twins after bilateral pedicled TRAM flap reconstruction. Parodi and colleagues [23] caution against patients becoming pregnant within 12 months after TRAM flap surgery, reporting a single case of a woman becoming pregnant at 4 months postoperatively and developing a hernia. She delivered vaginally at term. We also observed some pregnancies after TRAM flap without major diseases (Fig. 42.20).

42.9 Secondary TRAM Flap Reshaping

The possibility of a natural and symmetrical result with TRAM flap is high, but still be possible to improve it with a secondary reshaping. It isn't a standardized procedure. Surgical tips consist of mastectomy flap separation from TRAM flap that can be reduced, mobilized, liposucted, or lifted based on inferior pedicle. Then the skin is adeguated to the breast mount. In case of breast augmentation, implant pocket can be easily obtained under the flap. Also fat grafting is a valid alternative. A unique case of immediate breast reconstruction splitting a previous bipedicled contralateral TRAM flap in two was described by Rietjens et al. [24] (Fig. 42.21).

Fig. 42.20 Pregnancy after immediate reconstruction with TRAM flap. This patient underwent to cesarian delivery without complication for her and for the newborn. Abdominal bulge was observed 1 year post-delivery

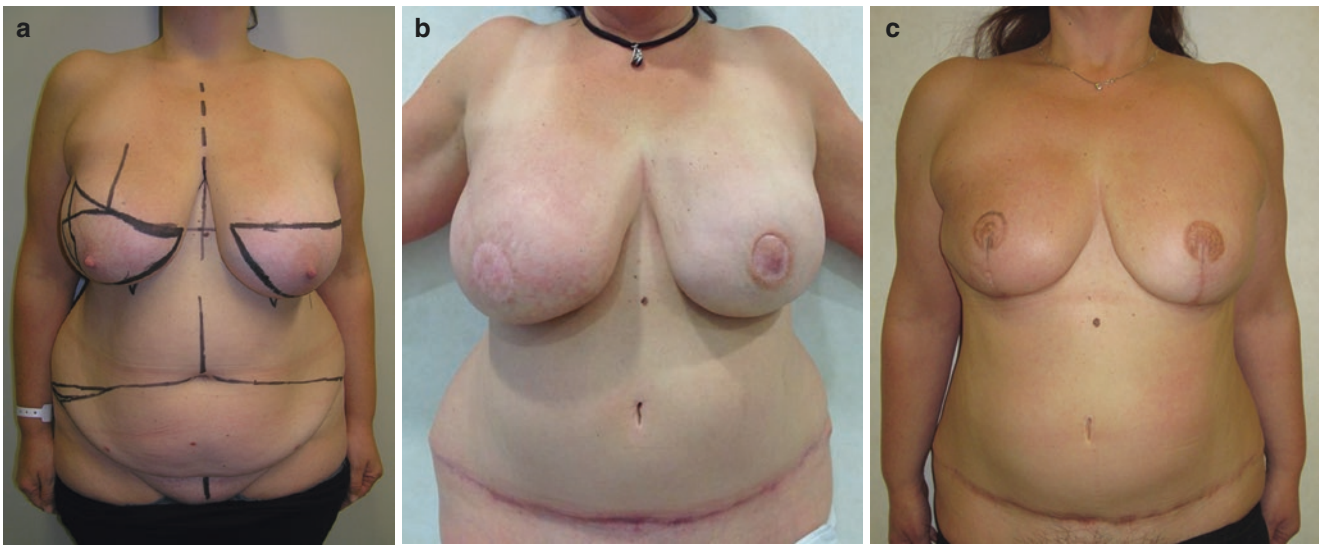


Fig. 42.21 (**a**–**c**) A case of bilateral tram flap reshaping with breast reduction. Preoperative view with marking (**a**), postoperative view after bilateral TRAM flap (**b**), and postoperative view after bilateral breast reshaping with inverted T mastopexy and liposuction (**c**)

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