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The free TRAM procedure in breast reconstruction: choice of vascular receptor site

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Abstract In this study, 70 consecutive cases of breast reconstruction with the use of a free Transverse Rectus Abdominal Myocutaneous (TRAM) flap were reviewed with respect to the type of recipient vessels. We describe our evolution of choice of the receptor vessels. The deep inferior epigastric artery was anastomosed to the thoracodorsal artery in 15 cases. In 55 cases the internal mammary artery (IMA) was used as a recipient vessel. The deep inferior epigastric vein was anastomosed to the thoracodorsal vein in 15 cases, to the cephalic vein in eight cases, the external jugular vein in 16 cases and to the internal mammary vein (IMV) in 31 cases. Total flap necrosis occurred in four cases. In an additional four cases there was partial necrosis requiring minor operative correction. In six cases venous outflow problems were the cause of flap necrosis. The external jugular vein ($n = 3$) and cephalic vein ($n = 2$) were relatively frequently involved in cases of venous outflow problems. One flap was rescued 5 days after surgery following venous thrombosis by inserting a vein graft. The IMA and vein proved to be reliable and easy to access as recipient vessels for anastomosing the vessels of the free TRAM.

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Introduction

Breast reconstruction after mastectomy has gone through a tremendous evolution over the past two decades. On the one hand the importance of the psychological impact of mastectomy has been acknowledged resulting in an increased demand for breast reconstruction. On the other hand new techniques have been developed which make it possible to reconstruct an aesthetically acceptable breast. One of these techniques is the Transverse Rectus Abdominis Myocutaneous flap (TRAM flap), which has established a definitive place within reconstructive breast surgery [1–4]. The procedure provides good aesthetic results and has a lower complication rate as compared with the latissimus dorsi flap or the tissue-expansion procedure [5].

In immediate reconstruction the TRAM procedure was shown to be aesthetically superior to other techniques [5]. Herniation, abdominal wall weakness and partial flap necrosis are less common in the free TRAM (FTRAM) compared to the pedicled TRAM flap. In addition shaping possibilities of the FTRAM are superior to the pedicled TRAM. For these reasons the FTRAM flap is often preferred [6–15]. The FTRAM method necessitates harvesting of a small part of the rectus abdominis muscle including the perforating vessels of the deep inferior epigastric artery and veins. In addition, the development of perforator flaps led to the DIEP (deep inferior epigastric perforator) flap, which is a sophistication of the FTRAM flap [16–21]. Dissection of only the perforating vessels within the muscle diminishes the amount of muscle that has to be sacrificed, further decreasing donor morbidity [22, 23]. The vessels of the FTRAM/DIEP flap have to be connected to recipient vessels in the thoracic area. There are several possible recipient arteries and veins for the FTRAM [24–29]. The thoracodorsal, subscapular, and internal mammary artery (IMA) can be used as arterial receptors, whereas the thoracodorsal, cephalic, external jugular

and internal mammary vein (IMV) may serve as venous receptors. In this study we describe our evolution in the choice of the different recipient arteries and veins, and their advantages and disadvantages will be discussed.

Materials and methods

The files of all patients who underwent a FTRAM flap procedure between August 1988 and January 1998 in the Sint Pieter University Hospital in Leuven were retrospectively reviewed. No patients were excluded from the study. In 64 patients 70 breast reconstructions by means of a FTRAM flap were performed. Mean age of the patients was 44 years and varied between 27 and 66 years (SD 8.2).

The following data were collected: type of anastomoses, operation time, smoking, and postoperative complications. Postoperative complications were classified as flap related or general complications reasons for mastectomy, type of mastectomy, tumor classification, and previous radiotherapy or chemotherapy were also studied.

Operative technique

The operation is performed by two teams. On the chest wall the skin below the mastectomy scar down to the inframammary fold is removed. The intercostal muscles and one or two ribs are partially removed to get access to the internal mammary vessels. The IMA is accompanied by a double venous system from the third to the sixth rib (Fig. 1). Between the first and the third rib often a single larger DCIV was present. In most cases a single vein was found at the 3rd or 4th intercostal space. This allowed a venous anastomosis between the deep inferior epigastric vein (DCIV) and the single IMV in cases where a large diameter deep epigastric vein was found. In cases where two IMV were present, both branches of the deep inferior epigastric vein could be anastomosed or a *Y*-shaped anastomosis was done with the common trunk of the DIEV.

Early in this series, an alternative venous drainage was obtained by bringing down the External Jugular Vein (EJV) from the neck, just with one incision in the middle of the neck and one supraclavicular incision (Fig. 2a, b). If required the cephalic vein could be harvested with a few incisions in the upper arm (Fig. 2c).

The operation was performed by two teams, one team harvesting the free flap in the abdomen and the other team preparing the recipient vessels such as the external jugular vein and the IMA (Fig. 2d). After removing a segment of two adjacent ribs (Fig. 3a) the IMA and one or both veins can be exposed just in front of the pleura. Care is taken not to open the pleura. When the internal mammary vessels are selected for venous drainage then one or two venous anastomoses can be performed in an end-to-end fashion using 9/0 nylon (Fig. 3b).

The flaps were dissected with preservation of the periumbilical perforators and as much rectus fascia as possible. In addition the amount of muscle included in the flap was kept as small as possible. The entire flap was used for reconstruction. The flap harvesting team will first identify the lateral and medial row of perforators. In most cases three lateral and two median perforators from the deep inferior epigastric axis are identified (Fig. 4a). After lifting the fat from the abdominal fascia the perforators are dissected out, and a small segment of rectus abdominis muscle is harvested together with the vascular pedicle (Fig. 4b, c). We prefer to include five perforators to obtain improved flap blood supply especially in zone IV. In our experience the whole TRAM area from the umbilicus to the suprapubic region and from the left to the right iliac spines can be harvested in one single pedicle (Fig. 4d). The area overlying the pedicle (zone I), the contralateral pedicle area (zone II), the area lateral to the pedicle (zone III), as well as the area far away from the pedicle (zone IV) are used in our method of breast reconstruction.

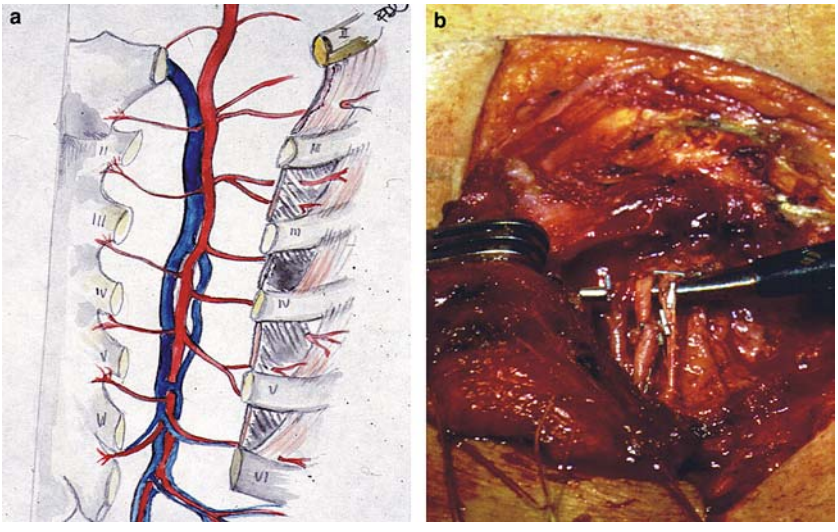

Fig. 1 **a** Internal mammary artery and two comittant veins below the 3rd rib. **b** Internal mammary artery and two comittant veins at 5th intercostal space

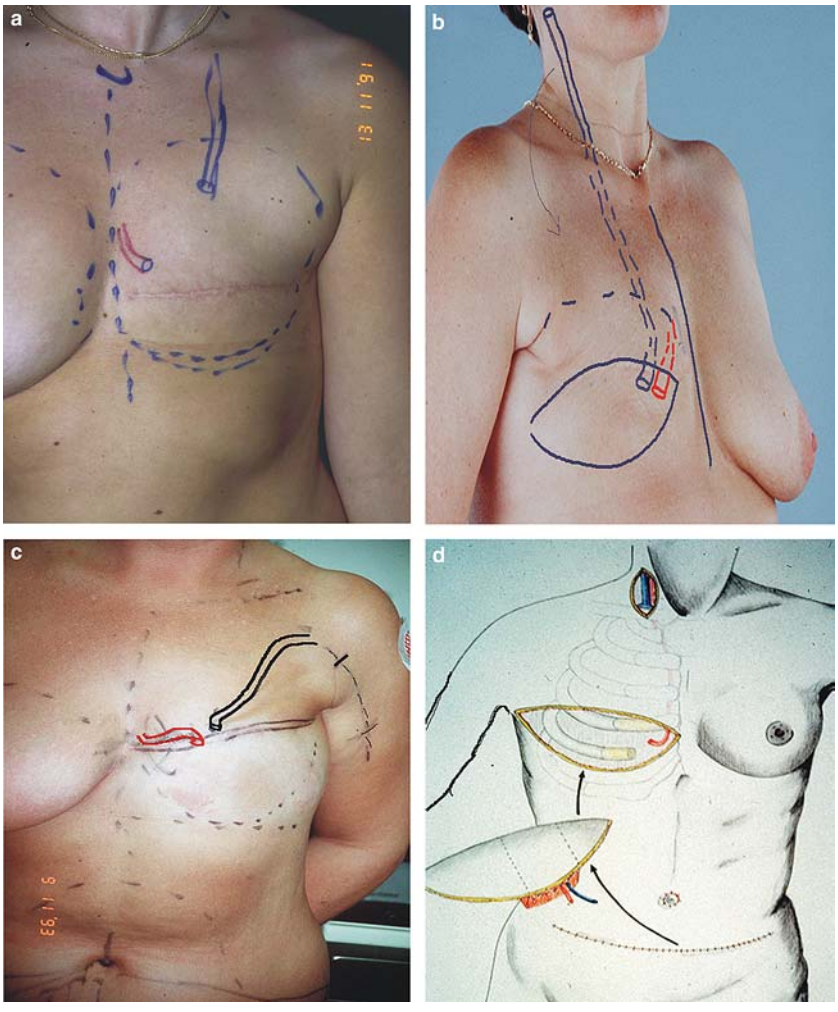

Fig. 2 **a** External jugular vein tunnel led down to 5th intercostal space. **b** IMA + EJV brought together at 5th intercostal space. **c** The Cephalic vein is tunneled down to the 5th inter costal space to the IMA. **d** The Tram free flap is brought up to the chest wall and anastomosed to the IMA

When the jugular vein or cephalic vein is used as a recipient vein, the deep inferior epigastric pedicle has to be split, separating the vein from the artery. The DIEV is turned upwards in the direction of the cephalic or jugular vein that is brought down through a subcutaneous tunnel (Fig. 4e).

As an example we show a patient with a right mastectomy (Fig. 5a) where the mastectomy scar has been opened and an lower incision is made at the inframammary fold. In this way, the TRAM flap can be inset, after anastomoses to the internal mammary vessels. The flap is inset as a hammock with extension of the zone IV towards the axillary region.

This zone IV is de-epithelialized to provide fullness of the upper lateral quadrant of the breast (Fig. 5b–d).

Results

In 58 patients the reconstruction was unilateral. In the majority of the patients a delayed reconstruction was performed (62 cases). In 68 cases the mastectomy was

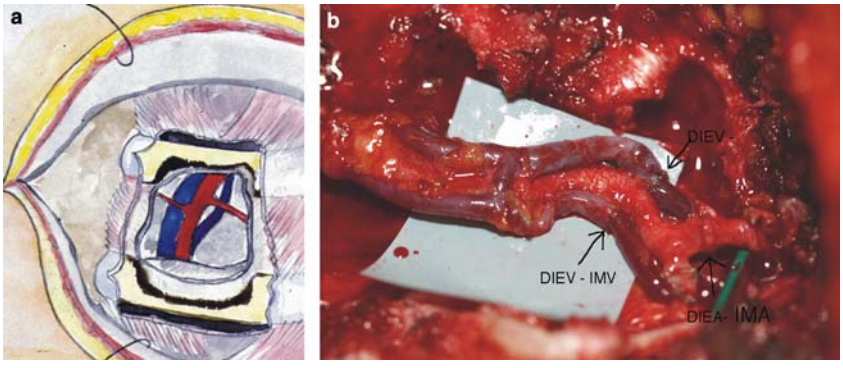

Fig. 3 **a** Removing the inter costal muscles and part of the rib cartilage exposing the IMA. **b** Two E–E venous anastomoses between the DIEV and IMV and the DIEA with the IMA

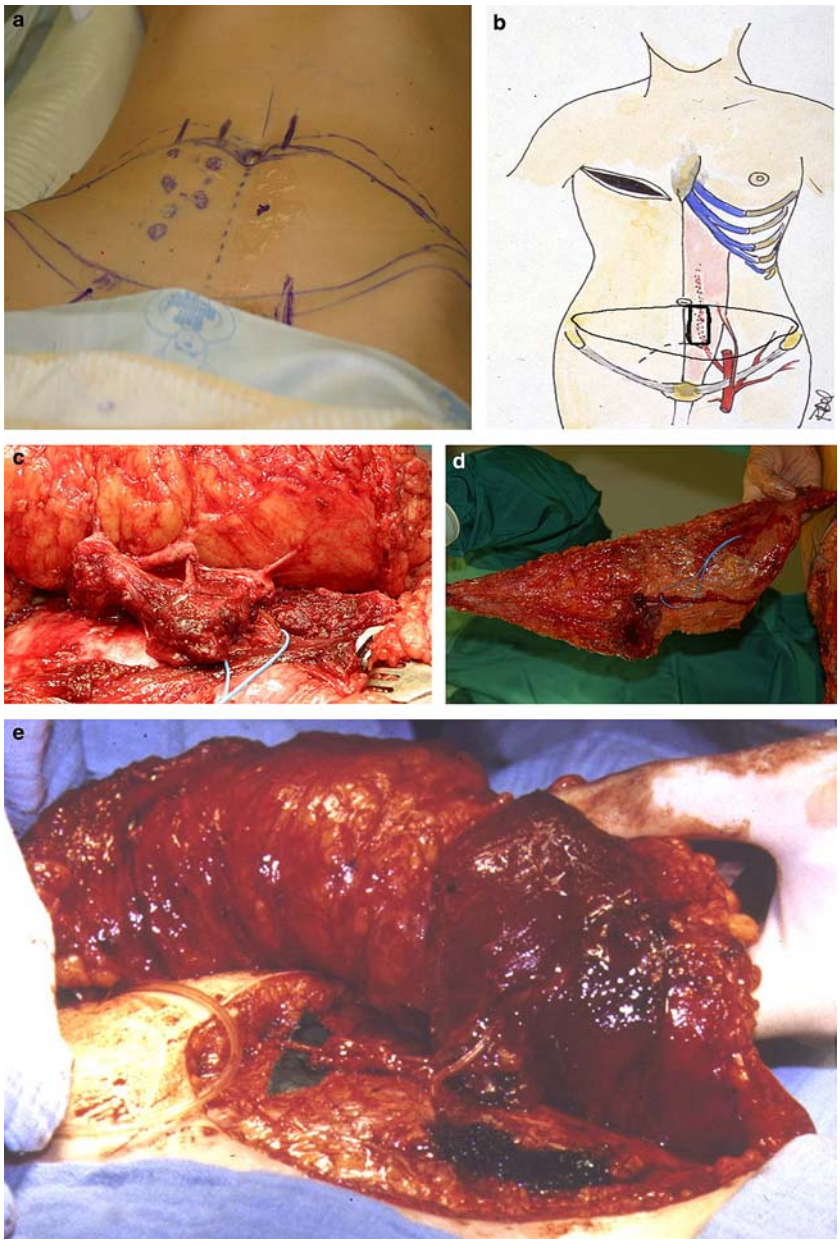

Fig. 4 **a** Before starting the operation two lateral and two medial perforators are identified by Doppler probe. **b** A small segment of rectus abdominis is muscle includes the five perforators. **c** Three lateral perforators are providing the blood supply to the flap. **d** The whole abdominal skin + fat overlying the rectus segment with the pedicle. **e** The DIEV is turned upwards to the external Jugular vein (*left*). The DIEA is anastomosed to the IMA (*right*)

done because of breast cancer. Mastectomy was performed twice because of cystic mastopathy. Modified radical mastectomy was performed in 65 cases. The remaining patients were treated by radical mastectomy (2), subcutaneous mastectomy (1), and lumpectomy (2). 33 cases the patients smoked at the time of the reconstruction. Tumour classification for the first 55 cases is shown in Table 1. In 13 cases tumor classification was not known or conflicting due to primary surgery elsewhere.

The abdominal sheath could be primarily closed in 42 cases. In the last 28 cases a mesh graft was also used. Initially in three patients Mersiline mesh was used. In the following 25 operations Vicryl mesh was used to close the abdominal wall defect. The majority of the arterial anastomoses ($n = 55$) were performed with the IMA. Other anastomoses were done to the thoracodorsal artery. The vein was anastomosed to the IMV ($n = 31$), the thoracodorsal vein ($n = 15$), the cephalic vein ($n = 8$), and the external jugular vein ($n = 16$). Operation time varied from 4 h and 10 min to 10 h and 45 min, with a progressive decrease of operation time during the course of this study.

Flap necrosis occurred in 4 of the 70 flaps (6.8%). An additional four flaps showed signs of partial necrosis, requiring minor operative correction. In two of these cases total necrosis was prevented by reintervention. In one flap there was leakage of the cephalic vein, which was solved by an additional stitch. In the other case the IMV proved to be too small and a venous graft between the deep inferior epigastric artery and a more proximal dissected part of the mammary vein was used to over-

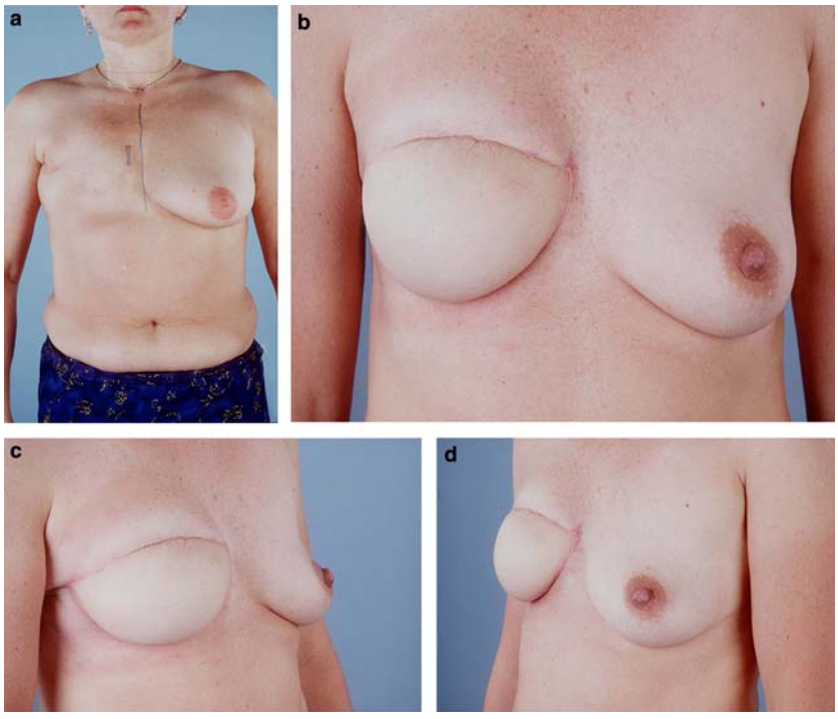

Fig. 5 **a** *Right* mastectomy. **b** Post op result after minimuscle TRAM. **c** Good symmetry post op. **d** Good projection post op

Table 1 Tumour classification and adjuvant treatment

Tumour classification	Breasts
Carcinoma in situ	2
T1	6
T2	17
T3	19
T4	2
Unknown	24
Chemotherapy	
Yes	29
No	30
036Unknown	11
Radiotherapy	
Yes	41
No	18
Unknown	11

come the problem. In the remaining two flaps with partial necrosis, reintervention was not performed. However, it was clear that venous congestion was the cause of the problem. In one case reintervention 5 days after surgery rescued the flap. Thrombosis of the venous anastomosis (IMV) was treated by extensive dissection and venous graft interposition again between the flap vessel and a more proximal IMV. The causes of total flap failure were: thrombosis of thoracodorsal artery, thrombosis of IMA, thrombosis of external jugular vein, and leakage of a cephalic vein anastomosis with hematoma and thrombosis of the vein. Taking total and partial flap necrosis, and flap rescue together, a total of nine flaps related problems were seen in our series. Of these, flap failure was caused four times by insufficiency of the venous anastomosis. The external jugular vein

Table 2 Type of anastomosis and complications

Arterial anastomosis	Venous anastomosis	Necrosis	Cause of failure	Revision
IMA	External jugularis	Partial	Venous congestion	Minor correction
IMA	External jugularis	Partial	Venous congestion	Minor correction
IMA	Internal mammary	Partial	Vein too small	Successful revision with venous graft and secondary minor correction
IMA	Cephalic vein	Partial	Leakage vein	Successful revision and secondary minor correction
IMA	Cephalic vein	Total	Kinking, leakage	Vein corrected
IMA	External jugularis	Total	V. calibre mismatch	Primary closure
Thoracodorsal artery	Thoracodorsal vein	Total	Torsion thoracodors artery	Flap failure
IMA	Cephalic vein	Total	Thrombosis thoracodors artery	Flap failure
IMA	Internal mammary vein	Rescued	Thrombosis vein	Vein interposition

was most frequently involved in causing flap necrosis (3 out of 16 external jugular vein anastomosis, 19%). The cephalic vein anastomosis was insufficient on two occasions, and resulted in flap necrosis (25% of all external jugular vein anastomosis). In two cases the IMV was the cause of thrombosis (6% of all IMV anastomosis). Only one mammary artery was involved in causing flap necrosis (2%) and one case was attributed to the thoracodorsal artery (7%).

Minor complications after the TRAM procedure were wound dehiscence in a patient with severe radiofibrosis, and one patient with a fistula due to osteomyelitis. In one patient partial fat necrosis became apparent some weeks after surgery. Abdominal wall herniation occurred in six cases. In one patient an abdominal wall seroma was observed which was treated with needle puncture. Major complications were observed in four patients. Two patients were transferred to the intensive care unit because of pneumonia within 4 days after surgery. Both cases responded well to intravenous antibiotics. One patient was treated for lung-oedema and another patient developed an adrenal bleeding postoperatively, which was treated conservatively.

Discussion

Although initial reports demonstrated excellent results using the pedicled TRAM flap [1, 2], later publications showed a considerable complication rate [3, 11]. In anatomical studies it was shown that the superior epigastric artery and vein do not supply the lower abdomen sufficiently, which explains the poor results with the pedicled TRAM flap [6, 7]. The free TRAM flap in which the inferior epigastric artery is used to perfuse the flap was developed and showed a lower complication rate. The avoidance of torsion and traction of the vascular pedicle and the better anatomical distribution of the blood supply of the free TRAM has made this flap a reliable option for breast reconstruction.

Although the complication rate of the free TRAM is less compared to the pedicled TRAM, the FTRAM is not without complications, as demonstrated in our study. The total complication risk of 38% (22/59) is high, but included a majority of minor complications such as abdominal seromas treated by aspiration. In addition, it is remarkable that a substantial number of postoperative complications were not directly related to the flap surgery itself. Three patients developed major pulmonary complications. In one of these patients bilateral reconstruction was performed. In another patient with bilateral reconstruction an adrenal bleeding complicated the postoperative course. The relative high rate of non-surgical complications in patients with bilateral reconstructions (2/8 in the bilateral group compared to 2/51 in the unilateral group) indicates that the operation time increased the risk of developing postoperative non-surgical complications, and should be considered when making the operative plan.

At a later stage, 3 months after the TRAM reconstruction ptosis correction of the opposite breast is performed together with nipple reconstruction.

We began performing free TRAM procedures in 1988 using the IMA as receptor artery. The literature at that time showed that the IMV was not always suitable for anastomosis [30]. In the first 19 TRAMs in which the IMA was used the venous anastomosis was performed using either the jugular vein or the cephalic vein. This was however not always without problems as seen in the relatively high incidence of these veins in venous congestion problems. In 1993 we started using the IMV as a venous receptor vessel. At that time we still performed the dissection of the IMA and IMV at the 6th intercostal space. Until 1995 we frequently had problems because in this location we frequently found two relatively small veins. This was the main reason for adjusting our technique and we started to perform the dissection at the 4th intercostal rib space. Although still in 70% of the cases there is a double venous system at this location the veins are bigger and it is easier to perform an anastomosis [28]. We routinely perform anastomoses on the IMA and IMV at the 4th intercostal space. Only during immediate reconstruction do we use the thoracodorsal system, because this has been already dissected by the general surgeon.

The dissection of the IMA is performed in the following way. A small amount of skin, subcutaneous tissue and superficial muscle medial to the mastectomy scar is removed perforators from the IMA are identified to localise the vessels. Between the 3rd and 4th costal cartilages, lateral to the sternum, part of the intercostal muscles is removed, we do not routinely perform a resection of the complete rib cartilage for exposure of the vessels, because this may result in pain complaints. We prefer to enlarge the intercostal space by partial resection of the cranial and caudal rib cartilages. Damage to the posterior perichondrium is avoided. Next, the posterior intercostal membrane is incised with a knife, giving access to the internal mammary vessels that lie very close to this membrane This creates exposure of the vessels over a distance of about 3 cm. This allows easy placement of one single disposable plastic TAMAI vascular clamp (Bear Co., Tokyo, Japan). We have not seen pleural problems such as pneumothorax or hematothorax in our series.

The central position of the anastomosis on the thorax offers a more comfortable and easy position for performing the microsurgical anastomoses without the need to reposition the patient. In addition, the anatomy of the internal mammary vessels is constant and reliable [18]. Furthermore, the central position of the recipient vessels allows better shaping of the flap, making it possible to place the flap in the horizontal as well as in the vertical direction. In most cases the flap was placed in a hammock shaped fashion allowing good projection and natural ptosis. This overcomes one of the inconveniences of using the thoracodorsal axis as receptor vessels. Lateral fullness

and deficient medial fullness of the reconstructed breast frequently occur.

The operating time was not different for the different techniques used. In addition, the IMA anastomosis was shown to be a reliable alternative to the axillary vessels. Only in one case was thrombosis of this artery observed. It is remarkable to note that venous failure was relatively more often observed after the use of the external jugular vein or cephalic vein compared to the IMV. When using an axillary approach (e.g. in immediate reconstruction) the comitant vein of the thoracodorsal artery is used as the venous recipient vessel. However, the major disadvantage of the axillary vessels is the possible damage after radiotherapy or dissection by the general surgeon. Therefore, in some cases the vein is not suitable and the cephalic vein has to be used. In our series the cephalic vein proved to be less reliable compared to the other recipient vessels. This is explained by the large diameter of the cephalic vein that leads to low-flow conditions. The increase of vessel diameter behind the anastomosis will cause stasis and increase the risk of thrombosis. The external jugular vein can also be used as a venous recipient vessel. Dissection takes place through small incisions in the cervical region at regular distances. The vein is then tunnelled from one incision to another. The vessel is reliable although care has to be taken that kinking of the vessel does not occur during tunnelling of the vessel. Kinking is the most prominent disadvantage of this vein. In our series, the IMV was most frequently used as the recipient vessel. The vein is very reliable as demonstrated by the fact that thrombosis of this vein was observed only once. In most cases there are two IMV of which one is dominant. Only one venous anastomosis is sufficient to achieve satisfactory venous outflow. Rarely there is insufficient venous drainage, and this can be successfully overcome by performing an *Y*-shaped anastomosis [31].

In this study several recipient axis for the free TRAM were compared. In conclusion we feel that the internal mammary vessels are suitable for anastomosing free abdominal flaps. Dissection of these vessels has proved to be relatively easy and the vessels were reliable recipient vessels. If, in immediate reconstructions, axillary vessels are prepared as part of a lymph node resection, these vessels are used as recipient vessels.

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