

Cephalic Vein Transposition versus Vein Grafts for Venous Outflow in Free-flap Breast Reconstruction

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Introduction: When recipient veins for free-flap breast reconstruction are unavailable or inadequate, vein grafts or cephalic vein transposition (CVT) an option to provide alternate venous outflow. There are no comparative data to elucidate the indications and outcomes for each. We hypothesize that the CVT is as reliable as vein grafts when indicated.

Methods: All consecutive cases where a CVT or venous vein grafts were used for free-flap breast reconstruction between 2000 and 2012 were reviewed. Patient demographics, operative notes, indications, and flap survival were compared between the 2 groups.

Results: Ten patients underwent a CVT and 38 patients received a vein graft for insufficient venous outflow. There were no differences in average age, body mass index, or comorbid conditions between the groups. Similarly, there was no difference in previous radiotherapy, timing of reconstruction, or side of reconstruction. A CVT was used for salvage following venous thrombosis in 7 patients (70.0%) and for primary venous outflow in the remaining patients due to inability to use the internal mammary vein. Vein grafts were performed primarily in 31 patients, 22 for augmenting venous drainage (supercharge), 9 for the dominant venous outflow, and 7 for salvage of a thrombosis. One patient in each group suffered a complete loss of the free flap (cephalic: 10.0% vs vein graft: 14.3%, $P = 0.36$).

Conclusions: The CVT is a reliable alternate venous outflow that can be used as a primary recipient vein or as a salvage option following venous thrombosis. Surgeons should consider a CVT when primary recipient veins are compromised or unavailable. (*Plast Reconstr Surg Glob Open* 2014;2:e141; doi: 10.1097/GOX.000000000000056; Published online 6 May 2014.)

The thoracodorsal (TD) vessels were once regarded as the first-line recipient vessels for microvascular free-flap breast reconstruction.¹

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With a consistent course and caliber, the TD vessels are reliable recipients and are also often already exposed as part of an axillary lymphadenectomy. However, the use of the TD system requires longer flap pedicle length and can displace the bulk of the flap volume more laterally resulting in suboptimal aesthetic outcomes. Previous studies have demonstrated that the TD system may not be usable in up to one third of the cases secondary to scarring from the prior axillary dissection or radiation.² Published literature has also reported an inadequate TD vascular system in up to 15% of cases with an associated 6% incidence of flap loss, particularly for reconstruction of the left breast.²⁻⁴ With the increased use of sentinel lymph

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node biopsies, and formal axillary node dissections less frequently performed, the internal mammary vessels have now become the preferred recipient vessels for breast free-flap reconstruction.^{2,5-7}

The internal mammary vessels have been shown to be reliable and also allow for more medial positioning of the flap providing more medial and superior pole fullness.⁸ They are readily accessible, often times through a rib sparing approach with minimal deformity or donor site morbidity.⁹ Preservation of the TD vessels also more reliably preserves the option of a pedicled latissimus dorsi myocutaneous flap as a salvage procedure in the setting of loss of the free flap. Microsurgeons have also used the internal mammary vessel perforators as recipient vessels or end-to-side anastomoses to preserve the main internal mammary artery for coronary artery bypasses.¹⁰⁻¹²

However, studies have also demonstrated that the internal mammary system may be inadequate for venous outflow in certain circumstances.^{13,14} The left internal mammary vein (IMV) is generally smaller than the right side, and in the setting of a delayed reconstruction, the scarring and radiation induced fibrosis can preclude the use of the IMV as recipients.¹⁵ Others have also cited the unpredictable nature of the branching pattern, size mismatch, and technical difficulty performing microsurgery with the movement of respiration as challenging aspects of using the internal mammary vessels as recipient vessels.¹³⁻¹⁵ In fact, the internal mammary system may be unusable in up to 20% of patients.^{4,8}

Consequently, the reconstructive microsurgeon should entertain the use of alternate recipient vessels when the ipsilateral IMV both antegrade and retrograde is insufficient, inaccessible, or for salvage of thrombosis or inadequate venous drainage. The armamentarium should include the use of vein grafts to reach alternate recipient vessels and transposition of the external jugular or the cephalic vein to obtain additional outflow systems.¹⁶⁻²¹ A cephalic vein transposition (CVT) provides adequate length to an alternate venous system. Although the need for a vein graft or CVT is a relatively uncommon occurrence, indications for their use and potential algorithm for salvage have not been defined. Here, we aim to review the technique of CVT, compare the indications and outcomes to traditional vein grafts, and propose an algorithm for selection.

METHODS

A retrospective review of a prospectively maintained database was performed for all consecutive patients undergoing autologous free-flap breast reconstruction following mastectomy from January

2000 to December 2012 at the University of Texas MD Anderson Cancer Center after institutional review board approval. We identified patients who underwent CVT or venous vein grafts. Vein grafts for arterial anastomoses were excluded. Patients' medical records were reviewed for demographics, comorbidities, prior radiotherapy, postoperative complications, and follow-up. We compared the recipient vessels, flap type, indications for CVT and vein grafts, side of reconstruction, vessel size, and flap loss and salvage rates between the 2 groups.

Statistical Analysis

Means and SDs were used to summarize continuous variables. Frequencies and proportions were used to summarize categorical variables. We compared patient characteristics between patients undergoing a CVT and vein grafts using chi-square test or Fisher exact test for categorical variables and Mann-Whitney or Kruskal-Wallis test for continuous variables as appropriate. All analyses were performed in SAS 9.2 (SAS Institute, Cary, N.C.), and *P* values less than 0.05 were considered statistically significant.

Surgical Technique of Cephalic Vein Harvest

The anatomy of the cephalic vein is relatively predictable. Identification of the deltoid and pectoralis major muscles and the deltopectoral groove provide reliable landmarks for the location of the cephalic vein. The deltopectoral groove can be palpated and then readily identified from the mastectomy breast pocket by visualizing a layer of fatty tissue between the muscles or based on the changes in the orientation of the muscle fibers. Once identified, the proximal extent of the cephalic vein can easily be dissected for a total length of 8–10 cm without the need for a counter incision. The pivot point for the cephalic vein is at the infraclavicular fossa where the vein pierces the coracoclavicular fascia to join the axillary or subclavian vein. If additional length is needed to reach the flap pedicle, either the vein can easily be dissected down the medial aspect of the arm through a small counter incision (Fig. 1) or it can be isolated through small sequential “step” incisions to limit the length of a continuous scar on the arm. Once an adequate length is obtained, the distal end is ligated and cephalic vein is marked in situ with a sterile marking pen to prevent a twist in the vein. A gentle curve should be employed to orient the cephalic vein to avoid a kink in the vein as it is mobilized into the mastectomy defect.

Surgical Technique for Vein Graft Harvest

A number of donor sites can be utilized for a vein graft taking into account vessel diameter size match,

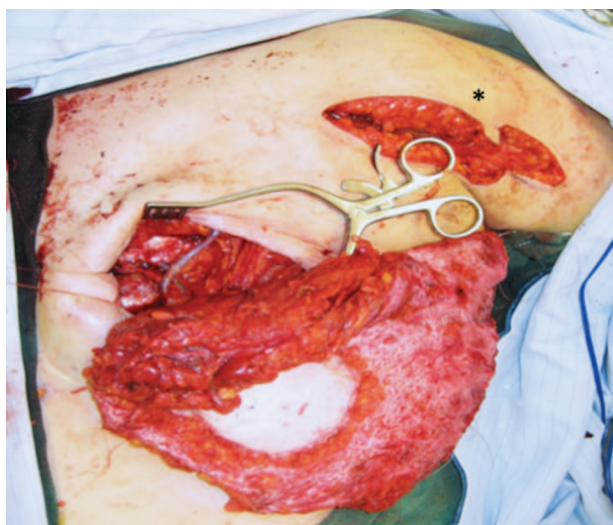


Fig. 1. Patient in case 10 at the time of her second re-exploration for left breast flap venous congestion. To better match the diameter of the deep inferior epigastric vein, a cephalic vein turn-down was performed, allowing use of a 3.5-mm coupler. Note the counter incision in the left brachium (*).

donor site morbidity, and which donor sites may already be prepped into the field. A cutaneous forearm vein is often used as it is typically prepped at our institution for patients undergoing a sentinel lymph node biopsy. Alternatively, a dorsal foot vein can be quickly prepped without disrupting the sterile field of the abdomen and torso. The final common donor site would be the superficial system, particularly the contralateral side in the setting of a unilateral

reconstruction. The selected vein is isolated, small branches are ligated with clips, and the proximal end is marked to orient direction of flow either with a marking pen or with a surgical clip.

RESULTS

Patients Undergoing Cephalic Vein Turndown

During the study period, 2686 free flaps were performed for breast reconstruction. Overall, 10 patients (0.37%) were identified who underwent a CVT for salvage of a venous thrombosis after an autologous free-flap breast reconstruction (Table 1). The mean age was 49.4 years (range, 38–59 years) with an average body mass index (BMI) of 29.9 kg/m² (range, 24–35 kg/m²). Six cephalic turndowns (60.0%) were performed on the left side and the remainder was performed on the right. Patient demographics and flap types are shown in Table 1 and were not different between the groups. Two patients utilized the cephalic vein as a means of “supercharging” the flap to provide an additional drainage of the superficial system due to venous insufficiency of the flap. In 1 patient, both the superficial and the deep systems were anastomosed to the cephalic vein and a branch of the cephalic vein. All but 1 flap survived (90%) secondary to venous thrombosis. The flap became congested on postoperative day 4 and was taken back to the operating room for salvage using a cephalic turn-down. Flow was initially re-established; however, the flap was ultimately lost 3 days after the CVT due to progressive venous thrombosis.

Table 1. Summary of Patient Demographics and Variables

Case	Flap Type	Timing	Side	Age (y)	Body Mass Index (kg/m ²)	Previous Radiotherapy	Previous Chemotherapy	IMV Size (mm)	Cephalic Vein Anastomosis
1	DIEP	Delayed	Left	64	24	Yes	Yes	2.5	2.5-mm coupler to SIEV
2	TRAM	Immediate	Right	56	32	No	No	3.0	Handsewn to DIEV
3	msTRAM	Delayed	Left	39	29	Yes	Yes	Unknown	Handsewn to SIEV and DIEV
4	DIEP	Immediate	Left	57	29	No	No	<1.0	3.0-mm coupler to DIEV
5	msTRAM	Immediate	Right	38	26	No	Yes	1.5	3.5-mm coupler to DIEV
6	DIEP	Delayed	Right	57	29	Yes	Yes	1.5	3.5-mm coupler to DIEV
7	DIEP	Delayed	Left	43	35	Yes	Yes	Unknown	2.5-mm coupler to DIEV
8	msTRAM	Delayed	Right	59	35	Yes	Yes	2.5	3.5-mm coupler to SIEV
9	SGAP	Immediate	Left	40	30	No	Yes	2.5	4.0-mm coupler to SGV
10	msTRAM	Immediate	Left	52	34	No	No	1.5	3.5-mm coupler to DIEV

DIEP, deep inferior epigastric perforator; DIEV, deep inferior epigastric vein; msTRAM, muscle-sparing TRAM; SGAP, superior gluteal artery perforator; SIEV, superficial inferior epigastric vein; TRAM, transverse rectus abdominus myocutaneous.

Patient Undergoing Vein Grafts

Vein grafts were performed in 47 patients, but 9 patients underwent a vein graft for the arterial anastomosis and were excluded. The remaining patients consisted of 33 patients (1.2%) who had only a venous vein graft and 5 received a vein graft for both the arterial and venous anastomosis. There were 8 transverse rectus abdominus myocutaneous flaps, 17 muscle-sparing transverse rectus abdominus myocutaneous flaps, 10 deep inferior epigastric perforator flap, 1 superficial inferior epigastric artery flap, and 2 superior gluteal artery perforator flaps that received vein grafts. The mean age was 50.8 years (range, 29–70 years) with a mean BMI of 29.2 kg/m² (range, 18–41 kg/m²). Thirty-one vein grafts (81.6%) were performed during the primary reconstruction. Twenty patients (52.6%) underwent a vein graft to “supercharge” the flap by draining the superficial system during the primary reconstruction due to venous insufficiency of the flap, whereas 8 patients (21.1%) had a vein graft to augment drainage of the deep system with a second anastomosis to the second vena comitantes. Three patients (7.9%) required a vein graft to lengthen the pedicle (artery and vein) to reach the recipient vessels. The remaining 7 vein grafts were performed for salvage following venous congestion ($n = 2$), thrombosis ($n = 4$), or pedicle avulsion ($n = 1$). There was 1 flap (14.3%) that could not be salvaged and resulted in a total flap loss due to venous thrombosis. All other flaps were successfully salvaged.

Comparison of CVT and Vein Grafts

There was no significant difference in age, BMI, smoking, and comorbidities between the 2 cohorts. Patients undergoing a CVT trended to be more likely to have undergone preoperative radiation (50.0% vs 28.9%; $P = 0.29$) and also to have had a delayed reconstruction (60.0% vs 44.7%; $P = 0.40$); however, none of the differences were significant. Interestingly, there were no differences in the distribution of grafts performed on the right compared with the left side (60.0% vs 57.9%, $P = 0.93$). Flap salvage rates were also not statistically different for patients undergoing a CVT compared with a vein graft (90.0% vs 85.7%, respectively, $P = 0.36$). No flaps that received a vein graft to augment the venous outflow were lost.

DISCUSSION

In this study, we demonstrate that salvage rates for venous compromised flaps are comparable using either a CVT or a vein graft. Overall, a CVT was always performed for salvage, and there was a trend toward performing a CVT in a radiated or delayed reconstructions. However, the majority of venous vein grafts were performed during the primary re-

construction (81.6%), to supercharge the venous outflow, increase pedicle length, or drain the superficial system and less commonly for salvage. To our knowledge, this is the first study to directly analyze the use of vein grafts in free-flap breast reconstruction and compare the outcomes in flap salvage to a CVT. Here, we demonstrate that salvage rates are comparable utilizing the 2 techniques as there were no differences in flap success rates between the groups.

The loss of a free flap in breast reconstruction is an uncommon occurrence with success rates well over 95%.^{22,23} Consequently, given the relative infrequency of flap losses, there is a paucity of literature guiding management of a compromised flap. When flap losses are further stratified into an arterial or venous issue, the numbers of flaps attributed to a venous issue are even more limited ranging from 0.3% to 3.3%.^{24,25} We also noted that the use of vein grafts or CVTs for venous outflow were exceedingly uncommon in our series (0.37% and 1.2%, respectively). It is therefore not surprising that the indications and outcomes have not been directly compared previously. Although previous studies have examined augmenting the venous drainage of an abdominal free flap using the retrograde IMV, conversion to the TD, or lateral thoracic vein, as well as using the external jugular or the cephalic vein, an algorithm for recipient vessel selection remains to be elucidated.^{17–19,26,27}

Other studies have also described the use of a cephalic vein turnover for salvage of failing flaps particularly on the left side.^{19,21} In our series, there was a trend toward a CVT more commonly performed on the left side particularly in the setting of a delayed reconstruction following radiation. Under these circumstances, the proximal antegrade IMV may be thrombosed or fibrosed requiring an alternate venous outflow. Often dissection into a more proximal rib space may provide a larger IMV or the confluence of 2 separate IMVs into a larger caliber vein more suitable as a recipient vein. However, in the setting of a previously irradiated and scarred field, the IMV can often be diminutive and friable precluding their use as recipient vessels even at a more cranial intercostal space. Therefore, we have a low threshold for performing a CVT on the left side particularly in a radiated, scarred field (Fig. 2).

In the setting when the IMV is smaller than can accommodate a 2.0-mm anastomotic coupler, or if venous congestion develops following an uncomplicated, technically intact venous anastomosis to the antegrade IMV, we prefer to use a CVT rather than a vein graft as this may indicate a more proximal insufficiency of flow in the internal mammary system. Changing to an alternate recipient system has been

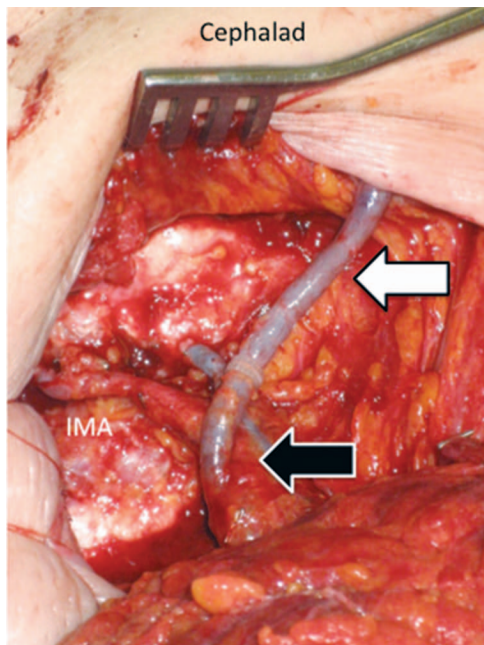


Fig. 2. Close-up of anastomoses with cephalic vein (white arrow) to the deep inferior epigastric vein (black arrow). The arterial anastomosis to the internal mammary artery (IMA) is marked medially. The top of the image is cephalad and the bottom of the photograph is caudad.

associated with improved salvage rates.²⁸ Although vein grafting to the TD system is a viable alternative, this often requires a longer vein graft if the arterial anastomosis is patent to the internal mammary artery. The use of the TD vein as a recipient may limit the use and/or the vascularity of a pedicle latissimus dorsi myocutaneous flap in the setting of a flap loss even if the anastomosis is performed distal to the serratus branch. Additionally, in the setting of radiation or a prior axillary dissection, the TD vessels may not be available or difficult to dissect without injuring the vessels.

If a flap demonstrates superficial dominance or the need for augmenting venous drainage, an additional venous anastomosis can be performed to a second IMV, the retrograde IMV, or an IMV perforator. Often times, this may not require a vein graft or a CVT and should be considered. If these options are not available, a CVT can be performed either as the primary venous outflow or to supplement venous drainage of the superficial system. In our series, 2 patients demonstrated a dominant superficial system for a CVT was performed to provide a second venous outflow. Two patients also underwent a vein graft for the same indication. A vein graft can also be as a second venous outflow to augment the venous drainage during the initial reconstruction as was performed in 20 patients. This is generally not our practice unless

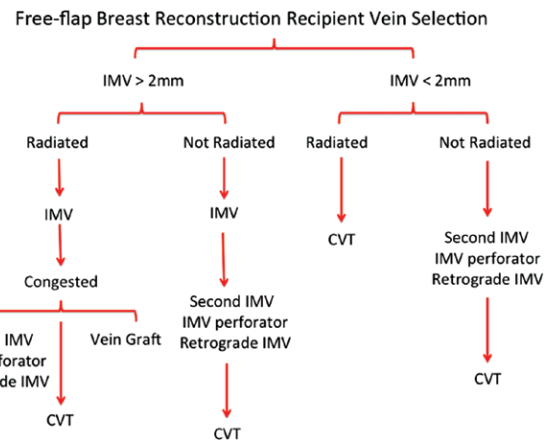


Fig. 3. Algorithm for recipient vein selection in free-flap breast reconstruction.

there is clear clinical evidence of venous congestion. Although some endorse the routine practice of dual venous drainage with an additional venous anastomosis, we prefer not to perform a second anastomosis largely since it has been shown to decrease flow through each individual anastomosis.^{29,30}

However, the decision for harvesting a vein graft vs a CVT remains at the discretion of the plastic surgeon given that the outcomes seem to be equivalent. Both a CVT and a vein graft incur some degree of donor site morbidity, and potentially a vein graft from the lower extremity may be preferable to extending the incision onto the arm. Another consideration would be the impact of performing a CVT in the setting of lymphedema which the present study is not able to address given the infrequency of CVTs performed.

The current study, similar to earlier studies, is limited by its retrospective nature, heterogeneous indications for a CVT or vein graft, small numbers, and surgeon preferences or biases for technique selection.^{18,19,21} The small number of patients undergoing these procedures is likely a reflection of the infrequency of recipient vein insufficiency and venous thrombosis. Despite these limitations, this study is the only to evaluate and compare these 2 techniques for salvage of venous congestion or thrombosis. These data presented raise awareness of the cephalic vein as a reliable alternate recipient vein and offer a potential algorithm for recipient vessel selection in autologous free-flap breast reconstruction (Fig. 3).

CONCLUSIONS

In the setting of venous congestion, superficial dominance, thrombosis of the primary recipient vein, or inadequate recipient veins, especially on the left side following radiation, a CVT should be consid-

ered. It is within the operative field, easily accessible, and a reliable alternate recipient vein when the IMV is not usable.

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