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CLINICAL PRACTICE REVIEW

Atlas of recipient vessels for the superficial venous system of DIEP-flaps – a systematic literature review and clinical practice review

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ABSTRACT
Background: Venous congestion contributes to up to 40% of failures in abdominally based free flaps, underscoring the importance of optimising superficial venous drainage in deep inferior epigastric perforator (DIEP) flap breast reconstruction. The superficial inferior epigastric vein (SIEV) is sometimes essential to flap outflow. This systematic review investigates the choice of recipient vessels for superficial venous supercharging.
Methods: A systematic review was performed according to a PROSPERO-registered protocol (CRD42022353591) and PRISMA guidelines. PubMed, CINAHL, Embase, and the Cochrane Library were searched for studies describing SIEV recipient vessels or vessel-selection algorithms. Extracted data included study design, recipient vessel, graft use, and decision strategies. A clinical practice review was also conducted at Sahlgrenska University Hospital, where prophylactic SIEV–cephalic vein (CV) anastomosis has been used for over two decades.
Results: Twenty-nine studies were included. Reported recipient vessels outside the flap comprised, for example, the following veins: internal mammary, cephalic, thoracoacromial, and thoracodorsal. Intra-flap options included anastomoses to branches or the caudal end of the deep inferior epigastric vein. Three studies described interposition grafts, and eight proposed selection algorithms, with no consensus. The internal mammary vein was most frequently used. At Sahlgrenska, a short axillary-fold incision provides consistent and cosmetically favourable access to the CV, adding minimal operative time.
Conclusion: Recipient vessel selection for SIEV anastomosis remains highly variable in the literature. Long-term institutional experience supports the CV as a reliable and versatile option. Prospective studies are needed to evaluate outcomes.

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Microsurgery; breast reconstruction; DIEP flap; venous supercharging; superficial inferior epigastric vein

Introduction

It has been estimated that venous congestion contributes to about 40% of failures of abdominally based free flaps, such as the deep inferior epigastric perforator (DIEP) flap [1, 2]. The arterial circulation of the DIEP flap is based on perforators from the deep inferior epigastric artery (DIEA), stemming from the external iliac artery [3], whereas the venous circulation arises from both the superficial and deep venous systems.

Already in 1987, Carramenha e Costa et al. [4] concluded that the venous drainage of the anterior abdominal wall is mainly from the superficial to the deep system and that the superficial system gains access to the deep system, mainly through paraumbilical perforators. It suggests that if only the deep system is connected, via the deep inferior epigastric vein (DIEV), the natural presence of vessels linking the superficial and the deep system is essential for a working flap. However, the venous flow might change when the flap is raised and then directed through the *venae comitantes* into the DIEV [4]. Missing superficial-to-deep connections and midline-crossing connections significantly increase the risk of postoperative complications [5]. The connections between the superficial and deep systems are missing in 7.7 [6] to 15% [7, 8] of patients, creating a *superficial system dominance* [9]. The importance of the superficial system also suggests that Scarpa's fascia should be conserved when the flap is thinned, so that the superficial system is preserved [4]. Vessels cross the midline at the level of the subdermal plexus, implicating that preservation of the dermis is essential for a functioning flap [10]. Scars affect the venous connections by disrupting them and, in some cases of Pfannenstiel scars, increase the total number of connections [11, 12]. Anatomical studies on the superficial and deep venous system in abdominally based free flaps are given in Supplementary file 1.

Anastomosis of the superficial venous system, venous supercharging, of DIEP flaps can be performed both therapeutically, if the flap has clinical signs of venous congestion, and prophylactically to reduce the risk of venous congestion [13]. Prophylactic routine use of venous supercharging DIEP flaps has been described by several authors [14–16].

If the superficial system needs to be anastomosed separately, it is most often done through the superficial inferior epigastric vein (SIEV), which is present in 78 [17] to 100% of patients [18–21]. A few anatomical SIEV variants have been described, namely the presence of a medial SIEV trunk in 88% of patients [18], and *the medial branch of the SIEV* (MSIEV) [15]. Anatomical studies on SIEV are summarised in Supplementary file 1.

Several recipient vessels have been described for the SIEV.

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This review aimed to systematically review the literature on recipient vessels and algorithms for selecting them, to create a clinically useful atlas for the reconstructive surgeon, and to describe the clinical practice of recipient vessels at Sahlgrenska University Hospital, Gothenburg.

Methods

The systematic review was performed according to a protocol pre-registered in PROSPERO (CRD42022353591) and reported according to the PRISMA guideline [22]. Previously, one study has been published according to the protocol [13]. Inclusion criteria were studies describing recipient vessels for the SIEV and strategies to choose recipient vessels. The authors independently assessed whether the articles met the inclusion criteria, and a discussion resolved disagreements. PubMed, CINAHL (EBESCO), Embase, and Cochrane Library databases were searched on 18 September 2023 as described in the previously published study [13]. The search string was (((DIEP) OR (deep inferior epigastric perforator)) OR (breast reconstruction)) AND (((superficial inferior epigastric) OR (SIEV)) OR (superficial venous)). In addition, all bibliographies of included studies were manually checked. The search was limited to studies published in English, French, German, Italian, Swedish, Danish, and Norwegian. When eligibility for inclusion could not be assessed with the information in the abstract, the entire article was read and evaluated. Extracted data included first author, year of publication, country of origin, study design and objective, number of included cases, and described techniques for recipient vessel and for strategies to choose vessel. The included studies were not assessed for risk of bias as the study aimed to create a clinical atlas, not to evaluate the evidence of the usage of different recipient vessels.

Atlas of previously described recipient vessels based on the systematic review

Study selection

A total of 371 abstracts were retrieved following the search and manual check of bibliographies (Figure 1). Of these, 46 did not meet the inclusion criteria and were excluded, leaving 343 articles read in full text. After a more detailed scrutiny, a further 302 articles were excluded, leaving 29 studies to be included in the review (Tables 1 and 2). Twenty studies described recipient vessels, three articles described interposition graft types (Table 1), and eight studies described algorithms (Table 2).

Recipient vessels

Recipient vessels were categorised into vessels outside the flap and vessels inside the flap (Table 1). Described recipient vessels outside the flap are the antero- and retrograde internal mammary vein (IMV) [27], a perforator of the IMV [16], the cephalic vein (CV) [30], the circumflex scapular vein [32], the basilic vein [33], the thoracoacromial vein (TAV) [34], a branch of the TAV [35], 'the lateral pectoral vein' [36], the thoracodorsal vein [37], the lateral mammary vein [38], and the external jugular vein [24].

The most studied recipient vessel is the IMV (Figure 2), where one cadaveric study concluded that it does not have valves [31], whereas another revealed that it does [26]. Flow has been seen in both anterograde and retrograde anastomoses [25, 27, 28], whereas the flow seems slower in retrograde anastomoses [25, 28]. One study has described a successful anastomosis of the SIEV end-to-side to the same IMV used to anastomose the DIEV [24]. Another commonly used recipient vessel throughout the studies (Table 1) is the CV.

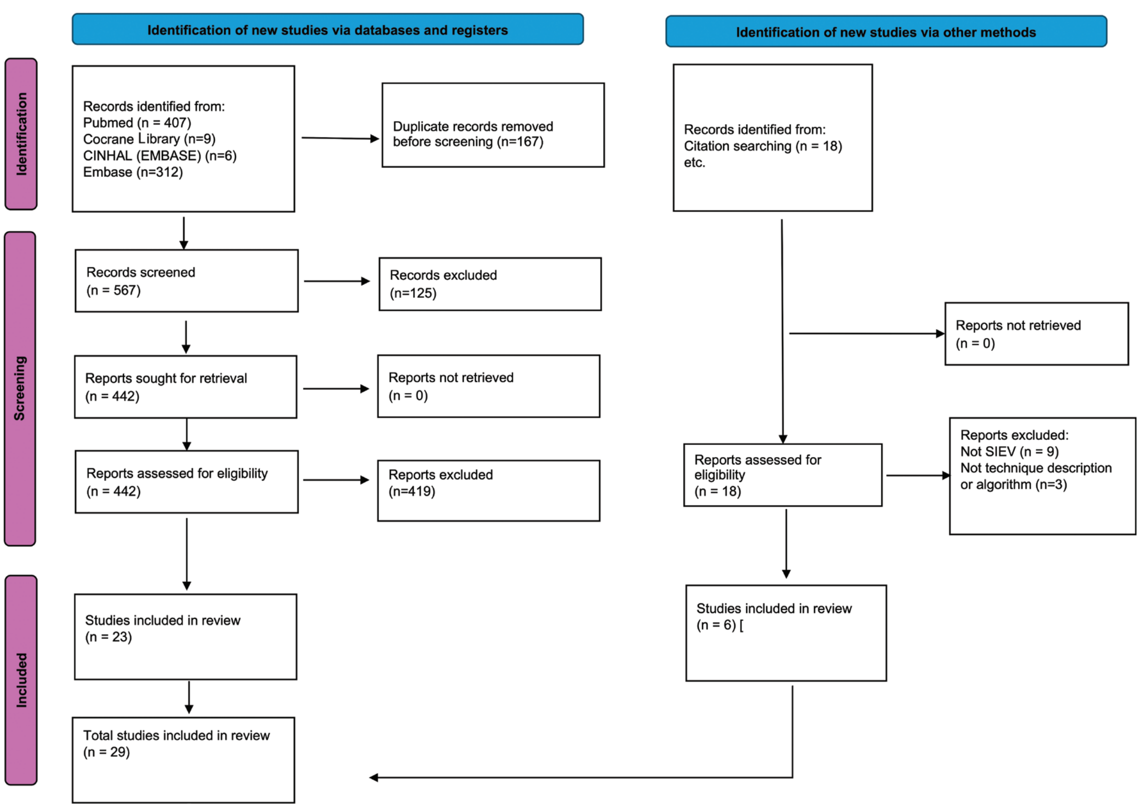

Figure 1. PRISMA diagram.

Table 1. Recipient vessels and interpositional grafts.

Author Year Country	Study groups; Intervention and control (n = no. of DIEPs)	Results	Comment
Specific recipient vessels			
Vessels outside the flap			
Internal mammary vein/ internal thoracic vein (IMV) (Figure 2)			
Al-Dhamin, Canda 2014 [23]	Microscopy of vein in 5 cadavers *(cadaveric study)*	There are no valves in the retrograde limb of the IMV.	
Ali, 2010, Taiwan [24]	Case series	SIEV to IMV end to side	
Kubota, 2014, Japan [25]	Measurement of flow in 5 anastomoses *(case series)*	Retrograde IMV anastomoses has a 60% patency rate The peak venous blood velocity was significantly slower in retrograde IMV anastomoses than anterograde IMV anastomoses	
Mackey, 2001, UK [26]	Cadaveric study and microscopy	A total of 21 valves were found in the cadavers (99 IMVs and branches). Twenty of the valves were bicuspid and 1 tricuspid. Valves were found before or after the branching point of the IMVs, and at multiple sites in some cases.	
Mohebali, 2010, USA [27]	Measurement of flow in anastomoses *(non- randomised study with controls)*	Flow was seen independently in both the anterograde and retrograde venous anastomoses. Indocyanine green (ICG) entered the anterograde anastomosis a few seconds before the retrograde anastomosis.	
Venturi, 2011, USA [28]	Measurement of flow 10 retrograde and 10 anterograde anastomoses *(non- randomised study with controls)*	Retrograde IMV / Anterograde IMV / p-value Velocity: 7.01 ± 2.93 mm/s / 10.13 ± 5.21 mm/s / 0.12 Blood flow: 57.84 ± 45.11 mm(3) /s / 81.33 ± 52.81 mm(3) /s / 0.3	Mean blood flow in the retrograde IMV was not affected by whether the donor vein was the vena comitantis (70.78 ± 61.43 mm(3) /s) or the SIEV (44.90 ± 19.70 mm(3) /s; $P = 0.40$).
Perforator of the IMV (Figure 2)			
Boutros, 2013, USA [16]	Case series	SIEV to intramuscular perforator of the IMV	
Cephalic vein (CV)			
Audolfsson, 2009, Sweden [29]	Description of technique	Anterior axillary-line skin fold incision was used for access to the CV.	
Barnett, 1996, Australia [30]	Description of technique	A transverse axillary incision was made and 15–18 cm of CV harvested. If this was not enough a series of step incision along the course of the CV was made. The CV vein was divided distally at the insertion of the deltoid muscle.	
Silhol, 2017, France [31]	Description of technique	The CV was accessed through the mastectomy scar. The length of the CV dissected varied from 15 to 25 cm and transposed. The mean time of dissection was 39 min.	
Circumflex scapular vein (CSV)			
Villafane, 1999, UK [32]	Description of technique	The SIEV was anastomosed to the CSV using a VG from the saphenous vein.	
Basilic vein (BV)			
Guzzetti, 2009 [33]	Description of technique	An ipsilateral BV was harvested with a long length (25 cm) and rotated in 180°.	
Thoracoacromial vein (TAV)			
Kim, 2019, South Korea [34]	Case series	The major pectoral muscle was split at the first intercostal space and the TAV identified in the fatty tissue under the muscle. Mean size of TA veins was 1.61 mm (range 9–25 mm). Harvested SIEV length was 51.4 mm (35–70 mm). Distance from the TAV to different anatomic structures were measured with CT.	
Branch of TAV			
Eom, 2011, South Korea [35]	Case series	SIEV to branch of TAV	
'Lateral pectoral vein'			
Niranjan, 2001, UK [36]	Description of technique	The SIEV was anastomosed to the lateral pectoral vein	
Thoracodorsal vein			
Wechselberger, 2001, Austria [37]	Case series	SIEV to thoracodorsal, lateral thoracic	
Lateral thoracic vein (LTV)			

Table 1. (*Continued*)

Author **Year** **Country**	**Study groups; Intervention and control (*n* = no. of DIEPs)**	**Results**	**Comment**
Wechselberger, 2001, Austria [37]	Case series	SIEV to lateral thoracic vein	
Lateral mammary vein (LVM)			
Al Hindi, 2019, France [38]	Case series	SIEV/DIEV to lateral mammary vein	
External jugular vein			
Ali, 2010, Taiwan [24]	Case series	SIEV/DIEV was anastomosed to the external jugular vein using an interposition vein graft	
Vessels within the flap (Figure 3)			
SIEV to SIEV			
Xin, 2012, China [39]	Description of technique Measurement of blood pressure in anastomosis (*n* = 3) Ultrasound of anastomosis on day 3	SIEV-SIEV reverse flow anastomosis. A lower pressure was achieved (14.3±2.5 mmHg) with the technique than without venous augmentation (22.7±2.1 mm Hg). The anastomses were patent on ultrasound on day 3	
Second DIEV of the pedicle			
Ali, 2010, Taiwan [24]	Case series	SIEV to second DIEV of the pedicle	
Sbitany, 2012, USA [40]	Case series	SIEV to second DIEV of the pedicle	
Cranial part of DIEV (superficial outside-flap shunt, SOS-technique)			
Davies, 2014, UK [41]	Description of technique	The SIEV is anastomosed to the cranial part of the DIEV that is anastomosed to the IMV	
Vena comitaites of the pedicle (DIEVc)			
Rohde, 2005, USA [42]	Description of technique	The SIEV is anastomosed to the vena comitantis of the pedicle proximal to the anastomosis to the internal mammary vein	'Technique does not require additional dissection of separate recipient vessels'
Interposition grafts			
Blondeel, 1999, Belgium [43]	Description of technique/ case report (2 cases)	An arterial graft was harvested from the remaining deep inferior epigastric artery where the flap had been harvested (between lateral border of rectus muscle and the external iliac artery). SIEV+arterial graft to one of the venae concomitantes of the IMA	The two patients are described as 'obese'. After these cases the author has started to routinely harvest the SIEVs at the beginning of the operation.
Nigam, 2017, USA [44]	Description of technique	Lateral thoracic interposition vein graft was used to anastomose the SIEV to the recipient vessel.	
Niranjan, 2001, UK [36]	Description of technique	A contralateral vein was anastomosed to the CV using a long-saphenous-vein interposition graft.	

IMV: internal mammary vein; SIEV: superficial inferior epigastric vein; DIEV: deep inferior epigastric vein; IMA: internal mammary artery.

Table 2. Choices of recipient vessel

Study Author, year, country	Study groups;Intervention and control (*n* = no. of DIEPs)	Results
Bartlett, 2018, USA [45]	Case series) (67 DIEPs)	Figure 1 ± VG 1. Intraflap re-routing is the first choice 1a. SIEV to second DIEV/DIEVc with anterograde flow 1b. SIEV to second DIEV/DIEVc with retrograde flow 2. Extraflap re-routing 2a. SIEV to anterograde IMV/perf of IMV 2b. SIEV to retrograde IMV The authors use the SCIV, SCIVc used in the same way as the SIEV 32/38 (80%) SIEV to DIEV/DIEVc. VGs (harvested from the groin) were used in 6 of them. The authors recommend that the extra vein is anastomosed before the pedicle anastomosis is performed.
Davies, 2014, UK [41]	Case series	If short superficial system: The superficial system is anastomosed to deep system, to perforator (antegrade to vv. comitantes at base of flap or retrograde) or to additional length of DIEV (SOS technique). If long superficial system: The superficial system is anastomosed to vessel extrinsic to flap (antegrade IMV, second vv comitantes of IMV, CV or TDV or branch of TDV).
Galanis, 2014, USA [46]	Description of centre's approach	If there is a paired IMV system and the SIEV is preserved and engorged it is anastomosed to 2nd IMV. If SIEV is not preserved, VC is anastomosed to 2nd IMV. If there is not a paired IMV system and the SIEV is preserved and engorged it is anastomosed to 2nd IMV. If it is not preserved VC is anastomosed to retrograde IMV.
La Padula, 2016, France [47]	Case series	DIEV to antegrade IMV and SIEV to retrograde IMV
Pignatti, 2021 [48]	Literature review	1st choice: SIEV – chest vein because safer 2nd choice: SIEV – DIEV because faster 3rd choice: DIEV – chest vein as last resource 4th choice: alternative methods
Tokumoto, 2019, Japan [49]	Case series	The authors first choice is to anastomose the SIEV to the LTV or the SA. If these vessels are not suitable, they anastomose the SIEV to the CV.
Wechselberger, 2001, Austria [37]	Case series	The authors state that if the main pedicle is anastomosed to the internal mammary vessels their first choice is to anastomose the SIEV to the thoracodorsal vein, lateral thoracic vein or the thoracoacromial vein and their second choice an intercostal vein or second venae comitantes.
Vijayasekaran, 2017, USA [15]	Case series	If SIEV is preserved and there is a paired IMV → VC to 1st IMV, SIEV to 2nd IMV. The second VC is preserved for further venous augmentation. If SIEV is preserved and there is not a paired IMV → VC to 1st IMV, SIEV to retrograde IMV. The second VC is preserved for further venous augmentation. If SIEV is not preserved, a 2nd VC is anastomosed to two IMVs if it is paired and to ante/retrograde IMV if it is not paired.

DIEP: deep inferior epigastric perforator; IMV: internal mammary vein; SIEV: superficial inferior epigastric vein; DIEV: deep inferior epigastric vein; SOS: superficial outside-flap shunt; CV: cephalic vein; VG: venous graft; TDV: thoracaodorsal vein; c: comitantis

Different accesses to it have been described, such as an anterior axillary-line skin fold incision [29], a transverse axillary incision [30], and through the mastectomy scar [31], not resulting in an extensive scar on the arm.

Techniques where the SIEV was anastomosed to another vein within the flap (Figure 3) (Table 1) comprise SIEV-SIEV reverse flow anastomosis [39], anastomosis to the second DIEV of the pedicle [24, 40], to a branch of the DIEV of the pedicle [42], and to the cranial part of the DIEV anastomosed as the primary vein, also called superficial outside-flap shunt (SOS) [41].

The three studies describing interpositional graft (Table 1) comprise both arterial grafts, from the remaining DIEA [43], as well as venous grafts from the lateral thoracic vein [44] and the long saphenous vein [36].

Algorithms for the choice of recipient vessel

Eight centres have described their preferences for choice of recipient vessels (Table 2), based on clinical experience. There was no consensus between the different studies. The details of the different algorithms are described in Table 2.

Clinical practice review: usage of the CV at Sahlgrenska University Hospital

The first abdominally based free flap for breast reconstruction was performed in Sahlgrenska University Hospital in 1979 [50]. Currently, the department of plastic surgery performs 90 DIEP flaps a year, both for immediate and delayed breast reconstruction. The department

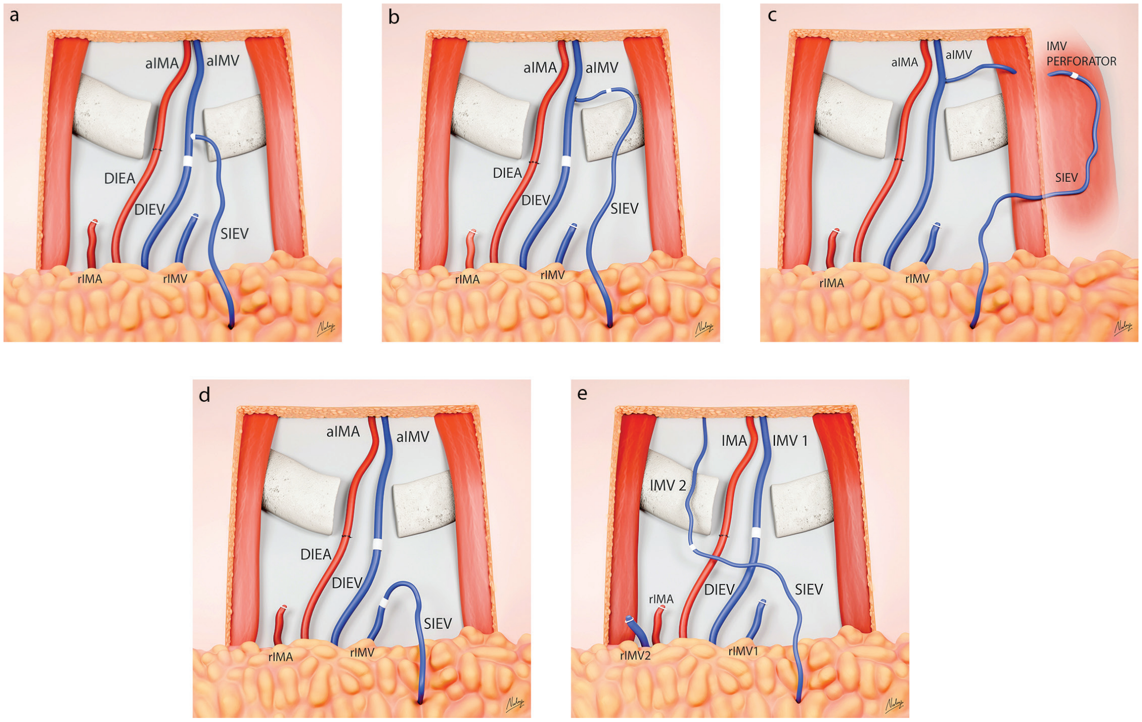

Figure 2. IMV as a recipient vessel for SIEV. (a) SIEV end to side to IMV. (b) SIEV to branch of IMV. (c) SIEV to muscle perforator branch of IMV. (d) SIEV to retrograde IMV. (e) SIEV to second IMV. Figure created by Niclas Löfgren, medical photographer, Department of Plastic Surgery, Sahlgrenska University Hospital, Gothenburg. A: anterograde; DIEA: deep inferior epigastric artery; DIEV: deep inferior epigastric vein; IMA: internal mammary artery; IMV: internal mammary vein; R: retrograde; SIEV: superficial inferior epigastric vein.

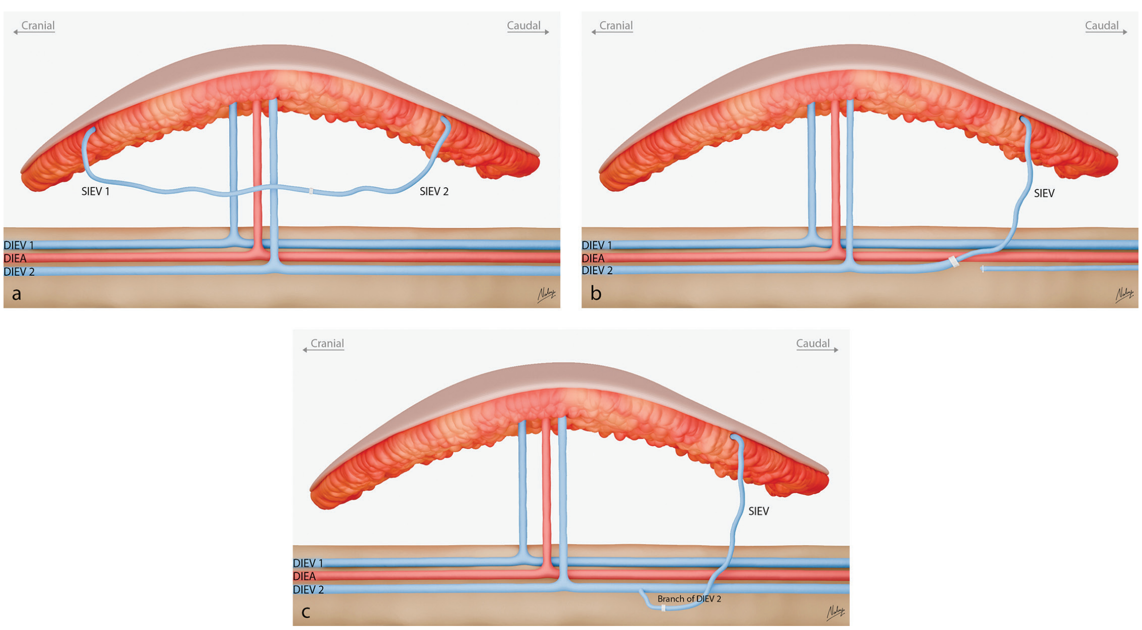

Figure 3. Intraflap recipient vessels for SIEV. (a) Right SIEV to left SIEV. (b) SIEV to caudal end of second DIEV (SOS). (c) SIEV to branch of second DIEV. Figure created by Niclas Löfgren, medical photographer, Department of Plastic Surgery, Sahlgrenska University Hospital, Gothenburg. DIEA: deep inferior epigastric artery; DIEV: deep inferior epigastric vein; SIEV: superficial inferior epigastric vein; SOS: superficial outside-flap shunt.

has researched DIEP flaps since the 1970s (e.g. [50– 61]). Traditionally in the department, autologous breast reconstruction has been performed principally in patients who have received radiotherapy [51]. However, as efficiency has increased, indications have been extended. In 2024, a partially randomised patient preference trial comparing DIEPs and implant-based reconstruction in non-radiated patients, GoBreast II, was initiated and currently includes patients [62].

Prophylactic SIEVs have been routinely anastomosed in our department to the CV since the early 2000s [63]. During the first years, the CV was dissected through two incisions along the arm and turned down [30]. The first series was described in 2006, and it was concluded that a prophylactic anastomosis of SIEV might lower complication rates and lead to a better cosmetic result [30]. The technique for dissecting the CV was later modified in the department to an access

Figure 4. The SIEV has been dissected during the DIEP flap raise. Photo: Jonas Löfstrand. DIEP: deep inferior epigastric perforator; SIEV: superficial inferior epigastric vein.

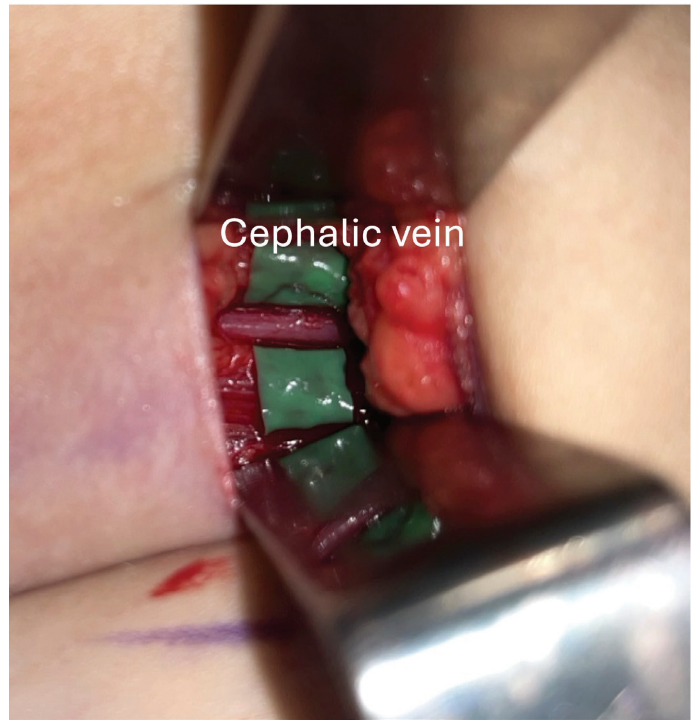

Figure 5. A 3 cm incision has been made in the axillary fold. Photo: Jonas Löfstrand.

through a three-centimetre (cm)-long vertical incision in the axillary fold (Figure 4), similar to the method later described by Audolfsson et al. [29]. The short vertical incision leaves a scar that is well disguised in the axillary fold and can be easily hidden in clothes, compared to the scars along the arm. The CV, or a branch thereof, is usually easily found in the deltopectoral groove and easily accessed through the incision (Figure 5). The contralateral SIEV is particularly suitable for anastomosis with the CV if the DIEP flap is rotated 180 degrees during inset. A subcutaneous tunnel is created between the axillary fold incision and the flap pocket, where the two vessels meet and can be anastomosed (Figures 6–9), allowing for the veins to curve favourably and create a physiological drainage of the flap (Figure 9). To perform the anastomosis without a graft, the SIEV must be harvested as long as possible, usually at least 7 cm (Figure 10). In cases where the SIEV cannot be harvested long enough, for example, in the case of a horizontal abdominal scar, such as a C-section scar, the contralateral SIEV can be harvested proximal to the scar and anastomosed to the distal end of the other SIEV. Since both the SIEV and the CV are usually large, it is easy to perform the anastomosis with a coupler device (Figure 8) in loupes (Figure 7). The additional dissection and venous anastomosis typically add about 15 minutes to the operative time. Another drawback is the increased complexity of any potential re-operations, as the flap becomes anchored by anastomoses to both the IM vessels and the CV.

The effect of routine venous supercharging is difficult to evaluate as the risk of venous congestion is multifactorial and dependent on several factors. In our department, we have chosen to use venous supercharging routinely, as the morbidity of the procedure is low and the additional operating time is limited. More studies on the routine use of venous supercharging are necessary to validate the effect.

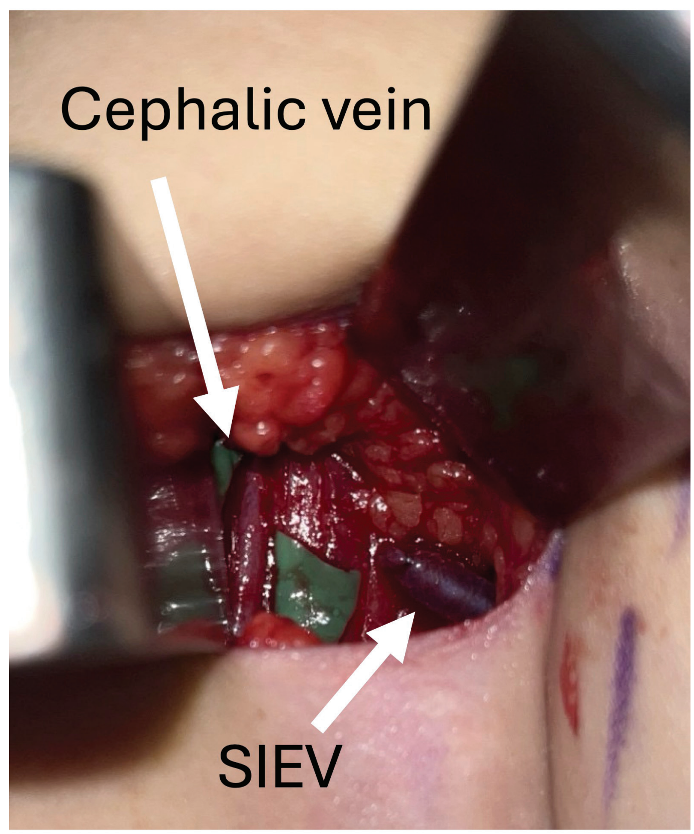

Figure 6. The CV has been dissected through the axillary fold incision. Photo: Jonas Löfstrand. CV: cephalic vein.

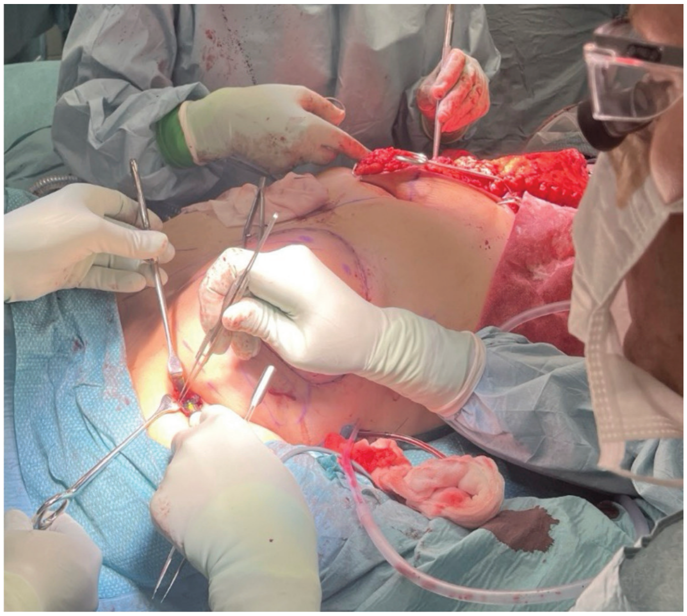

Figure 7. The SIEV has been tunnelled through a subcutaneous tunnel created between the axillary fold incision and the flap pocket. Photo: Jonas Löfstrand. SIEV: superficial inferior epigastric vein.

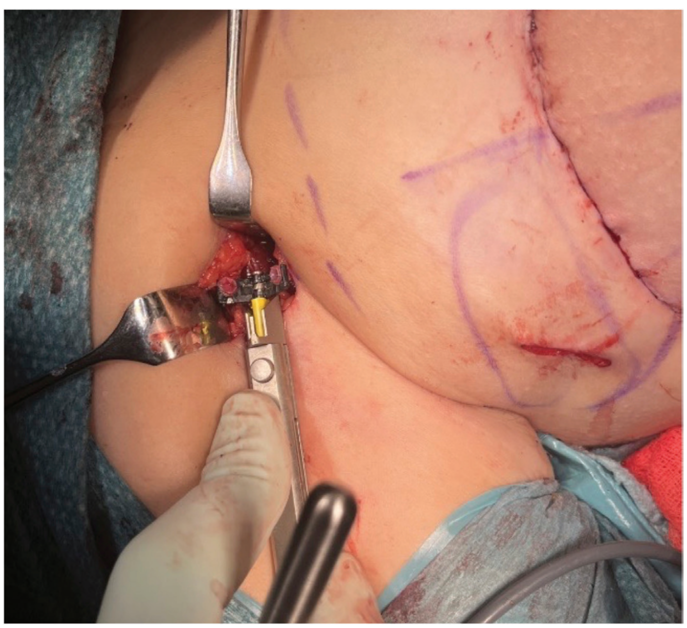

Figure 8. The SIEV-CV anastomosis is performed in loupes. Photo: Jonas Löfstrand. SIEV: superficial inferior epigastric vein; CV: cephalic vein.

Conclusion

Venous congestion remains a significant cause of partial or total flap failure in abdominally based free flaps, underscoring the importance of understanding and optimising venous drainage. This systematic review identified a wide range of recipient vessels described for the SIEV, both within and outside the flap, as well as several algorithms guiding vessel selection. However, no consensus currently exists regarding the optimal recipient vessel or decision-making strategy, reflecting the significant anatomical variability and the need for individualised surgical planning.

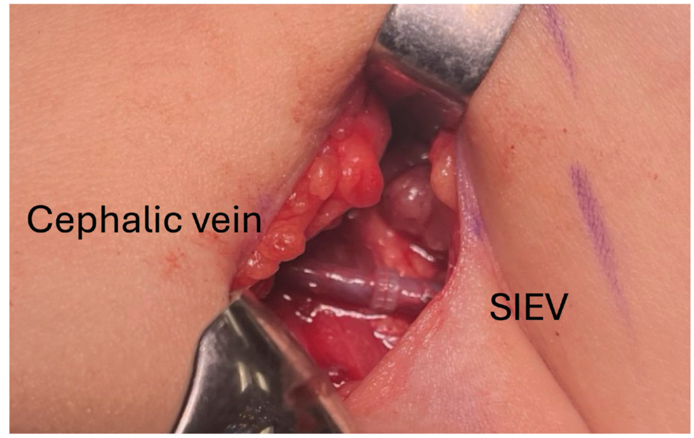

Figure 9. A coupler device is used to anastomose the SIEV and CV. Photo: Jonas Löfstrand. SIEV: superficial inferior epigastric vein; CV: cephalic vein.

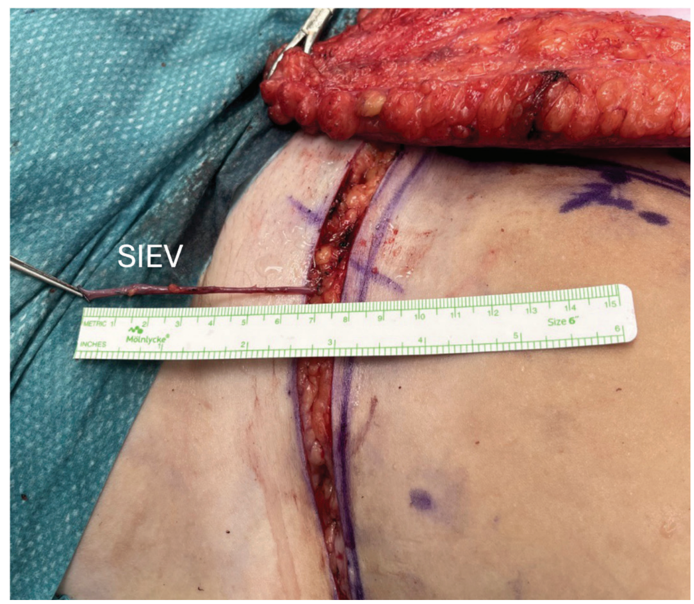

Figure 10. The patent SIEV-CV anastomosis. Photo: Jonas Löfstrand. SIEV: superficial inferior epigastric vein; CV: cephalic vein.

At Sahlgrenska University Hospital, the CV has been used as a reliable and versatile recipient vessel since the 1990s, and we routinely perform prophylactic anastomosis between the SIEV and the CV. The modified axillary access technique offers an easily reproducible approach with minimal donor-site morbidity and a well-concealed scar.

This review contributes a practical atlas of recipient vessel options and decision algorithms to guide reconstructive surgeons in managing superficial venous drainage in DIEP flap breast reconstruction. Future prospective and comparative studies are warranted to evaluate clinical outcomes.

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