TECHNICAL NOTE

# Chest wall perforator flaps for partial breast reconstruction: a novel approach for a better outcome

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## Introduction

Breast cancer surgery has evolved since William Halsted's radical mastectomy. Currently the oncoplastic breast surgery plays a vital role in both breast conservative surgery (BCS) and breast reconstruction (implant or autologous based) after mastectomy. There are different volume displacement and volume replacement techniques in BCS, and volume replacement techniques lead to partial breast reconstruction (PBR). The main decisive factor of a volume displacement or volume replacement depends on the breast size to tumour size ratio. Hence, wide local excision of a larger tumour in a small to medium-sized breast (cup size A to D) imposes a challenge in restoring the original breast shape and volume.

Volume replacement with chest wall perforator flaps (CWPF) is an emerging novel technique with aesthetically appealing outcomes being reported in recent literature [1],[2],[3]. However, a fascio-cutaneous flap derived from lateral thoracodorsal vessels, to assist implant-based breast reconstruction, was first described in 1986 by Holmstrom et al [4]. Later, Hamdi et al [5],[6],[7] described the use of pedicled and free fascio-cutaneous flaps based on the lateral chest wall perforators as volume replacement techniques in breast reconstruction

This article intends to give an update, including the surgical technique and outcome of CWPF in partial breast reconstruction following surgery for breast cancer and benign conditions of the breast.

## Indications for CWPF

Wide local excision in a small breast or quadrantectomy in a medium-sized breast is the most common indication to use a CWPF. Also, these flaps can be used to protect an implant, in the sub-pectoral plane, in implant-based reconstruction after mastectomy.

CWPF is also useful as a salvage option in partial flap failure in free or pedicle flap breast reconstruction.

Apart from breast cancer surgery, CWPFs are of value in breast augmentation with autologous tissue and correction of congenital deformities of breast. Furthermore, patients undergoing excision/quadrantectomy for granulomatous mastitis CWPF"s would certainly be a great option for the breast surgeon in restoring the breast volume and shape integrity.

## Contraindications for CWPF

There are very few contra-indications for CWPFs. If one of the parent vessels, from which each designated perforator originates is damaged, CWPF's are contraindicated. For example if, thoracodorsal vascular pedicle is damaged by previous axillary surgery (usually due to axillary clearance), performing a TDAP flap is a contraindication. Yet the lateral chest wall perforator-based flaps (Li CAP or LTAP) can be done in such situations. Patients who have undergone ipsilateral lateral thoracotomy may not be suitable for lateral chest wall perforator flaps (Li CAP or LTAP). These patients can be offered TDAP flap after preoperative Doppler confirmation.

Previous radiotherapy to the lateral and anterior chest wall is not an absolute contraindication for CWPF's, but should be cautious. Defects in post-irradiated breast tissue tend to be larger, and the viability of the perforators tends to be lower. Therefore, a much better option in such scenario would be distant free flaps (i.e. TUG or DIEP flap) as they carry their own blood supply and can harvest wider area of tissues for adequate reconstruction.

## Surgical anatomy and pre-operative marking

The course of an intercostal vessel can be divided into 4 segments: (i) vertebral, (ii) inter-costal, (iii) inter-muscular and (iv) the rectus segment. (Figure1).

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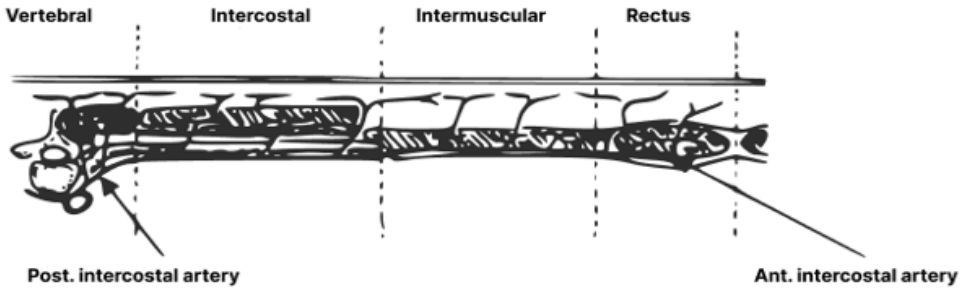


**Figure 1 :** The course of an intercostal vessel

For breast reconstruction the CWPFs are designed based on perforators arising from all segments of an intercostal vessel except the vertebral segment.

**1. Thoracodorsal artery perforator (TDAP) flap**

This flap is based on the Musculo-cutaneous perforators originating from the thoracodorsal vessel. Thoracodorsal (TD) vessel is the main vessel supplying the latissimus dorsi (LD) muscle. After giving its branch to serratus anterior (medially), the TD vessel divides into a descending branch vertically and a horizontal branch laterally. These branches give rise to perforators that supply the surrounding overlying skin and subcutaneous tissue. Cadaveric studies have shown 2 to 3 cutaneous perforators arising from the descending branch [1],[3],[5],[6].

A fairly constant perforator from this descending branch, that perforates the LD muscle, can be skin marked (with a Doppler device) 8 cm inferior to the posterior axillary fold and 2 cm medial to the lateral border of the LD muscle. A flap can be designed based on this perforator as an ellipse lying horizontally or sometimes vertically, depending on the tumour location and the surgeons' preference. (Figure 3)

**2. Lateral thoracic artery perforator (LTAP) flap**

The lateral thoracic artery descends down along the lateral chest wall mostly as a direct branch form the axially artery or sometimes as a branch form the thoracodorsal artery. It gives rise to perforators in the mid-axillary line from 3$^{rd}$ to 5$^{th}$ inter-costal spaces. This flap can be used to fill defects in the lateral half of the breast. Unlike the TDAP and Li CAP the LTAP perforators are not constant and can be smaller in caliber to enable it to perfuse the harvested flap on its own. Thus, in clinical practice LTAP will be used mostly to augment the perfusion of a LICAP flap.

**3. Lateral inter-costal artery perforator (Li CAP) flap**

This flap is based on the lateral perforator vessels arising from the costal segment of an intercostal vessel. Usually, there are two to four Li CAP perforators arising in an arbitrary triangle demarcated anteriorly by the anterior axillary fold, posteriorly by the mid axillary line and inferiorly by the upper border of the 6th rib. (Figure 2 and 3). This perforator flap is valuable, especially for upper outer quadrant, outer central and lower outer quadrant tumours.

The flap can be either propelled or flipped over into the WLE cavity for insetting. If the flap is raised on a single perforator, then it is easy to either flip over or propel it into the WLE cavity. However, if the flap is raised on more than one perforator, it is difficult to propel the flap but can be flipped over. Yet it should be stressed that in comparison to a TDAP flap, the perforator length in a LICAP flap is less, restricting the freedom of flap movement to a certain degree.

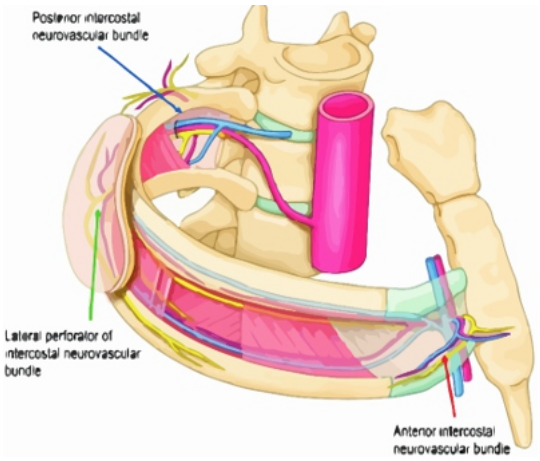


**Figure 2:** Anatomy of the intercostal neurovascular bundle

**4. Anterior inter-costal artery perforator (AiCAP) flap**

This flap is based on the inter-muscular and rectal segments of an vessel. As the name implies, these perforators arise anteriorly in the chest wall and lie along a horizontal line. For partial breast reconstruction the perforators arising below the infra-mammary crease are utilised. infra-mammary crease are utilised. The perforators arising from the middle 1/3 are

named as **Ai CAP** flaps. The Ai CAP perforators are not constant and can vary in their caliber. Thus, pre-operative mark-up with hand-held doppler is mandatory.

Ai CAP flaps are preferred for partial reconstruction of lower central volume defects.

**5. Medial inter-costal artery perforator flap (MI CAP) flap**

This flap is based on the perforators that arise medially from the rectal segments of an inter-costal vessel below the infra-mammary fold. Unlike the Ai CAP the MI CAP perforators are fairly constant and have the capacity to perfuse a lengthy flap. Thus, pre-operative Doppler mark-up may not be mandatory for a surgeon experienced in these perforator flaps. MI CAP flaps are preferred to replace a volume defect in the medial half of the breast; upper inner, lower inner or inner central.

**Surgical technique**

Pre-operative markup and flap design

As a principle, patient markup should be always done pre-operatively with the patient in the standing position. A hand-held uni-directional Doppler is helpful to locate the perforators and fine adjustments to the flap design can be made after marking the perforators. During flap raising, and later tunnelling into the recipient site, it may be necessary to sacrifice some of the marked perforates in order to reduce the tension on the perforators and to ease the flap inset without undue tension. Thus, it is important to mark all the perforators that can be detected via the Doppler device. Usually, one good perforator is adequate to maintain the vascularity of the flap.

Apart form perforator mark-up it is important to mark the infra-mammary fold and the breast footprint. The intended skin incision of the wide local excision to remove the tumor should also be marked if not using incisions marked for the flap.

**Flap raising and perforator dissection-**
**Li CAP and LTAP**

If PBR is done for a breast cancer; wide local excision (or quadrantectomy) and axillary surgery can be completed prior to raising the flap.

A long, elliptical shaped flap is marked starting from the anterior axillary fold to a point 3-4cm lateral to the spine. Usually there is a natural skin fold in this region and the width of the flap is around 6-8 cm as decided by the pinch test (Figure 3). It is noteworthy to pay attention to incorporate the perforators marked. Next, the skin incision is made down to the deep fascia along the pre-operatively marked lines. Flap raising is started medially and proceed laterally, with electrocautery dissection, until about 5 cm lateral to the marked perforators. Here onwards bipolar diathermy (set at 10 to 15) and tenotomy scissors are used for more delicate fine dissection under loupe magnification.

It is important to preserve all perforators marked pre-operatively. If the preoperatively marked perforators cannot be visualized during dissection it is advisable to use a unidirectional doppler device intra-operatively to locate the perforators. The perforators should be carefully dissected but should not be skeletonised at this stage. Once all the perforators are dissected, in order to ensure a tension-free flap inset into the wide local excision cavity, a decision can be made to sacrifice one or two perforators without hindering the vascularity to the flap. The biggest perforator close to the pivot point of the flap should be preserved. Usually, perforators of a Li CAP and LTAP are seen in at the mid-axillary fold. Retracting the anterior border of the latissimus dorsi muscle will enable to dissect perforators to gain adequate length. De-epithelialization of the flap skin is done after dissecting the perforators. Usually, the entire flap is de-epithelialized unless there is a need to replace a skin loss in the breast.

The Li CAP flap can be either flipped over or propelled into the wide local excision cavity after de-epithelialization. The vascularity can be assessed during de-epithelialization. If healthy arterial bleeding is noted from the de-epithelialized flap, especially at the distal end, the flap will survive without fat necrosis or flap failure. If venous congestion or no arterial bleeding noted, especially at the distal end (which is the furthest away from the perforators), this part of the flap can be excised.

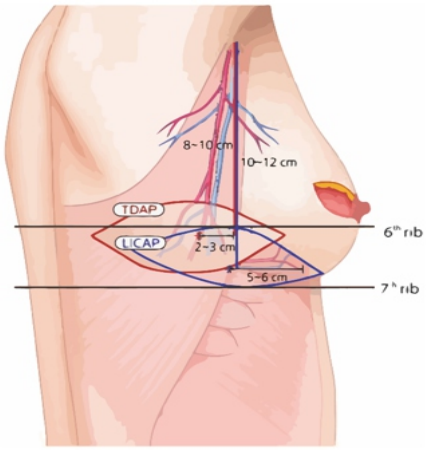


**Figure 3:** Flap design and range of locations for LICAP with a schematic depiction of the location in relation to the TDAP flap.

**TDAP's**

The flap design is mostly similar to a Li CAP flap and the dissection starts medial to lateral. When getting closer to the marked perforator the mono-polar diathermy has to be replaced with bi-polar forceps. The dissection should proceed under loupe magnification carefully. The perforator can be seen as a pulsatile vessel and if the surgeon is happy about the caliber of the perforator can continue to dissect it with small cuff of fascia of the LD muscle. The length of the perforator has to be assessed carefully as it may not be adequate, depending on the locality of the defect in the breast. Once the dissection is complete the flap can be much easily propelled or flipped over to the WLE defect in comparison to a Li CAP flap. Usually during a medial to lateral directed dissection a TDAP will be encountered prior to Li CAP. As the TDAP is usually larger in caliber it would be better to preserve this perforator whenever possible.

**MiCAP's**

A crescent shaped flap is marked using the IMF as the upper border of the crescent. MiCA perforators are located with the hand-held Doppler device. These are usually seen 2-3cm lateral to the sternal edge and 2-3cm inferior to the IMF. Therefore, these perforators are eccentric in location in relation to the flap. Hence, perfusion decreases towards the distal end increasing the likelihood of fat necrosis or even partial flap failure. However, it gives adequate flap mobility to fill the defects of the inner half of the breast.

After making the skin incision and deepening it to the external oblique aponeurosis, flap dissection starts at the lateral end, raising towards the medial end with mono-polar electrocautery. Closer to the marked perforators mono-polar is replaced with fine bipolar diathermy forceps and the dissection proceeds under loupe magnification. The perforators; usually two, can be seen emerging from the intercostal space at the medial end.

**Pros and cons of different CWPFs**

LTAP flap is a good choice for the outer central and upper outer quadrant breast defects. Yet as mentioned earlier LTAP is not constant and highly variable in presence as well as calibre. Therefore, it is not uncommon to augment the LTAP flap with Li CAP perforators to ensure adequate vascularity and perfusion. On the other hand, as the perforator of the LTAP flap is relatively long, the flap inset into the breast defect would be easier.

LiCAP's are relatively constant in comparison to the LTAP's. Henceforth there is good chance that a Li CAP flap can be raised solely on these perforators without the need to augment with other perforators. Yet in practice rarely these flaps can get the help of additional vascular supply from LTAP's as LiCAP's and LTAP's are in close proximity.

The TDAP is a constant perforator than LTAP or Li CAP. But as it is emerging through the LD muscle, dissection of this perforator, to gain adequate pedicle length, can be technically demanding. In return as the TDAP is relatively medial, than LTAP/Li CAP, the perfusion of the flap is relatively better. This helps to reduce the possibility of fat necrosis in distal part of the flap.

For tumors in the lower central part of the breast an AiCAP flap is preferred. The distance that the flap needs to be mobilized is short and as the perforator in an AiCAP flap is centrally located the perfusion of the distal two ends are much better. This lowers the risk of fat necrosis and partial flap loss. However, during the recreation of the neo-IMF (inframammary fold) the perforator location of the AiCAP flap can be a problem. If not adequately dissected and mobilized, inadvertently the tendency is to create a lower neo-IMF in comparison to the contralateral breast which is not cosmetically pleasing or acceptable.

The constant presence and wider caliber of the MiCAP's make it one of the reliable CWPF's. Creation of the neo-IMF is straight forward than the AiCAP as well. Although commonly it is used to fill defects of the medial-half of the breast it can be used for lower central or rarely for central tumors too.

**Discussion**

Pedicled chest wall perforator flaps have become a promising option for partial breast reconstruction. Although commonly utilized following surgery for breast cancer, these flaps can be surely used to fill defects following surgery for benign (i.e. benign Phyllodes) or inflammatory conditions (i.e. idiopathic granulomatous mastitis) of the breast. It provides very pleasing aesthetic and functional outcomes for the patient [6].

In conservative communities such as South-East Asia and Sri Lanka, where staged approach or re-excision following WLE for breast cancer is not acceptable by patients; CWPF's provide the answer. The breast surgeon can confidently make a wider excision (especially for T2 tumors and patients with DCIS) as filling the defect of the WLE can be easily done using a CWPF.

Apart from the aforementioned uses, CWPFs can be

harvested for autologous breast augmentation and to correct breast deformities such as tuberous breasts. In an era where the safety of silicone gel implants has been questionable due to the risk of implant associated anapestic large cell lymphoma (BIA-ALCL) [8] the value of these CWPF's could reach new heights. This is more truer to our part of the World as patients nor the Government cannot afford the cost of the silicone implants.

Furthermore, as these are muscle-sparing fascio-cutaneous flaps, the donor-site morbidity and complications are minimal. The incidence of donor-site wound dehiscence and seroma formation is not seen in our series which will be published once the study is concluded. As the latissimus dorsi (LD) muscle is spared it gives the opportunity for a LD or ELD (extended latissimus dorsi) flap in the future if required. Thus, by utilizing these CWPF's the breast surgeon do not burn the bridges but preserves the options for future. As many surgeries it does require structured training and would be best done in high volume centers dealing with these flaps on a regular basis. The learning curve for CWPF's have not specifically defined yet, but in general should not be too long for general surgeon with refined skills. More studies are needed from different centers and would like to highlight the importance of collaboration of breast surgery units, at least in the teaching hospitals, in order to uplift the standards of these CWPF's.

**Conclusion**

CWPF's should be popularized for partial breast reconstruction due to a multitude of benefits including safety, less donor site morbidity and providing the surgeon with freedom for a wider excision. It is a safe and promising alternative for partial breast reconstruction following breast-conservative surgery in more conservative communities where multiple procedures are not preferred. The knowledge of the perforator anatomy and meticulous surgical technique cannot be overemphasised in mastering these flaps for a reliable outcome.

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