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Clinical applications of the superior epigastric artery perforator (SEAP) flap: anatomical studies and preoperative perforator mapping with multidetector CT

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Summary *Background:* Pedicled superior epigastric artery perforator (SEAP) flaps can be raised to cover challenging thoracic defects. We present an anatomical study based on multidetector computerized tomography (MDCT) scan findings of the SEA perforators in addition to the first reported clinical series of SEAP flaps in anterior chest wall reconstruction.

Material and methods: (a) In the CT scan study, images of a group of 20 patients who underwent MDCT scan analysis were used to visualise bilaterally the location of musculocutaneous SEAP. *X*- and *Y*-axes were used as landmarks to localise the perforators. The *X*-axis is a horizontal line at the junction of sternum and xyphoid (JCX) and the *Y*-axis is at the midline. (b) In the clinical study, seven pedicled SEAP flaps were performed in another group of patients.

Results: MDCT images revealed totally 157 perforators with a mean of 7.85 perforators per patient. The dominant perforators (137 perforators) were mainly localised in an area between 1.5 and 6.5 cm from the *X*-axis on both sides and between 3 and 16 cm below the *Y*-axis. The calibre of these dominant perforators was judged as 'good' to 'very good' in 82.5% of the cases.

The average dimension of the flap was 21.7×6.7 cm. All flaps were based on one perforator. Mean harvesting time was 110 min. There were no flap losses. Minor tip necrosis occurred in two flaps. One of them was treated with excision and primary closure.

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Conclusion: Our clinical experience indicates that the SEAP flap provides a novel and useful approach for reconstruction of anterior chest wall defects. CT-based imaging allows for anatomical assessment of the perforators of the superior epigastric artery (SEA).

Muscle or musculocutaneous flaps[1–3] or omentum flaps[4] have been used for thoracic wall reconstruction. Based on the connection between the superior and inferior deep epigastric systems, large musculocutaneous flaps were harvested for different indications. The pedicled transverse rectus abdominis musculocutaneous (TRAM) flap was among the first techniques in breast and thoracic reconstruction.[5] During the last decade, many of the standard musculocutaneous flaps have been raised as perforator flaps. Perforator-free flaps using inferior epigastric vessels, such as the deep inferior epigastric artery perforator (DIEAP) flap, are now commonly used for reconstruction of breast defects. However, the use of a flap raised on perforators of the superior epigastric vessels was reported in only one case by Hallock.[6]

This study aims to describe the distribution of the perforators of the SEA by means of multidetector row CT (MDRCT) scan images using the same technique that was previously described for preoperative mapping of perforators.[7] In addition, clinical applications of pedicled perforator flaps based on these perforator vessels are presented.

Material and methods

CT study

Between October 2005 and November 2006, 20 female patients were prospectively included in a MDCT-based imaging study to visualise the musculocutaneous perforators of the SEA. The mean age of the patients was 50 years. The average weight was 68.2 kg, with an average BMI of 24.7 (range 18.7–32.2). None of the patients had any previous history of the upper abdominal wall surgery.

A CT scan (64-slice Somatom Sensation, Siemens, Erlangen Germany) with three-dimensional (3D) angiography was used as described previously.[7] Intravenous contrast 120 cc Iomeron 400 was injected with power injector 5 cc s^{-1} in medial antecubital vein.

Acquisition parameters were as follows: 64 × 0.6 mm acquisition, 0.5 s rotation time, B25 smooth filter, Eff mAs 200 and Kv 120. Automated scanning was done with 10 s delay for starting bolus tracking and measured every second.

Reconstruction parameters were as follows:

- 3 mm/3 mm B25f smooth, for diagnostical oncological screening send to PACS
- 1 mm reconstruction interval 0.7 mm B20f smooth, split in two series (thorax and abdomen). These images were sent to a 3D workstation (Vitrea) for 3D rendering, 450–650 images per series. (Three orthogonal images centred over the vessel of interest and one 3D skin volume rendered image was displayed on one screen to give the surgeon a good overview).
- Axial Maximal Intensity Projection (MIP) images are done as 7 mm every 2 mm B25f smooth send to PACS.

Since a fixed tube currenton (200 mA) is used, the radiation dose is almost identical for all patients. Higher doses are not used. The radiation dose is around 7 mSev.

Since slices are evaluated in MIP projections, tiny vessels up to 0.5 mm are well depicted in the subcutaneous fat (MIP only displays the pixel with the highest density). Partial volume effect also contributes to good visualisation of tiny vessels. The contrast resolution is crucial for good delineation of these small vessels. Therefore, a soft filter is used with high-contrast resolution. The thin source slices contribute to spatial resolution. The findings are translated into a work sheet with two axes (*X* and *Y*). The pointers used were as follows: The *X*-axis was the junction between corpus sternum and os xyphoideum and the *Y*-axis the sternal midline. All scans were performed and evaluated by the same radiologist (EVH). Images were taken exactly at the time of estimated perfusion of the perforators. The total number, calibre, and localisation and branching of the perforators were evaluated. The distribution of the four best perforators, that is, the 'dominant perforators' in each patient, was then evaluated within four zones (0–5, 5–10, 10–15, and 5–20 cm) on the *Y*-axis (Figure 1). The diameter of a good vessel measures around 1 mm. This diameter is very often slightly overestimated due to the partial volume effect. The veins cannot be seen distally.

The total number of perforators was compared between the right and the left sides using the chi-square test. In addition, their distribution among the four quadrants was compared using chi-square goodness-of-fit test with Bonferroni correction.

Clinical experience

Between February and December 2006, seven patients underwent a pedicled SEAP flap procedure for reconstruction of anterior chest wall defects following ablative surgery. The patients' data are summarised in Table 1.

The flaps were outlined over the upper abdomen on the side of the selected perforator (based on the MDCT findings). Depending on the skin laxity and indication, the flaps were designed vertically on the paramedian region, or transversely under the inframammary fold. The perforators were approached from the ipsilateral side above the abdominal musculature until the perforator was encountered. The SEA perforators usually have a suprafascial course above the deep fascia for 1–3 cm. The deep fascia was opened where the perforator pierces it. Rectus abdominis (RA) muscle fibres were split and the perforator dissection was performed in standard way by clipping or