Heating abdominal wall to improve CTA detectability of deep inferior epigastric perforators (DIEP) in 70 consecutive patients who underwent radical mastectomy followed by autologous breast reconstruction

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Purpose

Breast reconstruction is a cornerstone in the treatment plan of breast cancer patients.

The choice of autologous tissue allows reconstructing a breast mound which looks and feels most natural, and with a better result on the long time, anyway the procedure is more complex and the risks for potential postoperative complications are higher.

Deep Inferior Epigastric Perforators (DIEP) flap is the first choice for autologous breast reconstruction, where microsurgical team is available, as it allows to minimise donor site morbidity and pain while shortening recovery time. The flap relies for vascularization on perforator from the Deep Inferior Epigastric Artery (DIEA).

In perforator flap surgery doppler sonography is the most commonly used modality for preoperative localization of individual vessels; however, it offers a limited amount of informations and requires a greater amount of time. The specificity of this investigation is generally low. Therefore MDCT is a reliable method for precise identification of the position, course and caliber of the dominant abdominal wall perforators which is extremely valuable.

The microsurgeons must have a precise understanding of the surgical vascular anatomy of the patient. By deciding preoperatively which perforators are most suitable, the surgeons can proceed directly to the chosen perforator with much more confidence and ligate other perforators safely and quickly. Time saved in the operating room should be overbalanced with the extra cost of the CT scanning. Moreover this preoperative investigation reduces the rate of fat necrosis and partial flap loss because it allows the surgeon to choose the best vascularized region of abdominal tissue supplied by the dominant perforator. Any remarkable anatomic or vascular conditions are revealed, including those could be contraindications for surgery. Instead any favourable vascular condition can be report to the surgical equipe as an helpful option for the preoperative planning.

In the last 5 years, the cooperation with ours microsurgical team improve our experience in pre-operative planning with CT-angiographies especially in planning protocol for Deep Inferior Epigastric Perforators (DIEP) flaps that is the first choice for autologus breast reconstruction.

Deep Inferior Epigastric Artery is a constant vessel that ascend along the posterior surface of the rectus abdominis muscle. DIEA provides musculocutaneous perforators that supply abdominal fat and skin through the rectus sheath. In our experience there are 5 +/-2 (Average) perforators arising from the deep inferior epigastric artery with a mean caliber of 1mm.
Unfortunately course, branching pattern, caliber and perforators of this artery presents high variability and accurate preoperative reconstructions are essentials for microsurgeons.

After several years of continuous improvement of our acquisition protocol we tried to improve it further. In fact, during acquisition the patient is half-naked and the CT room is cooled to ensure the cooling equipment. This made us think about the fact that normal vasoconstriction reflex could affect the recognition of those thin perforators vessels.

At first we thought the use of vasodilators. However, these drugs have side effects and some contraindications, therefore can not be used safely in all patients and require technical training by medical and paramedical staff. So we tried to use a solution as simple as not invasive. We apply a rubber container filled with hot water on the abdomen of the patient in order to induce vasodilation of blood vessels course in the abdominal wall fat tissue.

This device allowed us to increase the detectability of these small vessels and increase the amount of arteries that can be displayed.

In absence of vasodilation this thin vessels probably will remain below the spatial resolution of the CT-scanner.

After 4 years of experience we have compared two groups of patients (those subjected to abdominal heating and those who were not) to see if there really was a difference in terms of absolute number of vessels recognized by the CTA technique.

Full volumes were reloaded on the postprocessing console and analysed specifically looking for presence and anatomy of the DIEA perforators.
Images for this section:

**Fig. 1:** Patient position on the CT table. The arm must be crossed to mimic the position they will assume on the surgical table. Underwear must be removed.

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**Fig. 19:** Rubber container filled with hot water an the patient abdomen. This device will be remover before the CT scanning

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Fig. 2: Anatomy of the Deep Inferior Epigastric Perforators. DIEA running under the rectus abdominis muscle and perforators pass through it.

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Fig. 3: correspondence between 3D volume rendering reconstructions and surgical findings.

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Fig. 5: Abdominal wall fat tissue that will be used for autologous breast reconstruction after mastectomy.

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**Fig. 4:** Surgical image. Deep Inferior Epigastric Perforators rising from the anterior face of rectus abdominis muscle.

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Fig. 6: Abdominal wall fat tissue with its AV vascular pedicle. It will be anastomosed with internal mammary artery.

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Fig. 7: Autologous breast reconstruction. Before and after the treatment.

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Methods and Materials

Our experience is based on 72 patients who underwent pre-operative CTA of abdominal wall for vascular mapping as candidates for breast reconstruction with the DIEP free flap.

The acquisitions were performed in a time period from January 2007 to December 2011. All the patients were female gender, median age of 57.7 years (range 36-73 years).

All the patients had indication to mastectomy due to breast cancer: 86% (62/72 cases) were planned as a single stage procedure, while 14% (10/72 cases) as delayed reconstruction; Unilateral and bilateral reconstruction was performed.

CTA studies were obtained with the use of a 64-detector CT scanner (Aquilion 64; Toshiba Medical, Tokyo, Japan) and a 256-detector CT scanner (Philips Brilliance iCT, Philips Medical, Andover, Massachusetts).

Patients were positioned supine on the CT table with crossed arms, to mimic the position they will assume on the surgical table. Patients were invited to undress, removing underwear which can distort the abdominal surface modifying the 3D reconstructions references.

Scan parameters were as follows; 0.4 sec gantry rotation speed, 0.5 mm slice thickness, 53 mm table movement per rotation, pitch 1.66.
Tube voltage was 120 kV and Z-axis dose modulation is disabled and fixed to 350mA. Double scout: diaphragm to femoral diaphysis was performed.

Patients were administered with 100 mL of high concentration (400 mgI/mL) nonionic iodinated contrast (Iomeron 400, 400 mgI/mL; Bracco, Milan, Italy), followed by a saline chase of 45 mL. The constrast medium and the saline were injected using a power injector (StellantTM CT Injection System; MEDRAD; Pavia, Italy) at a rate of 4.5mL/sec through a 18 gauge iv cannula inserted into the antecubital veins.

The scanning was triggered using a bolus tracking system with a ROI set on the aortic lumen at the level of L2-L3 vertebral body. When 200 H.U. intensity was reached, and after a preset 12-16 sec delay the acquisition was performed. Scan volume included a body region from the small trochanter up to 5 cm upward from the umbilical scar, in a foot to head direction.

A first group of 41 patients (Mean age of 56.4 years) was not implemented by any modification of our basic protocol and the scan was performed without any type of heating.
A second group of 31 patients (Mean age of 59.3 years) was instead subjected to heating of the abdomen with a rubber container full of hot water for 30 minutes before the examination. Scaut scanning was performed with the container still in place and it was removed only a few seconds before the injection of contrast medium and the CT scan.

Full volume dataset: (0.5mm native stack images), were retrospectively reloaded from PACS system (Esaote DICOMed PACS; Esaote, Genova, Italy), to the advanced visualization console for analysis (Vitrea, version 3.1.1; Vital Images, Plymouth, MN, USA)

Two blinded readers with different experience in the preoperative planning imaging (4 years and 1 year respectively) examined the full datasets calculating the amount of perforating arteries identified for each patient.

**Reconstruction protocol**

- **Coronal Thick Slab**

Initially a thick slice 20 - 25 mm MIP Coronal slab was performed, positioned very anterior, to include the full course of the DIEA, originating from the iliac arteries up to the midabdomen.

This was used to visualize presence and caliber of both DIEAs and as well to show the branching pattern. This reformat was not used directly to assess DIEA perforators.

- **Axial, Sagittal, Coronal with 3D-marking**

The volume was reformatted at 6 mm MIP on the Axial, Sagittal and Coronal plane.

Specifically looking for presence of the SIEA and to establish anatomy and measurements. Multiplanar 3D reference was commonly used to differentiate from various arteries present in the abdominal wall.
Fig. 8: Axial slab MIP reformat with electronic markers on the perforator origin.

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**Fig. 9:** Sagittal slab MIP reformat with electronic markers on the perforator origin.

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**Fig. 10:** Axial, Sagittal, Coronal slab MIP reformat and 3DVR with electronic markers on the perforator origin.

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Fig. 11: Coronal slab MIP showing the DIEA course

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Fig. 12: Coronal slab MIP showing the DIEA course with the perforators origin marker with electronic references

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**Fig. 13**: 3D VR reconstruction showing the DIEA course with the perforators origin marker with electronic references

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Fig. 14: Axial slab MIP reformat with electronic markers on the perforator origin.

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Fig. 15: 3D MIP reformat with electronic markers on the perforator origin.

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Results

In our study, both readers had similar results.

Two groups showed similar demographic characteristics.

Nevertheless, the two readers have recognized a higher number of mean perforating arteries in the group of patients undergoing preliminary heating of the abdominal wall before the CTA scanning.

Reader 1 recognised 9.03 mean vessels for each patient (SD 2.72 - Range 4-15) who underwent pre-scanning heating versus 5.01 mean vessels detected in the group without abdominal heating (SD 1.84 - Range 2-9).

The less experienced Reader 2 obtained similar results with good inter-reader agreement. He recognised 8.64 mean vessels (SD 2.98 - Range 3-17) in the group with pre-scanning heating versus 5.26 mean vessels in the other group (SD 2,16 - Range 1-10).
Fig. 16: 3D VR reformat with electronic markers on the perforator origin.

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**Fig. 17:** 3D VR superficial reformat with electronic markers on the perforator origin. This reformats is useful to the surgeons for pre-operative planning.

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**Fig. 18:** 3D VR superficial reformat with electronic markers on the perforator origin and chartesian references measured from ombelical scar.

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Conclusion

Our study showed that higher rate of DIEP perforator arteries is detectable in patient group that has been subjected to prior heating of the abdominal wall before the CTA-scanning.

This would be due to the normal mechanism of vasodilation of the skin and subcutaneous fat tissue. This would help to increase, albeit temporarily, the caliber of the perforating arteries and their thin veins. This phenomenon increases the detectability of these vessels but just during the scanning of arterial CT angiography.

Increasing the amount of arteries that can be identified in the CTA increase the number of vessels that can be chosen by the microsurgeon for the planning of the microsurgical abdominal free flap. This improves the volumetric planning of the flap size and volume for better breast reconstruction.
References


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