The Utility of Computed Tomographic Angiography in Preoperative Planning for Deep Inferior Epigastric Artery Flap Breast Reconstruction

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Abstract

Introduction: Abdominal donor site flaps are the standard for autologous breast reconstruction. Because of extreme variations of abdominal wall vascular anatomy between individuals, and even two hemi-abdomens of the same person, it seems valuable to use a sensitive method for preoperative evaluation. In this study, we evaluated the effects of preoperative abdominal wall computed tomographic angiography (CTA) in women who had undergone delayed unilateral breast reconstruction with abdominal perforator flaps.

Patients and methods: Between October 2007 and June 2008, 24 women with breast cancer were admitted to Henri Mondor General Hospital, Creteil, France, for breast reconstruction. We used CTA to identify the perforator vessels for dissection and compared the results with other previously used techniques.

Results: There was an absolute correlation between the radiological information and intraoperative findings. An average of one hour was saved in delayed unilateral breast reconstruction with deep inferior epigastric artery perforator flap by using CTA preoperatively.

Conclusion: Computed tomographic angiography provides valuable preoperative information in identification of the most suitable perforator, and its use before abdominal flaps breast reconstructions could be recommended.

Key words: CT Angiography, Perforator flap, Breast reconstruction, Abdominal flap, DIEP flap.

Introduction

Abdominal donor site flaps are the standard for autologous breast reconstruction [1, 2]. During the evolution of surgical techniques, from the pedicled Transverse Rectus Abdominis Myocutaneous (TRAM) Flap, to the muscle-sparing free TRAM, and then to the inferior epigastric artery perforator flaps, such as the Deep Inferior Epigastric Perforator (DIEP) Flap and the Superficial Inferior Epigastric Artery (SIEA) Flap, there has been a constant battle to minimize morbidity by reducing the dissection of the anterior abdominal wall, while maximizing flap blood flow and viability [3].

The inferior epigastric artery perforator flap has been the first choice in many centers for autologous breast reconstruction in recent years. This is due to its advantages, such as decreased donor site morbidities, including abdominal wall bulging and abdominal wall hernia, decreased post-operative pain and shorter recovery period and hospital stay, lower ratio of fat necrosis and partial flap loss, in addition to cost effectiveness, better acceptance by the patients, better abdominal aesthetic results and low rate of total flap loss [1, 3].

The few drawbacks of DIEP flaps include long operating time, the need for high microsurgery expertise and extreme variation of abdominal wall vascular anatomy between individuals, sometimes even two hemi-abdomens in the same person [4, 5].

In order to reduce the operating time of DIEP flap surgery, and to overcome the technical difficulties that are mainly due to irregular anatomical distribution, precise preoperative locating of perforating vessels seems unavoidable [6].

Several methods have been used to identify the vascular supply to perforator flaps, including physical exam, handheld Doppler, 2-dimensional

color flow Doppler imaging, scanning laser Doppler, thermography, magnetic resonance imaging and CT angiography [7, 8]. Among all these methods, Doppler ultrasound and colored Duplex sonography have been most widely used. Because of inconsistencies between the operative findings and the results of Doppler ultrasound, and the non-optimal presentation of ultrasonography findings to the surgeon, the search for a more favorable imaging modality continues, with recent interest in the use of CT angiography [9, 10]. Several studies have demonstrated a high sensitivity of CT angiography in imaging of DIEP perforators in concordance with operative findings [11].

Over the last 6 years, the gold standard for autologous breast reconstruction in our center has been DIEP flaps, and in October 2007, we started to use preoperative CT angiography for evaluation of the abdominal wall perforating vessels on which the planned DIEP flap would be based. The aim of this study was to determine the effectiveness of CT angiography in preoperative DIEP mapping, and consequently in decreasing operative time.

Patients and methods

From October 2007 to June 2008, twenty-four women in Henri Mondor Hospital's plastic surgery service were considered for delayed unilateral DIEP flap breast reconstruction after a preoperative CT angiography.

All candidates underwent a CT angiography preoperatively. Our criteria for choosing the best perforators to dissect were their calibre, location, intramuscular course and fascia penetration pattern.

Multidetector CT-scan studies were performed using a 64 multislice CT scanner (Volume Computed Tomography (VCT) General Electric's LightSpeed, Milwaukee, United States). Patients were positioned supine on the CT table exactly as they would be during surgery. CT scans were performed using the following parameters: 0.6-s gantry rotation speed, 0.625-mm slice thickness (X64), 55-mm table travel per rotation, and pitch 1.375. X-ray tube voltage was 120 KV and tube current was 250-300mA. All scans were performed after intravenous administration of 90 mL non-ionic iodinated contrast medium at a concentration of 400 mg I/mL (Iomeron 400; Bracco). The contrast material was mechanically injected at a rate of 4 mL/s through an 18-G catheter inserted into an antebrachial vein. The scanning delay was set by an automatic triggering system. Sections were obtained in a single breath hold from 5 cm above the umbilicus to the lesser trochanter of the hip.

Multiplanar Reformatted (MPR) images and 3D Volume Rendered (VR) images were generated on a dedicated workstation. Axial images were processed into MPR, Maximum Intensity Projection (MIP) and 3D-VR reconstructions, using commercially available software (General Electric's Advantage Workstation).

The deep inferior epigastric artery was evaluated along its entire length from its origin on the external iliac artery, paying special attention to the intramuscular course identifying the main trunk and its divisions, along with their predominance.

Secondly, we studied the perforator arteries, which are dependent on the deep inferior epigastric artery. Their caliber, course, and anatomic relationships were evaluated as well as the location of the exact point of emergence through the rectus abdominis aponeurosis. The objective was to choose the most appropriate perforator to constitute the flap pedicle in each hemi abdomen and determine its exact location at the level of the rectus fascia. We performed a 3D-VR reconstruction of the abdominal skin surface, and a MIP reconstruction of the deep inferior epigastric artery in a coronal oblique plane. The arrows were placed at the exact point where the chosen perforator vessels emerged from the rectus abdominis muscle fascia. According to a coordinate system centered on the umbilicus, we correlated each perforator with a coordinate point. Its distance from the umbilicus was measured on the skin surface.

An arterial perforator with the widest diameter in the zone of flap design, with the shortest intramuscular course and perpendicular penetration of fascia, was chosen for dissection according to data provided by the angioscan.

Two attending surgeons performed the operations. In all cases, the donor supply was a deep inferior epigastric artery with one or two perforators, and the recipient vessel was a circumflex scapular pedicle.

Assessment of real operating time in this situation, and a comparison with cases without CT angiography, were difficult because of various techniques and inaccurate recording of procedure

time. We selected our unilateral delayed reconstruction cases and compared their procedure time with the same number of similar operations performed prior to using the CT angiography data.

Our study received approval from the Ethical Committee of the hospital and all participants gave informed consent before entering the study.

Results

From October 2007 to June 2008, 24 women aged 34 to 75 years old were considered for delayed unilateral DIEP flap breast reconstruction after a preoperative CT angiography.

We had one patient in whom DIEP flap failed totally. One patient developed partial flap necrosis with eventual good cosmetic results after two weeks of debridement dressing.

During this 8-month period with 24 patients, all of the perforators detected by CT angiography were identified visually during the operation. There were no false negative or false positive findings. In all patients, we went directly to the flap side with the same dominant perforator that was chosen preoperatively by CT angiography.

In all patients with CT angiography, average operating time for unilateral delayed DIEP flap breast reconstruction was 5 hours and 2 minutes. The average time for the prior 24 delayed DIEP, before usage of CT angiography, was 6 hours and 6 minutes. The average operating time saved per patient by using CTA, compared to our previous DIEP flap without CTA, was about one hour.

Discussion

Because of the similarity to breast texture, better scar covering, and other aesthetic advantages, abdominal tissue is currently the best choice for autologous breast reconstruction. The DIEP flap, in addition to the benefits of free TRAM flap, decreases patients' morbidity [3]. However, it is crucial to use a highly sensitive method for the precise preoperative identification of the dominant perforator on abdominal wall, to prevent unnecessary perforator dissections and to enhance the safety of the procedure in a long, stressful operation like DIEP flap reconstruction.

Doppler sonography is a common, valuable and inexpensive tool for preoperative investigation, but it provides little information. It cannot distinguish perforating vessels from main axial vessels. Alonso, in his study, pointed at false positive results of this technique. Color Doppler, although highly sensitive, has some drawbacks, including being time consuming for both patient and staff, and offering no available reproduced information [3, 6].

According to many studies, CT angiography is a reliable method to detect the position, course and calibre of the dominant perforator [9, 7]. Improvement in preoperative mapping and decision making avoids spending valuable time during surgery without extensive overview of all the perforators, and thus could prevent unnecessary dissections. Consequently, this faster and safer way of operating decreases the surgeon's stress markedly [6, 11]. The findings of our study reinforce the benefits of CT angiography before DIEP flap breast reconstruction. There were no false positives or false negatives in determining dominant perforator, and we had an average saved surgery time of about one hour.

Acosta et al. also pointed to a dramatic decline in procedure times by using preoperative CT angiography. They reported that preoperative CT angiography decreased the time of 2-DIEP flaps procedures by 90 minutes [1]. Another study in 2009 indicated that preoperative CT angiography not only reduces the time of surgery but also reduces morbidity and cost. Saving of £1750 per patient was reported as a benefit for each preoperative CT angiography performed in that study. CT angiography also improved patient outcomes by decreasing the flap failure rate [5].

CT angiography is a quick and non-invasive procedure with minimal radiation exposure, so is easily tolerated by patients. The effective radiation dose is lower than that used in opaque enema. The dose associated with abdominal wall CT angiography was reported to be 8 mSv, while in an abdomen/pelvis CT examination it was 10 mSv [10, 7]. In addition, CT angiography is not operator dependent, has no false positive or false negative results, and allows presentation of the imaging to the surgeon in the operating room [6].

Based on these benefits and our study findings, we strongly recommend performing preoperative CT angiography before DIEP flap breast reconstruction.

Conclusion

CT angiography is a safe and reliable technique that can help reduce surgery time, by precise

determination of the dominant perforator. Our findings reinforce the current observed benefits of using this meticulous examination before DIEP flap breast reconstruction.

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