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Clinical utility of CT angiography in DIEP breast reconstruction☆

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Summary *Background:* CT angiography has become the gold-standard imaging modality prior to DIEP flap breast reconstructions. Recent studies show excellent correlation between CTA and operative perforator location, but not their clinical significance. This study seeks to specifically evaluate the clinical utility of CTA in DIEP free flaps.
Methods: Preoperative CT angiography of the deep inferior epigastric system was obtained in 52 sequential DIEP free flaps involving 37 patients with dominant perforators marked by radiologist. Planned and used perforators were documented by the surgeon before and after the operation.
Results: A total of 62 out of 76 planned perforators were ultimately used (82%). Of those not used, 71% were abandoned due to inadequacy of preoperative CT. An additional 38 perforators were used that were not part of the initial preoperative plan, 60% of which were added due to inadequacy of the preoperative CT for planning. In total 23/52 flaps (44%) involved intraoperative changes due to features not appreciated on preoperative CT.
Conclusion: CTA mapping of perforators prior to DIEP flap surgery increases surgeon confidence and reduces operative time; however, there are still a significant number of changes made based on clinical judgment. This study highlights the importance of surgeon review of CTA images. Caution is warranted in reliance on CTA mapping, and significant perforators should not be sacrificed until the anticipated perforator(s) have been exposed and evaluated.
Level of evidence: Level 3.
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Introduction

Autologous microsurgical breast reconstruction techniques have evolved significantly from the initial description of the free transverse rectus abdominus muscle flap (TRAM). While it was initially believed that the skin and subcutaneous tissue critical to the reconstruction of a breast mound was dependent on the transfer of the entire muscle, subsequent microsurgeons demonstrated first that these flaps could be transplanted with significantly less muscle harvest (via the muscle-sparing TRAM flap) and later without any muscle at all, based on as little as a single perforating vessel (via the DIEP flap). These perforator flaps, offer the patient an abdominally based microsurgical breast reconstruction with less morbidity inflicted on the abdominal muscle. However, the isolation of these perforator flaps is associated with increased technical difficulty, increased operative time, and an increase of possible complications secondary to less redundant blood supply. The mastery of these flaps includes a significant learning curve in both flap design, perforator selection and perforator dissection. The use of preoperative imaging for planning the selection of the best perforator has been proposed as one method to counteract some of the challenges associated with these flaps and perhaps lead to reduced operative times and better ultimate outcomes.

During the initial development of the DIEP flap for breast reconstruction the preoperative evaluation of perforators was limited to the use of the handheld pencil Doppler. While this technique continues to be helpful to document flow once a perforator has been identified, it offers no useful preoperative information about the flow, size or course of the perforator.[1] It was soon replaced by the use of color-duplex ultrasound to identify and evaluate the characteristics of the abdominal perforators.[2,3] Duplex ultrasound can provide the surgeon with the surface location of the perforator via a simple test that is non-invasive, has no intravenous contrast and no radiation exposure. However, this technology is user dependent, cannot necessarily predict the suitability of the perforator, the intramuscular course, or the quality of the superficial inferior epigastric vessels. The advances in computed tomography (CT) hardware, with the ability to generate three-dimensional reconstructions of vascular structures such as the deep inferior epigastric system revolutionized field of non-invasive angiography. CT angiography (CTA) provided surgeons, for the first time, not only the location of the perforators but a "road-map" of their course from their source vessel.

The use of CT angiography to preoperatively map the abdomen for perforator harvest has largely supplanted color-duplex ultrasonography. In a recent study, Scott et al. demonstrated significant superiority of CTA over color-duplex ultrasound in the identification of clinically important perforators.[4] In addition, CTA has been demonstrated to have excellent sensitivity and positive predictive value and several studies have shown that the routine use of preoperative CT angiography can decrease operative time and reduce surgeon stress.[5–8] This technology has also been suggested to decrease complications including flap necrosis and abdominal wall morbidity (bulges, hernias, etc.).[6,7] The increasing amount of clinical evidence supporting the use of CTA has quickly led its increasing popularity in preoperative imaging for DIEP reconstruction. However, despite the increasing use of this technology by groups that perform perforator flap breast reconstruction, some surgeons still question the true utility of the test in the operating room. To date no study has adequately examined the actual clinical utility of CTA in preoperatively predicting the perforators used. This study seeks to identify and quantify the manner in which preoperative CTA-based planning is clinically applicable during flap harvest. Prior studies have made it clear that it is accurate, but how does that accuracy translate into utility?

Methods

Performed as a retrospective analysis of prospectively collected data, between August 2009 and February of 2010, 37 patients were taken to the operating room for planned DIEP breast reconstruction at a single institution. Four surgeons at our institution were included in this study, all of whom had been performing DIEP flaps for at least 1 year. Including both flaps in bilateral reconstructions, the 37 patients received a total 52 free flap breast reconstructions; 30 were bilateral and 22 unilateral. All 52 flaps were included in the analysis.

All patients underwent preoperative CTA imaging of the abdominal wall from 4 cm superior to the umbilicus to the lesser trochanter in a cranial to caudal direction. Contrast injection consisted of 150 cc of omnipaque 350 (GE Healthcare, Chalfont St. Giles, UK) at 4 mL/s with acquisition at bolus peak plus ten seconds. The scan was performed using a 64-slice General Electric Lightspeed VCT Scanner (GE Healthcare, Chalfont St. Giles, UK), collimation 64×40 mm, helical beam pitch 1:1.375, tube voltage 120 kV, xyz tube current modulation with NI 30, rotation time 0.5 s. Axial images were processed into maximum intensity projection (MIP) and reformatted into multiple views including three-dimensional volume-rendered reconstructions at 0.625 mm thickness and spacing using commercially-available software (GE Healthcare, Chalfont St. Giles, UK).

Perforators were marked based on perforator size, with the three largest recorded, on 3D reconstructed skin view by one of three attending radiologists, each with at least one year of experience with CT angiography for DIEP flaps. Subsequently, the senior surgeon reviewed the CTA and documented on the worksheet the perforators that he planned to use for the flap. Postoperatively, the surgeon documented on the same worksheet the actual perforators used and the rationale for any deviation from the pre-operative plan. Hemi-abdominal perforators were evaluated for unilateral DIEPs; bilateral cases were recorded as two separate hemi-abdomens. This study was approved by the Institutional Review Board (IRB) of the University of Washington.

Statistical calculations were performed using SPSS 16 (SPSS, Chicago, IL). Significance values were calculated using two-tailed Fisher exact test.

Results

A total of 76 perforators were chosen preoperatively by surgeons (between one and three per flap) with 62 of these being ultimately used (82%). Figure 1 shows the distribution