Localization of the Dominant Deep Inferior Epigastric Artery Perforator by Computed Tomography Angiogram

Does the Standard Deep Inferior Epigastric Artery Perforator Flap Design Include the Dominant Perforator?

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Background: The deep inferior epigastric artery perforator (DIEP) free flap is the optimal autogenous reconstructive technique in many patients undergoing postmastectomy. Our aim was to evaluate the standard DIEP free flap design in relation to the dominant perforating vessels using computed tomography angiography (CTA).

Methods: We retrospectively reviewed CTAs from 75 patients who had undergone perforator flap reconstruction within the past year. Locations of the largest perforator with a minimum diameter of 2.0 mm piercing the anterior rectus fascia were recorded.

Results: Of 150 hemiabdomens reviewed, 146 (97.3%) had a dominant perforator. The median location for the dominant perforator was 3.3 cm lateral and 0.9 cm below the umbilicus. One hundred twenty-one (83%) of the dominant perforators arose within 3 cm of the umbilicus. One hundred one (69%) arose at or below the level of the umbilicus. Forty-five (31%) arose above the level of the umbilicus. Thirteen (9%) arose more than 2 cm above the umbilicus.

Conclusions: The standard DIEP flap design incorporates most of the dominant perforating vessels. However, a significant number of perforators arise at or above the umbilicus, which would be near the edge or out of the standard design of the DIEP. Our findings support the use of preoperative CTA in the evaluation of patients undergoing DIEP free flap reconstruction. Modification of flap design to include the dominant perforating vessels should be considered when the dominant vessel is outside the standard design of the DIEP.

Key Words: DIEP, dominant perforator, CTA, breast reconstruction

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BACKGROUND

Postmastectomy breast reconstruction has been shown to be of great psychological benefit to the patient with breast cancer. Reconstruction using autologous tissues is the first option for many reconstructive surgeons and patients. The deep inferior epigastric artery perforator (DIEP) flap has become the preferred flap for autologous breast reconstruction.[1]

Preoperative imaging by computed tomography angiogram (CTA) has been shown to reduce both surgical complications and operating time.[2] In the case of the DIEP flap, CTA imaging has been shown to accurately identify the relation of the perforating vessels to the tissue planning to be transferred.[3]

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The DIEP flap design involves making an incision across the lower abdomen to the anterior superior iliac spine and extending these incisions medially to a level directly above the umbilicus. This design is based on the thought that the dominant perforator will arise at or below the level of the umbilicus.[4] However, it has been the experience at our institution that this design may exclude large perforators that arise above the umbilicus, and this may be compromising the blood flow to the flap and may lead to more flap complications. Our goal was to locate the dominant perforator using preoperative CTA imaging and assess how this corresponds with the DIEP flap design.

METHODS

We retrospectively reviewed the preoperative CTA imaging of the abdominal wall in 75 patients who had undergone perforator flap reconstruction in the past year. These images generated 150 hemiabdomens for our review. The location of where the dominant perforating artery pierced the anterior rectus fascia was noted, and its relation to the umbilicus was recorded. Our field of study was from 7.5 cm above the level of the umbilicus to 7.5 cm below the level of the umbilicus. In our study, a dominant perforator is defined as the largest deep inferior epigastric perforator that could be identified in a hemiabdomen. Perforators less than 2.0 mm were excluded from consideration. Hemiabdomens without dominant perforators as defined above were not considered in statistical analysis. This study was approved by our institutional review board.

RESULTS

Of the 150 hemiabdomens reviewed, 146 (97.3%) had dominant perforators as defined above (Fig. 1). In relation to the umbilicus, the median location of the dominant perforator was 3.3 cm lateral and 0.9 cm below.

The 146 dominant perforating arteries were further classified by the area of abdomen in which they arose. One hundred twenty-one (83%) of the dominant perforators were found within 3 cm of the umbilicus.

One hundred one dominant perforators (69%) arose at or below the level of the umbilicus. Forty-five dominant perforators (31%) arose above the level of the umbilicus. Thirteen dominant perforators (9%) arose more than 2 cm above the level of the umbilicus.

Eighty-four dominant perforators (58%) were located 0 to 3 cm lateral to the umbilicus. Sixty-two dominant perforators (42%) were located between 3.5 and 8 cm lateral to the umbilicus. These data are summarized in Tables 1 and 2.

DISCUSSION

Postmastectomy breast reconstruction is an important part of the care for the patient with breast cancer. Receiving any type of postmastectomy reconstruction has been shown to improve vitality,

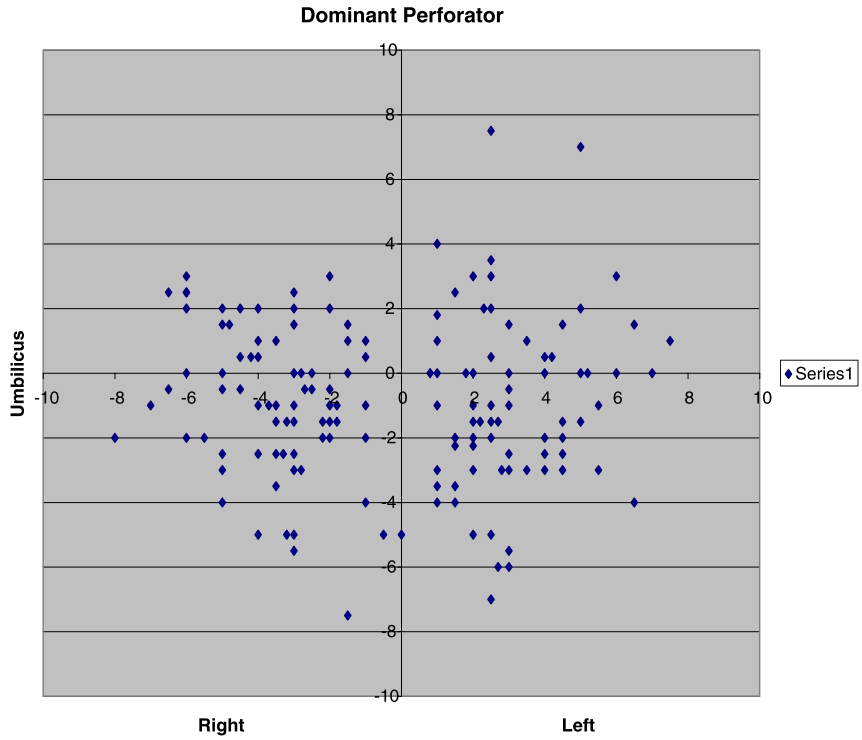

FIGURE 1. Physical location of the dominant perforators. X-axis marks the level of the umbilicus. Y-axis marks the midline. Note that 31% of the dominant perforators are at or above the level of the umbilicus.

general mental health, and emotional and functional well-being.[5] Women who receive postmastectomy reconstruction have shown significant improvement in social roles and comfort in their sexuality.[6] Women who receive immediate reconstruction have also been shown to have better long-term coping responses to the diagnosis of breast cancer.[7] However, minimizing the complications of these operations is imperative to patient satisfaction.[8]

Autologous reconstruction has many benefits over tissue expander and implant reconstruction. Implant reconstruction has been shown to have many complications, including implant extrusion and capsular contracture, especially when performed in postmastectomy radiation therapy.[9,10] Overall, women are more pleased with the aesthetic result of autologous reconstruction.[11,12] Furthermore, the results of autologous reconstruction generally are stable or improve with time. Patients undergoing implant reconstruction tend to develop problems related to the implants as time goes on after the reconstructive surgery. Those complications include implant failure and capsule contracture.[13]

The DIEP flap is based on the arteries and veins that perforate the rectus abdominis muscle from the deep inferior epigastric artery.[14] The harvest technique involves dissecting perforating arteries through the rectus abdominis muscle while keeping them attached to the overlying skin and fat.[15] The DIEP flap has become the ideal flap for many practitioners and has been shown to have many advantages in free tissue transfer procedures with abdominal donor sites.[1]

TABLE 1. Incidence of Dominant Perforator Location Along the X Axis

Location of Dominant Perforator (y-axis)	Incidence (n = 146)	Percentage
0–3 cm lateral to the umbilicus	84	58
3.1–8 cm lateral to the umbilicus	62	42

The DIEP flap remains a preferred method in breast reconstruction because of its decreased rate of abdominal complications and hospital course compared with other abdominal flaps such as free or pedicled transverse rectus abdominis myocutaneous flap. The DIEP flap has been shown to provide comparable vascular supply as the transverse rectus abdominis myocutaneous flaps without compromising the abdominal wall.[1]

Still, as with any procedure, there are morbidities associated with the DIEP flaps. Abdominal bulge or hernia accounts for only a very small percentage of complications (0%–0.7%) because the rectus abdominis muscle is left intact. Partial and total flap loss has been noted in a small subset of patients (approximately 3%), whereas another subset of patients (3.8%) experienced venous congestion. Fat necrosis has been the most common complication reported for the DIEP flap (12.9%).[16]

Minimizing risk in the DIEP procedure involves maximizing perfusion to the transferred tissue. All known risk factors for complications, such as smoking, hypertension, and postreconstruction radiation reduce the blood flow. Lower values of capillary perfusion using laser Doppler flowmetry and lightguide reflectance spectophotometry have been correlated to increased incidence of venous congestion and fat necrosis.[17] Our question, then, is a simple one:

TABLE 2. Incidence of the Dominant Perforator Location Along the Y Axis

Location of Dominant Perforator (x-axis)	Incidence (n = 146)	Percentage
Above the umbilicus	45	31
At or below the umbilicus	101	69
≤3 cm from the umbilicus	121	83
≥2 cm above the umbilicus	13	9

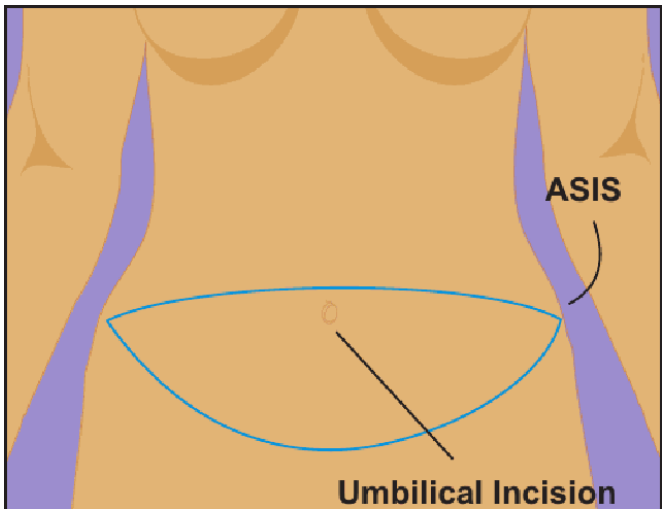

FIGURE 2. The standard DIEP design. The superior border of the flap as at or just above the level of the umbilicus.

does the standard DIEP flap design include a perforator that will provide an adequate blood supply for the most viable flap possible?

It is our practice to get CTAs on all patients who are to undergo DIEP breast reconstruction. Typically, preoperative imaging will show multiple perforators feeding 1 tissue transfer site.[18] However, the goal should be to identify the dominant perforator with the largest caliber. Including the dominant perforator will decrease the resistance to blood flow, provide better vascular supply, and increase chances of flap viability and decrease blood flow related complications.[19]

The current DIEP flap design uses either medial or lateral branches of the deep inferior epigastric artery that penetrate the rectus muscle and its sheath to supply the overlying adipose tissue. An incision is made at or directly above the umbilicus and continues almost to the anterior superior iliac crest. Dual bilateral incisions then follow the inguinal ligament before meeting at the lower abdomen directly above the mons pubis (Fig. 2). This design is based on the assumption that a medial or lateral perforator with sufficient blood flow will lie between the umbilicus and the pubic symphisis.[20]

As previously stated, blood flow through the perforator must be maximized. The first task is to define which characteristics of a vessel will make it optimal for blood flow. Flow can be defined as the change in pressure (ΔP) divided by resistance, or

$$Q = \frac{\Delta P}{R}.$$

The change in pressure is greatest over the arterioles, whose actions are largely dominated by local controls.[21] Our goal then should be to minimize the resistance across the anastomosis which we control: the perforating vessel. Resistance in a vessel can be defined as follows:

$$R = \frac{\eta L}{r^4},$$

where η symbolizes the viscosity of the liquid in question, L is the length of the vessel, and r is the radius. Taken together, flow and resistance can be related in Poiseuille law:

$$\Delta P = \frac{8\eta L Q}{\pi r^4}.$$

It follows from Poiseuille law that the best way to minimize resistance, and therefore maximize flow, will be to select the perforator with the largest diameter, which we have termed to be the dominant perforator.[22,23]

From the experience at our institution, we deemed the minimum diameter to be termed a "dominant perforator" was 2.0 mm. Below that, the labor involved in isolating the vessel combined with increased vessel resistance makes the vessel a poor choice for use in the DIEP flap. Our results show that 97.3% of hemiabdomens will contain a dominant perforator, making the DIEP flap useful in the most of breast reconstructive candidates.

By placing this dominant perforating artery centrally, the flap will provide the best vascular supply and a viable flap after operation. The area around the vascular pedicle of the flap has been shown to be better perfused than the peripheral areas.[24] The goal of flap design should be to maximize the blood flow to the central portion of the flap through the pedicle to make sure all parts of the flap are properly perfused.[19] To do so, the dominant perforator must be as close to the center of the flap as possible.

The data collected show that 58% of the dominant perforating arteries will supply the relative center of the standard DIEP flap design (within 0–3 cm lateral to the umbilicus or medial row). In these patients, the standard flap design will be ideal, and the flap does not need to be adjusted to account for the various perfusion zones. However, perforators that arise on a more lateral aspect of the abdomen will have different perforasomes than those arising on the medial aspect.[25] We found this to be the case in 42% of our patients. In this subset of patients, the flap design may be altered to accommodate a lateral row dominant perforator (from 3.5 to 8 cm lateral to the umbilicus) that will have different perfusion zones. However, if bilateral flaps are being used, flap design alteration based on medial or lateral row perforators is not possible.

The final question that remains is whether the dominant perforator will be included in the flap at all. Our study shows that the standard DIEP incision will be sufficient for approximately 69% of patients. However, in approximately one third of patients, the standard incision will place the dominant perforator at the edge of the superior aspect of the flap or outside of the flap completely. If the standard flap design is being used in this patient population, the risk of damaging or excluding the dominant perforator is great. (Fig. 3). Doing so will reduce the chances of flap viability by reducing

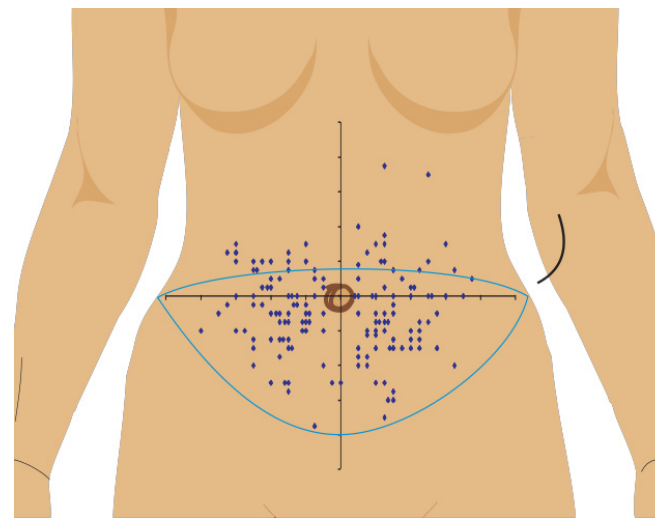

FIGURE 3. The standard DIEP design with the locations of the dominant perforators. Note that approximately one third of the perforators are at the edge or outside of the flap design (scale: each hash mark is 2 cm).

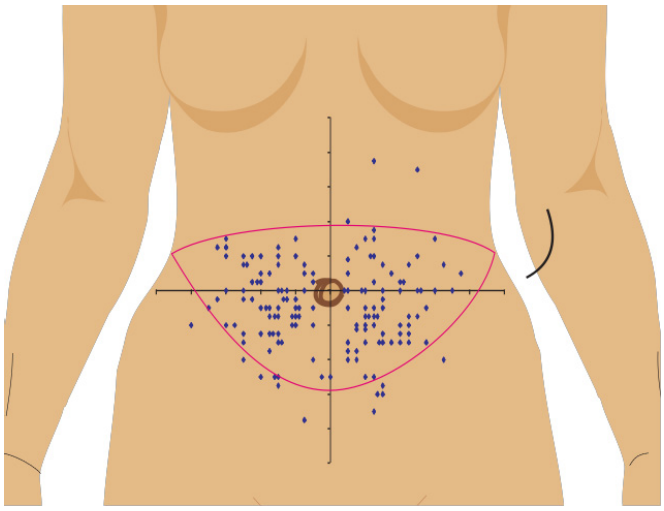

FIGURE 4. The standard DIEP flap has been shifted cranially. Note that the perforators that were outside the design in figure 3 are now well with in the boundaries of the flap (scale: each hash mark is 2 cm).

the predominant vascular supply. In this subset of patients, consideration should be given to moving the flap design cranially to include or better position the dominant perforator (Fig. 4). This will result in the scar being more cranial than in the standard flap; however, we feel that this is an acceptable consequence to ensure the best blood supply to the flap, which would not be the case if the dominant perforator is not included in the flap design. Thus far, the patients have been agreeable to this modification and have accepted a scar that is higher on their torso.

CONCLUSIONS

The DIEP flap has provided a choice for women facing breast reconstruction with minimal complications, outstanding cosmetic result, and a satisfaction rate that is very high overall. By using CTA to identify dominant perforating arteries, augmented flap designs can further decrease morbidity, increase the rate of success, and decrease complications such as fat necrosis. The surgeon can also be confident about the location of the dominant perforator before operation and can reduce time in the operating room.

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