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CT Angiography of Inferior Epigastric and Gluteal Perforating Arteries before Free Flap Breast Reconstruction[1]

TEACHING POINTS
See last page

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Muscle-sparing perforator free flap breast reconstruction with the use of an inferior epigastric or gluteal perforating artery to create a vascular pedicle is increasingly popular because it obviates breast implants and results in lower donor site morbidity than breast reconstruction with myocutaneous flaps. The tissue harvesting procedure for a perforator free flap involves dissecting the subcutaneous fat of the anterior abdominal wall or the buttock to locate and visually evaluate the perforating arteries so as to decide which one is most suitable for the vascular pedicle. The vessel selected depends on multiple anatomic and surgical considerations, and the decision-making process can be exceptionally time-consuming, in part because of the wide variation that occurs in vascular anatomy. Preoperative imaging can greatly improve the efficiency of the selection process. Doppler ultrasonography (US) is the most frequently used modality for vascular mapping, but the results are mixed because most perforating arteries have a diameter of less than 15 mm, the threshold for reliable visualization with US. A computed tomographic (CT) angiographic evaluation performed with the use of specific postprocessing and display techniques may be more accurate for identifying the most suitable vessel. CT angiography provides valuable information that can help optimize surgical planning, decrease time spent in the operating room, and improve the outcome of breast reconstruction surgery.

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Abbreviation: MIP = maximum intensity projection

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Introduction

Breast cancer is the second most common malignancy in women in the United States, with an estimated incidence of 254,650 for 2009 (1). Mastectomy remains a mainstay for treatment of breast cancer. With increasing frequency, women who undergo mastectomy for breast cancer treatment or for prophylaxis when their breast cancer risk is high also choose to undergo reconstructive surgery to restore the appearance of the breast (2).

Various options for breast reconstruction exist. Most women choose either silicone or adjustable saline implants, although the choice may commit them to undergo multiple surgical procedures in order to achieve a natural and long-lasting cosmetic result. The use of autologous tissue in place of silicone or saline implants offers a more durable result with less likelihood of complications. Traditionally, autologous reconstructions were performed by using musculocutaneous pedicle flaps (eg, latissimus dorsi or transverse rectus abdominis flaps [3]). However, because of donor site morbidity associated with the harvest of musculocutaneous flaps, newer techniques have been developed in which only the skin and fat surrounding a dominant vessel are isolated to create a vascular pedicle flap. Most commonly, a deep inferior epigastric or superior gluteal perforating artery provides the vascular pedicle in these so-called free tissue transfers (4,5). Because neither the rectus abdominis nor the gluteus maximus muscle is sacrificed with this technique, donor site morbidity is reduced substantially (6). A flap based specifically on a superficial inferior epigastric artery, because it does not require opening of the rectus sheath, is associated with lower donor site morbidity than either a deep inferior epigastric perforating artery flap or a transverse rectus abdominis myocutaneous flap (6).

The deep inferior epigastric artery has many variable anatomic features, including its location, its branching pattern, and the number of perforating vessels that it supplies. In addition, a superficial inferior epigastric artery that can be used as a vascular pedicle is present in only two-thirds of candidates for breast reconstruction (7). In patients who have undergone abdominal surgery, these vessels, particularly the superficial inferior epigastric artery, might be distorted or even absent. The use of Doppler ultrasonography (US), the current mainstay imaging modality for preoperative vascular mapping, has brought mixed results because the diameters of perforating arteries are often less than 15 mm, the threshold for reliable depiction at US (8). Preoperative computed tomographic (CT) angiography has emerged as a useful adjunct for evaluating the vascular anatomy and identifying the perforating vessels that are best suited for selection as the dominant vessel in the vascular pedicle. In addition, it facilitates the identification of other abnormal conditions (eg, an abdominal wall hernia) that might affect the surgical procedure. The routine use of preoperative CT angiography helps reduce both the duration of the surgical procedure and the overall postoperative morbidity after perforator free flap breast reconstruction (9,10).

Teaching Point

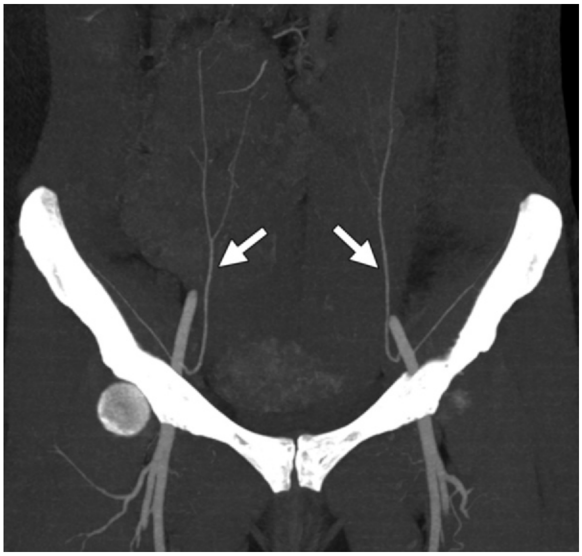

Figure 1. Coronal maximum intensity projection (MIP) image from CT angiography depicts the origin and course of the right and left deep inferior epigastric arteries (arrows).

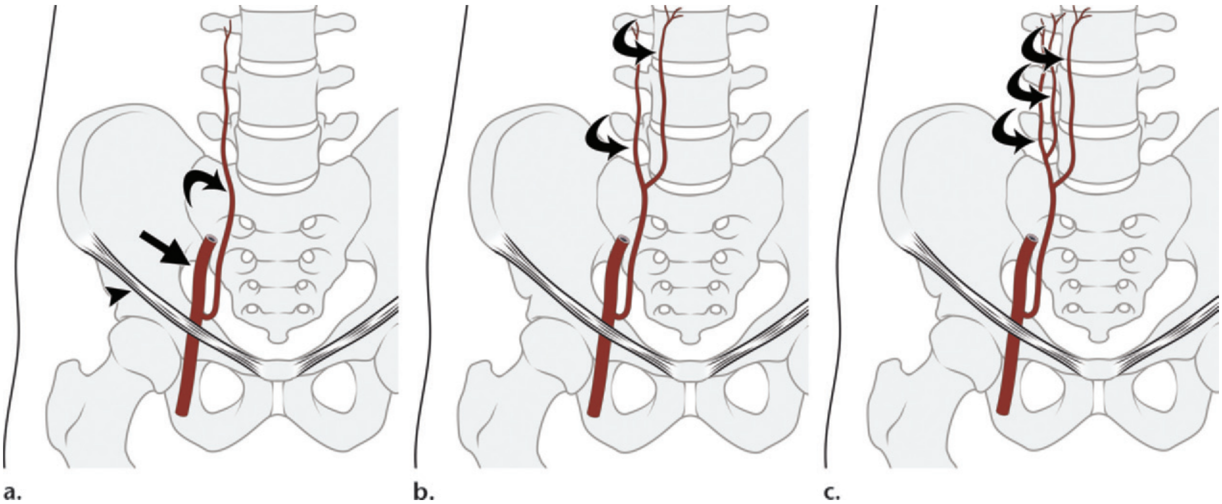

Figure 2. Diagrams (frontal views) show the origin and recognized branching patterns of the deep inferior epigastric artery, which arises from the external iliac artery (straight arrow in **a**) just above the inguinal ligament (arrowhead in **a**). From there, the epigastric artery courses upward in one of three branching patterns: remaining a single trunk (curved arrow in **a**), bifurcating into medial and lateral branches (arrows in **b**), or subdividing into three or more branches (arrows in **c**).

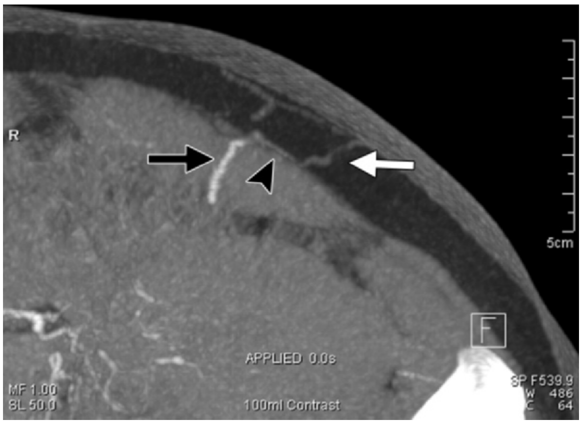

Figure 3. Axial MIP image from CT angiography depicts the intramuscular (black arrow), subfascial (arrowhead), and subcutaneous (white arrow) segments of a deep inferior epigastric perforating artery.

The purpose of the article is to familiarize readers with the acquisition and interpretation of CT angiograms so that they can relay to the surgical team information that is relevant for preoperative planning. The anatomic and surgical considerations that determine the selection of a perforating vessel for use in free flap breast reconstruction are discussed, and potential pitfalls are described.

Anatomy of the Inferior Epigastric Arteries

Deep Inferior Epigastric Artery

The deep inferior epigastric artery arises medially from the distal external iliac artery and courses superiorly, entering the rectus sheath just below the arcuate line (Fig 1). The artery then passes between the posterior layer of the rectus sheath and the rectus muscle (11). Three branching patterns of the deep inferior epigastric artery have been described: a single trunk, bifurcation, and division into three or more branches (11) (Fig 2). The deep inferior epigastric perforating vessels arise anteriorly from the main artery, traverse the rectus muscle, and pierce the anterior rectus sheath to supply a variable area of abdominal wall fat and skin (11). The course of a perforating artery is divided into intramuscular, subfascial, and subcutaneous segments (Fig 3).

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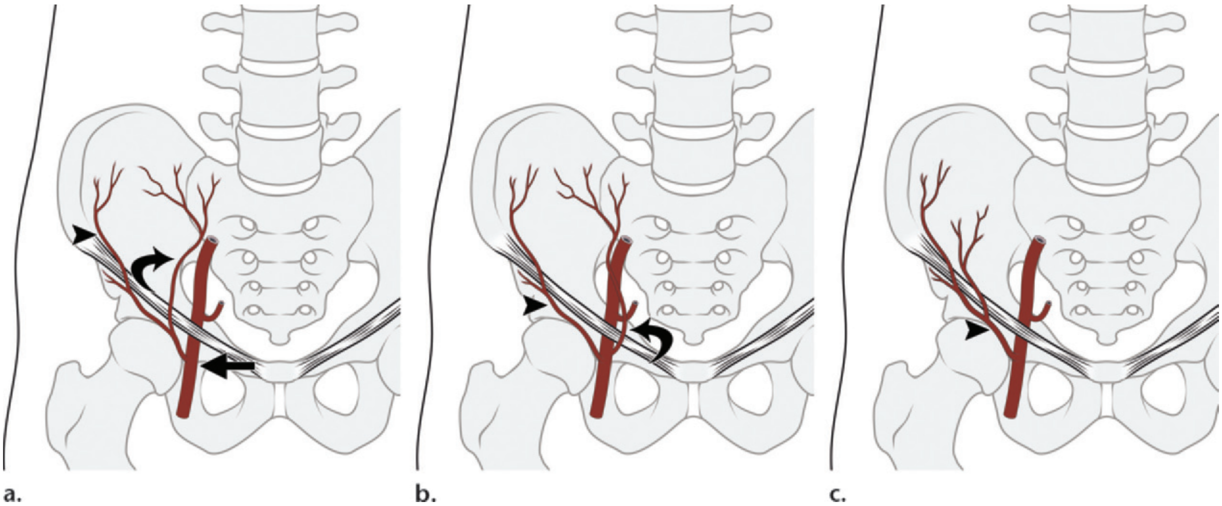


Figure 4. Diagrams (frontal views) show three common variants of superficial inferior epigastric artery (curved arrow) anatomy: common origin with the superficial circumflex iliac artery (arrowhead) from the common femoral artery (straight arrow) just below the inguinal ligament **(a)**, separate origin **(b)**, and absence **(c)**.

Table 1
Variables Considered When Selecting a Superficial Inferior Epigastric Artery for Free Flap Breast Reconstruction

Variable	Comments
Origin	Origin is best assessed on axial MIP (10-mm-thick) images. In 48% of people, the superficial inferior epigastric artery and superficial circumflex iliac artery have a common origin; in 35%, the superficial inferior epigastric artery is absent and the superficial circumflex iliac artery is large; and in 17%, the superficial inferior epigastric artery originates separately from the superficial circumflex artery.
Course	Course is best assessed on coronal and sagittal MIP (10-mm-thick) images. A medial direction is favorable.
Territory supplied	Territory size is best assessed on sagittal MIP images. Vessel caliber may be indicative of territory size.

Superficial Inferior Epigastric Artery

Teaching Point

In most people, the superficial inferior epigastric artery arises from the common femoral artery approximately 1 cm below the inguinal ligament and ascends in front of the rectus sheath. In approximately one-third of people, the superficial inferior epigastric artery shares a common origin with the superficial circumflex iliac artery; in another third, the two arteries have separate origins; and in the remaining third, the superficial inferior epigastric artery is absent (Fig 4) (7). The variables that must be kept in mind when evaluating the superficial inferior epigastric artery are summarized in Table 1.

Tissue Harvesting for Inferior Epigastric Artery Flaps

Under general anesthesia, the patient is positioned supine on the operating table. Sterile preparation of the surgical area is performed, and sterile drapes are placed over the patient from the chin to the upper thighs. The superficial inferior epigastric arteries are accessed first, one side at a time. If either of these arteries is of sufficient size and quality, its use as a vascular pedicle is favored over that of the deep inferior epigastric artery by surgeons at our institutions. First, the superficial inferior epigastric artery is traced to its origin from the common femoral artery. Next, a superficial inferior epigastric flap is obtained by incising the abdominal skin and fat lateromedially from

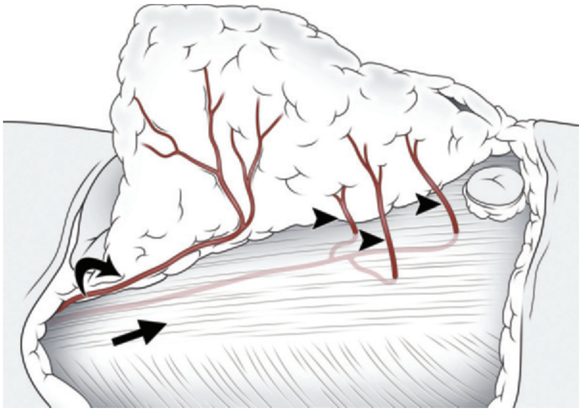


Figure 5. Diagram shows mobilization of an elliptic section of lower abdominal adipocutaneous tissue containing segments of the superficial inferior epigastric artery (curved arrow) and three deep inferior epigastric perforating vessels (arrowheads) for use in free flap breast reconstruction. The rectus sheath (straight arrow) remains intact.

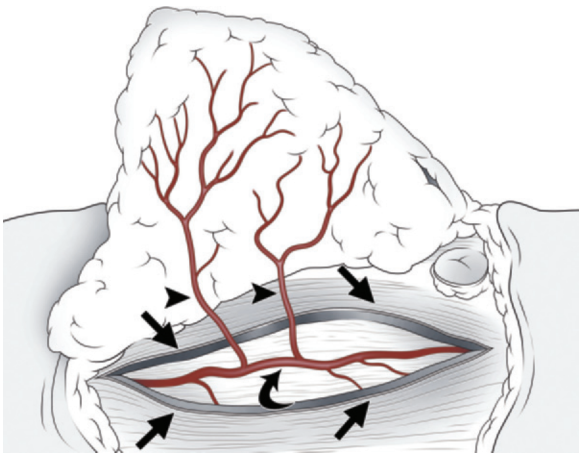


Figure 6. Diagram shows retraction of a mobilized elliptic section of lower abdominal adipocutaneous tissue, opening of the anterior rectus sheath, and vertical division of rectus muscle fibers (straight arrows) to expose the origins of the perforating vessels (arrowheads) from the deep inferior epigastric artery (curved arrow). The dissection continues until the origin of the deep inferior epigastric artery from the external iliac artery is seen.

both sides and lifting it off the rectus sheath (Fig 5). Any large deep inferior epigastric perforating vessels encountered are isolated and preserved. When the entire flap has been raised, vascular microclamps are placed across the isolated deep inferior epigastric perforating vessels, and only the superficial inferior epigastric artery is left to perfuse the flap. Perfusion is then assessed to determine whether a sufficient portion of the flap has an adequate blood supply to survive after engraftment (12).

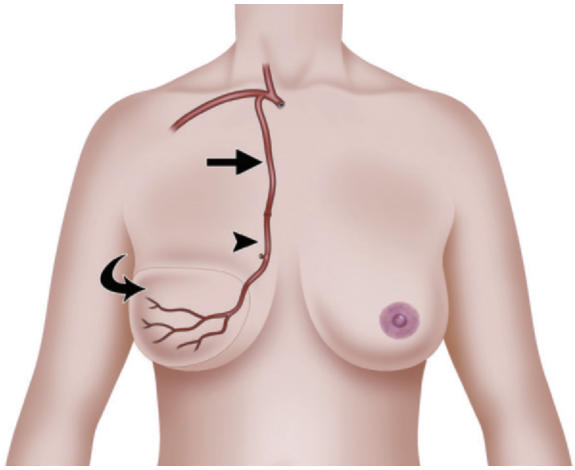


Figure 7. Diagram (frontal view) shows positioning of the flap over the recipient site (curved arrow) and anastomosis of the donor perforating artery (arrowhead) to the recipient internal mammary artery (straight arrow).

The benefits of using the superficial inferior epigastric artery must be balanced against the limitations, particularly when a large-volume breast reconstruction is planned. The volume of adipocutaneous tissue available for harvest with the superficial inferior epigastric artery may not be adequate in some patients (13). Hence, a detailed discussion with the surgeon about the scope of the planned reconstruction is important.

Teaching Point

If the superficial inferior epigastric artery is unsuitable or a deep inferior epigastric perforating artery is preferred, the superficial inferior epigastric artery is ligated and divided. After a suitable deep inferior epigastric perforating artery has been identified, an incision is made next to it in the rectus sheath to expose the course of the vessel through the rectus muscle. The rectus muscle is preserved and retracted as the dissection proceeds and the perforating vessel is traced to the parent deep inferior epigastric artery. The deep inferior epigastric artery is exposed and traced to the site of its origin from the external iliac artery (Fig 6). A long vascular pedicle is harvested so that the anastomosis of the donor vessel to the recipient vessel can remain tension free during positioning and shaping of the new breast (14) (Fig 7).

Table 2
Acquisition Parameters for CT Angiography of Epigastric and Gluteal Perforating Arteries

Parameter	Description
CT scanner	Helical, 16 detector rows (Somatom Sensation 16; Siemens Healthcare, Frimley, England)
Contrast material	100 mL iohexol (Omnipaque 350; GE Healthcare, Princeton, NJ) injected intravenously at 4 mL/sec
Beam collimation	3 mm
Acquisition volume*	16 × 0.75 mm
Beam pitch	1.15
Tube voltage	120 kVp
Tube current†	200 mA
Rotation time	0.5 sec
Section thickness and postprocessing algorithm for axial image reconstruction	1 mm, B20 smooth

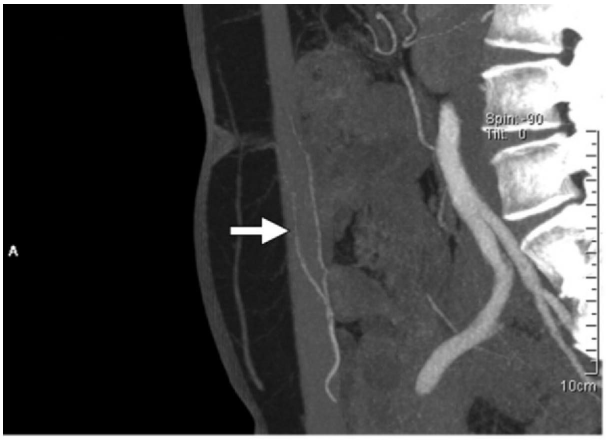
*The values given are the number of sections acquired, multiplied by the section thickness.
†The manufacturer-provided automatic exposure control system (CareDose v. 4; Siemens) is used.

Table 3
Variables Considered When Selecting Perforating Vessels for Free Flap Breast Reconstruction

Variable	Comments
Size	Size is best assessed on volume-rendered images at the point where the vessel pierces the anterior rectus sheath. The larger the vessel, the more suitable it is for use; a diameter of more than 2 mm is preferred.
Location	Location is best assessed on volume-rendered images. The perforating vessel should be below the umbilicus and not too lateral to the midline, preferably less than 3 cm inferior and less than 3 cm lateral.
Course	Course is best assessed on axial and sagittal MIP images. A tortuous intramuscular course and a substantial subfascial segment make dissection of the vessel more difficult and increase the likelihood of damage to the rectus muscle fibers.
Length	Length is best assessed on axial and sagittal MIP images. A short intramuscular segment, preferably less than 3 cm long, is preferable to limit trauma resulting from dissection.

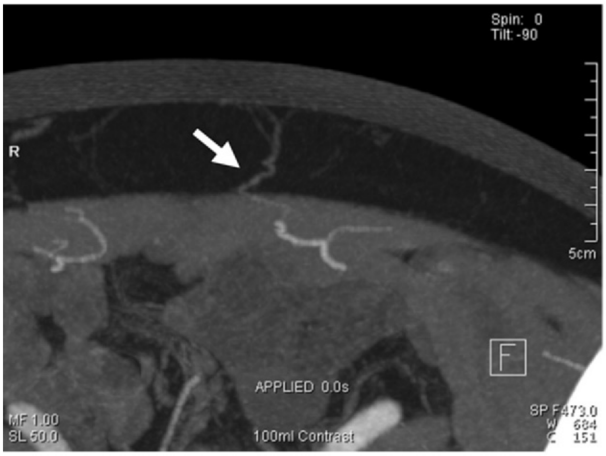
CT Angiography of the Inferior Epigastric Arteries

At our institutions, CT angiography is performed in all patients who elect to undergo breast reconstruction after mastectomy. To date, we have acquired and analyzed 132 CT datasets from our patient population. We currently acquire all CT angiographic images with a 16-section scanner (Table 2). The patient, with all undergarments removed, is positioned supine on the CT table. A bolus-tracked arterial phase acquisition is obtained from the xiphisternum to the lesser trochanters. The region of interest for bolus tracking is placed over the aorta at the level of the L1 vertebra. The inferior extent of the acquisition volume must be sufficient to

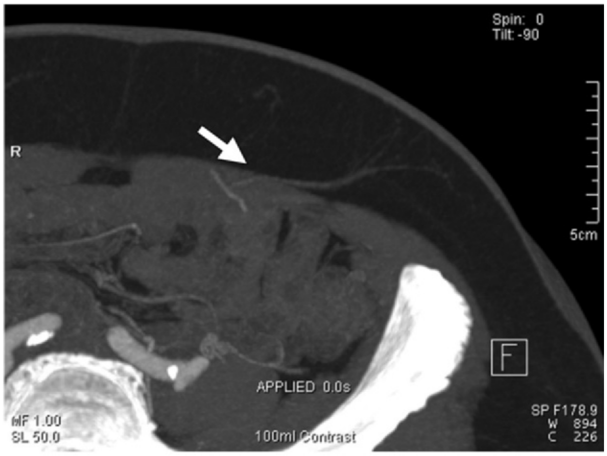


a.

Figure 8. Sagittal **(a)** and axial **(b, c)** MIP images from CT angiography show a deep inferior epigastric perforating artery (arrow) with multiple characteristics that are unfavorable for free flap breast reconstruction: lengthy subfascial and intramuscular segments **(a)**, a tortuous intramuscular segment **(b)**, and a lateral course **(c)**.



b.



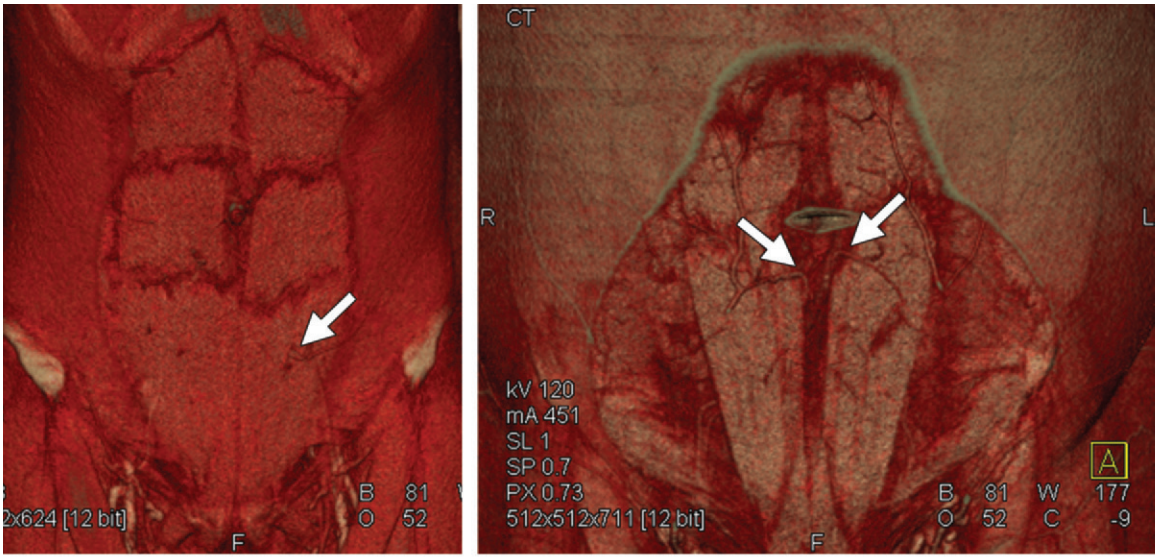
c.

ensure coverage of the origin of the superficial inferior epigastric artery. Postprocessing is performed, and images are reconstructed in MIP and volume rendering modes. An axial dataset obtained with a section thickness of 1 mm and a smooth postprocessing kernel (B20) is used for angiographic evaluations.

Selection of Favorable Deep Inferior Epigastric Perforating Arteries

The dataset is loaded onto a CT workstation running the scanner manufacturer–provided software for multiplanar reconstruction and interactive display of volume-rendered images (VR Inspace; Siemens Healthcare). The coronal MIP viewing function is used first to determine the patency and branching patterns of the deep inferior epigastric arteries. The thickness of the MIP images is set at 50 mm. When setting out to evaluate the deep inferior epigastric perforating arteries, the key anatomic variables to consider are the vessel size, location (relative to the umbilicus), course, and length (Table 3) (11,15). Characteristics that make a deep inferior epigastric perforating vessel unfavorable for use as a pedicle include a substantial subfascial segment (Fig 3), long intramuscular segment (Fig 8a), tortuous intramuscular segment (Fig 8b), and lateral course (Figs 8c, 9).

Teaching Point



a. b.

Figure 9. Volume-rendered CT images show a deep inferior epigastric artery with an unusually inferior origin (arrow in **a**) and perforating vessels (arrows in **b**) with origins medial to the rectus muscle.

Following manipulation of the volume-rendered dataset (Fig 10a–10c), the image is rotated along the vertical axis (Fig 10d–10f) to allow selection of the deep inferior epigastric perforating arteries with the most favorable size and location. Next, the axial and sagittal MIP viewing function is used to assess the course and length of these deep inferior epigastric "perforators" to identify the most suitable vessels for use. Usually, up to four perforators are labeled in order of preference as *P1* through *P4* for unilateral breast reconstruction, and up to six perforators are labeled in order of preference as *RP1* through *RP3* and *LP1* through *LP3* for bilateral breast reconstructions. A scaled grid is superimposed on the volume-rendered image with its center at the umbilicus so that the location of the perforating vessels relative to the umbilicus can be more easily determined during surgery (Fig 10g). The volume-rendered images with the grid and the deep inferior epigastric perforators labeled are saved with the axial and sagittal MIP images to the case folder on the picture archiving and communication system.

Selection of a Favorable Superficial Inferior Epigastric Artery

The superficial inferior epigastric arteries are assessed at the same time as the deep inferior epigastric perforating arteries. Axial MIP images are evaluated first. The thickness of the images for this assessment is set at 10 mm. By starting at the level of the umbilicus on the axial MIP images and scrolling downward, the reader can readily identify the superficial epigastric vein. The superficial inferior epigastric artery, if present, will be visible at the level of the arcuate line, lateral to the superficial epigastric vein and at a variable distance from it. The superficial inferior epigastric artery is traced to its origin to determine its branching pattern. A sagittal MIP image with a thickness of 10–15 mm is then reviewed to assess the course and caliber of the superficial inferior epigastric artery (Fig 11).

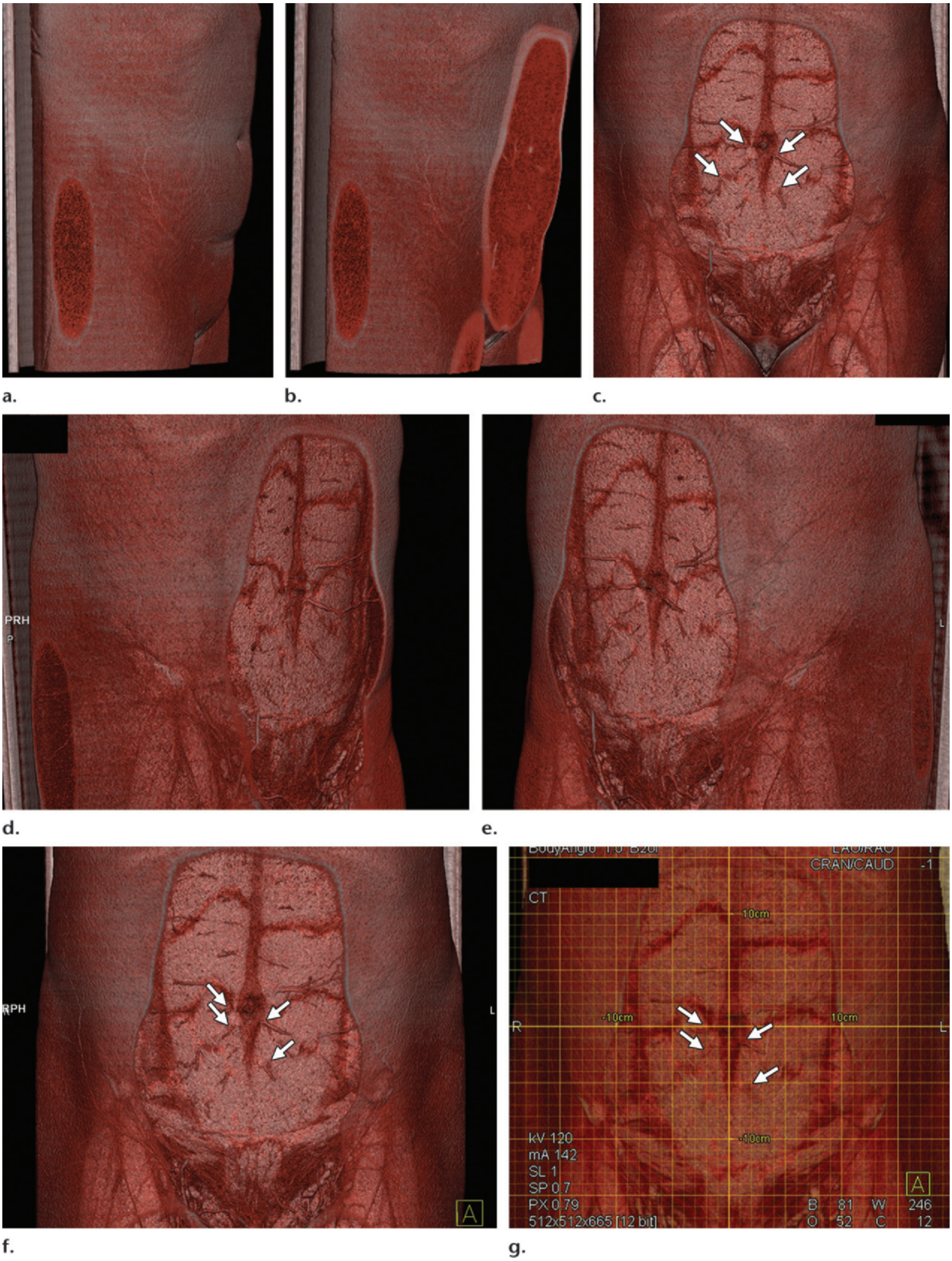
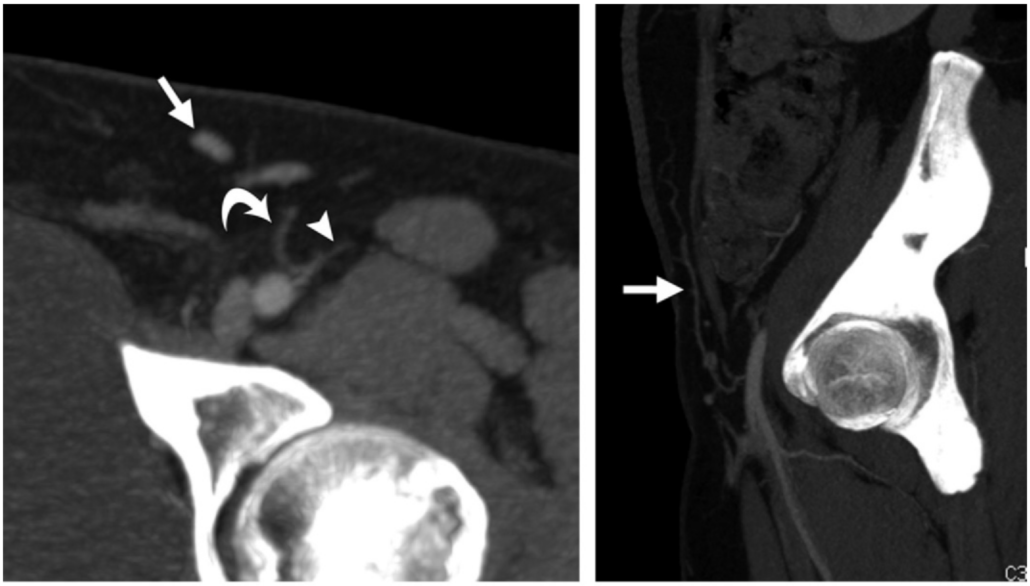


Figure 10. Volume-rendered images from CT angiography show the step-by-step assessment of deep inferior epigastric perforating arteries. **(a)** First, an oblique volume-rendered image is reconstructed and displayed. **(b)** Next, the skin is subtracted from the anterior abdominal wall. **(c)** The image is recentered, and the contrast and brightness are adjusted until the deep inferior epigastric perforating vessels (arrows) become visible. **(d, e)** The image is rotated toward the patient's right **(d)** and left **(e)** to allow more accurate assessment of the caliber and location of deep inferior epigastric perforating vessels. **(f)** The image is again recentered, and, after the MIP images have been reviewed, the most suitable perforating vessels (arrows) are marked. **(g)** A scaled grid is superimposed on the image to show the relations of the deep inferior epigastric perforating vessels (arrows) to the umbilicus.



a. b.

Figure 11. **(a)** Axial MIP image from CT angiography shows a common origin of the superficial inferior epigastric artery (curved arrow) and the superficial circumflex iliac artery (arrowhead) and location of the superficial inferior epigastric artery just lateral to the superficial epigastric vein (straight arrow). **(b)** Sagittal MIP image shows that the superficial inferior epigastric artery (arrow) courses anterior to the rectus muscle.

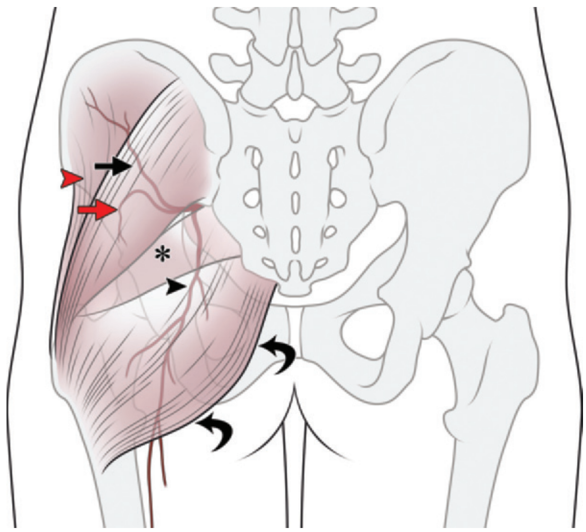


Figure 12. Diagram (frontal view) shows that after exiting the greater sciatic foramen, the superior gluteal artery passes superior to, and the inferior gluteal artery (arrowhead) passes inferior to, the piriformis muscle (*). The superior gluteal artery subdivides into superficial (straight black arrow) and deep (red arrow) branches. The relations of the gluteal vessels to the gluteus maximus (curved black arrows) and medius (red arrowhead) muscles also are depicted.

Anatomy of the Superior and Inferior Gluteal Arteries

Teaching Point

If the anterior abdominal wall cannot be used as a donor site because the patient has undergone multiple abdominal surgeries, or if there is more fat in the buttock area than in the abdominal wall, the gluteal perforating arteries are evaluated as potential donor vessels (16). The superior and inferior gluteal arteries, which are terminal branches of the posterior division of the internal iliac artery, exit the pelvis through the greater sciatic foramen (17). The superior gluteal artery passes superior to the piriformis muscle, and the inferior gluteal artery passes inferior to the muscle (Fig 12). Outside the greater sciatic foramen, the superior gluteal artery divides into superficial and deep branches. The

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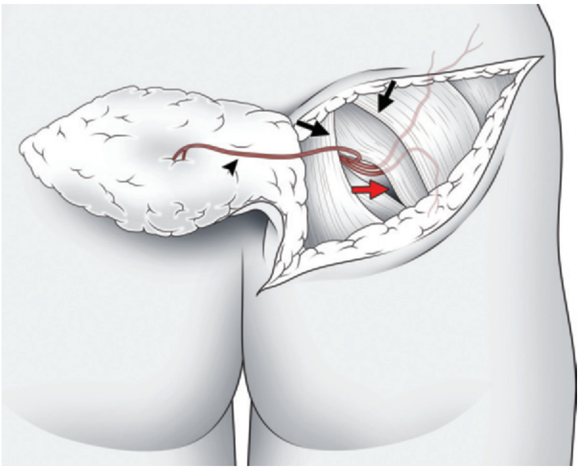

Figure 13. Diagram shows a raised, obliquely oriented elliptic flap of adipocutaneous tissue. The most suitable superior gluteal perforating artery (arrowhead) is traced to the anterior sheath of the gluteus maximus. The gluteus maximus sheath and muscle fibers (black arrows) are divided to allow the perforating vessel to be traced to its origin from the superior gluteal artery, medial to the border of the gluteus medius (red arrow).

superficial branch of the superior gluteal artery courses superolaterally to supply the gluteus maximus muscle (17). Perforating arteries arise from both the superficial and the deep branches of the superior gluteal artery, but perforators that arise from the superficial branch are more often used for free flaps. The perforating vessels pass through the gluteus maximus and pierce its anterior sheath to supply a variable territory of overlying adipocutaneous tissue (17). The inferior gluteal artery, accompanied by the sciatic nerve, descends between the greater trochanter and ischial tuberosity and branches into multiple perforating arteries that supply the lower portion of the gluteus maximus muscle and the overlying adipocutaneous tissue (17).

Tissue Harvesting for Gluteal Artery Perforator Flaps

Superior Gluteal Perforating Arteries

The patient lies on her side on the operating table, with the donor side buttock facing upward. A large section of skin and fat (flap) is raised by making an ellipse incision paralleling or at an oblique angle to the iliac crest. The fat on the superolateral aspect of the flap is dissected down to the level of the gluteus maximus fascia. The fascia is incised and dissected medially until the superior gluteal perforating artery chosen for use in the vascular pedicle is isolated. The muscle fibers are divided to expose the perforating vessel, which is then followed to its origin from the superior gluteal artery at the lateral edge of the sacrum (18) (Fig 13).

Inferior Gluteal Perforating Arteries

The surgical technique used to harvest tissue for inferior gluteal perforator flaps is similar to that used for superior gluteal perforator flaps. The patient lies on her side, with the donor side buttock facing upward. An ellipse incision is made that is oriented horizontally along the buttock crease. Dissection begins laterally over the tensor fasciae latae muscle and proceeds medially across the gluteus maximus until a suitable perforating vessel is found. The fascia is then opened and the muscle fibers are divided to allow the perforating vessel to be traced to its origin from the inferior gluteal artery (19).

CT Angiography of the Gluteal Arteries

CT angiography is performed with the patient lying on her side, donor side buttock up, in the same position that will be used during tissue harvesting for breast reconstruction. The image acquisition parameters are identical to those used at CT angiography of the inferior epigastric arteries and perforating vessels (Table 2). The most favorable superior and inferior gluteal artery perforators are selected on the basis of their size, location, and length. The perforators are ranked and marked according to their relative favorability, with the most favorable being labeled *P1*.

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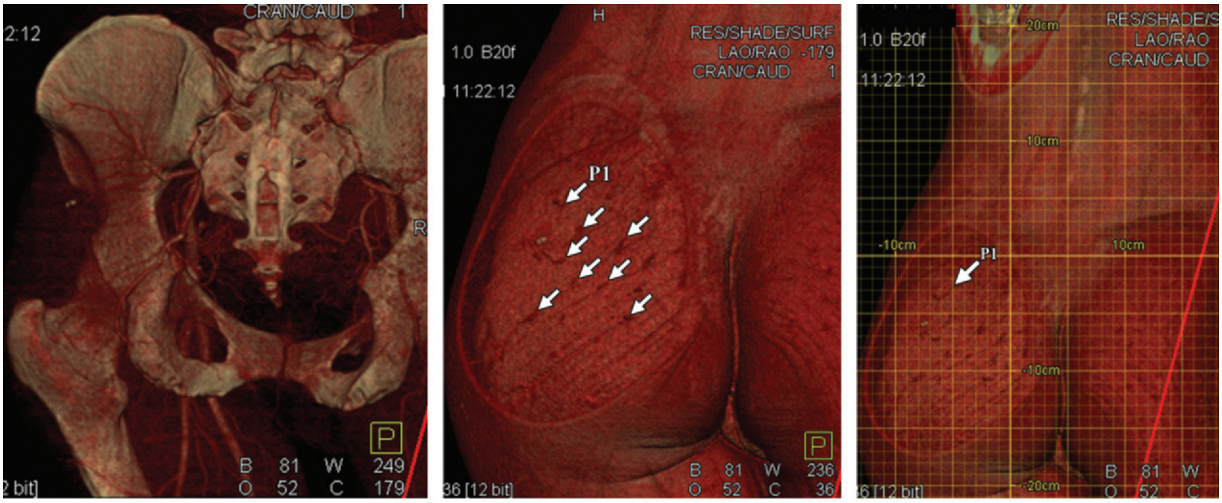

a. b. c.

Figure 14. Assessment of superior gluteal perforating arteries on volume-rendered CT images. **(a)** The display settings are adjusted to show the gluteal arteries exiting the greater sciatic foramen and coursing along the buttock region. **(b)** The display settings are adjusted again to depict the soft tissue, and the skin overlying the buttock is subtracted from the image to reveal the superior gluteal perforating arteries (arrows). The vessel with the largest caliber is labeled *P1*. **(c)** A grid is superimposed on the image in **b** and centered over the posterior superior iliac spine to show the relations of the superior gluteal perforating arteries to the bone landmark.

Selection of Favorable Superior Gluteal Perforating Arteries

The dataset is loaded onto the workstation for interactive display in the volume rendering mode. The superior gluteal artery is visible where it exits the greater sciatic foramen (Fig 14). The contrast and brightness are adjusted, and the skin overlying the buttock is subtracted from the image. The perforating arteries that penetrate the anterior sheath of the gluteus muscle are assessed to determine which one has the largest caliber, and this vessel is marked as the most favorable perforator for use (*P1*). Perforating arteries that arise more superolaterally are longer and hence preferred. A grid is superimposed on the image, with its centerpoint overlying the posterior superior iliac spine, to demonstrate the location of the perforating vessels in relation to a bone landmark.

Selection of Favorable Inferior Gluteal Perforating Arteries

On the volume-rendered image, a vertical line is drawn over the buttock, between the posterior superior iliac spine and the ischial tuberosity, and a horizontal line is drawn to bisect the vertical line, delineating four quadrants (Fig 15). The perforating vessels that appear in the inferolateral quadrant are those that originate from the inferior gluteal artery. The more inferior and more lateral gluteal perforating arteries are preferred for use in the flap.

Conclusions

CT angiography is a valuable tool that can enhance the precision of preoperative planning for perforator free flap breast reconstruction. Knowledge of the relevant anatomy, surgical technique, and protocols for acquiring and interpreting CT angiograms can help reduce procedure time and lead to better outcomes.

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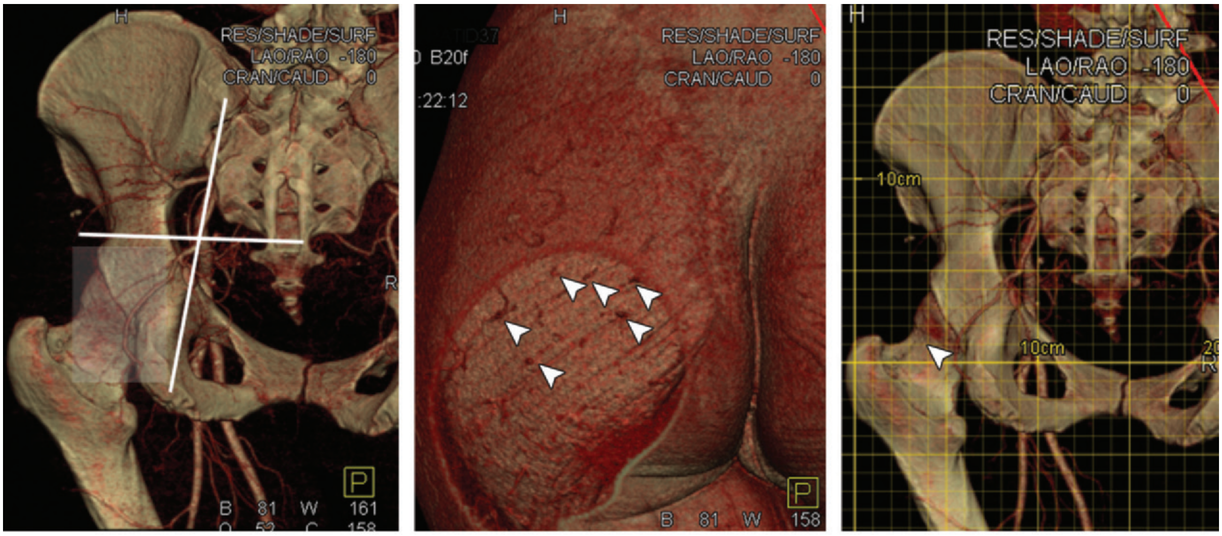

a. b. c.

Figure 15. Assessment of inferior gluteal perforating arteries on volume-rendered CT images. **(a)** On an image obtained with bone window settings, a vertical line is drawn over the buttock from the posterior superior iliac spine to the ischial tuberosity, and a horizontal line is drawn to bisect it. The perforating vessels that appear in the inferolateral quadrant (shaded area) originate from the inferior gluteal artery. **(b)** The display settings are changed to depict the soft tissue, and the skin is subtracted from the image to reveal the inferior gluteal perforating arteries (arrowheads). **(c)** A grid is superimposed on the image in **a** with its center over the greater trochanter to show the relations of inferior gluteal perforating arteries (arrowhead) to the bone landmark.

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CT Angiography of Inferior Epigastric and Gluteal Perforating Arteries before Free Flap Breast Reconstruction[1]

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The routine use of preoperative CT angiography helps reduce both the duration of the surgical procedure and the overall postoperative morbidity after perforator free flap breast reconstruction (9,10).

Page 1310 (Table on page 1310)
In most people, the superficial inferior epigastric artery arises from the common femoral artery approximately 1 cm below the inguinal ligament and ascends in front of the rectus sheath.

The variables that must be kept in mind when evaluating the superficial inferior epigastric artery are summarized in Table 1.

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The benefits of using the superficial inferior epigastric artery must be balanced against the limitations, particularly when a large-volume breast reconstruction is planned. The volume of adipocutaneous tissue available for harvest with the superficial inferior epigastric artery may not be adequate in some patients (13). Hence, a detailed discussion with the surgeon about the scope of the planned reconstruction is important.

Page 1313 (Table on page 1312)
When setting out to evaluate the deep inferior epigastric perforating arteries, the key anatomic variables to consider are the vessel size, location (relative to the umbilicus), course, and length (Table 3) (11,15).

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If the anterior abdominal wall cannot be used as a donor site because the patient has undergone multiple abdominal surgeries, or if there is more fat in the buttock area than in the abdominal wall, the gluteal perforating arteries are evaluated as potential donor vessels (16).