

**American College of Radiology
ACR Appropriateness Criteria®
Imaging of Deep Inferior Epigastric Arteries for Surgical Planning
(Breast Reconstruction Surgery)**

Variant 1: Imaging of deep inferior epigastric arteries for surgical planning (breast reconstruction surgery).

Procedure	Appropriateness Category	Relative Radiation Level
CTA abdomen and pelvis with IV contrast	Usually Appropriate	⊗⊗⊗⊗⊗
MRA abdomen and pelvis without and with IV contrast	Usually Appropriate	○
MRA abdomen and pelvis without IV contrast	May Be Appropriate	○
Arteriography abdomen and pelvis	Usually Not Appropriate	⊗⊗⊗⊗
CT abdomen and pelvis with IV contrast	Usually Not Appropriate	⊗⊗⊗⊗
US color Doppler abdomen and pelvis	Usually Not Appropriate	○
CT abdomen and pelvis without and with IV contrast	Usually Not Appropriate	⊗⊗⊗⊗
CT abdomen and pelvis without IV contrast	Usually Not Appropriate	⊗⊗⊗⊗
MRI abdomen and pelvis without and with IV contrast	Usually Not Appropriate	○
MRI abdomen and pelvis without IV contrast	Usually Not Appropriate	○

IMAGING OF DEEP INFERIOR EPIGASTRIC ARTERIES FOR SURGICAL PLANNING (BREAST RECONSTRUCTION SURGERY)

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Summary of Literature Review

Introduction/Background

The most common malignancy in women in the United States is breast cancer. Despite advances in treatment options, mastectomy followed by breast reconstruction remains a common therapeutic selection. There are various choices for breast reconstruction surgery ranging from saline or silicone implants to autologous tissue reconstruction. Autologous breast reconstruction is usually sought by patients and clinicians because it may provide a more aesthetic outcome than other breast reconstruction techniques. The breast can be reconstructed from a range of donor sites but the abdominal wall integument allows for versatility in flap volume and design [1].

Breast reconstruction using a flap from a lower abdominal donor site began with the development of the pedicled transverse rectus abdominis myocutaneous (TRAM) flap in 1982. It was soon discovered that morbidity could be decreased by reducing the amount of injury to the muscle at the donor site, which led to the development of muscle-sparing procedures, including segmental latissimus dorsi myocutaneous and free-TRAM flaps. To further minimize donor site morbidity, the rectus abdominis musculature was increasingly spared in muscle-sparing TRAM flaps. The preservation of the entire rectus muscle was realized with the deep inferior epigastric perforator (DIEP) flap.

The DIEP flap preserves the underlying muscle, reduces morbidity, and preserves functionality; however, it requires a more intensive surgery and microsurgical revascularization when compared to the TRAM flap procedures. The DIEP flap arterial supply is via intramuscular perforators from the deep inferior epigastric artery (DIEA), which arises from the external iliac artery [2]. The anatomy of the DIEA itself is consistent, making this vessel easily identifiable without preoperative imaging and allowing this operation before the advent of preoperative imaging planning.

The perforator branches of the DIEA have a variable anatomy that may even exist between the right and left hemiabdomen in the same patient. These perforator branches have been traditionally classified as a single (type 1), bifurcating (type 2), and trifurcating trunk (type 3) [2]. The perforator arteries are then individually divided into intramuscular, subfascial, and subcutaneous segments [3,4]. This unpredictable anatomy may lead to lengthy perforator vessel selection and therefore longer operative times when imaging is not used as part of the preoperative planning. Additionally, preoperative imaging planning that accurately maps the perforators and its branches leads to reduced operative time, reduced abdominal morbidity, and increased flap reliability [5-13].

The information most critical to the surgical team includes the location, size, and intramuscular course of the perforator branch. To best aid the surgical team, multiple perforators are identified, which are typically ranked based on size, location, and intramuscular course. The selection of the “best” perforator is the most difficult diagnostic challenge in preoperative imaging and during the surgery. The ideal perforator should have the largest caliber available given its influence on flap viability [14,15]. The ideal perforator should also be medially located within the flap with an extended vascular territory beyond the midline to best provide optimal perfusion, preservation of muscle innervation, and avoid fat necrosis [14-16]. Additionally, a short intramuscular course

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allows for successful dissection [3,14,15]. Regardless of the imaging modality, perforators are reported with the location where it pierces the anterior rectus sheath in relation to the umbilicus. This is an important distinction because the position of the perforator within the subcutaneous tissues can move with applied pressure; however, the rectus sheath is immobile relative to the umbilicus [17]. This concept is applied in computed tomography angiography (CTA) and magnetic resonance angiography (MRA) with localization of perforators on maximum intensity projection (MIP) images at the anterior rectus sheath and then superimposing the location onto 3-D skin surface rendered images [3,15]. Information about the perforator size and intramuscular course are also reported to help prioritize which perforators may be used for the procedure.

Preoperative Imaging

The goal of preoperative imaging is to aid the surgical team in preoperative planning given the variability of the DIEA perforator branches anatomy between patients, and even between the left and right hemiabdomen of the same patient. Improved clinical outcomes with preoperative imaging have been shown (predominantly with CTA) to include decreased length of surgery, decreased flap loss rate, decreased hernia rate, decreased intraoperative blood loss, shorter mean inpatient stay, reduced learning curve when compared with hand-held Doppler, and increased surgeon confidence [5-13].

Discussion of Procedures by Variant

Variant 1: Imaging of deep inferior epigastric arteries for surgical planning (breast reconstruction surgery).

US

Color Doppler ultrasound (US) allows for evaluation of perforator location, size, and associated information on vessel integrity including atherosclerotic disease, a prior surgery (scar tissue), or other vascular disorders. There is a significant challenge in interpreting real-time sonographic images into a report that is beneficial to the surgical team [17]. For this document, it is assumed the procedure is performed and interpreted by an expert. Color Doppler US remains a real-time imaging technique that cannot be fully used by the surgical team in the operating room. When compared to color Doppler US, CTA is a more intuitive modality that is favored by many surgeons and can also be used for reference in the operating room [17]. Multiple studies have shown the superior accuracy of CTA over color Doppler US in preoperative perforator imaging [18-22].

Arteriography

Conventional angiography with and without the use of cone-beam CT theoretically would aid preoperative planning for DIEP flaps given its relatively high spatial resolution and ability to selectively catheterize the DIEP. However, given the invasive nature of the procedure without therapeutic benefit and ionic contrast exposure, it is not routinely used in these patients. Prior to the development of noninvasive imaging modalities, DIEP flaps were performed without preoperative imaging given the consistency of the DIEA [2].

CTA

CTA is the current diagnostic modality of choice for evaluation of perforators in preoperative DIEP flap planning. CT is a readily available and fast imaging test with a positive predictive value of 100% for perforators >1 mm. CTA is extremely reproducible [23]. The diagnostic quality of CTA is dependent on optimal DIEA enhancement. Given the associated radiation, a single contrast-enhanced phase is obtained relying on a region of interest for automatic injection placed on the femoral artery [3,14]. Additionally, reversed caudal-cranial scanning from the pubic symphysis towards the umbilicus improves DIEA enhancement.

Perforators are localized on MIP images along the anterior rectus sheath; the location is then superimposed on 3-D skin surface rendered images. Additionally, axial and sagittal MIP images are used to depict the perforator's course through the subcutaneous tissues, including the intramuscular portion within the rectus muscle [3,24]. Perforators are typically ranked based on size, location, and intramuscular course. Additional information that can be obtained by CTA includes venous communication between the right and left abdomen, cutaneous perforators, as well as other parameters that can be used to calculate flap viability and flap weights, all of which can help preoperative planning by surgical teams [3,25,26]. Recent research has shown that 3-D postprocessing of CTA data may also improve accuracy in identifying perforators [6,27-29]. CTA has been accepted as the gold standard in preoperative planning for DIEP flaps with sensitivity of 96% for all perforators and sensitivity of 100% for perforators >1 mm [30].

Preoperative imaging with CTA demonstrates improved clinical outcomes including decreased length of surgery, decreased flap loss rate, decreased hernia rate, decreased intraoperative blood loss, shorter mean inpatient stay, reduced learning curve when compared with hand-held Doppler, and increased surgeon confidence [5-13]. Additionally, meta-analyses of preoperative imaging in DIEP flaps demonstrate improved clinical outcomes with CTA over color Doppler US, including overall flap-related complications, donor-site morbidity, and decreased length of surgery [19,22].

For the purposes of distinguishing between CT and CTA, the ACR Appropriateness Criteria topics use the definition in the [Practice Parameter for the Performance and Interpretation of Body Computed Tomography Angiography \(CTA\)](#) [31]:

“CTA uses a thin-section CT acquisition that is timed to coincide with peak arterial or venous enhancement. The resultant volumetric dataset is interpreted using primary transverse reconstructions as well as multiplanar reformations and 3-D renderings.”

All procedure elements are essential: (1) timing, (2) recons/reformats, and (3) 3-D renderings. Standard CTs with contrast also include timing issues and recons/reformats. Only in CTA, however, is 3-D rendering a **required** element. This corresponds to the definitions that CMS has applied to the CPT codes.

CT

There is no relevant literature regarding the use of standard CT without and/or with contrast.

MRA

MRA use in evaluation for DIEP flaps was described relatively recently, in 2009. The benefits of MRA are the lack of radiation exposure and iodinated contrast, which allows for multiple phases to be acquired and aids in optimal contrast timing. Although MRA has lower spatial resolution than CTA, MRA has higher contrast resolution, allowing the detection of submillimeter gadolinium-enhanced structures such as the DIEA perforators. MRA analysis and postprocessing is similar to CTA, which uses perforators localized on MIP images along the anterior rectus sheath, after which the location is superimposed on 3-D skin surface rendered images. Additionally, axial and sagittal MIP images are used to depict the perforator’s course. Of note, slight errors in measurement may be attributable to compression of the anterior abdominal wall by the applied MR torso coil [15]. Limitations of MRA include longer scan times than CT, and MRI contraindications including patient claustrophobia, implanted metallic devices, and renal impairment.

Early studies have shown accurate localization of perforators with MRA for DIEP flaps [1,15,32-37]. Application of novel MR techniques, such as the use of unenhanced MRA, has shown promise as the vessels can be visualized without intravenous administration of contrast [35]. A few small studies comparing CTA and MRA have shown that CTA is more accurate than MRA and remains the preferred modality due to its higher spatial resolution and higher sensitivity in identifying the perforator branches [23,38]. Larger studies are needed to evaluate the accuracy of the new emerging MRA techniques and their role in preoperative perforator branch imaging.

MRI

There is no significant literature supporting the use of standard MRI without and/or with contrast.

Summary of Recommendations

- In preoperative planning prior to breast reconstruction using DIEP flap, CTA abdomen and pelvis with IV contrast is the first-line imaging modality. MRA abdomen and pelvis without and with IV contrast is a reasonable alternative.

Summary of Evidence

Of the 39 references cited in the *ACR Appropriateness Criteria® Imaging of Deep Inferior Epigastric Arteries for Surgical Planning (Breast Reconstruction Surgery)* document, 2 are categorized as therapeutic references, including 1 well-designed study. Additionally, 35 references are categorized as diagnostic references including 9 good-quality studies and 12 quality studies that may have design limitations. There are 14 references that may not be useful as primary evidence. There are 2 references that are meta-analysis studies.

The 39 references cited in the *ACR Appropriateness Criteria® Imaging of Deep Inferior Epigastric Arteries for Surgical Planning (Breast Reconstruction Surgery)* document were published from 2008-2017.

Although there are references that report on studies with design limitations, 10 well-designed or good-quality studies provide good evidence.

Appropriateness Category Names and Definitions

Appropriateness Category Name	Appropriateness Rating	Appropriateness Category Definition
Usually Appropriate	7, 8, or 9	The imaging procedure or treatment is indicated in the specified clinical scenarios at a favorable risk-benefit ratio for patients.
May Be Appropriate	4, 5, or 6	The imaging procedure or treatment may be indicated in the specified clinical scenarios as an alternative to imaging procedures or treatments with a more favorable risk-benefit ratio, or the risk-benefit ratio for patients is equivocal.
May Be Appropriate (Disagreement)	5	The individual ratings are too dispersed from the panel median. The different label provides transparency regarding the panel's recommendation. "May be appropriate" is the rating category and a rating of 5 is assigned.
Usually Not Appropriate	1, 2, or 3	The imaging procedure or treatment is unlikely to be indicated in the specified clinical scenarios, or the risk-benefit ratio for patients is likely to be unfavorable.

Relative Radiation Level Information

Potential adverse health effects associated with radiation exposure are an important factor to consider when selecting the appropriate imaging procedure. Because there is a wide range of radiation exposures associated with different diagnostic procedures, a relative radiation level (RRL) indication has been included for each imaging examination. The RRLs are based on effective dose, which is a radiation dose quantity that is used to estimate population total radiation risk associated with an imaging procedure. Patients in the pediatric age group are at inherently higher risk from exposure, both because of organ sensitivity and longer life expectancy (relevant to the long latency that appears to accompany radiation exposure). For these reasons, the RRL dose estimate ranges for pediatric examinations are lower as compared to those specified for adults (see Table below). Additional information regarding radiation dose assessment for imaging examinations can be found in the ACR Appropriateness Criteria® [Radiation Dose Assessment Introduction](#) document [39].

Relative Radiation Level Designations		
Relative Radiation Level*	Adult Effective Dose Estimate Range	Pediatric Effective Dose Estimate Range
○	0 mSv	0 mSv
⊗	<0.1 mSv	<0.03 mSv
⊗⊗	0.1-1 mSv	0.03-0.3 mSv
⊗⊗⊗	1-10 mSv	0.3-3 mSv
⊗⊗⊗⊗	10-30 mSv	3-10 mSv
⊗⊗⊗⊗⊗	30-100 mSv	10-30 mSv

*RRL assignments for some of the examinations cannot be made, because the actual patient doses in these procedures vary as a function of a number of factors (eg, region of the body exposed to ionizing radiation, the imaging guidance that is used). The RRLs for these examinations are designated as "Varies".

Supporting Documents

For additional information on the Appropriateness Criteria methodology and other supporting documents go to www.acr.org/ac.

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The ACR Committee on Appropriateness Criteria and its expert panels have developed criteria for determining appropriate imaging examinations for diagnosis and treatment of specified medical condition(s). These criteria are intended to guide radiologists, radiation oncologists and referring physicians in making decisions regarding radiologic imaging and treatment. Generally, the complexity and severity of a patient's clinical condition should dictate the selection of appropriate imaging procedures or treatments. Only those examinations generally used for evaluation of the patient's condition are ranked. Other imaging studies necessary to evaluate other co-existent diseases or other medical consequences of this condition are not considered in this document. The availability of equipment or personnel may influence the selection of appropriate imaging procedures or treatments. Imaging techniques classified as investigational by the FDA have not been considered in developing these criteria; however, study of new equipment and applications should be encouraged. The ultimate decision regarding the appropriateness of any specific radiologic examination or treatment must be made by the referring physician and radiologist in light of all the circumstances presented in an individual examination.