6

Breast Reconstruction with DIEP and S/IGAP

Maria M. LoTempio, Grace Lucta Gerald and Robert J. Allen
Medical University of South Carolina, USA

1. Introduction

Breast reconstruction is an essential component in the treatment of breast cancer patients. It is being performed with increasingly sophisticated techniques to optimize the appearance and feel of the reconstructed breast and to decrease donor site morbidity. The use of autologous tissue allows the reconstruction of a breast which looks and feels more like a natural breast.

The abdomen is an ideal source of tissue for breast reconstruction. Most patients who develop breast cancer are at an age when they also have excess abdominal skin and fat. The fat is typically soft and easy for the surgeon to shape and closely approximate the look and feel of a native breast. In addition, an added bonus of an abdominal donor site for most patients is improved abdominal contour after flap harvest, with results similar to that of an abdominoplasty or "tummy tuck." However, women who have had abdominal surgeries in the past may not be candidates for abdominal free tissue transfer depending on the placement of the scar and the extent of their prior surgery.

Patient preference and body habitus play a role in determining the location from where autologous tissue is harvested. Some women do not like the long scar of the DIEP and prefer not to have surgery on their abdomen. Most women can be categorized into two main body shapes: pear and apple. The women who are apple shaped predominantly have fat in their abdomen whereas, women who are pear shaped have more fat in their thighs and buttock. The surgeon needs to take all of this into consideration before determining the appropriate donor site for a woman's breast reconstruction.

In this chapter we will review the deep inferior epigastric perforator flap (DIEP) and the superior/inferior gluteal artery perforator (S/IGAP) flap for breast reconstruction. We will also discuss the superior and inferior gluteal artery perforator flaps with the septocutaneous variations.

Our hope for the reader is to gain a knowledge base of the normal anatomy, the patient selection, surgical technique, post-operative management and potential complications one may encounter in pursuing this type of surgery. We will also include clinical examples.

2. DIEP

The deep inferior epigastric artery perforator (DIEP) flap is usually our first choice flap from the abdomen. It allows for the ease of transfer of skin and fat from the abdomen for the reconstruction of a new breast without the sacrifice of rectus muscle or fascia.

3. History

The modern era of autogenous breast reconstruction began with the TRAM flap, popularized by Carl Hartrampf. In 1982, he used the pedicle flap concept to transfer abdominal tissue to the chest for breast reconstruction using the superior epigastric artery and the rectus abdominus muscle as a carrier.[1] This flap came to be known as the transverse rectus abdominus myocutaneous, or TRAM, flap.

In 1973, the term "Free Flap"was used by Taylor and Daniel to describe the distant transfer of an island flap by microvascular anastomosis.[2,3] Two years later, they documented a detailed anatomical description of many of the more common free flap donor sites still in use today.[4]

The concept of donor site muscle sparing techniques were then embarked upon, as represented by Elliott with the split latissimus and by Feller with the partial rectus abdominus muscle transfer.[5,6] Koshima took this concept one step further and used the skin territory overlying the rectus abdominus muscle for reconstruction of head and neck defects.[7] The flaps were based on a single paraumbilical perforating vessel from the deep inferior epigastric artery.

The goal of muscle preservation became more apparent and in the early 1990's our group at Louisiana State University made the next significant advance in perforator flap breast reconstruction. By injecting fresh abdominoplasty specimens, it was determined that the skin and fat could be transferred without sacrifice of the rectus abdominus muscle. This led to the first DIEP flap for breast reconstruction by Allen in 1992.[8] The inception of free tissue transfer allowed an infinite range of possibilities to appropriately match donor and recipient sites.[9]

4. Indications

Most women who have had or will have mastectomies for breast cancer are possible candidates for a DIEP flap.[10] Absolute contraindications specific to abdominal perforator flap breast reconstruction in our practice include history of previous abdominoplasty, abdominal liposuction, or active smoking (within 1 month prior to surgery). A relative contraindication is previous large transverse or oblique abdominal incisions.

If the patient is undergoing radiation therapy we have them complete it six months prior to surgical breast reconstruction and if they are having chemotherapy we usually wait six weeks to obtain normal blood chemistries before proceeding to surgical breast reconstruction. This time allows radiation effects to stabilize and allows for the removal of damaged chest wall skin so that it can be replaced with soft, unirradiated abdominal skin and tissue.[11]

5. Anatomy

Like a TRAM flap, the DIEP flap is based on the deep inferior epigastric artery and vein. One, two, or three rows of perforating arteries and veins penetrate the rectus muscle on each side of the abdomen to provide the blood supply for the overlying skin and fat. The deep inferior epigastric artery is typically between 2 and 3 mm in diameter and the accompanying veins are between 2 and 3.5 mm in size.

In contrast to a TRAM flap, no rectus muscle or fascia must be sacrificed. Instead, the perforating vessels which supply the overlying skin and fat are dissected through the rectus muscle to their origins from the deep inferior epigastric vessels. The rectus muscle is spread apart in the direction of the muscle fibers during the dissection with minimal damage to the muscle. When nerves are encountered they are preserved to the best of our ability.

6. Surgical technique

All of our patients undergo a pre-operative CTA or MRA of the abdomen to determine the perforator vessels location, size, and intramuscular course. This study also allows us to differentiate between a musculocutaneous versus a septocutaneous variation of the DIEP and to assess the superficial inferior epigastric artery (SIEA) system. By knowing the specifics of the perforating vessels, the operating time is shortened by an hour.

The patient is usually seen in the office one day prior to surgery. The surgical plan is reviewed with the patient and any remaining questions are answered. Standard abdominoplasty markings are made in the sitting or standing position based around the selected perforator. The side of the abdomen contralateral to the side to be reconstructed is preferred, as this provides for easier insetting at the time of surgery. However, because a very long pedicle may be harvested, insetting typically is not a problem with either an ipsilateral or contralateral pedicle. Flaps are marked with their superior border just above the umbilicus and their inferior border approximately 12 cm below the umbilicus. The lateral flap markings extend approximately 22 to 24 cm from the midline. Then, with the patient in a supine position, a Doppler probe is used to audibly hear the main perforator selected by CTA/MRA. The superficial inferior epigastric artery and vein are likewise found with the Doppler probe and marked.

On the chest, the midline and the bilateral inframammary folds are marked. For patients undergoing immediate breast reconstruction, suggested skin markings for the surgical oncologist are drawn on the breast. If the patient is undergoing nipple-sparing procedures (usually BRCA patients), the incision mark is drawn from the inferior portion of the nipple straight down to the inframammary fold. In patients with cancer the lollypop incision marks are placed onto the breasts.

The operating room table is turned 180° to allow the surgeons to sit comfortably with legs under the table during the microvascular anastomosis. The morning of surgery, the patient receives 5000 units of heparin subcutaneously and sequential compression hose are placed prior to general anesthesia for deep vein thrombosis prophylaxis. Under general anesthesia, the patient is prepped and draped from the chin to the upper thighs. The ipsilateral arm may be prepped and included in the field if an immediate sentinel node biopsy or axillary node dissection is to be performed in addition to the mastectomy.

A two-team approach is used with simultaneous raising of the flap and preparation of the recipient vessels. The internal mammary artery (IMA) and vein (IMV) are used in over 90% of our cases. The thoracodorsal vessels are our second choice and are used when the internal mammaries are not available.

We approach the IMA in the second or third intercostal space. Occasionally, a large perforating artery and vein from the internal mammary vessels may be found emanating

from the second interspace and these vessels may be used as the recipients in the chest. The IMA and IMV are usually between 2.5 and 3 mm in size. Sometimes a second vein between 1.5 and 3 mm may be encountered. In the case of a narrow intercostal space a small portion of the rib cartilage above and below may be removed for better exposure and insetting of the pedicle.

When we perform a DIEP flap, the superior and inferior skin incisions are made and the superficial inferior epigastric vessels are first approached. If these are found to be of significant size and quality, they are followed down to their origin from the superficial femoral artery and an SIEA flap is performed instead. This avoids dissection of the fascia and any possible nerve injury. Often only the superficial inferior epigastric vein is present and this is dissected free for several centimeters. This can be used as a backup for the venous drainage of the flap if venous congestion is present after the anastomosis is performed in the chest. In our experience, this vein can prove invaluable in the rare case where congestion is present due to insufficient drainage through the deep system.

The abdominal skin island is carefully elevated from lateral to medial or medial to lateral based on the selected perforator from the CTA/MRA. When a large lateral perforator is selected, the flap may be based on this vessel. Additional perforators in the same row may also be dissected and included with the flap for additional perfusion. If no single dominant perforator is found two or even three smaller perforators in the same lateral or medial row may be taken to carry the flap, however this is all decided in most cases before the patient is in the operating room. In our experience, approximately 25% of flaps are based on one perforator, 50% on two perforators, and 25% on three or more perforators.[12]

Once the appropriate perforators are chosen, the anterior rectus sheath is opened around the perforators and the vessels are carefully dissected down through the rectus muscle to the deep inferior epigastric artery and vein. The muscle is spread apart in the direction of the fibers and care is taken to identify and preserve any intercostal nerves innervating the medial aspect of the muscle that might cross the pedicle. Dissection continues until the pedicle is of sufficient length, typically eight to ten cm long, and the vessels are of sufficient caliber to match the recipient vessels in the chest. It is often easier to dissect the two veins and artery free from one another before ligating them. We use methylene blue to mark the pedicle to prevent distortion and twisting when performing the anastomosis. High power loupe magnification and careful microsurgical technique are essential during this dissection.

Pure sensory nerves, which innervate the flap skin paddle, typically run with the perforators and may also be dissected free for anastomosis into divided recipient sensory nerves in the chest.

Once the recipient vessels are ready, the artery and then veins of the pedicle are ligated and the pedicle slid out from underneath any crossing intercostal nerves. The flap is then weighed and transferred to the anterior chest wall. Great care is taken to align the flap pedicle with that of the recipient vessels without any twists or kinks. While vascular problems occur rarely with these flaps, many of the venous difficulties that do occur result from a twist or a kink in the pedicle. Temporary stay sutures are placed in the flap and the operating microscope is brought into position.

Under magnification, the anterior surface of the recipient artery and vein are also labeled with a surgical marker and the larger vein is ligated distally. An anastomotic coupling device is typically used to connect the recipient and flap veins. A coupling device makes the anastomosis easier and faster and has the additional benefit of stenting the vein open after the vessels are joined. Typically, the arterial anastomosis is performed with a nylon 9-0 suture. In the case of a good size match between the flap and recipient arteries, a running suture is employed. Otherwise, interrupted 9-0 nylon sutures are usually used. After the anastomosis is complete the flap is checked for bleeding and capillary refill.

The abdominal fascia is closed and securely tied with interrupted 2-0 vicryls and a running size 0 PDS suture. Mesh or other synthetic materials are not required for the abdominal wall closure. The edges of the umbilicus are tacked down to the fascia with a 2-0 vicryl suture. The upper abdominal flap is elevated and the patient is flexed and the wound is closed in layers over two closed suction drains. Care is taken to approximate Scarpa's fascia with 2-0 interrupted vicryl sutures. As in an abdominoplasty, the umbilicus is brought out through the abdominal flap and secured in place.

The flap is typically inset with the narrower, more lateral portion of the flap placed up towards the axilla and the thicker, more medial aspect of the flap placed inferiorly and medially. The flap can be further medialized and kept from falling laterally into the axilla by suturing the superior, inferior medial, and lateral flap aspects to portions of the pectoralis major muscle. A minimal number of sutures should be considered for this as the sutures have a propensity to contribute to fat necrosis. The flap may also be folded over onto itself inferiorly to provide more natural looking inferior ptosis and fullness for the reconstructed breast. The insetting and closure are performed over a suction drain and great care is used to monitor the integrity of the pedicle at all times during the insetting. Excess skin is de-epithelialized and the flap is inset with a visible skin paddle left in place. The skin paddle allows easier postoperative monitoring for signs of venous congestion and provides tissue for the construction of a nipple at this time or at a later second stage revision.

6.1 Post-operative care

Postoperatively, the patient is observed in the recovery room for a few hours and then transferred to their private room where they will remain for the duration of their hospitalization. Postoperative pain is significantly less with the DIEP flap than with a TRAM flap reconstruction and so it is managed with oral pain medications beginning on postoperative day 1.[13] The patient's urinary catheter, IV, BP cuff, and oxygen are discontinued on day 1 and the patient begins to ambulate. She is discharged home on postoperative day 3 or 4 depending on her recovery.

A second stage revision and nipple creation are performed in the operating room between 8 and 12 weeks after the initial surgery to further refine and finish the appearance of the breast. We often use fat grafting to fill in any defects and to increase the volume of a flap if it initially falls short in volume. Any revisions at the donor site, such as dog-ear removal or liposuction, are also performed at this time.

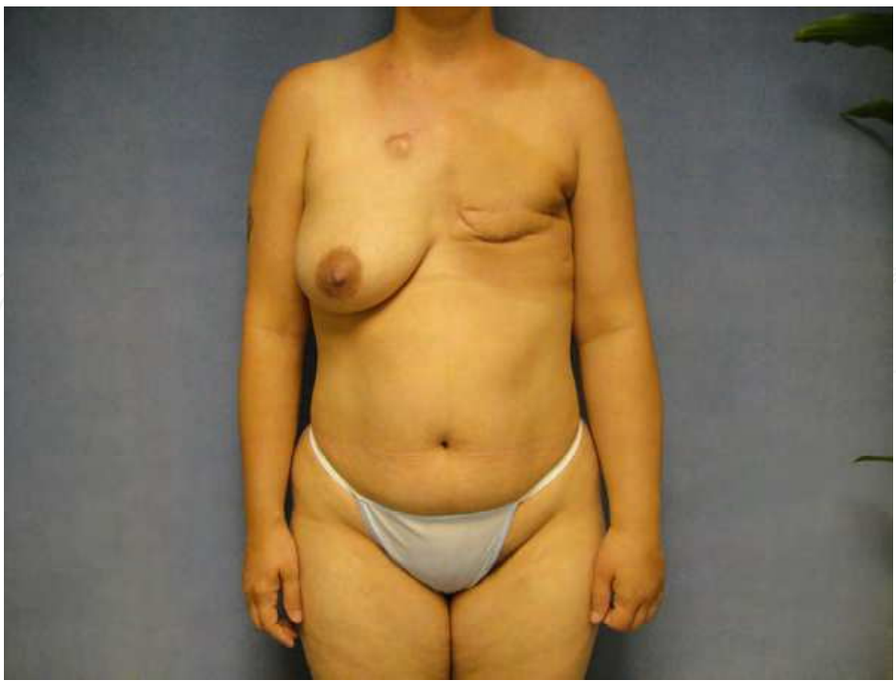


Fig. 1a. 38 year old female with a history of left breast cancer, s/p left mastectomy.

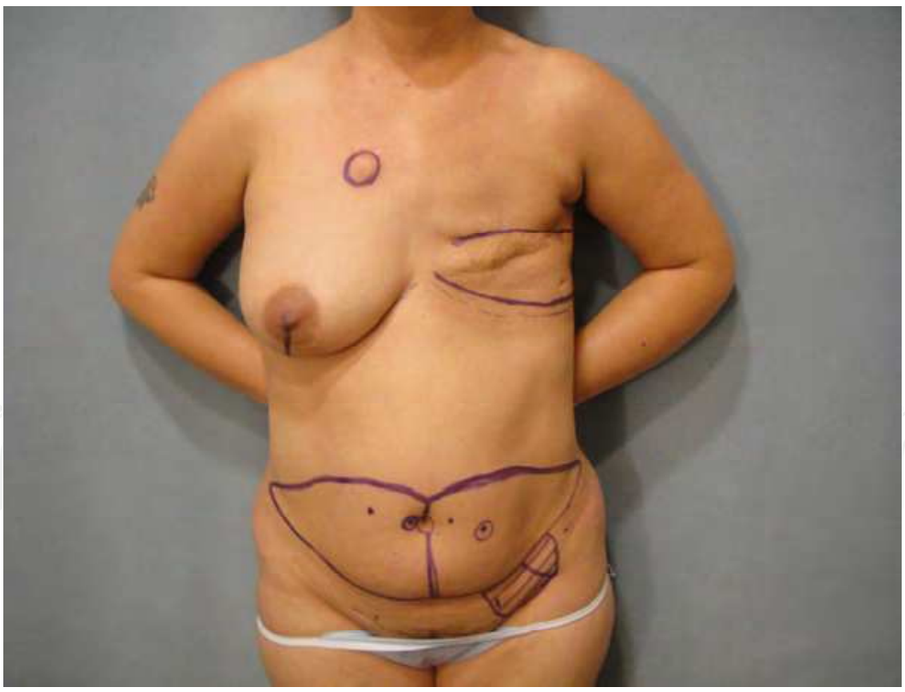


Fig. 1b. Pre-operative markings for the Bilateral DIEP with vascularized lymph node transfer. The right breast will undergo a nipple sparing mastectomy with DIEP, the left breast will have a DIEP with lymph nodes harvested from the groin and placed into the axilla for left arm lymphedema. The marks on the abdomen circled, are the perforators chosen for surgery.

Fig. 1c. Ten months post-operative.

6.2 Complications

Complications are infrequent. In a 10-year retrospective review of 758 DIEP flaps by our unit, 6% of patients returned to the operating room for flap related problems. Partial flap loss occurred in 2.5% while total flap loss occurred in less than 1% of all cases. Problems with the vein or venous anastomosis were almost 8 times more likely than problems with the artery or arterial anastomosis. Fat necrosis appeared in 13% of flaps. Seroma formation at the abdominal donor site occurred in approximately 5% of cases and abdominal hernia occurred in 0.7% of cases.[12]

7. Pearls

Pre-operative CT/MRA and reviewing with the radiologist the location of the perforator on an X/Y axis will decrease intra-operative time by at least an hour. Things to note are the intramuscular course, the type of branching pattern of the deep inferior epigastric artery, and where the perforator enters the main branch. Even though one large perforator is all that is needed to carry the vascular supply of the flap, a back up is necessary when choosing the perforators. The SIEA system is important because often when the deep inferior epigrastric perforators are small, less than 2 mm, the dominant supply to the flap is the SIEA system. Have the radiologist give you the coordinates and size of these vessels.

When beginning the dissection, beveling above the incision line is necessary in the thin person to obtain appropriate volume. Avoid midline beveling since this will decrease the vascularity of this region and when the abdomen is closed the tension can lead to an open wound.

Fig. 2a. 55 year old woman, undergoing bilateral nipple sparing mastectomies with immediate reconstruction with B DIEP.

Fig. 2b. Post-operative B DIEP-2 months.

Find the medial vein immediately when dissecting the lower limits of your dissection. This is your lifeboat if the flap is congested. A length of 6 cm is usually adequate. The perforator can be approached either medially or laterally. If done medially the lateral row can be preserved and may be evaluated later if a problem arises. Often the surgeon should already know the anatomy based on the CT/MRA, however inspection is the final course.

Once the perforator is identified, use only Westcott or similar scissors when dissecting through the fascia because using the bipolar may transmit heat and injure the small vessels. This is the most critical part of the dissection, go slow!

Once through the fascia, the bipolar can be used for ligations of small vessels but be careful not to tug on the vessels, just cauterize them and then ligate them with microscissors. Ligature clips should be used for medium or large vessels.

Always be gentle when holding the vessel; try not to manipulate the vessel directly but rather grab surrounding adventitia if possible. If your vessel goes into spasm use papervine and wait a few minutes before proceeding.

Always use the Doppler to check the vessel patency; this will help you localize the problem if you think you are in trouble.

If you encounter bleeding on the perforator, apply pressure with a moist gauze pad. Using the bipolar will transmit heat and damage the vessel.

Once in the main vessel, dissect for a total of 6 cm to give yourself enough room to position the flap on the chest wall for the anastomosis. Often times, it is easier to skeletonize the two veins and artery in-situ. The lateral vein should be clipped and the artery and medial vein on the flap side should be open after ligating the pedicle. Mark the artery and vein with methylene blue. Often times after transfer the pedicle will rotate.

When ligating the IMV, mark with methylene blue to avoid twisting when placing it into the coupler. Have the blue mark anterior to make sure alignment matches.

After the anastomosis, when placing the flap into the pocket, make sure the pocket is not too tight and check to see that the pedicle is lying in a comfortable position. Some of the pectoralis may need to be scored.

When securing the flap into the pocket, make sure the defect created by removing the rib and dissecting the vessels is completely covered by the flap. This contour deficiency post-operatively is difficult to rectify and the patient will comment on it.

Use minimal sutures to secure the flap because this can cause fat necrosis and become apparent to the patient later on.

7.1 S/IGAP history

In 1975, Fujino described the superior gluteal myocutaneous flap for breast reconstruction. The myocutaneous superior gluteal artery free flap for breast reconstruction was popularized by Dr. Bill Shaw.[14-18] The main limitation of this flap is the short vascular pedicle, which frequently requires vein grafting, increasing the difficulty, complications, and the time required for this technique. Le Quang performed the first breast reconstruction with an inferior gluteal myocutaneous flap in 1978.[19]

The superior and inferior gluteal artery perforator flaps for breast reconstruction were described by our group in 1993.[20] Advantages of the gluteal artery perforator flaps versus the previous myocutaneous gluteal flaps include preservation of the gluteus maximus muscle and additional length of the pedicle, negating the use of vein grafts. Bilateral simultaneous S/IGAPS are often done by our group but require two skilled microsurgeons in order to minimize operating time and ischemia time for the flaps.[21,22] Pre-operative CT/MRI angiograms allow identification of the septocutaneous variants of the S/IGAPS for breast reconstruction.[23,24] The angiograms identify the key perforators as being musculocutaneous or septocutaneous as well as their caliber, location, and course, allowing pre-operative mapping. As with other perforator flaps, donor site morbidity is minimal and no sacrifice of muscle is required. Overall the SGAP is slightly more popular than the IGAP, but the upper buttock donor site may have a scooped out appearance. When a patient has a saddlebag deformity, the IGAP is a good choice because of an improved donor site contour and a hidden scar, which lays in the crease.[20,25,26] These techniques can be difficult and complicated.

7.2 Patient selection

Some patients have more skin and fat in the gluteal region than the abdominal area. In this subset of patients, a gluteal artery perforator (GAP) flap may be used as a first choice for breast reconstruction.

Most women who have undergone or will undergo mastectomies and wish to be reconstructed with autologous tissue are potential candidates for SGAP/IGAP flaps. If the abdomen cannot be used as a donor site either due to previous abdominoplasty, liposuction, or the presence of multiple surgical scars, then the buttock should be considered. Also patients with excess tissue in the buttock versus the abdomen are ideal candidates. In general the buttock has a high fat to skin ratio, whereas the abdomen has a high skin to fat ratio. Patients who require mostly fat and little skin may be candidates for SGAP/IGAPS flaps. A significant amount of tissue may be harvested and, in our series, the average final inset weights of our GAP flaps were slightly greater than the weights of the mastectomy specimens removed.

Absolute contraindications specific to SGAP/IGAP flap breast reconstruction include previous liposuction at the donor site or active smoking within 1 month prior to surgery. Liposuction of the upper buttock is rare and so it doesn't often affect harvesting of the SGAP, but liposuction of the saddlebag area can affect the IGAP flap volume and circulation.

7.3 Anatomy

The superior gluteal artery is a continuation of the posterior division of the internal iliac artery. The artery has a limited length, which runs dorsally between the lumbosacral trunk and the first sacral nerve. It exits from the pelvis above the upper border of the piriformis muscle, where it quickly divides into both a superficial and deep branch. The deep branch travels between the iliac bone and gluteus medius muscle. The superficial branch continues to give off contributions to the upper portion of the gluteus muscle and overlying fat and skin. Anatomic location is planned when the femur is slightly flexed and

rotated inward; a line is drawn from the posterior superior iliac spine to the posterior superior angle of the greater trochanter. The point of entrance of the superior gluteal artery from the upper part of the greater sciatic foramen corresponds to the junction of the upper and middle thirds of this line. Perforating vessels are found off of the superior branch of the superior gluteal artery.[27,28] Pre-operatively CTA or MRA has greatly impacted planning of this procedure.

The inferior gluteal artery is a terminal branch of the anterior division of the internal iliac artery and exits the pelvis through the greater sciatic foramen.[29,30] A line is drawn from the posterior superior iliac spine to the outer part of the ischial tuberosity; the junction of its lower with its middle third marks the point of emergence of the inferior gluteal and its surrounding vessels from the lower part of the greater sciatic foramen. The artery accompanies the greater sciatic nerve, internal pudendal vessels, and the posterior femoral cutaneous nerve. In this sub-fascial recess, the inferior gluteal vein will receive tributaries from other pelvic veins. The inferior gluteal vasculature continues towards the surface by perforating the sacral fascia. It exits the pelvis caudal to the piriformis muscle. Once under the inferior portion of the gluteus maximus, perforating vessels are seen branching out through the substance of the muscle to feed the overlying skin and fat. The course of the inferior gluteal artery perforating vessels are more oblique through the gluteus maximus muscle than the course of the superior gluteal artery perforators, which tend to travel more directly to the superficial tissue up through the muscle. Thus, the length of the inferior gluteal artery perforator and the resultant pedicle length for the IGAP flap is 7-10cm while the SGAP pedicle is 5-8 cm in length. Because the skin island is placed inferior to the origin of the inferior gluteal vessels, a longer pedicle is usually obtained.

The direction of the perforating vessels can be superior, lateral, or inferior. Perforating vessels that nourish the medial and inferior portions of the buttock have relatively short intramuscular lengths, between 5 to 7 centimeters, depending on the thickness of the muscle. Perforators, which nourish the lateral portions of the overlying skin paddle, are observed traveling through the muscle substance in an oblique manner 4 to 6 centimeters before turning upwards towards the skin surface. By traveling through the muscle for relatively long distances, these vessels are longer than their medially based counterparts. The perforating vessels can be separated from the underlying gluteus maximus muscle and fascia and traced down to the parent vessel, forming the basis for the inferior gluteal artery perforator flap. Between 2 to 4 perforating vessels originating from the inferior gluteal artery will be located in the lower half of the gluteus maximus.[24]

After giving off perforators in the buttocks, the inferior gluteal artery descends into the thigh accompanied by the posterior femoral cutaneous nerve and follows a long course, eventually surfacing to supply the skin of the posterior thigh.[26] The branches of the inferior gluteal nerve (L5, S1-2) supply the skin of the inferior buttock. A neurosensory flap can be elevated if these nerves are preserved in the dissection of the flap.[31,32]

The superior gluteal nerve arises from the dorsal divisions of the fourth and fifth lumbar and first sacral nerves. It exits the pelvis through the greater sciatic foramen above the piriformis muscle, accompanied by the superior gluteal vessels, and divides into both superior and inferior branches. The superior and inferior branches of the nerves travel with

their corresponding arterial branches to end up in the gluteus medius, gluteus minimus, and tensor fasciae lata, respectively.

Fig. 3a. 45 year old women with BRCA positive gene. Pre-operative markings for nipple sparing mastectomies.

Fig. 3b. Pre-operative marking for the SGAP-crescent pattern. The perforator chosen is marked with the large X.

Fig. 3c. Pre-operative marking for the SGAP- crescent pattern.

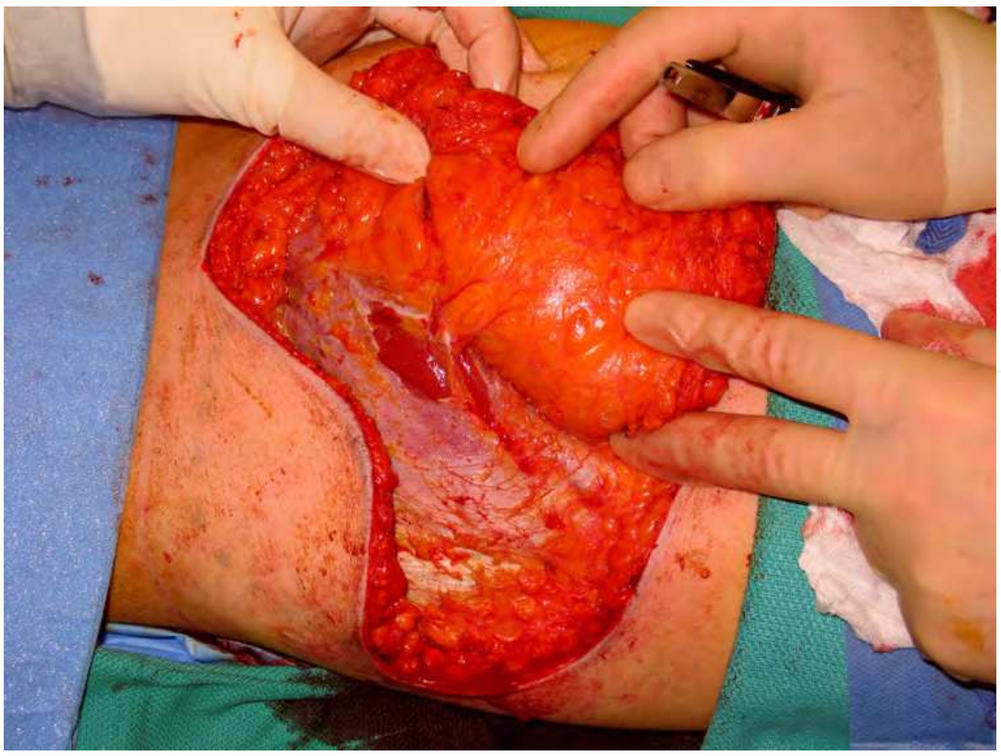


Fig. 3d. Intra-operative dissection showing the perforator.

Fig. 3e. Intra-operative dissection showing the perforator leading into the main pedicle.

Fig. 3f. Three months post-operative photo before the nipple/areola reconstruction.

Fig. 3g. Three months post-operatively.

The inferior gluteal nerve arises from the dorsal divisions of the fifth lumbar and first and second sacral nerves. It exits the pelvis through the greater sciatic foramen, below the piriformis muscle, and divides into branches that enter the deep surface of the gluteus maximus.

The posterior femoral cutaneous nerve innervates the skin of the perineum and posterior surface of the thigh and leg. It arises partly from the dorsal divisions of the first and second, and from the ventral divisions of the second and third sacral nerves, and issues from the pelvis through the greater sciatic foramen below the piriformis muscle, along with the inferior gluteal artery. It then descends beneath the gluteus maximus and the fascia lata to travel over the long head of the biceps femoris to the posterior knee. Finally, it pierces the deep fascia and accompanies the lesser saphenous vein to the middle of the posterior leg. Some terminal branches communicate with the sural nerve. All of its branches are cutaneous and distributed to the gluteal region, the perineum, and the posterior thigh and leg.

7.4 Surgical technique

The chest is marked in a sitting position. The midline and the inframammary crease on both sides are marked to be at the same level. If a patient is undergoing immediate breast reconstruction, skin markings are drawn on the breast, which include marks for the mastectomy as well as marking of the inframammary fold. In patients who are undergoing a nipple-sparring mastectomy vertical, lateral, or an inframammary incision is marked.

For unilateral SGAP flap markings, the patient is placed in a lateral decubitus position. Pre-operative CT or MR angiography along with the hand held Doppler probe are used to locate perforating vessels from the superior gluteal artery. These are usually located approximately one third of the distance on a line from the posterior superior iliac crest to the greater trochanter. Additional perforators may be found slightly more lateral from above. It should be noted that more laterally located perforators produce longer pedicles thus allowing for easier anastomosis. Septocutaneous perforators are the most lateral and course between the gluteal maximus and medius. The skin paddle is marked in an oblique pattern from inferior medial to superior lateral that includes these perforators. On average, the flap height and length is 7-10 cm and 18-24 cm, respectively. For bilateral SGAP planning, the patient is marked in the prone position.

For the IGAP flap, the gluteal fold is noted with the patient in a standing position. The inferior limit of the flap is marked 1 cm inferior and parallel to the gluteal fold. CT or MRA and the hand held Doppler probe are used to locate perforating vessels from the inferior gluteal artery. An ellipse is drawn for the skin paddle to include these perforators, which roughly parallels the gluteal fold with dimensions of approximately 7 x 18 cm. To include the "saddle bag" deformity, the skin pattern is shifted more laterally. This prevents harvesting of the fat pad over the ischial tuberosity just medial to the gluteus maximus muscle in order to prevent discomfort with sitting.

For unilateral procedures the patient is placed in the lateral decubitus position and a two-team approach is used. The recipient vessels are prepared, while the SGAP/IGAP flap is harvested. For breast reconstruction, the internal mammary vessels or internal mammary perforators are preferred for anastomosis to the superior or inferior gluteal vessels allowing easier medialization of the flap when it is inset. Often we need to remove some rib cartilage

in order to gain length necessary to perform the anastomosis. The IGAP flap often has a long enough pedicle to reach the thoracodorsal vessels, however the SGAP may be challenging due to a shorter pedicle length. For bilateral simultaneous GAP flap reconstruction the procedure is started supine. After mastectomy and recipient vessel preparation the patient is repositioned prone for flap harvest. Then the patient is returned to the supine position for anastomosis and insetting.

The skin incisions are made and dissection down to the gluteus maximus is performed circumferentially. Beveling is performed as needed, particularly lateral to the muscle in the superior and inferior direction to harvest enough tissue for width and volume to create a natural breast shape. The flap is elevated from the muscle in the subfascial plane and the perforators approached beginning from lateral to medial or medial to lateral. It is preferred to use a single large perforator, if present, but two perforators in the same plane and direction of the gluteus maximus muscle fibers can be taken together as well. The muscle is then spread in the direction of the muscle fibers and the perforators are followed through the muscle. The dissection continues until both the artery and the vein are of sufficient size to be anastomosed to the recipient vessels in the chest. Usually, the artery is the limiting factor in this dissection. The arterial perforator is visualized and preserved as it enters the main ascending superior gluteal artery or the descending inferior gluteal artery. The preferable artery and vein diameter for anastomosis is 2.0-2.5 mm and 3.0-4.0 mm, respectively. When using the internal mammary vein (IMV) perforators as recipients a shorter pedicle and smaller artery will suffice thereby simplifying flap harvest.

When the recipient vessels are ready, the gluteal artery and vein are divided and the flap is weighed. The skin and fat overlying the gluteus maximus muscle and posterior thigh with the IGAP are elevated superiorly and inferiorly to allow layered approximation of the fat of the donor site to prevent a contour deformity. The donor site is closed in several layers over a suction drain. Adding permanent removable skin sutures increases the strength of the skin closure.

The anastomosis is performed to the recipient vessels under the operating microscope. The flap is inset over a suction drain into the breast pocket with care taken not to twist or kink the pedicle. To create a spherical flap the ends of the ellipse are excised or approximated. The flap may be inset horizontally, vertically, or obliquely depending on the situation.

7.5 Postoperative care

Our patients have a one to two hour stay in the recovery room and then are transferred to their private room with monitoring of the flap circulation every two hours through the night and then every four hours starting on post-operative day one. The ICU is not necessarily needed although in institutions where experienced nursing staff is not available, it may be considered. Patients typically go home on the third or fourth postoperative day. The donor site drain usually remains for a minimum of ten days and is then removed once it is draining less than 40 cc in a twenty-four hour period. Breast drains are usually removed on post-operative day three.

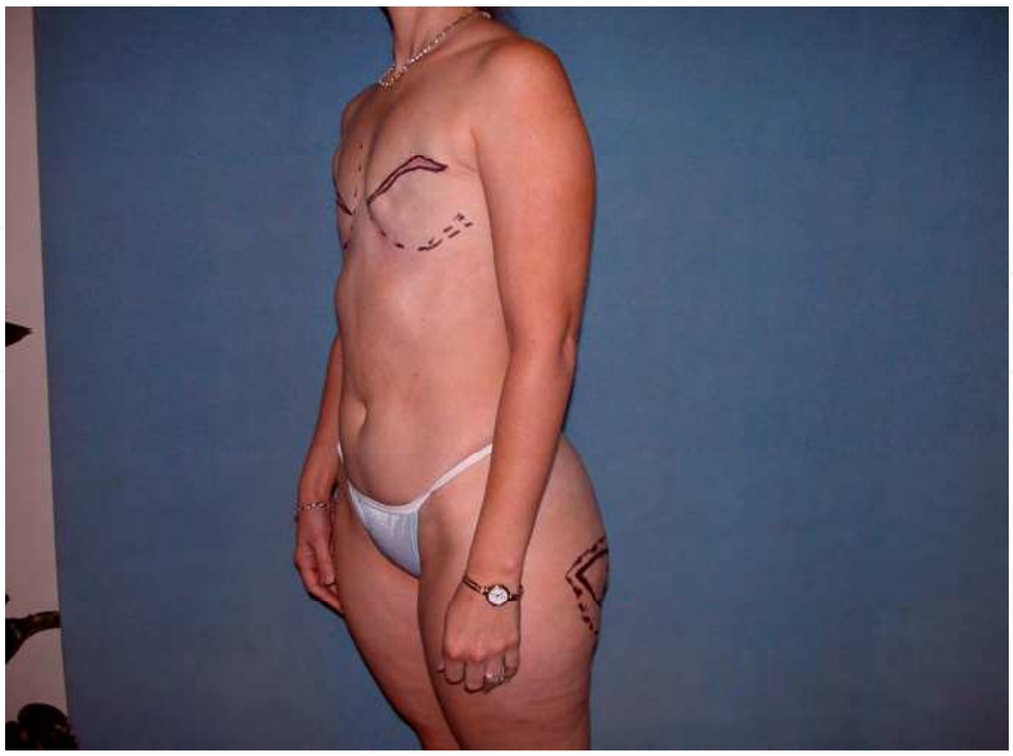


Fig. 4a. Pre-op IGAP markings

Fig. 4b. Ten months post-operatively from B IGAPS.

Fig. 4c. IGAP pre-op markings.

7.6 Complications

In a review of 492 GAP flaps performed by our unit for breast reconstruction, the incidence of complications was low. The overall take-back rate for vascular complications was 6%. More commonly there was a venous problem, accounting for 4% with arterial issues only occurring 2% of the time. The total flap failure rate was approximately 2%. Donor site seromas requiring aspiration occurred in 15% of patients. Approximately 20% of patients required revision of the donor site at the second stage of breast reconstruction.[19,21]

The most common reason for donor site revision in a SGAP patient is contour deformity of the upper buttock. The most common revision for the donor site in an IGAP patient is contouring of the lateral trochanteric fat with liposuction. Dog-ear revisions are often done at the time of second stage breast reconstruction in both S/IGAP patients. Recipient site complications include a fat necrosis rate of 8% in both S/IGAP flaps requiring revision. Breast flap contour asymmetry requires fat grafting or revision in approximately 10% of our cases.

Fig. 4d. Three months status post-operative IGAP

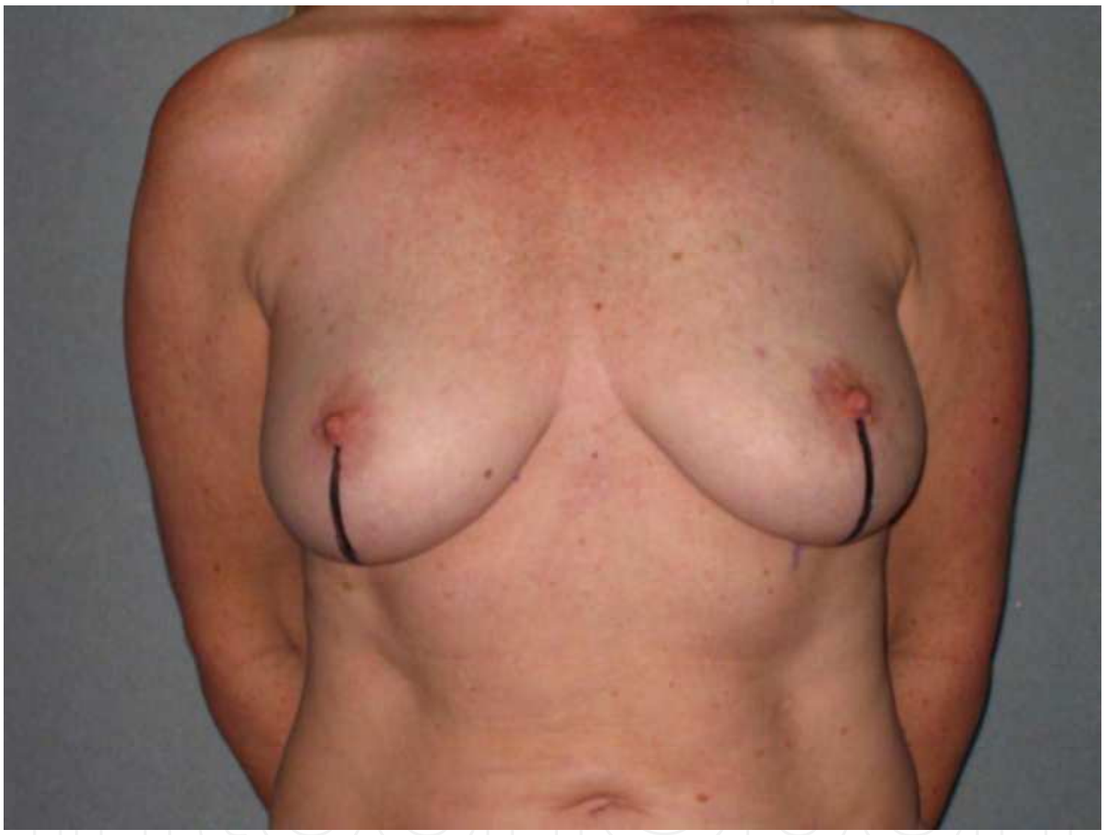


Fig. 5a. Pre-operative markings form nipple sparing with IGAP breast reconstruction.

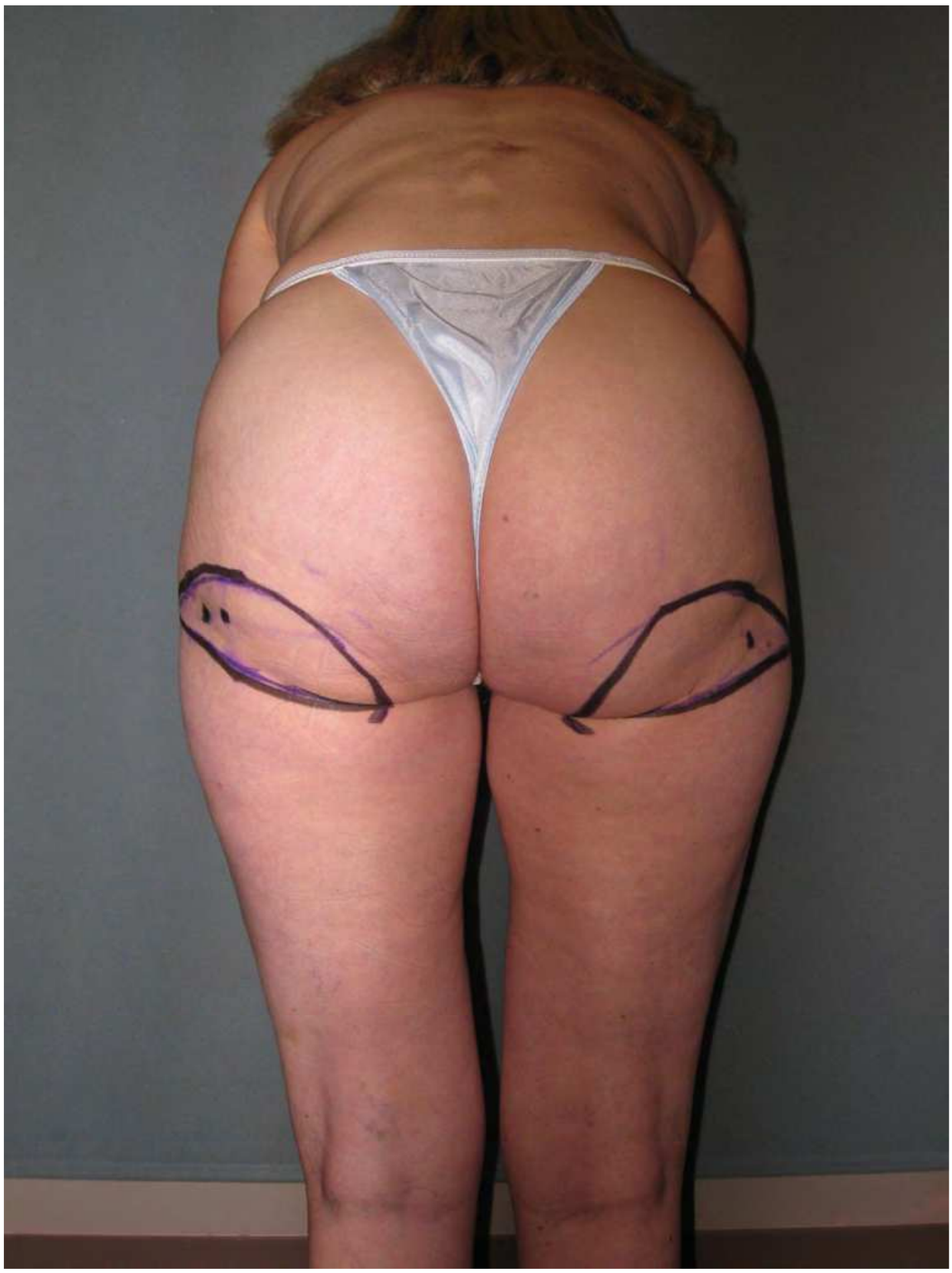


Fig. 5b. Pre-operative markings for B IGAPS. The dots are the selected perforators for surgery.

Fig. 5c. Three months post-operative from B IGAPS.

Fig. 5d. Three months post-operative from B IGAPS.

8. Pearls

Review the DIEP pearls, many of these apply to the S/IGAP dissection.

When drawing the markings on the upper or lower buttock, 7 cm should be the width. If this is wider, closure becomes more challenging and dehiscence is a possibility.

Beveling laterally to obtain the saddlebag area is necessary but if too aggressive fat necrosis will ensue.

When obtaining the perforator go layer by layer to find the perforator in the direction of the muscle fibers. This may take some time but with your pre-operative scanning you have a map.

Once the perforator is obtained, the first part of the dissection is straightforward. The last 1 cm of the vessel is the most delicate and tedious. This is where most surgeons run into problems. There is a confluence of vessels here. The problem is finding the main vessels and ligating the ancillary ones. Bleeding is your enemy here, the vessels are often thin walled and any tugging or coarse movement will cause bleeding. This is often difficult to manage without injuring the main vessel needed for anastomosis. Be meticulous at this level.

When the vessels have tributaries, the diameter is usually enlarging. The size of the vessel needed is 2 mm for anastomosis. Once this is obtained, the vessels can be ligated.

Try to skeletonize the vessels in-situ and mark them with methylene blue to be sure of their length. In-situ, the surgeon often feels they have enough length and size but when the flap is transferred to the chest, this is not the case.

The GAP dissections can be very tricky. A single surgeon should not try to perform a bilateral case. There is a learning curve with this flap. The surgeon should assist on as many of these as possible. In our group we always have a second skilled microsurgeon for all of our flaps.

9. General pearls

Pre-operatively discuss with the anesthesiologist about not giving any vasoconstricting agents. Make sure they communicate with you if the systolic blood pressure becomes less than 100 mmHg.

When performing the arterial and venous anastomosis have the blood pressure run high for the artery to remain patent.

Regardless of how well we perform the micro-anastomosis, intra-operatively about 10% will need to be re-done. If the flap shuts down more than two times, check the patient's blood pressure and redo the artery.

The first six hours after surgery is the most critical. This is when we see the most complications. If the artery or vein shuts down, the surgeon must immediately return to the OR to re-evaluate the anastomosis. Let the OR staff know about returns to the operating room during those first six hours. If the surgeons have residents or nurses that communicate

to you a problem, notify the OR staff immediately. This will save time arranging the patient's return to the OR.

If the artery has a problem intra-operatively, consider a heparin drip. We use 500-600 units an hour depending on body habitus.

Perforator flap surgery can be very challenging but very rewarding for all parties involved.

There is a learning curve so be patient. Consult with more experienced surgeons if you are encountering difficulties. Good luck!

10. References

[1] Hartrampf CR, Scheflan M, Black PW. Breast reconstruction with a transverse abdominal island flap. Plast Reconstr Surg. 1982 Feb; 69(2): 216-25.

[2] Daniel RK, Taylor GI. Distant transfer of an island flap by microvascular anastomoses. Plas Reconstr Surg 52: 111-117, 1973.

[3] Taylor GI, Daniel RK. The free flap: composite tissue transfer by vascular anastomoses. Australian & New Zealand J. Surg. 43: 1-3, 1973.

[4] Taylor GI, Daniel RK. The anatomy of several free flap donor site. Plas Reconstr Surg. 56(3): 243-253, 1975.

[5] Elliott LF, Raffel B, Wade J: Segmental latissimus dorsi free flap: clinical applications. Ann Plast Surg 1989; 23: 231 -238.

[6] Feller AM: Free TRAM. Results and abdominal wall function. Clin Plast Surg 1994; 21:223- 232.

[7] Koshima I, Moriguchi T, Soeda S, Tanaka H, Umeda N. Free thin paraumbilical perforator-based flaps. Ann Plast Surg. 1992 Jul; 29(1): 12-17.

[8] Allen, R. J., and Treece, P. Deep inferior epigastric perforator flap for breast reconstruction. Ann. Plast. Surg. 32: 32, 1994.

[9] Taylor GI, Daniel RK. The anatomy of f several free flap donor sites. Plast Reconstr Surg. 1975 Sep; 56(3): 243-53.

[10] Allen, R. Heitland, A. Autogenous Augmentation Mammaplasty with Microsurgical Tissue Transfer. Plast Reconstr Surg. 112(1): 91-100, July 2003.

[11] Rogers, N. Allen, R. Radiation Effects on Breast Reconstruction with the Deep Inferior Epigastric Perforator Flap. Plast Reconstr Surg. 109(6): 1919-1924, May 2002.

[12] Gill, P. Hunt, J. Guerra, A. et al. A 10-Year Retrospective Review of 758 DIEP Flaps for Breast Reconstruction. Plast Reconstr Surg. 113(4): 1153-1160, April 1, 2004.

[13] Kroll, S. Sharma, S. Koutz, C. et al. Postoperative morphine requirements of free TRAM and DIEP flaps. Plas Reconstr Surg. 107:338, 2001.

[14] Shaw WW. Breast reconstruction by superior gluteal microvascular free flaps without silicone implants. Plast Reconstr Surg. 1983 Oct; 72(4): 490-501.

[15] Shaw, WW: Microvascular free flap breast reconstruction. Clin. Plast. Surg. 11:333, 1984.

[16] Shaw, WW: Superior Gluteal free flap breast reconstruction. Clin. Plast. Surg. 25:267, 1998.

[17] Codner, MA, Nahai F. The Gluteal artery free flap breast reconstruction: making it work. Clin. Plast. Surg. 24:289, 1994.

[18] Fujino T, Harashina T, Aoyagi F. Reconstruction for aplasia of the breast and pectoral region by microvascular transfer of a free flap from the buttock. Plast Reconstr Surg.1975;56:178-181.

[19] Le-Quang C. Secondary microsurgical reconstruction of the breast and free inferior gluteal flap. Ann Chir Plast Esthet. 1992 Dec;37(6):723-41.

[20] Allen RJ, Tucker C Jr. Superior gluteal artery perforator free flap for breast reconstruction. Plast Reconstr Surg. 1995 Jun;95(7):1207-12.

[21] Guerra AB, Soueid N, Metzinger SE, Levine J, Bidros RS, Erhard H, Allen RJ. Simultaneous bilateral breast reconstruction with superior gluteal artery perforator (SGAP) flaps. Ann Plast Surg. 2004 Oct;53(4):305-10.

[22] DellaCroce FJ, Sullivan SK. Application and refinement of the superior gluteal artery perforator free flap for bilateral simultaneous breast reconstruction. Plast Reconstr Surg. 2005 Jul;116(1):97-103; discussion 104-5.

[23] Vasile JV, Newman T, Rusch DG, Greenspun DT, Allen RJ, Prince M, Levine JL. Anatomic imaging of gluteal perforator flaps without ionizing radiation: seeing is believing with magnetic resonance angiography. J Reconstr Microsurg. 2010 Jan;26(1):45-57.

[24] Tuinder S, Van Der Hulst R, Lataster A, Boeckx W. Superior gluteal artery perforator flap based on septal perforators: preliminary study. Plast Reconstr Surg. 2008 Nov;122(5):146e-148e.

[25] Allen RJ, Levine, JL, Granzow JW. The in-the-crease inferior gluteal artery perforator flap for breast reconstruction. Plast Reconstr Surg 2006 Aug;118(2):333-9.

[26] Granzow JW, Levine JL Chiu ES, Allen RJ. Breast reconstruction with gluteal artery perforator flaps. J Plast Reconstr Aesthet Surg. 2006;59(6):571-9.

[27] Guerra, A. Metzinger, S. Bidros, R. Gill, et al. Breast reconstruction with gluteal artery perforator (GAP) flaps: a critical analysis of 142 cases. Ann Plast Surg. 2004 Feb;52(2):118-25.

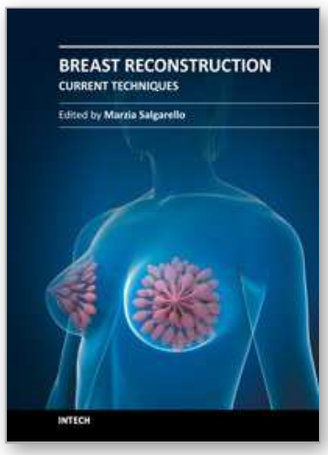
[28] Strauch B, Yu HL. Gluteal Region. In Strauch B., Yu H.L. Atlas of Microvascular Surgery: Anatomy and Operative Approaches. New York: Thieme Medical Publishers; 1993, pp102-119.

[29] Ao M, Mae O, Namba Y., and Asagoe, K. Perforator-based flap for coverage of lumbosacral defects. Plast. Reconstr. Surg. 101: 987, 1998.

[30] Roche NA, Van Landuyt K, Blondeel PN, Matton G, and Monstrey S J. The use of pedicled perforator flaps for reconstruction of lumbosacral defects. Ann. Plast. Surg. 45: 7, 2000.

[31] Koshima I., Moriguchi T, Soeda S, Kawata S, Ohta S, Ikeda A. The gluteal perforator-based flap for repair of sacral pressure sores. Plast Reconstr Surg. 91: 678-683, 1993.

[32] Windhofer C., Brenner E., Moriggl B., Papp C. Relationship between the descending branch of the inferior gluteal artery and the posterior femoral cutaneous nerve applicable to flap surgery. Surg Radiol Anat. 24(5): 253-7, 2002.



Breast Reconstruction - Current Techniques

Edited by Prof. Marzia Salgarello

ISBN 978-953-307-982-0
Hard cover, 276 pages
Publisher InTech
Published online 03, February, 2012
Published in print edition February, 2012

Breast reconstruction is a fascinating and complex field which combines reconstructive and aesthetic principles in the search for the best results possible. The goal of breast reconstruction is to restore the appearance of the breast and to improve a woman's psychological health after cancer treatment. Successful breast reconstruction requires a clear understanding of reconstructive operative techniques and a thorough knowledge of breast aesthetic principles. Edited by Marzia Salgarello, and including contributions from respected reconstructive breast plastic surgeons from around the world, this book focuses on the main current techniques in breast reconstruction and also gives some insight into specific topics. The text consists of five sections, of which the first focuses on the oncologic aspect of breast reconstruction. Section two covers prosthetic breast reconstruction, section three is dedicated to autogenous breast reconstruction, and section four analyzes breast reconstruction with a fat graft. Finally, section five covers the current approaches to breast reshaping after conservative treatment.

How to reference

In order to correctly reference this scholarly work, feel free to copy and paste the following:

Maria M. LoTempio, Grace Lucta Gerald and Robert J. Allen (2012). Breast Reconstruction with DIEP and S/IGAP, Breast Reconstruction - Current Techniques, Prof. Marzia Salgarello (Ed.), ISBN: 978-953-307-982-0, InTech, Available from: http://www.intechopen.com/books/breast-reconstruction-current-techniques/breast-reconstruction-with-free-flap

INTECH
open science | open minds

InTech Europe
University Campus STeP Ri
Slavka Krautzeka 83/A
51000 Rijeka, Croatia
Phone: +385 (51) 770 447
Fax: +385 (51) 686 166
www.intechopen.com

InTech China
Unit 405, Office Block, Hotel Equatorial Shanghai
No.65, Yan An Road (West), Shanghai, 200040, China
中国上海市延安西路65号上海国际贵都大饭店办公楼405单元
Phone: +86-21-62489820
Fax: +86-21-62489821

IntechOpen