

37 Rectus Abdominis Muscle Flaps

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◆ Classification

- Mathes-Nahai type III

◆ Vascular Pedicle

The rectus abdominis muscle is supplied by two dominant pedicles, which are the superior epigastric artery and the deep inferior epigastric artery (**Fig. 37.1**). The superior epigastric vessel supplies the proximally based pedicled transposition flaps whereas

the deep inferior epigastric supplies the inferiorly pedicled rectus flaps or the free muscle flaps. The 7th to 12th intercostal arteries are minor pedicles that supply the flap via a segmental distribution. The perfusion from these minor pedicles is not adequate enough to perfuse the flap reliably for transfer.

The deep inferior epigastric artery is the dominant inferior pedicle and also the larger of the two dominant pedicles. Free tissue transfer of the rectus muscle flap should be based on this pedicle.

- Mean arterial caliber: 1.5 to 2.5 mm. The deep inferior epigastric artery branches from the anteromedial aspect of the external iliac artery.

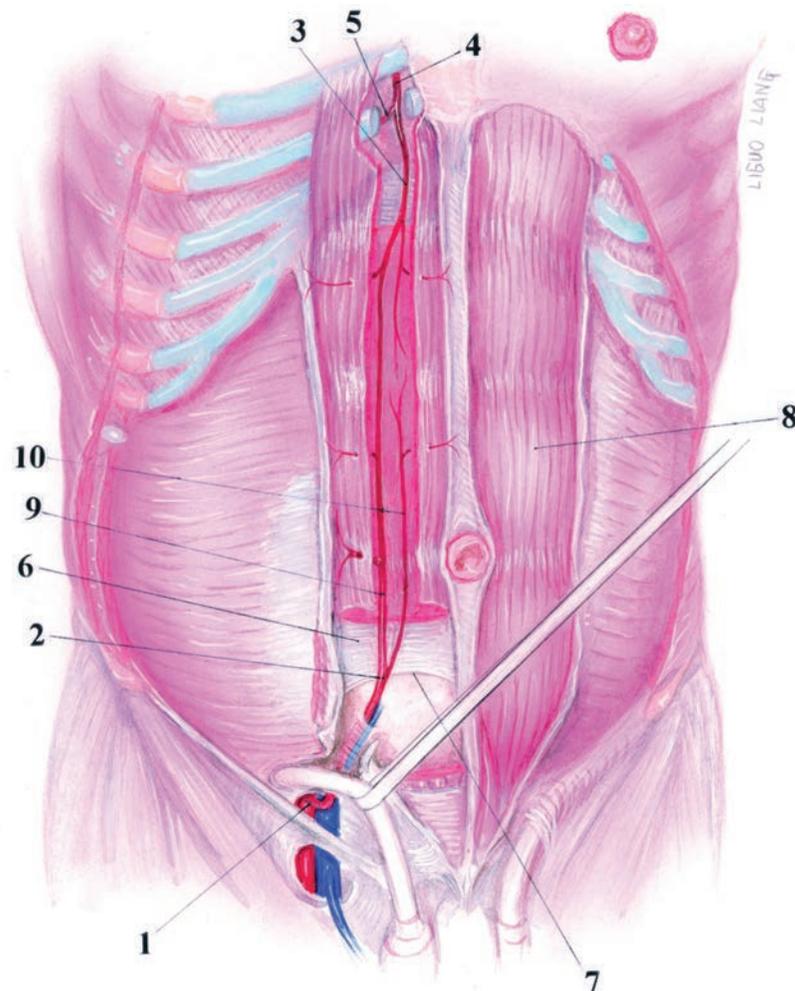


Fig. 37.1 Blood supply to the rectus abdominis muscle. The rectus abdominis muscle is supplied by the superior epigastric artery and the deep inferior epigastric artery. The deep inferior epigastric artery is the dominant blood supply to the flap. 1, External iliac artery; 2, deep inferior epigastric artery (DIEA); 3, superior epigastric artery; 4, internal mammary artery; 5, musculophrenic artery; 6, posterior sheath of rectus; 7, arcuate line; 8, rectus abdominis muscle; 9, lateral branch of DIEA; 10, medial branch of DIEA.¹

- Mean venous caliber: 2.0 to 3.0 mm. There are normally two accompanying venae comitantes with one vein being larger. These two veins converge to form a larger vein that drains into the external iliac vein.
- Length: 7 to 12 cm, if this is traced to the origin from the external iliac artery.
- Nerve supply
 - Motor: Segmental nerves from the 7th to the 12th intercostal nerves enter the deep surface of the muscle at its mid-to lateral aspect.
 - Sensory: The lateral cutaneous nerves from the 7th to the 12th intercostal nerve also provide sensation to the skin territory of the rectus abdominis muscle.

The superior and deep inferior systems anastomose at the periumbilical area through a system of choke vessels as described by Taylor. The most common variant is the dual system (60%), followed by the single vessel (29%), and the remainder (11%) exist as multiple smaller branches.

◆ Patient Positioning

The patient is positioned in the supine position. The abdomen is exposed from the xiphoid to the pubis.

◆ Surface Markings

1. Mark the linea alba, which divides the two rectus abdominis muscles, and the linea semilunaris.
2. Mark the entire length of the rectus abdominis muscle and the tendinous intersections.

3. Mark the paramedian incision, which lies two to three fingerbreadths lateral to the linea alba (**Fig. 37.2**).

◆ Raising the Flap

Step 1: Skin Markings

A paramedian incision is planned for the harvest of the rectus abdominis flap (**Fig. 37.2**). The rectus abdominis muscle is approximately 30×10 cm, originates from the xiphoid and costal margin, and inserts into the symphysis pubis and pubic crest. It is bounded medially by the linea alba and laterally by the linea semilunaris. The pedicle (deep inferior epigastric artery) is located at the inferolateral edge of the rectus abdominis muscle.

Step 2: Skin Incision

The paramedian incision is used. The skin incision is made and deepened through dermis and subcutaneous tissue straight to the anterior rectus sheath (**Fig. 37.3**). There is minimal undermining of the subcutaneous tissue to preserve the cutaneous blood supply (**Fig. 37.4**).

Step 3: Incision of the Anterior Rectus Sheath

The anterior rectus sheath is incised vertically with the use of a diathermy with care not to cut the underlying muscle (**Fig. 37.5**), from the costal margin to as far inferiorly as required. At the tendinous intersections, dissection is slowed (**Fig. 37.6**) to minimize

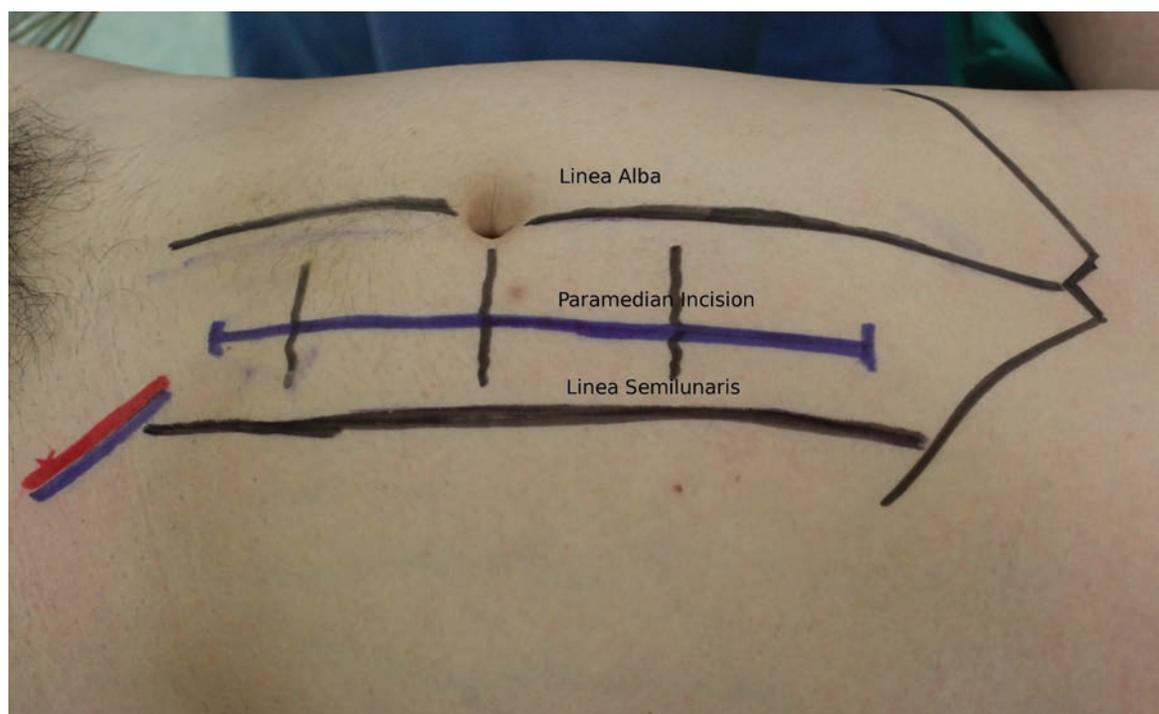


Fig. 37.2 A paramedian incision is made about two fingerbreadths lateral to the linea alba.

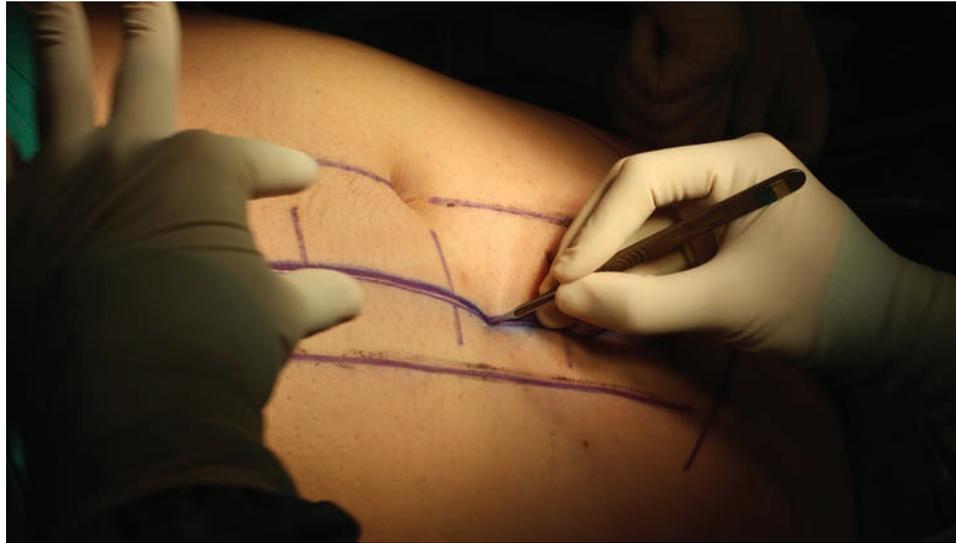


Fig. 37.3 The skin incision is made with a blade no. 15 and deepened with a monopolar diathermy.

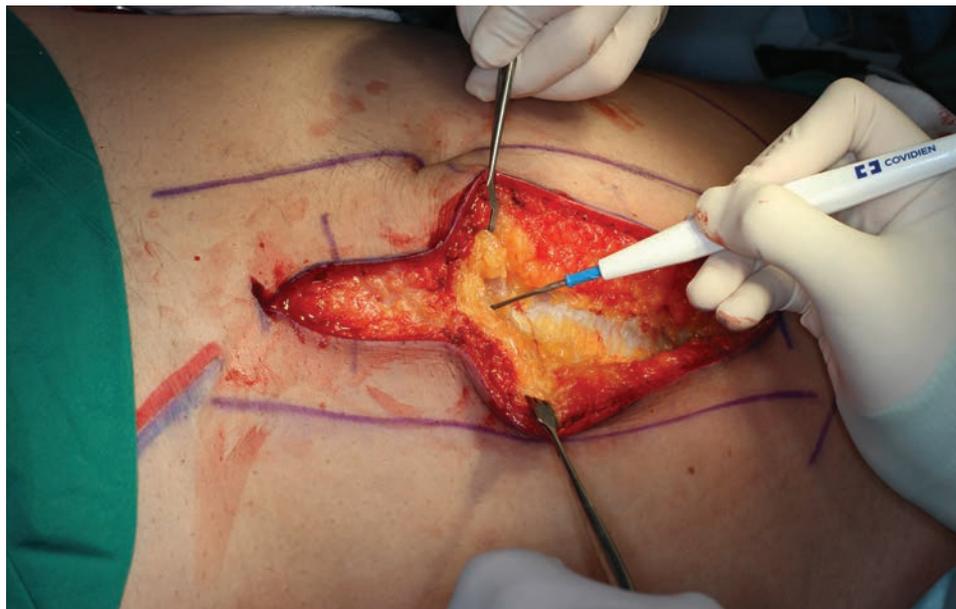


Fig. 37.4 The skin incision is deepened with a diathermy. There is minimal undermining done.

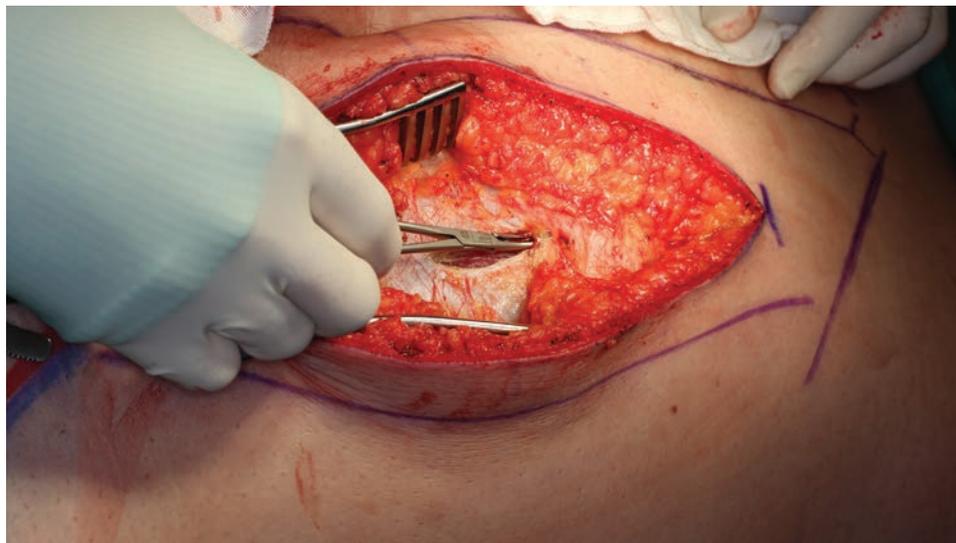


Fig. 37.5 The anterior rectus sheath is incised with care not to injure the underlying rectus abdominis muscle.

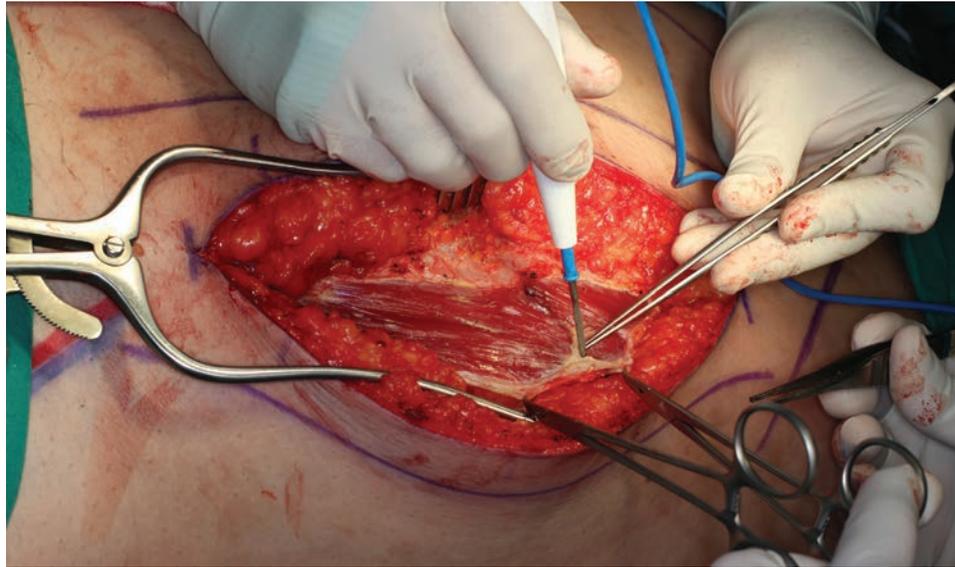


Fig. 37.6 At the tendinous intersections between the rectus abdominis muscle and the anterior rectus sheath, extra precaution is taken to separate the sheath from the muscle and to prevent injury to the pedicle which can come to lie superficially.

trauma to the rectus abdominis muscle and the epigastric vessels (which can come to lie quite superficially). The anterior rectus sheath is peeled off the rectus abdominis medially to the linea alba (**Fig. 37.7**) and laterally to the linea semilunaris. This exposes the entire width of the rectus muscle (**Fig. 37.8**). Skin perforators (*arrow*) from the DIEP are identified and ligated (**Fig. 37.9**).

Step 4: Dissection of the Muscle Off the Posterior Rectus Sheath

Once the anterior surface of the rectus muscle is exposed, the rectus muscle is undermined from its posterior sheath by blunt dissection. The underside of the rectus abdominis is peeled off

from the posterior rectus sheath with the intercostal vessels and nerves on the posterior aspect of the muscle. This is to ensure that the inferior epigastric pedicle is kept with the muscle (**Fig. 37.10**).

Step 5: Division of the Superior End of the Rectus Abdominis Muscle

Division of the proximal end of the rectus is done at the tendinous intersection to minimize bleeding (**Fig. 37.11**). Additional muscle length can be obtained by dividing the muscle more proximally at the costal origins. The cut ends of the muscle are over-sewn

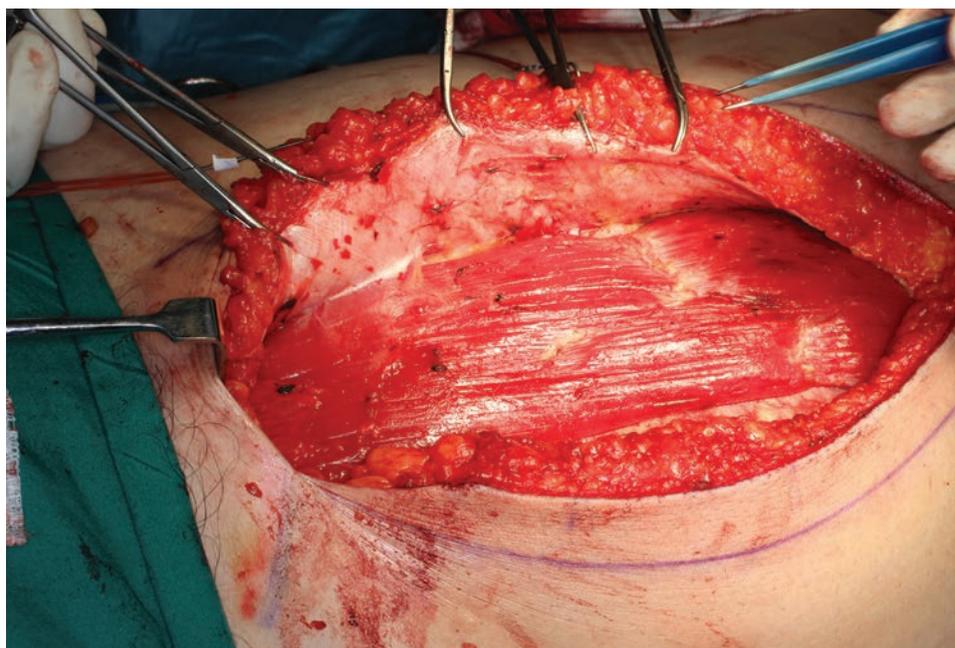


Fig. 37.7 There is a clear avascular plane between the rectus abdominis and the anterior rectus sheath.

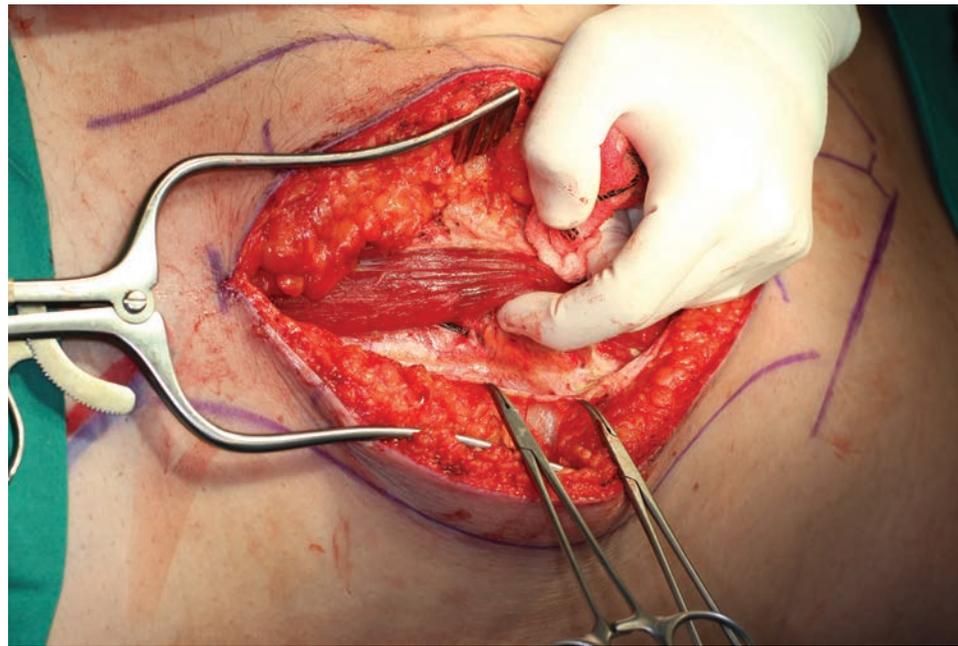


Fig. 37.8 The rectus abdominis muscle is can be lifted gently to expose the plane between the posterior rectus sheath and the underside of the muscle belly.

with Vicryl 2-0 sutures (Ethicon, Somerville, NJ) to ensure hemostasis (**Fig. 37.12**).

Step 6: Exposure of the Deep Inferior Epigastric Pedicle

The inferior epigastric pedicle lies inferior to the arcuate line and lateral to the rectus abdominis muscle. The appearance of adipose tissue, which invests the pedicle, suggests that the pedicle is close by (**Fig. 37.13**). Dissection is slowed down. Dissection through the fat pad will reveal the deep inferior epigastric pedicle. There is usually

one artery with two accompanying venae comitantes (**Fig. 37.14**). The inferior edge of the rectus abdominis muscle is detached from its insertion to the symphysis pubis and the pedicle is ligated.

Step 7: Completion of the Muscle Harvest

The harvested muscle has an in situ length of 30×10 cm but because of shrinkage after harvest, the flap unit can provide coverage for defects up to 20×8 cm. A smaller tailored muscle flap can also be harvested with just a perforator from the inferior

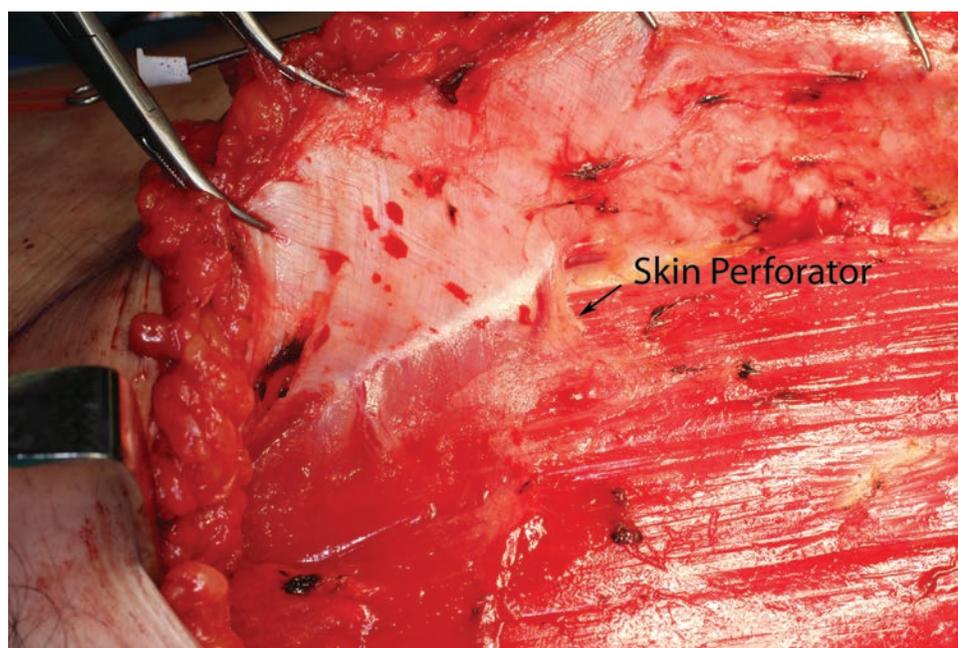


Fig. 37.9 Skin perforators from the deep inferior epigastric travel through the rectus sheath to supply the overlying skin. These perforators are ligated.

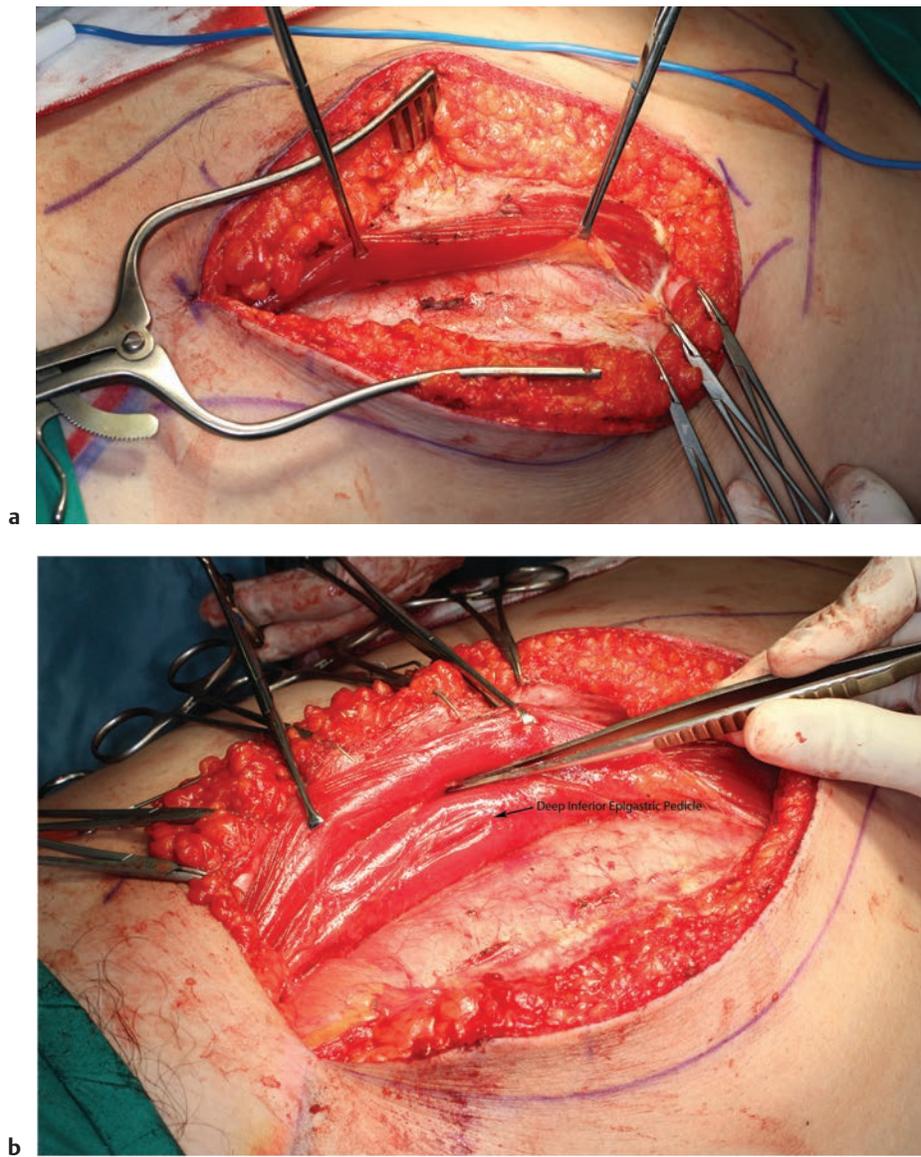


Fig. 37.10 Separation of the rectus abdominis from the posterior rectus sheath. **(a)** The intercostal vessels and nerves are elevated with the rectus muscle. This is the plane of dissection so that the branches from the deep inferior epigastric artery to the flap are preserved. **(b)** The *arrow* points to the deep inferior epigastric pedicle that traverses on the underside of the muscle flap.

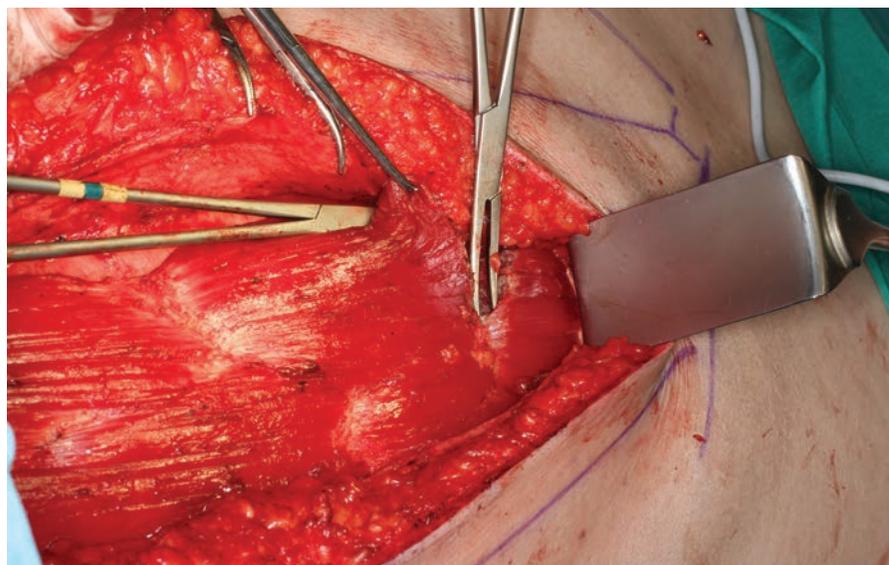
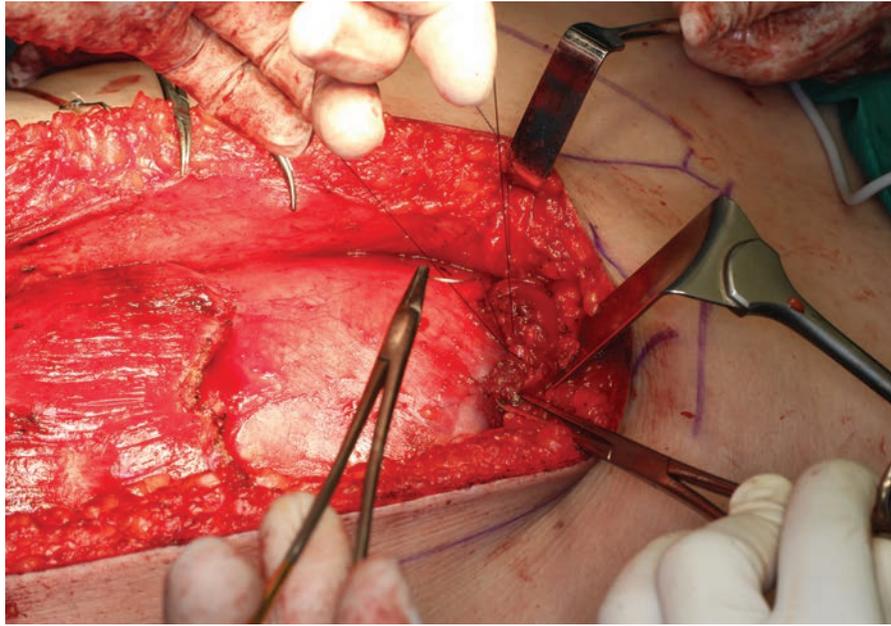
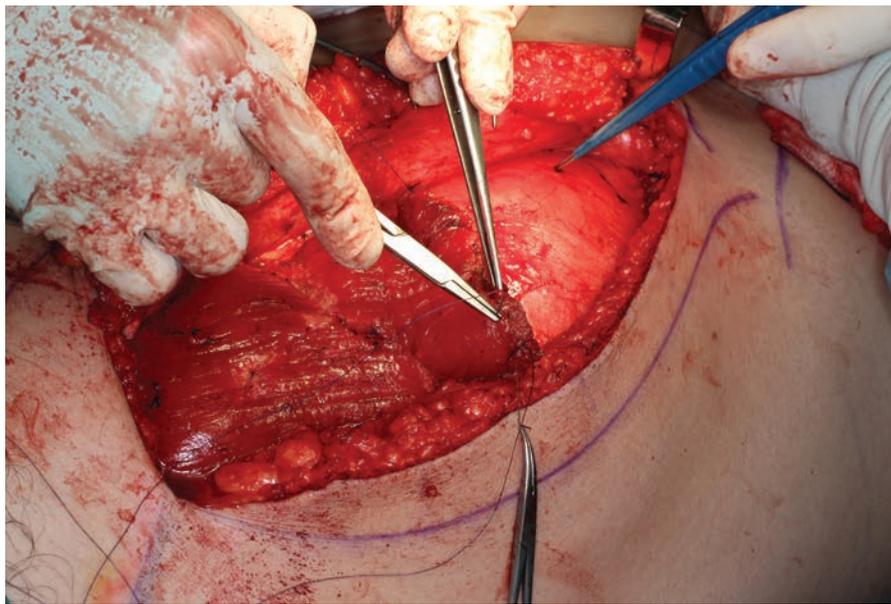


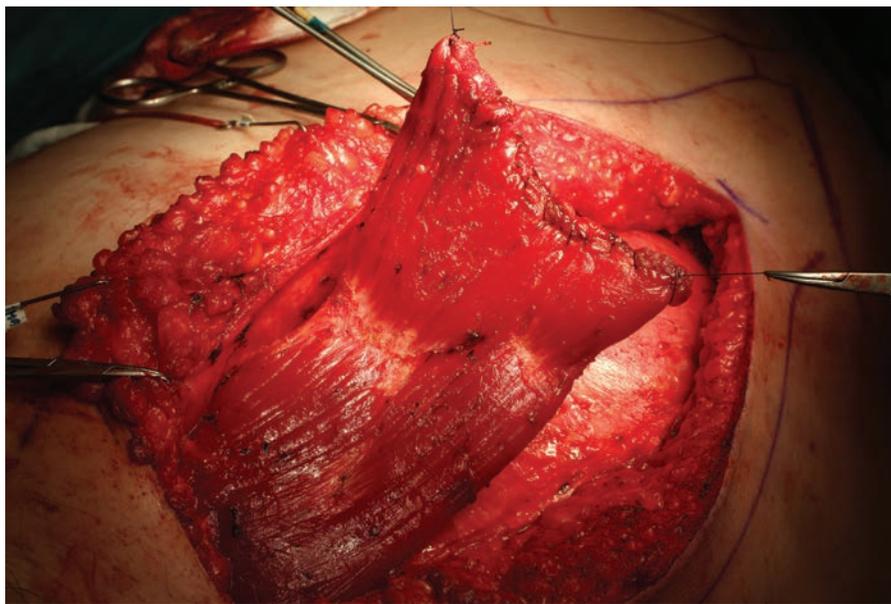
Fig. 37.11 The superior end of the muscle is divided at the tendinous intersection to minimize bleeding. Ligation of the superior epigastric artery is done.



a



b



c

Fig. 37.12 Division of the muscle. **(a)** Both ends of the cut muscle are overrun with 3-0 Vicryl as a hemostatic stitch. **(b)** Similarly, the cut edge of the flap is also overrun with Vicryl 3-0 suture. **(c)** Hemostatic running sutures reduce postoperative bleeding and provide a rigid edge for stitching.

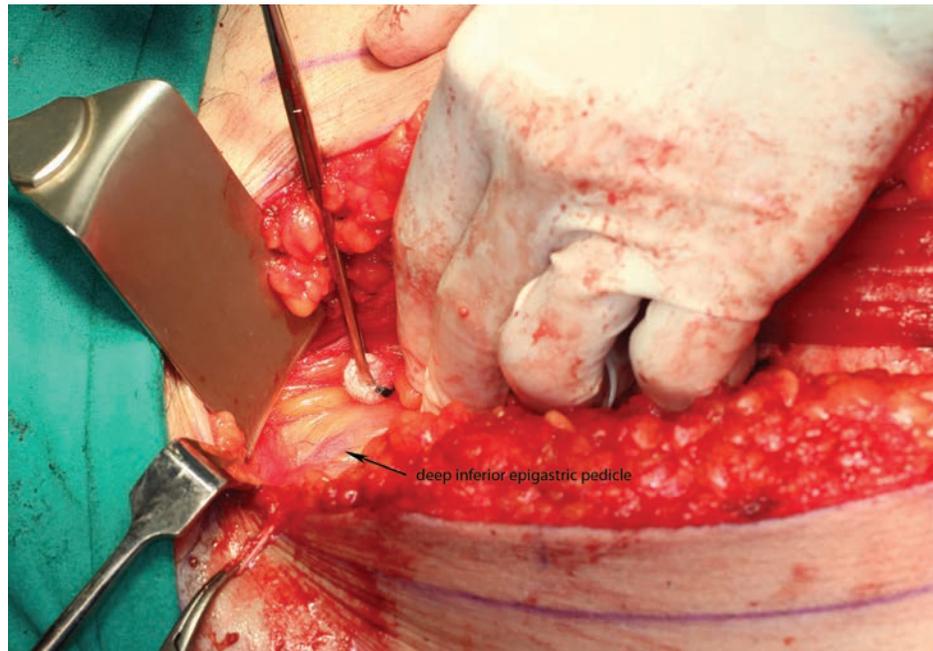


Fig. 37.13 The deep inferior epigastric pedicle is located at the inferolateral edge of the rectus muscle. It is usually invested in adipose tissue. The dissection slows down once the adipose tissue is noted.

epigastric artery. The underside of the muscle is shown here with the deep inferior epigastric pedicle running in the middle of the flap. A pedicle length of 10 cm can usually be obtained by dissecting it down to the external iliac artery (**Fig. 37.15**). There is usually a single artery (*arrow*) accompanied by two venae comitantes (*arrow*). The diameter of the artery averages 2 mm.

Step 8: Closure of the Donor Site

Closure of the anterior rectus sheath is important to prevent abdominal bulge and hernia. This is done either with interrupted Prolene 1-0 sutures (Ethicon) or with continuous Prolene

1-0 sutures. Closure is done over a Jackson-Pratt drain. Skin closure is done with Vicryl 2-0 and Vicryl 3-0 (**Fig. 37.16**).

◆ Important Anatomical Structures

Identified and raised with the flap:

- Intercostal nerves. The intercostal nerves are sacrificed with the harvest of the rectus abdominis muscle flap. These can be used to neurotize the flap to provide a functional muscle flap.

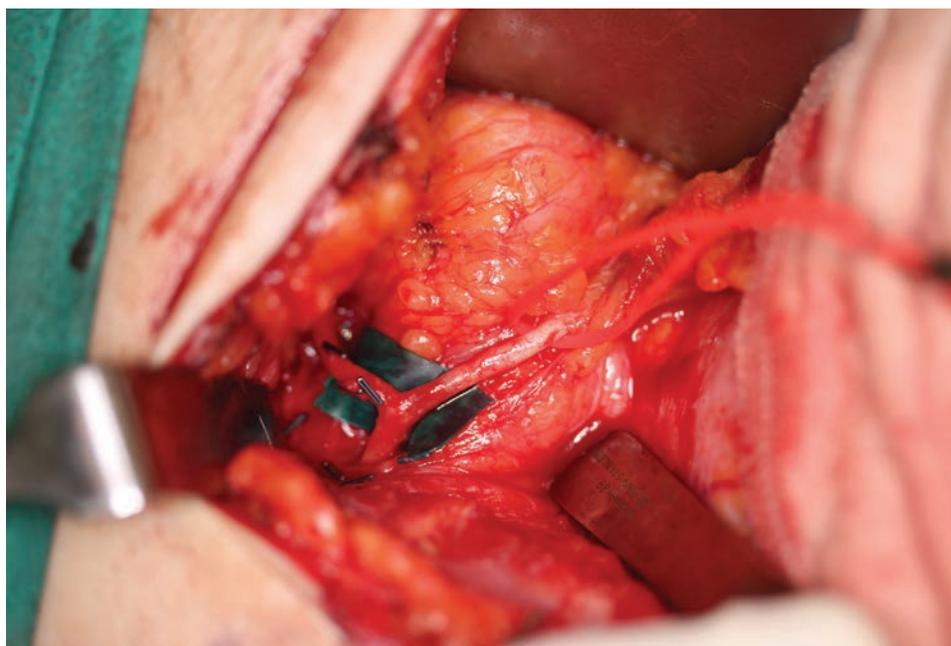
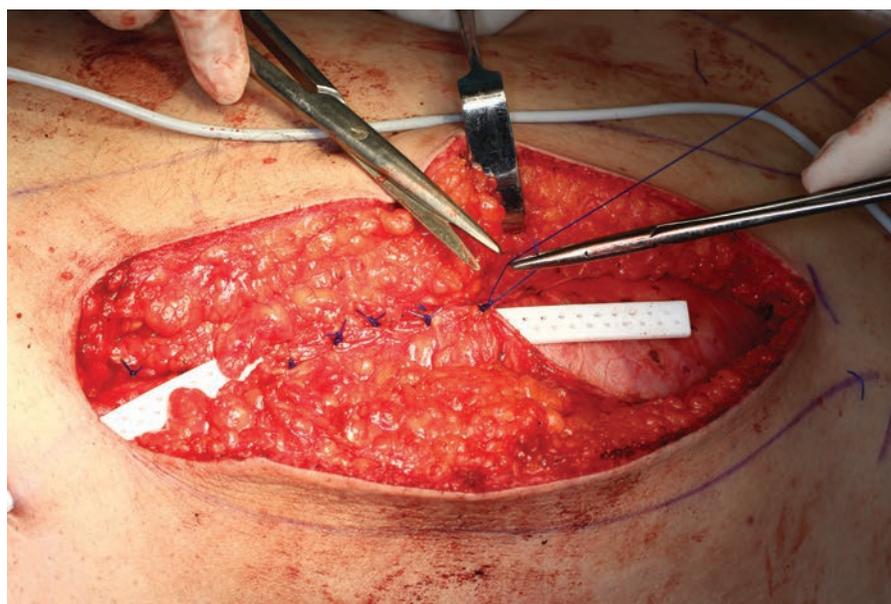


Fig. 37.14 The deep inferior epigastric pedicle can be traced until it branches from the external iliac artery. This provides a pedicle length of approximately 6 to 10 cm.



Fig. 37.15 The underside of the rectus abdominis muscle flap is shown with the deep inferior epigastric pedicle.



a



b

Fig. 37.16 Skin closure. **(a)** The anterior rectus sheath is closed securely with Prolene 1-0 and 2-0 sutures with care not to catch the posterior rectus sheath. **(b)** Skin closure is completed with Vicryl 3-0 sutures and Prolene 4-0 to the dermis.

Identified and preserved:

- Anterior rectus sheath. Minimal rectus sheath is harvested so as to allow tension-free closure of the donor site defect. Preservation of the anterior sheath particularly **above** the arcuate line will reduce incidence of bulge and abdominal hernia. A synthetic mesh or acellular dermal matrix can be used for sheath closure if there is excessive tension.
- External iliac artery. The deep inferior epigastric artery is ligated just as it branches from the external iliac artery.

◆ Clinical Perspectives

The rectus abdominis muscle flap can be raised as a pedicled flap or a free flap. As a pedicled flap for regional use, it can be employed for reconstruction of the anterior chest wall or for defects in the groin and perineal region. As a free flap, it can be used for reconstruction of head and neck and upper or lower limb defects. Modification of the flap harvest enables the use of this flap for breast reconstruction, functional muscle transfer for facial reanimation, and for vagina reconstruction.

◆ Reconstruction of Tibia Osteomyelitis with Rectus Abdominis Muscle Flap

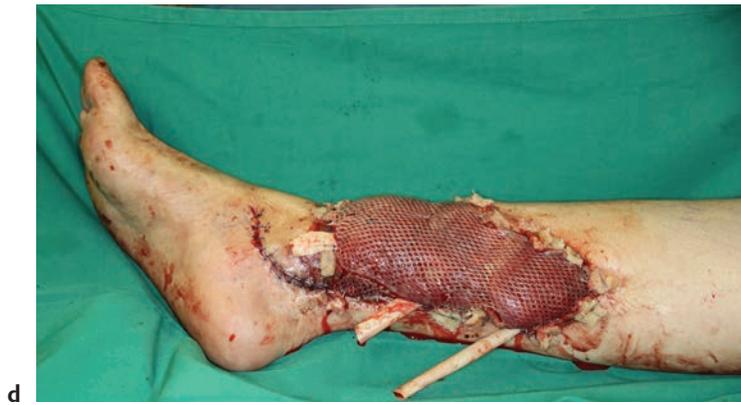
The patient is a 30-year-old man with chronic osteomyelitis affecting the distal third of the tibia (**Fig. 37.17a–c**). The surgical plan is for debridement of the infected bone and coverage with a rectus abdominis muscle flap and split skin graft. In view of the scarred limb, the plan was to explore the posterior tibia artery proximally and distally to assess the suitability for use as a recipient vessel.

Microanastomosis of the flap was completed under the operating microscope. The deep inferior epigastric artery (*arrow*) was anastomosed end-to-end to the posterior tibia artery and the venae comitantes to the respective venae comitantes of the posterior tibia artery (**Fig. 37.17d**). The flap is inset over the defect and split skin graft is laid over the muscle. Penrose drains were used.

The patient's recovery was uneventful. **Fig. 37.17e** shows the well-healed donor site and **Fig. 37.17f** shows the flap fully healed at the 6-month follow-up.



Fig. 37.17 Chronic osteomyelitis. **(a)** Chronic osteomyelitis of the right tibia has led to multiple discharging sinuses and scarring of the overlying skin. **(b)** Anterior view of the right leg. **(c)** Inset of the rectus flap: the deep inferior epigastric artery was anastomosed end-to-end to the posterior tibial artery and the venae comitantes was anastomosed end-to-end to the posterior tibial venae comitantes. (*continued*)



d



e



f

Fig. 37.17 (continued) **(d)** The rectus abdominis flap was inset over the defect with tie-over tulle-gras (TG) bolsters over Penrose drains. **(e)** The donor site scar has healed well without any bulge or herniation. The skin graft donor site over the right thigh has also epithelized. **(f)** Six months after the operation, the reconstructed limb has healed well and the patient is ambulating without assistance.

◆ Hints and Tips

1. This is one of the most versatile flaps in reconstructive microsurgery. This is due to its central location and the dual supply, which enables it to be used as a pedicled or free flap. As a pedicled flap, the rectus abdominis can reach superiorly up to the upper manubrium to reconstruct sternal defects and inferiorly to reconstruct proximal thigh or groin defects, as well as the pelvis, vagina, and perineum centrally. The size of the muscle bulk is substantial and a skin paddle can be included with the flap. The flap can also be neurotized for functional muscle transfer.
2. Midline scars are not a contraindication for use of the rectus abdominis muscle flap. Good preoperative planning allows the general surgeon to assess the abdominal cavity via a midline

incision while preserving the rectus muscle. It is also crucial to site the ostomy site on the contralateral abdominal wall.

3. The presence of a Kocher subcostal incision over the rectus muscle is an absolute contraindication for use of an ipsilateral superiorly based rectus muscle flap. Prior harvest of the internal mammary artery for cardiac bypass surgery is a relative contraindication for use of a superiorly based rectus abdominis flap if there is a contralateral rectus muscle. The muscle has been shown to survive reliably via transposition based on the eighth intercostal vessels.
4. Previous surgery involving the external iliac vessels is a contraindication to the use of the inferiorly based rectus muscle flap unless patency of the inferior epigastric artery is confirmed with preoperative arteriography. Prior pelvic surgery through a Pfannenstiel incision will generally not preclude the

use of this flap. The deep inferior epigastric vessels are rarely violated in gynecologic surgery. However, adhesions between the deep surface of the inferior rectus muscle and the pelvic viscera may be present.

5. Dissection of the deep inferior epigastric artery pedicle to its source vessel (external iliac artery) will provide an additional 2 cm of pedicle length. The size of the artery and vein will also be larger.
6. During the dissection of the rectus muscle off the posterior sheath, care must be taken inferior to the arcuate line of Douglas (**Fig. 37.10**) as the peritoneum is only separated by the thin fascia transversalis.
7. The morbidity from the harvest of the rectus muscle is usually acceptable due to the paired nature of this muscle and the contributory strength of the oblique and transversalis muscle. Some patients report diminished muscle strength and the inability to do sit-ups. However, with time, most of the patients report little or no negative impact on activities of daily living.

Suggested Further Reading

- Bakri K, Mardini S, Evans KK, et al. Workhorse flaps in chest wall reconstruction: the pectoralis major, latissimus dorsi, and rectus abdominis flaps. *Semin Plast Surg* 2011;25(1):43–54
- Brooks D, Buntic RF. Partial muscle harvest: our first 100 cases attempting to preserve form and function at the donor site. *Microsurgery* 2008;28(8):606–611

- Bunkis J, Walton RL, Mathes SJ. The rectus abdominis free flap for lower extremity reconstruction. *Ann Plast Surg* 1983;11(5):373–380
- Koshima I, Soeda S. Inferior epigastric artery skin flaps without rectus abdominis muscle. *Br J Plast Surg* 1989;42:645
- Koshima I, Tsuda K, Hamanaka T, et al. One-stage reconstruction of established facial paralysis using a rectus abdominis muscle transfer. *Plast Reconstr Surg* 1997;99(1):234–238
- Musharafieh R, Macari G, Hayek S, Elhassan B, Atiyeh B. Rectus abdominis free-tissue transfer in lower extremity reconstruction: review of 40 cases. *J Reconstr Microsurg* 2000;16(5):341–345
- Netscher DT, Eladomikdachi F, Goodman CM. Rectus abdominis muscle flaps used successfully for median sternotomy wounds after ipsilateral internal mammary artery ligation. *Ann Plast Surg* 2001;47(3):223–228
- O'Shaughnessy KD, Rawlani V, Hijawi JB, et al. Oblique pedicled paraumbilical perforator-based flap for reconstruction of complex proximal and mid-forearm defects: a report of two cases. *J Hand Surg Am* 2010;35(7):1105–1110
- Piza Katzer H, Balogh B. Experience with 60 inferior rectus abdominis flaps. *Br J Plast Surg* 1991;44:438–443
- Shukla HS, Hughes LE. The rectus abdominis flap for perineal wounds. *Ann R Coll Surg Engl* 1984;66(5):337–339
- Soltanian CG, Zochowski K, Chepla J, et al. The first muscular branch of the deep inferior epigastric artery: an anatomical study and clinical applications. *Plast Reconstr Surg* 2012;129(2):463–468
- Taylor GI, Corlett RJ, Boyd JB. The versatile deep inferior epigastric (inferior rectus abdominis) flap. *Br J Plast Surg* 1984;37:330–350

Figure Credits

1. Strauch B, Yu HL. *Atlas of Microvascular Surgery: Anatomy and Operative Approaches*. 2nd ed. New York, NY: Thieme; 2006