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CHAPTER 11.4

Functional Restoration

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(Print pagebreak 1124)

Microsurgery-Free-Flap Reconstruction

Surgical Considerations

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Description: Microsurgical reconstruction involves moving tissue from one site of the body to another (see Fig. 11.4-1, Table 11.4-1). This may be muscle, skin, bone, or any combination of these tissues. An artery and vein that supply the tissues are connected to an artery and vein at the new recipient site, thereby reestablishing blood flow and ensuring tissue survival. Once transplanted, the tissue is molded and shaped to replace the missing part. Vascular anastomoses are performed on vessels as small as 1.5 mm in diameter. Complex reconstructions may require 12 hours of GA with significant blood loss and fluid shifts. Patients with comorbid conditions may need additional medical tests before surgery to ensure that they are able to withstand this type of operation.

Peripheral, central, and arterial lines should be placed at the start of the case only after consultation with the reconstructive surgeon. For example, radial forearm flap may be injured by placement of a peripheral iv in the antecubital fossa or within the body of the flap. The neck is a common site for microvascular anastomoses in head and neck reconstruction. The placement of internal jugular lines should be discussed with the surgeon before surgery. The rectus muscle flap relies on the deep inferior epigastric vessels for its perfusion. Femoral arterial or venous line placement may injure these vessels and is, therefore, contraindicated. In bilateral breast reconstruction with free flaps, the iv lines should be placed in the lower extremities if possible. The reconstructive surgeon will try to operate in conjunction with the extirpative surgeon to minimize operating time. This often necessitates repositioning the patient as the case progresses.

Microsurgical reconstructions are often long operations, and large surface areas of the patient are exposed during the surgery. The patient's core temperature should be monitored closely with the use of a bladder or esophageal temperature probe. Body and fluid warmers should be used routinely to maintain the patient's body temperature. There is no *(Print pagebreak 1125)* standard practice for anticoagulation in microsurgery. No randomized prospective clinical trial has definitively documented the efficacy of a particular type of anticoagulation in routine reconstructive microsurgery. Aspirin, dextran, and heparin are the most commonly used agents. Close communication between the surgeon and anesthesiologist is critical so that the desired agent is administered at the appropriate time.

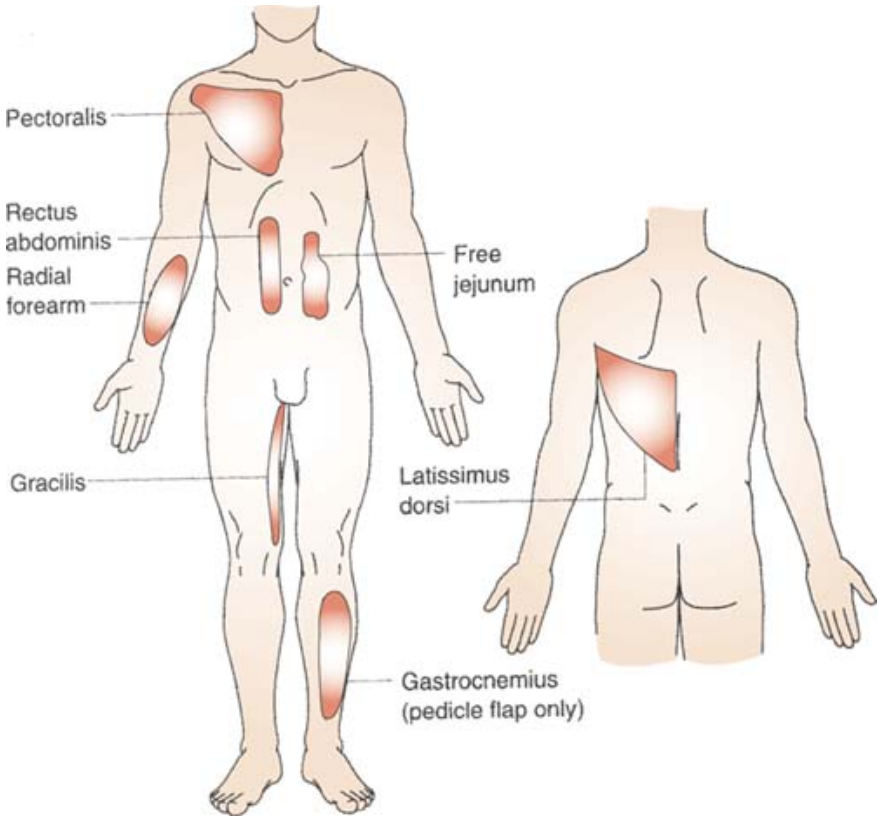

Figure 11.4-1. 1. Locations of commonly used flaps. (Reproduced with permission from Greenfield, LJ, Mulholland MW, Oldham KT, et al, eds: *Surgery: Principles and Practice,* 2nd edition. Lippincott-Raven: 1997.)

Table 11. 4-1. Types of Flaps

Reconstruction	Commonly Used Flaps	Location	Positioning
Head and neck	Fibula	Leg	Supine
	Radial forearm	Arm	Supine
	Scapula	Back	Lateral decubitus
	Iliac crest	Hip	Supine
	Anterolateral thigh	Thigh	Supine
	Gracilis	Thigh	Supine
Breast	TRAM	Abdomen	Supine
	Gluteal	Buttocks	Lateral decubitus
	Rubens/iliac crest	Hip	Supine
	Tensor fascia lata	Lateral thigh	Supine
	Latissimus dorsi	Back	Lateral decubitus
Lower extremity	Rectus abdominis	Abdomen	Supine
	Latissimus dorsi	Back	Lateral decubitus
	Serratus anterior	Back	Lateral decubitus
	Gracilis	Thigh	Supine

The survival of the flap relies on the patency of the anastomosis. Thrombosis requires reexploration and may → complete loss of the tissue. Anastomotic patency is diminished by vasospasm or vascular constriction. The common causes of vasoconstriction include dehydration, hypothermia, pain, and administration of vasoconstrictors; therefore, during microsurgery, vasoconstrictors are contraindicated and should be given only when absolutely necessary, after consultation with the reconstructive surgeon. The patient must be adequately hydrated so that there is good perfusion to the transplanted tissue. Diuretics should be avoided. Postop pain control is important to prevent vasoconstriction on emergence from anesthesia. After surgery, patients are transferred to an area of the hospital where the free flap can be monitored. In many hospitals, this is an ICU.

Usual preop diagnosis: Trauma, cancer, chronic wounds, congenital anomalies, and burns are some of the common diagnoses that result in the need for microsurgical reconstruction.

Summary of Procedures

Position	Requirements of the recipient site take precedence; optimal position for the donor site is then considered.
Incision	Each site will have specific incision.
Special instrumentation	Microscope; tourniquet for extremities
Unique considerations	Multiple surgical teams; avoid hypothermia; ± anticoagulation; if intraop nerve stimulation is planned, muscle relaxants should be avoided.
Antibiotics	Cefazolin (1 g iv) in uncomplicated cases; broader coverage in complicated circumstances
Surgical time	Simple flap: 4–6 h Complex cases: 8–12 h
Closing considerations	Splints and dressings should be secured before emergence.
EBL	Skin flap: 200 mL Muscle flap: 200–500 mL Bone flap: 500–1000 mL
Postop care	ICU for flap perfusion monitoring
Mortality	< 2% (usually associated with coexisting disease)
Morbidity	Soft-tissue complications: 20–30% Vascular complications requiring reexploration: 5–10% Flap failure: 5%
Pain score	3–5

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Patient Population Characteristics

Age range	2–90 yr
Male:Female	1:1
Incidence	50–200/yr/major center
Etiology	Malignancy; trauma; chronic infection
Associated conditions	Complications of underlying disease (e.g., anemia)

Anesthetic Considerations

Preoperative

These surgeries are carried out on patients who have sustained major soft-tissue losses and require flap procedures to cover the defects. There are four typical patient populations presenting for this surgery: (a) those presenting for reconstruction following cancer surgery (e.g., radical neck dissection and mastectomy); (b) patients following trauma, usually with upper or lower-limb defects; (c) patients with congenital defects; and (d) previous burn victims. In general, these patients should present few problems for the anesthesiologist. In a patient with a congenital lesion, however, it is prudent to look for evidence of CHD, musculoskeletal deformities, and airway problems.

Exposure of the thorax to radiation may produce pathologic changes in the lungs and related structures, including pneumonitis (→ dyspnea, hypoxemia) that may progress to fibrosis (→↓ pulmonary compliance). Tracheal or bronchial fibrosis may → partial airway obstruction. Many burn patients have pulmonary pathology 2° smoke inhalation injury. The pathology usually include edema, inflammation, and loss of ciliary activity, but can

Respiratory	vary depending on the length and amount of smoke exposure, as well as the composition of the material that burned. Patients with breast cancer may have been treated with chemotherapeutic agents (e.g., methotrexate, cyclophosphamide, bleomycin) that may cause pulmonary fibrosis, interstitial infiltrates, and pleural effusions. **Tests:** Consider CXR, PFT, and pulmonary consult.
Cardiovascular	Exposure of the heart to radiation may produce pathologic changes in the heart and related structures, including accelerated atherosclerotic changes, myocardial fibrosis, pericarditis, and valvular dysfunction. Patients with breast cancer may have been treated with doxorubicin (Adriamycin), which may produce cardiomyopathy (usually seen at total doses >550 mg/m^2) → CHF. XRT increases the incidence of clinically significant cardiomyopathy.
Hematologic	Myelosuppression may be present in patients with Hx of chemotherapy. **Tests:** CBC, with differential and Plt count
Laboratory	Other tests as indicated from H&P.
Premedication	Standard premedication (see p. B-1).

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Intraoperative

Anesthetic technique: GETA. Coordinate iv and/or invasive monitoring sites with the surgical team. Adjunctive regional anesthesia is an option for the appropriate patient who will not be anticoagulated. Some authors propose that the resultant vasodilation causes ↑ blood flow through the flap, but this has not been definitely shown in clinical trials.

Induction	Standard induction (see p. B-2) and intubation. Avoid succinylcholine in burn patients.	
Maintenance	Standard maintenance (see p. B-2). Muscle relaxation usually is required. The patient must be kept warm and well hydrated to minimize peripheral vasoconstriction, which might impair graft perfusion. Surgeon may request intraop anticoagulation, usually in the form of aspirin, dextran, or heparin.	
Emergence	Smooth emergence to avoid disrupting the surgical repair. Patients usually are transported to the ICU for continuous monitoring of flap perfusion.	
Blood and fluid requirements	Moderate blood loss IV: 16 ga × 1 NS/LR @ 4–5 mL/kg/h Warm fluids. Humidify gases.	Keep patient warm, and maintain a positive fluid balance. A Hct of 30–35% will provide adequate O_2 transport, while minimizing vi scosity. Dextran 40 usually is used to further ↓ viscosity, thereby ↑ flap blood flow.
Monitoring	Standard monitors (see p. B-1). UO	
	± Arterial line	An arterial line may be useful for prolonged procedures where regular ABGs and blood chemistries will be needed.
Positioning	and pad pressure points. eyes.	These can be very lengthy surgeries, and careful monitoring of pressure points is essential.
	Hypothermia	Maintain normal body temperature with warming blankets, fluid, and airway warmers.
Complications	Decubitus ulcer	Pressure necrosis can occur in as little as 2 h. Carefully pad and repeatedly pressure points.
		Prophylactic use of very low molecular

	Dextran reaction	weight dextran (Promit) usually prevents allergic reactions to higher-molecular-weight dextran. Adult dose = 20 mL 1–15 min before dextran infusion.

Postoperative

Complications	Arterial thrombosis Hematoma	May require reexploration. May require reexploration.
Pain management	Parenteral opiates (see p. C-2). PCA (see p. C-3).	Pain should be treated promptly to minimize reflex peripheral vasoconstriction and impaired graft perfusion.

Suggested Readings

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Microsurgery-Replantation

Surgical Considerations

Description: Patients who require replantation surgery are trauma victims and must be evaluated carefully preop, by both surgeons and anesthesiologists, to ensure that replantation is appropriate and that other injuries are not overlooked. In these cases, time is critical, as the amputated tissue is ischemic and may require immediate revascularization if it is to be salvaged. Coordination between the microsurgeon, anesthesiologist, and trauma team is important to minimize the time between injury and replantation.

As in any microsurgical procedure, it is critical to prevent vasoconstriction in these procedures. These patients may have experienced significant blood loss at the time of the trauma and require iv hydration and/or blood transfusion. The need for hemodynamic support often indicates another injury that may preclude transplantation. The patient may be hypothermic and require

active rewarming. Vasoconstrictors and diuretics should be avoided unless absolutely necessary. During the replantation procedure, other tissues (e.g., skin, vein, bone) are required to aid in the reconstruction. These are routinely harvested from the leg, groin, or foot, which will be prepped into the surgical field.

The amputated stump is initially examined using loupe magnification. The arteries, veins, and nerves are dissected and tagged. The surgeon determines if the part is replantable. The amputated stump is prepared by dissecting the recipient arteries, veins, and nerves. The need for a vein graft may be determined at this time. The sequence of replantation varies; however, a general algorithm is:

Bone fixation → Extensor tendon repair → Flexor tendon repair → Nerve repair → Arterial and venous anastomoses → Skin closure

The replanted tissue must be monitored on an hourly basis to ensure continued viability. In many hospitals, this is performed in a microsurgical unit, while in others the ICU is used. Patients should be kept adequately hydrated, warm, and pain-free to prevent vasoconstriction and subsequent thrombosis. Vascular thrombosis requires immediate exploration and revision of the vascular anastomosis.

Specific variations of replantation procedures have unique features, as follows.

Replantation of fingers and hands: Generally, two surgeons work simultaneously. One surgeon at the back table explores the amputated parts, tagging significant nerves, vessels, and tendons. A second surgeon débrides the amputation sites and identifies the stumps of reparable structures. The surgeons then proceed with replantation. Generally, bone fixation and tendon repairs are performed first. Vessel and nerve repairs are performed next, using a microscope. The need for vein grafting and anticoagulation is determined intraop. Blood transfusions are rarely needed except when using anticoagulants.

Replantation of extremities: Replantation of arms or legs must be handled very efficiently since irreversible muscle damage occurs within 4 hours of ischemia. Generally, the sequence of surgery is similar to finger replantation, with the exception being that a temporary arterial circulation (using a dialysis shunt) is established as soon as possible to minimize ischemia time in an amputated part. Ongoing venous blood loss occurs while skeletal repairs are done, and transfusion is frequently required. Definitive vessel repairs (often requiring vein grafts) and nerve repairs are done under the microscope.

Scalp replantation: Scalp avulsions are caused by entanglement of hair in machinery. These amputations are frequently replantable, sparing the patient a grotesque and unstable deformity. Initial evaluation should include careful assessment of the C-spine, since the patient transiently hangs by the neck until the scalp separates. Initial blood loss *(Print pagebreak 1129)* can be significant and should be replaced preop. Replantation proceeds by identifying matching vessels at the margin of the defect and the avulsed scalp. The superficial temporal vessels are most commonly repaired, and use of vein grafts should be anticipated. Following the first artery repair, brisk bleeding generally occurs at the scalp margin until vein repairs are completed. This blood loss should be anticipated.

Usual preop diagnosis: Trauma

Summary of Procedures

	Fingers/Hands	Extremities	Scalp
Position	Supine, injured arm extended	Supine	Supine or side (depending on vessel position)
Incision	Conventional hand exposure	Extension of injury; fasciotomies may be done.	Preauricular
Special instrumentation	Microscope; hand table; tourniquet	Microscope; tourniquet	Microscope; neurosurgical headrest
Unique considerations	Anticoagulation		RAE or anode tube; table, turned 180°
Antibiotics	Cefazolin 1g iv		
Surgical time	1st finger: 3–4 h; 2 h/subsequent finger Hand: 4 h	4–8 h	4 h
Closing considerations	Splint applied before emergence.	Cast or splint applied before emergence.	Elevate head as much as possible.
EBL	100–200 mL	2–6 U	2–8 U

Postop care	ICU for monitoring		
Mortality	None	Rare	None
Morbidity	Replant failure: 5–15%	Failure: 10–20%	Vascular occlusion → reexploration
Pain score	5–6	5–6	3–5

Patient Population Characteristics

Age range	Childhood-old age		Young adult
Male:Female	> 10:1		1:2
Incidence	250/yr/major center	Rare	
Etiology	Trauma		
Associated conditions	Other injuries	Other injuries, blood loss	C-spine injuries, blood loss

Anesthetic Considerations for Replantation

Preoperative

In general, there are two patient populations for replantation procedures: (a) isolated limb and scalp injury patients (common), and (b) multiple trauma victims (rare). Most patients are otherwise healthy and the preop workup is routine.

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Gastrointestinal	All of these patients should be considered to have full stomachs and, therefore, are at increased risk for aspiration pneumonitis. In general, they should receive preop medication to reduce stomach volume and acidity (e.g., metoclopramide 10 mg iv and ranitidine 50 mg iv) 30–60 min before induction, time permitting.
Metabolic	50% of trauma victims are intoxicated. Anesthesia-related implications of acute ethanol intoxication include: ↓ anesthetic requirements, diuresis, vasodilation, and hypothermia.
Neurologic	Assess for possible head or C-spine injury, particularly in the trauma patient presenting with facial or scalp injuries.
Laboratory	As suggested by coexisting disease.
Premedication	Standard premedication (see p. B-1). Full-stomach precautions: Na citrate 0.3 M 30 mL immediately before induction of anesthesia.

Intraoperative

Anesthetic technique: GETA, after rapid-sequence induction. These procedures are often lengthy, and regional anesthesia is usually not appropriate as the primary technique but may be considered as an adjunct.

Induction	Rapid-sequence induction (see p. B-4) is mandatory in emergency cases, unless awake intubation is performed. C-spine fracture patients or those with facial injuries may require awake fiber optic intubation (see p. B-5).	
Maintenance	Standard maintenance (see p. B-1) for stable patients.	
Emergence	Difficult airway or full-stomach cases require awake extubation.	
Blood and fluid requirements	Significant blood loss possible IV: 16 ga × 1–2 (extremity/scalp) IV: 18 ga × 1 (digit) NS/LR @ 1.5–3 mL/kg/h + 3 × blood loss	A 16-ga iv catheter in a nonoperated upper extremity should be adequate in hemodynamically stable patients. Keep patient warm and hydrated to maximize

	Fluid/blood warmers, heating blanket, warmed circuit humidifier	perfusion to the replanted site. Avoid vasoconstrictors if possible.
Monitoring	Standard monitors (see p. B-1). ± Arterial line, CVP	Invasive hemodynamic monitoring should be considered in cases where large blood loss is anticipated.
Positioning	and pad pressure points. eyes.	
Control of blood loss	Tourniquet may be used.	Inflation pressure is typically 100 mmHg greater than systolic pressure. Maximum 'safe' tourniquet time is 1.5–2 h, followed by a 5- (preferably) 15 min reperfusion interval, if further tourniquet time is necessary.
Special considerations	Tourniquet deflation and limb reperfusion	Mild ↓ BP is common. In patients with moderate-to-severe lung disease, continue controlled ventilation until after the lactic acid that has accumulated in the ischemic limb is metabolized (3–5 min), since these patients may be unable to increase ventilation adequately to buffer this acid load.
Complications	Hemodynamic instability	Previously unrecognized injuries (e.g., pneumothorax, cardiac tamponade, intracranial bleeding) should be considered as a cause of unexplained intraop hemodynamic instability in all acute-trauma victims.

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Postoperative

Complications	Reperfusion failure	May require immediate reexploration.
Pain management	PCA (see p. C-3)	
Tests	None routinely indicated.	Reimplant perfusion must be monitored.

Suggested Readings

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Breast Surgery—Introduction

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Angeline Lim

Patients presenting for plastic surgery of the breast can be grouped into four basic categories along a continuum ranging from amastia/hypomastia to hypertrophy. Plastic surgery procedures are designed to create or make adjustments in the amounts of skin and glandular tissue or to make adjustments in their relationship to each other to create an aesthetic breast. The first type of patient is one who has acquired amastia after undergoing a mastectomy; it is this patient who is featured in this section on functional restoration. In this patient, the goal is to replace the missing tissue, both skin and glandular, with like tissue or an implant. The second type is a person presenting for augmentation mammoplasty (see p. 1084). In this situation, the breast is deficient of skin and glandular tissue. The third type is the patient who presents for a reduction mammoplasty (see p. 1086). In this situation, there is an excess of glandular tissue and skin. The fourth type is the patient who presents for a mastopexy or breast lift (see p. 1088). In this patient, there exists a discrepancy between the amount of glandular tissue present and the volume of the skin envelope, resulting in ptosis.

For all breast procedures, the patient's breasts are marked preop with the patient in either the sitting or standing position. This is a necessity, and its importance cannot be overstated. The appearance of the breasts in the supine position versus the upright position is significantly different due to the effects of gravity.

Breast Reconstruction

Surgical Considerations

Description: The goal of breast reconstruction is to create an aesthetic breast that is symmetrical with the contralateral breast. Typically, this can be accomplished in three ways: expander/implant reconstruction; latissimus flap reconstruction, ± an implant; and TRAM flap reconstruction, performed using either a pedicled technique or a free-tissue *(Print pagebreak 1132)* transfer. Each type of reconstruction follows the principle of replacing glandular and cutaneous breast tissue. In patients undergoing mastectomy, reconstruction may be performed immediately after the mastectomy or it may be delayed and performed at a later date.

In **expander/implant reconstruction** (Fig 11.4-2), a tissue expander is placed underneath the pectoralis major muscle and a portion of the serratus anterior muscle, followed by skin closure. Thus, two layers exist above the implant—skin and muscle. The patient returns to the office for expansions, with saline being injected into the implant port. This is continued until the desired size is reached. Then, the patient returns to the OR for the exchange of the expander for a permanent implant that contains either saline or silicone gel as filler material. Except for the psychosocial aspects of patient management, much of the technique and perioperative concerns are similar to those for breast augmentation (see p. 1084).

Autologous breast reconstructions: Two types of flaps are used for these procedures—latissimus myocutaneous flap and transverse rectus abdominus muscle (TRAM) flap. The **latissimus dorsi myocutaneous flap** consists of the muscle with overlying skin that is rotated from the back to the anterior chest for the creation of a breast. The flap does not supply sufficient bulk to be used in breast reconstruction unless the contralateral breast is very small. Usually a breast implant is placed between the latissimus and pectoralis muscles, thus increasing the volume of the reconstruction. The patient is placed in the lateral decubitus position for the latissimus flap harvest. The incision is designed to surround the skin paddle. The ellipse of skin is incised, and the dissection then proceeds along the superficial surface of the latissimus muscle towards its lateral, superior, and inferior borders. Dissection is performed underneath the latissimus muscle to separate it from the deep tissues of the back. The muscle is released from its insertions on the posterior superior iliac crest, medial fascial attachments, and surrounding muscle attachments (i.e., serratus anterior, teres major). The flap is tunneled through the axilla, and the back wound is closed (Fig 11.4-3). The patient is then returned to the supine position. The muscle is disinserted from the humerus, if necessary, and brought out onto the anterior chest wall. At this point, the muscle is inset into the mastectomy defect. An implant or tissue expander may be placed under the muscle if necessary for

size and symmetry. Often, the patient is placed in the seated or semi-Fowler position for closure. The incisions are closed over a drain and dressings are applied. The skin flap is monitored postop for signs of flap ischemia and congestion, which may necessitate a return to the OR.

The **TRAM flap** procedure replaces the breast with an ellipse of abdominal skin and subcutaneous tissue based on the rectus abdominus muscle (Fig 11.4-4). In selecting patients for a TRAM flap reconstruction, the patient must have adequate lower abdominal tissue to make a breast; however, obese patients, smokers, diabetics, and those with a Hx of prior abdominal surgery may have a higher incidence of complications and flap loss. The benefit of this procedure is that it creates a natural appearing breast from the patient's own tissue without an implant. As a bonus, the abdominal donor site is closed as though the patient had undergone abdominoplasty (‘tummy tuck’). The myocutaneous perforators that arise from the superior epigastric and inferior epigastric arteries provide blood supply to *(Print pagebreak 1133)* the flap. This flap can be harvested in either a pedicled fashion, based on the superior epigastric artery, or as a free flap, based on the inferior epigastric artery. The inset of the flap and closure of the donor site are the same in both cases. The basic difference between the two methods of flap transfer is that, in the free TRAM procedure, the flap is removed from the abdomen, brought into the mastectomy wound, and the operating microscope is used to suture the vascular pedicle of the flap to the recipient vessels, either the thora-codorsal or internal mammary arteries. In the case of the pedicled TRAM flap, the flap is passed through a tunnel, created under the skin, maintaining the blood supply via the superior epigastric artery. The flap is brought out into the mastectomy wound where it is sutured into position.

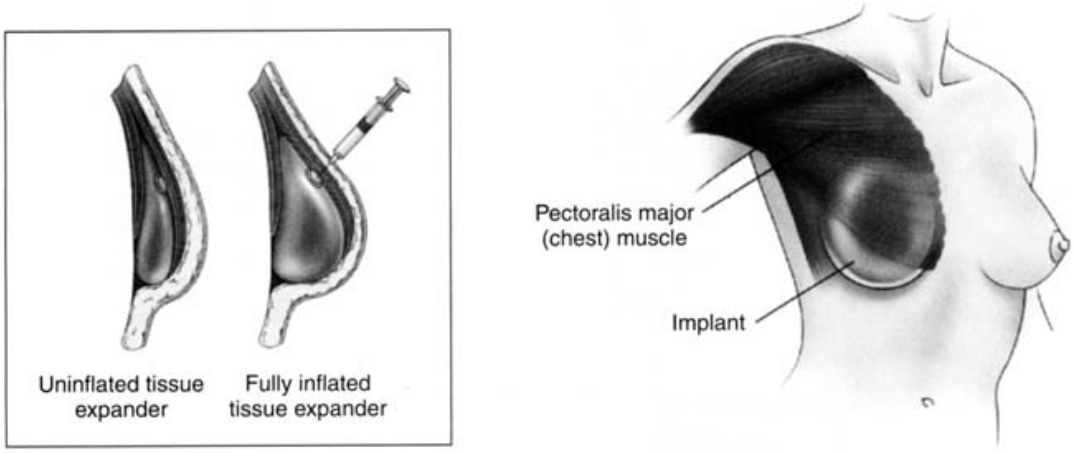

Figure 11.4-2. 2. Expander-implant reconstruction. (Reproduced with permission from Greenfield LJ, et al, eds: *Surgery: Scientific Principles and Practices*, 3rd edition. Lippincott Williams & Wilkins, 2001.)

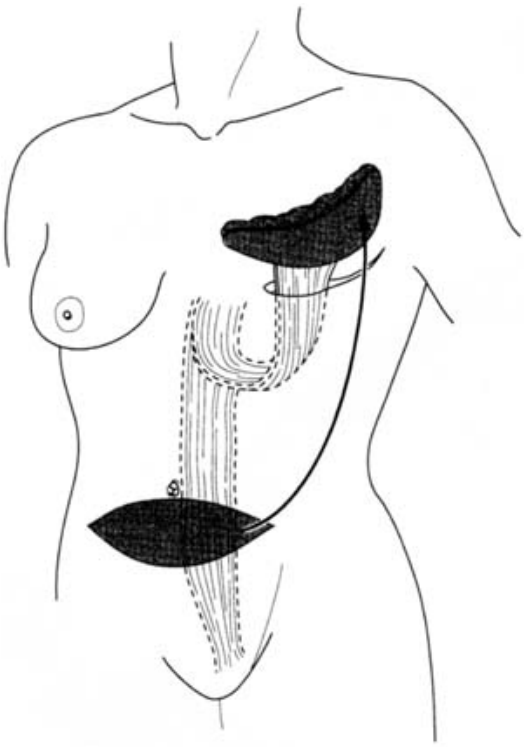

Figure 11.4-4. 4. Breast reconstruction using free TRAM flap. (Reproduced with permission from Greenfield, LJ, et al,

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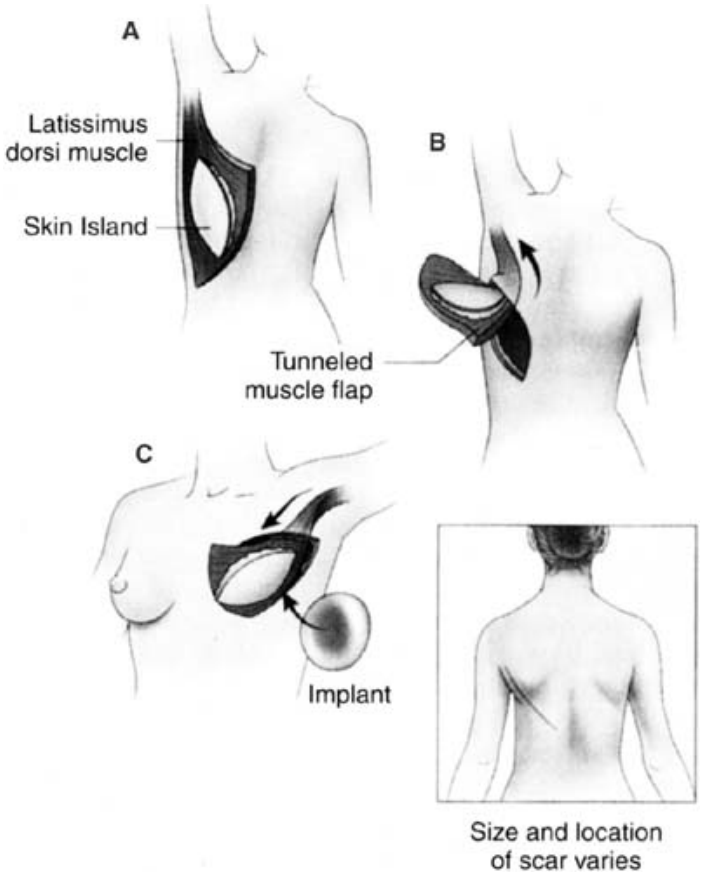

Figure 11.4-3. 3. (A–C) Latissimus dorsi flap reconstruction. (Reproduced with permission from Greenfield LJ, et al, eds: *Surgery: Scientific Principles and Practices*, 3rd edition. Lippincott Williams & Wilkins, 2001.)

Pedicled TRAM flap: The patient is marked preop in the upright position. The midline and inframammary folds are marked, as is the abdominal ellipse. The arms are placed at 90° abduction. The breasts and abdomen are prepped and draped. A general surgeon performs the mastectomy and, if possible, the TRAM flap harvest is started at the same time. Incising the skin along the superior marking of the abdominal ellipse begins the harvest of the flap. The upper abdominal skin and subcutaneous fat are elevated off the abdominal wall fascia up to the level of the costochondral cartilage, as in an abdominoplasty. The table is then flexed, and the upper skin and subcutaneous tissue is brought to overlap the TRAM flap to ensure that the location of the marked incision at the lower border of the flap will allow for abdominal closure. The patient is returned to the supine position. The skin and subcutaneous tissue of the flap are raised from a lateral to medial direction off the abdominal wall fascia until the lateral border of the rectus muscle is identified. Care is taken to preserve the myocutaneous perforators supplying the flap. The anterior rectus sheath is incised and the rectus muscle is elevated away from the posterior rectus sheath. The inferior epigastric vascular pedicle is identified and divided, preserving as much length as possible. The portion of the rectus muscle below the flap is transected so that the muscle, along with the overlying ellipse of skin and subcutaneous tissue can be rotated into the mastectomy site. A tunnel is created under the skin to connect the abdominal wound and mastectomy site. The flap is passed through this tunnel and rotated into position on the chest wall (Fig 11.4-5).

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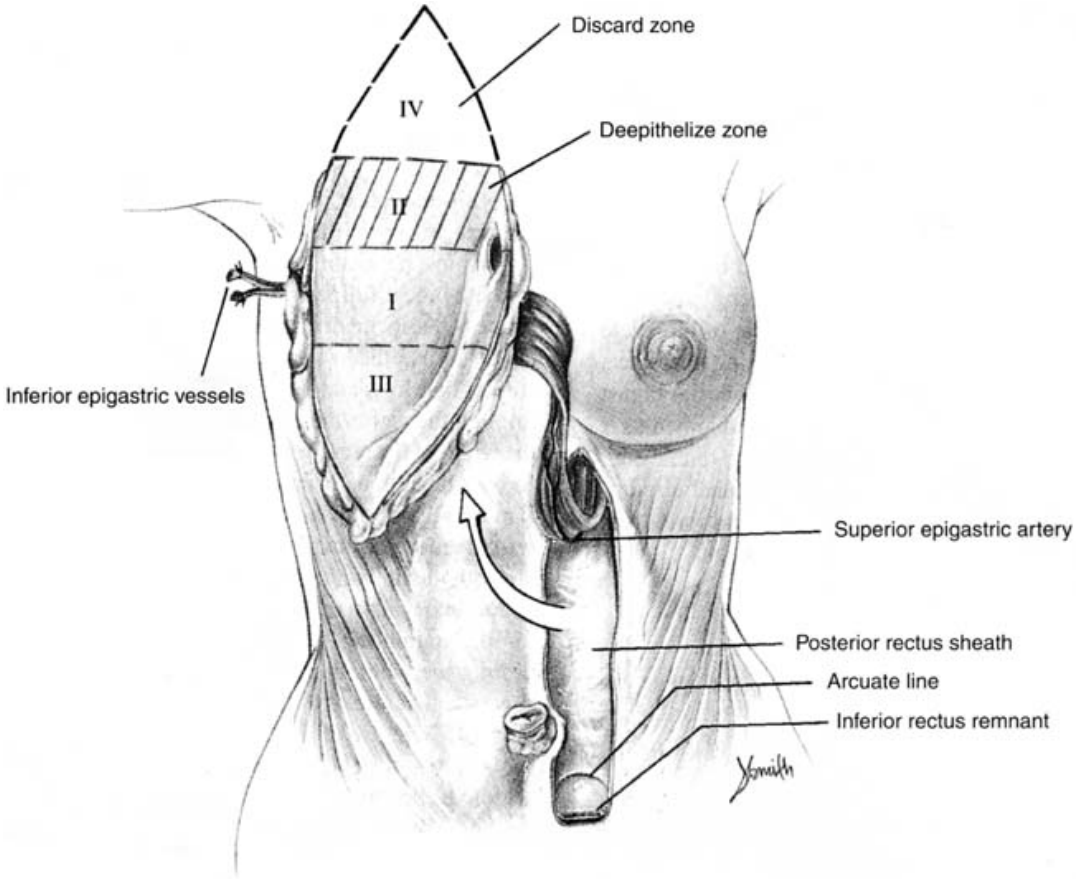

Figure 11.4-5. 5. TRAM flap reconstruction of the breast. A contralateral pedicled TRAM flap has been elevated and will be tunneled under the skin to be inset at the mastectomy site. The zone of tissue furthest from the blood supply is discarded. A portion of the TRAM flap will be deepithelialized and placed under the mastectomy skin flaps. (Reproduced with permission from Spear SL: *Surgery of the Breast: Principles and Art*. Lippincott-Raven, 1998.)

In flap reconstructions, the harvested tissue receives its blood supply through a single artery and vein. It is important in these cases to maintain a stable BP that will allow for continued perfusion of the flap tissue. Vasopressors are to be avoided, as they will constrict the artery and thus restrict the inflow into the flap. It is preferred, if possible, to maintain a stable BP with volume replacement. Once the flap is in place at the mastectomy site, the table is again flexed as much as 45–60° for closure. Drains are placed within both the chest and abdominal wound beds. The flap is trimmed and sutured into position to create symmetry with the contralateral breast. The abdomen is closed in a fashion similar to an abdominoplasty. Many surgeons prefer that N_2O (which can distend the abdomen) be avoided during the abdominal closure. The surgeon will evaluate the flap to monitor for signs of ischemia and congestion. This is done both by clinical evaluation (color, temperature, and turgor) and by Doppler. If inflow or outflow is inadequate for flap survival, blood flow may be supplemented by performing a microvascular anastomosis between the inferior epigastric pedicle and the thoracodorsal vessels. In some cases, the surgeon may choose to convert the pedicled flap to a free flap.

Usual preop diagnosis: Carcinoma of the breast; radiation therapy; cardiovascular surgery; Poland syndrome

(Print pagebreak 1135)

Summary of Procedures

	Tissue Expander/Implant	Latissimus Dorsi Flap	TRAM Flap
Position	Supine	Lateral decubitus → supine	Supine
Incision	Breast	Posterior (supine); lateral (thorax)	Abdominal
Unique considerations	May have to place patient in sitting position during procedure; SCDs; Foley catheter if case > 3–4 h.		+ Avoid use of N_2O.

Surgical time	1–2 h	4 h (+ mastectomy time)	6–8 h (free TRAM) 4 h (pedicled TRAM) (not including mastectomy time)
Closing considerations	Extensive dressing required		+ Flex table for abdominal closure.
EBL	Minimal-100 mL	200–300 mL	200–400 mL
Postop care	PACU → room		(free TRAM flap → ICU)
Mortality	Rare		
Morbidity	Capsular contraction: ± 30% Decreased sensation: 15% Hematoma: 2.2% Fat/skin necrosis: 1.7–1.9% Nipple areola necrosis: 1.4%	– – Flap loss: Rare	– – Abdominal hernia: Infrequent
Pain score	5	5	5

Patient Population Characteristics

Age range	30–70 yr
Male:Female	Mostly female
Incidence	Breast reconstruction is performed in 9% of female population
Etiology	Cancer; trauma; idiopathic; radiation or postcardiovascular surgery
Associated conditions	Breast cancer; cardiovascular disease; S/P chemotherapy; pulmonary disease

Anesthetic Considerations

See Anesthetic Considerations for Breast and Chest-wall Reconstruction, p. 1137.

Suggested Readings

1. Abeloff MD, et al: Breast. In *Clinical Oncology*. Churchill Livingstone, New York: 1995.

2. American Society of Plastic Surgeons' Website: www.plasticsurgery.org.

3. Desidero DP, Kross RA, Bedford RF: Evaluation of the patient with oncologic disease. In *Principles and Practice of Anesthesiology*, 2nd edition. Longnecker DE, Tinker JH, Morgan GE Jr, eds. Mosby-Year Book, St. Louis: 1998, 379–96.

4. Spear SL, ed: Breast reconstruction. In *Surgery of the breast: Principles and art*. Lippincott-Raven, Philadelphia: 1998,335–672.

5. Spear SL: Primary implant reconstruction. In *Surgery of the Breast: Principles and Art*. Lippincott-Raven, Philadelphia:1998, 347–56.

6. Vasconez HC, Holley DT: Use of the TRAM and latissimus dorsi flaps in autogenous breast reconstruction. *Clin Plast Surg* 1995; 22(l):153–66.

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Chest-Wall Reconstruction

Surgical Considerations

Description: Chest-wall reconstruction is most commonly performed for infections, sternal dehiscence, tumor extirpation, and radiation injuries. Complications after median sternotomy make up a large number of these cases. The patients often have comorbidities and are at high risk for anesthetic and surgical complications. The goals of reconstruction are to provide a stable chest-wall for respiration, to eradicate infection, and to obtain a healed wound.

Sternal wound infections and dehiscences: Wound complications after median sternotomy include dehiscence of the sternum and mediastinitis. In these cases, radical debridement of all devitalized tissue is the cornerstone to a successful outcome. The initial debridement is, therefore, performed in conjunction with the cardiovascular surgeons. During this debridement, blood loss may be extensive, requiring transfusion. The resulting dead space around the heart and great vessels is obliterated, most commonly with **pectoralis major or rectus abdominis muscle (TRAM) flaps.** For patients who have failed the initial reconstruction or are not candidates for these flaps, a **latissimus dorsi muscle flap** may be used. In spite of radical excision of the sternum, the respiratory function of these patients remains adequate and no bony stabilization is required.

Tumor extirpation and radiation injury: Tumor resection or removal of osteoradionecrosis of the chest wall often involves the full-thickness removal of skin, muscle, and underlying rib cage. The rib cage may be reconstructed with prosthetic mesh or bone grafts. These structures are then covered with muscle flaps. The pectoralis major, rectus abdominis, and latissimus dorsi muscles are the muscle flaps most commonly used. After surgery, the patient's ventilatory capacity may be diminished by the rib resection, and this should be anticipated preop.

Usual preop diagnosis: Chest-wall infections; tumor; sternal dehiscence; radiation injuries

Summary of Procedures

	Pectoralis Flap	Latissimus Flap	Rectus (TRAM) Flap
Position	Supine	Lateral decubitus → supine	Supine; table flexed
Incision	Chest	Posterolateral thorax	Abdominal
Antibiotics	Cefazolin 1 g		
Surgical time	3 h		4–6 h
Closing considerations	flap perfusion.		
EBL	200–400 mL		300–500 mL
Postop care	PACU → room		
Mortality	Rare		
Morbidity	Thrombosis/flap failure Hematoma Fat/skin necrosis		Abdominal hernia: Infrequent
Pain score	4–5	4–5	4–5

Patient Population Characteristics

Age range	30–80 yr
Male:Female	1:1
Incidence	Uncommon
Etiology	Cancer; trauma; radiation; postcardiovascular surgery
Associated conditions	Breast cancer; cardiovascular disease; S/P chemotherapy; pulmonary disease; mediastinitis

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Anesthetic Considerations for Breast and Chest-Wall Reconstruction

Preoperative

These surgeries are performed most commonly for reconstruction following cancer surgery, such as radical neck dissection and mastectomy (see Anesthetic Considerations for the primary procedure), as well as complications after median sternotomy. The following considerations focus on patients undergoing reconstruction postchemotherapy.

Respiratory	Pulmonary fibrosis may complicate chemotherapy. Bleomycin (> 200 mg/m^2) carries the greatest risk of pulmonary toxicity (10%), but alkylating agents (e.g., cyclophosphamide and melphalan) may cause a degree of pulmonary toxicity as well. Avoid FiO_2 > 30% in bleomycin patients (to prevent progressive pulmonary fibrosis and edema). Patients presenting with complications from a prior sternotomy may have ↓ respiratory function/reserve and will require further work-up. **Tests:** CXR; ABG and PFTs as indicated from H&P.
Cardiovascular	Cardiomyopathy and CHF may result from chemotherapy, especially doxorubicin (Adriamycin) > 550 mg/m^2. Previous XRT increases risk of clinically significant cardiomyopathy. Patients with median sternotomy-related complications who have undergone prior cardiac surgery will require careful evaluation of their current cardiovascular status. **Tests:** ECG; ECHO, if indicated from H&P.
Neurological	Note any previous damage to long thoracic nerves, as evidenced by winged scapula deformity.
Musculoskeletal	It is traditional to avoid iv and BP cuff on mastectomy side.
Hematologic	Myelosuppression/toxicity from chemotherapuetic agents may be present. **Tests:** CBC; Plt count; coag profile; Hb/Hct
Renal/Hepatic	Methotrexate can produce renal and hepatic dysfunction. Elevated alkaline phosphatase may suggest metastatic bone invasion. **Tests:** Electrolytes; BUN; Cr; LFTs
Gastrointestinal	Tamoxifen, used in hormonal chemotherapy, can cause preop N/V and dehydration.
Laboratory	Other tests as indicated from H&P, prior chemotherapy.
Premedication	Midazolam 1–2 mg iv immediately preop, or Valium 5–10 mg po 1 h preop

Intraoperative

Anesthetic technique: GETA

Induction	Standard induction (see p. B-2) and intubation. Avoid iv and NIBP monitoring on mastectomy side.
Maintenance	Standard maintenance (see p. B-2). Muscle relaxation is usually appropriate. These patients should be kept warm and well hydrated to minimize peripheral vasoconstriction, which might impair graft perfusion.
Emergence	During some of the procedure and for application of dressing, patient may be moved to sitting position, with consequent coughing, bucking, etc. (Rx: deeper anesthesia, e.g., propofol 0.5 mg/kg or lidocaine 1 mg/kg.) Watch BP carefully and treate orthostatic hypotension if it occurs, usually with a fluid bolus if the patient is not fluid-sensitive (e.g., Hx of CHF or renal failure).

Blood and fluid requirements	IV: 16 ga × 1 NS/LR @ 4–6 mL/kg/h Warm fluids.	Extensive blood loss may occur with debridement of sternum in cases of infection or dehiscence. Keep patient warm and maintain a positive fluid balance.
	Humidify gases.	Hypothermia may impair flap perfusion.
Monitoring	Standard monitors (see p. B-1). UO	Use invasive monitoring in cardiovascular-challenged patients or in cases with significant expected blood loss, where regular ABGs and blood chemistries will be useful.
Positioning	and pad pressure points. eyes.	
Complications	Pneumothorax	Pneumothorax should be considered with any ↑ lung inflation pressure, ↓ O_2sat or ↓ BP.
	Decubitus ulcer	Pressure necrosis can occur in as little as 2 h. Carefully pad and repeatedly pressure points.
	Dextran reaction	Prophylactic use of very low molecular weight dextran (Promit) usually prevents allergic reactions to higher molecular weight dextrans. Adult dose = 20 mL (pediatric dose = 0.3 mL/kg) iv 1–2 min (maximum 15 min) before dextran infusion.

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Postoperative

Complications	Pneumothorax ↓ Flap perfusion	
Pain management	Parenteral opiates (see p. C-2). PCA (see p. C-3).	Pain should be treated promptly to minimize reflex peripheral vasoconstriction and impaired graft perfusion.

Suggested Readings

1. Buggy DJ, Kerin MJ: Paravertebral analgesia with levobupivacaine increases postoperative flap tissue oxygen tension after immediate latissimus dorsi breast reconstruction compared with intravenous opioid analgesia. *Anesthesiology* 2004; 100(2):375–80.

2. Hu E, Alderman AK: Breast reconstruction. *Surg Clin North Am* 2007; 87(2):453–67.

3. Roth DA: Thoracic and abdominal wall reconstruction. In *Grabb and Smith's Plastic Surgery,* 5th edition. Aston SJ, Beasley RW, Thorne CHM, eds. Lippincott-Raven, Philadelphia: 1997, 1023–30.

4. Skoracki RJ, Chang DW: Reconstruction of the chestwall and thorax. *J Surg Oncol* 2006; 94(6):455–65.

Pressure-Sore Reconstruction

Surgical Considerations

Description: Pressure sores occur when constant pressure is placed on an area of the body. They tend to occur in debilitated,

bedridden, paralyzed, and wheelchair-bound patients. Multiple factors—including altered sensory perception, poor nutrition, incontinence, moisture, and shear forces—also may contribute to the formation of the pressure sores. The most common locations are the sacrum, ischium, and greater trochanter regions, as well as the heel and scalp.

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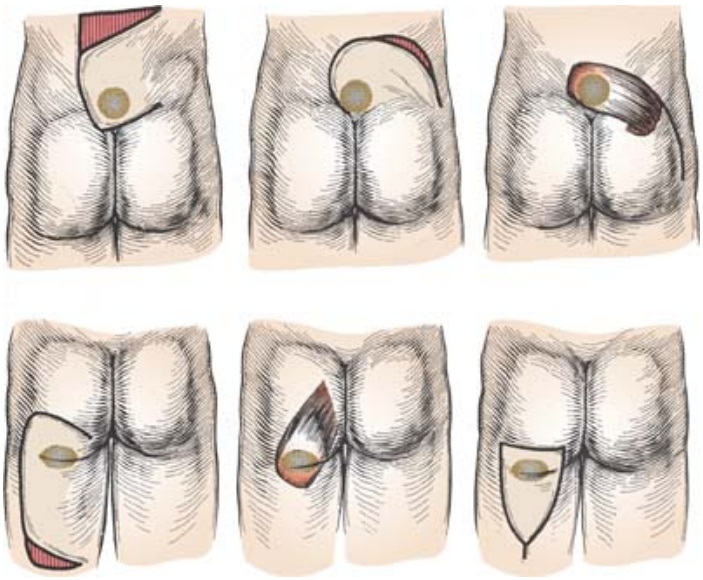

Figure 11.4-6. 6. Commonly used flap designs for coverage of sacral and ischial pressure sores. (Reproduced with permission from Aston SJ, Beasley RW, Thorne CHM: *Grabb and Smith's Plastic Surgery,* 5th edition. Lippincott-Raven, 1997.)

The management of pressure sores is multidisciplinary and involves more than just debridement and wound closure. Patient compliance is the most important factor of wound management, as recurrence rates after closure are high. All components that contributed to the formation of the ulcer must be addressed before wound closure. This is best done in a team setting, with the goal of preventing further sores. In this effort, nutrition must be optimized; infection, muscle spasm, and contractures controlled; pressure relief measures instituted; and the psychological issues addressed. Once these are in place, wound reconstruction may begin.

Reconstruction is based on adequate debridement, elimination of dead space and pressure points, and closure of the wound with healthy, durable tissue. Multiple flap designs have been described for the coverage of pressure sores, depending on their location (Fig. 11.4-6). An important point in the design of a flap is the consideration for future reconstructions because of the high incidence of recurrent wounds. The choice of flap also needs to take into consideration the donor site morbidity. Skin-only flaps, fasciocutaneous flaps, and musculocutaneous flaps are commonly used.

The patient is placed in the prone position and may be jackknifed to facilitate exposure of the wound. Debridement of the wound is performed; and the bursa and underlying bony prominences may be removed. Hemostasis is obtained and the wound is irrigated with pulsed lavage. The flap to be used is designed over the vascular pedicle. The donor site for sacral, gluteal, and greater trochanteric wounds are typically the tissues of the buttocks and posterior thigh. The skin is incised and the flap is raised to include the appropriate layers of tissue, depending on whether a skin, fasciocutaneous, or musculocutaneous flap is to be used. The flap is then *(Print pagebreak 1140)* rotated into position in the wound. A portion of the flap may be deepithelialized and placed into the wound to eliminate dead space. Drains are placed into the wound and the flap is sutured into its new location. The donor site defect that occurs after rotation of the flap may be closed directly or may require a skin graft. Once the operation is complete, the patient is transferred to a pressure-relief bed (e.g., Clinitron or air-fluidized bed) and extubated.

Usual preop diagnosis: Pressure sores

Summary of Procedures

Position	Prone or lateral decubitus
Incision	Gluteal or posterior thigh
Unique considerations	Foley catheter; SCDs

Antibiotics	Cefazolin 1 g iv. Some surgeons may prefer broader polymicrobial coverage.
Surgical time	3 h
Closing considerations	None
EBL	200–300 mL
Postop care	Strict bed rest on a pressure-relief bed for up to 3 wk. Care must be taken to ensure that the patient is turned every 2 h so that excessive pressure is not transferred to a new location. Antibiotics and the control of urine and stool are important to prevent soiling of the suture lines.
Mortality	0–1%
Morbidity	Infection: 2–3% Dehiscence: 1% DVT: 1% Recurrence
Pain score	4–6 (depends on spinal cord status)

Patient Population Characteristics

Age range	20–70 yr
Male:Female	Predominantly male
Etiology	Immobility; unrelieved pressure; altered sensation
Associated conditions	Paraplegia; debilitation; quadriplegia

Anesthetic Considerations

Preoperative

Typically, these surgeries are carried out on nonambulatory patients, with the spinal cord injury patient comprising a large subset. Anesthesia for plegic patients may well present several challenges, as discussed below.

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Respiratory	Plegic patients may have intercostal muscle weakness → atelectasis and ↓ clearance of secretions → recurrent URIs and V/Q mismatching → hypoxemia. **Tests:** PFT; ABG; others as indicated from H&P.
Cardiovascular	Autonomic hyperreflexia (AH) may present as acute episodes of uninhibited hyperactivity in the patient with an injury level of T10-T7 or above. The main clinical signs are paroxysmal HTN and bradycardia, in response to stimulation below the lesion. Severe HTN can result in pulmonary edema, myocardial ischemia and cerebral hemorrhage. Identify triggering stimuli (e.g., bowel or bladder distension, cutaneous stimulation). T4 or higher lesions may →↓ BP on induction of GA or regional anesthesia, initiation of IPPV, or postural changes. **Tests:** ECG; others as indicated from H&P.
Neurological	level of cord injury. AH in patient with spinal cord injury (see Cardiovascular, above) may manifest as headaches, sweating, facial flushing or syncope. Hyperreflexia below injury level.
Musculoskeletal	Immobility → skeletal muscle atrophy, osteoporosis, and decubitus ulcer formation.

Gastrointestinal	Spinal cord injury →↓ GI function → constipation/full stomach.
Renal	Chronic spinal cord injury → recurrent UTIs and calculi → renal failure. Foley catheter placement may → AH. **Tests:** UA; BUN; Cr; others as indicated from H&P.
Laboratory	Immobility →↑ Ca^{++} → dysrhythmias and nausea. **Tests:** Others as indicated from H&P.
Premedication	Standard premedication (see p. B-1) is usually appropriate. Patients with limited respiratory reserve should receive minimal sedation. Nifedipine (10 mg sublingually 5 min or po 20 min before induction) may be used to blunt AH.

Intraoperative

Anesthetic technique: GETA. If flap donor and recipient sites are confined to the lower half of the body, regional anesthesia may be considered for short procedures. Spinal or epidural anesthesia will minimize AH; however, anesthetic level may be difficult to assess and regional anesthesia may not be tolerated for prolonged surgery. Lighter levels of GA will not prevent AH.

Induction	Standard induction (see p. B-2) and intubation. Although the risk of ↑ K^+ 2° succinylcholine is reportedly decreased 6 mo after injury, NMRs are still preferred. AH may occur with Foley catheter placement.	
Maintenance	Standard maintenance (see p. B-2). Muscle relaxation is usually appropriate and may be necessary to reduce muscle spasticity. Avoid drugs that are primarily renally excreted in patients with CRI. Direct arterial vasodilators and alpha-adrenergic blocking agents should be readily available. Plegic patients are prone to hypothermia. These patients should be kept warm and well hydrated to minimize peripheral vasoconstriction, which might impair graft perfusion.	
Emergence	AH 2° distended bladder or rectum may occur on emergence from anesthesia.	
Blood and fluid requirements	IV: 16 ga × 1 NS/LR @ 4–6 mL/kg/h Warm fluids. Humidify gases.	Keep patient warm and maintain a positive fluid balance. Hypothermia may impair flap perfusion. Initial debridement of ulcer may be extensive and significant blood loss can occur. T&C as appropriate.
Monitoring	Standard monitors (see p. B-1). UO ± Arterial line	An arterial line may be useful in patients susceptible to AH and for prolonged procedures where regular ABGs and blood chemistries will be useful.
Positioning	and pad pressure points. eyes.	Many of these patients may be osteoporotic, so great care should be used in moving and positioning.
Complications	Hypothermia	Patients with spinal cord injury often have impaired thermoregulation. Maintain normal body temperature with warming blankets, fluid, and airway warmers.
	AH	AH should be promptly controlled with SNP bolus (5–50 mcg) and infusion, while anesthesia is deepened. A continuous trimethaphan infusion (0.5–4 mg/min) is another option.
	Decubitus ulcer	Pressure necrosis can occur in as little as 2 h. Carefully pad and repeatedly pressure points.

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Postoperative

Complications	Respiratory Insufficiency	Quadriplegic Patients May Have ↓ Vc And ↓ Erv And Be Uniquely Susceptible To Residual Respiratory Depressant Effects.
	AH	AH may occur 2° distended bladder or rectum. Rx: phentolamine 1 mg Iv Q 1 min and/or SNP bolus/infusion; removal of stimulus.
Pain management	Parenteral opiates (see p. C-2). PCA (see p. C-3).	Pain should be treated promptly to minimize reflex peripheral vasoconstriction and impaired graft perfusion.

Suggested Readings

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2. Bauer J, Phillips LG: MOC-PSSM CME article: pressure sores. *Plast Reconstr Surg* 2008; 121(1 Suppl):1–10.

3. Levi B, Rees R: Diagnosis and management of pressure ulcers. *Clin Plast Surg* 2007; 34(4):735–48.

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