Sternal Infection

50

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Introduction

Thoracic sternal infection may result from infection, malignant or benign tumor, metastatic direct extension of tumor, trauma, or radiation injury. The most common cause of sternal infection is median sternotomy. Median sternotomy is a standard procedure in open heart surgery that may cause mediastinitis as well as sternal infection. Although both complications are rare, with an incidence of 1–3 %, they have a mortality rate of up to 50 %. Associated risk factors are insulin-dependent diabetes mellitus, excess weight, immune suppression, chronic obstructive pulmonary disease, sternal osteoporosis, radiation treatment in the operative area, double–mammary artery removal, short stature, renal failure, and improper surgical technique.

The most common organisms include *Staphylococcus aureus*, *Staphylococcus epidermidis*, enterococci, pseudomonads, and *Serratia marcescens*. Benign chest wall neoplasms include fibrous dysplasia and osteochondroma, which usually are treated by local excision. The most common primary malignant chest wall tumors are chondrosarcomas, which are treated with radical resection. Breast cancer is the most common malignant disease of the chest wall in plastic surgery. The metastatic and extensive growing character of the tumor requires radical and extensive surgery and is demanding because of reconstruction.

If a sternal infection occurs, there is no standard therapeutic algorithm; however, all approaches aim to control the infection and to achieve sustainable sternal stability with adequate tissue coverage. This lack of standardization has led to multiple wound healing strategies that sometimes are used simultaneously, including open wound healing, irrigation–suction drainage, vacuum-assisted closure (VAC) therapy, and soft tissue reconstruction. Open wound healing and irrigation–suction drainage are accompanied by high mortality rates: 50 and 36 %, respectively. Although open drainage no longer is used as a single treatment option, it still is used in conjunction with other treatment options. VAC, introduced in 1997 by Argenta and Morykwas as a wound healing therapy, applies consistent and local vacuum on the wounded area. The vacuum promotes wound drainage, resulting in decreased edema and a reduction in bacterial count. Furthermore, the negative pressure dilates the capillaries, which in turn leads to improved arterial blood flow, angiogenesis, and increased granulation.

Although the number of surveyed cases is limited and the healing mechanisms are relatively unknown, recent studies show promising results for VAC therapy. A combination of increased partial pressure of oxygen and increased lactate levels may explain the accelerated wound healing. VAC may be used as briefly as possible as a bridge to final soft tissue reconstruction. Overall, the goals of treating sternal infection and osteomyelitis are:

1. Radical removal of infected, necrotic tissue and additional contaminated osseous material as well as bacterial monitoring with proper adjustments in antibiotic therapy
2. Sternal restabilization based on indication and time of first operation
3. Restoration of functionality by stabilizing thoracic deficiencies
4. Coverage of vital structures and filling in of dead space
5. Closure and consideration of esthetic aspects

To achieve these goals, the surgeon's philosophy is to start with the simplest treatment. If that treatment fails, one must climb the reconstructive ladder to the next step, that is, the next more complex procedure. The ladder is built as follows, from the simplest to the most complex procedure:

1. Conservative treatment, secondary healing
2. Simple dressings, vacuum sealing attachment
3. Direct closure
4. Split-skin graft
5. Local tissue transfer
6. Distant tissue transfer
7. Free tissue transfer

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Débridement and Stabilization

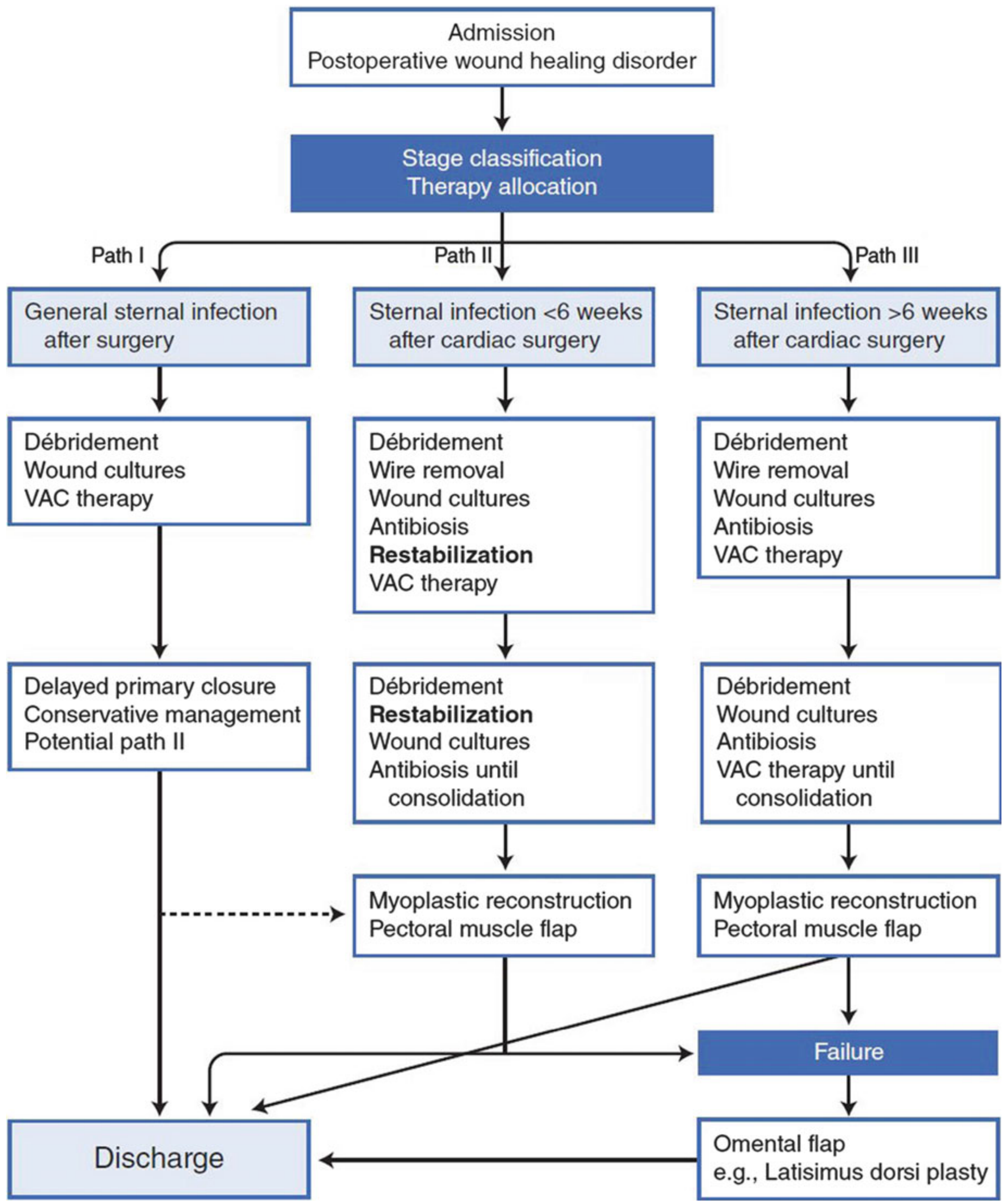
Figures 50.1 and 50.2

(**a**–**d**) The most important step is radical surgical débridement with complete removal of all infected and necrotic material. This step also includes removal of all wires or other foreign material, as continued infection positively maintains necrosis, destroying tissue needed for myoplastic coverage. If this occurs, there is no chance the infection will heal. This step also is necessary to dislodge all infected and necrotic osseous material. Partial or total sternal resection must be performed if necessary. It is important to preserve and fix vital sternal remains because they sustain thoracic stability and impede respiratory insufficiency. Following this procedure, the whole wound must be bowdlerized mechanically and by jet lavage. Swabs are taken routinely; as a complementary procedure, systemic antibiotic therapy is initiated based on antibiogram results and infection progression. If the wound conditions are perfect, closure may follow directly. Otherwise, VAC therapy is recommended. The sponge is trimmed as small as possible to prevent shrinkage of soft tissue, which makes reconstruction more difficult. Surgical débridement and VAC should be performed until the wound is decontaminated and ready for reconstruction; a low bacterial count is acceptable (Fig. 50.1, path I). Special conditions exist in patients who had prior cardiac surgery, especially more recent surgery. Patients readmitted within 6 weeks after cardiac surgery are most endangered and receive therapy according to path II. Rupture of the right ventricle may occur as the result of a different etiology, such as:

1. Continued spread of infection
2. Sharp sternal edges
3. Increased intrathoracic pressure or loss of vacuum, either accidental or because of system disconnection
4. Adhesions between the heart and chest wall

Despite the stabilizing subatmospheric pressure from VAC therapy, surgical intervention may result in right ventricle rupture due to the aforementioned causes (Fig. 50.2). Sternal refixation or placement of a layer between the heart and sternum is mandatory to avoid damage to the heart and is imperative after each surgical débridement. We prefer refixation, as it ensures that mediastinal organs are not damaged by the sternum or its remains. With this approach, wires and cords must be removed and applied again after each débridement; however, complete rewiring is unnecessary as three to four cerclages or polydioxanone cords are sufficient. This applies to the ongoing VAC therapy as well as to the reconstructive procedures. As a result of the punctual fixation, the mediastinum may be drained easily while safety is maximized. Additionally, unwanted pressure losses due to accidental dressing removal or system disconnection may be fixed easily without subjecting the patient to the risk of ventricular rupture. This procedure is postponed until consolidation and subsequent plastic reconstruction. After consolidation, direct closure or, in most cases, myoplastic reconstruction may be undertaken. If more than 6–8 weeks have passed between sternotomy and infection treatment, radical surgical débridement with wire removal is performed. Thus, rewiring is not necessary in most cases. Ample connective tissue regeneration and a fixed ledge above the heart are required. Stabilization is achieved by applying a connective tissue plate and VAC. With the patient's consent, pseudoarthrosis may be appropriate. After consolidation, myoplastic reconstruction is performed (Fig. 50.1, path III)

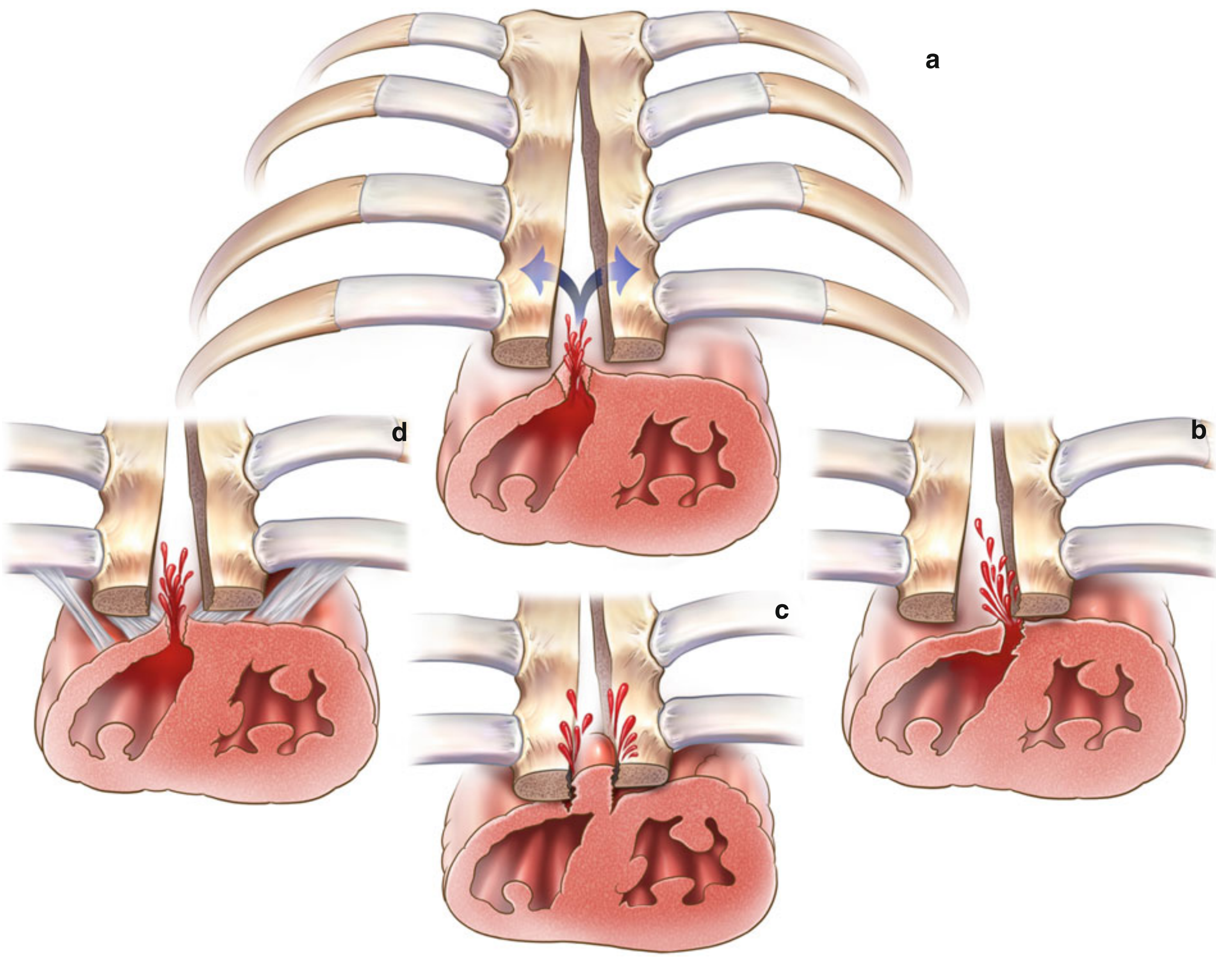
Figure 50.1


Admission
Postoperative wound healing disorder
Stage classification
Therapy allocation
Path I
Path II
Path III
General sternal infection after surgery
Sternal infection <6 weeks after cardiac surgery
Sternal infection >6 weeks after cardiac surgery
Débridement
Wound cultures
VAC therapy
Débridement
Wire removal
Wound cultures
Antibiosis
Restabilization
VAC therapy
Débridement
Wire removal
Wound cultures
Antibiosis
VAC therapy
Delayed primary closure
Conservative management
Potential path II
Débridement
Restabilization
Wound cultures
Antibiosis until consolidation
Débridement
Wound cultures
Antibiosis
VAC therapy until consolidation
Myoplastic reconstruction
Pectoral muscle flap
Myoplastic reconstruction
Pectoral muscle flap
Failure
Discharge
Omental flap
e.g., Latisimus dorsi plasty

Figures 50.1 and 50.2

(continued)

Figure 50.2



Reconstruction

Reconstruction may be achieved using autologous or synthetic tissue. Muscle flap options for reconstruction of anterior chest wall defects due to sternal infections are:

1. Greater pectoral muscle flap, unilateral or bilateral, with or without deinsertion of the tendon insertion (advancement, turnover, transposition flap)
2. Greater pectoral–rectus abdominis continuous flap
3. Greater omentum flap
4. Latissimus dorsi flap
5. Rectus abdominis flap (pedicled, free)
6. Tensor muscle of fascia lata flap (free)
7. Anterolateral thigh flap (free)

Because of the plentitude of nearby tissue, most defects due to sternal infections can be reconstructed with local tissue, in most cases with a greater pectoral muscle flap. This approach undoubtedly is more beneficial than using synthetic tissue. The following figures depict surgical procedures according to their frequency of application.

Figure 50.3

(**a**–**c**) Greater pectoral muscle flap. The favored muscle for covering the sternum via tissue transfer is the greater pectoral. Its main blood supply is from the thoracoacromial trunk, but it also is supplied by segmental perforators from the lateral thoracic and internal mammary arteries. The greater pectoral muscle originates at the aponeurosis of the external oblique, anterior sternum, second to sixth costal cartilages, and medial half of the clavicle. It inserts at the lateral lip of the bicipital groove by a flat trilaminar tendon. Its functions are flexion, adduction, and internal rotation of the arm, and it serves as the external respiratory muscle. Greater pectoral muscle flaps may be myocutaneous, osteomyocutaneous, pedicled, or free. Different techniques are possible for mobilizing the flap. The patient is placed in the supine position with the arms prepared for eventual deinsertion. The flap is harvested unilaterally or bilaterally. The muscle is dissected from the sternal origin in continuity with the subcutaneous fatty tissue if the surgeon does not want to dissect the insertion. The muscle and fatty tissue are dissected separately if the surgeon is going to dissect the insertion at the humerus. Cautery is used to raise the full length of the muscle from its sternal origin, then the pedicle is dissected from the clavicular part as far as necessary. If the sternal origin is dissected, further preparation may be done mostly bluntly up to the armpit. The perforators must be cauterized carefully. This way of harvesting the flap on both sides should be sufficient for an advancement flap. If more length is needed, unilateral or bilateral dissection of the insertion is required. An axillary incision adjacent to the insertion is helpful. Additional length is provided by dissecting the flap from its costal origins. In this way, the pedicle can be completely isolated on the thoracoacromial trunk. Another method of facilitating the stressless midline closure of the muscles is splitting the pedicle in the middle part longitudinally, taking the blood supply into account. For a unilateral harvest of greater pectoral muscle flap, the nondominant arm is preferred. To prepare a turnover flap, the pedicle is dissected from the insertion at the humerus, the costal parts, and the blood supply of the thoracoacromial branch and also is raised from the clavicular part. The blood supply is guaranteed by the perforators of the internal mammary artery. In this way, the pedicle can be turned into the sternal space. This procedure is possible only with an intact ipsilateral mammary artery. Because of its location, distinct blood supply, and excellent rotational ability, the muscle offers the possibility of covering at least two thirds of the sternum. In the case of extensive defects, particularly those involving the lower third of the sternum, the greater pectoral muscle can be raised in continuity with the rectus abdominis to cover the whole defect. The ipsilateral internal mammary artery should be intact if this approach is taken. Donor site morbidity is low, and there is no functional defect. As a reconstructive method after surgical débridement, greater pectoral musculoplasty has multiple advantages. There is no need for an additional entry method; surgical complexity is low, with little donor site morbidity; and the cosmetic results are good. However, turnover flaps might be bulky

Figure 50.3

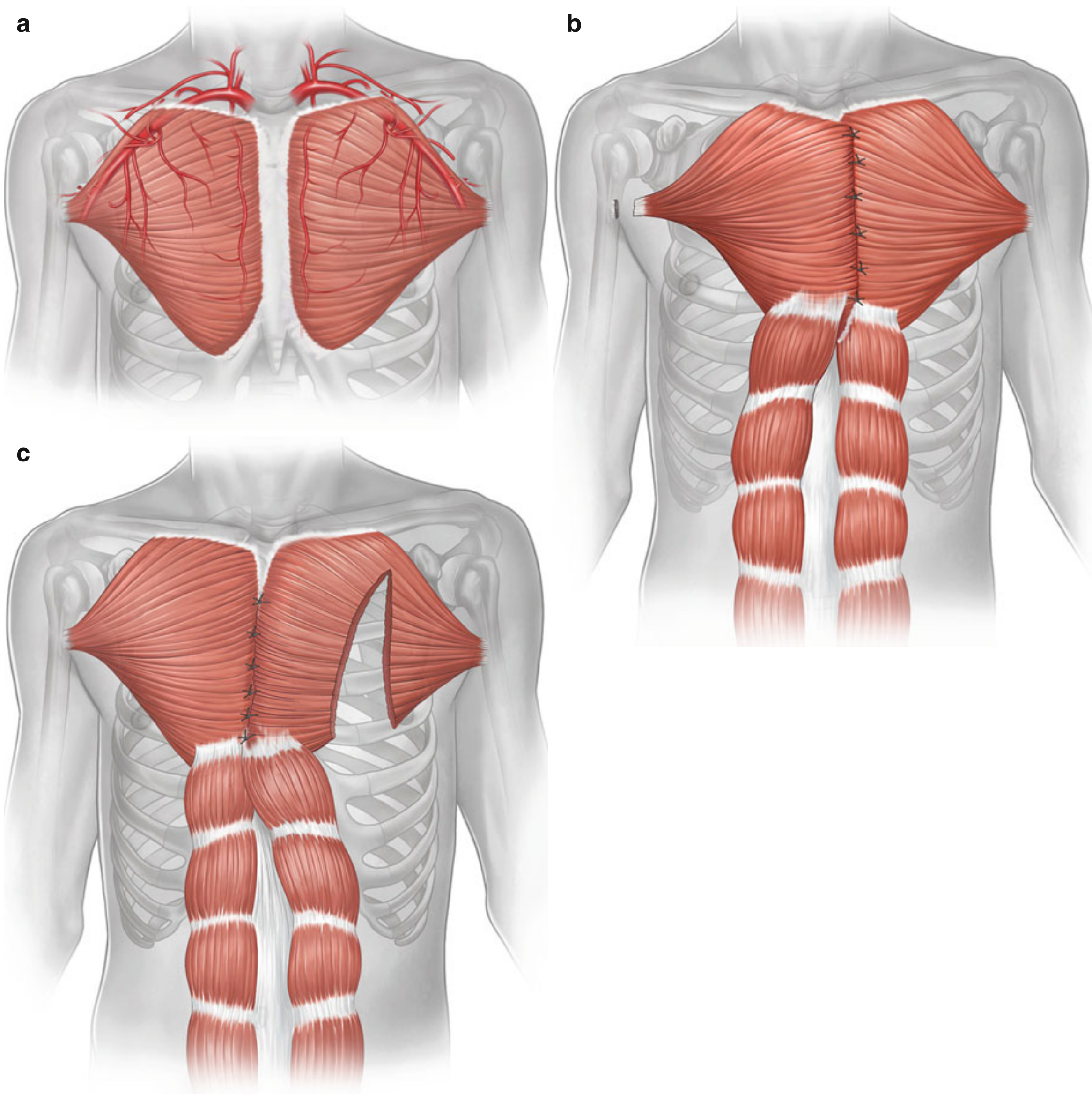


Figure 50.4

Omental flap. The omentum's main blood supply is via the gastroepiploic vessels from the arcade along the greater curvature of the stomach. The greater omentum is a double layer of peritoneum containing lymphatic and adipose tissue. It has a high degree of lymphocytic activity and immune competence. The flap territory is wide; the whole mediastinum may be filled, and it is perfectly suited for filling dead space. The flap may be based on the right or left gastroepiploic vessel. Normally, the right vessel is greater in diameter. During dissection of the vessels, the greater omentum should be kept under tension. The length of the pedicle may be increased by dissecting it from the proximal flap side. The arcades must be conserved; diaphanoscopy may help. A disadvantage of this technique is its two-cavity approach, which carries an increased risk of hernia and abdominal infection

Figure 50.4

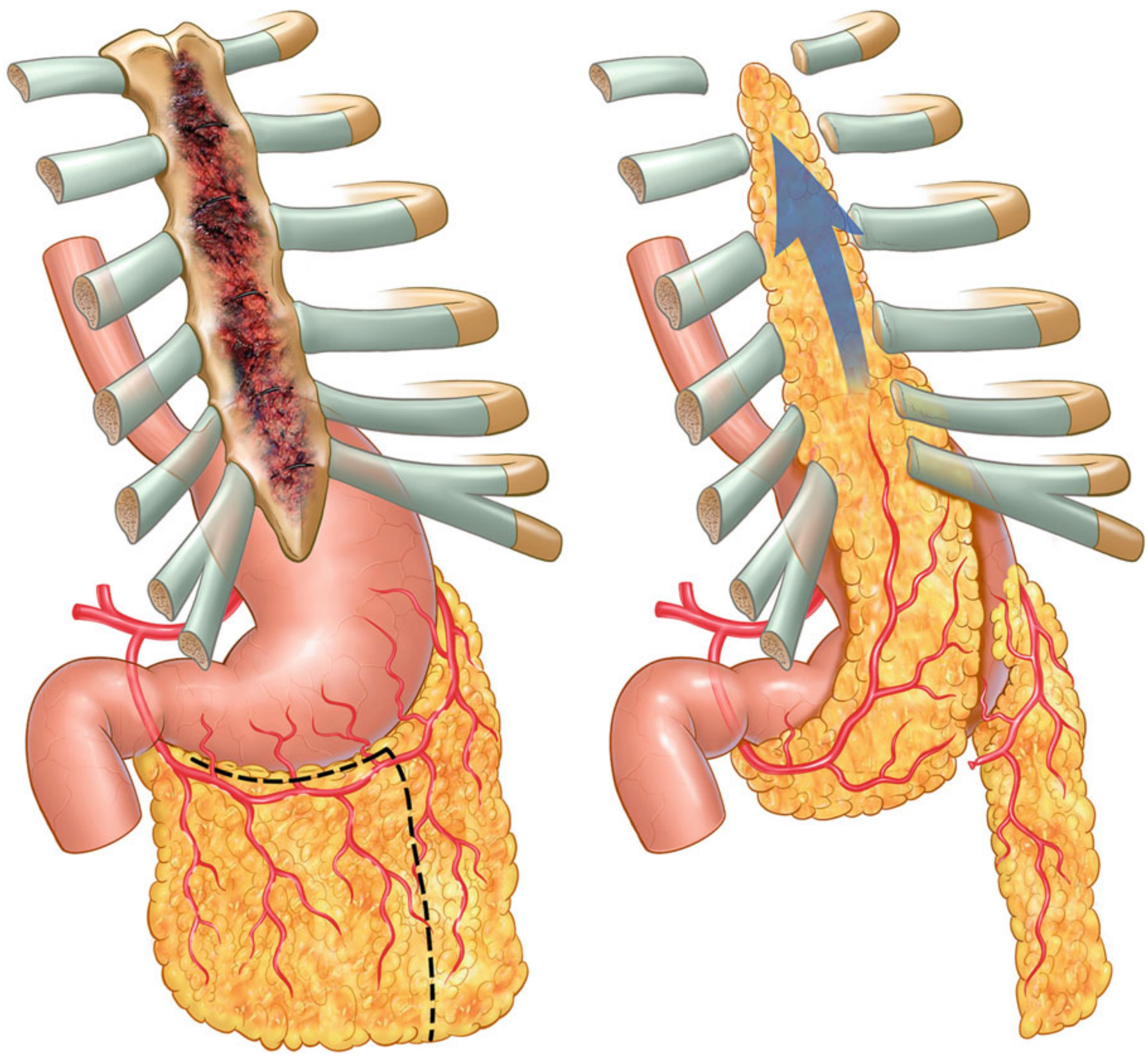


Figure 50.5

Latissimus dorsi flap. The main blood supply of the latissimus dorsi is via the thoracodorsal artery; it also is supplied by intercostal and lumbar perforators. This muscle originates from the tendinous fibers of the spinous process of the six lower thoracic vertebrae, the posterior layer of the thoracolumbar fascia, and the outer iliac lip. Its insertion is at the crest of the lesser tubercle of the humerus. The flap may be free or pedicled. Coverage of the anterior chest wall usually is achieved with a pedicled latissimus dorsi flap. Its arc of rotation is wide and reliable. The skin island may be designed up to 10 cm in length, and its orientation may be horizontal, vertical, or oblique. The patient is placed in the lateral position while the flap is harvested, but a change of position during the operation might be necessary. There is little functional deficit; however, seromas are common

Figure 50.5

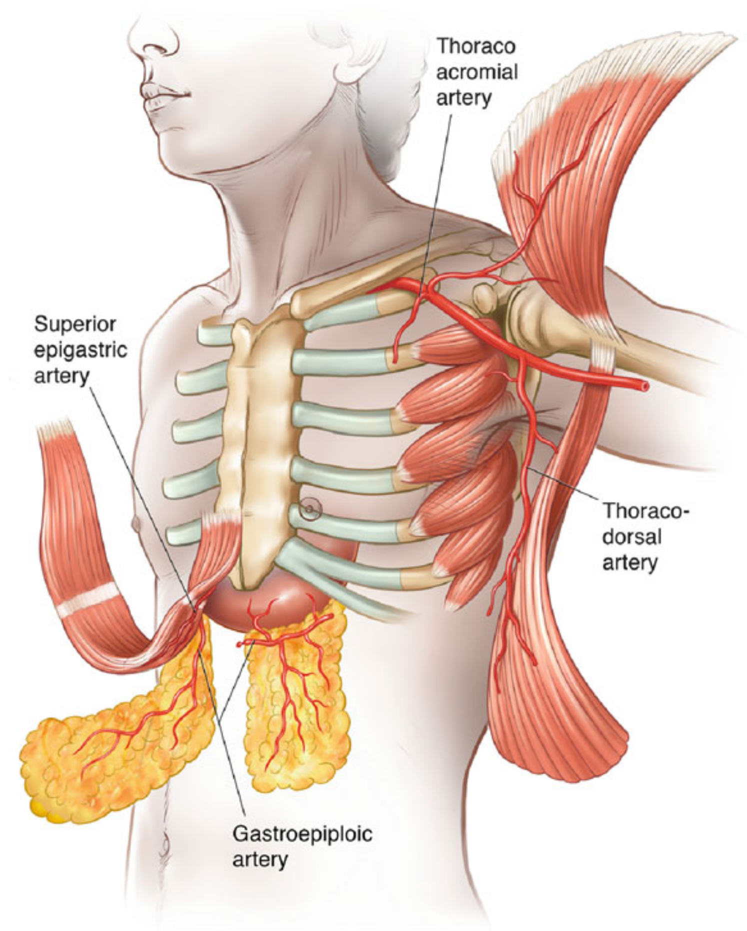
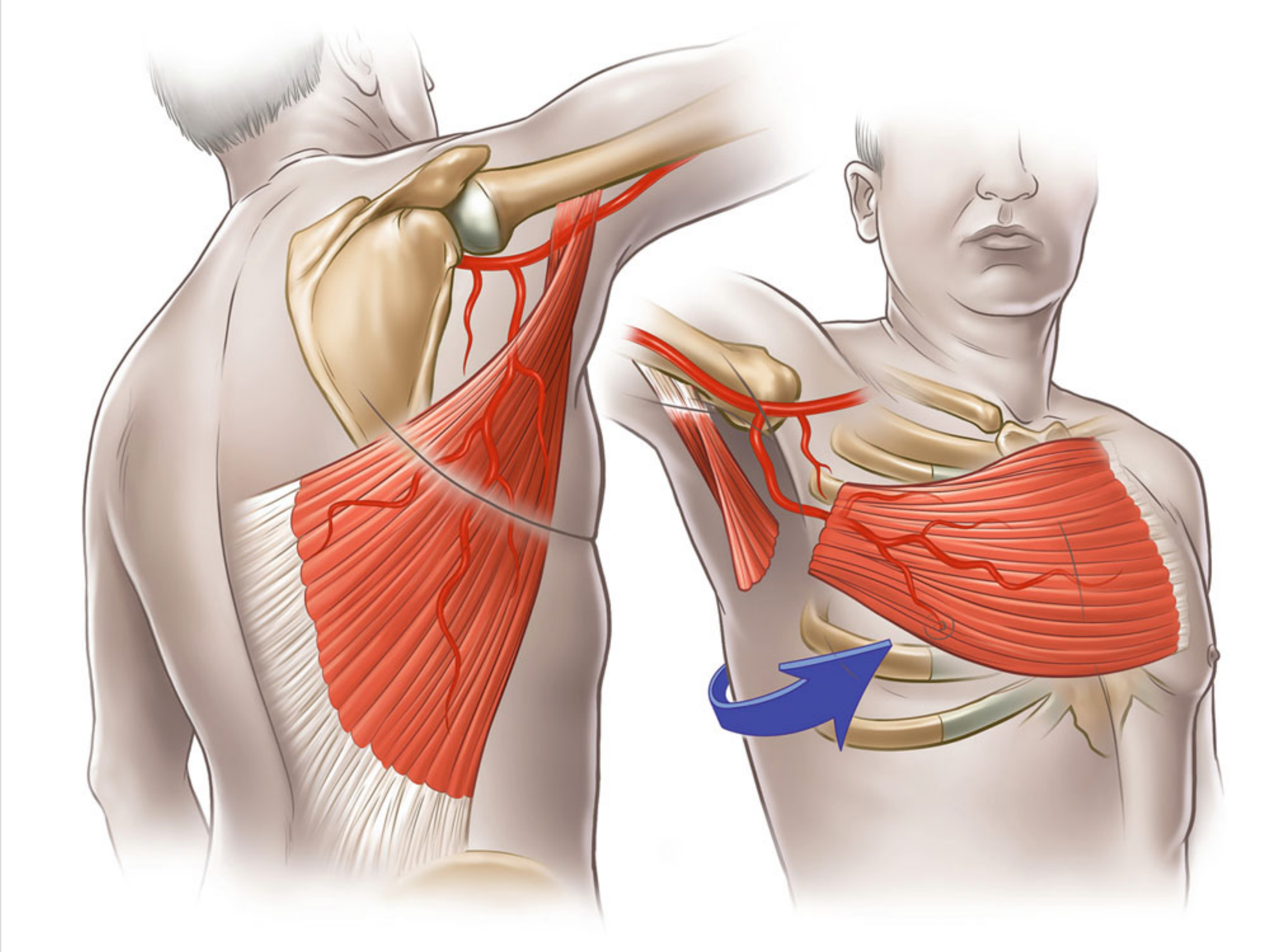

Thoraco
acromial
artery
Superior
epigastric
artery
Thoraco-
dorsal
artery
Gastroepiploic
artery

Figure 50.6

Rectus abdominis flap. Rectus musculoplasty should be performed only if the mammary artery is intact (*see also* Fig. 50.3). Because the blood flow to this muscle is already impaired when the mammary arteries are used, the risk of flap necrosis is increased. A hernia often occurs. The other aforementioned flaps are individual cases and are not explained explicitly

Figure 50.6



Conclusion

The diagnosis of postoperative wound healing disorders is made clinically. Prior to revision, patients have wound secretion, leukocytosis, increased C-reactive protein values, and fever. Sternum crepitus occurs in 50 % of patients. In a few cases, an open wound with broken or stripped out cerclages has already developed. In obscure cases, CT or MRI may help determine the diagnosis.

Use of the bilateral mammary arteries as grafting material increases the risk of developing postoperative sternal infection or mediastinitis by 16 %. The artery dislodgement impairs soft tissue metabolism postoperatively and may be the reason wound healing is hampered and sternal infection is more likely to occur. Thus, the surgeon faces a conflict in choosing between better grafting material and a potentially lower risk of mediastinitis. Respiratory disorders and other side effects caused by immolation of muscles important for respiration are rare. The use of pectoral and latissimus dorsi muscle is considered unproblematic with regard to respiratory capacity; however, it should be noted that respiratory capacity is weakened by the use of abdominal muscle.

Although sternotomy offers many advantages, postoperative complications such as post-sternotomy mediastinitis still occur and result in severe complications, further operations, a hospital mortality rate of about 10.4 %, and an increase in late mortality. These complications go hand in hand with a longer hospital stay and an increased nursing burden. A recent trend shows treatment moving away from open wound healing toward the use of irrigation–suction drainage as a stand-alone procedure; however, VAC therapy has been used increasingly since 1990. For the cardiac surgeon, it is a relatively new method that shows promising results. VAC therapy in the algorithm presented here is used as a bridge (in the shortest time possible) to final wound closure. When used in conjunction with early and aggressive débridement followed by plastic reconstruction, VAC therapy is an effective strategy to treat post-sternotomy mediastinitis. Patients benefit by receiving a pedicled pectoral or omental flap after VAC therapy. Reconstruction using latissimus dorsi muscle is another option, but it is more complex and results in greater donor site morbidity. Flap reconstruction also may be used prophylactically in the treatment of deep sternal infections and shows good functional results with no recurrent infection.

Radical surgical débridement with VAC therapy as a bridge to conditioning treatment with successive myoplastic reconstruction has proved to be a safe and reliable technique for treating deep sternal infection and mediastinitis, with justifiable risk.

Selected Bibliography

Allen MS (2008) Radionecrosis and infection of the chest wall and sternum. In: Patterson GA, Cooper JD, Deslauriers J, Pearson FG, Luketich JD (eds) Pearson's thoracic and esophageal surgery, vol 1, 3rd edn. Churchill Livingstone, Philadelphia, pp 1253–1270

Argenta LC, Morykwas MJ (1997) Vacuum-assisted closure: a new method for wound control and treatment: clinical experience. Ann Plast Surg 38:563–576

Din AM, Evans GRD (2005) Chest wall reconstruction. Curr Ther Plast Surg 10:362–366

Ennker IC, Pietrowski D, Vöhringer L et al (2008) Surgical debridement, vacuum therapy and pectoralis plastic in post sternotomy mediastinitis. J Plast Reconstr Aesthet Surg 62:1479–1483

Robiscek F (2008) Complications of midline sternotomy. In: Patterson GA, Cooper JD, Deslauriers J, Pearson FG, Luketich JD (eds) Pearson's thoracic and esophageal surgery, vol 1, 3rd edn. Churchill Livingstone, Philadelphia, pp 1243–1252

Roth DA (1997) Thoracic and abdominal wall reconstruction. In: Aston SJ, Beasley RW, Thorne CHM, Grabb WC, Smith JW (eds) Plastic surgery, 5th edn. Lippincott-Raven, Philadelphia, pp 1023–1029

Sjögren J, Gustafsson R, Nilsson J et al (2005) Clinical outcome after post-sternotomy mediastinitis: vacuum-assisted closure versus conventional treatment. Ann Thorac Surg 79:2049–2055

Vogt PM (2011) Praxis der Plastischen Chirurgie. Springer, Heidelberg