18

Above-elbow and Below-elbow Amputations

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OVERVIEW

Above-elbow amputations are indicated for advanced soft-tissue and bone sarcomas of the forearm; below-elbow amputations are performed for such tumors of the forearm and the hand. The location of the tumor mass on the medial aspect of the distal arm and elbow joint, in close proximity to the main neurovascular bundle, may in large part determine feasibility of a limb-sparing procedure. Above- and below-elbow amputations are performed to achieve wide surgical margins while preserving as much length as possible of the extremity. The level of amputation will vary with the location of the tumor in the forearm, at the elbow joint, and even at the lower portion of the arm.

During the procedure, muscle flaps are tapered and closed tautly in two layers over the cut ends of the bones in order to facilitate mobility. A rigid dressing is applied immediately postoperatively to decrease pain and edema and facilitate maturation of the stump.

INTRODUCTION

Above- and below-elbow amputations are rare procedures because: (1) the distal arm, forearm, and arm are relatively rare locations for soft-tissue and bone tumors; (2) unlike tumors of the buttocks and lower extremities, because of the fact that these locations are exposed, the tumors are noticed in relatively early stages and in most cases are resectable; and (3) administration of preoperative chemotherapy, and especially via the intra-arterial route or using isolated limb perfusion, significantly decreases tumor size and facilitates a limb-sparing procedure. The feasibility of limb-sparing was further augmented by the development of endoprosthetic devices that allow replacement of the distal humerus, proximal ulna, proximal radius, and even the distal radius, and which offer satisfactory function.

Nonetheless, above- and below-elbow amputations retain a definitive role in the management of soft-tissue and bone tumors of the upper extremity (Figure 18.1). These are required for tumors that cannot be removed with a wide margin. However, rarely should a grade I soft-tissue sarcoma that is not expected to metastasize be initially treated by amputation. In this case, because of the efficacy of adjuvant radiation therapy, even a marginal margin is acceptable. Indications for above- and below-elbow amputations include:

1. *Local recurrence* was once considered a primary indication for amputation. The mere presence of a recurrent sarcoma is no longer an immediate indication for an amputation. The capability to resect the recurrent tumor without compromising the function of the extremity is the determining factor on which the decision to amputate is based.
2. *Major vascular involvement*. The neurovascular bundle within the arm is tightly integrated in a closed anatomic space. The cephalic vein usually provides sufficient collateral flow if the brachial or the axillary vein has to be sacrificed. However, although occasionally the tumor mass can be delicately dissected off the brachial artery, in most cases of vascular involvement the brachial artery is extensively encased and amputation is inevitable.

   The compact nature of the vascular supply to the wrist makes involvement of the radial and ulnar arteries likely when a large tumor invades the volar aspect of the distal forearm. In this instance the incidence of morbidity and failure associated with resection and reconstruction using a vascular graft of one of these vessels is prohibitively high.
3. *Major nerve involvement*. In general, one nerve around the arm can be sacrificed and a two-nerve deficit is tolerated. Sacrifice of the three major nerves leaves the patient with a functionless extremity that is better off amputated. Nerve grafting for replacement of a section of the median, radial, or ulnar nerves is still not associated with satisfactory function.
4. *Extensive soft-tissue contamination* as a result of a pathologic fracture, or an inappropriate biopsy or resection attempt. This is a frequent indication for below-elbow amputation; the anatomy of the hand and lack of true biologic compartments allow both lateral and longitudinal extension of the tumor.
5. *Infection* around the tumor or along the biopsy tract may negate a resection attempt, prohibit the use of a prosthetic device, and delay the administration of adjuvant chemotherapy. Limb-sparing surgery is feasible only if the infection is completely controlled prior to surgery, or if the infected tissues can be completely removed at surgery.

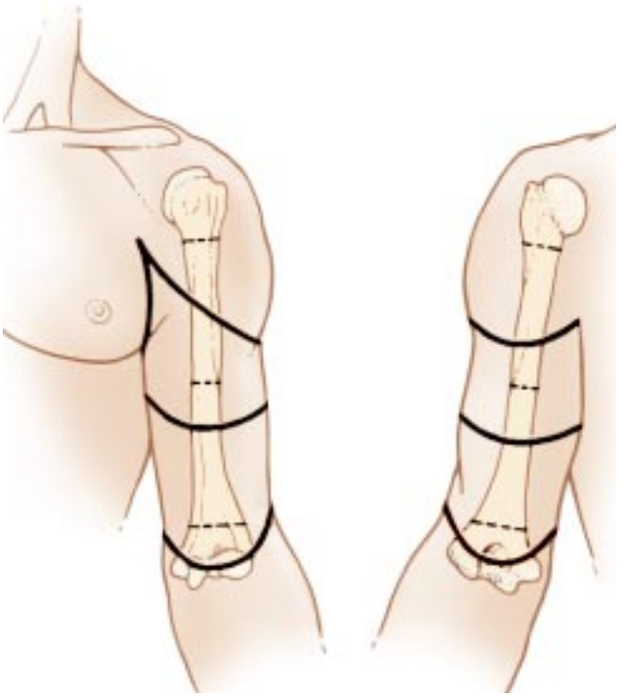

Figure 18.1 Above-elbow amputations are indicated for advanced soft-tissue and bone sarcomas of the forearm. Skin incisions and osteotomy sites for metaphyseal (high), diaphyseal, and supracondylar above-elbow amputations.

Cancer patients who are candidates for an amputation face a unique psychological problem because not only do they face a threat to their lives, but they will also lose their upper extremity. Besides an obvious aesthetic deficit, loss of the upper extremity, and especially the dominant one, has a profound functional impact. Therefore, the rehabilitation of these patients begins at the time of staging studies. The entire health-care team must develop a trusting and honest relationship with the patient and include him or her at the early stages of all decision making. Building upon this interaction, the patient will be better able to accept the amputation and set realistic goals for return to a productive life. The patient's family, significant peers, and each member of the care team are crucial to this adjustment.

All patients undergoing an amputation may experience phantom limb pain. This is not nearly so severe with distal amputations as it is with proximal amputations. Nonetheless, it should be discussed with the patient prior to surgery. The patient should understand that it is normal and that, if uncomfortable, can be effectively treated.

CLINICAL CONSIDERATIONS

Patients requiring above- or below-elbow amputations for a soft-tissue or primary bone sarcoma must undergo complete staging in order to allow the surgeon to determine the level of amputation and extent of soft-tissue resection. Complete staging allows determination of full tumor extent and as a result the site for skin incision, shape of the flaps, and site of osteotomy. The combined use of plain radiography, computerized tomography (CT), and magnetic resonance imaging (MRI) is necessary to determine the proximal extent of the intraosseous and soft-tissue components of the tumor. In general, the more proximal of the two levels of involvement (i.e. bone or soft tissue) determines the level of amputation.

Above-elbow amputations can be metaphyseal (high), diaphyseal, or supracondylar (Figure 18.2). High above-elbow amputations are those proximal to the deltoid tuberosity. Patients who undergo amputation proximal to the insertions of the deltoid and pectoralis major muscles have far greater difficulties adjusting to their prosthesis than do those who have undergone a more distal amputation. Below-elbow amputations should preserve the maximal length of both radius and ulna. While tumors of the hand are treated by a standard below-elbow amputation, performed through the distal third of the forearm, tumors of the distal forearm require a higher amputation and warrant special consideration. A minimum of 2.5–3 cm of bony stump, measured from the radial tuberosity, is required to preserve function.

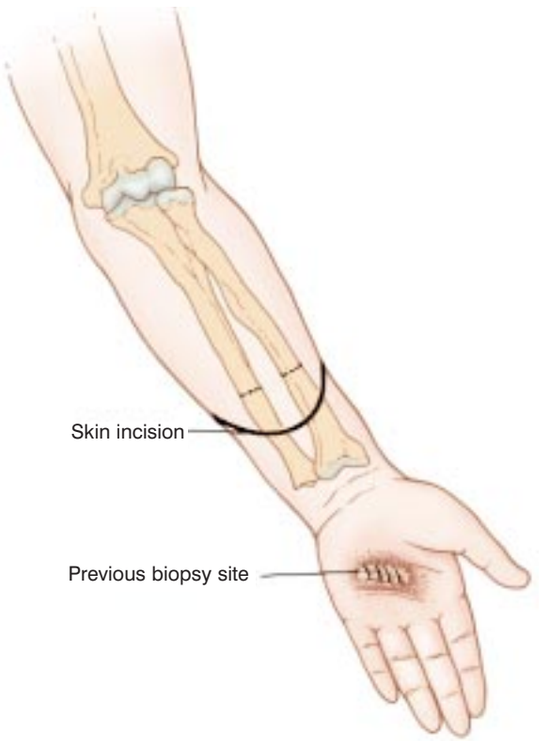

Figure 18.2 Below-elbow amputations are indicated for advanced soft-tissue and bone tumors of the forearm and hand. Skin incision and osteotomy site for below-elbow amputation.

Additional length in a very short stump can be obtained by releasing the biceps tendon; adequate flexion of the stump will be provided by the brachialis muscle.

SURGICAL TECHNIQUE

The patient is supine with the ipsilateral shoulder slightly elevated. Standard anterior/posterior "fish-mouth" flaps are used. Occasionally, medial-lateral flaps are needed. Because of the excellent blood supply to the upper extremity, wound healing is rarely a problem.

The skin and superficial fascia are divided perpendicular to the skin surface (Figure 18.3). Large blood vessels are ligated in continuity and then suture-ligated. The nerves are handled delicately. They are pulled approximately 2 cm from their muscular bed, doubly ligated with nonabsorbable monofilament suture, and cut with a knife. Muscles are transected

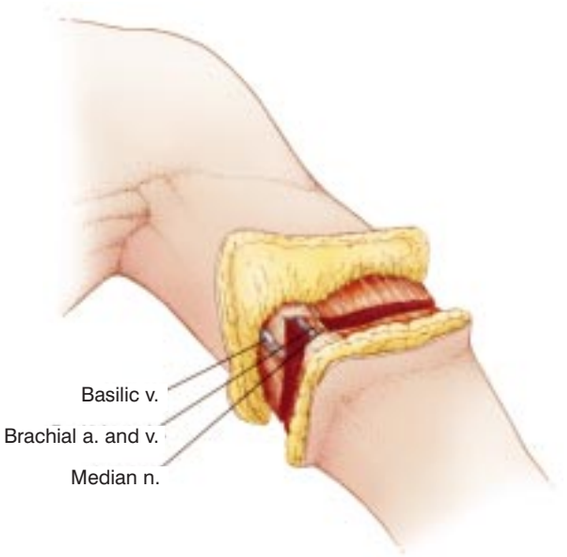

Figure 18.3 The skin and superficial fascia are divided perpendicular to the skin surface.

according to the flap design and the humerus or the radius and ulna are cut at the appropriate location, as determined by the preoperative imaging studies (Figure 18.4). The radius and ulna are transected at equal lengths.

For optimal function of the stump, it is important that muscle groups will be positioned tightly and securely over the transected bone ends (Figure 18.5). Myodesis is reinforced by Dacron tapes, passed through drill-holes made in the cut end of the bone. Superficial fascia and skin are closed over closed-suction drains (Figures 18.6 and 18.7).

A rigid dressing is used to decrease postoperative pain and edema (Figure 18.8). Care must be taken to adequately protect the skin that directly overlies the bone. Stump edema is rarely a significant problem in the upper extremity and prosthesis training should begin as soon as possible after surgery.

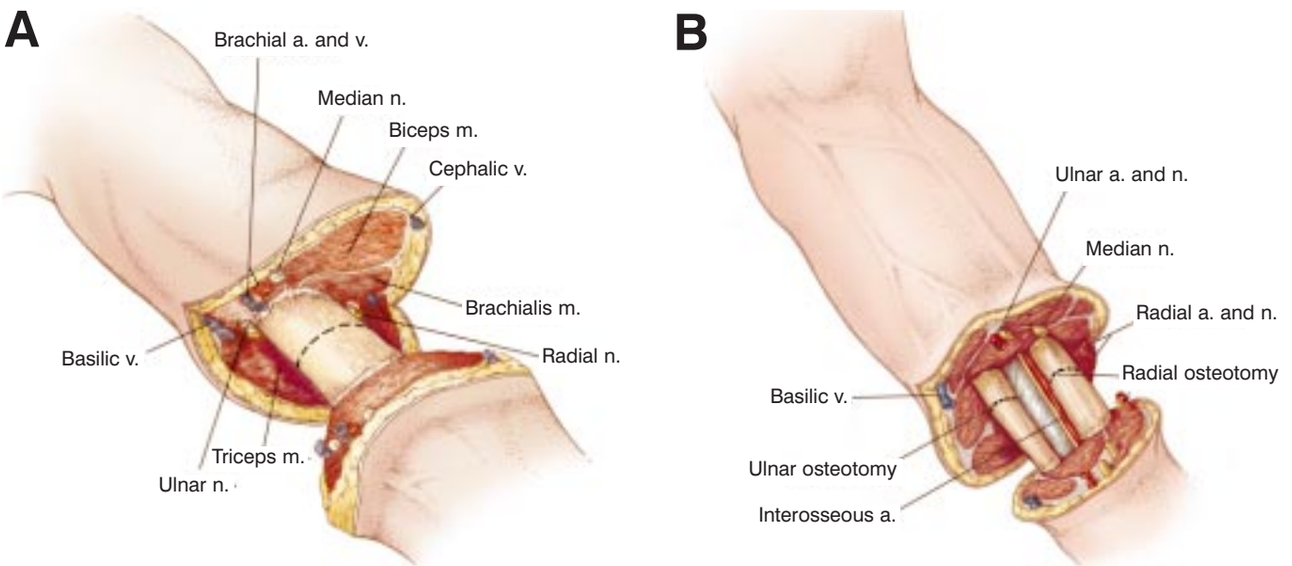

Figure 18.4 Osteotomies are performed at the appropriate location, as determined by the preoperative imaging studies: (**A**) above-elbow amputation, (**B**) below-elbow amputation. The radius and ulna are transected at equal lengths.

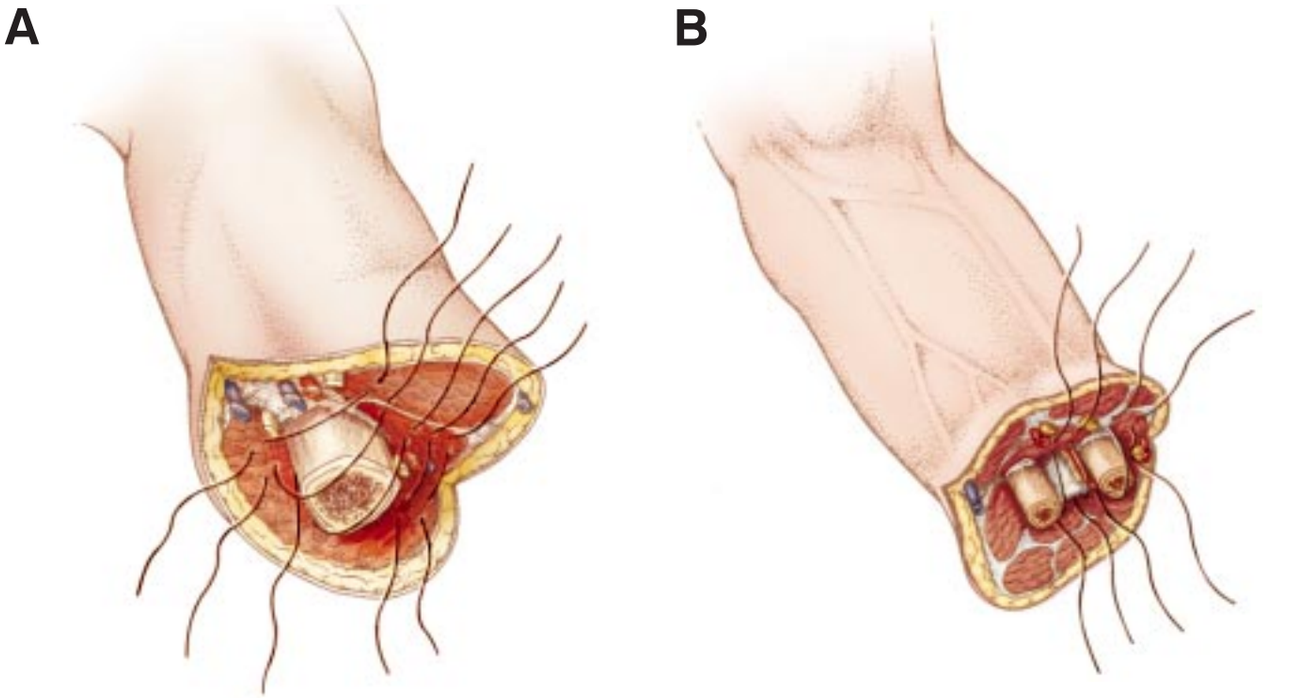

Figure 18.5 Muscle groups are positioned tightly and securely over the transected bone ends: (**A**) above-elbow amputation, (**B**) below-elbow amputation.

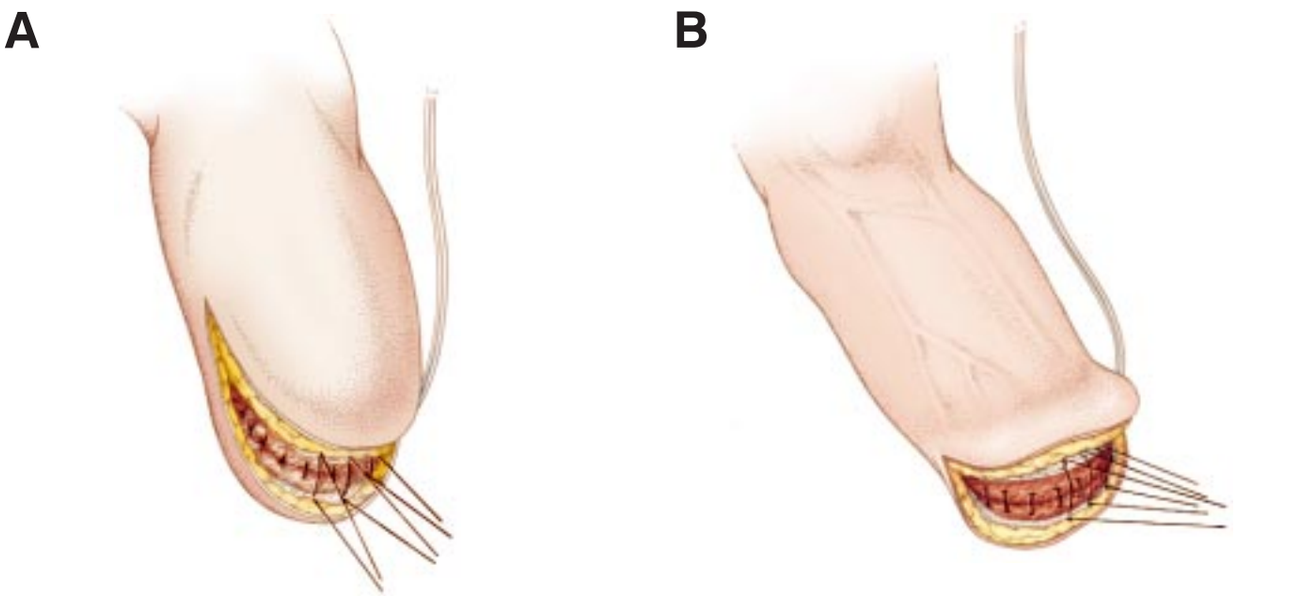

Figure 18.6 Superficial fascia and skin are closed over closed-suction drains: (**A**) above-elbow amputation, (**B**) below-elbow amputation.

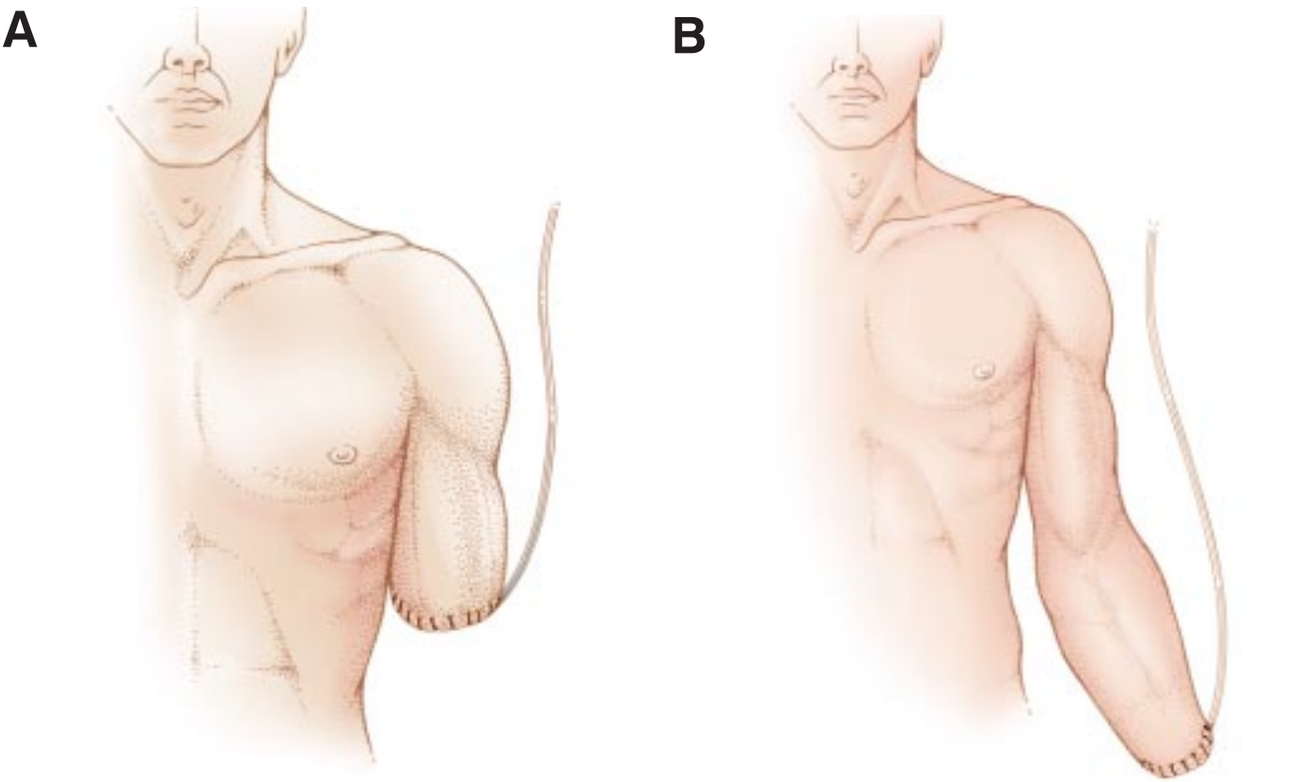

Figure 18.7 Final closure for (**A**) above-elbow amputation, (**B**) below-elbow amputation with closed-suction drains.

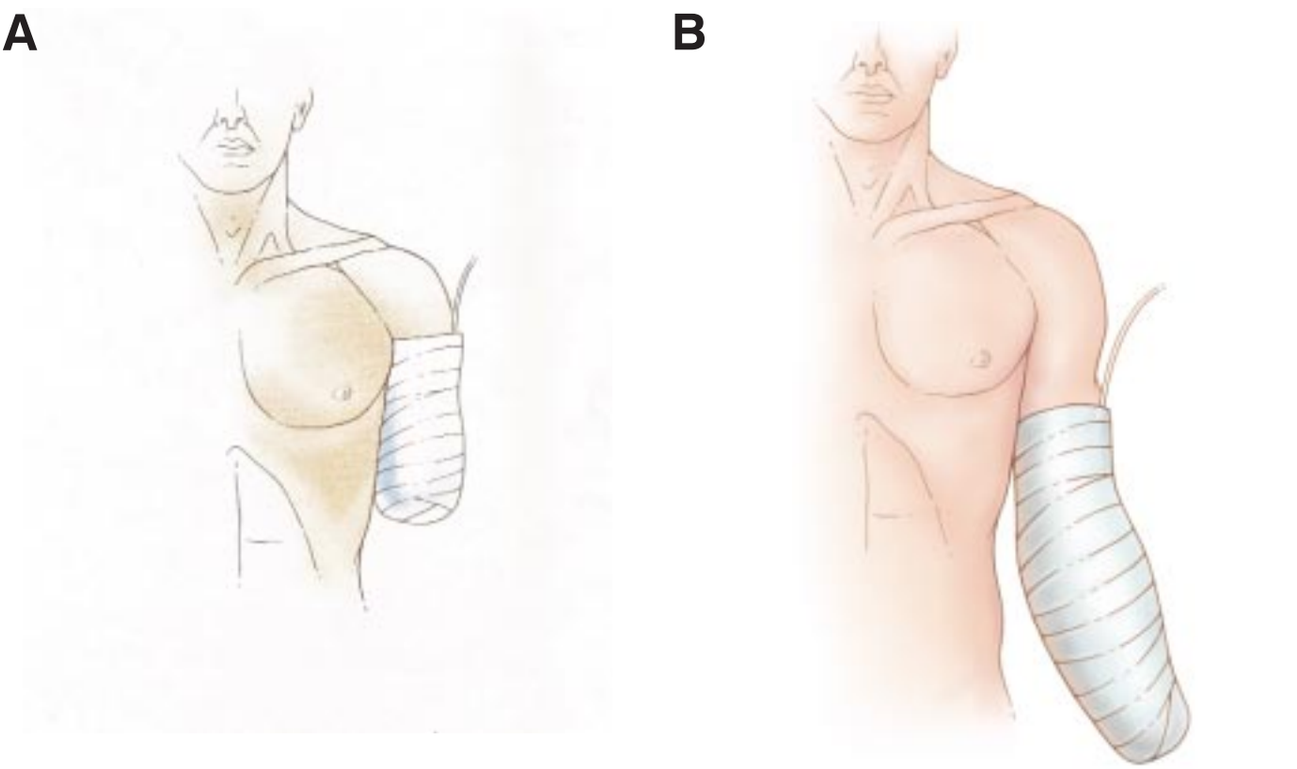

Figure 18.8 A rigid dressing is used to decrease postoperative pain and edema: (**A**) above-elbow amputation, (**B**) below-elbow amputation.