BACKGROUND

Forequarter amputation (interscapulothoracic amputation) entails en bloc removal of the upper extremity together with the scapula and the lateral aspect of the clavicle. This mutilating amputation of the upper extremity traditionally was done for high-grade sarcomas around the proximal humerus and scapula (FIG 1). Tumor response to chemotherapy and radiation therapy and the option of endoprosthetic reconstruction have made these procedures rare, and limb-sparing resections are safe alternatives in 90% to 95% of these cases.

ANATOMY

The upper extremity and scapula are attached to the upper torso and chest wall by soft tissue elements (ie, the rhomboid, levator scapulae, trapezius, pectoralis major and minor, latissimus dorsi, teres major, and serratus anterior muscles) and a single bone (ie, the clavicle). All of these must be transected to allow the performance of a forequarter amputation.

The axillary vessels and infraclavicular portion of the brachial plexus pass just inferiorly to the coracoid process, which is easily palpable, and lie below the deltopectoral fascia. These structures should be evaluated before surgery to determine the segment that can be safely transected and ligated, especially because large tumors may come close to the thoracic outlet.

Large tumors of the periscapular area may easily extend into the posterior triangle of the neck, the adjacent paraspinal muscles, and the underlying chest wall. Tumor extension into these anatomic sites must be evaluated carefully before surgery in case en bloc resection of a chest wall segment or a concomitant neck dissection is required.

INDICATIONS

Large soft tissue tumor around the proximal arm or axilla with neurovascular encasement and compromise and extension across the joint.

Large bone tumor (primary bone sarcoma or metastatic lesion) of the proximal humerus and scapula with and extensive soft tissue component and invasion into the shoulder joint and surrounding muscles.

Extensive locoregional tumor recurrence around the shoulder girdle.

Palliation of intractable pain or tumor fungation, associated with a rapidly enlarging lesion that has not responded to chemo- or radiation therapy (FIG 2).

Forequarter amputation usually is contraindicated when the tumor extends to the chest wall or to the posterior triangle of the neck and paraspinal muscles. This surgery can be considered in selected cases with no metastases, in which concomitant chest wall resection or neck dissection can achieve negative margins and patients can withstand the physiologic impact of these combined major surgeries.

IMAGING AND OTHER STAGING STUDIES

The combined use of CT and MRI allows the extent of bone and soft tissue tumor involvement to be determined and, thus, the potential size of the soft tissue margins to be estimated at the neck, paraspinal muscles, and chest wall (FIG 3).

Angiography is extremely helpful in locating the anatomic position of the axillary and brachial vessels, and in evaluating whether these structures are involved by tumor. Physical anomalies (eg, a duplicate axillary artery) occasionally are identified as well. Angiography also makes it possible to determine accurately the best level of ligation of the axillary vessels. No imaging studies can distinguish precisely whether the brachial plexus is infiltrated by tumor or whether the vessels and plexus are simply displaced, and they provide only indirect evidence of tumor extension to the nerves. On the other hand, venography of the axillary veins is a simple and accurate method of determining brachial plexus involvement. A brachial venogram will show complete obstruction of the main axillary veins when tumor is infiltrating the brachial plexus, whereas it will show venous patency and displacement when a tumor is adjacent to, but not infiltrating, the plexus.

SURGICAL MANAGEMENT

Position

The patient is placed in a full lateral position and is secured to the operating table at the hips with tape. Alternatively, a VAC pack can be used to secure the torso. An axillary roll is placed under the axilla to allow full excursion of the chest, and a sponge-rubber pad is placed under the hip to prevent ischemic damage to the skin in this area. The skin is prepared in the usual manner, and the tumor-bearing extremity is draped free (FIG 4).

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FIG 1 • A. Forequarter amputation entails en bloc removal of the upper extremity together with the scapula and the lateral aspect of the clavicle. B. MRI scan showing an extremely large axillary sarcoma involving the shoulder joint. A forequarter amputation was performed. A forequarter amputation is less commonly performed today than in the past. The most common indications include large sarcomas or carcinomas of the axillary space with involvement of the bony shoulder girdle or tumor fungation through the axilla. Occasionally, metastatic breast carcinoma to the axilla requires forequarter amputation if there is brachial plexus involvement (as a palliative procedure).

FIG 2 • A. Surgical illustration. B. Lymphoma of the shoulder girdle and brachial plexus with a non-union pathological fracture and no response to radiation therapy. This patient's arm was essentially useless and was extremely painful. It is rare for lymphomas to fail to respond to adjuvant therapy. C. Clinical photograph demonstrating tumor fungation through the skin.
FIG 3 • A. Plain radiograph showing destruction of the proximal humerus and the shoulder joint, as well as a non-union fracture. B. Plain radiograph demonstrating very large soft tissue mass in the axillary region caused by extraosseous growth of a Ewing sarcoma. C. CT scan showing a large mass protruding into the axillary space with probable involvement of the brachial plexus. D. Coronal MRI scan of a 63-year-old woman who presented with a fungating sarcoma of the axilla with extension to the proximal arm and scapula. The neurovascular bundle was encased and compressed by the tumor, and the patient had overt edema of the upper extremity and compromised radial and median nerve functions. E. CT scan demonstrating a large Ewing sarcoma. F. MRI scan showing the tumor protruding through the skin, fungating from the axillary area and deep, near the serratus anterior chest wall. G. Axillary venography showing that the axillary vein is almost completely thrombosed from compression by surrounding tumor. This appearance has proven to be an extremely reliable prognostic finding of brachial plexus involvement. If axillary venography shows axillary vein obstruction, a forequarter amputation almost is always required at the time of exploratory surgery.
FIG 4 • A. The patient is placed in a full lateral position and is secured to the operating table at the hips with tape. Alternatively, a VAC pack can be used to secure the torso. An axillary roll is placed under the axilla to allow full excursion of the chest, and a sponge-rubber pad is placed under the hip to prevent ischemic damage to the skin in this area. The skin is prepared, and the tumor-bearing extremity is draped free. B,C. Positioning of a 35-year-old woman with a recurrent sarcoma of the axilla. Note the scar from the previous surgery at the deltopectoral groove. D. Intraoperative photographs showing a locally recurrent osteosarcoma at the proximal arm and axilla in a 34-year-old patient. E. A 59-year-old woman with a locally recurrent malignant melanoma extensively involving the arm, axilla, and shoulder that grew rapidly despite chemotherapy, immunotherapy, and radiation. F. Anterior approach. The first structure transected is the pectoralis major muscle. G. Posterior approach. The incision starts proximal over the shoulder and extends distally along the axillary border of the scapula and curves toward the midline. A large subcutaneous (or fasciocutaneous) flap is developed. The pectoralis major muscle has been transected; this photograph demonstrates the pectoralis minor over the tumor. H. A large posterior fasciocutaneous flap following a forequarter amputation for a large fungating tumor of the anterior axillary area. Therefore, a large posterior fasciocutaneous flap has been raised using a component of skin from the posterior two-thirds of the arm. This is a common technique when the usual anterior flap is compromised. I. This extended posterior fasciocutaneous flap is extremely reliable and can be rotated to close large chest wall and anterior defects as well as the posterior triangle of the neck. J. Closure of the entire surgical defect. Note the flap has covered the large area extending to the midline anterior, to the base of the neck, and the adjacent chest wall. (A: Courtesy of Martin M. Malawer.)
Incision

- The anterior component of the incision starts over the clavicle about 2 cm lateral to the sternoclavicular joint. Caudally, the incision line is in or near the deltopectoral groove; superiorly, it crosses the tip of the acromion. These two lines meet below the axilla to include the skin-bearing axillary hair and hematoma that results from the biopsy (TECH FIG 1).

- The final shape of the flaps and position of the lines of incision will vary according to the individual tumor extent. Because of the excellent blood supply to the skin in this region, long anterior or posterior flaps generally survive even though they are closed under considerable tension.

TECH FIG 1 • A. The anterior component of the incision starts over the clavicle about 2 cm lateral to the sternoclavicular joint. Caudally, the incision line is in or near the deltopectoral groove; superiorly, the incision line crosses the tip of the acromion. Intraoperative photographs showing the anterior (B) and posterior (C) arms of the incision. These two lines meet below the axilla to include the skin-bearing axillary hair. D. The anterior flap is elevated, exposing the clavicle, acromion, and the overlying origin of the pectoralis major muscle. E. The origin of the muscle is detached from the clavicle and an osteotomy is performed. F. The underlying brachial plexus and subclavian vessels are identified and clamped.
tension. Occasionally, large tumors extend to the overlying skin and require en bloc resection with a substantial area of skin. This results in a wound defect that cannot be closed primarily and will require a skin graft or be left for a delayed wound closure.

- The anterior skin flap, which can be extended to the mid-sternum, usually is constructed first, with the surgeon standing in front of the patient. The surgeon then switches position to stand behind the patient and constructs the posterior flap to the medial border of the scapula.

### Removal of the Affected Limb and Scapula

- Anterior vascular exploration is performed by detaching the pectoralis major muscle from the clavicle. A clavicular osteotomy is performed at the proximal one-third junction, and the underlying brachial plexus and subclavian vessels are identified. A Statinski clamp can be placed high along the vessels, and surgery can then proceed as planned.

- The posterior approach is used to detach the scapula from the rhomboid, trapezius, levator scapulae, and latissimus dorsi muscles. The scapula is lifted from the chest wall by detaching the serratus anterior muscle from its inner plate and the latissimus dorsi at its lowest point. This exposes the posterior chest wall and allows the surgeon to place his or her hand into the axillary space to check for chest wall or intercostal muscle involvement, whereupon the planned amputation can proceed.

- If the chest wall is involved, a combined chest wall and forequarter amputation can be performed. An axillary incision is made to connect the anterior and posterior incisions. The entire forequarter is removed after ligation and transection of the brachial plexus and subclavian vessels (TECH FIG 2).

### Soft Tissue Reconstruction and Wound Closure

- The area is copiously irrigated. The large posterior flap is closed over the remaining chest wall defect (TECH FIG 3A,B). Marked redundancy of the skin may present an unacceptable cosmetic appearance, so every effort should be made to ensure that the skin flaps are carefully approximated.

- The mid-portion of the long posterior skin flap is approximated to the mid-portion of the anterior flap. Carrying out the closure in this way pleats the longer posterior skin flap and prevents unsightly folds of skin. A two-layered closure, first of superficial fascia and then of skin, is used. Generous suction drainage under the anterior and posterior skin flaps is secured (TECH FIG 3C,D). Suction drains are removed when serous drainage is minimal.

![TECH FIG 2 • A,B. Detachment of the scapular attachments of the rhomboids, trapezius, levator scapulae, and latissimus dorsi muscles. (continued)
TECH FIG 2  •  (continued) C,D. The scapula being lifted from the chest wall by detaching the serratus anterior muscle from its inner plate and the latissimus dorsi at its lowest point. E,F. Exposure of the posterior chest wall. This allows the surgeon to palpate the surface of the chest wall and axilla for tumor detection and determine if amputation can proceed as planned or if additional chest wall resection is required. G. The subclavian vessels are ligated and the brachial plexus transected. H. This allows removal of the forequarter. I. Gross findings showing tumor involvement of the brachial plexus as well as the axillary artery and vein. Because this tumor closely approached the neck, the subclavian artery was ligated proximally.
TECH FIG 3 • **A.** Illustration showing the exposed chest wall and fasciocutaneous flaps remaining after forequarter amputation. **B.** Intraoperative photograph showing mobilization of the large posterior flap anteriorly over the chest wall. Illustration (C) and intraoperative photograph (D) showing split-thickness graft used to cover the chest wall in tumors with skin infiltration over a wide area.

PEARLS AND PITFALLS

| Preoperative                        | ■ Detailed radiologic assessment of the soft tissue extent of the tumor, its vascular anatomy, and determination of neck and chest wall invasion. If the latter exists and amputation is feasible, make the necessary preparations for concomitant chest wall resection or neck dissection. |
| Intraoperative                     | ■ Patient is placed in a full lateral position. Clavicular osteotomy and clamping of the subclavian vessels are done first.  
 ■ Intraoperative palpation of the chest wall to assess tumor extension.  
 ■ Trimming of the posterior flap to avoid redundancy and formation of skin folds.  
 ■ Bupivacaine (Marcaine) infusion through an epineural catheter in the nerve sheath in an effort to decrease postoperative pain and causalgia. |
| Postoperative                      | ■ Assisted postoperative ambulation to avoid loss of balance. Early occupational therapy. |

POSTOPERATIVE CARE AND REHABILITATION

■ Continuous suction usually is required for 5 to 7 days, and perioperative intravenous antibiotics are continued until the drainage tubes are removed. Phantom pain (causalgia) is a major problem following high-level amputations. We use an epineural catheter placed into the axillary sheath at the time of surgery and infuse 0.25% Marcaine for 3 to 5 days postoperatively. This decreases postoperative pain and may lessen late causalgia syndromes.

■ Patients initially have difficulty in keeping their balance because of the acute weight inequality of their upper torso and tend to fall toward the contralateral side. This problem typically resolves itself after a few days of assisted walking.

■ It is crucial to have an occupational therapist involved early in the postoperative period to teach the patient how to perform the activities of daily living with a single upper extremity. This is even more critical when the amputated extremity is the dominant one.

■ A cosmetic prosthesis can be fitted on wound healing and resolution of wound edema, usually 4 to 6 weeks after surgery.

OUTCOMES

■ Forequarter amputation is a mutilating procedure that has a profound aesthetic, psychological, and functional impact on patients. Furthermore, it is done for large and aggressive tumors that bear a high risk of metastatic dissemination. Most patients who undergo forequarter amputation gain local con-
control over their tumor but still face the likelihood of distant metastases.
- Pain relief and improved quality of life are pronounced in patients who have undergone palliative amputation to control intractable pain associated with a rapidly enlarging tumor that had not responded to chemo- and radiation therapy. Most patients who undergo forequarter amputation regain reasonable function and are able to perform most daily activities.
- For some still undefined reason, phantom limb pain is less common and less disturbing than that associated with high amputation of the lower extremities.

**COMPLICATIONS**
- Flap ischemia, usually superficial and marginal because of the good blood supply of the shoulder girdle (FIG 5); it usually resolves spontaneously.
- Occasionally, full-thickness necrosis of the posterior flap. A clear demarcation line appears after 4 to 7 days, after which debridement of the necrotic segment and primary closure is carried out.
- Phantom limb pain
- Local tumor recurrence

**REFERENCES**

**FIG 5** • Superficial flap ischemia occurring 3 days after surgery in a 37-year-old patient who underwent forequarter amputation for locally progressive malignant melanoma. The ischemic changes resolved spontaneously after 5 days.