Utilitarian Shoulder Approach for Malignant Tumor Resection

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Malignant tumors involving the shoulder girdle can arise from four distinct locations: the proximal humerus, scapula, periscapular muscles, and axillary structures. This article describes a utilitarian shoulder approach that can be used to resect these tumors.

The utilitarian shoulder approach can be used to resect shoulder girdle tumors. It accomplishes wide exposure of all shoulder girdle tumors and the adjacent neurovascular structures, facilitating mobilization and protection of key structures and enabling adequate resection.

Malignant tumors involving the shoulder girdle can arise from four distinct locations: the proximal humerus, scapula, periscapular muscles, and axillary structures. Surgical resection often is technically challenging as most tumors in these locations require resection via anterior and posterior exposure (Figure 1). An adequate surgical margin and a safe resection are best facilitated by complete exposure of the tumor and axillary vessels/brachial plexus.

To reduce the surgical complexity and complications associated with limb-sparing surgery for tumors in this region, the senior author (M.M.M.) has developed an approach for resection, termed the utilitarian shoulder approach, which accomplishes safe exposure of the neurovascular structures; permits a reliable, wide excision of all tumors; and reduces morbidity associated with resections in this difficult anatomic area.

The utilitarian shoulder approach is based on an incision with three arms: anterior (A), posterior (B), and anteroinferior (C) (Figure 2). The anterior approach (extended deltopectoral groove incision A) combined with detachment and mobilization of the pectoralis major and strap muscles (eg, coracobrachialis, short head of the biceps, pectoralis major), permits complete visualization of neurovascular structures (eg, the infraclavicular...
brachial plexus and axillary vessels). The posterior approach (B incision) accomplishes wide exposure of the scapula, deltoid, trapezius, rhomboids, and latissimus dorsi. The anteroinferior axillary incision (incision C) is a modification of the anterior approach that extends medially from the deltopectoral groove and curves into the axilla. It provides wide exposure of the axillary contents and is useful for large tumors in this area.

The success of the utilitarian shoulder approach is based on wide exposure and exploration of the tumor, axillary vessels, and brachial plexus. This facilitates mobilization and protection of all key structures amenable to preservation. Anterior and posterior approaches can be combined, which is particularly useful for large scapular and proximal humeral tumors. For smaller or low-grade tumors, any portion of any arm can be used or extended, depending on the anatomic location and extent of the tumor. In instances where the tumor is deemed unresectable after anterior exploration, the approach can be converted to a forequarter amputation without unnecessary contamination of skin and muscle flaps.

**SURGICAL TECHNIQUES**

**Utilitarian Incision**

The utilitarian incision consists of three arms (A, B, and C) (Figure 2). Each arm of the incision results in the formation of a skin flap in which the base is at least as wide as the length of the flap. The anterior arm (A) is used primarily for proximal humerus resections and is modified for axillary tumors (C). The incision is extended posterolaterally over the shoulder (portion of B incision) for an extra-articular proximal humerus resection. A portion of the anterior incision (A) and the entire posterior incision (B) are used for extra-articular scapula resections and total scapulectomies. Any combination of incisions can be used for resecting soft-tissue sarcomas; this decision is based on the muscle of origin. Each arm is used to varying degrees depending on the anatomic location and extent of the tumor.

We recommend an anterior approach be performed first so immediate exploration and mobilization of the brachial plexus can occur. At this point, if the tumor is deemed unresectable, the procedure can be converted to a forequarter amputation. Following the incision, skin flaps (fasciocutaneous, if possible) are raised to gain adequate exposure.

**Incision A: Anterior Approach**

The anterior incision (extended deltopectoral incision) extends from the middle third of the clavicle and passes 1 cm medial to the coracoid process, across the axillary fold, and distally along the anteromedial aspect of the arm, following the course of the neurovascular bundle. The key step for exposing the neurovascular bundle is releasing the pectoralis major from its humeral insertion and releasing the strap muscles (e.g., pectoralis minor, short head of the biceps, and coracobrachialis) from their insertions on the coracoid (Figure 3). After the pectoralis major is released, the musculocutaneous nerve is dissected at the point where it enters the coracobrachialis and short head of the biceps (2-7 cm inferior to the coracoid).
ated with #0 silk ties and metallic clips. This step is crucial for mobilization of the neurovascular bundle. The axillary nerve is ligated for proximal humerus tumors that require an extra-articular resection. Scapular and large axillary tumors may require ligation of any of the following structures: upper and lower subscapular nerves, subscapular artery, thoracodorsal nerve, lateral thoracic artery, and long thoracic nerve.

Incision B: Posterior Incision

The posterior incision begins superiorly over the shoulder, extending from the clavicular origin of the extended deltopectoral (anterior) incision. It follows the axillary border of the scapula to its tip and curves medially approximately 2-3 cm to permit construction of a large, medially-based flap. A fasciocutaneous (not subcutaneous) flap is used if deemed oncologically safe.

Traditional scapular incisions have been constructed obliquely across the body of the scapula and have not allowed for adequate visualization and mobilization of the periscapular muscles. This medially-based flap not only fully exposes the scapula, rhomboids, levator scapulae, and trapezius muscles, but also permits entrance to the posterior axillary space. A lateral flap also is developed that exposes the deltoid, proximal triceps, and teres minor and teres major muscles. Thus, all appropriate muscles can be resected or preserved and later transferred during the reconstruction phase of the procedure. For scapular tumors, early exploration of the chest wall once the rhomboid muscles are detached is performed initially to determine chest wall involvement and hence operability.

Incision C: Axillary Approach

The axillary incision is useful for resecting large axillary tumors that fill the axillary space (Figure 2). The axillary incision is a 6-cm extension of the anterior incision. It courses medial and inferior to the pectoralis major toward the base of the axillary space. It permits complete visualization of the inferior aspect of the axilla and lateral chest wall. The anterior component permits mobilization of the neurovascular structures whereas the axillary extension allows access to the axillary contents.

TUMOR RESECTION

Proximal Humerus Tumors

When an extra-articular resection of the proximal humerus is performed, anterior exposure of the neurovascular structure and ligation of the axillary nerve is performed first. Then the incision is extended posterolaterally (portion of B), over the top of the shoulder (Figure 4). A medially-based fasciocutaneous skin flap is developed. The trapezius is released from the scapula and lateral clavicle. An incision is then made through the rotator cuff medial to the coracoid, extending from the subscapularis and passing sequentially through the supraspinatus, infraspinatus, and teres minor muscles. The latissimus dorsi and teres major are then released from the proximal humerus.

Osteotomies are made through the humeral shaft at least 2 cm distal to the anatomic extent of the tumor, through the lateral one-third of the clavicle, and through the scapula medial to the coracoid. An extra-articular resection is completed (type VB resection, Malawer classification). Care must be taken at this point to avoid unnecessary traction on the axillary artery and the brachial plexus. The resected specimen consists of the proximal humerus removed en bloc with the lateral portion of the scapula, intact glenohumeral capsule, overlying rotator cuff, proximal portion of the long head of the biceps tendon, and the deltoid muscle. For an intra-articular resection (type IA resection, Malawer classification), only the anterior arm of the approach is used. The deltoid, rotator cuff, and capsule are released from the humerus. The axillary nerve is preserved. Humeral osteotomy is performed.

Scapular Tumors

In an extra-articular scapula resection, following neurovascular explo-
ration (A incision), the incision is extended posterolaterally to create a wide, medially-based skin flap (B incision) (Figure 5). All periscapular muscles, specifically the trapezius, rhomboids, levator scapulae, and latissimus dorsi, are sequentially released and tagged with a #0 nonabsorbable suture. An osteotomy is made through the proximal humerus at the inferior border of the subscapularis muscle (extra-articular osteotomy). A clavicular osteotomy is made through the lateral one-third of the clavicle. The scapula and tumor are removed en bloc with rotator cuff, capsule, and proximal humerus (Malawer type IVA resection).

**Axillary Tumors**

Incision C is used for axillary tumors. Release and mobilization of the pectoralis major muscle toward the chest wall provides excellent exposure of the entire axilla. Following dissection and mobilization of the brachial plexus and neurovascular structures from the tumor and ligation of the tethering neurovascular structures, the tumor can be removed en bloc (Figure 6).

**Soft-Tissue Tumors**

Soft-tissue sarcomas that arise in proximity to the neurovascular bundle are approached in a similar manner to that of axillary tumors. The utilitarian incision that is used depends on the muscle origin and the extent of the tumor. In general, at least the entire muscle of origin is resected for high-grade sarcomas. Soft-tissue sarcomas rarely invade adjacent bony structures and rarely require en bloc resection with a portion of the shoulder girdle. If bony invasion occurs, resection and reconstruction follow the principles outlined for scapular or proximal humerus tumors.

**RECONSTRUCTION AND CLOSURE**

Following resection, bony reconstruction is performed for tumors that required a major bony resection. We recommend endoprosthetic reconstruc-

tion of the proximal humerus or scapula, although the utilitarian approach for resection described herein may be used in conjunction with any reconstruction method.

Following bony reconstruction, soft-tissue reconstruction commences. The short head of the biceps is tenodesed proximally to the coracoid (intra-articular proximal humerus reconstruction) or to the clavicle (extra-articular proximal humerus reconstruction) or pectoralis major (total scapula resection). The pectoralis minor also is tenodesed back to its origin, when possible, or to the scapula to protect the neurovascular structures. The pectoralis major is repaired to its humeral insertion, or in cases requiring extra-articular proximal humerus reconstruction, transferred to cover the prosthesis with soft tissues. The latissimus dorsi may be transferred laterally to function as an external rotator following extra-articular proximal humerus resection.

In total scapula reconstruction, the periscapular muscles are tenodesed to the prosthesis with heavy nonabsorbable sutures or tapes. In total scapula reconstruction, the periscapular muscles are tenodesed to the prosthesis in a manner that covers the entire prosthesis with muscle. Following isolated axillary tumor resection, the distal (numeral) cut edge of the latissimus dorsi is rotated into the defect and sutured to the superficial surface of the subscapularis muscle to fill the dead space. Large-bore closed suction drains are routinely placed prior to skin closure (Figure 7).

**DISCUSSION**

Traditionally, shoulder girdle tumors often have been resected through exposures that provide poor visualization of neurovascular structures.
humeral tumors have been resected through a limited anterior deltopectoral approach; scapular and periscapular tumors through a limited oblique surgical incision based over the posterior scapula. Axillary tumors have been resected through a limited inferiorly-based axillary approach. In all cases, poor exposure of the brachial plexus and axillary vessels may result in unnecessary complications and the inability to resect the tumor with adequate surgical margins.

We describe a utilitarian approach that has been used for surgical resection of proximal humerus, scapula, and axillary tumors in 155 patients. This approach permits wide exposure of the infraclavicular brachial plexus, axillary vessels, and major nerves, (axillary, musculocutaneous, median, ulnar, and radial). The incision consists of three components: anterior, posterior, and axillary. Any portion, or all three elements, can be used for resection of bone and soft-tissue tumors of the proximal humerus, scapula, periscapular muscles, and axilla. Releasing the pectoralis major from the proximal humerus and the coracoid insertions of the strap muscles is the key to exposure of the brachial plexus and axillary vessels. This ensures safe mobilization of major neurovascular structures. Optimal surgical margins are facilitated, and unnecessary complications (eg, inadvertent neurovascular injury) and local recurrence are minimized. Pectoralis major, triceps, and biceps strength return with rehabilitation. This approach is recommended for major resection of bone and soft-tissue tumors of the shoulder girdle.

REFERENCES