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 all key structures and enabling adequate tumor resection.

Malignant tumors involving the shoulder girdle can arise from four distinct locations: the proximal humerus, scapula, periscapular muscles, and axillary structures (e.g., axillary lymph nodes, nerves, and vessels). Surgical resection often is technically challenging as most tumors in these locations are large, juxtaposed to the axillary vessels and brachial plexus, involve multiple muscles, and often 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 (E) (Figure 2). The anterior approach (extended deltopectoral groove incision A) combined with detachment and mobilization of the pectoralis major and strap muscles (e.g., coracobrachialis, short head of the biceps, pectoralis major), permits complete visualization of neurovascular structures (e.g., the infraclavicular...
The posterior approach accomplishes wide exposure of the neurovascular structures. The posterior approach (B) begins above the supraspinatus area and proceeds along the axillary border of the scapula, curving medially at the inferior angle of the scapula to develop a large medial-based fasciocutaneous flap. The anteroinferior incision (C) is a modification of the anterior approach that extends medially from the deltoid to expose the neurovascular structures. The anteroinferior incision (C) is a modification of the anterior approach that extends medially from the deltoid to expose the neurovascular structures.

Figure 2: The utilitarian shoulder approach consists of an incision with three arms: anterior (A), posterior (B), and anteroinferior (C). The anterior approach (A) accomplishes complete exposure of the neurovascular structures. The posterior approach (B) begins above the supraspinatus area and proceeds along the axillary border of the scapula, curving medially at the inferior angle of the scapula to develop a large medial-based fasciocutaneous flap. The anteroinferior incision (C) is a modification of the anterior approach that extends medially from the deltoid to expose the neurovascular structures.

Figure 3: Anterior incision. Intraoperative photograph showing the release of the pectoralis major from its humeral insertion (A). Following release of the pectoralis major, the pectoralis minor and short head of the biceps muscles are released from the coracoid process (B). This exposes the infrascapular portion of the brachial plexus and the axillary vessels (C). The curved arrow shows the musculocutaneous nerve (pectoralis minor has retracted down to the pectoralis major). Abbreviations: B=short head of the biceps muscle, L=latissimus dorsi, P=pectoralis major, S=subscapularis, and V=vein.

Surgical Utilitarian Incision

The utilitarian three arms (A, B, C) are used in combination to provide exposure of the entire shoulder with a flail flap on the humerus. Each arm of the incision provides a base that extends medially from the deltoid to expose the neurovascular structures. The anteroinferior approach allows for exposure of the axillary vessels and the brachial plexus. The posterior approach provides wide exposure of the neurovascular structures. The anteroinferior approach, when combined with the posterior approach, allows for exposure of the neurovascular structures and the axillary vessels. In instances where tumors are deemed unresectable, the exploration is converted to a fore without unnecessary skin and muscle flap.

The success of the shoulder approach is based on the exploration of the neurovascular structures and brachial plexus. The anteroinferior approach can be combined with the posterior approach and is useful for large scapular tumors. Grade tumors, any can be used or extended to expose the anatomic local tumor. In instance deemed unresectable, the approach is converted to a fore without unnecessary skin and muscle flap.

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brachial plexus and axillary vessels). The posterior approach (B incision) accomplishes wide exposure of the scapula, deltoitd, 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 and the entire posterior incision are used for extra-articular scapula resections and total scapulectomies.

_Take Home “Pearl”...

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**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. Medial and lateral fasciocutaneous skin flaps are raised. The key step for exposing the neurovascular bundle is releasing the pectoralis major from its humeral insertion and releasing the strap muscles (eg, 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). The short head of the biceps and coracobrachialis are then released from their coracoid insertions while protecting the underlying plexus and musculocutaneous nerve. The pectoralis minor is released from the coracoid (Figure 3). The entire neurovascular bundle from the clavicle to the proximal humerus can now be visualized.

Next, the axillary nerve, at the lower border of the subscapularis muscle, and the radial nerve, at the lower border of the latissimus dorsi muscle, are identified and surrounded with vessel loops. Anterior and posterior humeral circumflex vessels are isolated and doubly lig-

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ORTHOPEDICS wants to hear from you. Send submissions to Steven F. Harwin, MD, % ORTHOPEDICS, 6900 Grove Rd, Thorofare, NJ 08086; or contact Robin J. Vadel, Managing Editor, at (856) 848-1000; fax (856) 848-6091; e-mail rvadel@slackinc.com; or www.slack-inc.com/ortho.htm.
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 superiority 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 major 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 tumor. 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 exposure (A incision), the lateral one-third of the scapular osteotomy is removed. Scapular tumors are approached through an osteotomy of the subscapular osteotomy. An axillary approach 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.

Soft-Tissue Tumor

Soft-tissue proximity to the axilla is approached that of axillary incision that muscle origin tumor. In general, muscle of ori grade sarcoma rarely invade and rarely resection with a portion bony invasion resection outlined for humerus tumours.
lateral incision permits neurovascular exposure of the axillary vessels. The technique is as follows. Through the transthoracic incision (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 reconstruction 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 reconstruction). 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 resection, the peri- scapular 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.6 Proximal
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 (e.g., 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

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