Large Tumors of the Axilla
Limb-sparing Resection Versus Amputation in 27 Patients

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Tumors of the axilla are rare and pose a surgical challenge because they are usually large at presentation and in close proximity to the major neurovascular bundle of the upper extremity. The use of detailed preoperative evaluation studies and extensile surgical exposure for these tumors enabled us to determine tumor resectability and proceed with a safe resection or perform an amputation when required. We retrospectively reviewed 27 patients who underwent resection of an axillary tumor from 1989 to 2004 and analyzed their presenting symptoms, results of preoperative studies, type of surgery, and functional outcome. Tumors were exposed using a utilitarian shoulder approach that revealed no tumor invasion of the neurovascular bundle in 19 patients and invasion in eight. The former group was treated with tumor resection and the latter with forequarter amputation. Neurologic deficit, limb edema, and angiographic observation of arterial narrowing were associated with amputation. Good function was achieved in 15 of 19, shoulder range of motion was preserved in 14 of 19, and local tumor control was maintained in 16 of 19 patients who underwent a limb-sparing resection.

Level of Evidence: Level IV, therapeutic study. See the Guidelines for Authors for a complete description of levels of evidence.

The axilla is a relatively small space through which the major neurovascular bundle (NVB) to the upper extremity and a rich network of lymph nodes and channels pass. Tumors at this site are rare and usually reach a considerable size before clinical detection probably because of the elasticity of the tissues confining the walls of the axilla and their deep location. Axillary tumors usually wrap around, push, and occasionally invade the NVB. Tumor extension into the chest wall also has been documented. As a result, a segment of the brachial artery or an adjacent component of the chest wall may require removal with the tumor to achieve free margins of resection. Gross invasion of the NVB necessitates forequarter amputation to achieve local tumor control.

The unique anatomic considerations pose a challenge because of the proximity of the tumors to the NVB and the potential damage to the function and viability of the upper extremity. Resection with the traditional approach through the base of the axilla is difficult because the tumor cannot be fully seen and the NVB cannot be identified and mobilized before resection. Chest wall resections and vascular reconstructions cannot be performed through such limited space.

The decision of whether to resect an axillary tumor is made only after surgical verification the NVB has not been invaded by the tumor and the spared limb will be functional. We therefore sought specific signs or symptoms at presentation, and results of preoperative imaging and nerve conduction studies, that would enable preoperative evaluation of NVB tumor extension and thus predict the feasibility of performing a limb-sparing resection of an axillary tumor. We also questioned whether an extensile surgical approach to the axilla would allow wide exposure of the NVB and safe tumor resection in cases where such resection was feasible.

MATERIALS AND METHODS
We retrospectively reviewed 27 patients who underwent preoperative evaluation and surgery for large (average diameter, 7.5
cm; range, 5–12 cm) soft tissue tumors of the axilla from 1989 to 2004 (Fig 1). There were 17 women and 10 men. The median age was 54 years (range, 28–81 years). The axillary mass was asymptomatic and detected incidentally in 14 patients. It was associated with local discomfort in eight patients, and five patients reported paresthesias along the distribution of a specific nerve (two radial, two ulnar, one medial). Patients were followed for a minimum of 2 years (mean, 5.3 years; range, 2.5–11 years).

Preoperative assessment included evaluation of arterial pulses, presence of upper extremity edema, and neurologic status of the ipsilateral upper extremity. Imaging studies included plain radiography, computed tomography (CT) and/or MRI, and angiography of the entire ipsilateral shoulder girdle. Plain radiography and CT were used to rule out invasion by the tumor of the proximal humerus, scapula, and chest wall. We used MRI to evaluate tumor extent and its relation to the adjacent NVB and the surrounding cuff of muscles. We used angiography to assess the relation of the axillary and brachial vessels to the tumor, the pattern of possible vascular displacement, the presence of vascular anomalies, and vascular patency. All patients had electromyography of the upper ipsilateral extremity. Histopathologic diagnoses were made using a CT-guided core needle biopsy in 22 patients and an open technique in five. The diagnoses included 15 primary and 12 metastatic tumors (Table 1). Three of the six patients who had metastatic tumors of the axilla had additional lung metastases; all six patients were expected to survive for at least 6 months postoperatively.

Clinical preoperative evaluation of the study patients showed intact arterial pulses in all patients, diffuse swelling of the upper extremity in six, and neurologic deficit in six (two patients, one nerve; one patient, two nerves; three patients, three nerves) (Table 2). Imaging studies showed arterial displacement in 10 patients and chest wall invasion in two. Electromyography showed neuropathologic changes in six patients with neurologic deficits and in an additional four patients in whom neurologic deficits were not clinically evident. Angiograms were performed in 21 patients. Arterial displacement, narrowing, or both were documented in 15 patients. None of the arteriograms showed evidence of frank vascular invasion.

Of the eight patients with high-grade sarcoma of the axilla, five were treated with pre- and postoperative chemotherapy, one was treated with postoperative chemotherapy only, and the remaining two patients with neither. All eight of these patients received postoperative radiotherapy using 6500 Gy external beam radiation.

All tumors were exposed using the utilitarian shoulder approach. We used a deltopectoral incision (utilitarian shoulder approach) that started at the junction of the outer and middle thirds of the clavicle, continued along the deltopectoral groove, and terminated over the anterior axillary fold (the inferior border of the pectoralis major muscle) (Fig 2). We opened the superficial fascia, ligated the cephalic vein, and raised the medial and lateral fasciocutaneous flaps. Exposure of the axillary cavity was achieved after detaching and reflecting two muscle layers. One was a superficial layer that included the pectoralis major muscle and the other was a deep layer that included the coracobrachial attachment of the pectoralis minor and the conjointed tendon (ie, the coracobrachialis muscle and the short head of the biceps muscle). The pectoralis major was detached from its insertion to the proximal humerus leaving at least 1 cm of the tendon for reattachment (Fig 3). The coracobrachialis process then was observed and the muscle attachments were divided and detached at their insertion. The conjointed tendon was reflected caudally, taking care to prevent traction injury to the musculocutaneous nerve, which penetrates the substance of the coracobrachialis muscle, after which the pectoralis minor muscle was reflected medially (Fig 4A–C). All edges of the reflected muscles were tagged with a suture for later identification for use in reconstruction. The anatomic relation of the tumor to the NVB then was determined.

![Fig 1. An MR image shows a large high-grade malignant fibrous histiocytoma of the right axilla.](image-url)

**TABLE 1. Histopathologic Diagnoses of the 27 Study Patients**

<table>
<thead>
<tr>
<th>Histopathologic Diagnoses</th>
<th>Number of Patients</th>
</tr>
</thead>
<tbody>
<tr>
<td>Benign lesions</td>
<td></td>
</tr>
<tr>
<td>Atypical lipoma</td>
<td>4</td>
</tr>
<tr>
<td>Benign-aggressive lesions</td>
<td></td>
</tr>
<tr>
<td>Fibromatosis</td>
<td>3</td>
</tr>
<tr>
<td>Soft tissue sarcomas</td>
<td></td>
</tr>
<tr>
<td>Malignant fibrous histiocytoma</td>
<td>3</td>
</tr>
<tr>
<td>Synovial cell sarcoma</td>
<td>2</td>
</tr>
<tr>
<td>Radiation-induced angiosarcoma</td>
<td>1</td>
</tr>
<tr>
<td>High-grade spindle cell sarcoma</td>
<td>2</td>
</tr>
<tr>
<td>Malignant melanoma</td>
<td></td>
</tr>
<tr>
<td>Adenocarcinoma of the breast</td>
<td>3</td>
</tr>
<tr>
<td>Metastatic carcinomas</td>
<td></td>
</tr>
<tr>
<td>Squamous cell carcinoma</td>
<td>3</td>
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<tr>
<td>Total</td>
<td>27</td>
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</table>
### TABLE 2. Relation of Positive Preoperative Evaluation Findings to Surgical Decision Making

<table>
<thead>
<tr>
<th>Number</th>
<th>Diagnosis</th>
<th>Neurologic Deficit</th>
<th>Findings on Imaging Studies</th>
<th>Angiographic Findings</th>
<th>Type of Surgery Performed</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Atypical lipoma</td>
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<td></td>
<td>NVB displacement</td>
<td>Limb-sparing resection</td>
</tr>
<tr>
<td>2</td>
<td>Atypical lipoma</td>
<td>+</td>
<td></td>
<td>NVB displacement</td>
<td>+</td>
</tr>
<tr>
<td>3</td>
<td>Atypical lipoma</td>
<td>+</td>
<td></td>
<td>NVB displacement</td>
<td>+</td>
</tr>
<tr>
<td>4</td>
<td>Fibromatosis</td>
<td>+</td>
<td></td>
<td>NVB displacement</td>
<td>+</td>
</tr>
<tr>
<td>5</td>
<td>Fibromatosis</td>
<td>+</td>
<td></td>
<td>NVB displacement</td>
<td>+</td>
</tr>
<tr>
<td>6</td>
<td>Malignant fibrous histiocytoma</td>
<td>+</td>
<td></td>
<td>NVB displacement</td>
<td>+</td>
</tr>
<tr>
<td>7</td>
<td>Synovial cell sarcoma</td>
<td>+</td>
<td>Chest wall invasion,</td>
<td>+</td>
<td>Forequarter amputation</td>
</tr>
<tr>
<td>8</td>
<td>Adenocarcinoma of breast</td>
<td>+</td>
<td>Chest wall invasion,</td>
<td>+</td>
<td>Forequarter amputation</td>
</tr>
<tr>
<td>9</td>
<td>Adenocarcinoma of breast</td>
<td>+</td>
<td>Chest wall invasion,</td>
<td>+</td>
<td>Forequarter amputation</td>
</tr>
<tr>
<td>10</td>
<td>Synovial cell sarcoma</td>
<td>+</td>
<td>Chest wall invasion,</td>
<td>+</td>
<td>Forequarter amputation</td>
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<tr>
<td>11</td>
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<td>+</td>
<td>Chest wall invasion,</td>
<td>+</td>
<td>Forequarter amputation</td>
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<tr>
<td>12</td>
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<td>Chest wall invasion,</td>
<td>+</td>
<td>Forequarter amputation</td>
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<tr>
<td>13</td>
<td>Malignant fibrous histiocytoma</td>
<td>+</td>
<td>Chest wall invasion,</td>
<td>+</td>
<td>Forequarter amputation</td>
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<tr>
<td>14</td>
<td>Malignant melanoma</td>
<td>+</td>
<td>Chest wall invasion,</td>
<td>+</td>
<td>Forequarter amputation</td>
</tr>
<tr>
<td>15</td>
<td>Radiation-induced angiosarcoma</td>
<td>+</td>
<td>Chest wall invasion,</td>
<td>+</td>
<td>Forequarter amputation</td>
</tr>
<tr>
<td>16</td>
<td>High-grade spindle cell sarcoma</td>
<td>+</td>
<td>Chest wall invasion,</td>
<td>+</td>
<td>Forequarter amputation</td>
</tr>
</tbody>
</table>

NVB = neurovascular bundle
for deciding on tumor resectability (Fig 4D). We preferred to widely resect malignant and benign-aggressive tumors with at least a few millimeters of normal tissue beyond the tumor pseudocapsule. Atypical lipomas were removed with their enveloping capsule without an additional cuff of normal tissue. We believe tumor extension to the brachial plexus precludes limb-sparing tumor resection and mandates forequarter amputation. When we cannot find a plane of dissection between the brachial artery and the tumor, we recommend resection en bloc with the tumor and reconstruction with a graft.

Exposure revealed a safe plane of dissection between the tumor and NVB in 19 patients who underwent tumor resection. En bloc resection of a chest wall segment was performed in two patients with evidence of chest wall invasion. In another patient, the brachial artery was encased in the axillary tumor mass with no evident plane of dissection. We subsequently performed en bloc resection of the artery with the tumor mass and reconstruction with a medial saphenous vein graft. The remaining eight patients had gross invasion of the NVB by the tumor and underwent forequarter amputation. None of the patients diagnosed with a benign tumor required amputation to achieve local tumor control.

After tumor removal, the pectoralis minor and conjoined tendons were reattached to the coracoid process with a nonabsorbable suture, the latissimus dorsi was rotated into the defect, and the pectoralis major was reattached to its stump on the proximal humerus in the same manner (Fig 5). The wound was meticulously closed over suction drains and the upper extremity was kept in an arm sling. Continuous suction was required for 3 to 5 days. Perioperative intravenous antibiotics were continued until the drainage tubes were removed. We then introduced postoperative mobilization emphasizing gradual shoulder range of motion (ROM). Patients diagnosed with soft tissue sarcomas and metastatic carcinomas were treated postoperatively with radiotherapy consisting of external beam radiation of 6500 Gy and 3000 Gy, respectively.

**Fig 2.** An illustration shows the deltopectoral incision, which started at the junction of the inner and middle thirds of the clavicle, continued along the deltopectoral groove, and terminated over the anterior axillary fold.

**Fig 3A-B.** (A) An illustration shows reflection of the superficial muscle layer; the pectoralis major muscle was detached from its insertion to proximal humerus, leaving at least 1 cm of the tendon for reattachment. (B) An intraoperative photograph shows detachment of the pectoralis major.
For the first 2 postoperative years, the patients were evaluated at 3-month intervals and underwent a physical examination, plain radiography, and chest CT at each visit. They then were evaluated semiannually for an additional 3 years and annually thereafter. An orthopaedic oncologist (EM, JB) analyzed the clinical records and operative reports. We recorded histopathologic diagnoses, results of staging studies, type of surgery, complications, rates of local tumor recurrence and patients’ survival, ROM of the ipsilateral shoulder, and functional outcomes. Functional evaluations were performed according to the American

Fig 4A–D. (A) An illustration shows reflection of the deep muscle layer; the conjoined tendon was reflected caudally and the pectoralis minor muscle was reflected medially. (B) Intraoperative photographs show reflection of the conjoined tendon (C) the pectoralis minor. (D) The NVB was dissected and mobilized. The plane of dissection between the tumor and NVB allowed execution of a limb-sparing resection; otherwise, a forequarter amputation would have been required to achieve local tumor control.
Musculoskeletal Tumor Society System, which assigns numeric values for each of six categories: pain, function, emotional acceptance, hand positioning, dexterity, and lifting ability. Final assessment was based on each patient’s most recent followup and expressed as the proportion of full normal function in all six categories.

We used Fisher’s exact test to evaluate the relation of neurologic deficit, diffuse swelling, angiographic findings of arterial narrowing, and the execution of a limb-sparing resection. Significance was set at the p < 0.05 level.

RESULTS

Of the 20 study patients with malignant axillary tumors, 17 (85%) survived more than 1 year postoperatively, 13 (65%) survived more than 2 years, and 11 (55%) survived more than 3 years.

Findings of preoperative clinical evaluation and imaging studies were associated with the intraoperative finding of NVB tumor invasion and the necessity of performing a forequarter amputation. Specifically, clinical evidence of a neurologic deficit(s) (p < 0.015), diffuse swelling, angiographic findings of arterial narrowing, and the execution of a limb-sparing resection. Significance was set at the p < 0.05 level.

DISCUSSION

Resecting large tumors of the axilla poses a surgical challenge because of their close proximity to the NVB of the upper extremity. These tumors rarely invade the overlying cuff of muscles. Therefore, the pectoralis minor, coracobrachialis, and pectoralis major usually can be spared and used for reconstruction and preservation of function. When dealing with malignant tumors of the axilla, it is impossible to achieve a safe wide margin of resection as one would be able to do when dealing with the same tumor around the thigh because of the immediate proximity of the NVB at that site. Forequarter amputation, however, occasionally is required to achieve local tumor control because of tumor extension into the NVB. Our study consists of a large variety of tumor types and biologic behavior patterns, some of which rarely require amputation for their local control. These tumors were grouped together because the concept of their preoperative evaluation and surgical exposure are identical.

Our study was designed to evaluate the adequacy of preoperative evaluation studies and efficacy of a surgical
exposure technique for management of large axillary tumors. Because of the rarity of such tumors, it is a relatively small and uncontrolled series, but it provides valuable information regarding the validity of preoperative evaluation studies in predicting the need for performing a limb amputation and the efficacy of the extensile axillary approach in widely exposing the NVB.

All patients who underwent forequarter amputation had tumor extension into at least two cords of the brachial plexus. Limited tumor extension into the brachial plexus and the need to sacrifice only one cord might result in a reasonable function and allow a limb-sparing resection. We did not, however, encounter such findings in our series.

The MRI scans did not provide data that assisted in the evaluation of tumor resectability. Magnetic resonance imaging scans only showed vascular displacement, which did not predict tumor irresectability. Vascular narrowing, which was only evident on angiograms, predicted neurovascular extension of the tumor. However, the majority of our patients were treated before the availability of an MR angiogram, which provides anatomic data regarding the lesion and adjacent blood vessels. This type of imaging study possibly may show vascular morphology in addition to its displacement and be helpful in preoperative evaluation of axillary tumors.

The utilitarian shoulder incision originally was described by Henry for wide exposure of the proximal humerus. It since has been used routinely with slight modifications for resection of tumors of the proximal humerus and, with posterior extension, for resections of the scapula. We performed the same incision and surgical steps for exposure and resection of large axillary tumors because they provide good exposure of the entire axillary cavity and allow dissection and mobilization of the NVB. This approach is compatible with the basic principle of wide exposure of the tumor and mobilization of vulnerable structures before resection, and it was associated with what we considered acceptable morbidity. Attempting to resect an axillary tumor using the traditional axillary approach, which is used for axillary lymph node dissection, provides a relatively small aperture through which the surgeon has to expose the entire extent of the tumor and manipulate the NVB. It would be very difficult to achieve a truly wide exposure and perform a safe resection with it as we could with the extensile approach used in the study patients. Entering the axilla through its base provides one disadvantage of the extensile approach, which is the resultant scar along the anterior aspect of the shoulder. This cosmetic deficit is relatively inconsequential, considering the potential role of this extensile approach in preventing unnecessary injury to major nerves and blood vessels and local recurrence of an inadequately resected tumor. Functional outcome was good in most patients and the limited shoulder ROM in three patients was attributed to adjuvant radiation therapy rather than sequelae of surgery.

The objective of resection of axillary tumors is to achieve local tumor control. Patient survival is determined by the presence of metastatic disease and its response to adjuvant treatments. We believe the rate of local recurrence is the most appropriate criterion to evaluate the adequacy of surgical exposure and tumor resection. The low percentage (11%) of patients with local recurrence suggests the utility of the approach we used.

The results of preoperative evaluations provide information essential for determining the necessity of performing additional chest wall resection and suggest the possibility of performing a limb-sparing resection. The presence of limb edema, the neurologic findings, and the evidence of arterial narrowing on the arteriograms correlated with a likelihood of neurovascular tumor extension and the consequent recommendation to perform limb amputation to achieve local tumor control. However, the final decision to perform limb-sparing resection or an amputation was based on the intraoperative findings of tumor.

Fig 6. The functional parameters of 15 patients who underwent limb-sparing tumor resections are shown. Although pain was alleviated satisfactorily and hand positioning and dexterity were preserved in most patients, the decline in lifting ability, probably the result of loss of motion around the axilla, was the prominent determinant in the loss of function observed after surgery.
extension to the NVB and the inability to find a plane of dissection between them. The utilitarian shoulder incision allowed optimal observation of an axillary tumor, and the surrounding nerves and blood vessels. It is a reliable approach for exploring and resecting axillary tumors and one that allows the amount of local tumor control associated with tolerable morbidity.

Acknowledgment
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References