Interscapulothoracic (forequarter) amputation for malignant tumors involving the upper extremity: surgical technique and case series

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**Background:** Forequarter amputation (FQA) is reserved for large, multifocal, or recurrent tumors affecting the shoulder and upper extremity. Although it is performed less frequently with the advancement of limb salvage surgery, FQA remains an important treatment in select patients. The purpose of this study is to illustrate the surgical technique in a case series of 4 patients.

**Methods:** Between 2010 and 2012, 4 patients (mean age, 61 years; range, 36-78 years) presented with malignant disease of the upper extremity that was not amenable to or had failed limb salvage. All patients had FQA by the illustrated anterior clavicular osteotomy technique. Patient data were retrospectively reviewed from preoperative workup until last follow-up or death.

**Results:** All patients had tumors that involved major neurovascular structures of the upper extremity and shoulder girdle. One presented with neuroendocrine carcinoma and has achieved local control after FQA. Three presented with high-grade sarcoma. One of these had recurrence after prior limb salvage and neoadjuvant radiation and unfortunately succumbed to metastatic disease 6 months after FQA. An additional sarcoma patient who presented after shoulder arthroscopy for a “labral cyst” with recurrent and fulminant synovial sarcoma succumbed to her disease. The remaining sarcoma patient has had no recurrence and minimal phantom pain at last follow-up.

**Discussion:** Obtaining vascular control early in the procedure is crucial to minimize blood loss. When it is indicated, FQA is a relatively safe and reliable procedure for dealing with otherwise challenging tumors of the shoulder girdle and upper extremity.

**Level of evidence:** Level IV, Case Series, Treatment Study.

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**Keywords:** Forequarter amputation; interscapulothoracic; sarcoma; shoulder girdle; surgical technique

Interscapulothoracic (forequarter) amputation has been an established surgical procedure for the past 2 centuries. The first reported forequarter amputation (FQA) was performed in the setting of trauma by Ralph Cuming, an English naval surgeon, in 1808.11 Roughly 30 years later, an additional report from Cairo would be presented, also in the setting of trauma.
trauma. The first surgeon to perform FQA for treatment of malignant disease was Dixie Crosby of New Hampshire. In 1836, Crosby performed this procedure to cure a patient of an osteosarcoma of the upper extremity, but there are limited medical records of the details. FQA was not made popular until the published work of Paul Berger, Professor of Surgery and Pathology at Faculté de Médecine de Paris, in 1887. In his *L’Amputation du membre supérieur dans la contiguïté du tronc*, he provided a detailed monograph explaining the removal of the upper extremity for an enchondroma of the proximal humerus. Whereas his indications for FQA would no longer be accepted today, the technical details of his procedure continue to be used in the modern age for this rare procedure.

Today, the use of FQA for upper extremity malignant disease has declined as a result of advances in radiation therapy, chemotherapy, and limb salvage surgical techniques, and it is required in less than 5% of cases. The overall loss of an upper limb for the patient not only is difficult functionally but also has a major psychological effect on outcome, necessitating extensive preoperative counseling before its undertaking. Therefore, FQA today is reserved for a narrow set of indications typically pertaining to malignant disease: patients with local-regional disease of the shoulder girdle that is not amenable to limb-saving procedures; failure of chemotherapy and radiation therapy or recurrence after limb salvage; pathologic fracture through a high-grade sarcoma with poor response to induction chemotherapy; and palliation for tumor ulceration, severe lymphedema, impaired function, intractable pain despite high-dose analgesics, bleeding, infection, or tumor fungation. Less commonly, FQA may be performed in the setting of trauma; however, electrocution has been described as an additional indication when the limb is left functionless.

The purpose of this study is to illustrate the surgical technique of FQA and to highlight the unique presentation and outcome in a case series of 4 patients who underwent this rare procedure.

**Materials and methods**

Between 2010 and 2012, 4 patients (mean age, 61 years; range, 36-78 years) presented with large multifocal or recurrent sarcoma or carcinoma of the upper extremity that was not amenable to or had failed limb salvage. All 4 patients underwent FQA by the anterior clavicular osteotomy surgical technique. Patient data
were retrospectively reviewed from preoperative workup until last follow-up or death. Patient data such as age, sex, presence of comorbidities, prior surgery, radiation treatment, chemotherapy, presence of metastatic disease, recurrence, and presence of phantom pain were collected. If follow-up data for a minimum of 1 year were not available in the medical records, patients were contacted by telephone with telephone consent.

**Surgical technique**

The patient is placed in a lateral position with the support of a beanbag (Fig. 1). A hydraulic arm holder (Spider Arm Positioner, Tenet Medical Engineering, Calgary, Alberta, Canada) is used to support the affected limb and to facilitate traction. This limb is draped free, and the surgical field is prepared from the opposite nipple line, extending to include the neck on the ipsilateral side of the lesion both anteriorly and posteriorly.

Our incision planes are shown in Figure 2. The incision begins just lateral to the sternocleidomastoid and extends laterally over the clavicle. Here it divides into an anterior component and a posterior component, which forms a Y. The posterior limb of the Y is extended farther posteriorly over the acromion and is then carried inferiorly along the vertebral border of the scapula to its inferior angle. Here it connects with the anterior limb of the Y, which has been extended inferriorly along the deltopectoral groove.

The anterior portion of the approach is addressed first. The entire clavicle should be exposed by dividing its muscle attachments and elevating the platysma, pectoralis major, deltoid, and supraclavicular nerves. The sternocleidomastoid may be sectioned or released as the clavicle is next osteotomized just lateral to its insertion. At this point, it is crucial to obtain early vascular control by ligature of the subclavian artery and vein. The midclavicular osteotomy facilitates this critical step (Fig. 3).

After this step is completed, several anatomic structures can then be divided and ligated. The subclavius is divided medially. The pectoralis major tendon is sectioned and retracted medially. The clavicular origin of the pectoralis major is reflected distally or sectioned, depending on its bulk. The deltoid is retracted laterally. The tendons of pectoralis minor, coracobrachialis, and short head of biceps are divided at their insertions on the coracoid. This step may be necessary after clavicular osteotomy to further facilitate exposure of the neurovascular bundle. The transverse cervical vessels and the suprascapular vessels are ligated as they cross the thyrocervical trunk. Brachial plexus branches are ligated proximally.

After the posterior limb of the incision is advanced to meet the anterior limb at the angle of the scapula, the scapula can then be elevated with the arm holder to allow access to the muscle attachments. Achieving vascular control is also crucial here in that identifying and ligating vasculature must be done before muscle attachments are removed. The trapezius, levator scapulae, and rhomboids are sectioned at their attachments sequentially. The last remaining muscles at this point are the serratus anterior and latissimus, which connect the shoulder girdle to the thorax. Sectioning of these muscles’ tendinous attachment completes the amputation (Fig. 4).

Afterward, the limb can be elevated at the scapula and removed while retaining the posterior skin flap as shown, which allows closure of the surgical wound. We routinely use both anterior and posterior drains to prevent hematoma formation and wound complication (Fig. 5).

**Results**

Patient 1, a 61-year-old man, presented to our service with a 6-month history of a painful enlarging mass of the right shoulder and axilla. He reported that the mass had been
present for about 12 years but did not cause any symptoms and had not changed in size until recently. Physical examination revealed a 15-cm firm, tender mass overlying the deltoid muscle. He had mild limitation in range of motion without any abnormalities in strength or distal sensation or pulses. A core needle biopsy performed in the clinic was inconclusive and therefore open biopsy was performed, diagnostic for poorly differentiated metastatic large cell neuroendocrine carcinoma. Staging workup including positron emission tomography, performed twice, interestingly revealed no other sites of active disease. The patient had a poor response to neoadjuvant radiation, with continued growth of the tumor now encompassing his entire proximal humerus with extension into the mid-clavicle. He was requiring narcotic medication for pain control. He subsequently underwent FQA and has been disease free at latest follow-up without complaints of phantom pain.

Patient 2, a 78-year old woman, presented to our service with a 9-month history of a painful, rapidly enlarging mass of her left upper arm extending from midarm to the pectoralis insertion. Physical examination revealed a "biceps rupture." Physical examination revealed a firm, nontender mass. Workup had previously been performed for a "biceps rupture." Staging workup with a 9-month history of a painful, rapidly enlarging mass of her left upper arm extending from midarm to the pectoralis insertion. Range of motion, strength in all muscle groups, and neurovascular examination findings were unremarkable. Magnetic resonance imaging subsequently showed a tumor that encased her biceps and neurovascular structures invading into her pectoralis major. Needle biopsy definitively diagnosed high-grade pleomorphic liposarcoma. The patient subsequently underwent FQA to achieve local control as the location of her lesion was not

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**Figure 4** (A) Dissection continues posteriorly over the acromion and the spine of the scapula. Care is maintained to preserve a large posteromedial full-thickness skin flap for coverage. (B) The Army-Navy retractor (top of image) exposes the scapulothoracic space. The large rake retractor (bottom of image) shows the sectioned rhomboids and levator scapulae with large posterior full-thickness skin flap. (C) The medial border of the scapula is well exposed after sectioning of rhomboid major and minor as well as levator scapulae from their insertion sites. The serratus anterior and latissimus dorsi remain intact in this image. (D) A ligature device facilitates quick ligation of the lateral thoracic artery, long thoracic nerve, thoracodorsal artery and nerve, and serratus anterior and latissimus muscles. (E) The brachial plexus is the final structure connecting the arm to the trunk. The major cords and branches are individually suture ligated and cut sharply under tension.
amenable to limb salvage. She has been disease free at latest follow-up with no complaints of phantom pain.

Patient 3, a 67-year-old man, presented with a rapidly enlarging mass over the arm for 6 months. A core needle biopsy was diagnostic for high-grade pleomorphic soft tissue sarcoma with immunohistochemical staining positive for smooth muscle. A negative staging workup and preoperative radiation were performed. He subsequently underwent a wide resection of his arm mass. At 3-month follow-up, the patient unfortunately presented with recurrence adjacent to his surgical bed (Fig. 6). Surveillance computed tomography of the chest revealed a pulmonary nodule in the right middle lobe. Computed tomography–guided biopsy was negative for metastasis. Because of recurrence within the limb and tumor fungation, FQA was subsequently performed. The patient initially did well with minimal complaints of phantom pain. At 5 months, he had developed a pleural effusion with multiple unresectable lung and rib metastases and shortly thereafter succumbed to his disease under palliative care.

Patient 4, a 36-year-old woman, was referred to us after previous shoulder arthroscopy for removal of a “labral cyst.” Her history included 9 months of increasing numbness and severe pain (10/10) with no improvement from her original surgery. She also reported fevers and chills. Physical examination revealed a large tumor that encompassed both her anterior and posterior arthroscopy portals, with limited range of motion and no evidence of neurovascular compromise (Fig. 7). Magnetic resonance imaging demonstrated a large soft tissue mass with intra-articular and extra-articular components involving her rotator cuff and deltoid. Core biopsy was subsequently done in the clinic, which was diagnostic for a high-grade synovial sarcoma. Because of the location of her disease and after discussion of treatment options, the patient underwent FQA in June 2010. She eventually succumbed to metastatic disease to the lungs within 1 year.

All 4 patients completed the surgical procedure without any immediate complications. On follow-up, patients 1 and 2 have been cancer free with minimal complaints of phantom pain. Patients 3 and 4 were initially doing well at 6 and 8 months after surgery, respectively, with minimal complaints of phantom pain. Unfortunately, both of these patients succumbed to pulmonary metastasis. At 1 year, our postoperative survival rate is 50% (2/4 patients).

Discussion

FQA is performed uncommonly; most major centers today report an amputation rate of 5% or less. Malignant tumors of the upper extremity can remain a challenging problem for the patient and surgeon, however, and FQA is an option for patients who have failed to respond to other treatments. FQA is a salvage procedure performed only for narrow indications. Furthermore, as FQA is a salvage operation, the patient should receive multidisciplinary counseling before its undertaking. The end result is often perceived by the patient as disfiguring. At this time, there
also are limited options for an aesthetically pleasing prosthesis and, moreover, one that is functionally useful. Functional prosthetic use after FQA is less successful because suspension of the prosthesis is difficult to maintain. Patients typically prefer a passive cosmetic arm and hand prosthesis. Consideration is given to providing a shoulder cap to allow the patient to wear clothing with more ease and to improve cosmesis. In our study, none of our 4 patients used prostheses.

Aside from suboptimal cosmesis, which for the most part is an unavoidable sequela rather than a complication, other potential morbidities include failure to achieve clear margins, extensive blood loss, hematoma, and phantom limb pain. Wound necrosis or wound dehiscence has been reported in the literature in 7% to 12.5% of cases. Since the time of Berger in the 19th century, there have been different modifications of FQA to address these potential complications. Wittig et al previously described a utilitarian shoulder girdle incision and combined anterior and posterior approach. Exposure of the major neurovascular structures is done by release of the pectoralis major from its humeral insertion and of the pectoralis minor, coracobrachialis, and short head of biceps from the coracoid. The clavicle is not osteotomized until after both anterior and posterior exposures are complete. The addition of regional epineural bupivacaine infusion has helped optimize analgesia and minimize phantom pains.

Ferrario et al described a similar anterior and posterior approach with emphasis on mobilization of the specimen first, followed by excision of 4 cm of the clavicle and ligation of the subclavian vessels at the conclusion of the case, to obtain a more generous proximal margin. Kumar et al recently described a single-incision technique in which the axillary vessels and brachial plexus are accessed through the axilla. A lateral clavicular osteotomy is performed to retract the scapula superolaterally to expose the muscles along its inner aspect rather than for obtaining vascular control. Other FQA techniques include posterior approaches, deltoid fasciocutaneous flaps, and forearm free flaps as varying modifications to this procedure.

We believe our technique is unique in that we present the original Berger 2-incision anterior approach with special emphasis on achieving early vascular control from complete exposure of the clavicle and osteotomy at its midpoint, before major muscle releases. By accessing and controlling the major neurovascular structures in the beginning of the case, we are able to prevent excessive blood loss, to improve visualization, to decrease surgical time, and ultimately to lessen patient morbidity.

**Conclusion**

In a select group of patients, FQA remains a relatively safe and reliable procedure for curative or palliative treatment of upper extremity malignant disease when other less radical options have failed. As highlighted in our surgical technique, a crucial step in the procedure is to obtain early vascular control through a midclavicular osteotomy to ensure good surgical outcome with minimal blood loss.

**Disclaimer**

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