

Robert W. Thompson

Abstract

Brachial plexus compression in neurogenic thoracic outlet syndrome (TOS) may occur either at the level of the supraclavicular scalene triangle and/or the infraclavicular subcoracoid space. As highlighted elsewhere by Sanders (Chap. 15), it has only recently been recognized that nerve compression at the level of the pectoralis minor muscle tendon can make a substantial contribution to symptoms in neurogenic TOS, and that in many cases nerve compression at this level may dominate over that occurring at the level of the scalene triangle. Untreated pectoralis minor compression of the brachial plexus may therefore represent an important factor in persistent or recurrent symptoms following operations for neurogenic TOS, and undoubtedly explains a proportion of surgical failures in previous clinical series. Moreover, it is now apparent that a significant number of patients may have a clinical diagnosis of neurogenic TOS represented by isolated brachial plexus compression at the level of the pectoralis minor muscle, for whom isolated pectoralis minor tenotomy may provide a minimally-invasive surgical option associated with rapid postoperative recovery and a high likelihood of clinical success. Recognition and treatment of this condition has therefore been an important step in our evolving understanding of neurogenic TOS.

Introduction

Brachial plexus compression in neurogenic thoracic outlet syndrome (TOS) may occur either at the level of the supraclavicular scalene triangle and/or the infraclavicular subcoracoid space. As highlighted elsewhere by Sanders (Chap. 15), it has only recently been recognized that nerve compression at the level of the pectoralis minor muscle tendon can make a substantial contribution to symptoms in neurogenic TOS, and that in

R.W. Thompson, MD
Department of Surgery,
Section of Vascular Surgery,
Center for Thoracic Outlet Syndrome,
Washington University, Barnes-Jewish Hospital,
660 S Euclid Avenue, Campus Box 8109/Suite 5101
Queeny Tower, St. Louis, MO 63110, USA
e-mail: thompson@wudosis.wustl.edu

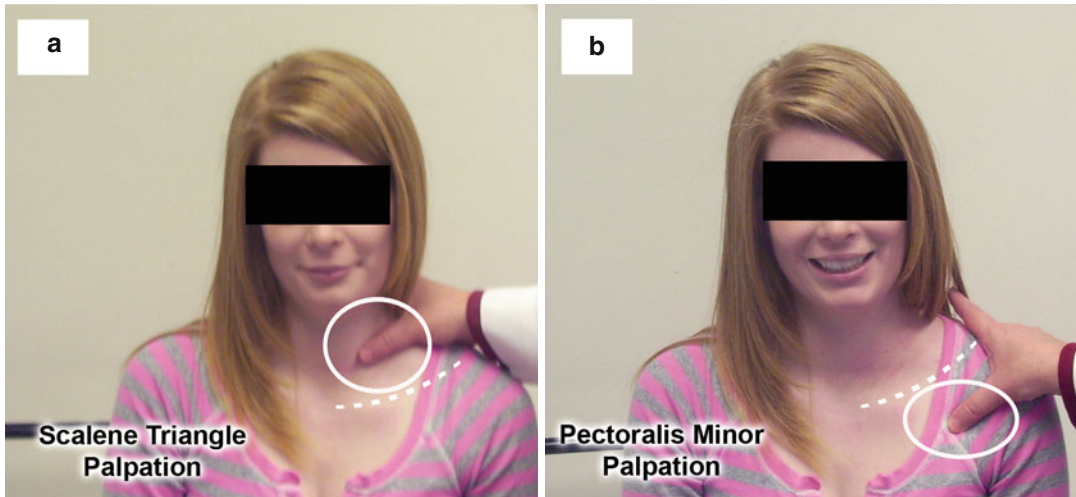


Fig. 30.1 Diagnosis of pectoralis minor compression in neurogenic TOS. Illustration of physical examination depicting localized tenderness and reproduction of upper extremity symptoms during palpation over the

supraclavicular scalene triangle (a) and/or the infraclavicular subcoracoid (pectoralis minor) space (b). The position of the clavicle is shown by the *dashed line*

many cases nerve compression at this level may dominate over that occurring at the level of the scalene triangle [1, 2]. Untreated pectoralis minor compression of the brachial plexus may therefore represent an important factor in persistent or recurrent symptoms following operations for neurogenic TOS, and undoubtedly explains a proportion of surgical failures in previous clinical series [3]. Moreover, it is now apparent that a significant number of patients may have a clinical diagnosis of neurogenic TOS represented by isolated brachial plexus compression at the level of the pectoralis minor muscle, for whom isolated pectoralis minor tenotomy may provide a minimally-invasive surgical option associated with rapid postoperative recovery and a high likelihood of clinical success. Recognition and treatment of this condition has therefore been an important step in our evolving understanding of neurogenic TOS.

Diagnosis and Indications for Procedure

Pectoralis minor tenotomy is indicated for patients with disabling neurogenic TOS that have not had a satisfactory response to appropriately

targeted physical therapy, in whom physical examination reveals significant tenderness and/or reproduction of upper extremity neurogenic symptoms upon palpation over the subcoracoid space. Symptoms suggesting pectoralis minor compression include infraclavicular, anterior chest wall, and/or axillary pain, but the nature of upper extremity symptoms and the response to upper extremity positional maneuvers is similar to that of patients with brachial plexus compression at the scalene triangle [2]. Physical examination is used to help distinguish whether there is brachial plexus nerve compression at the level of the pectoralis minor muscle in isolation, as the dominant source of symptoms, or in combination with compression at the level of the scalene triangle (Fig. 30.1). One valuable and specific examination maneuver is to demonstrate tenderness and/or reproduction of upper extremity symptoms during direct palpation over the subcoracoid space, which is resolved when the patient simultaneously contracts the pectoralis major muscle (Fig. 30.2).

In addition to physical examination, the response to radiographically-guided muscle blocks with local anesthetic can be particularly helpful to verify the presence of nerve compression exacerbated by pectoralis minor muscle

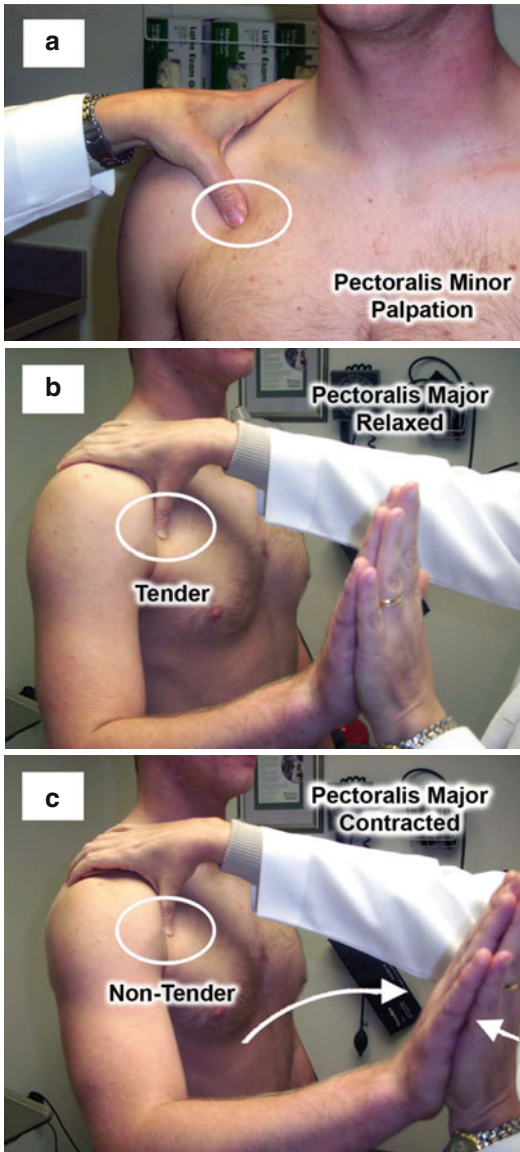


Fig. 30.2 Physical examination to distinguish pectoralis minor compression. Physical examination can often distinguish between pectoralis minor compression (neurogenic TOS) and more generalized pectoralis muscle tenderness. There is localized tenderness and reproduction of upper extremity symptoms during palpation over the infraclavicular subcoracoid (pectoralis minor) space (a). An important finding is the resolution of these findings when the patient simultaneously contracts the pectoralis major muscle, which prevents transmission of digital pressure to the underlying pectoralis minor tendon. In this maneuver, there is localized tenderness and reproduction of arm/hand symptoms during firm palpation over the subcoracoid space while the pectoralis major muscle is relaxed (b), but diminished symptoms during palpation with simultaneous flexion (contraction) of the pectoralis major muscle (c)

spasm [4]. Although we use combined anterior scalene and pectoralis minor muscle blocks in the evaluation of most patients with neurogenic TOS, an isolated pectoralis minor block is used when this is considered the dominant site of nerve compression and when isolated pectoralis minor tenotomy might be considered as an initial operative approach to treatment. Pectoralis minor muscle blocks can also be useful in patients with persistent or recurrent neurogenic TOS that have previously undergone transaxillary or supraclavicular decompression procedures, in whom pectoralis minor tenotomy may also be considered. A summary of the operations performed in our Center over the past 2 years demonstrates the increasing frequency with which pectoralis minor tenotomy is utilized for neurogenic TOS, with this procedure being included in approximately 80 % of all primary operations and as an isolated procedure in up to 30 % of patients (Fig. 30.3).

Surgical Techniques

Deltopectoral (Anterior) Approach

Under general anesthesia, the patient is positioned supine with the head of the bed elevated to 30° and the arms held comfortably at the side. The neck, upper chest and affected upper extremity are prepped into the field, with both sides prepped simultaneously for bilateral procedures. A short vertical incision is made in the deltopectoral groove, beginning approximately 1 in. below the coracoid process (Fig. 30.4a). The edges of the deltoid and pectoralis major muscles are gently spread apart from each other by blunt dissection (Fig. 30.4b), with the plane of dissection carried deeper medial to the cephalic vein (Fig. 30.4c). The lateral edge of the pectoralis major muscle is separated from its fascia and gently lifted in a medial direction with a small Deaver retractor. The plane underneath the pectoralis major muscle is separated by blunt fingertip dissection to further expose the underlying fascia over the pectoralis minor muscle, where the muscle can be easily identified by palpation (Fig. 30.4d). The fascia along the medial border of the pectoralis minor muscle is incised and the

muscle is encircled using blunt fingertip dissection around its medial border. The fascia along the lateral border of the pectoralis muscle is then incised to ensure separation of the pectoralis minor from the long head of the biceps muscle, which fuses with the pectoralis minor tendon

close to the coracoid process. The pectoralis minor tendon is then completely encircled near its insertion on the coracoid process, taking care to protect the underlying neurovascular bundle, and it is elevated with an umbilical tape or rubber tubing (Fig. 30.4e). The insertion of the pectora-

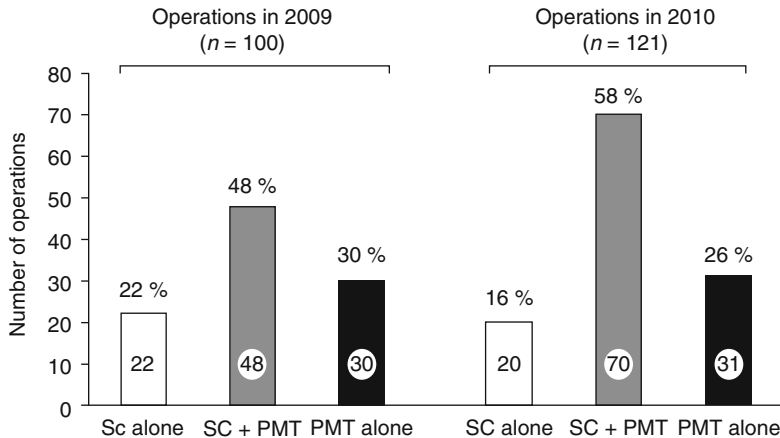


Fig. 30.3 Pectoralis minor tenotomy in the surgical treatment of neurogenic TOS. Bar graph illustrating the number of operations performed for neurogenic TOS at Washington University/Barnes-Jewish Hospital in St. Louis over a recent 2-year period. During 2009 and 2010, the proportion of operations that included pectoralis minor

tenotomy (PMT) was 78 and 84 %, respectively, with approximately 30 % of patients undergoing isolated PMT. Supraclavicular (SC) thoracic outlet decompression consisted of complete anterior and middle scalenectomy, brachial plexus neurolysis and first rib resection, either alone or in combination with PMT

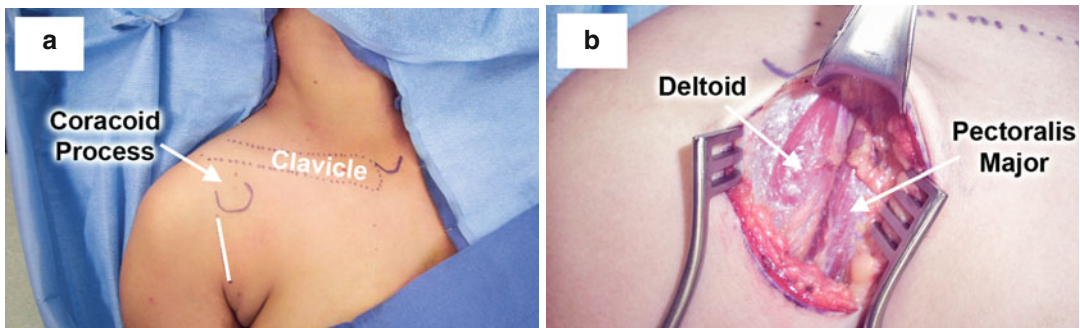


Fig. 30.4 Pectoralis minor tenotomy (deltopectoral approach). (a) Landmarks for pectoralis minor tenotomy include the clavicle and the coracoid process, which is easily palpable as a bony prominence inferior to the lateral aspect of the clavicle and medial to the shoulder. A short vertical incision is made in the deltopectoral groove (white line). (b) The edges of the deltoid and pectoralis major muscles are separated by blunt dissection. (c) The cephalic vein is identified as the deltoid and pectoralis major muscles are separated further, with the plane of dissection carried deeper medial to the vein along the lateral edge of pectoralis major. (d) The pectoralis major

muscle is lifted medially with a Deaver retractor to expose the underlying fascia over the pectoralis minor muscle. (e) The pectoralis minor muscle is encircled near its insertion on the coracoid process and elevated with an umbilical tape, prior to division with the electrocautery. (f) The edges of the divided pectoralis minor muscle have retracted to relieve compression of the underlying neurovascular structures (embedded in surrounding fat). The inferior edge of the muscle will be oversewn with a series of interrupted sutures for hemostasis and to facilitate its contraction underneath the pectoralis major muscle

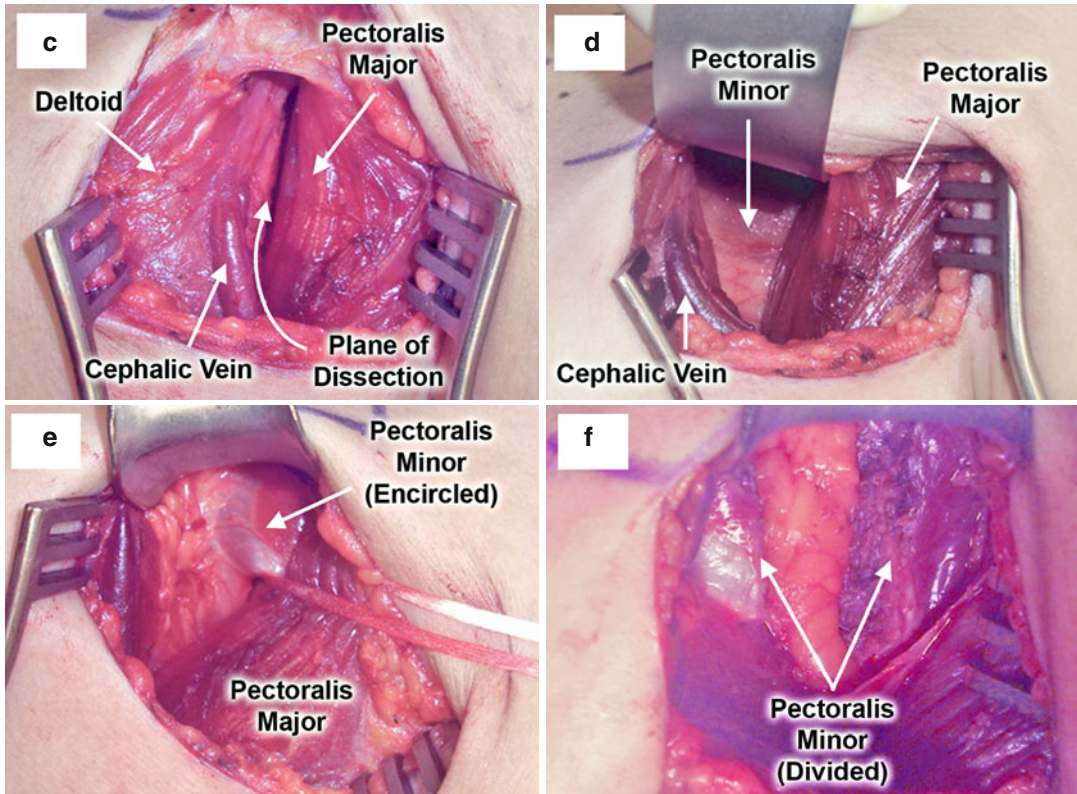


Fig. 30.4 (continued)

lis minor tendon on the coracoid process is exposed and isolated with a Richardson retractor, and the pectoralis minor muscle is injected with approximately 10 mL of 0.5 % bupivacaine. The muscle is then divided under direct vision with the electrocautery, within 2 cm of the coracoid process, with a finger placed behind the muscle to prevent thermal injury to the underlying neurovascular bundle. After the pectoralis minor muscle has been divided, the edges are seen to retract from each other to release any compression of the neurovascular bundle (Fig. 30.4f). The inferior edge of the divided muscle is oversewn with a series of interrupted figure-of-eight 2–0 silk sutures, to ensure hemostasis and to facilitate contraction of the muscle underneath the pectoralis major. The remaining clavipectoral fascia is also incised to the level of the clavicle, along with any other anomalous fascial bands that might be present overlying the brachial plexus, such as Langer’s axillary arch [5]. No further dissection

of the brachial plexus nerves or the axillary vessels is performed. After infiltrating the edge of the pectoralis major muscle with a long-acting local anesthetic, the wound is irrigated and closed with several interrupted sutures in the deep subcutaneous layer followed by subcuticular closure of the skin, and dressed with a single steristrip.

Infraclavicular/Subclavicular (Anterior) Approach

Pectoralis minor tenotomy may be performed as a component of operations for venous or arterial TOS, in which an infraclavicular or paraclavicular approach is used, particularly to provide sufficient exposure for vascular reconstruction. In these situations the exposure obtained through a transverse infraclavicular incision is extended laterally far enough to directly expose the pectoralis minor muscle, and the muscle is divided near the cora-

roid process under direct vision with the electrocautery. This permits easy exposure for vascular bypass graft reconstructions in which the peripheral anastomosis is constructed at the level of the axillary vessels, and avoids any compression of the graft or anastomotic site which might otherwise occur from the overlying pectoralis minor muscle.

Transaxillary (Lateral) Approach

Utilizing either general or local anesthesia with heavy sedation, the patient is placed in a lateral position with the affected arm raised and held over the head. A transverse incision is made at the base of the axillary hairline and carried through the subcutaneous tissue to the chest wall. The second intercostal brachial cutaneous nerve is avoided by maintaining dissection along the anterior axillary fold. The edge of the pectoralis major muscle is identified and retracted anteromedially, and is used as a guide to expose the underlying pectoralis minor tendon at the level of the coracoid process. The pectoralis minor tendon is divided under direct vision with the electrocautery, and in some situations several centimeters of the muscle may also be excised.

Followup Care

Isolated pectoralis minor tenotomy, whether performed on one side or both, is conducted as an outpatient procedure, and the vast majority of patients are able to return home the same day. Muscle spasm, tightness and pain in the lateral pectoralis major muscle may occur over several days following operation, but has usually resolved within 1 week. Most patients are allowed full activity with the affected arm, and may return to work activities within several days (Fig. 30.5). We have not identified any specific limitations or restrictions in use of the upper extremity following pectoralis minor tenotomy, including in overhead throwing athletes. Furthermore, unlike patients that have undergone transaxillary first rib resection or supraclavicular scalenotomy, where muscle reattachment with recurrent symptoms is

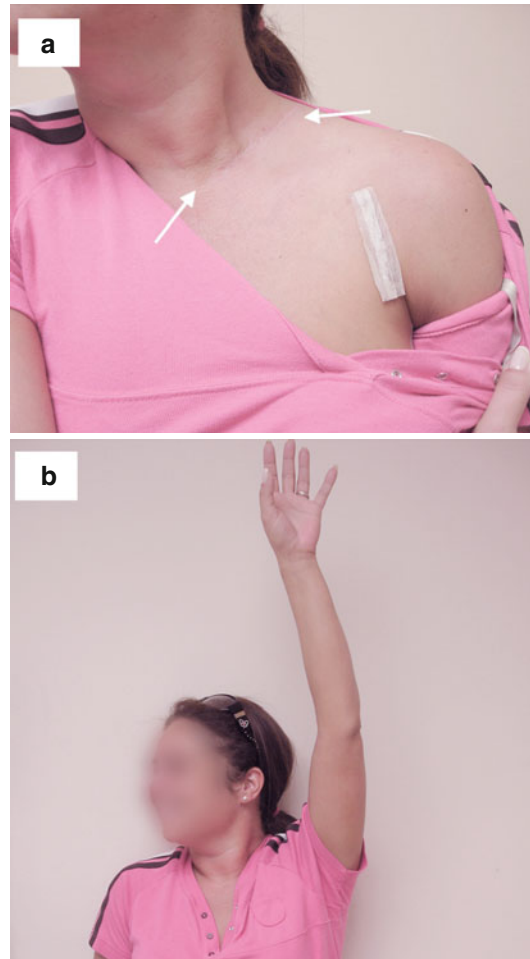


Fig. 30.5 Follow-up after pectoralis minor tenotomy. Photographs depicting a patient that had developed disabling symptoms of recurrent neurogenic TOS 9 months after supraclavicular thoracic outlet decompression, which were refractory to conservative measures. She was found to have no tenderness in the supraclavicular space, but had marked tenderness and reproduction of symptoms upon palpation over the subcoracoid area. Pectoralis minor tenotomy was performed as an isolated procedure through an anterior deltopectoral approach (**a**). The pectoralis minor tenotomy incision is covered by the steristrip dressing (the previous supraclavicular incision is indicated by the arrows). There was a complete resolution of symptoms and a full range of motion demonstrated 2 weeks after operation (**b**)

a relatively frequent occurrence, during several years of follow-up we have not identified an instance in which there has been reattachment of the divided pectoralis minor or recurrent brachial plexus compression at this level.

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