Published in final edited form as:

Am J Phys Med Rehabil. 2014 December ; 93(12): e9–e14. doi:10.1097/PHM.0000000000000197.

ULTRASOUND OF THE PECTORALIS MAJOR MUSCLE AFTER REVERSE SHOULDER ARTHROPLASTY: A CASE REPORT

Angelie L. Mascarinas, MD¹, Joel S. Newman, MD², Jon J.P. Warner, MD³, and Nitin B. Jain, MD, MSPH^{1,4}

¹Department of Physical Medicine and Rehabilitation, Harvard Medical School/Spaulding Rehabilitation Hospital, Charlestown, MA

²Department of Radiology, New England Baptist Hospital, Boston, MA

³Department of Orthopaedics, Massachusetts General Hospital, Boston, MA

⁴Department of Orthopaedics, Brigham and Women's Hospital, Boston, MA

Abstract

Only a few reports exist in the literature for sonographic assessment of the pectoralis major muscle. We present a case of pectoralis major muscle atrophy as a cause of persistent internal rotation weakness diagnosed via ultrasound in a patient with multiple prior surgeries and contraindication to MRI due to a shoulder implant. This patient's physical examination suggested an abnormal contour of the pectoralis major muscle on contraction, so he was referred for diagnostic ultrasound. The ultrasound was key to guiding the management of this patient since a surgical repair of a torn pectoralis major muscle was planned if this was found. No pectoralis major tear or rupture was seen on ultrasound, but there was evidence of pectoralis major muscle atrophy. Accordingly, surgery was avoided and the patient was able to continue with his physical therapy program.

Keywords

pectoralis major muscle atrophy; ultrasound; reverse shoulder arthroplasty

Introduction

Ultrasound allows for non-invasive point-of-care assessment of soft tissues and facilitates bilateral comparisons to evaluate abnormalities found on physical exam. Hence, ultrasound has become an increasingly popular diagnostic modality in patients with shoulder complaints. Ultrasound can be of even more value in post-arthroplasty cases when a prosthesis can result in image degradation from artifact on magnetic resonance imaging (MRI). This case report describes the effectiveness of sonography to diagnose internal

Corresponding Author: Angelie L. Mascarinas, Department of Physical Medicine and Rehabilitation, Spaulding Rehabilitation Hospital, 300 First Avenue, Charlestown, MA 02129, amascarinas@partners.org. Phone: 617-952-5243, Fax: 617-952-5934.

Disclaimers: No financial biases exist for any author. A poster presentation of the abstract of this case report was also presented at the 2014 Annual Meeting for Association of Academic Physiatrists in Nashville, TN.

rotation weakness in a patient with multiple prior shoulder surgeries, including a reverse shoulder arthroplasty.

Case Description

A 67 year old right-handed male who was a truck driver by occupation presented to the referral practice of an affiliated shoulder surgeon (JPW) with persistent left shoulder pain and loss of strength despite two prior rotator cuff surgeries. His initial injury was a result of a fall onto his left shoulder at work when he dove out of the way of heavy objects. He noted immediate shoulder weakness and pain. The patient denied any preceding shoulder pain or weakness prior this fall, but did report a remote history of left shoulder open debridement for bone spurs greater than 10 years prior and his shoulder was fully functioning thereafter. An arthroscopic rotator cuff repair was performed at an outside facility one month after his fall. Eight months later, he developed a re-tear of the rotator cuff, and subsequently underwent a patch-reconstruction at the outside facility.

When the patient presented to this practice at approximately seven months after his second rotator cuff surgery, he had pseudoparalysis of his left shoulder with active forward flexion to only 20 degrees. Strength-testing with a hand-held dynamometer revealed profound weakness in the supraspinatus with only 2.6 kilograms of resisted abduction force generated on the left compared with 17 kilograms generated on the right. He also had a positive lag sign of 20 degrees indicating an infraspinatus tear and a positive belly press test indicating a subscapularis tear. A shoulder MRI [Figure 1] obtained approximately two months after initial evaluation showed profound fatty degeneration of the supraspinatus, infraspinatus and the upper portion of the subscapularis. Fatty degeneration was measured as described by Goutallier et al. and determined to be Grade IV for supraspinatus, infraspinatus, and subscapularis¹. The axial images demonstrated a full-thickness tear involving most of the subscapularis tendon. The coronal images demonstrated static superior displacement of the humeral head and full-thickness tears with retraction of the entire supraspinatus and infraspinatus tendons.

Considering the patient's irreparable rotator cuff damage and two prior failed surgeries, the shoulder surgeon recommended reverse total shoulder arthroplasty. Additionally, this patient had infraspinatus atrophy demonstrated by external rotation weakness and a positive lag sign making him also a candidate for latissimus dorsi and teres major tendon transfers. The patient was scheduled for surgery two months later. However, his surgery was delayed another month because of a skin boil on the ipsilateral arm. Pre-operative shoulder radiographs demonstrated moderate degenerative joint disease of the glenohumeral and acromioclavicular joints, as well as superior migration of the left humeral head [Figure 2].

The patient underwent a complex revision reconstruction of his left shoulder at our institution with reverse total shoulder arthroplasty, latissimus dorsi and teres major tendon transfers [Figure 3] about thirteen months after his second surgery. Intra-operatively, the biceps tendon was identified to be scarred, thickened and enlarged within the bicipital groove. Hence, it was tenodesed. The patient had no intra-operative complications. He was placed in an external rotation immobilizer for six weeks after the surgery. Thereafter, he

began passive shoulder range of motion, deltoid isometrics, and active range of motion in the elbow, wrist, and hand motion under the supervision of a physical therapist, as outlined in the institution's regimented physical therapy protocol². He gradually progressed to active shoulder range of motion, strengthening exercises, and worked on biofeedback to reeducate the latissimus dorsi muscle to function as an external rotator. At about 12–16 weeks postoperatively, the patient reported almost no shoulder pain on reassessment. However, he had decreased sensation over the left deltoid. Due to concern for axillary neuropathy, an electrodiagnostic study was obtained at 16 weeks postoperatively.

Needle electromyography (EMG) of the left deltoid demonstrated active denervation changes in the form of 3+ fibrillation potentials as well as chronic reinnervation changes in the form of large amplitude, long duration motor unit action potentials and reduced recruitment. This was consistent with moderate to severe active and chronic left axillary nerve dysfunction. Nevertheless, in subsequent follow-up, the patient had intact axillary nerve sensation and deltoid contraction; thus he proceeded with his physical therapy program. The needle EMG also showed evidence for a mild chronic left C7-C8 radiculopathy, demonstrated by chronic reinnervation changes in the form of large amplitude, long duration motor unit action potentials in the left triceps, flexor carpi radialis, and first dorsal interosseus muscles. Needle EMG of the left biceps, brachioradialis, abductor digiti minimi, abductor pollicis brevis, and cervical paraspinal muscles were normal.

At approximately eleven months postoperatively, the patient was able to forward flex to 90–100 degrees. However, he complained of internal rotation weakness. The patient described how his left arm tended to externally rotate away from his body when he was supine, and that he was unable to actively internally rotate his arm to bring it back towards him. Palpation of the pectoralis major muscle of the left shoulder during resisted internal rotation showed abnormal contour of the pectoralis major muscle at its origin on contraction when compared to the contralateral side. There was concern for pectoralis major injury at its chest wall origin. Since the patient was functionally subscapularis deficient and the teres major had been transferred to make it an external rotator, the pectoralis major was the only viable internal rotator after his tendon transfers.

MRI was relatively contraindicated in this patient due to the presence of a shoulder prosthesis. Thus, the shoulder surgeon (JPW) referred the patient for an ultrasound, which was performed by the senior author (NBJ with assistance from JN for interpretation) to assess the integrity of the pectoralis major muscle at eleven months postoperatively. The ultrasound protocol was based on Rehman et al³. The patient was placed in a supine position. A portable ultrasound system (General ElectricLOGIQe, Waukesha, WI, USA) with a 13-8 megahertz linear array transducer was used to capture long axis views and short axis views of the pectoralis major origin at the chest wall. The left pectoralis major muscle was assessed using extended-field-of-views and compared to the contralateral extremity. The ultrasound showed that both the sternal and clavicular heads of the left pectoralis major were intact at its origin on the chest wall. However, in comparison to the contralateral shoulder, there was increased hyperechogenicity of the left pectoralis major muscle indicating moderate fatty infiltration [Figure 4]. There was also evidence for atrophy of the

left sternal head of the pectoralis major muscle which measured 1.18 centimeters in thickness versus 1.43 centimeters in thickness of the right pectoralis major muscle [Figure 4].

Since no pectoralis major tear was found, the patient was recommended to continue with his outlined physical therapy protocol² and home exercise program with strengthening and active range of motion of his left upper extremity. The patient's most recent follow-up was at 15 months after his reconstruction surgery. He was able to actively forward flex his arm to 120 degrees and was able to actively externally rotate to 20 degrees with no lag sign. He continued to have internal rotation weakness but noted improvement in function in his shoulder to 70% of normal compared to 20% preoperatively. He was instructed to follow-up in one year.

Discussion

We present a complex case from diagnostic and treatment perspectives. This patient achieved substantial functional and pain improvements after reverse shoulder arthroplasty and tendon transfers for an irreparable rotator cuff tear involving the supraspinatus, infraspinatus, and subscapularis, with failed prior rotator cuff repairs, and moderate glenohumeral osteoarthritis. Yet, the patient continued to have internal rotation weakness after surgery raising concern for a pectoralis major tear at its origin. Imaging of patients after prosthetic implantation can be challenging since the quality of MRI is degraded by artifact. Hence, ultrasound was a valuable diagnostic tool for this patient and assisted in further surgical decision-making.

Anterior and posterior rotator cuff tears result in superior translation of the humerus and subsequent loss of deltoid tension⁴. Thus, deltoid contraction results in superior migration of the humerus instead of arm elevation, since the deltoid loses its usual fulcrum of the humeral head within the glenoid⁴. In fact, this patient's shoulder radiographs [Figure 2] confirm superior displacement of the left humeral head and he also had resultant shoulder pseudoparalysis on examination. Reverse shoulder arthroplasty treats shoulder pseudoparalysis by allowing the deltoid to be the primary muscle for shoulder elevation². This is accomplished by inverting the shoulder joint anatomy by resurfacing the humeral head into a concave component that articulates with a glenosphere that covers the glenoid fossa². This recreates an adequate fulcrum for the deltoid since the shoulder joint's new center of rotation is directed caudally and medially towards the glenoid^{2,4}.

However, when the infraspinatus and teres minor muscles are torn or atrophied, patients also have difficulty with active external rotation⁵. Thus, tendon transfers of the latissimus dorsi and teres major, which are normally internal rotators, allow these muscles to substitute as external rotators⁵. In this situation, the pectoralis major and subscapularis muscles then remain as the primary internal rotators. Expected shoulder ranges of motion after reverse shoulder arthroplasty with tendon transfers are 90–120 degrees of forward flexion and 10–15 degrees of external rotation, which this patient did successfully achieve².

Since the teres major had been transferred to the posterolateral humerus and because the patient was functionally subscapularis deficient, the pectoralis major was the only viable internal rotator of the arm. Besides serving as an internal rotator, the pectoralis major muscle is also an adductor and flexor of the humerus^{6,7}. Pectoralis major muscle tears are rare but have increased in incidence in the past two decades secondary to weight-training injuries⁶. A systematic review of pectoralis major tears found only 279 reported cases between 1990 and 2010⁶. Pectoralis major muscle injuries usually occur during eccentric contraction of the pectoralis major muscle under heavy load, such as when performing a bench press^{6,8}. A direct blow to the shoulder while the arm is abducted and externally rotated can also injure the pectoralis major muscle⁷. Injury can also occur from breaking a fall with an outstretched arm in abduction and external rotation, with a resultant force across a contracted pectoralis major muscle³. The patient in this case fell on his left shoulder during his initial injury, although it is unclear if this was the source of his pectoralis major weakness.

Although this patient had an intact pectoralis major muscle, we found evidence for pectoralis major atrophy as well as fatty infiltration, which appears as increased echogenicity in ultrasound⁹. The pectoralis major tendon insertion was presumed to be intact since it was not of concern on physical examination. Hence, the patient's internal rotation weakness was concluded to be related to the pectoralis major muscle atrophy and fatty infiltration, as this muscle was the only remaining internal rotator in the setting of a deficient subscapularis muscle and teres major tendon transfer.

The pectoralis major muscle atrophy was likely multifactorial. Possible reasons include prolonged immobility from pain and disuse after his fall and multiple surgeries. His multiple surgeries could have also damaged his left axillary nerve and contributed to shoulder disuse. A neurogenic cause of pectoralis major atrophy is also a possibility, since EMG demonstrated a mild chronic C7-C8 radiculopathy and parts of the clavicular head (lateral pectoral nerve, C5-C7) and the sternocostal head (medial pectoral nerves, C6-T1) are innervated by the C7 and C8 nerve roots¹⁰. Lastly, medial cord and lateral cord brachial plexopathies, which result in medial pectoral nerve and lateral pectoral nerve dysfunction respectively, are other possible etiologies of pectoralis major atrophy. Yet these nerve conduction studies were not performed postoperatively since the patient did not complain of internal rotation weakness until after his EMG.

Although the success of ultrasound images remain operator-dependent, prior reports have shown that ultrasound is an effective modality for identifying and localizing a pectoralis major muscle tear or rupture^{3,7,8,9,11,12}. In particular Weaver et al. were able to retrospectively correlate sonographic findings of six patients with pectoralis major tears to their MRIs, surgical findings, and clinical exams⁷. Furthermore, ultrasound can be performed dynamically and one can perform side-to-side comparisons. An advantage of ultrasound over MRI is its ability to discriminate between the clavicular, manubrial, and abdominal laminae of the pectoralis major muscle which coalesce into a trilaminar tendon that inserts into the bicipital groove of the humerus^{3,7,9}. Also, a standard shoulder MRI does not capture the pectoralis major insertion, unless the image is set more caudally to include the area between the quadrilateral space and the deltoid tuberosity¹¹. Lastly, MRI has been

noted to be less accurate in differentiating between a pectoralis major muscle tear versus a rupture¹¹.

Ultrasound was essential in the management of this patient since the ultrasound demonstrated an intact pectoralis major muscle and thus precluded surgery. Ultrasound as a diagnostic modality for assessment of the pectoralis major muscle has only been described in a few reports^{3,7,8,9,11,12}. Yet, despite the paucity of prior literature, ultrasound was an excellent diagnostic tool in assessing the integrity of the pectoralis major muscle in this patient.

Acknowledgments

Grants received: NIH, Foundation for PM&R, Biomedical Research Institute (Grant #K23AR059199). This outside source of funds was not involved in data collection, data analysis, or the preparation or editing of the manuscript.

References

- Goutallier D, Postel JM, Bernageau J, Lavau L, Voisin MC. Fatty muscle degeneration in cuff ruptures. Pre- and postoperative evaluation by CT scan. Clin Orthop Relat Res. 1994 Jul.(304):78–83.10.1097/00003086-199407000-00014 [PubMed: 8020238]
- Wilcox, RB.; Boudreau, S. Reverse Total Shoulder Arthroplasty with Latissimus dorsi tendon transfer Protocol. The Brigham and Women's Hospital, Inc. Department of Rehabilitation Services; 2008. Available at http://www.brighamandwomens.org/Patients_Visitors/pcs/rehabilitationservices/PhysicalTherapyStandardsofCareandProtocols/Shoulder-ReverseTSAwithLatissimusDorsitransferprotocol.pdf [Accessed Oct 8, 2013.]
- Rehman A, Robinson P. Sonographic evaluation of injuries to the pectoralis muscles. AJR Am J Roentgenol. 2005 Apr; 184(4):1205–11.10.2214/ajr.184.4.01841205 [PubMed: 15788595]
- Drake GN, O'Connor DP, Edwards TB. Indications for reverse total shoulder arthroplasty in rotator cuff disease. Clin Orthop Relat Res. 2010 Jun; 468(6):1526–33.10.1007/s11999-009-1188-9 [PubMed: 20049573]
- Boileau P, Chuinard C, Roussane Y, Bicknell RT, Rochet N, Trojani C. Reverse Shoulder Arthroplasty Combined with a Modified Latissimus Dorsi and Teres Major Tendon Transfer for Shoulder Pseudoparalysis Associated with Dropping Arm. Clin Orthop Relat Res. 2008 Mar; 466(3):584–593.10.1007/s11999-008-0114-x [PubMed: 18219547]
- ElMaraghy AW, Devereaux MW. A systematic review and comprehensive classification of pectoralis major tears. J Shoulder Elbow Surg. 2012 Mar; 21(3):412–22. Epub 2011 Aug 10. 10.1016/j.jse.2011.04.035 [PubMed: 21831661]
- Weaver JS, Jacobson JA, Jamadar DA, Theisen SE, Ebrahim F, Kalume-Brigido M. Sonographic findings of pectoralis major tears with surgical, clinical, and magnetic resonance imaging correlation in 6 patients. J Ultrasound Med. 2005 Jan; 24(1):25–31. <http://www.jultrasoundmed.org/content/24/1/25.full.pdf>. [PubMed: 15615925]
- Wang Y-C, Jeng C-M, Shen P-W, Kung C-H, Wu C-Y, Lee W-Y, et al. Pectoralis Major Muscle Tear Diagnosed with Magnetic Resonance Imaging and Ultrasound—A Case Report. Tzu Chi Med J. 2005; 17:441–444. <http://www.tzuchi.com.tw/file/tcmj/94-6/2-6.pdf>.
- Jacobson, JA. Fundamentals of Musculoskeletal Ultrasound: Expert Consult-Online and Print 2e [Fundamentals of Radiology]. Vol. 36–38. Philadelphia: Elsevier Saunders; 2013. Shoulder Ultrasound; p. 64–65.
- Mackinnon, SE.; Fox, IK.; Yee, A.; Kahn, L.; Law, HZ.; Brown, JM. Pectoralis Major. Peripheral Nerve Surgery: A Resource for Surgeons. Washington University School of Medicine; St. Louis: <http://nervesurgery.wustl.edu/ev/brachialplexus/medialpectoralnerve/Pages/pectoralismajor.aspx> [Accessed February 1, 2014.]

11. Provencher MT, Handfield K, Boniquit NT, Reiff SN, Sekiya JK, Romeo AA. Injuries to the pectoralis major muscle: diagnosis and management. *Am J Sports Med.* 2010 Aug; 38(8):1693–705.10.1177/0363546509348051 [PubMed: 20675652]
12. Grechenig W, Tesch PN, Clement H, Mayr J. Sonoanatomy of the muscles and fascia spaces of the pectoral regions. *Ultraschall Med.* 2005 Jun; 26(3):216–22.10.1055/s-2004-813747 [PubMed: 15948058]

Figure 1.
Pre-operative left shoulder T1 Sagittal MRI at four months before reverse shoulder arthroplasty, demonstrating Grade IV fatty infiltration of supraspinatus, infraspinatus, and subscapularis muscles

Figure 2.
Pre-operative left shoulder radiographs at six days before reverse shoulder arthroplasty.

Figure 3.
Left shoulder radiograph on post-operative day seven after reverse total shoulder arthroplasty.

Figure 4.

Comparison of the left and right sternal heads of the pectoralis major muscles demonstrating fatty infiltration and muscle atrophy of the left pectoralis major (left pectoralis major measures 1.18 cm in thickness versus 1.43 cm on the right).