Sonographic Differences in the Appearance of Acute and Chronic Full-Thickness Rotator Cuff Tears

Sharlene A. Teefey, MD, William D. Middleton, MD, Gregory S. Bauer, MD,
Charles F. Hildebolt, DDS, PhD, Ken Yamaguchi, MD

This study was undertaken to identify differences in the sonographic appearance of acute and chronic full-thickness rotator cuff tears. The ultrasonograms of 24 patients with an acute rotator cuff tear and 20 with a chronic tear were reviewed for tear size (width), location, and the presence and distribution of fluid. Among these 24 patients, 75% with a mid-substance tear location had an acute tear; 64% of patients with joint or bursal fluid had an acute tear; 80% of patients with a nonvisualized rotator cuff due to a massive tear had a chronic tear; and 73% of patients with no sonographic evidence of bursal or joint fluid had a chronic tear. In conclusion, a mid-substance location and the presence of joint or bursal fluid were more commonly associated with an acute tear. A nonvisualized cuff and the absence of joint and bursal fluid were more commonly observed with a chronic tear. KEY WORDS: Shoulder, trauma; Rotator cuff tear; Tear, rotator cuff; Full-thickness rotator cuff tear.

Identification of acute RCT is important not only because early surgical intervention is indicated but also because such patients are more likely to benefit from minimally invasive arthroscopically assisted techniques. In fact, recent studies have shown that patients with rotator cuff tissue that is of good quality, freely mobile, minimally retracted, and associated with functional cuff muscles (absence of fatty infiltration and atrophy) are better suited for arthroscopic repair and have a good surgical outcome.[1–5] These cuff characteristics are found in patients with more acute RCTs.[1–3]

Recent studies have shown that MR imaging of the shoulder can identify many of these cuff and muscle characteristics.[4–6] Only one study has shown that ultrasonography can determine the integrity of cuff tissue and assess its importance in predicting functional outcome.[7] Harryman and coworkers found that the integrity of the cuff at postoperative follow-up evaluation, as determined by ultrasonography, was the major determinant for functional outcome after repair of an RCT.[7] The purpose of our study was to determine if sonographic differences

ABBREVIATIONS

RCT, Rotator cuff tear; MR, Magnetic resonance

Received December 29, 1999, from the Mallinckrodt Institute of Radiology (S.A.T., W.D.M, C.F.H.), and The Shoulder and Elbow Service, Department of Orthopedic Surgery (G.S.B., K.Y.), Washington University School of Medicine, St. Louis, Missouri. Revised manuscript accepted for publication February 22, 2000.

Address correspondence and reprint requests to Sharlene A. Teefey, MD, Mallinckrodt Institute of Radiology, Washington University School of Medicine, 510 South Kingshighway Boulevard, St. Louis, MO 63110.

can be noted in the appearances of acute and chronic RCTs in preoperative patients with a painful shoulder.

MATERIALS AND METHODS

The clinical histories and operative reports of 127 consecutive patients with shoulder pain who had undergone standardized preoperative shoulder ultrasonography and subsequent arthroscopy (bilateral studies and arthroscopic examinations in six patients) between November 1995 and August 1998 were reviewed retrospectively to identify those patients with a full-thickness RCT who met the criteria for an acute or chronic tear. An acute RCT was considered to be present when (1) the clinical history revealed a distinct injury within 6 months from the time of operation in a previously asymptomatic shoulder and (2) the operative findings showed blunt, frayed cuff edges, tendon quality and thickness comparable to those of an intact cuff, and a freely mobile cuff. A chronic RCT was considered to be present when (1) the clinical history revealed the presence of shoulder pain but no history of trauma for longer than 1 year and (2) the operative findings showed tapered, thinned cuff edges, poor tendon quality, and an immobile, fixed cuff. Using all of these criteria, all cases were categorized as acute or chronic by the orthopedic surgeon participating in the study (K.Y.). In this group, 15 men and 9 women (age range, 31 to 79 years; mean, 59 years) met the criteria for an acute tear, and 8 women and 12 men (age range, 49 to 83 years; mean, 64 years) met the criteria for a chronic tear. These 44 patients composed the study group. In the 83 patients who were excluded from the study, either information was not available to categorize an RCT as acute or chronic, the patient had had previous rotator cuff surgery, film images did not show a full-thickness tear, or the aforementioned criteria for differentiating acute and chronic RCT overlapped.

Sonographic Technique

All sonograms were obtained in real time with an ATL HDI 3000 (Advanced Technology Laboratories, Bothell, WA), a Siemens Elegra (Siemens Medical Systems, Issaquah, WA), or an Acuson 128XP/10 (Acuson, Mountain View, CA) scanner. All scans were obtained with a high-frequency linear array transducer (7.0 to 10 MHz). All patients underwent a standardized bilateral shoulder sonographic examination by one of two radiologists experienced in the technique.

Shoulder ultrasonography was performed with the patient seated on a stool. First, the biceps tendon was examined in a transverse plane from the level of the acromion inferiorly to where it unites with the biceps muscle. The transducer was then rotated 90 degrees to examine the tendon longitudinally. Next, the subscapularis tendon was imaged with the patient's arm in external rotation. The transducer was placed in a transverse anatomic orientation at the level of the lesser tuberosity and moved medially to examine the tendon.

The supraspinatus tendon was imaged with the arm extended, the elbow flexed, and the hand placed on the iliac wing. This position was required to expose as much of the supraspinatus tendon as possible from beneath the acromion. The transducer was placed parallel to the long axis of the tendon fibers (approximately 45 degrees between the coronal and sagittal planes) to visualize the tendon in a longitudinal plane, and it was moved anteriorly to posteriorly to visualize the supraspinatus and infraspinatus tendons, respectively. The transducer was rotated 90 degrees to examine the tendons in a transverse plane.

Sonographic Review and Criteria

All ultrasonographic hard copy film images of each patient in the study group were reviewed retrospectively and independently by two radiologists who were blinded to the patient's history and operative findings. All images were then re-reviewed jointly to achieve a consensus. At our institution, shoulder ultrasonography is performed in a standardized manner and representative hard-copy film images are taken of all relevant findings, including images showing RCT width and location and the absence or presence of fluid. Nevertheless, the data from the retrospective review of the images were correlated with information in the original report to ensure consistency and, in particular, a consensus regarding the presence and distribution of abnormal fluid collections. When a consensus could not be reached between reviewers, the real-time impression as indicated in the dictated report was used as the final arbiter. This was necessary in only a limited number of cases.

All images were reviewed for the width of the full-thickness tear (measured in a transverse plane perpendicular to the tendon fibers—i.e., anterior to posterior). If the tear extended 1.5 cm or less from the intra-articular portion of the biceps tendon, it was considered to involve only the supraspinatus tendon, and if it extended for more than 1.5 cm, it was

considered to involve both the supraspinatus and infraspinatus tendons. The teres minor tendon was not evaluated separately when determining tear extent. Images also were reviewed for the location of the tear (that is, whether it occurred at the bone-tendon junction at the level of the greater tuberosity [insertional] or within the substance of the cuff [midsubstance]). Finally, images were reviewed for the absence or presence and distribution of fluid about the shoulder. A very small amount of biceps tendon sheath fluid was considered normal. The presence of any fluid in the subdeltoid bursa or posterior glenohumeral joint space was considered abnormal.

Surgical Technique

All arthroscopic examinations and operative procedures were performed by a single orthopedic surgeon (K.Y.). Cases were performed and recorded in a standardized manner. Representative arthroscopic images were taken of the RCT. The width and location of the tear, thickness and character of the cuff edge, tendon quality, and mobility of the cuff were recorded in the operative report.

Data Analysis

Sonographic findings of tear width and location were correlated with the chronicity of the tear. The presence or absence of fluid as determined at sonography could not be correlated with arthroscopic findings.

RESULTS

RCT width did not correlate with the chronicity of the tear. Fifteen of the 44 patients (34%) entered into the study had an RCT width less than or equal to 1.5 cm. Nine (60%) of these 15 patients had an acute tear and six (40%) had a chronic tear. Twenty-nine of the 44 patients (66%) had an RCT width greater than 1.5 cm. Fifteen (52%) of these 29 patients had an acute tear, and 14 (48%) had a chronic tear. The rotator cuff could not be visualized in five patients because it was retracted beneath the acromion. One (20%) of these five patients had an acute tear and four (80%) had a chronic tear.

The RCT was located at the bone-tendon junction at the level of the greater tuberosity in 36 of the 44 patients (82%). Among these, 18 (50%) patients had an acute tear and 18 (50%) had a chronic tear. Eight of the 44 patients (18%) had a midsubstance tear medial to the bone-tendon junction. Six (75%) of these eight patients had an acute tear (Fig. 1) and two (25%) had a chronic tear.

Joint or bursal fluid was present in 33 of the 44 patients (75%). Twenty-one (64%) of these 33 patients had an acute tear and 12 (36%) had a chronic tear. Eleven of the 44 patients (25%) had no sonographic evidence of bursal or joint fluid. Of these 11, 3 (27%) patients had an acute tear, and 8 (73%) had a chronic tear (Fig. 2).

Absence of joint and bursal fluid and nonvisualization of the rotator cuff was present in only three patients (7%), but all three had chronic RCT (Fig. 3).

DISCUSSION

RCT is a very common cause of shoulder pain and can result in significant loss of function and strength. Although a majority of patients have chronic pain as a presenting feature, a small percentage of patients without a previous history of shoulder pain have an acute, traumatic cause for their RCT.[8] Acute tears are considered an indication for early surgical intervention because a delay in repair may result in attritional changes in the cuff tendon, muscle, or both. These chronic changes may make the repair more difficult technically and the functional outcome less satisfactory.[3,7–10] Early repair generally affords the best opportunity for return of shoulder function and strength in addition to pain relief.[2,11–14] Although patient history, physical examination, and plain radiographs can provide information about the chronicity of a cuff tear, the diagnosis may not always be clear, and imaging tests, such as ultrasound may be important in providing additional information.

Figure 1 Ultrasonogram shows an acute RCT with a midsubstance location. Fluid separates the torn tendon ends (*arrow*). The image is oriented in a plane parallel to the longitudinal axis of the tendon.

Figure 2 Ultrasonogram shows a chronic RCT producing a focal concave defect in the normally curvilinear convex cuff (*arrow*). Joint and bursal fluid are absent. The image is oriented in a plane parallel to the longitudinal axis of the tendon.

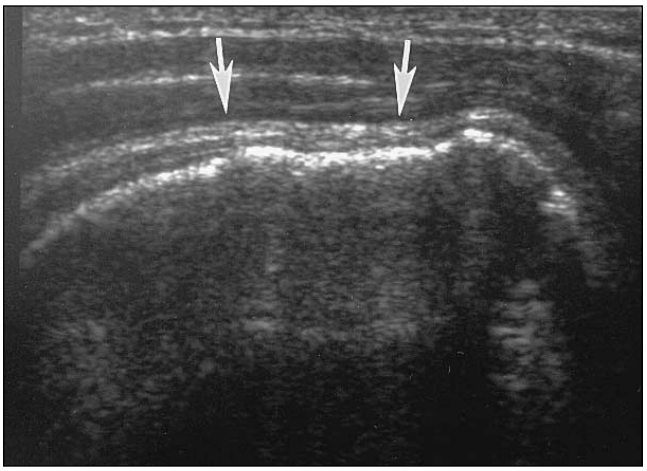

Figure 3 Ultrasonogram shows a massive, chronic RCT producing nonvisualization of the cuff. Note close apposition of the deltoid and peribursal fat (*arrows*) to the humeral head and greater tuberosity. The image is oriented in a plane parallel to the longitudinal axis of the tendon.

The purpose of our study was to identify ultrasonographic findings that would help to differentiate acute from chronic RCT in patients with a painful shoulder. Sonographic findings were compared specifically to operative findings previously established in the orthopedic literature to distinguish acute and chronic tears.[1,3] This information would be useful to the orthopedic surgeon not only in treatment planning but also in counseling patients regarding the success of conservative therapy, surgical options (simple decompression, complete arthroscopic repair, mini-open repair, and formal open repair), and eventual outcome.

In this series, although the size (width) of an RCT did not correlate with the chronicity of the tear, we found that the presence of a nonvisualized cuff suggested a chronic tear. These findings are somewhat different from those reported by Farin and Jaroma, who studied 98 patients with ultrasonography within 3 weeks of injury and correlated findings with those at arthroscopy or open repair.[15] These authors described a wide variety of appearances consistent with acute RCT, including nonvisualization of the cuff.[15] However, in their study, it was unclear whether patients had a history of shoulder pain prior to injury, and the appearance and quality of the cuff tissue at operation were not reported. Thus, it is possible that some patients in their study may have had chronic RCT or acute extension of chronic tears—in particular, those with nonvisualized cuffs. Other studies have reported the sonographic finding of nonvisualization of the cuff as indicative of a massive RCT,[16–21] a finding that our data suggested correlates with a chronic tear. Of the five patients in our study with nonvisualization of the rotator cuff, four (80%) had a chronic tear.

All six patients with a surgically proven midsubstance tear location had acute tears. The finding of a midsubstance tear at operation, although uncommon, is observed almost exclusively in the setting of an acute RCT. Our data supported this observation; at operation, six of the eight patients we categorized by ultrasonography as having a midsubstance location of the tear had an acute tear. However, two patients with chronic tears that we categorized by ultrasonography as having midsubstance tears actually had insertional tears at operation. We believe these two false positive cases were due to the geometry of the tear.

Joint or bursal fluid was present in 64% of patients with an acute RCT and in 36% with a chronic tear. Because acute tears are more likely to have a significant hemorrhagic and an inflammatory component with subsequent fluid exudation, increased joint or bursal fluid would be expected to occur in these cases. Joint or bursal fluid was absent in most patients with a chronic RCT. Of the 11 patients with no sonographic evidence of bursal or joint fluid, eight (73%) had a chronic tear. The combination of a nonvisualized rotator cuff and absence of joint or bursal fluid was present in only three patients in our study, but all three had a chronic RCT.

Our retrospective study has several limitations. First, in addition to the aforementioned criteria, we attempted to evaluate the appearance of the torn tendon edge as a criterion for determining the acuteness

of a cuff tear. We reviewed the hard copy film images and categorized the tendon edges as blunt, tapered, or complex in order to predict the quality and thickness of the tendon tissue. However, we found it difficult to define and quantify these terms objectively, and we could not achieve reader consensus. Furthermore, in the absence of fluid, it was not possible to distinguish the torn tendon edge from thickened bursal tissue.

Second, our sample sizes were small. Although the comparisons between the sonographic findings in acute and chronic RCT in our study approached statistical significance, the sample sizes were not large enough to demonstrate a significant relationship. This does not imply that our results were not clinically important. The design of our study allowed us to identify sonographic criteria that could be compared with surgical findings consistent with either an acute or a chronic tear. Identification of such criteria is a necessary prerequisite to determining their utility in a larger, blinded, prospective study.

Finally, we realized that the clinical and surgical criteria we used to categorize our patients as having acute or chronic RCT created two relatively "pure" populations of patients. However, these two populations have been associated with distinctly different outcomes regarding long-term shoulder function. The functional outcome for those patients in whom the chronicity of their tear lies somewhere between these two relatively pure populations is less clear.

In conclusion, our findings suggest that differences exist in the ultrasonographic appearance of acute and chronic RCT. The presence of a midsubstance tear location or fluid in the joint or bursa suggests an acute tear, whereas the presence of a nonvisualized cuff or absence of joint and bursal fluid suggests a chronic tear.

REFERENCES

1. Warner JP, Goitz RJ, Ingang JJ, et al: Arthroscopic-assisted rotator cuff repair: Patient selection and treatment outcome. J Shoulder Elbow Surg 6:463, 1997
2. Rockwood CA, Matsen FA, Wirth MA, et al: The Shoulder. 2nd Ed. Philadelphia, WB Saunders, 1998, p 812
3. Neviaser RJ: Tears of the rotator cuff. Orthop Clin North Am 11:295, 1980
4. Buirski G: Magnetic resonance imaging in acute and chronic rotator cuff tears. Skeletal Radiol 19:109, 1990
5. Thomazeau H, Boukobza E, Morcet N, et al: Prediction of rotator cuff repair results by magnetic resonance imaging. Clin Orthop 344:275, 1997
6. Zanetti M, Gerber C, Hodler J: Quantitative assessment of the muscles of the rotator cuff with magnetic resonance imaging. Invest Radiol 33:163, 1998
7. Harryman DT, Mack LA, Wang KY, et al: Repairs of the rotator cuff. J Bone Joint Surg [Am] 73:982, 1991
8. Bassett RW, Cofield RH: Acute tears of the rotator cuff. Clin Orthop 175:18, 1983
9. Bateman JE: The diagnosis and treatment of ruptures of the rotator cuff. Surg Clin North Am 43:1523, 1963
10. Codman EA: Rupture of the supraspinatus. Am J Surg 42:603, 1938
11. Bartolozzi A, Andreychik D, Ahmad S: Determinants of outcome in the treatment of rotator cuff disease. Clin Orthop 308:90, 1994
12. Itoi E, Tabata S: Conservative treatment of rotator cuff tears. Clin Orthop 275:165, 1992
13. Bokor DJ, Hawkins RJ, Huckell GH, et al: Results of nonoperative management of full-thickness tears of the rotator cuff. Clin Orthop 294:103, 1993
14. Hawkins RH, Dunlop R: Nonoperative treatment of rotator cuff tears. Clin Orthop 321:178, 1995
15. Farin PU, Jaroma H: Acute traumatic tears of the rotator cuff: Value of sonography. Radiology 197:269, 1995
16. Farin PU, Jaroma H, Hargu A, et al: Shoulder impingement syndrome: Sonographic evaluation. Radiology 176:845, 1990
17. Mack LA, Matsen FA, Kilcoyne RF, et al: US evaluation of the rotator cuff. Radiology 157:205, 1985
18. Crass JR, Craig EV, Feinberg SB: Ultrasonography of rotator cuff tears: A review of 500 diagnostic studies. J Clin Ultrasound 16:313, 1988
19. Middleton WD, Reinus WR, Totty WG, et al: Ultrasonographic evaluation of the rotator cuff and biceps tendon. J Bone Joint Surg [Am] 68:440, 1986
20. Bretzke CA, Crass JR, Craig EV, et al: Ultrasonography of the rotator cuff: Normal and pathologic anatomy. Invest Radiol 20:311, 1985
21. Wiener SN, Seitz WH: Sonography of the shoulder in patients with tears of the rotator cuff: Accuracy and value for selecting surgical options. AJR 160:103, 1993