Sonography of the Shoulder in Patients with Tears of the Rotator Cuff: Accuracy and Value for Selecting Surgical Options

Stephen N. Wiener
William H. Seitz, Jr.

OBJECTIVE. The management of patients with signs and symptoms referable to the rotator cuff depends on the presence of cuff injury and the size of the tear. Treatment options include conservative nonsurgical management for patients with an intact or partially torn cuff, arthroscopic decompression of the coracohumeral space for those not responding to nonsurgical management, and a range of surgical techniques to repair full-thickness tears. This study was designed to determine whether sonographic evaluation with classification of the extent of cuff injury is accurate for purposes of treatment planning.

SUBJECTS AND METHODS. Preoperative sonography of the rotator cuff was performed on 225 patients, and findings were classified into intact, partial tear, small full-thickness tear, large full-thickness tear, and massive tear groups. Surgical correlation with the predicted sonographic classification was provided by arthroscopic inspection or open surgery.

RESULTS. The sonographic findings were surgically confirmed for 206 (92%) of the 225 patients. More extensive cuff injury was encountered during surgery than had been predicted sonographically in 11 patients (5%); less extensive injury than predicted was found during surgery in eight patients (4%).

CONCLUSION. Our results show a high correlation between the sonographic classification of rotator cuff injury and the surgical findings. The selection of appropriate treatment programs can be reliably based on the sonographic classification.

AJR 1993;160:103–107

Alleviation of disabling signs and symptoms and restoration of function are the goals of therapy for patients with complaints referable to the rotator cuff in the shoulder. Medical treatment and a range of surgical therapeutic options are available, and the choice between them depends on the presence and magnitude of the pathologic changes. Sonography of the shoulder is effective for detecting tears of the rotator cuff. The size of the tear can be classified and the findings used as a basis for management decisions. This report assesses the accuracy of preoperative sonography of the shoulder and the implications of the findings on subsequent surgical management.

Subjects and Methods

From 1985 to 1991, 800 patients with signs and symptoms referable to impingement and suspected tears of the rotator cuff were referred for shoulder sonography. Of these, 106 men and 119 women 21–81 years old (mean, 59 years old) ultimately required surgical management.

Shoulder sonography was performed as described by Crass et al. [1] with either a Diasonics DRF 400 or an Acuson 128 system and with the patient seated. A 7.5-MHz linear-array transducer was used routinely; an additional 5-MHz linear-array transducer was used for patients with large shoulders. The shoulder was examined anteriorly and laterally in both axial and sagittal planes with the patient's arm in neutral and in internally rotated positions; the latter was achieved by placing the patient's wrist against the small of the patient's back.
Sonographic observations and conclusions were made during real-time imaging by using the imaging monitor. Observations were made on the presence and magnitude of joint fluid, calcifications, the appearance of the long tendon of the biceps muscle and the adjacent bicipital groove, the contour of the humeral head and tuberosities, and the thickness and echogenicity of the subscapularis and supraspinatus portions of the rotator cuff. Criteria used for tears of the rotator cuff (Fig. 1) were as follows: (1) partial-thickness tear: a focal hypoechoic zone within the substance of the rotator cuff, small hypoechoic discontinuities of the internal or external surfaces of the cuff, or the presence of a large dominant linear echogenic focus within the substance of the cuff with or without associated diminution of the cuff thickness; (2) full-thickness tear: a hypoechoic zone extending through the entire substance of the cuff or segmental or complete loss of rotator cuff substance with visualized tear margins; and (3) massive tear: nonvisualization of the rotator cuff with "approximation" of the deltoid muscle to the surface of the humeral head. Cuff arthropathy was indicated by irregular changes in contour involving the humeral head; these usually were associated with a high-riding humeral head. An estimate of the size of a full-thickness tear was made from images recorded in both axial and sagittal planes (Fig. 2). The plane in which the tear was largest was used for classification purposes. In the axial plane, the width of the cuff defect or the hypoechoic zone or the distance between the visualized cuff margins was measured. In the sagittal plane, the distance was measured from the greater tuberosity to the visualized cuff margin or the length of the depressed interface between the supraspinatus and overlying deltoid muscle. If the supraspinatus portion was not visualized, the tear was classified as massive and was assumed to be greater than 3 cm. The sonographic findings were classified as intact normal, partial-thickness tear, small full-thickness tear (<1 cm), large full-thickness tear (1-3 cm), or massive tear with or without cuff arthropathy (Fig. 3).

The surgical treatment was generally based on the sonographic classification. Patients with a classification of intact normal or partial tear who did not respond to medical management within a designated time had arthroscopic decompression of the subacromial space. Before the decompression, the rotator cuff was completely evaluated by means of arthroscopic visualization and palpation through multiple portals of the rotator cuff [2, 3]. In each instance, the subscapularis, supraspinatus, and infraspinatus portions of the rotator cuff were examined from their insertion to their musculotendinous junctions. Patients with small full-thickness tears were treated by arthroscopic decompression combined with a limited anterolateral splitting incision of the deltoid muscle with local reattachment of the locally detached tendon edge. The rotator cuff was examined arthroscopically as described. Patients with large full-thickness or massive tears had formal open surgical exposure for examination and repair of the rotator cuff. The integrity of the cuff and the size of the tear were graded on the basis of surgical findings, and the results were compared with the sonographic classification.

Results

Table 1 lists the results of the sonographic examinations and the corresponding surgical findings. On the basis of sonographic findings, 71 patients had an intact rotator cuff, and 154 had either a partial- or a full-thickness tear. When the surgical findings were used as the gold standard, the sonographic findings correlated with the surgical findings in 206 (92%) of 225 patients. A normal rotator cuff was confirmed surgically in 63 (89%) of the 71 patients; three had partial-thickness tears, and five had small full-thickness tears. A partial- or full-thickness tear was confirmed for 143 (93%) of 154 patients. The sonographic finding of a partial-thickness tear was not confirmed surgically for five patients; four had a normal rotator cuff, and one had a small full-thickness tear. The sonographic finding of a full-thickness tear was confirmed surgically in 84 (99%) of 85 patients. One of the 85 had a partial-thickness tear, the size of the tear was classified incorrectly for five patients. The binary decision charts that show the effectiveness of using shoulder sonograms to detect the presence of a tear and to correctly classify the extent of a tear are shown in Figure 4.
Fig. 3.—Axial (A, C, and E) and sagittal (B, D, and F) sonograms of rotator cuff and tears of rotator cuff.

A and B. Normal intact cuff with convex arc of peritendinous fat (long arrows) and attachment of supraspinatus tendon to greater tuberosity (short arrow in $B$).

C and D. Small full-thickness tear. Note edges (arrows in $C$) on axial view and decreased thickness of cuff and subtle loss of peritendinous convexity (arrows in $D$) on sagittal view.

E and F. Large full-thickness tear. Short arrows indicate extent of tear. Long arrows indicate marked loss of peritendinous convexity.

Discussion

For patients with symptoms of rotator cuff impingement, a range of management options can be used to alleviate symptoms that may be disabling and to restore normal shoulder movement. A spectrum of rotator cuff abnormalities may be encountered, from early inflammation of the subacromial-subdeltoid bursa and rotator cuff tendon through partial-thickness injury to full-thickness tear, detachment, and progressive retraction, and finally, degenerative changes affecting the glenohumeral joint. Knowledge of the extent of damage and of the quality of the remaining rotator cuff tissue is key to management. Patients with an intact rotator cuff or a partial-thickness tear are initially managed nonsurgically. Medical management includes antiinflammatory agents and rehabilitative physiotherapy designed to strengthen the cuff.
TABLE 1: Sonographic vs Surgical Findings in Tears of the Rotator Cuff

<table>
<thead>
<tr>
<th>Surgical Findings</th>
<th>No. of Patients</th>
<th>Normal</th>
<th>Partial-Thickness Tear</th>
<th>Full-Thickness Tear</th>
<th>Massive Tear</th>
</tr>
</thead>
<tbody>
<tr>
<td>Normal</td>
<td>71</td>
<td>63</td>
<td>3</td>
<td>5</td>
<td>0</td>
</tr>
<tr>
<td>Partial-thickness tear</td>
<td>69</td>
<td>4</td>
<td>64</td>
<td>1</td>
<td>0</td>
</tr>
<tr>
<td>Small full-thickness tear</td>
<td>29</td>
<td>0</td>
<td>0</td>
<td>27</td>
<td>2</td>
</tr>
<tr>
<td>Large full-thickness tear</td>
<td>32</td>
<td>0</td>
<td>0</td>
<td>1</td>
<td>29</td>
</tr>
<tr>
<td>Massive tear</td>
<td>24</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>1</td>
</tr>
<tr>
<td>Total</td>
<td>225</td>
<td>67</td>
<td>68</td>
<td>34</td>
<td>32</td>
</tr>
</tbody>
</table>

Fig. 4.—Binary decision matrices for sonography vs surgery in tears of the rotator cuff. For detection of tears, sonography has a sensitivity of 95% (150/158), a specificity of 94% (63/67), a positive predictive value of 97% (150/154), and a negative predictive value of 89% (63/71). For staging of tears, sonography has a sensitivity of 91% (143/158), a specificity of 94% (63/67), a positive predictive value of 97% (143/147), and a negative predictive value of 81% (63/79).

Several radiologic techniques have been used to detect tears of the rotator cuff. Each has limitations, and no clear consensus on the optimal diagnostic study has emerged. Contrast arthrography is an invasive procedure and does not show tears when no free communication with the subacromial-subdeltoid bursa occurs. MR imaging is currently expensive and time-consuming and MR criteria for diagnosis of a tear are not universally accepted [8–10]. Our results and those from other studies [11–16] emphasize the accuracy of shoulder sonography for determining the integrity of the rotator cuff. Although surgical proof was lacking for 575 patients and the surgical group was biased in favor of those with persistent signs and symptoms or functional limitations of the shoulder joint, the surgical findings confirmed the sonographic findings and grade of rotator cuff injury in most patients (Table 1).

Unfortunately, less favorable results of shoulder sonography have been reported [17–19] and have discouraged the general use of this technique [20]. Insufficient experience is often cited as the cause for poor results [13, 17]. This reason...
would appear to be more of an indictment of the operator then an inherent limitation of the technique. The selection of inappropriate criteria also contributes to diagnostic error, especially if hyperechoic foci are considered to be tears [11, 15, 19, 21, 22]. A frank full-thickness tear is seen as a hypoechoic zone. Inferior results have also been reported when partial-thickness tears were included in the assessment of overall results [2]. Many patients with partial-thickness tears are asymptomatic [3]. As described previously, the presence of a partial-thickness tear has minimal impact on the choice of therapeutic option. From a practical point of view, patients with a partial-thickness tear are managed initially just as those with an intact cuff are managed. Finally, although images were obtained in the axial and sagittal planes for record-keeping purposes, active viewing of the texture and thickness of the rotator cuff from the imaging monitor was considered essential for diagnosis. In our experience with more than 2500 shoulder sonograms, judgments based solely on the “hard copy” are frequently in error. Shoulder sonography, performed by the radiologist, can be completed and a diagnosis established within 15 min. The simplicity, rapidity, low cost, and accuracy of the examination make it especially attractive as a screening and presurgical staging study. The benefits include more precise preoperative planning, reduction in surgical morbidity, and better estimates of recovery time.

REFERENCES


The reader’s attention is directed to the commentary on this article, which appears on pages 109–110.