SONOGRAPHIC EVALUATION OF SHOULDER JOINT PAIN WITH MRI CORRELATION

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ABSTRACT

BACKGROUND

Shoulder pain is one of the most common complaints encountered in clinical practice. It is also the commonest musculoskeletal ultrasound examination request. It often leads to considerable disability, hence an early diagnosis allows proper surgical treatment planning that can prevent functional impairment. Magnetic Resonance Imaging (MRI) is the state of the art diagnostic tool for evaluation of the shoulder. It allows the evaluation of the bone marrow, tendons, muscles, ligaments, capsules and bursae, but its limitations lie in the evaluation of the labrum and glenohumeral ligaments for which MRI arthrography is the study of choice. Improvement in the resolution of USG machines, refined techniques and better understanding of the pathology have contributed to high accuracy in the diagnosis of rotator cuff pathology. With an experienced sonologist and good equipment, accuracy of USG equals that of MRI for full-thickness tears and is slightly better than MRI for partial-thickness tears. USG's real-time capability, low cost and dynamic nature makes it the preferred imaging modality over MRI in several institutes.

MATERIALS AND METHODS

The present study is a case series study carried out at Katuri Medical College and Hospital in the Department of Radiodiagnosis and includes 50 patients with the complaint of shoulder joint pain with suspected rotator cuff pathologies, were evaluated with ultrasound examination which was further followed by MRI and the results were compared and analysed for significance. Machines used- USG-Philips Envisor, GE LOGIQ F8, MRI- GE 0.2 Tesla machine.

RESULTS

50 patients with shoulder pain with a clinical suspicion of rotator cuff tear were evaluated. USG examination of the affected shoulder was done in comparison with the normal shoulder and the findings were correlated with the subsequent MRI findings. Ultrasound can be used for the initial investigation of suspected rotator cuff pathologies. Advantages of ultrasound are non-invasive, real time, low cost, no radiation and the advantage of dynamic examination and comparison with the normal side.

CONCLUSION

In our study of 50 patients with suspected rotator cuff pathology, ultrasound demonstrated a high sensitivity and specificity more so for supraspinatus tendon pathologies and least for peribicipital tendon fluid collection and SASD bursitis. Also USG is a reliable dynamic diagnostic tool and provides direct correlation of the imaging findings with the symptoms of the patient, and helps with guided interventional procedures. Therefore, it should be considered as an accurate modality for the initial investigation of rotator cuff, especially supraspinatus tears. MRI is preferably done after sonography in doubtful cases or for evaluation of shoulder pathologies like labral tears.

KEYWORDS

Shoulder Joint, MRI, Ultrasound, Rotator Cuff, Tendons.

HOW TO CITE THIS ARTICLE: Narra R, Jehendren VM, Bollipo JP, et al. Sonographic evaluation of shoulder joint pain with MRI correlation. J. Evolution Med. Dent. Sci. 2017;6(37):3007-3013, DOI: 10.14260/Jemds/2017/649

BACKGROUND

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Financial or Other, Competing Interest: None.

Submission 18-03-2017, Peer Review 24-04-2017,

Acceptance 01-05-2017, Published 08-05-2017.

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DOI: 10.14260/Jemds/2017/649

Rotator cuff disease may result from a variety of causes including degenerative, repetitive overhead activities at work or through involvement in sports or due to trauma. The most common causes of a painful shoulder include periarticular soft tissue lesions involving tendons and bursae and are often associated with chronic impingement of the rotator cuff on the anterolateral margin of the acromion. Magnetic Resonance Imaging (MRI) is the state-of-the-art diagnostic tool for evaluation of the shoulder. It allows the evaluation of the bone marrow, tendons, muscles, ligaments, capsules and bursae, but its limitations lie in the evaluation of the labrum and glenohumeral ligaments for which MRI arthrography is the study of choice.

Improvement in the resolution of USG machines, refined techniques and better understanding of the pathology have contributed to high accuracy in the diagnosis of rotator cuff pathology. With an experienced sonologist and good equipment, accuracy of USG equals that of MRI for full-

thickness tears and is slightly better than MRI for partial-thickness tears. USG's real-time capability, low cost and dynamic nature makes it the preferred imaging modality over MRI in several institutes.

Aims and Objectives

- Evaluation of shoulder joint pain with USG as the first line of imaging emphasising on rotator cuff pathology.
- Correlation of the accuracy of USG with that of MRI in the evaluation of rotator cuff pathologies.
- To delineate pitfalls and limitation of USG when compared with MRI during image interpretation of rotator cuff pathologies in a patient with shoulder pain.

MATERIALS AND METHODS

The present study was a case series study carried out at Katuri Medical College and Hospital in the Department of Radiodiagnosis, which included 50 patients with the complaint of shoulder joint pain with suspected rotator cuff pathologies who were evaluated with ultrasound examination, which was further followed by MRI and the results were compared and analysed for significance. The following inclusion and exclusion criteria were taken into confidence.

Inclusion Criteria

The study includes,

- All patients with shoulder pain with a clinical suspicion of rotator cuff injuries.
- All age groups irrespective of sex.

Exclusion Criteria

The study excludes,

- Patient having history of previous surgery with placement of prosthesis, cardiac pacemakers and metallic foreign body in situ.
- Patient having history of claustrophobia.
- Known cases of rheumatoid arthritis.

Machines Used

USG- Philips Envisor, GE LOGIQ F8.

MRI- GE 0.2 Tesla machine.

Ultrasound Technique

Shoulder ultrasound was performed using a high frequency (5 - 12 MHz) linear array probe with tissue harmonic imaging. Patient was made to sit on a rotating stool facing the examiner close to the USG machine. Both static and dynamic assessment of the affected shoulder in comparison with the normal shoulder was done.

The following structures were examined: Biceps tendon, subscapularis, supraspinatus (including test for impingement), infraspinatus, teres minor, posterior glenoid labrum and glenohumeral space, coracoacromial ligament and finally the acromioclavicular joint.

MRI

Imaging was done with 0.2 Tesla GE machine using shoulder coil. The following sequences were selected as required.

- Coronal oblique T1W/ PD Fast Spin Echo (FSE) sequence.
- Coronal oblique STIR sequence.
- Sagittal oblique T2W FSE sequence.

- Axial T2WI.
- Axial PDW FSE.
- Field of view 20 x 20 cm, slice thickness 4 mm and matrix- 256 x 160.

Statistical Methods

Significance is assessed at 5% level of significance. Spearman correlation and Kappa coefficient has been used to find the significance of study parameters on categorical scale between two or more groups. Diagnostic statistics like Sensitivity, Specificity, PPV, NPV and Accuracy have been computed to find the correlation of USG with MRI findings.

RESULTS

50 patients with the complaint of shoulder joint pain were evaluated using ultrasound, which was further followed by MRI.

Age	Male	Female	Total	Percentage
21 - 30	3	1	4	8
31 - 40	3	4	7	14
41 - 50	11	4	15	30
51 - 60	13	6	19	38
61 - 70	3	0	3	6
71 - 80	1	1	2	4

Table 1. Age Distribution

Gender	Number of Patients	Percentage
Male	34	68
Female	16	32
Total	50	100

Table 2. Gender Distribution

Tendons	Partial Thickness	Full Thickness	Intra-Substance	Tendinosis	Normal
Subscapularis	02 (4%)	0	0	0	48 (96%)
Supraspinatus	20 (40%)	9 (18%)	0	7 (14%)	14 (28%)
Infraspinatus	0	0	0	0	50 (100%)
Teres Minor	0	0	0	0	50 (100%)
Biceps	0	0	0	3 (6%)	47 (94%)

Table 3. Ultrasound Findings- Pathology (Tears)

Criteria	Number of Patients	%
Present	20	40
Absent	30	60

Table 4. USG Finding of Peribicipital Tendon Fluid

Bursal Fluid/ Bursitis	Criteria	Number of Patients	%
SASD	Absent	40	80%
	Present	10	20%

Table 5. Ultrasound Findings- Bursal Fluid/Bursitis

Tendons	Partial Thickness	Full Thickness	Intra-Substance	Tendinosis	Normal
Subscapularis	2 (4%)	0	0	1 (2%)	47 (94%)
Supraspinatus	25 (50%)	7 (14%)	0	7 (14%)	11 (22%)
Infraspinatus	0	0	0	0	50 (100%)
Teres Minor	0	0	0	0	50 (100%)
Biceps	0	0	0	3 (6%)	47 (94%)

Table 6. MRI Findings of Tendon Tears

Criteria	Number of Patients	%
Present	39	78
Absent	11	22

Table 7. MRI Findings- Peribicipital Tendon Fluid

Other Findings	No. of Patients	Percentage
No Other Findings (NIL)	46	92
Spinoglenoid Notch Cyst (SGC)	1	2
Calcification in Tendon (CA)	1	2
Axillary Lymphadenopathy (AX.LAD)	2	4

Table 8. MRI other Findings

Sl. No.	Pathology	TP	FP	FN	TN	Detection Rate by USG	Detection Rate by MRI
1	Subscapularis	1	1	1	47	4%	4%
2	Supraspinatus	35	0	3	12	70%	76%
3	Infraspinatus	0	0	0	50	0%	0%
4	Teres Minor	0	0	0	50	0%	0%
5	Biceps Tendon	2	1	1	46	6%	6%
6	Peribicipital Tendon Fluid	20	0	19	11	40%	78%
7	SASD Bursitis	7	3	21	19	20%	56%

Table 9. Correlation of USG and MRI Findings

Sl. No.	Pathology	Sensitivity	Specificity	PPV	NPV	Accuracy	P Value by Spearman	Kappa Coefficient
							Correlation	Values and Agreement
1	Subscapularis	50%	97.92%	50%	97.92%	94%	< 0.001 Significant	0.315 Fair
2	Supraspinatus	92.11%	100%	100%	80%	94%	< 0.001 Significant	0.848 Almost Perfect
3	Infraspinatus	-	100%	-	100%	100%	-	-
4	Teres Minor	-	100%	-	100%	100%	-	-
5	Biceps Tendon	66.67%	97.87%	66.67%	97.87%	96%	< 0.001 Significant	0.645 Substantial
6	Peribicipital Tendon Fluid	51.28%	100%	100%	36.67 %	62%	0.012 Significant	0.317 Fair
7	SASD Bursitis	25%	86.36%	70%	47.5 %	52%	0.119 Non-Significant	0.104 Slight

Table 10. Correlation of USG with MRI Findings- Statistical Significance

Figure 1. USG Axial and Longitudinal Views of Biceps Tendon showing Peribicipital Fluid Collection (Arrows)

Figure 2. USG Supraspinatus Tendon showing Partial Thickness Tears

Figure 3. USG- Comparison of both Shoulders in a Patient-Normal SS on the Left and SS Partial Thickness Tear on the Right

Figure 4. USG Supraspinatus Tendon showing Heterogeneity of Tendon with Calcification- a Case of Calcific Tendinitis

Figure 5. MRI Coronal T2WI showing Complete Tear of Supraspinatus Tendon

Figure 6. MRI Axial T2WI showing Spinoglenoid Notch Cyst

Figure 7. MRI T2WI, STIR Coronal showing Hyperintensity in the Supraspinatus Tendon- S/O Tendinosis

DISCUSSION

A prospective study of 50 patients with shoulder pain with a clinical suspicion of rotator cuff tear was undertaken. USG examination of the affected shoulder was done in comparison with the normal shoulder and the findings were correlated with the subsequent MRI findings.

Age Group Wise Incidence

The age group of the study was from 21 - 80 years with maximum number of patients being of the age between 40 - 60 years constituting 68% of the study population. Hiroshi Minagawa et al¹ studied the prevalence of tears in general population and found that the prevalence in each decade was 0% in the 20s to 40s, 10.7% in the 50s, 15.2% in the 60s, 26.5% in the 70s and 36.6% in the 80s, whereas in our study it was 8% in the 20s, 14% in the 30s, 30% in the 40s, 38% in 50s, 6% in 60s, 4% in 70s. In their study, the prevalence increased with age in general population. In our study, the

prevalence increased with age till the 50s and then declined. The discrepancy in the prevalence in our study is probably related to the selection bias as our study was on the symptomatic patients reaching the hospital, whereas the study done by Hiroshi Minagawa et al was on the general population in a village.

Gender Distribution

Of the 50 patients 34 (68%) were males and the rest 16 (32%) were females, indicating a male predominance. The number of males in the age groups from 21 - 80 were more than double the number of females in the same age group. The number of males were higher than the number of females in the age group from 21 - 70, but in the age group from 71 - 80 the number of males and females were equal. This was similar to the prevalence study done by Hiroshi Minagawa et al,¹ where the prevalence of tear was significantly greater in male than in female in the 50s and 60s, but not in the 70s and 80s.

Side of Pathology

The number of patients with pathology on the right side was 30 accounting for 60% of the cases, whereas those with left-sided shoulder pathologies accounted for 20 (40%) of the cases.

Duration of Symptoms

More than half of the cases (27 out of 50 patients- 54%) had an acute history of less than 1 month before presenting for an USG examination; 19 (38%) of the cases had a history of 1 - 6 months duration and only 4 (8%) had a history of more than 6 months.

Pathology

Rotator cuff pathologies include partial, full thickness, intrasubstance tears and tendinosis. Supraspinatus tendon was the commonest tendon to be involved. USG detected 35 cases (70%) patients and MRI detected 38 patients with supraspinatus tendon pathologies. This is comparable to the study by Zlatkin et al,² wherein they found that supraspinatus tendon involvement was present in around 80% of their cases.

Supraspinatus

The sensitivity and specificity of USG in detection of supraspinatus pathologies were 92.11% and 100% respectively. The positive predictive value was 100% and negative predictive value was 80%. Accuracy of the study was 94%. Spearman correlation value of p was < 0.001 and Kappa coefficient was 0.848 indicating that the value obtained was almost perfect.

Partial Thickness Tears

In our study, sensitivity and specificity values for partial thickness tear of supraspinatus was 80% and 100%.

Our study showed a high specificity of 100% for partial thickness tears. The specificity findings were comparable with the study done by Read, John W and Mark Perko,³ in which the specificity of ultrasound for partial thickness tears was 97%. Similarly, our results for sensitivity of partial thickness tears were also comparable with the results of Rutten et al⁴ whose study showed a sensitivity of 89% for

partial thickness tears on ultrasound compared with the 80% sensitivity in our study.

Cullen et al⁵ compared the ultrasound and surgical results obtained from 68 patients. In their study, ultrasound showed a sensitivity of 79% and specificity of 94% (Positive Predictive value 87%) for partial-thickness tears, which was comparable with our study. They found that shoulder ultrasound in the hands of an experienced radiologist with the use of modern high-resolution equipment is highly sensitive in differentiating complete tears and partial-thickness tears. Our results for partial thickness tears were comparable with the results of their study.

Van-Holsbeeck et al⁶ (Van-Holsbeeck Kolowich 1995)⁶ described that the sensitivity of US in depiction of partial-thickness tears was 93% and specificity was 94%. The positive predictive value was 82% and the negative predictive value was 98%.

Full Thickness Tears

Sensitivity and specificity values for full thickness tear of supraspinatus were 100% and 95.35%. The findings of our study were comparable with the study done by Read, John W³ and Mark Perko in 1998. They studied the findings in 42 consecutive surgical cases and compared them with the preoperative sonographic readings. Ultrasound detected all of the 10 full-thickness cuff tears identified at surgery (Sensitivity 1.0, specificity 0.97), but detected only 6 of 13 partial-thickness cuff tears (sensitivity 0.46, specificity 0.97). They concluded that ultrasound is a sensitive and accurate method of identifying patients with full-thickness tears of the rotator cuff, extracapsular biceps tendon pathology or both. Similarly, our study showed a high sensitivity of 100% and specificity of 95.35% for full thickness tears.

Cullen et al⁵ showed a sensitivity of 89% and specificity of 100% (Positive Predictive value 100%) for full-thickness tears using ultrasound. They showed a high specificity of 100%, whereas in our study specificity was 95.35%. This was attributable to the false positive cases of full thickness tears on ultrasound, which were proven to be partial thickness tears on MRI. There are pitfalls with ultrasound, which give rise to such false positive cases.

Accuracy

PPV, NPV for partial thickness and full thickness tears were 100%, 83.33%, 77.78% and 100% respectively.

In our study, the accuracy values for partial thickness and full thickness tears of supraspinatus were 90% and 96%. This was comparable with the study done by Anastasia N. Fotiadou et al.⁷ Anastasia N. Fotiadou et al⁷ studied ninety-six patients with clinically suspected rotator cuff pathology using USG and MRI. The accuracy in the detection of full-thickness tears was 98% and 100% for ultrasonography and magnetic resonance imaging respectively. The accuracy in the detection of bursal or articular partial-thickness tears was 87% and 90% for ultrasonography and magnetic resonance imaging respectively. They concluded that in experienced hands, ultrasonography should be considered.

Spearman Correlation and Kappa Statistic

The tests of significance- the spearman correlation and the Kappa statistic values for partial thickness and full thickness tears were 0.800 (substantial association), 0.852 (almost

perfect association) indicating that the values obtained are significant.

This was comparable with the study done by Shahnawaz Bashir et al.⁸ Shahnawaz Bashir et al⁸ studied 50 patients, out of which a total of 34 patients were diagnosed as having rotator cuff tears on ultrasound, while 16 patients were

normal. When MRI examination was conducted in these patients it showed 38 cases of rotator cuff tears, while 12 patients were diagnosed as normal. The agreement between the two methods was assessed using Kappa coefficient. The strength of agreement between USG and MRI for the diagnosis of rotator cuff tears was found to be 'very good.'

Findings	Our Study					Bashir Shahnawaz et al				
	TP	FP	FN	TN	Kappa Value	TP	FP	FN	TN	Kappa Value
Partial Thickness	20	0	5	25	0.800 Substantial	12	2	4	12	0.818
Full Thickness	7	2	0	4	0.852 Almost Perfect	20	0	2	12	

Table 11. Comparison of Kappa Values

Biceps Tendon

The pathologies of biceps tendon in our study included tendinosis alone with no case of tear/dislocation. Sensitivity and specificity values for Biceps tendon pathologies were 66.67% and 97.87%, which were comparable with that of the study done by Shih-Wei et al.⁹

Shih-Wei Huang et al⁹ studied a total of 336 shoulder pain patients with suspected biceps tendinitis, of which a total of 136 patients were classified with biceps tendinitis and 200 patients were classified as not having biceps tendinitis based on the diagnostic criteria. The sensitivity was 68% and the specificity was 90% in the standard deviation of the transverse view, and the sensitivity was 81% and the specificity was 73% in the standard deviation of the longitudinal view to diagnose biceps tendinitis.

PPV of 66.67%, NPV of 97.87%, accuracy of 96%, p value of spearman correlation < 0.001, significant and Kappa coefficient was 0.645 suggesting a substantial association.

Subscapularis

Sensitivity and specificity values for subscapularis pathologies was 50% and 97.92%, PPV of 50%, NPV of 97.92%, accuracy of 94%, p value of spearman correlation <0.001, significant and Kappa coefficient was 0.315 suggesting a fair association.

Infraspinatus and Teres Minor

No pathology of infraspinatus and teres minor was observed on either USG or MRI giving them the specificity, negative predictive value and accuracy of 100%.

Peribicipital Tendon Fluid

Sensitivity and specificity values for peribicipital fluid was 51.28% and 100%, PPV of 100%, NPV of 36.67%, accuracy of 62%, p value of spearman correlation 0.012, significant and Kappa coefficient was 0.317 suggesting a fair association.

Subacromial Subdeltoid Bursitis

Sensitivity and specificity values for subacromial, subdeltoid bursitis was 25% and 86.36%, PPV of 70%, NPV of 47.5%, accuracy of 52%, p value of spearman correlation 0.119, non-significant and Kappa coefficient was 0.104 suggesting a slight association. Therefore, for detection of peribicipital fluid and subacromial subdeltoid bursitis, MRI is the preferred modality over USG as ultrasound has very low sensitivity.

Four cases had calcifications on ultrasound and only one of them observed on MRI.

Ultrasound can be used for the initial investigation of suspected rotator cuff pathologies. Advantages of ultrasound are non-invasive, real time, low cost, no radiation and the advantage of dynamic examination and comparison with the normal side. However, it has the following pitfalls.

The pitfalls in ultrasound evaluation of rotator cuff pathologies on shoulder include those related to anisotropy, calcific tendinitis complex anatomy in the region of the rotator interval and tendinous interdigitation.

- The rotator cuff appears echogenic when the angle of insonation is perpendicular or near perpendicular to the surface. Minor deviation from this orientation results in a false positive appearance of a tear.
- Intratendinous deposition of calcium is manifested by both focal echogenicity and acoustical shadowing. Failure to recognise these coexistent findings may result in inadvertent misinterpretation of the hypoechoic, shadowing zone as a rotator cuff tear.
- The rotator interval, which is normally devoid of cuff tissue may be mistaken for a rotator cuff defect.
- The edge of the intraarticular biceps tendon may be mistaken for a torn and retracted cuff tear. The hypoechoic interface between the biceps and adjacent supraspinatus tendons may simulate a longitudinal cuff tear.
- Heterogeneity of the normal rotator cuff can be normally observed, because of the complex interdigitation of fibres from the various contributions.
- Steep learning curve and interobserver variation in results.

Even MRI has its own Limitations and Pitfalls-

The limitations are claustrophobia, obese patients, post-surgical metallic implant fixations.

Pitfalls of MR imaging include the magic angle effect and normal fibre interdigitation. Tendons that course at or near the magic angle of 55° exhibit markedly augmented signal intensity that is most pronounced with short-echo-time sequences. The supraspinatus tendon is particularly vulnerable, since it curves along its course between the musculotendinous junction and its insertion on fibrocartilage. Furthermore, magic angle augmentation of signal intensity within the biceps tendon may be misinterpreted as focal cuff pathologic conditions near the rotator interval. The complex arrangement of rotator cuff fibres is frequently manifested by striations that may be mistaken for intrasubstance tears.

CONCLUSION

In our study of 50 patients with suspected rotator cuff pathology, ultrasound demonstrated a high sensitivity and specificity more so for supraspinatus tendon pathologies and least for peribicipital tendon fluid collection and SASD bursitis. Also, USG is a reliable dynamic diagnostic tool and provides direct correlation of the imaging findings with the symptoms of the patient, and helps with guided interventional procedures. Therefore, it should be considered as an accurate modality for the initial investigation of rotator cuff, especially supraspinatus tears. MRI is preferably done after sonography in doubtful cases or for evaluation of other pathologies of the shoulder joint like labral pathologies.

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