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ROLE OF ULTRASONOGRAPHY IN DIAGNOSIS OF ROTATOR CUFF TEARS IN COMPARISON TO MAGNETIC RESONANCE IMAGING

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ABSTRACT Rotator cuff tear is one of the most common causes of shoulder pain. In addition to history and physical examination, evaluation of a patient with shoulder trauma often involves assessment of the rotator cuff with a diagnostic test such as high-resolution ultrasonography or MRI.Ultrasonography is as accurate as MRI for both full thickness and partial thickness tears, these results combined with low cost for ultrasound suggests that ultrasound may be the most cost-effective imaging method of screening for rotator cuff injuries. **Objective-** To evaluate the role of USG and MRI in rotator cuff injuries and correlation of their findings. **Methodology-** Study group consists of 40 patients with the provisional diagnosis of rotator cuff tears and clinical features. Ultrasonography followed by MRI will be done in all the patients.Diagnostic statistics like Sensitivity, Specificity, PPV, NPV and Accuracy have been computed to find the correlation of USG with MRI findings. **Result** - There is a good agreement between USG and MRI to diagnose partial tear in rotator cuff muscles and it is statistically significant (kappa is 0.72 ,P value at 5% significance level is < .001. In case of diagnosing full thickness tear of rotator cuff muscles, there is excellent agreement in between USG and MRI and it is statistically significant (kappa 0.9, P value at 5% significance level is< .001. **Conclusion-** Our study demonstrated high sensitivity and specificity of high-resolution USG when compared to MRI for diagnosis of both full and partial thickness rotator cuff tears.Thus considering the comparable diagnostic measurements of both these modalities, high-resolution USG can be used as first-line investigation for diagnosis of rotator cuff tears whereas MRI can be used secondarily as a problem-solving tool in case of equivocal USG findings or in cases where accurate delineation of anatomy is needed for surgical corrections.

KEYWORDS : Ultrasonography , Magnetic Resonance Imaging, Rotator Cuff Tear, Diagnostic Imaging

INTRODUCTION

Rotator cuff tear is one of the most common causes of shoulder pain. In addition to history and physical examination, evaluation of a patient with shoulder trauma often involves assessment of the rotator cuff with a diagnostic test such as high-resolution ultrasonography or MRI[1].Several radiological techniques have been used to detect tears of the rotator cuff. Each has limitations and no clear consensus on the optimum diagnostic study has emerged[2].

The radiological diagnosis of rotator cuff tears has traditionally been performed with arthrography and more recently with ultrasonography and MRI[3]. Arthrography is quite accurate in detecting complete tears but it is an invasive procedure with some associated risk and discomfort, in addition it is insensitive to partial tears involving superficial surface or substance of the cuff. The diagnosis of partial tears, however, is important because many orthopedic surgeons will operate to relieve impingement of supraspinatus tendon before it progresses to full thickness tear. The relative ease with which they are seen on MRI suggests that MRI may have a role in their diagnosis[3].

MRI can provide information about rotator cuff tears such as tear dimensions, tear depth or thickness and tear shape, involvement of adjacent structures (eg, rotator interval, long head of biceps brachii tendon etc) and muscle atrophy, all of which have implications for rotator cuff treatment and prognosis. Information about coraco-acromial arch and impingement as it relates to rotator cuff tears can also be obtained with MRI[4].

Although non-invasive, MRI is considerably more expensive than ultrasonography and will probably not replace it as a screening procedure for those trained in its use. For those cases in sonogram yields indeterminate results or in those institutions in which no one is trained to do sonography of the shoulder, MRI may be a useful screening test[3].

The major disadvantages of MRI are the long examination time, expense and that the study may be unsuccessful in very large or claustrophobic patients[5].

Ultrasonography is effective for detecting tears of rotator cuff. The size of tears can be classified and the findings used as a basis for management decisions[2].

Ultrasonography is as accurate as MRI for both full thickness and partial thickness tears, these results combined with low cost for ultrasound suggests that ultrasound may be the most cost-effective imaging method of screening for rotator cuff injuries provided that the examiner is trained in this operator dependent technique. For practitioners without ultrasound expertise, MRI can be used. Arthrography can be performed in those cases in which ultrasound and MRI are not definitive[6].

Ultrasonography can also reveal the presence of other abnormalities that may mimic rotator cuff tear including tendinosis, calcific tendinitis subacromial sub-deltoid bursitis, greater tuberosity fracture and adhesive capsulitis[7]. Ultrasonography of rotator cuff is quick and painless procedure. There is no risk of infection and in contrast to arthrography there is no discomfort following procedure[8]. The simplicity, rapidity, low cost and accuracy of the examination make it especially attractive as a screening and presurgical staging study[2].

This is a study design for evaluation of role of USG and MRI in rotator cuff injuries and correlation of their findings.

MATERIALS AND METHODS

The proposed study to be conducted in imaging and ultrasonography room under the Department of Radio diagnosis, Bankura Sammilani Medical College and Hospital (BSMCH), Bankura, West Bengal. The MRI study was conducted in AMRI, MRI Centre under BSMCH.

All the patients referred to the department of Radio diagnosis from department of Orthopedic with the provisional diagnosis of rotator cuff tears and clinical features.

Ultrasonography followed by MRI will be done in all the patients. The calculated sample size(n) for this study is around 41(40).

Inclusion Criteria

- All the patients who are referred to our department of Radiology with clinical suspicion of rotator cuff tears or injuries.

Exclusion Criteria

Post operative or idiopathic shoulder joint arthropathy.

- Patients who are contraindicated for MRI procedure (patients with history of metallic implants in situ, cardiac pacemaker and metallic foreign body in situ).
- Patients with other shoulder joint pathologies that are likely to obscure the diagnosis of tear like present shoulder joint infection of that side or any structural abnormality that can hinder proper positioning of USG probe.
- Claustrophobic patients.

Imaging Variables

- Thickness of tear (full /Partial)
- Peri-bicipital tendon fluid
- Bursal fluid
- Tendinosis
- Impingements
- AJC arthrosis and other associated relevant finding(s).

METHODOLOGY

This study was conducted after getting permission from Institutional Ethics Committee and approval of The West Bengal University of Health Sciences. Patients, referred from Department of Orthopedics of Bankura Sammilani Medical College and Hospital with high likelihood of rotator cuff tear or injury, evaluated thoroughly in our Department of Radiology, BSMCH. Initially the patients were examined sonologically. Selection for further study (i.e., MRI study) based on inclusion and exclusion criteria were done. Written informed consents were taken from all the willing participants after proper explanation of the purpose, procedure and expected outcome of the study in their own vernacular language.

Ultrasound examination of the shoulder

The examination on the affected shoulder was carried out with High Resolution Linear Array Probe (5-12 MHz),GE in comfortable sitting position. Adequate exposure of the examined area with maintenance of patient's privacy was assured. The rotator cuff tendons and muscles were examined following the aforementioned sonographic protocol for shoulder evaluation. Dynamic examinations were also carried out. Comparison of the opposite shoulder was also done.

MRI study of the shoulder

The MRI scans were performed on GE Brivo MR355 1.5T machine using shoulder coil and the following sequences were selected.

Outcome definition and Parameters:

- Full thickness tear-proportion of patients sustaining full thickness tear.
- Partial thickness tear- proportion of patients sustaining partial thickness tear.
- Sensitivity- percent of diseased individuals detected by 'test' test (here, USG).
- Specificity- percent of non-diseased individuals detected as non-diseased by'test' test (here, USG)
- Positive predictive value (PPV)-percent of diseased individuals identified by positive result of test.
- Negative predictive value (NPV)- percent of non-diseased individuals identified by negative result of test.

Statistical Methods

Descriptive statistical analysis has been carried out in the patient study. Results on continuous measurements are presented on Mean, SD and results on categorical measurements are presented in number (%). Significance is assessed at 5% level of significance. Chi-square/ Fisher Exact test has been used to find the significance of study parameters on categorical scale between two or more group. Diagnostic statistics like Sensitivity, Specificity, PPV, NPV and Accuracy have been computed to find the correlation of USG with MRI findings.

The statistical software namely SAS 9.2, SPSS 15.0, Stata 10.1, MedCalc 9.0.1, Systat 12.0 and R environment ver.2.11.1 were used for analysis of the data and Microsoft Word and Excel have been used to generate.

RESULTS

Most of the patients were in the age groups of 20-39 years (50%) and 40-59 years (40%) with a male predominance of 72.5%. Majority of the patients suffered from symptoms for the duration of 1-6 months (37.5%) and more than a year (37.5%). Most of the patients were right-handed (90%) and the right shoulder was affected in 77.5% of the cases with restriction of movements in 70% cases. Occurence of rotator cuff tear was mostly due to trauma (72.5%).

Peri bicipital tendon fluid was seen in 42.5% cases when USG was done whereas on MRI 62.5%cases.

On USG subacromial sub-deltoid bursal fluid in 22.5% and subcoracoid in 0% but on MRI the respective percentage was 57.5% and 15%.

AJC arthrosis was seen in 22.5% cases in USG and 47.5% cases in MRI.

Table 1: Distribution of patients with full/partial thickness rotator cuff tears on MRI and USG.

Tendon (n=40)	USG /MRI	Partial thickness tear	Full thickness tear	Tendinosis	Normal	Total
Supraspinatus	USG	20	7	7	6	40
	MRI	22	8	8	2	40
Infraspinatus	USG	2	0	0	38	40
	MRI	3	1	0	36	40
Subscapularis	USG	6	1	6	27	40
	MRI	6	1	8	25	40
Teres Minor	USG	0	0	0	40	40
	MRI	1	0	0	39	40
Biceps Tendon	USG	0	0	8	32	40
	MRI	0	0	15	25	40

There is a good agreement between USG and MRI to diagnose partial tear in rotator cuff muscles and it is statistically significant (kappa is 0.72 ,P value at 5% significance level is < .001.

In case of diagnosing full thickness tear of rotator cuff muscles, there is excellent agreement in between USG and MRI and it is statistically significant (kappa 0.9, P value at 5% significance level is < .001.

Table 2: Diagnostic accuracy of USG in case of Partial Thickness Tear of Rotator Cuff.

		MRI					
		Positive		Negative		Total	
		N	%	N	%	N	%
USG	Positive	20	86.95	2	11.76	22	55
	Negative	3	13.05	15	88.24	18	45
	Total	23	100	17	100	40	100

Table 3: Diagnostic accuracy of USG in case of Full Thickness Tear of Rotator Cuff.

		MRI					
		Positive		Negative		Total	
		N	%	N	%	N	%
USG	Positive	7	87.5	0	0	7	17.5
	Negative	1	12.5	32	100	33	82.5
	Total	8	100	32	100	40	100

Table 4: Correlation of Diagnostic Accuracy of USG findings for full and partial thickness tears with MRI.

N=40	Sensitivity	Specificity	PPV	NPV
Partial thickness tear	86.96	88.24	90.91	83.33
Full thickness tear	87.50	100	100	96.97

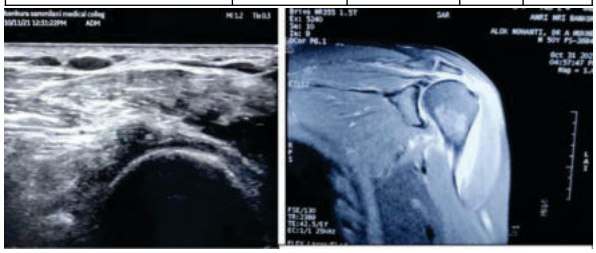

Figure-1: Long axis USG examination reveals a full thickness defect replacing the entire thickness and width of right supraspinatus tendon with medial retraction of the tendon ; suggestive of full thickness

Figure-2: Coronal PD image shows a full thickness tear of supraspinatus tendon , which is retracted medially, uncovering the humeral head and with subacromion sundeltoid bursal fluid collection.

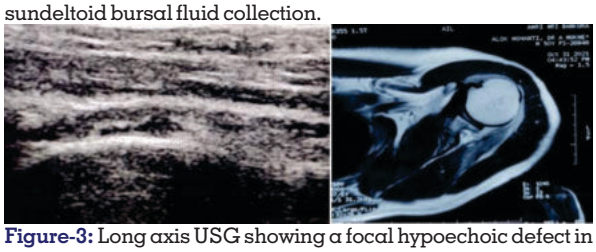

Figure-3: Long axis USG showing a focal hypoechoic defect in inferior deep surface of the infraspinatus tendon , deep fibres are disinserted and retracted ; suggestive of partial thickness tear.

Figure-4: T2 WI axial image demonstrates defect in inferior deep fibres of infraspinatus tendon; partial thickness tear of infraspinatus tendon.

DISCUSSION

Herein, we studied on 40 patients who presented with clinical sign and symptoms of rotator cuff injury. They were evaluated by high-resolution linear array ultrasound of frequency 5-12MHz,GE machine. Then individual case was followed by dedicated shoulder MR imaging study of the affected shoulder using 1.5 Tesla MRI machine.

The findings on ultrasonography and MRI were then correlated systematically.

We included patients of all ages. The minimum and maximum age of the patients presenting here was 18 years and 61 years, respectively. Mean age of presentation was 37.3 years. Maximum patients were between 20-39 years (50%) followed by 40-59 years (40%), <=20 years (7.5%), >=60 years (2.5%).

We found a definitive male to female predominance of 2.64:1 in our study. This is in contrast with most other studies that report no marked difference in prevalence amongst both genders[9].

Right shoulder was affected in 31 (77.5%) of our cases, while the left side was affected in only 9 (22.5%) patients. This is consistent with study of Patidar et al. Right hand was dominant in 36 (90%) of our cases and left hand was dominant in 4 (10%) patients.

In our study, 29 (72.5%) patients had previous history of trauma to the affected shoulder. Mathew P. Lungren et al reported that tears of rotator cuff tendons may occur as a result of tendon degeneration or from a single traumatic event but commonly a combination of these factors are in play. Rotator cuff tendon degeneration and accidental falls are both known to increase the incidence with the age. The majority,23 (72.5%) reported a fall associated with their rotator cuff tear. The tear nearly always occurred on the same side as the fall. The findings highlight that falls are the leading cause of injury in the rotator cuff tear patient population[10].

On clinical examination, 12 (30%) patients showed normal range of motion, while 28 (70%) showed various degree of restricted motion in involved shoulder depending the rotator cuff pathology.

The rotator cuff pathologies evaluated in our study included partial thickness tear, full thickness tear, intrasubstance tear and tendinosis. Some associated pathologies like bursal fluid, joint cavity fluid, ACJ arthrosis, impingement, bicipital tendinosis, muscular,labral and osseous pathology were also evaluated simultaneously.

In our study, amongst the rotator cuff tendons, Supraspinatus tendon was found to be affected most with 34 cases (85%) showing abnormality on USG and 38 cases (95%) on MRI. Subscapularis was next most commonly affected tendon with 13 cases (32.5%) showing abnormal findings on USG and 15 cases (37.5%) on MRI. Infraspinatus tendon showed abnormality in 2 cases (5%) on USG and 4 cases (10%) on MRI. Teres minor was normal in all cases in USG and showed 1 full thickness tear on MRI.

Concordant to our study, studies done by Iagnocco et al[11] and Naredo et al[12], have also demonstrated supraspinatus to be the most commonly involved tendon and teres minor is the least commonly involved. However, in contrast to the studies of Iagnocco et al and Naredo et al where infraspinatus is the second most common tendon to be involved, we found subscapularis was affected more than infraspinatus. This variability could be attributed to difference in sample size.

The reason for frequent involvement of supraspinatus tendon is because of characteristic anatomical location of this tendon between two bones (head of humerus and acromion). This leads to ischemia, mechanical stress, vulnerability to get degenerated and subsequent traumatic or non -traumatic tendon tear.

Partial thickness tears were found to be more common than full thickness tears in our study. This correlated with study of Brennke et al[13], which showed partial thickness tears to be more prevalent.

MRI detected supraspinatus partial thickness tear in 22 patients, whereas USG was able to detect 19 of these 22 cases and presented no obvious abnormality in the rest 2 of these 22 cases. These 2 cases proved to be partial thickness tear which

were falsely detected as normal on USG.1 case was misinterpreted by USG ; 1 case of partial thickness tear was falsely diagnosed as tendinosis of supraspinatus tendon.

MRI detected subscapularis partial thickness tear in 6 patients and USG correctly diagnosed 5 of these 6 cases and showed no abnormality in 1 of these 6 cases.MRI detected subscapularis tendinosis in 8 cases whereas USG correctly detected 5 of these 8 cases but showed no abnormality in rest 2 of these 8 cases. 1 case of tendinosis diagnosed on MRI was misinterpreted as partial thickness tear on USG.

MRI detected infraspinatus tendon partial thickness tear in 3 cases whereas USG detected 2 of these 3 partial thickness tears and showed no abnormality in rest 1 case.

MRI detected teres minor tendon partial thickness tear in 1 case but USG showed no abnormality and detected it as normal.

MRI detected full thickness tears of supraspinatus tendon in 8 patients. USG detected full thickness tears in 7 of these 8 cases and misinterpreted 1 of these 8 cases of full thickness tear as high-grade partial thickness tear.

MRI detected full thickness tear of subscapularis tendon in 1 patient and USG correctly identified it. case of full thickness tear of infraspinatus was diagnosed on MRI but USG could not detect it 0and showed no obvious abnormality.

The USG criterion for detection of partial thickness tears were was focal discontinuity of tendon either at the bursal or articular surface. USG criterion for full thickness tears was complete absence of tendon with retraction of the tendon or a hypoechoic defect. The space over the humeral head is filled by deltoid muscle and a thickened subacromial-subdeltoid bursa due to fluid accumulation. Tendinosis was diagnosed by USG, in the form of thinning of tendon and heterogenous echotexture or bulky tendon with hypoechoic echogenicity.

MRI criteria for detection of partial thickness tears involved the presence of focal region of fibre discontinuity that was filled with fluid signal. Besides a focal defect, additional findings included surface fraying or changes in tendon calibre, such as attenuation or thickening. MRI criterion taken into account for full thickness tears was tendon discontinuity. Tendon retraction was also another sign to detect full thickness tears[14]. The presence of fluid signal in subacromial -subdeltoid bursa, although not specific was found to be another indirect sign of it.

Imaging abnormalities in long head of biceps tendon were found in 25 out of 40 patients suspected to have rotator cuff injuries. Common abnormalities were found to be peri-bicipital tendon fluid in 25 cases followed by tendinosis in 15 cases and 2 cases of tendon subluxation. Tendon sheath effusion along biceps tendon was the most common associated finding of rotator cuff tear. These findings are in accordance with Iagnocco et al[11] and Naredo et al[12].

Biceps tendon is subjected to mechanical forces that contribute to cuff impingement because of its anterior location in the impingement area. Also, the synovial sheath of biceps tendon is an extension of glenohumeral synovial membrane. Hence, the frequent association of cuff tears with biceps tendon abnormalities is observed.

SA-SD bursal fluid was found in 23 of 40 patients (57.5%) with suspected rotator cuff injury. 19 of these 23 (82.6%) patients had supraspinatus involvement which is in accordance with the study done by Hollister et al[15] and Goyal et al[16].

Fluid within both bursa and joint cavity in presence of a full thickness tear of rotator cuff is due to direct communication between these two compartments through the defect. Fluid in a partial thickness tear is more likely due to direct mechanical irritation of bursa by impingement or fenestrations within the partially torn cuff, allowing the communication. In full thickness tear, volume of fluid within bursa is far greater than that seen in partial thickness tear or impingement.

Acromioclavicular joint arthrosis was found in 19 of 40 cases (47.5%) in this study. 17 of these 19 cases had supraspinatus tendon abnormality, which is in accordance with study done by Iagnocco et al[11].

CONCLUSION

Our study demonstrated high sensitivity and specificity of high-resolution USG when compared to MRI for diagnosis of both full and partial thickness rotator cuff tears. USG showed a sensitivity of 87.50% and a specificity of 100% for full thickness rotator cuff tears and a sensitivity of 86.96% and a specificity of 88.24% for partial thickness rotator cuff tears.There is good agreement in between USG and MRI to diagnose full thickness as well as partial thickness rotator cuff tears and it is statistically significant. The Kappa coefficient of association was 0.90 for full thickness tears and 0.88 for partial thickness tears.Thus considering the comparable diagnostic measurements of both these modalities, high-resolution USG can be used as first-line investigation for diagnosis of rotator cuff tears whereas MRI can be used secondarily as a problem-solving tool in case of equivocal USG findings or in cases where accurate delineation of anatomy is needed for surgical corrections.

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