

ULTRASONOGRAPHIC EVALUATION OF THE ANTERIOR AXILLARY RECESS IN THE NORMAL SHOULDER

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ABSTRACT

OBJECTIVES: The objectives of the study were to demonstrate the usefulness of ultrasound to estimate the thickness of the anterior axillary recess (AAR) in the shoulder, determine if the thickness of the anterior axillary recess is altered with the patient's position, the degree of arm abduction, gender and laterality; compare the thickness of the anterior axillary recess obtained with the normal value reported in current scientific literature.

MATERIAL AND METHODS: Descriptive, longitudinal, prospective study, carried out in 32 normal volunteers aged between 18-60 years, excluding people who had a history of inflammatory and traumatic pathology of the rotator cuff, rheumatic diseases, diabetics and hypothyroid patients. An ultrasound evaluation protocol was designed considering the variables patient position, arm position in abduction of 90°, 60° and 45°, laterality and gender. The descriptive statistical analysis of the quantitative variables was carried out by calculating the mean, standard deviation, error of the mean and confidence intervals; The variation of AAR according to position, laterality and gender was analyzed with one-way ANOVA. The thickness AAR by ultrasound and MRI was compared with the t-student test for a single sample; after determining normality with the Shapiro-Wilk test.

RESULTS: Of 32 normal volunteers, 20 (62.5%) women and 12 (38.5%) men, obtaining 64 cases. The thickness of the anterior axillary recess without discriminating the patient's position or the degree of abduction was 2.07 mm, (SD ± 0.34mm), 95% CI [2.03 – 2.11 mm]. No statistically significant difference was found in the anterior axillary recess according to the patient's position, arm abduction ($p=0.055$) or laterality ($p=0.085$). According to gender, the AAR is thicker in men, 2.38mm, 95% CI [2.16 – 2.58 mm], the difference was significant ($p=0.00$). When comparing the thickness of the anterior axillary recess obtained with the normal value reported in current scientific literature, a statistically significant difference was found ($p=0.00$).

CONCLUSIONS: Ultrasound allows the evaluation of the anterior axillary recess of the shoulder, the thickness is not altered with the patient's position or the degree of arm abduction, but it is thicker in men than in women and the average thickness obtained differs from the normal reference value.

KEYWORDS: ANTERIOR AXILLARY RECESS, ULTRASOUND, SHOULDER.

INTRODUCTION

In joints, recesses are folds or extensions of the joint capsule composed of two layers of synovium and a small amount of synovial fluid that extend outside the joint space. In the shoulder, the anterior axillary recess (AAR) reflects the integrity of the joint capsule¹. For this reason, several studies consider that thickening of the AAR indicates a significant structural change and serves as a key radiological sign in the diagnosis of adhesive capsulitis^{2,3}.

Currently, imaging evaluation of the AAR can be performed using magnetic resonance imaging (MRI) and ultrasonography. MRI has higher sensitivity and specificity, and it also allows for the assessment of the entire joint to detect other abnormalities. Ultrasonography, on the other hand,

is also widely used for shoulder evaluations, particularly for the rotator cuff tendons^{6,7}. Although the standard protocol does not include an evaluation of the AAR, as joint capsule pathology is rare, it is suggested that in patients with suspected adhesive capsulitis (AC), the evaluation be extended to the axilla to assess the AAR³.

The thickness of the anterior axillary recess (AAR) is considered normal if it measures less than 4 mm, as reported in the current scientific literature^{8,10}. However, this value was obtained from arthro-MRI studies and extrapolated as a reference for ultrasonography. In this regard, some studies on adhesive capsulitis using ultrasonography have used the thickness of the AAR as a parameter, finding that in normal shoulder controls, the AAR thickness ranged from

$1.6 \pm 0.72 \text{ mm}^2$ to $2.2 \pm 0.16 \text{ mm}^3$.¹¹

Ultrasonographic evaluation of the shoulder is generally performed in a seated position^{6,7}, and in some cases, it can be done in the supine position, especially when there is suspicion of an inflammatory process in the joint capsule, as the shoulder relaxes, allowing access to the axilla. For the ultrasonographic evaluation of the AAR, it is recommended that the arm be in abduction and external rotation (ABER position), as this position exposes the AAR, facilitating its identification and characterization. However, in adhesive capsulitis (AC), there is a limitation in arm abduction, and the AAR should be assessed within the degrees of abduction permitted by the patient⁸.

The advantages of ultrasonography over magnetic resonance imaging, besides its accessibility and lower cost, include the fact that it does not require the use of intra-articular contrast, allows the patient and arm to be moved to evaluate different positions¹, and can be used as a guide for minimally invasive treatments¹⁰. Therefore, it is important to demonstrate the usefulness of ultrasonography in estimating the thickness of the anterior axillary recess by proposing a simple and easily reproducible ultrasound technique, applied to the shoulders of healthy volunteers. The objective is to determine whether the thickness of the AAR changes with patient position, degree of arm abduction, gender, and laterality, and finally, to compare the AAR thickness obtained with the normal values reported in the current scientific literature.

Anatomical Reminder

The glenohumeral joint is a ball-and-socket joint formed by the convex surface of the humeral head and the glenoid cavity of the scapula. Its articular surfaces are covered with hyaline cartilage, and the glenoid margin is surrounded by a fibrocartilaginous tissue called the labrum, which forms a ring that complements and deepens the glenoid cavity. The structures that fix and stabilize both bones are the joint capsule and the coracohumeral and glenohumeral ligaments¹.

The joint capsule is composed of loose fibrous tissue and is covered by the synovial membrane on its deep surface. It extends from the scapula to the humerus, encompassing the entire joint. It has two openings: a superior opening for the passage of the long head of the biceps tendon in the rotator interval and for communication with the subscapular recess; in the inferior portion, the joint capsule is loose and redundant, forming a fold known as the anterior axillary recess¹. See Fig. 1.

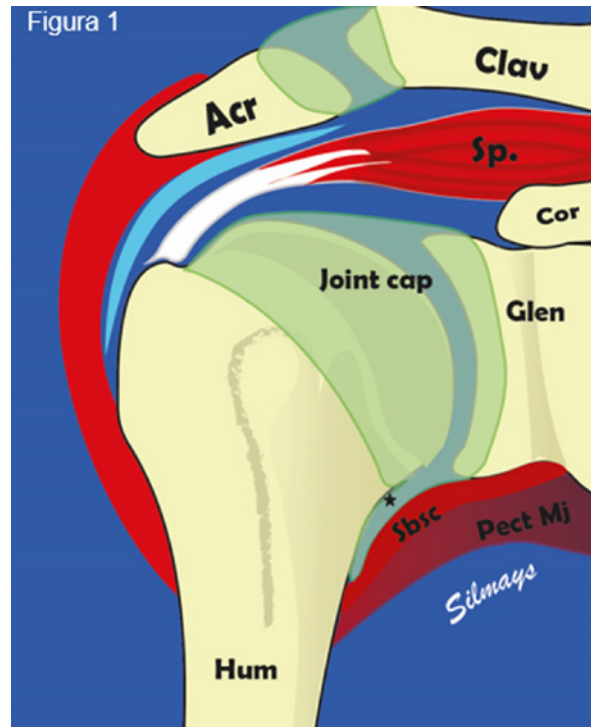


Figure 1. Schematic representation of the shoulder joint. Joint Cap: Joint capsule; black asterisk: Anterior axillary recess; Sbsc.: Subscapularis muscle; Pect Mj: Pectoralis major; Glen: Glenoid cavity; Acr: Acromion; Clav: Clavicle; Cor: Coracoid; Hum: Humerus.

MATERIAL AND METHODS

This descriptive, longitudinal, prospective study was conducted with 32 healthy volunteers aged between 18 and 60 years, excluding individuals with a history of inflammatory and traumatic rotator cuff pathology, rheumatic diseases, diabetes, and hypothyroidism.

Ultrasonographic Evaluation Protocol

The ultrasonographic evaluation was performed by two radiologist doctors specializing in musculoskeletal imaging, applying a simple and easily reproducible ultrasound technique to assess the AAR in the axilla, using a high-resolution multifrequency linear transducer of 10-16 MHz in grayscale. Gain and focus were adjusted according to the patient's anatomy.

Ultrasonographic Technique

- The ultrasonography was initiated with the person seated in a swivel chair, with the physician facing the shoulder to be evaluated. When the person was in the supine position, the physician positioned themselves adjacent to the shoulder being assessed.

- The arm's position in abduction and external rotation (ABER position) and the degrees of arm abduction established for the study were 90°, 60°, and 45°, which were measured using a universal goniometer (Fig. 2).



Figure 2: Ultrasonographic technique: Patient in a seated position (A) and in the supine position (B); a universal goniometer was used to determine the angle of arm abduction at 90° (A) and 60° (B).

- In the ABER position, the anterior axillary line was identified, and the ultrasound transducer was positioned with its orientation directed toward the arm, following the long axis of the humerus. The ultrasound transducer was adjusted at different angles according to the degree of arm abduction while maintaining reference to the long axis of the humerus (Fig. 3A).

- In the ultrasound image, the anatomical structures were identified: in the deep plane, the profile of the humerus can be recognized, with the head and anatomical neck represented by a hyperechoic line with posterior acoustic shadowing. Immediately above, the hyperechoic folds that form the AAR were observed, followed by the muscular plane formed by the inferior border of the subscapularis muscle and the pectoralis major muscle in the more superficial plane, just below the skin (Fig. 3B and 3C).

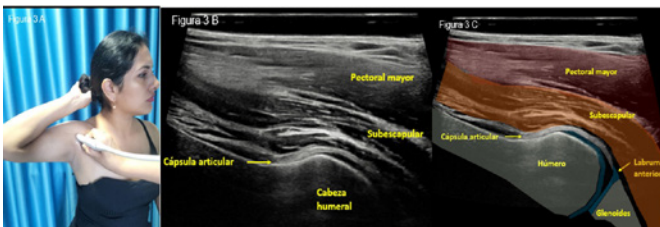


Figure 3. Ultrasonographic technique of the AAR in the axilla. A. Ultrasound transducer positioned on the anterior axillary line following the profile of the humerus. B. Ultrasound image of the joint capsule and the AAR. C. Color-coded identification of the anatomy.

- The measurement of the thickness of the anterior axillary recess was performed from the superficial border of the humeral periosteum, located immediately distal to the anatomical neck, to the superficial border of the capsule beneath the subscapularis muscle, preferably at its thickest portion (Fig. 4A). In a normal shoulder, the AAR is usually collapsed or presents a thin anechoic line due to synovial fluid; the thickness of the two echogenic layers of the recess-

es was measured (Fig. 4A and 4B). The AAR should not be confused with the folds of the muscle fascia or the subscapularis muscle, which at this level has its lower bundles inserting into the humerus. To avoid this confusion, the echogenic image of the capsule should be followed to the joint cavity to verify its continuity (Fig. 5A and 5B).

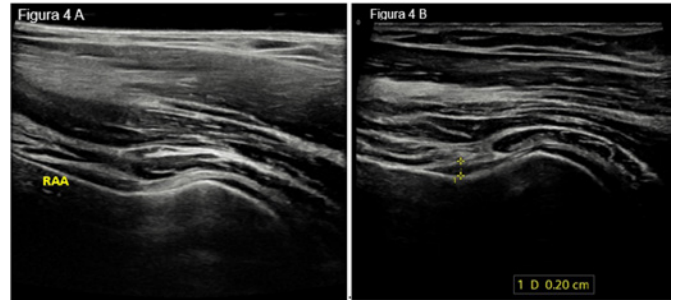


Figure 4. Measurement of the AAR in the axilla. A. Collapsed AAR, showing two hyperechoic lines. B. Open AAR with a linear anechoic synovial fluid.

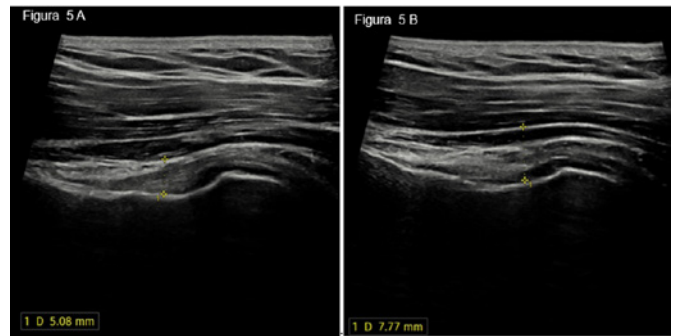


Figure 5. Measurement errors of the AAR. A. The AAR is confused with the recess of the subscapularis muscle fascia. B. The AAR is confused with the lower bundle of the subscapularis muscle.

Statistical Analysis

Descriptive statistical analysis of the quantitative variables was performed by calculating the mean, standard deviation, standard error of the mean, and confidence intervals. The analysis of the variation in anterior axillary recess (AAR) thickness based on position (sitting and supine), degrees of arm abduction (ABER 90° - 60° - 45°), laterality, and gender was conducted using the one-way ANOVA test. To compare the obtained AAR thickness with the normal reference value (4 mm), a one-sample t-test was performed after determining normality with the Shapiro-Wilk test. A 5% probability of error was considered ($p < 0.05$). The data were processed using SPSS v.27 for Windows 10, and the tables and graphs were represented in Excel.

RESULTS

Ultrasound was performed on 32 healthy volunteers, of whom 20 (62.5%) were women and 12 (37.5%) were men. Both shoulders were assessed, resulting in a total of

64 cases. The mean age of the volunteers was 40.77 years (range: 18-60 years).

The mean thickness of the anterior axillary recess (AAR), regardless of patient position and degree of abduction, was 2.07 mm (SD ± 0.34 mm), with a 95% confidence interval [2.03 – 2.11 mm].

Considering the position and degree of arm abduction, the greatest thickness of the AAR was obtained in the supine position with ABER at 90°, with a mean of 2.18 mm, 95% CI [2.07 – 2.29 mm]. The smallest thickness of the AAR was observed in the sitting position with ABER at 45°, with a mean of 1.98 mm, 95% CI [1.88 – 2.08 mm]. When comparing the means across all positions and degrees of ABER, no statistically significant difference in AAR thickness was found (p=0.055). See Table 1 and Graph 1.

Position - ABER	Mean	Standard Deviation	Standard Error	95% Confidence Interval		ANOVA
				Lower Limit	Upper Limit	
Decúbito 90°	2.18	0.38	0.43	2.07	2.29	p = 0.055
Decúbito 60°	2.10	0.32	0.38	2.01	2.20	
Decúbito 45°	2.05	0.33	0.39	1.95	2.14	
Sentado 90°	2.11	0.41	0.05	2.01	2.22	
Sentado 60°	2.00	0.39	0.05	1.91	2.10	
Sentado 45°	1.98	0.40	0.05	1.88	2.08	
Total	2.07	0.41	0.02	2.03	2.11	

Table 1: Comparison of AAR Means According to Position - ABER

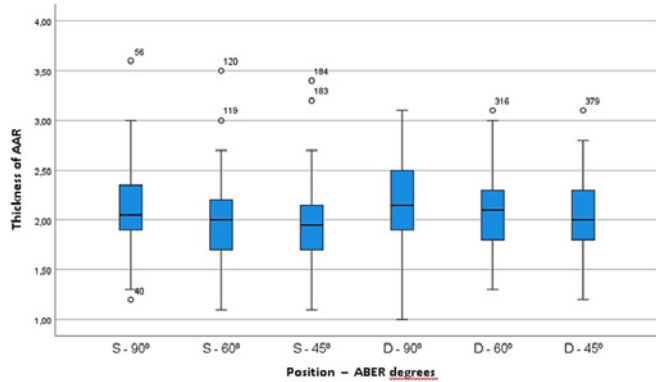
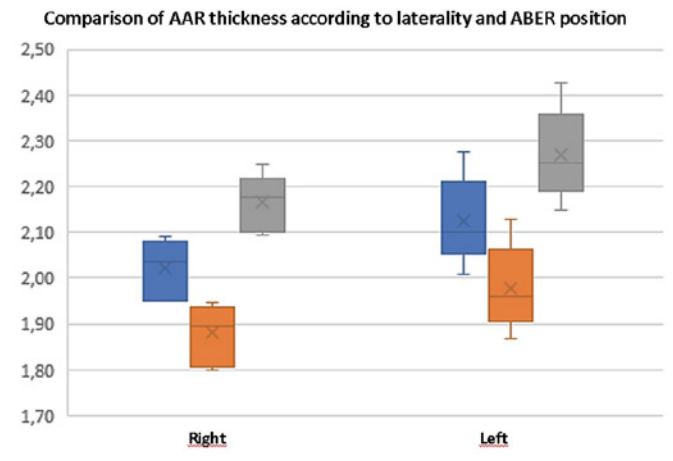


Table 2: Comparison of Anterior Axillary Recess (AAR) Means According to Laterality and Position – ABER 90°, 60°, 45°

Regarding laterality, no significant difference was found in the thickness of the anterior axillary recess between the right and left shoulders in either the supine or sitting position, nor with different degrees of arm abduction. See Table 2 and Graph 2.

Position - ABER	N	Mean	Standard deviation	Standard error	95% Confidence Interval		p-value
					Lower limit	Upper limit	
Sitting Right	33	2.05	0.42	0.07	1.90	2.19	p= 0.173
-90° Left	31	2.19	0.40	0.07	2.04	2.33	
Sitting Right	33	1.95	0.40	0.07	1.81	2.09	p= 0.235
-60° Left	31	2.07	0.38	0.07	1.93	2.21	
Sitting Right	33	1.95	0.43	0.07	1.80	2.10	p= 0.569
-45° Left	31	2.01	0.38	0.07	1.87	2.15	
Supine Right	33	2.09	0.44	0.08	1.93	2.25	p= 0.085
-90° Left	31	2.28	0.41	0.07	2.13	2.43	
Supine Right	33	2.08	0.37	0.06	1.95	2.21	p= 0.537
-60° Left	31	2.14	0.40	0.07	1.99	2.28	
Supine Right	33	2.03	0.38	0.07	1.89	2.16	p= 0.683
-45° Left	31	2.07	0.41	0.07	1.92	2.22	

Table 2: Comparison of Anterior Axillary Recess (AAR) Means According to Laterality and Position – ABER 90°, 60°, 45°

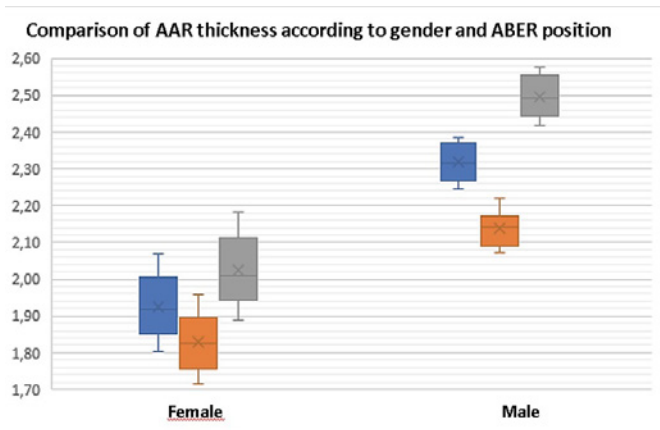


Graph 2: Comparison of AAR averages according to laterality and position – ABER 90°, 60°, 45°.

Regarding gender, it was found that the axillary recess is thicker in males than in females, remaining thicker in both positions and at all degrees of arm abduction; this difference was statistically significant. The maximum thickness was obtained for the male gender in the supine position at ABER-90°, with an average value of 2.38 mm, 95% CI [2.16 – 2.58 mm]. See Table 3 and Figure 3.

Position ABER / Gender	N	Mean	Standard deviation	Standard error	95% CI		p-value
					Lower limit	Upper limit	
Sitting Female	40	1.98	0.34	0.05	1.87	2.09	p= 0.001
-90° Male	24	2.33	0.44	0.09	2.15	2.52	
Sitting Female	40	1.87	0.30	0.05	1.77	1.96	p= 0.000
-60° Male	24	2.25	0.41	0.08	2.07	2.42	
Sitting Female	40	1.80	0.27	0.04	1.72	1.89	p= 0.000
-45° Male	24	2.28	0.42	0.09	2.10	2.45	
Supine Female	40	2.07	0.35	0.06	1.96	2.18	p= 0.007
-90° Male	24	2.38	0.50	0.10	2.16	2.58	
Supine Female	40	1.94	0.27	0.04	1.85	2.02	p= 0.000
-60° Male	24	2.38	0.39	0.08	2.22	2.55	
Supine Female	40	1.90	0.31	0.05	1.80	1.99	p= 0.000
-45° Male	24	2.30	0.39	0.08	2.14	2.46	

Table 3: Comparison of average axillary recess thickness according to gender and position – ABER 90°, 60°, 45°



Graph 3. Box plot comparing AAR thickness according to gender and ABER position.

The thickness of the RAA obtained in this study differs from the reference mean value (4 mm). When comparing these data using the one-sample t-test, the result demonstrated that this difference is statistically significant; this result persisted with postural changes and different degrees of arm abduction. See Table 4.

	Test Value = 4					
	t	df	p - value	Mean Difference	Lower	Upper
Sitting - 90°	-36.48	63	0.000	-1.89	-1.99	-1.78
Sitting - 60°	-41.03	63	0.000	-1.99	-2.09	-1.90
Sitting - 45°	-39.97	63	0.000	-2.02	-2.12	-1.92
Supine - 90°	-33.65	63	0.000	-1.82	-1.93	-1.71
Supine - 60°	-39.57	63	0.000	-1.90	-1.99	-1.80
Supine - 45°	-39.95	63	0.000	-1.95	-2.05	-1.86

Table 4: Values of the One-Sample t-Test

DISCUSSION

The assessment of the anterior axillary recess at the shoulder joint has gained importance in recent years due to the increase in cases of adhesive capsulitis. Although the diagnosis of this pathology is strictly clinical and the European Society of Musculoskeletal Radiology does not recommend the use of ultrasonography as an imaging modality for diagnosis, articles have recently been published identifying the radiological signs of adhesive capsulitis with ultrasound. The thickening of the anterior axillary recess is considered a sign of adhesive capsulitis, with a sensitivity ranging from 68.9% to 100% and specificity between 90.2% and 98%^{2,3}.

In our study, the mean thickness of the anterior axillary recess (AAR) in healthy volunteers was 2.07±0.3mm. This result is in agreement with the study by Stella et al.², where the mean thickness of the AAR in the normal shoulder was 1.6mm; in the study by Do et al.³, it was 2.6mm; and in the study by Moragues et al.¹¹, the mean thickness of the AAR was 2.2mm. The thickness of the AAR increased in the supine position with 90° abduction, reaching a maximum value of 2.29mm (95% CI). The variation was not significant; likewise,

the AAR did not show significant thickening when comparing the right shoulder with the contralateral side.

Contrary to the previously mentioned findings, when comparing the thickness of the anterior axillary recess (AAR) by gender, male participants exhibited a thicker AAR than female participants, reaching a maximum thickness of 2.58mm (95% CI) in the supine position with 90° abduction, and the difference was significant in all positions and degrees of abduction. The ultrasound results, considering the changes in position, abduction angle, and gender in this study, could not be compared with other publications, but we believe it is important to understand these characteristics during the evaluation of a pathological shoulder.

Stella et al.² published the ultrasound signs of adhesive capsulitis, comparing the thickness of the anterior axillary recess (AAR) in patients diagnosed with adhesive capsulitis and healthy volunteers or with the healthy contralateral shoulder. Ninety-three percent of patients with adhesive capsulitis had an AAR greater than 4mm, and the remaining 7%, although they did not have a thickness greater than 4mm, were found to be thickened by more than 60% when compared to the healthy contralateral shoulder. The interval found for the 7% of patients who had a thickness of less than 4mm showed AAR values between 3-4mm in the pathological shoulder.

Do et al.³ evaluated the signs of adhesive capsulitis relating clinical deterioration and ultrasound parameters, with one of the parameters being the thickness of the anterior axillary recess (AAR), considered pathological if, when compared to the healthy contralateral side, the value obtained in the suspected shoulder exceeded 4mm. The ultrasound evaluation was performed with the patient in the supine position and with the arm at 90°, concluding that an AAR thickness greater than 4mm has a sensitivity of 68.9% and specificity of 90.2% for the diagnosis of adhesive capsulitis, and it was found to be thickened in all clinical stages of the disease. These results would have greater sensitivity and specificity if compared with the AAR of their healthy controls rather than with the normal average of 4mm.

In previous studies, the normal thickness of the anterior axillary recess (AAR) is considered to be less than 4mm, a value obtained from studies using arthro-resonance⁸⁻¹⁰, and this value was extrapolated to ultrasound to define the AAR as thickened or not^{2,3}. However, the results of this study showed that the thickness of the AAR measured by ultrasound has a significant difference compared to the reference average. This difference may be attributed to the bulging caused by the contrast agent in the AAR. On the other hand, ultrasound does not use contrast agents in the joint; therefore, the thickness of the synovium and the increase in intra-articular fluid must be considered solely and exclusively as a result of a pathological process of the articular capsule.

CONCLUSION

Ultrasonography allows for the evaluation of the anterior axillary recess (AAR) of the shoulder using a simple and easily

reproducible technique. In normal individuals, the thickness does not change with variations in patient position or the degree of arm abduction, but it is thicker in men than in women, and the average thickness obtained differs from the normal reference value.

We recommend ultrasonography for the evaluation of the anterior axillary recess (AAR) in the shoulder, differentiating the normal thickness of the AAR according to the imaging modality. It is important to consider that the normal thickness of the AAR for ultrasonography is 2.07 mm (SD \pm 0.34 mm), without distinction of position and laterality; in men, a maximum normal thickness of 2.58 mm (95% CI) should be considered. Based on the results of this study and other publications, it would be advisable to reach a consensus to validate the ultrasonographic findings of normal AAR.

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