Original Article

Subacromial Content to Subacromial Space Ratio in Neutral Position of the Arm as Diagnostic Criteria of Subacromial Impingement Syndrome

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Abstract

Background: Shoulder impingement syndrome is one of the main causes of shoulder disability of working-class individuals. Currently, dynamic sonography of the shoulder is the modality of choice for the evaluation of shoulder impingement syndrome. The ratio of subacromial contents (SAC) and subacromial space (SAS) in neutral arm position could be used as a diagnostic parameter for the subacromial impingement syndrome (SIS), especially in patients who have difficulties in the elevation of their shoulders due to pain. To use the SAC to SAS ratio as a sonographic criterion for the diagnosis of SIS. **Methods:** SAC and SAS of 772 shoulders were vertically measured in coronal view with linear transducer 7–14MHz of Toshiba Xario Prime ultrasound unit, while the patient arm was kept in the neutral position. The ratio of both the measurements was calculated, to be used as a diagnostic parameter of the SIS. **Results:** The mean SAS was 10.79 ± 1.94 mm and SAC was 7.65 ± 1.43 mm. SAC-to-SAS ratio for normal shoulders was a focused value with narrow standard deviation (0.66 ± 0.03). However, shoulder impingement is confirmed by any value falls out of the range of ratio for normal shoulders. Area under the curve at 95% confidence interval was 96%, while the sensitivity at 95% confidence interval was 99.25% (97.83%–99.85%), and specificity was 80.86% (76.48%–84.74%). **Conclusion:** SAC-to-SAS ratio in neutral arm position is a relatively more accurate sonographic technique for the diagnosis of SIS.

Keywords: Reliability of ultrasound, rotator cuff, subacromial contents, subacromial impingement syndrome, subacromial space

Introduction

Shoulder impingement syndrome is grossly differentiated into four categories: subacromial (superior), sub-coracoid (anterior), infraspinatus impingement (internal), and suprascapular nerve entrapment.[1,2] However, superior impingement is the most common type and objectively focused in this study. Subacromial impingement syndrome (SIS) is one of the most common causes of shoulder pain and disability.[3] It affects various aspects of an individual's life including, social, economic, psychological, and many more. It consumes a substantial amount of time and the annual budget worldwide. Shoulder impingement is the painful entrapment of the soft tissues in the shoulder outlet.[4] The estimated prevalence of shoulder complaints is 7%–34% with about 1.47% incidence. SIS is believed to be the most common cause of shoulder pain, accounting for 44%–65% of all shoulder complaints.[5]

The causes of shoulder impingement syndrome are broadly divided into two main categories; narrowing of the shoulder outlet or thickening of its contents (supraspinatus tendon, subacromial subdeltoid bursa (SASD), joint capsule, etc.).[6,7] The 1-month prevalence of shoulder pain is between 16% and 30%.[8] Historically multiple imaging and clinical examination techniques were used for the evaluation of shoulder pain syndrome. Neer and Hawkin's tests have been

Received: 26-10-2021 **Revised:** 14-12-2021 **Accepted:** 02-03-2022 **Available Online:** 27-05-2022

Video available on: www.jmuonline.org

Access this article online

Quick Response Code:

Website: www.jmuonline.org

DOI: 10.4103/jmu.jmu_195_21

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How to cite this article: Bacha R, Gilani SA, Hanif A, Manzoor I. Subacromial content to subacromial space ratio in neutral position of the arm as diagnostic criteria of subacromial impingement syndrome. J Med Ultrasound 2023;31:17-21.

used for a long period. However, multiple imaging modalities including radiation based and ultrasound are being used for its evaluation.[9]

In adjunct to physical examination, ultrasound has been used for decades in the evaluation of shoulder impingement syndrome.[10] With the help of dynamic ultrasonography, the moment of the supraspinatus and SASD could be observed while passing underneath the acromion during arm abduction in real-time.[11] Corticosteroid injection along with dynamic sonography is used for improvement in the diagnosis of shoulder impingement syndrome.[12] No other imaging modality can evaluate structure in real-time during a physiologic moment.[13,14] Plenty of variation in the findings of different examiners was found in the literature. However, for more uniform and consistent sonographic results in the evaluation of shoulder impingement syndrome, some objective criteria must be developed. In the current study, the subacromial contents-to-subacromial space (SAC to SAS) ratio measured in a neutral position is used as a diagnostic criterion for SIS.

Materials and Methods

The study was conducted at Gilani Ultrasound Center, Lahore, Pakistan. The duration of the study was 2 years from April 1, 2018 to March 25, 2020. Two groups of individuals were included in this study to evaluate the accuracy of the new sonographic criteria. Dynamic sonography was taken as a gold standard, so, all the individuals diagnosed with SIS were included in one group. While others with the same age group from the same population with no clinical symptoms and sonographic findings of SIS were included in the second group. The study was commenced after the proper presentation of the title and synopsis in the board of study of the department. Approval of the study was also taken from the Institutional Review Board (IRB) and the Ethical Committee of the University of Lahore with reference number: IRB-UOL-FAHS/00203A. A single ultrasound unit Toshiba Xario Prime with linear transducer frequency ranging from 7 to 14 MHz was used for this study. Patients have been explained the procedure and aim of the research and written informed consent was signed. American Institute of Ultrasound in Medicine guidelines for shoulder ultrasound scanning were followed in this study.[15] Dynamic evaluation of the SIS was performed in coronal view while keeping one end of the transducer directed toward the acromion and the other to the greater tuberosity of the humerus. The patient was asked to raise their arm (abduction) gently while observing the smooth moment of the SAC [Video 1].

The measurement of the SAC was taken from the echogenic cortical part of the lateral margin of the acromion to the echogenic line of the cortical part of the humeral head. Similarly, the SAC were measured from the interface between the acromial-origin of the deltoid muscle and SASD interface to the echogenic line of the cortical part of the humeral head. The supraspinatus tendon was measured from the echogenic interface between the SASD and supraspinatus tendon to the echogenic line of the cortical part of the humeral head [Figures 1-3] and then the sonographic SAC to SAS ratio was calculated while the arm of the patient was kept in the neutral position. The SASD was measured between the echogenic lines bounding the faint hypoechoic bursa [Figures 1-3]. Statistical Package for the Social Sciences version 24 (SPSS 24, IBM, Armonk, NY, United States of America) software was used for the evaluation of data.[16] Sensitivity, specificity, positive predictive value, and negative predictive value were calculated with the help of a two-by-two contingency table.

Results

Seven hundred and seventy-two shoulders of 386 individuals with a mean age of 44.42 ± 17.00 years were included in this study. The means and standard deviations with ranges of the demographic parameters are given in Table 1. Among all the participants; 440 (57%) were male and 332 (43%) were female. Cortical bone irregularity was found in 412 (53.4%)

Table 1: Mean, standard deviation and range of subacromial space, subacromial content, supraspinatus, subacromial subdeltoid bursa, subacromial contents-to-subacromial space ratio

Descriptive statistics of 772 shoulders	Minimum - maximum	Mean±SD
SAS (mm)	5.10-35.00	10.79±1.94
SAC (mm)	4.40-17.00	7.65±1.44
Supraspinatus thickness (mm)	1.00-11.10	5.61±1.27
SASD bursa thickness (mm)	0.20-33.30	0.83±1.23
SAC to SAS ratio	0.38-0.97	0.71±0.09

SASD: Subacromial subdeltoid bursa, SAC to SAS: Subacromial contents to subacromial space, SD: Standard deviation

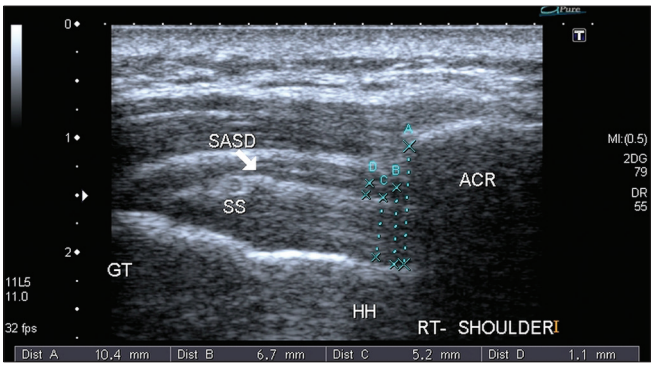

Figure 1: Ultrasound image of the right normal shoulder in neutral arm position of a 39-year-old male. (A) Subacromial space, (B) Subacromial contents, (C) Supraspinatus tendon thickness, (D) Subacromial subdeltoid bursa. The Subacromial contents to subacromial space ratio is 0.64 while there is no impingement syndrome, and negative by dynamic sonography for SIS. Key: HH: Humeral head, SASD: Subacromial subdeltoid bursa, GT: Greater tuberosity, ACR: Acromion, SS: Supraspinatus tendon, SIS: Subacromial impingement syndrome

while absent in 360 (46.6%) shoulders. According to the dynamic sonography 371 (48.1%) had no findings of SIS while 401 (51.9%), participants were positive for SIS. However, by evaluating them with the help of SAC-to-SAS ratio, 469 (60.8%) were positive and 303 (39.2%) were negative for SIS. For the SAC-to-SAS ratio, the area under the curve (AUC) was 96%. At the cutoff value of 0.59 of SAC to SAS ratio, the sensitivity was 94.8% and specificity 68%. From the entire results, the specificity is relatively low because SIS lies at the two extremes of the ratio, while in normal individuals, it is a rather sharp value (0.66 ± 0.03) with a small standard deviation [Figure 1].

At the highest extreme where the SIS was diagnosed, the mean value of the SAC-to-SAS ratio was 0.80 ± 0.06 [Figure 2]. On the other hand, at the low SAC-to-SAS ratio, the mean value was 0.55 ± 0.04 [Figure 3]. Detail of normal shoulders and SIS at low and high SAC-to-SAS ratio is given in Table 2. However, at two different cutup values, the sensitivity and specificity of this technique become increase to a great extent. At a high ratio, the AUC is 99.5%. Moreover at the cut-point of ratio 0.70, the sensitivity and specificity were 99.1% and 90.3% respectively. While at low ratio AUC is 96%. And at cutoff value of 0.59, the sensitivity is 94.8% and specificity 96.8%. While using two different cut-points for upper and lower limits of the SAC to SAS ratio the impingement could be diagnosed with high reliability irrespective of the expertise of the operator.

By comparing the diagnosis of SAC-to-SAS ratio with dynamic sonography; at 95% the sensitivity was 99.25% (97.83%–99.85%) and specificity was 80.86% (76.48%–84.74%). The positive and negative predictive values were 99.00% (98.76%–99.18%) and 85.05% (64.79%–94.62%), respectively. And the overall accuracy of the test was 98.33% (97.16%–99.11%)

Discussion

Shoulder impingement syndrome is a musculoskeletal disorder affecting individuals at any stage of life but is most common in senile-aged individuals. There are numerous causes of shoulder impingement syndrome but irrespective of the causes it affects the range of shoulder moment. During arm abduction, the SAC (supraspinatus tendon and SASD) slide underneath the acromion and the greater tuberosity come closer to the greater tuberosity. For the smooth moment of the supraspinatus tendon and SASD are provided with a room between the acromion and humeral head which is called SAS or shoulder outlet. If the space beneath the acromion is not enough as in the cases of inflammation in the SAC then they become entrapped and

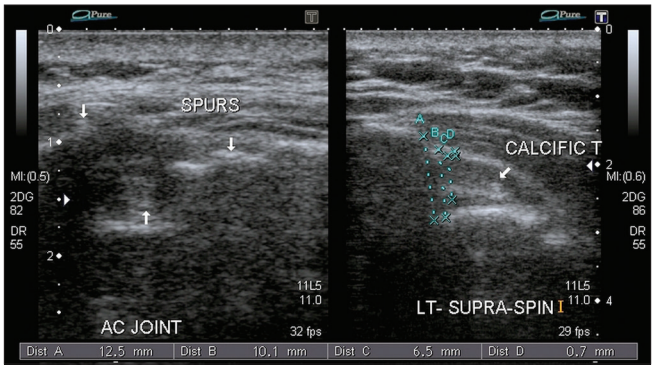

Figure 2: Ultrasound image of the left impinged shoulder in neutral arm position of a 46-year-old female. (A) Subacromial space, (B) Subacromial contents, (C) Supraspinatus tendon thickness, (D) Subacromial subdeltoid bursa. The subacromial contents-to-subacromial space ratio is 0.80 while there was shoulder moment restriction and positive by dynamic SIS. HH: Humeral head, SASD: Subacromial subdeltoid bursa, GT: Greater tuberosity, ACR: Acromion, SS: Supraspinatus tendon, AC: Acromioclavicular joint, (Calcific T) Calcific tendinitis, SIS: Sonography for impingement syndrome

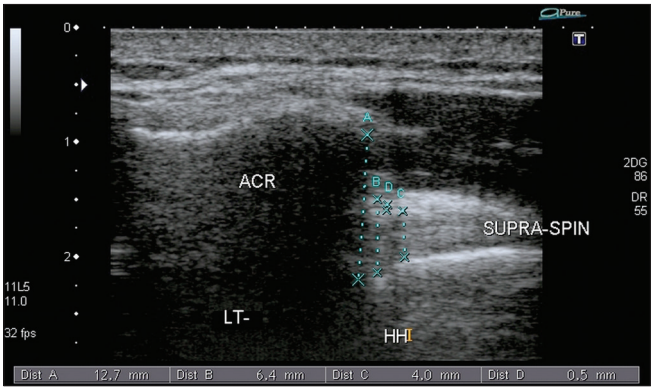

Figure 3: Ultrasound image of the left impinged shoulder in neutral arm position of a 31-year-old male. (A) Subacromial space, (B) Subacromial contents, (C) Supraspinatus tendon thickness, (D) Subacromial subdeltoid bursa. The subacromial contents-to-subacromial space ratio is 0.50 while there was shoulder moment restriction and positive by dynamic sonography in SIS. HH: Humeral head, LT: Left, ACR: Acromion, and (supra-spin) supraspinatus tendon, SIS: Subacromial impingement syndrome

Table 2: Comparison of the means of subacromial contents-to-subacromial space ratio in normal and impinged shoulder cases at a low and high level

SAC to SAS ratio	Shoulder impingement through dynamic sonography		No-impingement through dynamic sonography
	SAC to SAS ratio impingement at the upper limit	SAC to SAS ratio impingement at the lower limit	SAC to SAS ratio no impingement
Number	344	55	373
Mean±SD	0.79±0.06	0.55±0.04	0.66±0.03

SAC to SAS: Subacromial contents to subacromial space, SD: Standard deviation

irritated during an abduction. However, the ratio of the SAC and SAS is important for the smooth easy moment of the shoulder during an abduction. And this ratio could be used for the diagnosis of SIS.

To use this ratio 772 shoulders of 386 individuals with mean age 44.42 ± 17.00 years were recruited in the current study. Among them 57% were male and 43% were females. Obviously, there was no substantial difference between gender. Imagama *et al*., conducted a study, while including 384 patients the male and female were included as 41% and 59%, respectively.[17] McLaine *et al*., included 40% males and 60% females in a similar study.[18] While evaluating overuse of the shoulder as risk factor for shoulder pain, Andersson *et al*. included 329 elite handball players including 51% male and 49% females.[19] In the current study among all the participants, cortical bone irregularity was found in 53.4% of the painful shoulders.

Hassan *et al*. described in a review article that cortical bone irregularity could easily be evaluated on ultrasound and play an important in the diagnosis of various rheumatologic disorders, giving rise to shoulder impingement syndrome.[20] Refaat *et al*., found cortical bone irregularity was in 47.3% of the shoulders in their study.[21] To identify the sonographic findings in the patients of rheumatoid arthritis a cohort of 50 patients was evaluated in a study. Along with other different conditions in 35% of individuals, the cortical bone irregularity was appreciated.[22] El IE-HA, *et al*. evaluated the agreement of musculoskeletal ultrasound and related special tests in individuals operating wheelchairs manually in the shoulder pathologies. Cortical bone irregularity was seen in 90% of the individuals.[23]

In the current study, according to the dynamic sonography 401 (51.94%) individuals were positive for SIS while 371 (48.05%) were normal. These individuals were subjected to ultrasonography, and the SAC-to-SAS ratio was calculated in the neutral position of the arm. According to that ratio, 469 (60.8%) were positive, but, 303 (39.2%) were negative for SIS. For the evaluation of SIS through SAC-to-SAS ratio AUC was 96%. Rowbotham and Grainger, included thirty patients and calculated the sensitivity, specificity, positive and negative predictive values were almost 100% for each in the diagnosing full-thickness tear of supraspinatus tendon using magnetic resonance imaging (MRI) as reference. However, in the cases of partial-thickness tears, the sensitivity, specificity, positive, and negative predictive values were 80%, 95%, 88.9%, and 90.5%, respectively.[24] According to the results of a study, ultrasonography is better than MRI in the evaluation of subacromial impingement and increased synovial vascularity by applying color-Doppler techniques.[25] According to the results of Rowbotham and Grainger, study on dynamic sonography the sensitivity was 85.7% in the rotator cuff partial-thickness tear and 90% for rotator cuff full-thickness tear.[24,26] Moreover, it was observed in a number of studies that sonography is a noninvasive imaging technique and is widely accepted.[24]

It was observed that impingement of the shoulder can occur at both extremes of the SAC to SAS ratio. An abnormally high or low SAC-to-SAS ratio reflects that either there is shoulder joint instability and the distance between the acromion and humeral head is abnormally increased or SAC are thickened. In both cases, the moment of the arm at the shoulder joint is restricted. However, the mean SAC to SAS ratio in normal shoulders was 0.66 ± 0.03. However, any SAC-to-SAS ratio above 0.80 or below 0.55 represents SIS with high sensitivity and specificity. Ultrasound is widely used in the assessment of SIS while using different techniques. Just as; dynamic sonography is used in the evaluation of SIS and its different causes. According to a study, dynamic shoulder sonography is a useful adjunct to clinical assessment in the diagnosis of impingement.[27] Musculoskeletal sonography can objectively detect trapezius atrophy and rotator cuff disorders in patients with shoulder pain. Acromiohumeral distance was used in a study to diagnose shoulder impingement, while at the cut-off value of 10.20 mm sensitivity 0.90 (90%).[28] Distention of the subacromial bursa during arm abduction was considered as a criterion for the diagnosis of SIS with 88.2 sensitivity and 96.3% specificity.[26] Various sonographic methods and criteria for the diagnosis of SIS are followed in the previous studies. However, there is no such an objective diagnostic method which is followed in the current study is known to us in the literature.

Conclusion

SAC to subacromial distance ratio is a more reliable and objective technique for the diagnosis of SIS. It is used in still imaging neutral arm position, which is more comfortable for shoulder pain syndrome patients.

Financial support and sponsorship

Nil.

Conflicts of interest

There are no conflicts of interest.

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