The shoulder in a production line: clinical and ultrasound study

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ABSTRACT

Introduction: The correlation among shoulder pain, abnormal physical examination and ultrasonography is controversial in the occupational scenario. **Objective**: Establish the association between pain, physical examination and ultrasounds in workers of a pharmaceutical industry. **Patients and methods**: One hundred workers were invited to take part in the study and submitted to the inclusion and exclusion criteria, and 93 were included. All enrolled patients gave written informed consent, and had a physical examination performed by one of the authors. Ultrasound examination was performed, at the latest one month of the physical examination, by an experienced operator who was blind to the clinical setting. **Results**: There was statistical correlation between pain and clinical maneuvers in 57 shoulders for supraspinatus tendon (SE) (P = 0,000) and no correlation with biceps tendon maneuvers (P > 0,05). In the comparison between clinical findings and ultrasonography, the maneuvers of Neer, Hawkins and Jobe had statistical association (P < 0,05). The association between pain and altered ultrasonography was statistically significant (16 among 57 individuals with pain, with P < 0,05), but there was significant false-positive ultrasound findings in asymptomatic shoulders (7 individuals). **Conclusion**: The precise diagnosis is a complex process, which requires the association of clinical and occupational anamnesis, accurate physical examination and ultrasonography performed by an experienced operator.

Keywords: occupational medicine; shoulder pain; repetitive strain injuries; work-related musculoskeletal disorders; shoulder ultrasonography; occupational diseases.

INTRODUCTION

Shoulder pain is a frequent complaint in the general population.[1,2] A common situation as the impact syndrome can occur when the supraspinatus tendon is compressed between the humeral head, the anterior edge of the acromion, the coracoacromial ligament and sometimes the bottom edge of the articulation acromioclavicular.[3,4] Several other disorders are common, among them: tendinitis of other tendons, tendinoses, bursitis and tendinous calcification. Clinical symptoms may arise from a variety of articular lesions and periarticular structures of the shoulder. The correlation between pain, change in physical examination, and ultrasound abnormalities is controversial.[2-9] Often, the ultrasound findings may have no relationship with pain symptom. In the occupational setting, it is of paramount importance to establish the correct diagnosis due to legal issues involved. In this study, we propose to analyze the shoulder of workers in an industry, from a clinical, semiological and ultrasonographic perspective.

The objectives of the study were: 1. Assess the relationship between shoulder pain and the main semiological tests on a sample of workers from a production line; 2. Assess the relationship between shoulder pain and ultrasound examination; 3. Assess the relationship between semiological tests and ultrasound findings. 4. Assess the prevalence of ultrasound changes in asymptomatic shoulders.

PATIENTS AND METHODS

Individuals of a pharmaceutical industry were invited to voluntarily participate in a "study on shoulders". One hundred workers were interviewed and accepted. The inclusion criteria were: active workers of both sexes, age between 18 and 60 years, without involvement in contentious issues. And the

Received on 02/02/09. Approved on 05/07/09. We declare no conflict of interest.
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exclusion criteria were: previous shoulder surgery, history of inflammatory arthropathies, shoulder traumatic injuries. From a total of 100 workers, 7 were excluded because they didn't meet the inclusion criteria. Thus, 93 patients (186 shoulders) were included. All subjects were examined by one of the authors following a predetermined protocol, which included demographic and occupational data. There were clinical maneuvers, as described by the authors: Neer,[10] Hawkins,[11] Jobe,[12] Yocum,[13] Appley,[14] Speed[15] and Yergason,[16] as described below.

All enrolled patients gave written informed consent, and had a physical examination performed by one of the authors. This study was approved by the Research Ethics Committee on april, 30, 2003 under the number 0273/02.

Main maneuvers for testing supraspinatus (SE) tendon

Neer's maneuver: Performed with the elbow in extension and forearm prone. Prevention of scapula rotation is made with one hand. A passive elevation of the upper limb is done, which may cause the impact of the SE region insertion with the bottom edge of the acromion.

Hawkins' maneuver: The examiner maintains the shoulder in flexion of 90° and the elbow also flexed to 90°. With the other hand, holds the wrist of the examined and does a rapid internal rotation, causing SE tendon impact against the anteroinferior edge of the acromion, and against the coracoacromial ligament.

Jobe's test: Position the arm abducted to 90°, flexed to 30° in the frontal plane and internally rotated, with the thumbs pointed to the floor. The elbows should remain extended. Next, the examiner lowers the upper limb against the patient resistance. The test is considered positive when there is pain, SE weakness or failure secondary to a rupture, or associated with impact.

Apley's test: Ask the patient to place the hand of the affected shoulder behind the head, and touch the upper angle of the opposite scapula. Then, ask the patient to place the hand behind the back, and try to touch the lower angle of the opposite scapula. Shoulder pain will be referred if there is tendonitis, usually of the SE.

Yocum's maneuver: Pain is referred when patient puts the palm of the hand on the opposite shoulder, while the examiner elevates the elbow to a horizontal position, causing SE friction under the coracoacromial arch and under the acromioclavicular joint. This test may also indicate acromioclavicular joint injury.

Main maneuvers for other rotator cuff tendons

Patte's test: Only for infraspinatus tendon. The arm is positioned at 90° of abduction and elbow at 90° of flexion. Request the patient to resist the force of internal rotation by the examiner's hand placed on the hand dorsum of the patient. The decreased resistance may indicate tendon rupture.

Gerber's test (Lift-off test**):** Place the shoulder to be examined in extension and internal rotation with the hand on the back (elbow at 90º). Then, ask the patient to open the distance between hand and back. The inability to perform the maneuver indicates an altered test, and probable inflammation/ rupture of the subscapular tendon.

Main maneuvers for the long head of the biceps tendon

Speed's test (palm up): The test is performed with the patient flexing the arm anteriorly against resistance, with the elbow extended and the forearm in supine. The test is positive when the pain is located in the bicipital groove.

Yergason's maneuver: Place the patient with the arm near the trunk, with the elbow flexed at 90° and the shoulder in neutral position. Request the patient to perform supination against resistance. The test is positive if pain is presented on bicipital groove.

Lipmann's test: The test will begin with the patient elbow flexed at 90° and the arm near the trunk. If the patient reports pain in the bicipital groove during elbow flexion against resistance, the test is considered positive. This test can also detect biceps tendon luxation or subluxations out of the bicipital groove.

Ultrasound examination was performed by another investigator who was blind to the clinical condition of the patient, using the protocol established by Mack:[17] with the patient sitting in front of the examiner, and the shoulder in neutral position, the biceps tendon is assessed longitudinally and crosswise. Then, with the maximum external rotation, the subscapular tendon is examined. The following structure is the supraspinatus tendon, with the shoulder in hyperextension, adduction and internal rotation to place the tendon anteriorly. And finally, with the shoulder in neutral position, the structures of the back are analyzed, the infraspinatus and glenoid labrum. The equipment used was an Aloka model SSD900 with a 7.5 MHz linear transducer. No more than thirty days elapsed between the clinical and ultrasound evaluations.

Statistical analysis included the Chi-square test (x2) to compare nominal variables between groups, with the objective to

test the hypothesis that the groups are independent of the variables in question, i.e., we assessed if the occurrence of the features was the same regardless of the group of patients; and the Fisher's test, a non-parametric technique for nominal data analysis, when the necessary condition for the Chi-square test was not met, the ratio test for two independent samples. Two-sided test was performed at $\alpha = 0.05$, whose hypotheses are: null hypothesis, the ratio between the variables is equal in both samples; alternative hypothesis, the variables are not independent; the ratio between samples is different. The level of significance was set at 5%.

RESULTS

Ninety-three workers were included in the study (186 shoulders). Forty-two individuals were symptomatic (45.2%), 51 asymptomatic (54.8%). As some had bilateral pain, a total of 57 shoulders were considered symptomatic (30.64%) of 186. The group consisted of 11 male and 82 female (mean age 36.4 years). There was no difference in these variables between symptomatic and asymptomatic workers. The mean time of pain was 4.5 years (ranging from three months to 12 years).

Semiological maneuvers usually related to abnormalities in supraspinatus tendon (Neer, Hawkins, Jobe, Yocum and Appley) were more frequent in symptomatic individuals, when compared with those who were asymptomatic.

The comparison between shoulders with or without pain and ultrasound changes (Table 1) was significant (P = 0.005). Comparatively, there are more altered ultrasound in symptomatic shoulders than in asymptomatic shoulders and, proportionately, more normal ultrasound in shoulders without pain.

Table 2 shows the number of positive semiological tests in individuals with and without pain, and the results of statistical comparison between them, indicating that only the tests for biceps (Speed and Yergason) showed no significance in relation to the pain complaint.

Table 3 shows the results between pain and abnormal ultrasound of the biceps and supraspinatus tendons. Comparison between the percentage of shoulders with and without pain, whose ultrasound presented alteration of supraspinatus and biceps tendons, showed statistically significant relevance in the symptomatic shoulders.

The proportion of workers with altered ultrasound of supraspinatus tendon and painful symptoms was 19.3%, compared to 4.65% of asymptomatic individuals (P = 0.005), 8.77% and 0.78% for biceps tendon, respectively (P = 0.019).

Abnormal ultrasound was found (17 in supraspinatus tendon, six in bicipital tendon and eight in acromioclavicular joint, one in "the acromial" and a subacromial-subdeltoid bursitis) in 24 shoulders. There were shoulders with two or more alterations. From these 24 shoulders, 14 were symptomatic and 10 asymptomatic. Therefore, the prevalence of ultrasound changes in asymptomatic shoulders was 7.75%.

Table 4 shows the results from the ultrasound abnormalities for supraspinatus tendon (17 shoulders), and the long head of the biceps tendon (6 shoulders), and their positive clinical maneuvers.

In this study, we had six changes in the long head of the biceps and a subacromial-subdeltoid bursitis, all accompanying changes of supraspinatus tendon. The Speed's test (or palm up) and Yergason, which are considered more specific for long head biceps lesions, were not significantly different at 5% level.

Table 1
Distribution of combined frequency between shoulder pain and altered ultrasonography for supraspinatus tendon. Proportion test between p1 (19.3%) and p2 (4.7%) → P = 0.005

	Shoulder		
	With pain	**Without pain**	**Total**
US altered	11 (19.3%)	6 (4.70%)	17
US normal	46 (80.7%)	123 (95.3%)	169
Total	57 (100%)	129 (100%)	186

Table 2
Proportion of shoulder with pain (57), without pain (129) and semiologic positive maneuvers

	Shoulder			
	With pain (57)	**Without pain (129)**	**Total**	**p**
Neer	11 (19.30%)	3 (2.30%)	14	0.000
Hawkins	20 (35.09%)	7 (5.43%)	27	0.000
Jobe	13 (22.81%)	4 (3.10%)	17	0.000
Yocum	15 (26.31%)	1 (0.77%)	16	0.000
Appley	17 (29.80%)	8 (6.20%)	25	0.000
Speed	9 (15.79%)	8 (6.20%)	17	0.055
Yergason	1 (1.80%)	2 (1.60%)	3	0.920

Table 3
Pain and abnormal ultrasonography for supraspinatus and long head of biceps tendons injuries

	Shoulder			
	With pain (57)	**Without pain (129)**	**Total**	**P**
Supraspinatus	11 (19.3%)	6 (4.65%)	17	0.005
Biceps	5 (8.77%)	1 (0.78%)	6	0.019

Table 4
Proportion of shoulder with normal and altered ultrasonography of supraspinatus and the long head of biceps tendons and their positive semiology maneuvers

Maneuver	Ultrasonography			
Supraspinatus	**Normal (169)**	**Altered (17)**	**Total**	**P**
Neer	7 (4.14%)	7 (41.18%)	14	0.000
Hawkins	18 (10.65%)	9 (52.94%)	27	0.000
Jobe	11 (6.51%)	6 (35.29%)	17	0.005
Yocum	11 (6.51%)	5 (26.70%)	16	0.033
Appley	20 (11.80%)	5 (29.40%)	25	0.077
Bíceps	**Normal (180)**	**Altered (6)**		
Speed	17 (9.44%)	0 (0%)	17	0.285
Yergason	3 (1.67%)	0 (0%)	3	0.660

This study showed that the clinical testing for the supraspinatus tendon (Neer, Hawkins, Yocum and Jobe) were statistically associated ($P < 0.05$), when compared with painful symptoms. Only one of five of these tests had no statistical association, when compared with ultrasound test (Appley's test), which was associated only with the confidence level of 10%. However, a larger sample is needed to test this maneuver. There was no statistical association between pain, semiological and ultrasound tests for the long head of the biceps tendon.

DISCUSSION

Shoulder pain is a frequent clinical symptom that presents imaging and semiologic difficulties for final diagnosis.[2,9] In the occupational setting, these difficulties can lead to conflicts in clinical practice and in legal decisions.[18]

Controversy surrounds about the relationship between clinical complaint (pain), symptomatic maneuvers, and the findings of anatomical changes in ultrasound.[2,6] Therefore, it is appropriate to investigate these associations in an assembly line for active workers.

All subjects participated voluntarily in this study. About 90% of the company's employees are women, and it explains the high percentage of females in our sample.

The characteristic of our population, with a narrower age range, reduces the possibility of having older individuals who are more susceptible to present degenerative changes in shoulders.

Shoulder pain is a very common condition. In general population, the prevalence varies from 5 to 47%.[1,2,19,20] Because of its subjectivity, we considered all types of pain in this study (at rest, moving on, at night, and so on). We found prevalence of 45%, therefor, a number that reflects what happens in general population. There was no difference between age, work and sex between individuals with and without pain.

There are different causes of shoulder pain, including injuries involving the rotator cuff, biceps tendon, subacromial-subdeltoid bursa and acromioclavicular joint.[1,2,21] Tendon degeneration occurs as part of a progressive process of tendon aging, leading to rupture of the rotator cuff.[2,6,22-24] Consequently, tendinitis and rupture of rotator cuff generally occur in patients over 50 years of age.[25] However, it can be found in young people.[26] In the present study, we did not find any individual with total rupture of rotator cuff. There were six partial ruptures, which occurred in individuals older than the average age of our sample (42.6 years *versus* 36.4 years). Although all tendons were investigated, no significant change was found in infraspinatus, teres minor and subscapular.

There is no clear guideline for the diagnosis of shoulder pain.[2] At the professional environment, the differential diagnosis and origin of these lesions are very important to determine the causal link with the job done. In a near past, it was thought to be caused by repetitive strain injuries, but today, the concept of *impingement* is the unification of a spectrum of disorders.[27] The most prevalent movements in our sample were flexion, extension and rotation.

There is strong evidence that a more intense pain and older age (45-54 years) are both associated with worse outcomes in the work population.[1]

Involvement of the biceps tendon has been found in about 85% of the patients with rotator cuff painful injuries.[28] Moreover, the increase of liquid in the subacromial-subdeltoid bursa usually accompanies rotator cuff impingement syndrome or total ruptures of it.[27] This is due to the fact that the synovial sheath of biceps tendon is an extension of the glenohumeral synovial membrane, and the subacromial-subdeltoid bursa communicates with the glenohumeral joint in the total ruptures of the rotator cuff.[29] A series of maneuvers was conceived to diagnose symptomatic periarticular changes on shoulder.[2] They increase the contact of acromial arch with rotator cuffand determine the location of tendinous lesions, when testing movement against resistance.[7] Clinically, it may be difficult to distinguish the patterns of pain from rotator cuff injuries, bicipital tendon and subacromial-subdeltoid bursitis.[6] Obviously, any position in which the rotator cuff is compressed by the acromial arch causing pain during the examination is highly predictive of rotator cuff injury. However, this result may be indicative of any rotator cuff injury, such as tendinitis

and a partial or complete rupture, and also bursitis. However, in this study, statistical data showed that the association between pain and clinical maneuvers of SE tendon was significant, and the same association for bicipital tendon was negative.

The ultrasound is an operator-dependent examination, which requires extensive learning and training. It plays an important role in the diagnosis and in the decision about therapeutic strategy. However, there are technical limitations, as the difficulties to measure the size of tendon ruptures, to analyze subacromial structures; different results among different operators, and in consecutive evaluations performed by the same operator; induction of results; altered results in asymptomatic individuals; anisotropic effect caused by inadequate inclination of the transducer, among others. Success depends on operator experience, and diagnosis should be done in real time and not from image.[30-33]

In this study it was used a transducer of 7.5 MHz. It is necessary to elucidate that the higher the frequency of the transducer, the better the ultrasound picture quality, but worst the penetration of the sound beam. For the shoulder structures examined in this study, which lies deeper, the assessment should involve a range of frequencies between 7.5 and 10MHz.

The results showed that painful shoulder, clinical maneuvers and ultrasonography have statistical correlation when compared to supraspinatus tendon, but a weak association when compared to biceps tendon. Therefore, the final diagnosis can not be confirmed with only two of these variables because the number of false positives is high and important. Other authors have reported low accuracy of clinical assessment, compared with intraoperative injuries in the diagnosis of shoulder periarticular conditions.[34,35] We haven't used any gold standard as magnetic resonance imaging or surgery, so we did not calculate values, such as sensitivity, specificity and predictive values.

Norwood *et al.*[35] attempted to define the clinical signs and symptoms that indicate the presence of a rotator cuff rupture and predict its severity. They concluded that the pain characteristics and rupture site was not useful, as well as the weakness of abduction against resistance. Our results, and those of others, were expected because most patients with shoulder pain have impact syndrome and several periarticular lesions, usually involving different tendons and subacromial-subdeltoid bursa.

A possible explanation for the low accuracy of clinical tests is the lack of correlation between clinical findings and anatomical abnormalities in the shoulder.[6] A variable prevalence of shoulder periarticular lesions, especially rotator cuff injuries, has been reported in asymptomatic shoulder.[8,9,34-37] Therefore, the presence of ultrasonography changes in asymptomatic shoulders may in part explain the low sensitivity of clinical evaluation of cuff rotator injuries.[6]

This study showed that asymptomatic individuals may have ultrasound changes. Is was observed too a high frequency of normal ultrasound examinations with painful shoulder (80.7%). These facts deserve consideration and care, as they have generated discussion and controversy in the occupational, welfare and judiciary settings.

With regard to the work environment, the work-related musculoskeletal diseases represent a heterogeneous group of disorders with a high incidence on daily medical practice, which commonly occur in individuals who are outside the occupational setting. Often, even these conditions do not have identifiable cause and are interpreted as idiopathic. In addiction to these facts, misinterpretation and use of tests such as ultrasonography, which often has been inappropriately used as definitive in the diagnosis of cuff lesions, are also associated. Thus, ultrasound findings separately should not be used to decide on a possible absence or return to work. Therefore, injuries of the shoulder may occur in asymptomatic individuals without trauma history. These lesions are not necessarily associated with pain. Image findings must be interpreted within the clinical context and should not be used as a sole diagnostic tool for decision.

CONCLUSIONS

Professionals with shoulder pain had a statistically significant association with clinical testing for supraspinatus tendon (Neer, Hawkins, Jobe, Appley and Yocum), compared to asymptomatic workers, on the other hand, this result was not observed for biceps tendon.

The prevalence of ultrasonography changes in symptomatic shoulders is significantly higher than in asymptomatic shoulders.

Neer, Hawkins, Yocum and Jobe tests had statistical association with ultrasonography.

The prevalence of ultrasonography changes in asymptomatic workers was 7.75%. This percentage is statistically significant. This is an important finding in the study, which shows the possibility of false-positive results with ultrasonography.

REFERENCES

1. Kuijpers T, van der Windt DA, van der Heijden GJ, Bouter LM. Systematic Review of Prognostic Cohort Studies on Shoulder Disorders. Pain 2004;109:420-31.

2. Dinnes J, Loveman E, McIntyre L, Waugh N. The Effectiveness of Diagnostic Tests for the Assessment of Shoulder Pain Due to Soft Tissue Disorders: a Systematic Review. Health Technol Assess 2003;7:1-166.
3. McFarland EG, Singh Selhi H, Keyurapan E. Clinical Evaluation of Impingement: What to Do and What Works. J Bone Joint Surg [Am] 2006;88:432-41.
4. Michener LA, McClure PW, Karduna A R. Anatomical and Biomechanical Mechanisms of Subacromial Impingement Syndrome. Clin Biomech 2003;18:369-79.
5. Kayser R, Hampf S, Pankow M, Seeber E, Heyde CE. Validity of Ultrasound Examinations of Disorders of the Shoulder Joint. Ultraschall Med 2005;26:291-8.
6. Naredo E, Aguado P, De Miguel E, Uson J, Mayordomo L, Gijon-Baños J *et al.* Painful Shoulder: Comparison of Physical Examination and Ultrasonographic Findings. Ann Rheum Dis 2002:61(2):132-6.
7. Park HB, Yokota A, Gill HS, El Rassi G; McFarland EG. Diagnostic Accuracy of Clinical Tests for the Different Degrees of Subacromial Impingement Syndrome. J Bone Joint Surg [Am] 2005;87(7):1446-56.
8. Schibany N, Zehetgruber H, Kainberger F, Wurnig C, Ba-Ssalamah A, Herneth AM *et al*. Rotator Cuff Tears in Asymptomatic Individuals: a Clinical and Ultrasonographic Screening Study. Eur J Radiol 2004;51(3):263-8.
9. Winter AF, Jans MP, Scholten RJ, Deville W, van Schaardenburg D, Bouter LM. Diagnostic Classification of Shoulder Disorders: Interobserver Agreement and Determinants of Disagreement. Ann Rheum Dis 1999;58:272-7.
10. Neer CS. Anterior Acromioplasty for the Chronic Impingement Syndrome in the Shoulder: A Preliminary Report. J Bone Joint Surg [Am] 1972;54:41-50.
11. Hawkins RJ, Kennedy JC. Impingement Syndrome in Athletes. Am J Sports Med 1980;8:151-8.
12. Jobe FW, Jobe CM. Painful Athletic Injuries of the Shoulder. Clin Orthop 1983;173:117-24.
13. Yocum LA. Assessing the Shoulder. History, Physical Examination, Differential Diagnosis, and Special Tests Used. Clin Sports Med 1983;2:281-9.
14. Cipriano JJ. Testes ortopédicos do ombro. In: Cipriano JJ. Manual fotográfico de testes ortopédicos e neurológicos. 1 ed. São Paulo: Manole, 1999, pp. 71-112.
15. Crenshaw AH, Kilgore WE. Surgical Treatment of Tenosynovitis. J Bone Joint Surg [Am] 1966;48:1496-502.
16. Yergason RM. Supination Sign. J Bone Joint Surg 1931;13:160-5.
17. Mack LA, Matsen FA, Kilcoyne JF, Davies PK, Sickler ME. Ultrasound Evaluation of the Rotator Cuff. Radiology 1985;157:205-9.
18. Lehner B, Loew M. Etiology of Rotator-cuff-tears and Consequences for Legal Assessment. Zentralb Chir 2002;127:187-93.
19. Van der Heijden GJ. Shoulder Disorders: A State-of-the-art Review. Bailliere's Best Pract Res Clin Rheumatol 1999;13:287-309.
20. Picavet HS, Schouten JS. Musculoskeletal Pain in the Netherlands: Prevalences, Consequences and Risk Groups, the DMC(3)-study. Pain 2003;102:167-78.
21. Bartolozzi A, Andreychik D, Ahmad S. Determinants of Outcome in the Treatment of Rotator Cuff Disease. Clin Orthop 1994;308:90-7.
22. Tempelhof S, Rupp S, Seil R. Age-related Prevalence of Rotator Cuff Tears in Asymptomatic Shoulders. J Shoulder Elbow Surg 1999;8:296-9.
23. Fukuda H. The management of Partial-Thickness Tears of the Rotator Cuff. J Bone Joint Surg [Br] 2003;85:3-11.
24. Loehr JF, Uhthoff HK. The Pathogenesis of Degenerative Rotator Cuff Tears. Orthop Trans 1987;11:237-43.
25. Dalton SE. The Conservative Management of Rotator Cuff Disorders. Br J Rheumatol 1994;33:663-7.
26. Cofield RH. Current Concepts Review. Rotator Cuff Disease of the Shoulder. J Bone Joint Surg [Am] 1985;67:974-9.
27. Neviaser TJ. The Role of the Biceps Tendon in the Impingement Syndrome. Orthop Clin North Am 1987;18:383-6.
28. Crenshaw AH, Kilgore WE. Surgical Treatment of Biciptal Tenosynovitis. J Bone Joint Surg [Am] 1966;48:1496-502.
29. Hollister MS, Mack LA, Patten RM, Winter TC, Matsen FA, Veith RR. Association of Sonographically Detected Subacromial-Subdeltoid Bursal Effusion and Intraarticular Fluid with Rotator Cuff Tear. Am J Roentgenol 1995;165:605-8.
30. Mack LA, Nyberg DA, Matsen FA. Sonographic Evaluation of the Rotator Cuff. Radiol Clin North Am 1988;26:161-77.
31. Katthagen BD. Anatomy as Revealed by Sonography. In: Ultrasonography of the Shoulder: Technique, Anatomy, Pathology. New York: Thieme Medical 1990; 45-59.
32. Middleton WD. Ultrasonography of the Shoulder. Radiol Clin North Am 1992;30:927-40.
33. Teefey SA, Rubin DA, Middleton WD, Hildebolt CF, Leibold RA, Yamaguchi K. Detection and Quantification of Rotator Cuff Tears - Comparison of Ultrasonographic, Magnetic Resonance Imaging, and Arthroscopic Findings in Seventy-One Consecutive Cases. J Bone Joint Surg [Am] 2004;86:708-16.
34. Leroux JL, Thomas E, Bonnel F, Blotman F. Diagnostic Value of Clinical Tests for Shoulder Impingement Syndrome. Rev Rhum (Engl Ed) 1995;62:423-8.
35. Norwood LA, Barrack R, Jacobson KE. Clinical Presentation of Complete Tear of the Rotator Cuff. J Bone Joint Surg [Am] 1989;71:499-505.
36. Milgrom C; Schaffler M; Gilbert S; van Holsbeeck M. Rotator-Cuff Changes in Asymptomatic Adults. The Effect of Age, Hand Dominance and Gender. J Bone Joint Surg [Br] 1995;77:296-8.
37. Sher JS, Uribe JW, Posada A, Murphy BJ, Zlatkin MB. Abnormal Findings on Magnetic Resonance Images of Asymptomatic Shoulders. J Bone Joint Surg [Am] 1995;77:10-5.