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## ● Original Contribution

# COMPARISON OF ULTRASONOGRAPHIC FINDINGS OF THE ROTATOR CUFF BETWEEN DIABETIC AND NONDIABETIC PATIENTS WITH CHRONIC SHOULDER PAIN: A RETROSPECTIVE STUDY

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(Received 11 February 2010; revised 28 July 2010; in final form 11 August 2010)

**Abstract**—It is still unclear whether diabetic mellitus (DM) is associated with rotator cuff lesions. The object of this retrospective study was to compare the ultrasonographic (US) findings of rotator cuffs in diabetic patients with those of nondiabetic patients with chronic shoulder pain. In total, 419 patients (80 diabetic, 339 nondiabetic) who had chronic shoulder pain and had been referred to receive US examination between January 2005 and January 2008 in a medical center were included in this study. The US findings of rotator cuff lesions were classified into two main categories: rotator cuff tears (RCTs) and calcifying tendinopathy (CT). In total, 114 (25.2%) shoulders with CT of the rotator cuff and 160 (35.3%), 15 (3.3%) and 5 (1.1%) shoulders with supraspinatus, infraspinatus and subscapularis tears, respectively, were noted. No difference in the ratio of tears of RCTs was found on US examinations between two groups. The crude odds ratio (OR) for CT of diabetic patients was 1.85 ( $p = 0.014$ ); however, the adjusted OR for CT in diabetic patients became insignificant after controlling for the other variables (OR = 1.59,  $p = 0.08$ ). To our knowledge, this is the first study to explore US findings among diabetic and nondiabetic patients with chronic shoulder pain. Further study is advised to confirm our findings. (E-mail: [csc@tmu.edu.tw](mailto:csc@tmu.edu.tw)) © 2010 World Federation for Ultrasound in Medicine & Biology.

**Key Words:** Diabetes mellitus, Shoulder pain, Ultrasound, Rotator cuff tendinopathy, Tears.

## INTRODUCTION

Shoulder pain and stiffness are common musculoskeletal problems in diabetic patients (Del Rosso et al. 2006). Bilateral involvement, a higher recurrence rate and greater resistance to treatment are generally found more frequently in diabetic than nondiabetic patients (Kim 2002; Del Rosso et al. 2006). Adhesive capsulitis is one of the most common causes of painful shoulder stiffness (Harrast and Rao 2004; Tauro and Paulson 2008). The presence and severity of adhesive capsulitis in diabetic patients are reportedly correlated with age, the duration of diabetes mellitus (DM), existing neuropathies and hand problems (Arkkila et al. 1996; Balci et al. 1999).

A large population survey found that 25.7% of diabetic patients had shoulder pain, but only 4.3% of diabetic

patients fulfilled the criteria of a frozen shoulder (Thomas et al. 2007). It is reasonable to propose that a significant proportion of diabetic patients with shoulder pain may suffer from other shoulder pathologies. Rotator cuff disease is also a highly prevalent pathology in patients with shoulder pain (Rodgers and Crosby 1996). In addition, tendons and tendon synovial sheaths can be affected in diabetic patients, particularly over the hands (Kim 2002). However, to our knowledge, there are few studies exploring the involvement of rotator cuff tendons in diabetic patients. The aim of our study was to compare the ultrasound (US) findings of rotator cuff lesions in diabetic patients who had shoulder pain with nondiabetic patients.

## METHODS

### Patient selection

Subjects who were referred for a US examination of the shoulder between January 2005 and January 2008 were retrospectively surveyed. A detailed history was taken from every patient, and they received a physical

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examination before the US examination. Data on 419 subjects who fit the selection criteria were collected from a database consisting of 918 subjects who had received a shoulder US examination. The inclusion criteria included age more than 40 y and chronic shoulder pain for more than one month. Exclusion criteria were a known systemic rheumatologic disease, such as rheumatoid arthritis (RA) or ankylosing spondylitis (AS); a known malignancy; surgery; major trauma; or fracture of the shoulder. Subjects who had received steroid injections to the affected shoulder less than one month before the US examination were also excluded from this study, given that there may have been US artefacts from crystal deposition of the drugs involved. Patients with type II DM were identified from a chart review. There were 80 diabetic and 339 nondiabetic subjects and a total of 453 shoulders enrolled for further analysis. The review of medical records and waiver of informed consent of subjects were approved by the local institutional review board.

#### US examination

We mainly followed the protocol of shoulder US examinations described in previous studies (AIUM 2003; Fotiadou *et al.* 2008). US was performed with patients sitting on a stool in a relaxed, erect posture. All US procedures were performed by an experienced physician who had more than 8 y of experience in musculoskeletal US examinations. All US images were obtained in real time using a high-resolution, variable high-frequency, linear-array transducer (6–13 MHz) (SonoSite Micromaxx, SonoSite, Bothell, WA, USA). Six main windows of the scanning plane of the rotator cuff were used for US in each subject, including the short and long axes of the biceps brachii tendon, the short and long axes of the supraspinatus (SS) tendon, the long axes of the infraspinatus (IS) and teres minor tendons and the long axis of the subscapularis (SC) tendon (AIUM 2003; Rutten *et al.* 2007). A dynamic view of the long axis of the SSP tendon during active abduction movement of the shoulder was also examined. Compression of the rotator cuff tendon under US examination was performed to find whether the contour of the rotator cuff collapsed, which would indicate the presence of a hypoechoic or anechoic lesion at the rotator cuff.

The US findings of rotator cuff lesions were classified into two main categories: rotator cuff tears (RCTs) and calcifying tendinopathy (CT). RCTs were further classified into partial-thickness tears (PTTs) (bursal surface, intrasubstance and articular surface) and full-thickness tears (FTTs). The criteria of US findings of rotator cuff FTTs were (i) total nonvisualization of the tendon; (ii) a hypoechoic or anechoic defect in the tendon, extending from the bursal to the articular side; and (iii) a retractable or compressible defect of the tendon when the subject

performed active abduction or compression on a dynamic scan. Findings of PTT were (i) a focal hypoechoic or anechoic discontinuity at the tendon, which was found at the bursal, articular or intrasubstance site; and (ii) a focal flattening of the bursal site with fluid accumulation (*i.e.*, a bursal site tear). Findings of CT were a presentation of focal hyperechoic lesions in the rotator cuff tendons, usually with posterior shadowing. The calcifying lesions could be unifocal or multifocal, and their shapes could be arcs, spots or amorphous. Typical pictures of US examination of RCTs and CT are shown in Fig. 1. All US findings were confirmed in two different scanning planes (long and short axes) or through adequate tilting of the scanning probe to prevent anisotropic artefacts of US images.

#### Statistical analysis

Data on continuous variables are presented as the mean  $\pm$  standard deviation. Student's *t*-test was applied to compare the means of basic variables between the diabetic and nondiabetic groups. A chi-squared test was applied to analyze the presentation of US findings between the two groups. A multivariate logistical regression analysis was applied to analyze variables contributing to the risk of rotator cuff findings. The adjusted odds ratio (OR) with the 95% confidence interval (CI) was calculated by adjusting for age, gender and the side of the affected shoulder. Statistical significance was set at  $p < 0.05$ , and statistical analyses were processed using SPSS software (SPSS, Inc., Chicago, IL, USA).

## RESULTS

Included in this study were 419 patients (80 diabetics and 339 nondiabetics) with 453 symptomatic shoulders, each with a complete US examination. The basic profiles of the diabetic and nondiabetic subjects are listed in Table 1. The age difference between the two groups was statistically significant ( $62.6 \pm 8.9$  y for diabetics,  $56.9 \pm 8.9$  y for nondiabetics;  $p < 0.001$ ). In each group, there were more female subjects than male; the difference in the gender ratio between the diabetic and nondiabetic groups, however, was not significant. The duration of DM of the subjects was  $6.6 \pm 3.2$  y (35, 37 and 8 subjects for  $<5$ ,  $5\sim 10$  and  $>10$  y, respectively). Right shoulder involvement was more common in both diabetic and nondiabetic patients (53% and 60%, respectively). The difference between the two groups in terms of side prevalence was insignificant, although there was significantly higher symptomatic bilateral shoulder involvement in diabetic patients (13.8% for diabetics, 6.8% for nondiabetics,  $p = 0.04$ ).

US findings of subjects are summarized in Table 2. In total, 114 (25.2%) shoulders (106 at SS; 8 at IS) with CT were noted; 160 (35.3%), 15 (3.3%) and 5 (1.1%)

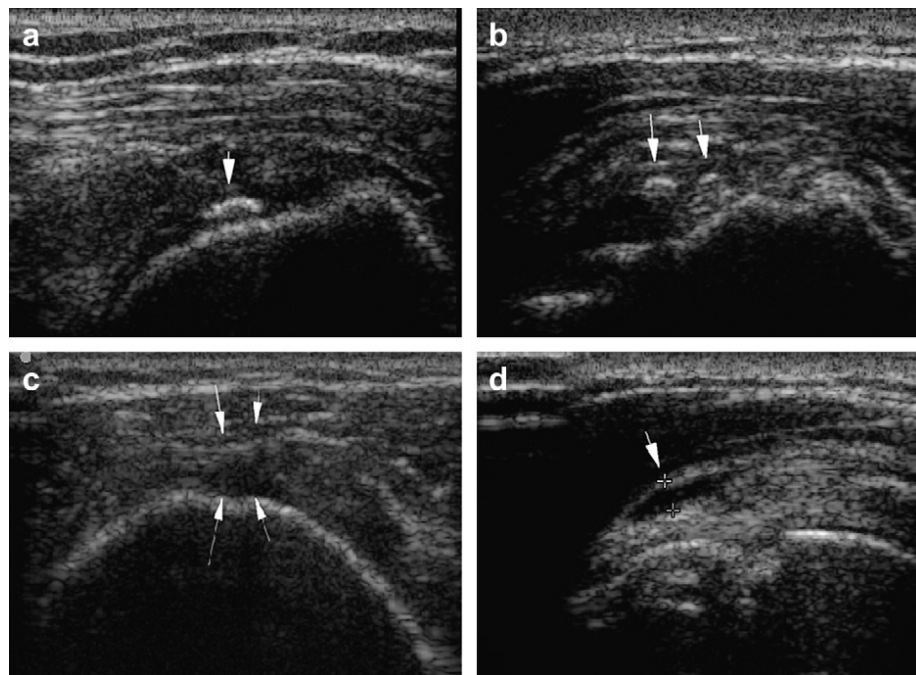


Fig. 1. Typical US findings of rotator cuff diseases. There are several typical findings of rotator cuff lesions on a US examination. (a) Calcifying tendinopathy (CT) over the supraspinatus (SS) tendon. (b) Multifocal calcifications. (c) Full-thickness tears of the SS tendon. (d) Partial-thickness tears of the SS tendon at the bursal site.

shoulders with SS, IS and SC tears, respectively, were identified by US examination. Thirty-two (35.2%) of the shoulders of diabetic patients and 82 (22.7%) of the shoulders of nondiabetic patients were noted to have CT on the US examination. Thirty-three (36.3%) of the shoulders of diabetic patients and 127 (35.1%) of the shoulders of nondiabetic patients were noted to have SS tears. Four (4.4%) of the shoulders of diabetic patients and 11 (3.0%) of the shoulders of nondiabetic patients were noted to have IS tears. Two (2.2%) of the shoulders of diabetic patients and three (0.8%) of the shoulders of nondiabetic patients were noted to have SC tears. We found no patients with tears of the teres minor tendon by US exam. More cases of CT or RCTs were demonstrated on US examinations in diabetic than nondiabetic patients ( $p = 0.02$ ). However, no difference in the ratio of tears of RCTs was found on US examinations between diabetic and nondiabetic patients.

Table 1. Basic variables of all subjects

|                         | DM             | Non-DM         | <i>p</i> -value |
|-------------------------|----------------|----------------|-----------------|
| Patients ( $n = 419$ )  | 80             | 339            |                 |
| Age (y)                 | $62.6 \pm 8.9$ | $56.9 \pm 8.9$ | $< 0.001^*$     |
| Gender (F:M)            | 50:30          | 214:125        | 0.951           |
| Shoulders ( $n = 453$ ) | 91             | 362            |                 |
| Right                   | 48             | 216            |                 |
| Left                    | 43             | 146            |                 |
| Bilateral               | 11             | 23             | 0.04*           |

\*  $p < 0.05$ .

A summary of the crude and adjusted ORs for rotator cuff lesions on US examinations for diabetic patients compared with nondiabetic patients is given in Table 3. The crude ORs for RCT tears of diabetic patients compared with nondiabetic patients were 1.05, 1.20 and 2.69 for the SS, IS and SC tendons ( $p = 0.833$ , 0.518 and 0.264), respectively. The adjusted ORs for RCTs tears of diabetic patients compared with nondiabetic patients were 1.05, 1.20 and 2.69 for the SS, IS and SC tendons ( $p = 0.833$ , 0.518 and 0.264), respectively. Furthermore, the crude OR for CT of diabetic patients was 1.85 ( $p = 0.014$ ) compared with nondiabetic patients; however, the adjusted OR for CT in diabetic patients became insignificant after controlling for the other variables (OR = 1.59,  $p = 0.08$ ).

## DISCUSSION AND SUMMARY

Although most studies agree that adhesive capsulitis is the main cause of painful shoulder stiffness in diabetic patients (Kim 2002; Del Rosso et al. 2006; Aydeniz et al. 2008; Tighe and Oakley 2008), it is reasonable to propose that rotator cuff lesions may contribute to shoulder disability in some diabetic patients, because its prevalence is also high in this age group (Rodgers and Crosby 1996; Schibany et al. 2004; Tighe and Oakley 2008). Moren-Hybbinette et al. (1986) studied diabetic patients with shoulder pain; using only physical examinations, they found that 62% of subjects had restricted

Table 2. Ultrasonographic findings of diabetic and nondiabetic patients with painful shoulder stiffness

|                  | Total<br>( <i>n</i> = 453) | DM<br>( <i>n</i> = 91) | Non-DM<br>( <i>n</i> = 362) | <i>p</i> -value |
|------------------|----------------------------|------------------------|-----------------------------|-----------------|
| SS tears         | 160 (35.3%)                | 33 (36.3%)             | 127 (35.1%)                 | 0.902           |
| PTT              | 124 (27.4%)                | 26 (28.6%)             | 98 (27.1%)                  | 0.793           |
| FTT              | 36 (7.9%)                  | 7 (7.7%)               | 29 (8.0%)                   | 0.920           |
| IS tears         | 15 (3.3%)                  | 4 (4.4%)               | 11 (3.0%)                   | 0.515           |
| SC tears         | 5 (1.1%)                   | 2 (2.2%)               | 3 (0.8%)                    | 0.264           |
| CT (all tendons) | 114 (25.2%)                | 32 (35.2%)             | 82 (22.7%)                  | 0.021*          |

No patients with tears of the teres minor tendon.

PTT = partial-thickness tears; FTT = full-thickness tears.

\*  $p < 0.05$ .

joint mobility and 27% had tendinopathy without joint mobility restriction. In their study, it could not be determined whether DM increased the risk of rotator cuff diseases, because no control group was available. Longo *et al.* (2009) reported that the patients with RCTs had normal but higher fasting plasma glucose levels than patients who had meniscal tears. They stated that high fasting plasma glucose level may be a risk factor for RCTs. However, we found no difference between the diabetic and nondiabetic groups with chronic shoulder pain, in terms of the ratio of RCT and CT demonstrated by US examinations after adjusting for age in our study. Our study does not support an association between DM and rotator cuff diseases.

Two important issues should be addressed regarding our study. First, it should still be emphasized that some patients with RCTs are asymptomatic (Milgrom *et al.* 1995; Sher *et al.* 1995). We focused on symptomatic shoulders because they have more clinical significance in practical view. Exploration of our findings to asymptomatic shoulders should be further studied. Second, RCTs are associated with an advanced age, and certain occupations, activities and anatomical variations have been identified (Luopajarvi *et al.* 1979; Soslowsky *et al.* 1994; Rodgers and Crosby 1996; Longo *et al.* 2009). Because the prevalence of RCTs is significantly associated with age (Milgrom *et al.* 1995; Rodgers and Crosby 1996; Schibany *et al.* 2004), it is necessary to control for age in the statistical analysis.

CT has various clinical presentations and is responsible for about 7% of painful shoulder syndromes (Faure and Daculsi 1983; Uhthoff and Loehr 1997). Some authors noted that CT of the shoulder was a usual finding in patients with shoulder stiffness or frozen shoulder (Del Rosso *et al.* 2006). In any case, there are still limited data exploring the relationship between DM and CT. Mavrikakis *et al.* (1991) surveyed standard radiograph films and found that 32% of the diabetic and 10% of the nondiabetic patients had calcific shoulder periarthritis. They concluded that DM and calcific shoulder periarthritis have a close pathogenic interrelation (Mavrikakis *et al.* 1991). Although we found the ratio of CT to SSP tendons in diabetic patients with shoulder pain to be high, the influence of DM was insignificant after controlling for age.

Some literature supports that biochemical and biomechanical factors of the shoulder can be altered in diabetic patients. Increased vascular endothelial growth factor expression and an abnormal angiogenesis process were reportedly involved in subacromial bursa in type II diabetic patients with shoulder contracture and rotator cuff disease (Handa *et al.* 2003). It was also noted that increased joint and soft-tissue stiffness were associated with altered nonenzymatic glycosylation and the cross-link formation of collagen (Bai *et al.* 1992; Naresh and Brodsky 1992; Grant *et al.* 1997; Mentink *et al.* 2002). Although there was no difference between the diabetic and nondiabetic groups in our study in terms of the ratio of RCTs and CT from US findings, the influence

Table 3. Crude and adjusted odds ratios for rotator cuff lesions on ultrasonographic examination of diabetic patients compared with nondiabetic patients

|                  | Crude OR<br>(95% CI) | <i>p</i> -value | Adjusted OR*<br>(95% CI) | <i>p</i> -value |
|------------------|----------------------|-----------------|--------------------------|-----------------|
| SS tears         | 1.05 (0.65~1.70)     | 0.833           | 1.32 (0.79~2.2)          | 0.288           |
| PTT              | 1.08 (0.65~1.80)     | 0.774           | 1.61 (0.63~1.82)         | 0.806           |
| FTT              | 0.96 (0.41~2.26)     | 0.920           | 1.71 (0.69~4.28)         | 0.250           |
| IS tears         | 1.20 (0.46~4.72)     | 0.518           | 1.13 (0.46~1.26)         | 0.288           |
| SC tears         | 2.69 (0.44~16~34)    | 0.264           | 2.44 (0.37~16.25)        | 0.356           |
| CT (all tendons) | 1.85 (1.13~3.04)     | 0.014†          | 1.59 (0.95~2.67)         | 0.08            |

FTT = full-thickness tears; PTT = partial-thickness tears.

\* Adjusted OR was calculated by multivariate logistic regressions (adjusted for age, gender, and side of the affected shoulder).

†  $p < 0.05$ .

of DM in rotator cuff diseases still needs to be further evaluated.

There are some limitations to our study. First, the prevalence of rotator cuff lesions in US findings within the general population with DM cannot be estimated from our study because of the selection bias of our study design. A population-based survey of diabetic patients using US should be conducted to address this issue. Second, this study used a cross-sectional design; from our study, it is difficult to assert the temporal evolution of US findings in diabetic patients with painful shoulder stiffness. It is possible that US findings and shoulder symptoms could vary in different stages of the disease. A prospective, longitudinal study should be undertaken to confirm our findings. Third, direct inspection by arthroscopy or surgery is considered the “gold standard” in diagnosing rotator cuff lesions as described in the literature (Teefey et al. 2000; Fotiadou et al. 2008). However, it is difficult to conduct a large population study with arthroscopy because of the invasiveness of the procedure. The accuracy of US on the shoulder has been well established in some lesions of the shoulder, particularly in RCTs. Therefore, US can serve as a good image modality in an initial examination of the rotator cuff of the shoulder. Finally, we did not analyze whether some other lesions of the rotator cuff as studied with US—such as impingement and tendinopathy—were associated with DM. The criteria and reliability of US findings of these lesions are not well established, although they have been described extensively in clinical US evaluations.

In conclusion, we found no difference between the diabetic and nondiabetic groups of individuals with chronic shoulder stiffness, in terms of the ratio of RCT and CT demonstrated on US examinations after adjusting for age. To our knowledge, this is the first study to explore US findings of rotator cuff among the diabetic and nondiabetic patients with chronic shoulder pain. Further study is advised to confirm our findings.

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