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Diagnostic Accuracy of Clinical Shoulder Tests in Establishing the Etiology of Rotator Cuff Related Shoulder Pain

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Abstract

Background: Clinical testing is essential in establishing the etiology of non-traumatic Rotator Cuff Related Shoulder Pain.

Study aims: To assess the Sensitivity and Specificity of the Painful Arc test, the Neer test, the Hawkins-Kennedy test, the Jobe or Empty Can test and the Cross-Body-Adduction test in different pathologies of non-traumatic Rotator Cuff Related Shoulder Pain such as bursitis, cuff tendinopathy and cuff tear.

Study design: Cross sectional cohort study.

Materials and methods: Fifty-five subjects with shoulder pain for more than 12 weeks without preceding shoulder trauma underwent clinical investigation, diagnostic ultrasound and indirect MRI arthrography scan.

Results: The Sensitivity of the shoulder tests ranges from 50% to 90% in a subacromial bursitis, from 56% to 89% in a cuff tendinopathy and from 56% to 72% in a cuff tear. The Specificity of the shoulder tests ranges from 18% to 44% in a subacromial bursitis, from 25% to 46% in a cuff tendinopathy and from 14% to 46% in a cuff tear.

Conclusion: The diagnostic accuracy of these five clinical tests is limited for distinguishing bursitis, cuff tendinopathy and cuff tear as etiology of non-traumatic Rotator Cuff Related Shoulder Pain. Optimal diagnosis requires integration of the patient history, the physical examination and the findings of radiological imaging.

Keywords: Clinical shoulder testing, Non traumatic cuff pathology, Validity, Sensitivity, Specificity, Accuracy

Introduction

Shoulder pain is one of the most common musculoskeletal concerns driving patients to seek medical advice [1,2]. Up to 70% are accounted for by disease of the rotator cuff. Rotator Cuff Related Shoulder Pain (RCRSP) is common, affecting 40% of the population over the age of 60 [3–5]. The tendons of the M. Supraspinatus, M. Infraspinatus, M. Teres minor and M. Subscapularis muscles fuse to form the rotator cuff tendon, which covers the humeral head and functions to produce movement, stability and sensorimotor control at the glenohumeral joint. Charles Neer introduced in 1972 the label "Subacromial Impingement Syndrome" (SIS) [6,7]. Since about 2010 there has been criticism on the veracity and the usefulness of this label [8–10]. It is now generally accepted that SIS is a syndrome and covers a lot of different etiologies of shoulder pain. As the current evidence indicates that the impingement theory has become antiquated, the term SIS must be abandoned as it refers to a mechanical theory [11]. The term Rotator Cuff Related Shoulder Pain (RCRSP) has gained universal acceptance [12,13]. The three recognized pathologies in RCRSP are subacromial bursitis, cuff tendinopathy and partial or full thickness cuff tears. For each of these disorders evidence-based treatments such as physiotherapy, high-energy extracorporeal shock-wave, injections with corticosteroids, platelet rich plasma

or hyaluronic acid, needling and lavage and chirurgical approaches are available [14–17]. Because the management of shoulder pain differs, accurate diagnosis of the underlying etiology is important to guide further decision making toward the most appropriate and effective form of management for these patients. Clinical testing requires not much time and no apparatus is needed. Physical examination of the shoulder can be relatively easily learned and applied. There exists a number of studies on the validity of shoulder tests to assess the presence of SIS but studies on the validity of shoulder testing assessing a subacromial bursitis, a cuff tendinopathy or a cuff tear are rare. There is still great uncertainty about the value of these physical tests in the assessment of rotator cuff pathology because many tests lack acceptable levels of sensitivity (Se) and specificity (Sp) to assess clinically the status of the rotator cuff with confidence [18–20]. The aim of this investigation was to determine the validity of the Painful Arc test, the Neer test, the Hawkins-Kennedy test, the Jobe or Empty Can test and the Cross Body Adduction test in diagnosing subacromial bursitis, cuff tendinopathy and cuff tear. Diagnostic accuracy studies are like other clinical studies at risk of bias due to shortcomings in design and conduct. To ensure the trustworthiness and applicability of the study the STARD statement (Standards for Reporting of Diagnostic Accuracy Studies) was applied. The STARD is a checklist to ensure that a report of a diagnostic accuracy study contains the necessary information [21]. Diagnostic accuracy studies must describe the study population, the participant recruitment, the participant sampling and the data collection. They also must describe the reference standard, the expertise of the people executing the tests, the blinding to the results and the statistical methods used.

Materials and Methods

Ethical concerns

Ethical approval was obtained and all stages of the study were approved by the institutional medical ethics review boards before commencing the study. Subjects were informed of their rights including the right to withdraw from the investigation at any stage without providing an explanation and all signed an informed consent form.

Selection of study participants and demographics of the cohort

Subjects with non-traumatic shoulder pain referred to one clinician in a physical medicine and rehabilitation department of a university hospital were recruited for this investigation. The inclusion criteria for the eligible subjects were non-traumatic shoulder pain for at least 12 weeks, full active and passive movement of the involved shoulder and age over 18 years. Exclusion criteria were previous surgery on the shoulder, shoulder pain caused by rheumatic disease, pain catastrophizing or any symptoms of neurologic origin. Careful history and neurological examination excluded patients with neurologic, neuromuscular and systemic diseases. The final group patients recruited for the study was composed of 55 patients. There were 37 men (67%) and 18 women (33%). The mean age of the total cohort was 48.4 y (21y to 69y). The symptomatic shoulder was 30 times (55%) the right shoulder and 25 times (45%) the left shoulder. Depending on the Ultrasound (US) and the Magnetic Resonance Arthrography (MRA) findings the cohort was divided into three groups according to solely the presence of subacromial bursitis, cuff tendinopathy or cuff partial or full-thickness tear as well on the US and the MRA examination. Ten subjects presented with the diagnosis of a subacromial bursitis, 27 subjects with a cuff tendinopathy and 18 with a cuff tear.

Investigators

The clinical investigator is a specialist in physical and rehabilitation medicine with more than 30 years of experience in musculoskeletal practice and a special interest in shoulder pathology. The US and MRA imaging were performed in the same university hospital radiology service on the same day and read by two musculoskeletal radiologists holding a PhD degree with a large experience, the first in US and the latter in MRA. The ultra sonographer and the MRA specialist were blinded to each other's results, and the clinician was blinded to the imaging results.

Procedure

Potential participants who met the inclusion criteria and did not fulfill the exclusion criteria were invited to consider participation in the investigation. Those who agreed completed informed consent documentation before participation. At this stage demographic data including age, duration of symptoms, occupation and hobbies and dominant shoulder were collected for each participant by the clinical investigator. History also noted the onset, the baseline pain, and the activities worsening the symptoms.

Clinical tests

The clinical investigator performed the following five clinical tests on both shoulders. Each test was performed standing and repeated twice. Test one: The Painful Arc test. With the patient standing the shoulder is abducted in the scapular plane. While abducting the arm the patient must tell when he experiences pain. The test is considered to be positive if the patient experiences pain between 60 and 120 degrees of abduction and pain is reduced once past 120 degrees of abduction [22]. Test two: The Neer impingement test or Neer test. The Neer impingement sign was performed with the patient standing. The scapula was stabilized by the

examiner, and the arm was forward flexed until the patient reported pain or full elevation was reached [23]. Test three: The Jobe test or Empty Can Test. The patient abducts his arm actively to 90 degrees in the scapular plane. The shoulder is internally rotated so that the thumb is in a downward position. The examiner applies a downward pressure to the abducted arm. The test is considered positive if pain occurs while withstanding the pressure [24]. Test four: The Hawkins -Kennedy test. The examiner places the patient's shoulder in 90 degrees of flexion with the elbow flexed to 90 degrees and then internally rotates the arm. The test is considered positive if the patients experiences pain during the internal rotation [25]. Test five: The Cross Body Adduction test. With the arm in 90 degrees of forward elevation and the elbow flexed in 90 degrees the patient horizontally adducts the arm resting the hand on the opposite shoulder. The examiner pushes the arm in further cross. The test is considered positive if pain occurs around the shoulder [26].

Diagnostic ultrasound (US)

US was performed on the affected and nonaffected shoulder using a 7–9 MHz array transducer. The time between the clinical tests and the ultrasound examination was never longer than 7 days. A single radiologist with years of experience in US of the shoulder and holding a PhD degree performed all US examinations. This eliminated the risk of misinterpretation due to inter observer variation. Each component of the rotator cuff was examined using the EURO-MUSCULUS / USPRM protocols for the shoulder [27]. Subacromial bursitis was defined as focal or diffuse bursal thickening of more than 2 mm transverse thickness with associated hypo echogenicity with or without bursal fluid. Tendinopathy was defined as tendon thickening associated with abnormal echogenicity of the normal fibrillar echotexture. A cuff tear was defined as a discontinuity of the tendon fibers resulting at the articular or bursal surface appearing as a hypoechogenic or anechoic defect.

Magnetic Resonance Artrography (MRA)

In this study the non-traumatic origin of the pain was an important issue and people with labral lesions were excluded. Contrast MRA was performed because different studies have reported sensitivities and specificities of over 90% in detecting labral lesions by MRA [28–31]. Indirect arthrography is a less invasive technique than the direct arthrography and has the great advantage of better patient compliance, a superior safety profile and is logistically preferred in a radiology service [32,33]. The indirect MRA was performed with a large shoulder coil with the arm by the side in neutral position. A single radiologist with years of experience in MRA of the shoulder and holding a PhD degree performed all examinations. This reduces the possibility of misinterpretation and the bias following interobserver variation. Subacromial bursitis was characterized by the presence of fluid signal hyperintensity and subacromial bursal enhancement. Tendinopathy was characterized by localized increased signal intensity within the tendon and swelling of the tendon on T2 weighted images. A partial-thickness tear was defined by incomplete tendon discontinuity at the bursal or articular surface of the cuff. A full thickness tearing was defined by observed complete tendon discontinuity.

Reference standard of the study

Although arthroscopy is mostly considered as the criterion standard in evaluating clinical tests of the shoulder there are methodologic issues that may confound the results of research using this procedure as a reference test. First of all, for ethical concerns it is not appropriate to examine shoulders using an invasive reference test and secondly there is the lack of blinding of the examiner because surgeons are likely aware of the clinical and the imaging results. Multiple studies focused on the assessment of the diagnostic value of MRA, MRI and US in the different structural abnormalities of the cuff and the subacromial bursa. Zhang *et al.* reported that US has a Se of 93% and a Sp of 75% in diagnosing rotator cuff tears [34]. A meta-analysis on US assessed a Se of 60% to 93% and a Sp from 80% to 100% in diagnosing tendinopathies [35]. In another study US had a Se of 91% and a Sp of 85% in partial and a Se of 94% and a Sp of 92% in full cuff tears [36]. A recent review on the use of US in shoulder complaints assesses a Se of 89% and a Sp of 73% in partial tears and a Se of 88% and a Sp of 93% in complete tears [37]. A Cochrane database systematic review on MRI reports a Se of 94% and a Sp 93% for full cuff tears [36]. A review on the diagnostic accuracy of MRI for bursal-sided partial-thickness cuff tears showed a Se of 77% and a Sp of 96% [38]. Data have indicated that MRA is more sensitive and specific than MRI for the detection of partial and full thickness tears. Additionally, MRA is also the most accurate procedure for detecting labral lesions [39]. This synthesis of the research literature proves the good diagnostic accuracy of US and MRA for evaluating the etiology of RCRSP. The radiological findings of the US and the MRA examination were used as the golden standard in our study. Patients were only included in a category of disabilities such as bursitis, cuff tendinopathy or cuff tear when the US and the MRA came to the same pathological findings.

Sample size estimation

This study was designed as a preliminary investigation to evaluate the potential and gather information for conducting a larger study in the future. As such, no formal sample size calculation was performed.

Statistical analysis

For each test we measured diagnostic performance. The ability of the five tests to differentiate between the three

diagnoses is assessed by their Se and Sp. Se and Sp are essential indicators of test accuracy and allow clinicians to determine the appropriateness of the diagnostic test. For each test and each diagnosis, Se and Sp are reported in percentage together with 95% confidence intervals. Positive Predictive Value (PPV), Negative Predictive Value (NPV) and Accuracy (Acc) were not determined as these values are impacted by disease prevalence.

Results

The results for the clinical tests are in case of a bursitis: the Painful Arc test (PA) has a Se of 80% and a Sp of 18%, the Neer test (NT) has a Se of 60% and a Sp of 40%, the Empty-Can test (EC) has a Se of 50% and a Sp of 44%, the Hawkins-Kennedy test (HK) has a Se of 90% and a Sp of 31% and the Cross Body Adduction test (CBA) has a Se of 50% and a Sp of 40%. In case of a cuff tendinopathy: the PA has a Se of 89% and a Sp of 25%, the NT has a Se of 59% and a Sp of 39%, the EC has a Se of 56% and a Sp of 46%, the HK has a Se of 70% and a Sp of 25% and the CBA has a Se of 56% and a Sp of 39%. In case of a cuff tear: the PA has a Se of 72% and a Sp of 14%, the NT has a Se of 61% and a Sp of 41%, the EC has a Se of 56% and a Sp of 46%, the HK has a Se of 67% and a Sp of 24% and the CBA has a Se of 67% and a Sp of 46%. We were not able to identify a clinical test that showed both a high sensitivity and a high specificity. As such no single physical test appears to accurately diagnose a bursitis, a cuff tendinopathy or a cuff tear (See **Table 1** the results for the Se and the Sp).

Literature review

The literature regarding the reliability and the validity of clinical shoulder testing was reviewed. In several expert reviews on physical examination maneuvers, clinical tests are described to assist in diagnosing the etiology of shoulder pain, but most of these studies assess the results addressing shoulder pain as SIS but not as bursitis, cuff tendinopathy or cuff tear [18–20]. Literature on the latter subject emerges only from 2013 on when the syndrome SIS was replaced by the term RCRSP. These studies are relatively sparse and most of them are not conducted following the STARD checklist for accuracy studies [21]. Most of the studies are not describing in a sufficient matter the studied population, the participant sampling, the data collection, the reference standard, the expertise of the people executing the tests, the blinding to the results and the statistical methods used. This means that the results of these studies can be subject to criticism. We refer to **Table 2** to **Table 7** in the **appendix** for the different publications on the validity of these five tests in diagnosing a bursitis, a cuff tendinopathy or a cuff tear. Only one publication on the validity of these tests for the diagnosis bursitis was retained [40]. The Se varies depending of the test from min 25% to max 86% and the Sp varies from min 45% to max 80%. Three publications were retained for the diagnosis tendinopathy [41–43]. The Se varies depending of the test from min 38% to max 87% and the Sp varies from min 18% to max 61%. Nine studies were retained for the diagnosis cuff tear [40,43–50]. The Se varies depending on the test from min 52% to max 97% and the Sp varies from min 43% to max 83%.

The retrieved publications show varying degrees of validity. Population differences, methodological concerns and lack of investigation of comprehensive clinical examination variables in these studies make it very difficult to compare the results. Most studies present a moderate high Se but a low Sp giving little evidence regarding the reliability and the validity of physical examinations. The results of the literature review are matching the results of our study.

Discussion

The aim of the study was to evaluate reliability and the validity of physical evaluation of the shoulder with the use of five specific shoulder tests by determining their Se and Sp. Our results and the results of the literature review show for most of the tests a moderate strong and acceptable level of Se but a weak Sp. This unacceptable level of Sp causes great uncertainty about the value of these tests in assessing the status of the rotator cuff. No single physical test appears to diagnose accurately a bursitis, a cuff tendinopathy or a cuff tear. This study proves that clinical testing only has minimal

Table 1. Results (in %) of this study for the clinical tests.

Results in %		PA	NT	EC	HK	CBA
Bursitis	Se	80	60	50	90	50
	Sp	18	40	44	31	40
Tendinopathy	Se	89	59	56	70	56
	Sp	25	39	46	25	39
Cuff Tear	Se	72	61	56	67	67
	Sp	14	41	46	24	46

PA: Painful Arc test; NT: Neer Test; EC: Empty-Can; HK: Hawkins-Kennedy; CBA: Cross Body Adduction

diagnostic value for the diagnosis of the different etiologies of RCRSP. Clinicians should not assume that they can confidently rule in the presence of subacromial bursitis, cuff tendinopathy or cuff tear using one of these tests. For more appropriate patient assessment and management, future research needs to address these issues. This is a feasibility study and without doubt a larger sample size will give greater confidence in the interpretation of the results. This could also be the case in combining the results of the different tests. Till new insights in this matter are reached, the etiology of the pain in RCRSP can only be revealed from the combined data of the questioning, the clinical investigation and the radiological investigations. Clinical testing will always keep its interest as a tool to differentiate real shoulder problems from referred pain and contribute to an understanding of the presentation of non-traumatic subacromial pathology. As many reported clinical outcomes are still based on physical testing, the five tests will provide evidence on the effectiveness of a treatment.

Strengths and limitations

In other studies, on the same subject the extreme diversity in the performance and interpretation of the tests hindered synthesis of the evidence and clinical applicability of the findings. This is not the case in this study where only five well described tests are investigated. In addition, few studies addressed the issue of between-rater agreement which is fundamental to the validity of clinical tests and radiographic examinations. In our investigation all clinical and radiological tests were executed and interpreted by the same investigators with years of experience. We acknowledge that as limitation of the study there was only one examiner for the clinical tests and the radiographic examination and therefore the inter-tester reliability is not known. Many studies also lack the necessary imaging, leading to a weak reference standard. By examining each affected shoulder with US and MRA we were excluding any posttraumatic pathology and absolutely sure about the underlying etiology. Most studies report on the validity of clinical testing in subjects with SIS but our investigation is one of few where three different etiologies of RCRSP are clearly set. Data generated by testing must be cautiously handled taking into account the possible impact of discomfort or pain during testing and the rather small study population certainly the subjects with bursitis are surely limitations of the study. Shoulder pain provocation tests do not provide diagnostic accuracy on the source of the pain which could be possible from other sources than the shoulder, so this could be another limitation of this study.

Conclusions

This study demonstrates that clinical testing has only moderate diagnostic value in identifying the different etiologies of RCRSP. Clinicians should not assume that subacromial bursitis, cuff tendinopathy, or cuff tear can be confidently ruled in using a single test. Future research should address these limitations to improve patient assessment and management. A larger sample size will undoubtedly increase confidence in interpreting the results and combining multiple tests can also strengthen the diagnostic value. Until new evidence emerges, the etiology of RCRSP should be determined through a combination of patient history, clinical examination, and radiological investigations. Clinical testing will, however, remain valuable for differentiating true shoulder pathology from referred pain and for providing outcome measures in clinical rating scales.

Author Contributions

Peter Verspeelt contributed to the manuscript's conception, performance of work, interpretation and analysis of data, and preparation. Peter Verspeelt participated in the design of the study, carried out the tests and the analysis, did the interpretation of the data and drafted the manuscript. Martine De Muynck, Guy Vanderstraeten, Astrid Vermeersch, and Gaetane Stassijns contributed to the revision for important intellectual content and supervision of the manuscript.

Ethical Considerations

Commission for medical ethics, University Hospital Ghent (approval number PA2012/007).

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Competing Interests

The authors have no conflicts to report.

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