



Empty can and drop arm tests for cuff rupture : Improved specificity after subacromial injection

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Shoulder disorders are common in the general population : they occur in about 25 of every 1000 patients per year. A rather large majority are caused by cuff disorders. Differentiating between impingement and cuff rupture is essential to adequate treatment. Clinical tests have been developed, but their accuracy is limited. This study was performed to improve clinical accuracy by combining single tests and adding a subacromial injection. We postulated that the empty can and drop arm tests would result in higher sensitivity and specificity after subacromial injection.

Method : We prospectively assessed 49 patients with the empty can and drop arm tests and used ultrasound to compare the individual and combined results.

Results : The ultrasound found six cuff ruptures. Specificity improved and sensitivity decreased after subacromial injection.

Conclusions : Only specificity improved after subacromial injection. Combining the test results led to an increase in both sensitivity and specificity without injection.

Keywords : subacromial impingement ; diagnostic accuracy study design ; rotator cuff ; empty can test ; drop arm test ; sensitivity ; specificity.

INTRODUCTION

Shoulder disorders are frequently encountered in general practice : the reported incidence rates of

new episodes of shoulder disorders in general practice range from 12 to 25 per 1000 patients per year (42). The cumulative incidence of shoulder disorders in the general population in the Netherlands has been estimated at 11.2 per 1000 patients per year (95% CI 10.1-12.3) (43). Shoulder disorders involve pain in the upper arm and deltoid region accompanied by stiffness. Pain and stiffness limit a person's ability to perform normal daily activities (41).

The majority of patients have a painful arc : pain within a specific range (usually between 90 and 140 degrees) of shoulder abduction. This painful

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arc originates from cuff impingement, which is supposedly caused by an inflammatory reaction. A sustained inflammatory reaction can lead to effusion and occasionally calcification in the subacromial space (35). Long-lasting impingement causes cuff degeneration and cuff rupture, for which surgical treatment is needed (12).

Subacromial impingement is a common cause of shoulder disorders, but differentiating between impingement and cuff rupture is essential to adequate treatment. Without differentiation, the number of missed or misdiagnosed cuff ruptures will increase. This may lead to more extensive cuff ruptures, making complex surgical interventions necessary (23). With large and degenerative cuff ruptures, the chance of complete recovery after surgery is small (7,13,22).

Traditional physical examination is insufficient for making a valid and reproducible differentiation of the causes and sources of shoulder disorders (11). Recent reviews of physical tests for shoulder impingement advocate the use of multiple tests for diagnosing pathological shoulder disorders (2,14).

A number of clinical tests have been developed to prove and exclude rotator cuff tears. However, the evidence for their diagnostic accuracy is very limited. Estimates of sensitivity and specificity are based on research in specialised care settings and have large confidence intervals. The tests are generally compared to arthrography, findings during surgery or subacromial infiltration (8,24,29). Available clinical tests for assessing rotator cuff ruptures are based on an assessment of muscular strength and an assessment of pain. The accompanying pain might influence muscular strength and mask a cuff rupture.

The current interpretation of tests is not adjusted for the influence of pain. We conducted this study to examine the effect of pain on individual shoulder tests. In accordance with the STARD (STandards for Reporting of Diagnostic Accuracy) initiative, the clinical tests under study will be referred to as index tests and ultrasound will be referred to as the reference test (4,6,5,31,36,37).

The majority of patients suffering from shoulder disorders are seen and treated by their general practitioners or orthopaedic surgeons. Given the limited

value of the currently used individual shoulder tests, there is a need for tests that can differentiate between impingement and cuff rupture and that are suitable for use in both primary and secondary health care.

The available clinical tests designed to detect cuff ruptures have limited accuracy. This study will assess the accuracy of the empty can and drop arm tests before and after subacromial injection to differentiate between the presence and absence of cuff ruptures in patients with shoulder disorders. The effect of the subacromial injection and the results of the clinical tests will be compared, individually and together, with ultrasound (i.e. the reference test). We postulate that the empty can and drop arm tests for cuff rupture will be more sensitive and specific after the administration of an anaesthetic than before injection.

PATIENTS AND METHODS

This study was approved by the Medical Ethics Review Committee of our hospital and was performed at the outpatient clinic of our orthopaedic surgery department. Data were prospectively collected from consecutive patients diagnosed with subacromial impingement, referred by their general practitioners. Based on histories and regular physical examinations, the diagnosis was confirmed and patients were treated according to standard conservative treatment: administration of a subacromial corticosteroid injection.

Patients were eligible for this study if they were 18 years of age or older, had consulted an orthopaedic surgeon for pain in their shoulder and had a painful arc (painful movement between 90 and 140 degrees of abduction). Patients were excluded if they exhibited clinical signs of instability, or if a frozen shoulder or a cervical radicular syndrome were the suspected or definite cause of their shoulder disorders.

This was a cohort diagnostic accuracy study. All clinical tests, including the subacromial injection, were performed during intake at the outpatient clinic. The reference test (i.e. ultrasound) was performed within two weeks after intake.

Reference Test

Ultrasound was used as the reference test for detection of cuff ruptures because it can detect both full and partial

thickness ruptures. Sensitivity and specificity for the assessment of partial thickness ruptures were 0.84 and 0.89, respectively. For detection of full thickness rotator cuff tears, sensitivity was 0.96 and specificity was 0.93 (3,9,15-17,20,21,25-27,30,33,38-40,44).

All the ultrasound diagnostics for this study were performed by two radiologists who are specialised in musculoskeletal radiology. They are highly trained and experienced in using ultrasound to diagnose shoulder disorders.

The result of the ultrasound was noted as either positive or negative for cuff rupture. If it was positive, the type of rupture was described as either full or partial thickness with the size given in centimetres.

Empty Can Test (Jobe Test)

This test is used to determine the presence of weakness in the supraspinatus muscle due to cuff rupture or pain (in the case of tendonitis). During this test, the patient is either standing or sitting in an upright position. The shoulder is fully internally rotated to 90 degrees of abduction and 30 degrees of ante flexion. The patient is instructed to resist the downward pressure exerted by the examiner.

The results of this test are positive if there is limited function (i.e. the patient is unable to withstand the applied resistance) or negative if there is good function (19). For this test, a mean pooled sensitivity of 69% and a mean pooled specificity of 62% have been reported (1).

Drop Arm Test (Codman's Sign)

After maximal passive abduction, the patient is asked to actively lower the arm in the frontal plane. Based on muscle weakness, pain or cuff rupture, the arm will drop. The test results are positive if the arm drops while it is being lowered and negative if there is good function (10). For this test, a mean pooled sensitivity of 21% and a mean pooled specificity of 92% have been reported (1).

Neer Test

The Neer test is performed with the patient in an upright sitting position and both arms hanging down. The arm is passively elevated in ante flexion while the ipsilateral scapula is fixed to prevent movement. The occurrence of pain during this ante flexion movement is a painful arc. The test is performed again approximately a quarter of an hour after 10 ml of lidocaine 1% has been

injected in the subacromial bursa. When there is no more pain during the passive elevation, the Neer test results are positive (28).

During the injection, the patient is seated in an upright position with zero degrees of abduction. Just medio caudal of the dorsal lateral acromial edge, a soft spot can be palpated (i.e. the posterior of the greater tubercle): this is the injection site. It is marked with the back of a cotton bud and disinfected with iodine in alcohol or, in case of a known iodine allergy, with a chlorhexidine 0.5% solution. The injection is then made at the marked spot (34). The injections used in this study consisted of 2 ml Triamcinolone acetonidum 10 mg/ml (2 ml) and lidocaine 1% (8 ml) and were used both diagnostically and therapeutically.

Combination of Tests

The empty can and drop arm tests are part of the regular physical examination to detect cuff ruptures in cases of subacromial impingement. Since the drop arm test generally causes more pain, the empty can test was performed first. They were performed individually before and after subacromial injection. The results were then analysed for the individual tests and the combined tests. The test results were documented as either positive or negative.

During the consultation for shoulder disorders, an orthopaedic surgeon (first author) took the regular history and performed the physical examination. The orthopaedic surgeon was well trained and experienced in taking histories and performing physical examinations related to shoulder disorders. All the patients were examined and injected by the same orthopaedic surgeon.

The results of the tests under study were compared with the reference test (ultrasound). Based on these comparisons, we constructed 2×2 tables and calculated the sensitivity and specificity of testing and the 95% confidence intervals. We also calculated the derived positive predictive value, the negative predictive value, overall accuracy, pre-test probability, pre-test odds, likelihood ratio, post-test odds and post-test probability.

For the analysis of the combined test results before and after injection, we used a rule for parallel testing. This means that in order to obtain a positive test result for the combination of tests, either the drop arm test or the empty can test had to have a positive result. In serial testing, the result would be positive when both tests had positive results. After applying this rule of parallel testing, we constructed new 2×2 tables to calculate sensitivity and specificity.

Table I. — Demographic Data

Participants (n = 49)	
Sex	41% male / 59% female
Age	mean = 56.5 years ; range = 26-80 years
Affected side	41% left / 59% right
Dominant side	10% left / 90% right
Trauma	22% yes / 78% no

RESULTS

We originally enrolled 50 patients in this study. One patient was not assessed by ultrasound and thus

excluded. The final study group consisted of 49 patients, 20 male and 29 female, with a mean age of 56.6 years (range 26-80 years). Most patients were affected on the right-hand side (n = 29). Eleven patients had suffered a shoulder trauma that was considered to be the cause of their complaints (Table I).

Ultrasound performed on the patients found six rotator cuff ruptures : five full thickness ruptures and one partial thickness rupture (Figs. 1 and 2). All the ruptures were located in the supraspinatus tendon. The size of the full thickness ruptures ranged from 1.0-2.5 cm. The partial thickness rupture was 0.8 cm in size.

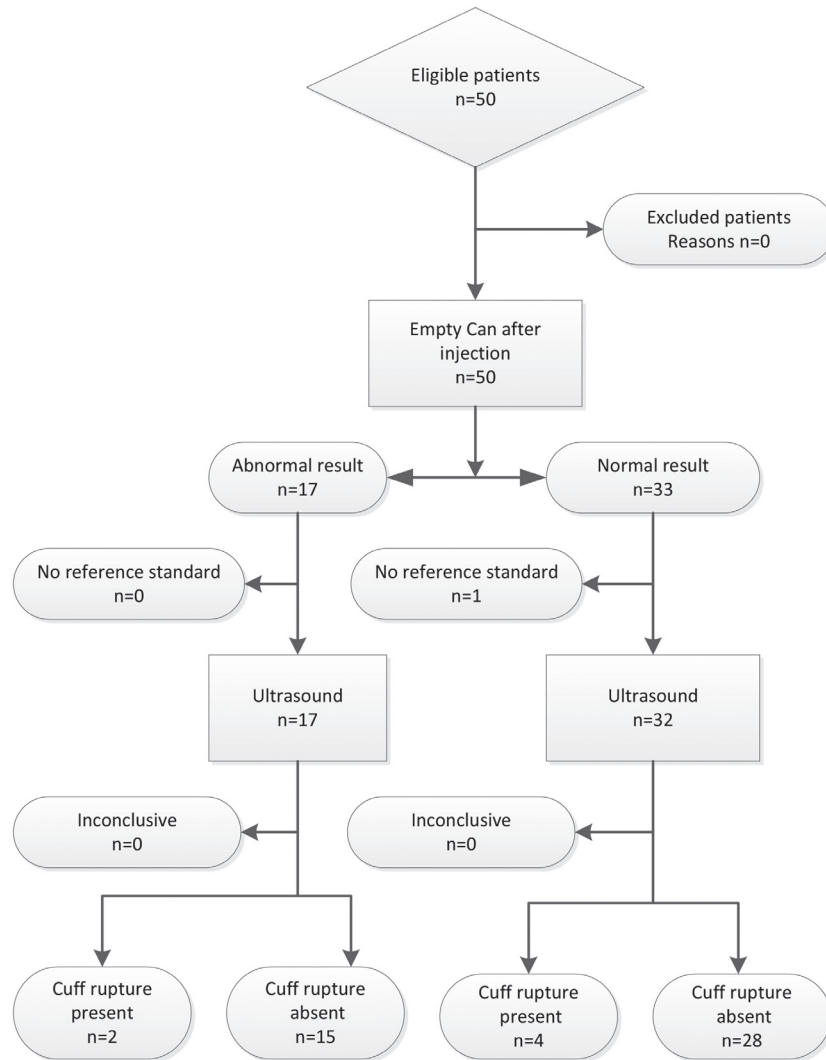


Fig. 1. - STARD Flowchart for the Empty Can Test

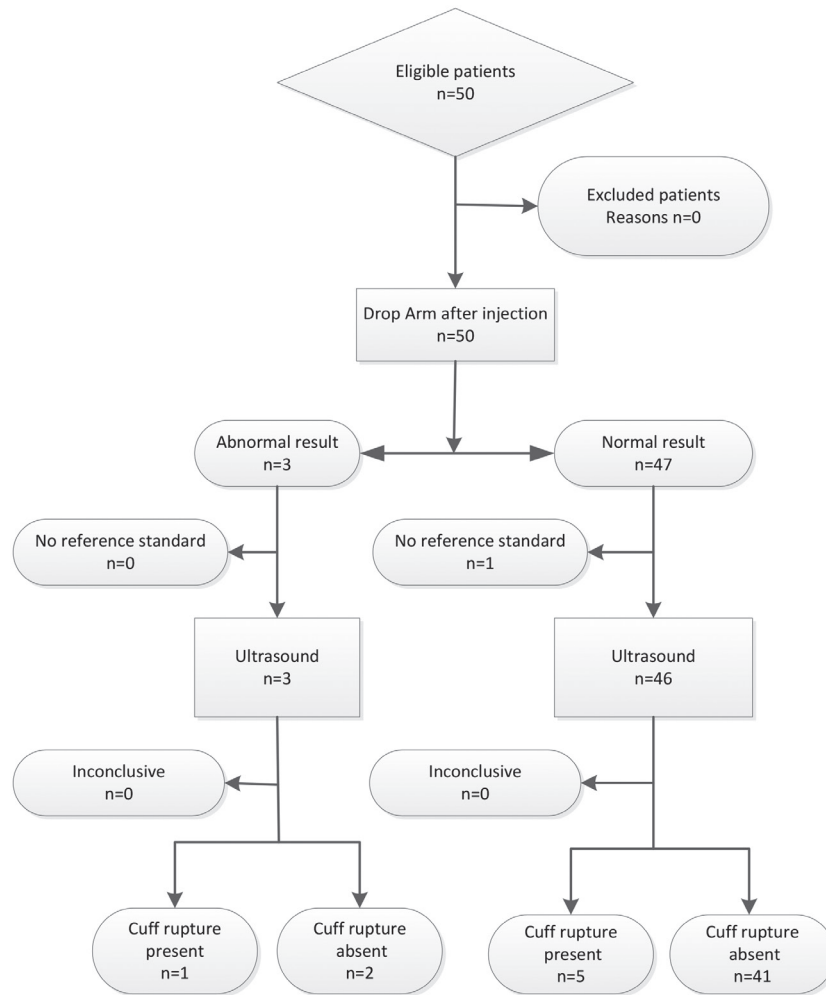


Fig. 2. - STARD Flowchart for the Drop Arm Test

Empty Can Test

The results were dramatically different before and after injection. Before injection, the test results were positive for 65% of the patients ($n = 32$) and negative for 35% ($n = 17$). The test showed a sensitivity of 67% (95% CI 0.3-0.90) and a specificity of 35% (95% CI 0.22-0.49 ; $LR+ = 1$; $LR- = .95$). After injection, the results of the empty can test switched : it was positive for 35% of the patients ($n = 17$) and negative for 65% ($n = 32$). It showed a sensitivity of 33% (95% CI 0.09-0.70) and a specificity of 67% (95% CI 0.52-0.79 ; $LR+ = 1$; $LR- = 1$) after injection.

Drop Arm Test

Patients also performed better on the drop arm test after injection. Before injection, the test results were positive for 12% of the patients ($n = 6$) and negative for 88% ($n = 43$). The test showed a sensitivity of 17% (95% CI 0.03-0.56) and a specificity of 88% (95% CI 0.75-0.94 ; $LR+ = 1.4$; $LR- = 0.94$). After injection, the test results were positive for 6% of the patients ($n = 3$) and negative for 94% ($n = 46$). The sensitivity remained 17% (95% CI 0.03-0.56) with a specificity of 95% (95% CI 0.84-0.98 ; $LR+ = 3.58$; $LR- = 0.87$).

Table II. — Results

Test	Positive	Negative
Neer test	34	15
Empty can test before injection	32	17
after injection	16	33
Drop arm test before injection	6	43
after injection	3	46
Cuff rupture on ultrasound	6	43

Neer Test

After injection, 69% (n = 34) of patients tested positive.

Combined Results

Combining the results of the empty can and drop arm tests, we found a sensitivity of 72% before injection and 44% after injection. We found a specificity of 92% before injection and 98% after injection (Table III).

DISCUSSION

The empty can test had an intermediate sensitivity of 67% and a low specificity of 35% compared to the reference test without anaesthesia. In contrast, for cuff ruptures, the drop arm test had a low sensitivity of 17% and a high specificity of 88% (LR+ = 1.4 ; LR- = +0.94) compared to the reference test without anaesthesia. When the tests were performed after administering anaesthesia, the specificity of testing improved for both tests. In contrast to our hypothesis, only specificity improved after injection.

Some of our results and techniques were different than those of other studies. Several other studies have used different techniques for detecting rotator cuff tears : arthrography, findings during surgery or magnetic resonance imaging (25-27,32,33,40). Compared to results in the literature, we found that the empty can test resulted in rather low sensitivity and specificity (1,18). This might be due to the small number of cuff ruptures in our population. When we compared specificity, we found that the numbers were equal to those in the literature for the drop arm test (8). The combination of the empty can and drop

Table III. — Overall Calculated Results

	Empty Can Test		Drop Arm Test		Combined Tests	
	Before injection	After injection	Before injection	After injection	Before injection	After injection
Sensitivity (95% CI)	67% (.23 - .94)	33% (.05 - .80)	17% (.03 - .63)	17% (.03 - .63)	67% (.23 - .95)	33% (.05 - .77)
Specificity (95% CI)	34% (.21 - .50)	67% (.51 - .81)	88% (.75 - .97)	95% (.80 - .99)	33% (.19 - .49)	65% (.49 - .79)
Predictive value						
Positive	13%	13%	17%	33%	12%	12%
Negative	12%	12%	12%	11%	88%	88%
Overall accuracy	8%	63%	80%	86%	8%	4%
Probability						
Pre-test	12%	12%	12%	12%	12%	12%
Post-test	13%	13%	17%	33%	12%	12%
Odds						
Pre-test	.14	.14	.14	.14	.14	.14
Post-test	.14	.14	.20	.50	.14	.13
Likelihood ratio	1	1	1.4	3.5	.98	.95

arm tests showed that, in contrast to the individual test results, sensitivity and specificity increased before injection. After injection, the specificity improved even more, although there was a decrease in sensitivity. These results stress the importance of combining different tests when making physical examinations of shoulder disorders, as other researchers also concluded (2,14).

CONCLUSIONS

We found relatively low to intermediate sensitivity and specificity levels for the empty can and drop arm tests. Administration of an anaesthetic and repeated performance of the tests improved the specificity of testing, but decreased the sensitivity. When the tests were combined, we found higher sensitivity and specificity levels before injection and higher specificity after injection.

Competing Interests

The authors declare that they have no competing interests.

Authors' Contributions

Authors 1, 2, 3 and 5 participated in the design of the study. Authors 1 and 4 collected the data and Author 1 analysed it. All the authors participated in the writing of the manuscript and read and approved the final version.

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