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A practical, evidence-based, comprehensive (PEC) physical examination for diagnosing pathology of the long head of the biceps

Samuel Rosas, MS[a], **Michael K. Krill, BS, ATC**[b,c], **Kelms Amoo-Achampong, BA**[d], **KiHyun Kwon, MS**[e], **Benedict U. Nwachukwu, MD, MBA**[f], and **Frank McCormick, MD**[g,h,*]

[a]Department of Orthopedic Surgery, Baptist Health, Wake Forest University, Winston-Salem, NC, USA

[b]Florida Atlantic University Charles E. Schmidt College of Medicine, Boca Raton, FL, USA

[c]Jameson Crane Sports Medicine Institute, The Ohio State University Wexner Medical Center, Columbus, OH, USA

[d]Icahn School of Medicine at Mount Sinai, New York, NY, USA

[e]Florida International University Herbert Wertheim College of Medicine, Miami, FL, USA

[f]Department of Orthopedic Surgery, Hospital for Special Surgery, New York, NY, USA

[g]Department of Orthopedics, Beth Israel Deaconess Medical Center, Harvard Medical School, Boston, MA, USA

[h]Department of Sports Medicine, Beth Israel Deaconess Medical Center, Harvard Medical School, Boston, MA, USA

Abstract

Background: Clinical examination of the shoulder joint has gained attention as clinicians aim to use an evidence-based examination of the biceps tendon, with the desire for a proper diagnosis while minimizing costly imaging procedures. The purpose of this study is to create a decision tree analysis that enables the development of a clinical algorithm for diagnosing long head of biceps (LHB) pathology.

Methods: A literature review of Level I and II diagnostic studies was conducted to extract characteristics of clinical tests for LHB pathology through a systematic review of PubMed, Medline, Ovid, and Cochrane Review databases. Tests were combined in series and parallel to determine sensitivities and specificities, and positive and negative likelihood ratios were determined for each combination using a subjective pretest probability. The “gold standard” for diagnosis in all included studies was arthroscopy or arthrotomy.

[*]Reprint requests: Frank McCormick, MD, 330 Brookline Ave., Boston, MA02215, USA. drfrankmccormick@yahoo.com.

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Results: The optimal testing modality was use of the uppercut test combined with the tenderness to palpation of the biceps tendon test. This combination achieved a sensitivity of 88.4% when performed in parallel and a specificity of 93.8% when performed in series. These tests used in combination optimize post-test probability accuracy greater than any single individual test.

Conclusion: Performing the uppercut test and biceps groove tenderness to palpation test together has the highest sensitivity and specificity of known physical examinations maneuvers to aid in the diagnosis of LHB pathology compared with diagnostic arthroscopy (practical, evidence-based, comprehensive examination). A decision tree analysis aides in the practical, evidence-based, comprehensive examination diagnostic accuracy post-testing based on the ordinal scale pretest probability.

Level of evidence: Level II, Systematic Review

Keywords

Biceps tendon; long head; physical examination; pathology; diagnosis; shoulder examination

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The physical examination is a requisite and inexpensive component to medical diagnosis. The shoulder examination, in particular, encompasses a myriad of special provocative maneuvers, displaying a wide range of sensitivities and specificities pertaining to diagnostic accuracy. Accurate understanding from the correct sequence of maneuvers or tests increases diagnostic yield.

Clinical diagnosis in the modern era heavily relies on imaging modalities including ultrasound, magnetic resonance imaging (MRI), computed tomography (CT), arthrography, and arthroscopy to diagnose shoulder pathology.[21,33] Current “gold standard” diagnostic testing options have limitations. MRI has poor statistical characteristics for diagnostic accuracy because it is very reader and technician dependent, adds direct and indirect costs, and may be less accurate than the physical examination.[37] Diagnostic arthroscopy is successful in diagnosing intra-articular pathology but is limited in visualization for extra-articular pathology, is costly, and increases patient risk.[37] Increased use of diagnostic imaging contributes to rising health care costs.[14,30,32,38] According to the Centers for Medicare & Medicaid Services, diagnostic imaging costs are significant, accounting for up to 40% of overall health care expenditure increases during the past 10 years.[25] Advanced imaging techniques result in not only higher direct costs but may also increase indirect costs and jeopardize outcomes.[36,39]

As the health care landscape transitions to cost minimization and value-based health care delivery, the development of an efficient, cost-effective, shoulder examination is desired. Shoulder examinations have poor sensitivity or specificity, or both, that makes diagnosing certain pathologies difficult.[4,28,30,33] Thus, evaluating the long head of the biceps brachii tendon (LHB) pathology with high-yield examination maneuvers can aid physicians through increasing the accuracy of shoulder diagnoses and aid in surgical decision making.

Previously published studies focused on the following questions: whether physical examination special tests correlate with surgical findings; whether imaging correlates with surgical findings; and whether physical examination tests are accurate enough to diagnose pathology effectively.[5,9,10,26,28,29,33] Currently, there is a need to develop new algorithms to provide shoulder practitioners with a practical but comprehensive evidence-based approach to diagnose LHB pathology during an office visit and to further reduce the need for diagnostic imaging.[20,22,34]

The purpose of this study was to perform a systematic review and a secondary sensitivity analysis based on preformed likelihood scenarios based on the history of present illness, past medical history, and epidemiology to provide clinicians a practical, evidence-based clinical (PEC) physical examination algorithm to accurately diagnose patients with LHB pathology. Specific objectives were to compile the peak performing physical examination tests extracted from Level I and II studies within the English literature, synthesize the most accurate test combination, develop a clinical algorithm to provide quantify LHB diagnostic accuracy, and create a diagnostic accuracy reference guide.

Materials and methods

A systematic literature review with the terms “proximal,” “biceps,” “clinical,” and “examination” in the PubMed, Ovid, and Cochrane Review databases was completed in May 2015. The searches included the use of Boolean operators such as “and” and “or”. The databases were scrutinized independently by 3 authors.

Inclusion criteria included studies that were focused on physical examination tests and compared with the diagnostic “gold standard” from Level I and II studies published in scientific journals. Exclusion criteria were non-English, nonfull text, Level III of evidence or lower, related to superior labrum anterior-to-posterior lesions, investigated rheumatoid arthritis patients, or did not compare tests to a validated “gold standard”. The validated “gold standard” used for all included studies and systematic reviews were diagnostic arthroscopy or arthrotomy to confirm anatomic findings.

Relevant studies were independently assessed, and conflicting studies were included only if there were consensus among the authors. References of included studies were evaluated to identify additional articles for inclusion. Applicable data were extracted by reverse calculation where the information desired was not directly stated.

Using Preferred Reporting Items for Systematic Reviews and Meta-Analyses guidelines for systematic reviews (Fig. 1), we retrieved 2086 studies from PubMed, Ovid, and Cochrane Review databases in our original search. A review of references from each article included in the systemic review resulted in 28 additional records. After duplicates were removed, the initial search yielded 2112 studies. Subsequently, 1689 studies were removed for irrelevant titles or abstracts, and an additional 362 were excluded because they were not in English. Lastly, the remaining 61 articles were assessed for eligibility; of these, 14 were excluded for nonfull text, 22 were excluded for not being a Level I or II study, and 18 were excluded for nonrelevant data.

The data extracted were summarized and analyzed according to the statistical methods described by Eusebi et al,[12] focusing on test specificity, sensitivity, positive predictive value, and negative predictive value.

Next, clinical tests were combined to assess improved diagnostic accuracy. The clinical tests were applied in parallel and in series. The first approach, in parallel analysis, consists of 2 special tests performed in theory at approximately the same time. The parallel analysis can interpret the findings in an “and” or “or” technique. When a parallel analysis is performed in an “or” technique, the overall sensitivity of the 2 tests is greater than the sensitivity of either special test alone. This parallel analysis allows for 2 opportunities to observe the potential pathology. If both tests are negative, then it is considered a “negative” finding in the algorithm and rules out the pathology, but if just 1 of the 2 special tests is positive, then it is not considered a “negative” result in parallel analysis.[7]

The second approach, in series analysis, consists of 2 special tests performed; however, the overall “negative” or “positive” finding depends on the outcomes of both special tests. By using 2 special tests in an “and” technique in series, the specificity for both tests is higher than for either test alone. If both special tests are positive, then it is considered a “positive” result. If either special test is negative, then the in series analysis cannot be considered a “positive” result.[7]

To calculate the post-test diagnostic probability of LHB diagnosis, we performed calculations for each test with 4 pretest probability options. Pretest probability is defined as the probability of a patient having the target disorder before a diagnostic test result is known. Therefore, pretest probability is based on patient history, subjective complaints, epidemiologic probability, and the medical opinion of the provider ordering the test. The ordinal scale created has 4 probabilities: very unlikely, 0.2 (20%); unlikely, 0.4 (40%); likely, 0.6 (60%); and very likely, 0.8 (80%).

The physical examination test combination with the optimal test performance was identified (named the PEC examination). A decision tree analysis was developed to determine the PEC examination diagnostic accuracy post-testing based on the ordinal scale pretest probability. Figure 3 was created as a simple reference guide to use in the clinical setting.

Results

The initial electronic database search retrieved 2112 unique articles, with 28 obtained from a manual search of reference lists. Of these, 2051 studies were unrelated to the topic of interest based on titles and abstract review, resulting in 61 full-text articles evaluated according to the selection criteria. We excluded 54 articles for the following: full-text unavailable (n = 14), not a Level I or II study (n = 22), and irrelevant data after full-text review (n = 18). Seven relevant articles were identified through the systematic review and scrutinized (Table I).

From the reviewed articles, special tests and modalities evaluated included Speed’s, Yergason’s, bicipital groove tenderness, uppercut, bear hug, belly press, O’Brien’s, and anesthetic injection. Statistical characteristics for each test are documented in Table II. The bear hug and uppercut special tests demonstrated the highest sensitivity for the physical examination special maneuvers (79% and 73%, respectively), whereas the belly press and Yergason’s tests demonstrated the lower spectrum of sensitivity (31% and 41%, respectively). The belly press and O'Brien's special tests demonstrated the highest special test specificities (85% and 84%, respectively), whereas the bear hug and bicipital groove tenderness tests showed the lowest specificities (60% and 72%, respectively). Diagnostic ultrasound imaging, used as a reference and also included to study as a potential application for in-office point of service testing, demonstrated the highest sensitivity (88%) and specificity (98%) of all statistical characteristics revealed through the review.

In series and in parallel assessments determined 2 physical examination tests improved test performance over any single test. Performing more than 2 physical examination tests decreased diagnostic accuracy. The uppercut test combined with the tenderness to palpation of the LHB test provided the highest physical examination accuracy for diagnosing pathology at the proximal biceps. This combination has a parallel testing sensitivity of 88.3% and a series specificity of 93.3%. We characterize this as the PEC exam. Additional combinations, including diagnostic ultrasound imaging, are reported in Table III. The uppercut test and diagnostic ultrasound imaging in parallel revealed the highest sensitivity (97%). Each of the Speed's, Yergason's, and upper cut tests paired with diagnostic ultrasound imaging all achieved the highest specificity (100%).

A decision tree analysis aides in the PEC examination diagnostic accuracy post-testing based on the ordinal scale pretest probability (Fig. 2). A quick reference guide is provided to use in the clinical setting (Fig. 3).

Discussion

LHB pathology is an increasingly recognized generator of shoulder pain and functional impairment in symptomatic patients. Physicians are faced with diagnostic challenges owing to nonspecific clinical presentations and lack of direction based on physical examination findings. As such, the purpose of this study was to perform a decision-tree analysis to create a clinical algorithm to diagnose biceps pathology with increased accuracy compared with previously reported diagnostic examinations.[6,11,15–17,19,22,24] This was achieved by conducting a systematic literature review including only Level I and II studies. Special test sensitivities and specificities were combined in series and parallel. Analysis showed that the uppercut test combined with tenderness to palpation of the LHB within the bicipital groove provided the highest accuracy physical examination tests for diagnosing pathology at the proximal biceps. Application of this PEC examination, coupled with pretest probability assignments, can now provide clinicians diagnostic confidence in the office. In equivocal cases, a point-of-care ultrasound examination can further improve diagnostic accuracy.[2,31] Applying the PEC algorithm provides a simple, efficient, and reproducible physical examination protocol for shoulder clinicians yielding an accurate diagnosis in the clinic. Now, with the calculated accuracy reference guide available, a clinician may rely on the office-based diagnosis with improved certainty and may consider forgoing advanced imaging, thereby avoiding additional cost, treatment delays, and possible patient risk.

To cover an array of clinical scenarios, we used a pretest probability range of 20% to 80% at 20% increments according to the likelihood of pathology. After addressing the disease prevalence, history of present illness, and past medical history, the pretest probability likelihood of LHB pathology was appointed. If the pretest probability was above 90% or below 10%, we then assume there is no need to perform additional testing with acceptance of a 10% error rate.

The combination of physical examination techniques demonstrated that the uppercut test combined with tenderness to palpation of the LHB provided the highest accuracy for diagnosing pathology at the proximal biceps. This combination has a parallel testing sensitivity of 88.3% and a series specificity of 93.3% (Table III). The values of the test used in series and in parallel were definitive and overpowered the value of the pretest probability assessment in many clinical scenarios. This adds credibility to a reproducible, simplified 2-step PEC examination without the need for performing additional maneuvers. Furthermore, we feel that the application of the PEC test is generalizable to nonshoulder specialists, facilitating both increased use and diagnostic accuracy of LHB disease.

Many studies have explored the accuracy of physical examination and special test maneuvers in diagnosing LHB pathology with limited conclusions regarding its efficiency.[18,22,23,37] However, our study is unique in that it additionally produces a diagnostic tool, both enabling accurate point of care diagnosis of LHB injury and minimizing the need for advanced imaging.

The value of the PEC examination corroborates with current clinical recommendations. Armstrong et al[3] in 2006 and Churgay[8] in 2009 stated that bicipital groove point tenderness is the most common isolated finding during the physical examination of patients with biceps tendinitis and that ultrasonography is the best modality for evaluating isolated biceps tendinopathy extra-articularly. With regards to diagnostic accuracy and fluidity of the examination, our study revealed that the best maneuver combination for diagnosing biceps pathology is the uppercut test and tenderness to palpation. Incidentally, our study has also concluded that the use of ultrasound imaging after an equivocal physical examination findings improves the sensitivity and specificity of all evaluated test combinations. Unlike past studies, we incorporated a diagnostic algorithm to aid efficient shoulder examination and to increase physician confidence in biceps tendon diagnosis.

In addition to enhancing diagnostic accuracy, development of a value-based clinical decision pathway may play a small but essential role in the improvement of the current state of the health care system.A high-yield, algorithm-derived examination, such as our proposed sequence, further alleviates the number of follow-up visits needed until diagnosis, which often delays expedient care delivery.[35,39] Moreover, simplified diagnostic algorithms may also result in cost reduction and decreased iatrogenic injury associated with unnecessary advanced imaging studies. A shoulder examination that provides an accurate diagnosis provides multiple advantages that benefit physicians and the health care system with the ultimate goal of improving patient outcomes. However, it is important to note that clinical decisions should be tailored to the patient’s clinical presentation and that MRI may be a more appropriate diagnostic modality for surgical candidates or patients with an inconclusive preliminary workup.

These findings provide evidence toward the current trend in orthopedic surgery education as more national conferences and residency programs are increasing the incorporation of musculoskeletal ultrasound courses into their curriculums. Accordingly, the American Medical Association for Sports Medicine has endorsed increased integration of sports ultrasound into sports medicine fellowship curriculums.[13] Studies have proposed that proficient level diagnostic skills may be quickly obtained by the inexperienced orthopedist with an established examination protocol.[1]

Murphy et al[27] investigated the diagnostic improvement in 4 orthopedic surgeons who attended a formal training course to identify and size tears on the rotator cuff through ultrasound imaging. In the later training period, results showed positive predictive value improving by 16%. An additional study by Roy et al[32] also demonstrated improved diagnostic accuracy of ultrasound imaging irrespective of whether a trained radiologist, sonographer, or orthopedic surgeon operated the device. Further studies are required to evaluate the cost-effectiveness of ultrasound compared with advanced imaging techniques such as MRI or arthroscopy, but an algorithm (Fig. 3) may provide a simple, evidence-based decision analysis for physicians to rely on when considering LHB as the major source of pain.

This study, however, also has its limitations. Foremost, most of the studies included in our data collection did not solely focus on LHB pathology. True positives may have included superior labrum, anterior-to-posterior lesions within the diagnosis of biceps pathology. Studies may have also incorporated biceps pathology into other diagnostic categories (eg, “impingement”). Therefore, finding studies that solely focused on diagnostic accuracy of LHB pathology was difficult.

In addition, only Level I or II studies were considered for diagnosis that routinely compare a diagnostic testing algorithm to the “gold standard” of diagnosis. Unfortunately, there are no clearly defined arthroscopic findings for diagnosis of LHB pathology.

To aid in any study misinterpretations caused by inaccurate language translations, only articles originally written in English were evaluated, and only published articles were included. This may have introduced both publication or selection bias, or both.

A method to eliminate some of these potential biases would be to perform a truly systematic review and meta-analysis combining results from multiple studies; however, even this can be hindered by bias with the lack of currently published methods for meta-analyses evaluating diagnostic testing.

Another future direction for this study may be to further evaluate the accuracy of new special tests described to evaluate LHB pathology, specifically the uppercut test. Currently, the uppercut test has only been described and analyzed in a single Level I or II study that we used for our algorithm.[24] Further validation testing for this specific test may be warranted.

Conclusion

Performing the uppercut test and biceps groove tenderness to palpation test together has the highest sensitivity and specificity of known physical examinations maneuvers to aid in the diagnosis of LHB biceps pathology compared with diagnostic arthroscopy (the PEC examination). A decision tree analysis aides in the PEC examination diagnostic accuracy post-testing based on the ordinal scale pretest probability. A quick reference guide is provided to use in the clinical setting.

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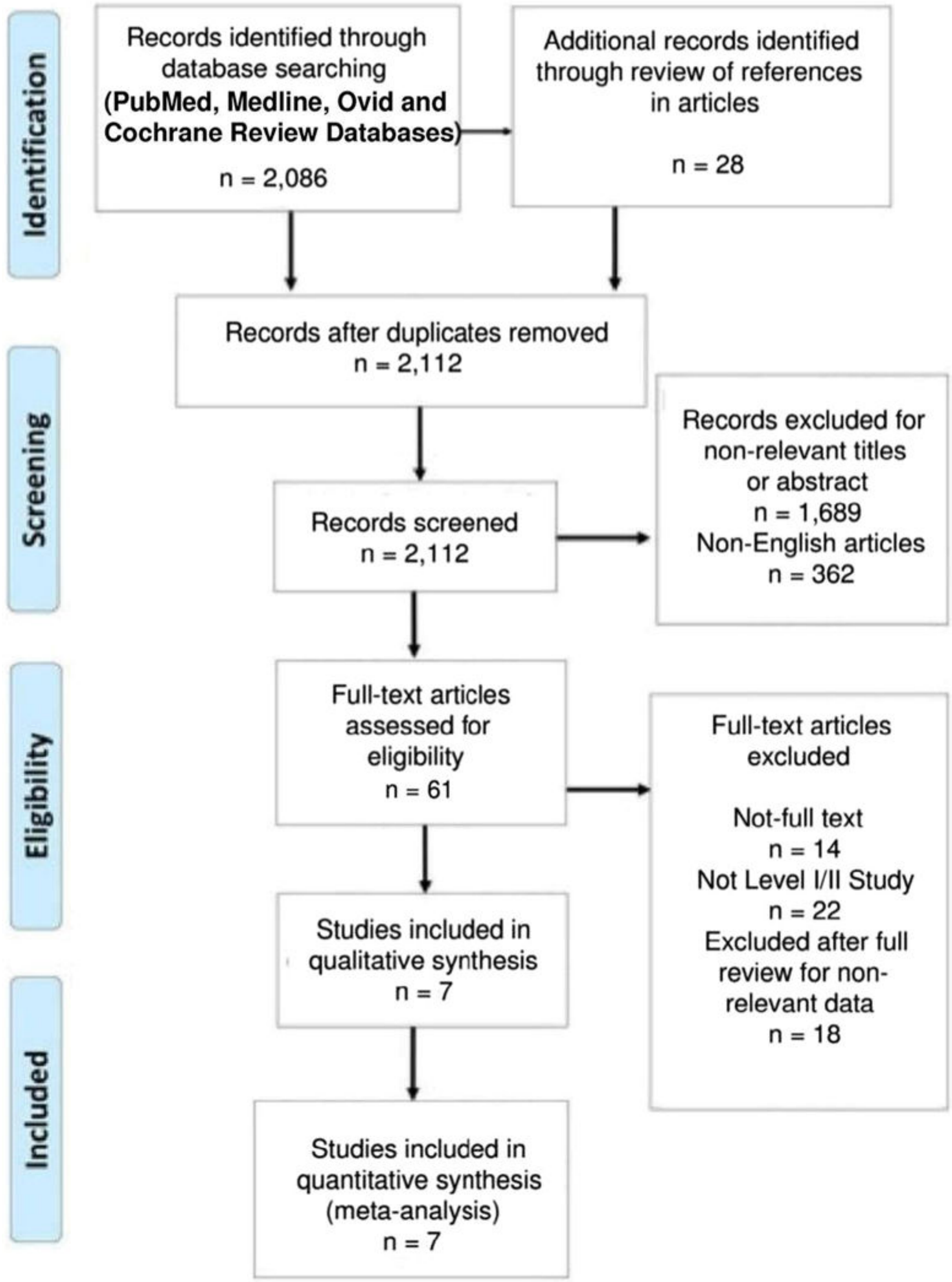

Figure 1.

Preferred Reporting Items for Systematic Reviews and Meta-Analyses flow diagram. This figure displays the process and rationale behind why studies were omitted from the systemic review.

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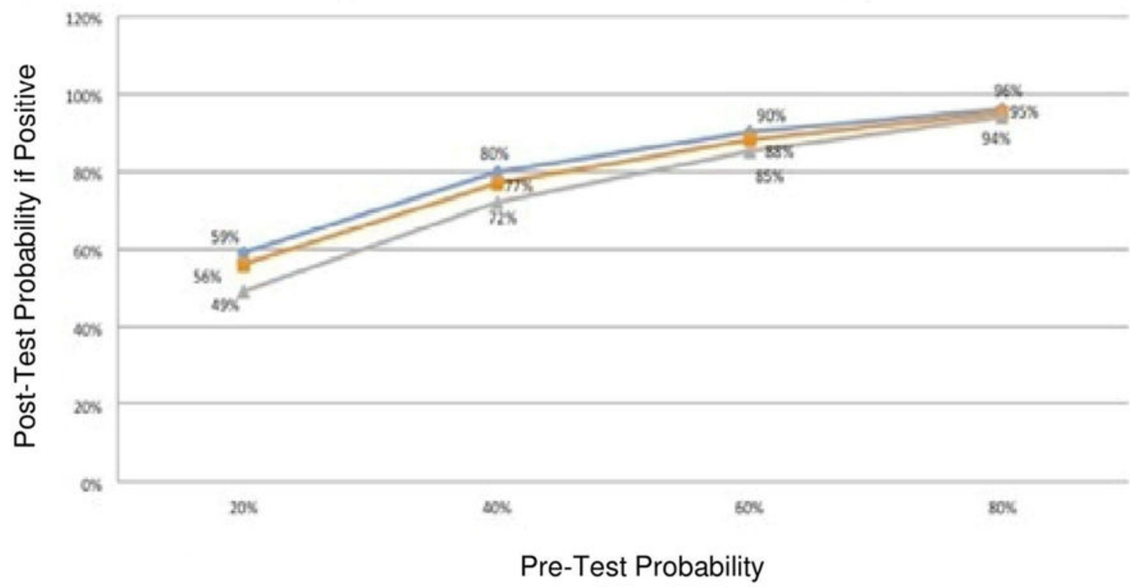
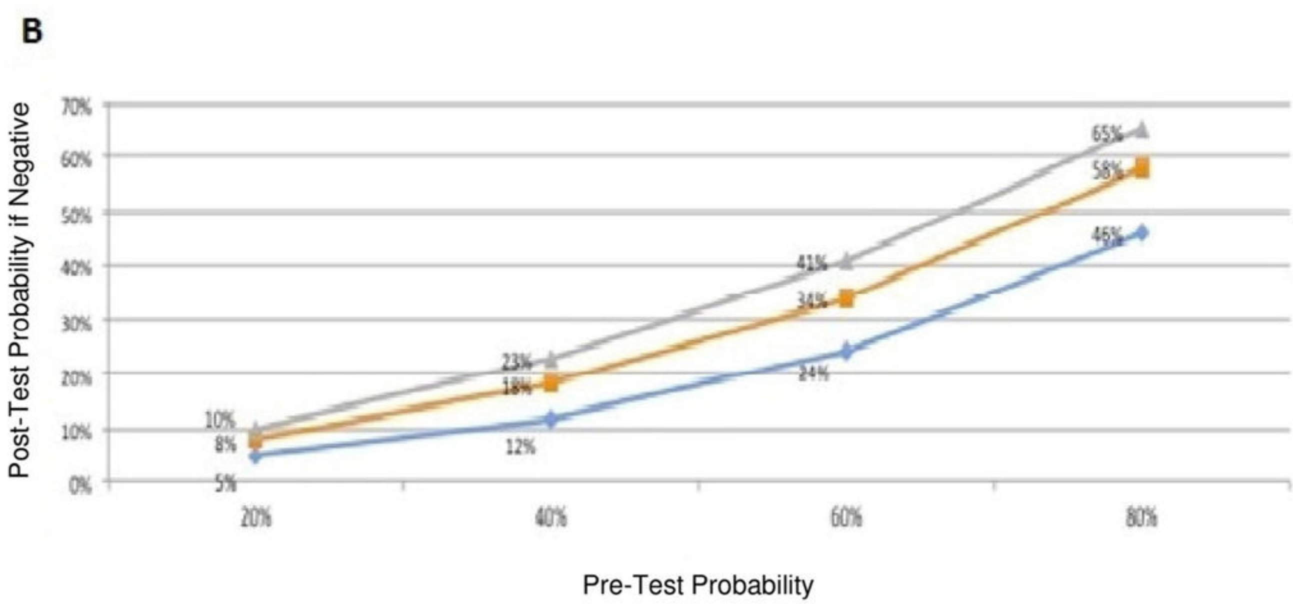


Pre-Test Probability	TTP+Uppercut in Series	TTP+Speed's in Series	TTP+Yergason's in Series
	Post-Test Probability if Positive [95% CI]	Post-Test Probability if Positive [95% CI]	Post-Test Probability if Positive [95% CI]
20%	59% [52%,66%]	56% [47%,64%]	49% [40%,58%]
40%	80% [74%,84%]	77% [70%,83%]	72% [64%,79%]
60%	90% [86%,93%]	88% [83%,92%]	85% [79%,90%]
80%	96% [93%,98%]	95% [92%,97%]	94% [90%,96%]



Pre-Test Probability	TTP+Uppercut in Parallel	TTP+Speed's in Parallel	TTP+Yergason's in Parallel
	Post-Test Probability if Negative [95% CI]	Post-Test Probability if Negative [95% CI]	Post-Test Probability if Negative [95% CI]
20%	5% [4%,7%]	8% [6%,10%]	10% [8%,13%]
40%	12% [10%,16%]	18% [16%,22%]	23% [21%,27%]
60%	24% [20%,29%]	34% [30%,38%]	41% [37%,45%]
80%	46% [40%,52%]	58% [54%,62%]	65% [61%,69%]

Figure 2.

(**A**) Diagnostic combination to rule in pathology: These findings demonstrate that the combination of tests that best help rule out pathology are the tenderness to palpation (*TTP*) of the long head of the biceps within the bicipital groove plus the uppercut test when performed in series. If both tests are negative in a scenario with a low pretest probability (ie, prevalence), then there is a very small chance of pathology being present (*diamond,* TTP + uppercut in series; *square,* TTP + Speed's in series; *triangle,* TTP + Yergason's in series). (**B**) Diagnostic combination to rule out pathology: These findings demonstrate that the combination of TTP + uppercut test in parallel allows us to diagnose the presence of pathology even when the pretest probability (ie, prevalence) is small. When there is a high pretest probability, the combination of the 2 tests provide similar results (*diamond,* TTP + uppercut in parallel; *square,* TTP + Speed's in parallel; *triangle,* TTP + Yergason's in parallel). *CI*, confidence interval.

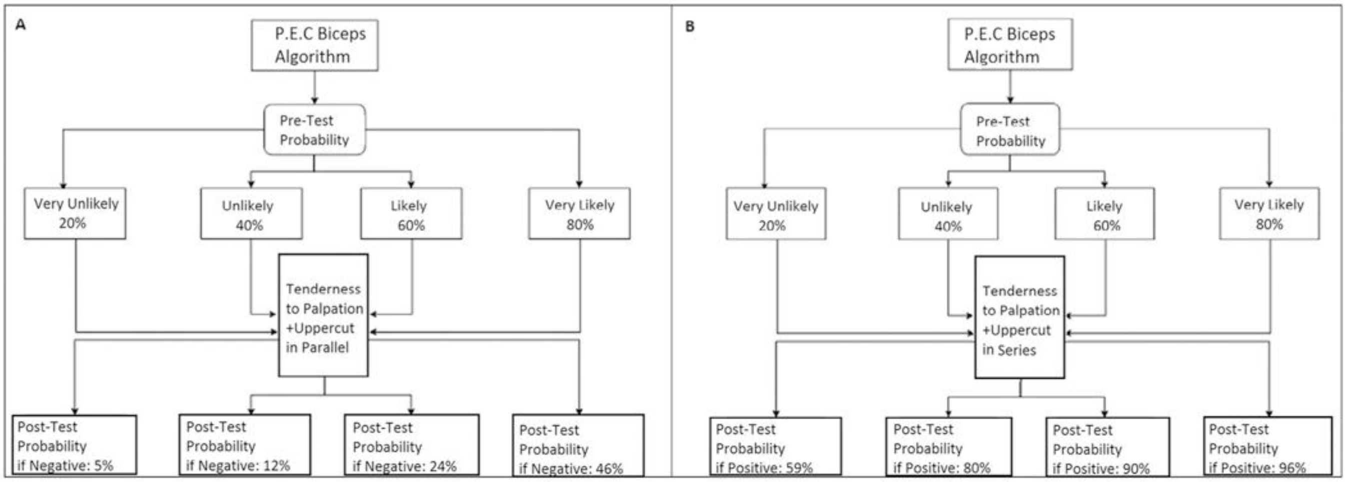


Figure 3.

Practical, evidence-based, comprehensive (*PEC*) biceps algorithm in (**A**) parallel and (**B**) in series.

Table I

Studies considered after initial literature review

Title	Authors	Level of evidence	Year	Clinical examinations included
The efficacy of ultrasound in the diagnosis of long head of the biceps tendon pathology	Armstrong et al[3]	II (diagnostic cohort)	2006	-Ultrasound -Diagnostic arthroscopy
Improving the accuracy of the preoperative diagnosis of long head of the biceps pathology: the biceps resisted flexion test	Arrigoni et al[4]	II (diagnostic cohort)	2014	-Biceps resisted flexion (digital dynamometer) -Speed's -O'Brien's
Specificity of the Speed's test: arthroscopic technique for evaluating the biceps tendon at the level of the bicipital groove	Bennett[5]	II (diagnostic cohort)	1998	-Speed's -Arthroscopy
Physical examination for partial tears of the biceps tendon	Gill et al[16]	II (diagnostic cohort)	2007	-Bicipital groove tenderness -Lift-off -Speed's
Which physical examination tests provide clinicians with the most value when examining the shoulder? Update of a systematic review with meta-analysis of individual tears	Hegedus et al[22]	I (systematic review with meta-analysis)	2012	-Active compression (O'Brien's) -Anterior slide -Bear hug -Belly press -Modified dynamic labral shear -Bicipital groove tenderness -Speed's -Yergason's
Clinical utility of traditional and new tests in the diagnosis of biceps tendon injuries and superior labrum anterior and posterior lesions in the shoulder	Kibler et al[24]	II (diagnostic cohort)	2009	-Belly press -Upper cut -Bear hug -Yergason's -Speed's -Modified dynamic labral shear -Anterior slide -O'Brien's
Shoulder ultrasound: diagnostic accuracy for impingement syndrome, rotator cuff tear, and biceps tendon pathology	Read and Perko[31]	II (diagnostic cohort)	1998	-Ultrasound -Arthroscopy

Table II

Statistical characteristics of physical examination maneuvers used for analysis

Test	Sensitivity	Specificity	Predictive value		Likelihood ratio	
			Positive	Negative	Positive	Negative
	(%)	(%)	(%)	(%)		
Speed’s	54	81	56	79	2.77	0.58
Yergason’s	41	79	48	74	1.94	0.74
Bicipital groove tenderness (TTP)	57	72	57	72	2.07	0.59
Uppercut	73	78	63	85	3.38	0.34
Bear hug	79	60	47	86	1.95	0.36
Belly press	31	85	50	72	2.1	0.81
O’Brien’s	61	84	80	67	3.83	0.47
Anesthetic injection *	66	87.5	60	90	5.33	0.38

TTP, tenderness to palpation of the long head of the biceps within the bicipital groove.

* Values were extracted through reverse calculation.

Table III

Results of physical examination test combinations Test

Test combinations	Method	Sensitivity (%)	Specificity (%)
Uppercut + US	Series	64	100
	Parallel	97	76
Speed's + US	Series	48	100
	Parallel	94	79
TTP + US	Series	50	99
	Parallel	95	71
Yergason's + US	Series	36	100
	Parallel	93	77
TTP + Uppercut	Series	42	94
	Parallel	88	56
TTP + Speed's	Series	31	95
	Parallel	80	58
TTP + Yergason's	Series	23	94
	Parallel	75	57

TTP, tender to palpation in biceps groove; *US*, ultrasound.