Can Preoperative Serum Lab Tests Help Predict Bacterial Presence at the Time of Revision Shoulder Arthroplasty?

Andrew P Collins, Julie Young Bishop, Norman Douglas Boardman[1], Matthew Daniel Budge[2], Michael Cusick[3], Gregory L Cvetanovich[4], Thomas Richard Duquin[5], Vahid Entezari[6], Catherine Julia Fedorka[7], Kyle R Flik[8], Grant E Garrigues[9], Mohit Gilotra[10], Jason Ho[11], Galen S Kam, Michael S Khazzam, Hyunmin Mike Kim[12], Joseph John King[13], Xinning Li[14], Frederick A Matsen[15], Surena Namdari[16], Gregory P Nicholson[17], Nathan Orvets, Ryan Rauck, Eric Thomas Ricchetti[11], Brandon Anthony Romero, Howard David Routman[18], Vani Janaki Sabesan[19], Jennifer Lane Vanderbeck, Alexander Robertson Vap[20], Jonathan O Wright[21], Thomas W Wright[22], Anastasia Whitson[23], Jason Hsu

[1]MCV VCUMC, [2]Kaiser Permanente Northwest, [3]Fondren Orthopedic Group L.L.P., [4]Jameson Crane Sports Medicine Institute, [5]University Orthopaedics, [6]Cleveland Clinic Foundation, [7]Cooper University Hospital, [8]Orthony, [9]Midwest Orthopaedics at Rush, [10]University Of Maryland Medical Orthopaedic Department, [11]Cleveland Clinic, [12]University of Missouri, [13]UF Orthopaedics & Sports Medicine Institute, [14]Boston University School of Medicine, [15]Univ of Washington Med Ctr, [16]Rothman Institute, [17]Midwest Ortho At Rush, [18]The Orthopedic Foundation, [19]Palm Beach Shoulder Service - HCA Atlantis Orthopa, [20]Virginia Commonwealth University, [21]University of Florida, [22]UF Orthopaedics, [23]University of Washington

INTRODUCTION:

Surgeons and patients wish to know whether bacteria are likely to be present in a failed shoulder arthroplasty prior to revision so that surgical and antibiotic management can be planned. The most common organisms causing shoulder periprosthetic joint infections (PJI) are classified as non-virulent (such as *Cutibacterium*); PJI caused by these organisms often presents without typical signs of infection. While serum inflammatory markers are used with the current International Consensus Meeting (ICM) criteria for diagnosing PJI, their utility in diagnosing shoulder PJI in patients without obvious clinical evidence of infection is not clear. We tested the hypothesis that routine serum laboratory tests and inflammatory markers had utility in predicting the presence of bacteria at the time of revision shoulder arthroplasty in such cases.

METHODS:

Data were prospectively collected on consecutive revision shoulder arthroplasties from 20 institutions and 33 surgeons using the American Shoulder and Elbow Surgeons (ASES) Revision Shoulder Arthroplasty and PJI Multicenter database. Preoperative and intraoperative testing was standardized among participating surgeons prior to data collection. Preoperative serum lab values included serum inflammatory markers (erythrocyte sedimentation rate [ESR], C-reactive protein [CRP], and d-dimer) as well as complete blood count differentials (% neutrophils, lymphocytes, monocytes, eosinophils, basophils) and ratios (neutrophil-to-lymphocyte, neutrophil-to-monocyte, neutrophil-to-eosinophil, neutrophil-to-basophil). To assess the value of these tests in patients without obvious infections, only subjects without Definite PJI (defined as intra-articular pus, sinus tract, or ≥2 cultures positive for virulent bacteria per 2018 ICM criteria) were analyzed. The utility of serum markers in determining bacterial presence (≥2 positive cultures for the same non-virulent bacterial species) at the time of revision was studied by constructing receiver operating characteristic (ROC) curves. Area under the curve (AUC) was calculated to determine which tests provided the best diagnostic accuracy. The Youden index was utilized to identify optimal threshold for each test, and the sensitivity, specificity, positive predictive value (PPV), and negative predictive value (NPV) of each diagnostic test were calculated based on that threshold.

RESULTS:

The median patient age was 66 (IQR, 58-73), and 53% were male. A total of 129 patients had cell counts from serum samples; 238 patients had serum inflammatory marker tests. The bacteria most commonly recovered from deep surgical cultures were *Cutibacterium* (32%) and coagulase-negative *Staphylococcus* (19%). Serum ESR and CRP had very low AUCs (0.408 and 0.477, respectively) (Table 1). Using an ESR threshold of 54.5, sensitivity was 0.106 and specificity was 0.922. Using a CRP threshold of 0.9, sensitivity was 0.652 and specificity was 0.453. Cell count differentials also had poor diagnostic accuracy (AUC 0.339 to 0.543) as did neutrophil-to-lymphocyte ratio (AUC 0.513). Neutrophil-to-eosinophil ratio had the highest AUC of all metrics tests but still had poor discriminative ability (AUC 0.626).

DISCUSSION AND CONCLUSION:

This is the first large-scale study in revision shoulder arthroplasties measuring the discriminative ability of routine serum laboratory tests in predicting the presence of non-virulent bacteria at the time of revision arthroplasty. We found that routine serum laboratory cell count differentials, cell count ratios, and inflammatory markers all had poor diagnostic accuracy in shoulders that did not meet the ICM criteria for definite PJI.

Table 1: Diagnostic characteristics of serum laboratory values prior to revision shoulder arthroplasty in patients with ≥2 positive deep cultures that did not meet ICM criteria for definite periprosthetic infection.

Metric	AUC	Optimal Cut-Off	Sensitivity	Specificity	PPV	NPV	Sample size
Neutrophil %	0.543	>54.9%	0.944	0.238	0.347	0.908	120
Lymphocyte %	0.500	>24.4%	0.667	0.500	0.364	0.778	120
Monocyte %	0.515	>7.1%	0.694	0.393	0.329	0.750	120
Eosinophil %	0.339	>0.3%	0.944	0.083	0.306	0.776	120
Basophil %	0.440	>1.2%	0.056	0.952	0.333	0.702	120
Neutrophil-to-Lymphocyte Ratio	0.513	>1.3	0.972	0.143	0.327	0.923	120
Neutrophil-to-Monocyte Ratio	0.525	>6.3	0.778	0.321	0.329	0.771	120
Neutrophil-to-Eosinophil Ratio	0.626	>52.3	0.382	0.823	0.482	0.756	113
Neutrophil-to-Basophil Ratio	0.558	>58.2	0.853	0.284	0.333	0.822	115
D-Dimer	0.602	>2.78	0.923	0.419	0.250	0.963	75
Erythrocyte Sedimentation Rate (ESR)	0.408	>54.5	0.106	0.922	0.293	0.772	201
C-Reactive Protein (CRP)	0.477	>0.85	0.652	0.453	0.254	0.820	207