Defining Optimal Synovial Aspirate Thresholds in Predicting Bacterial Presence at the Time of Revision Shoulder Arthroplasty

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INTRODUCTION:

Introduction: Determination of whether a failed shoulder arthroplasty is infected or not can be a challenge prior to revision surgery. Currently, sampling and culturing of deep tissue specimens is the most definitive way of determining if bacteria is present around a shoulder arthroplasty implant. Given that these results are not available until after revision arthroplasty, the surgeon is often unsure if procedures and antibiotics aimed at addressing infection are necessary. Clinical signs and symptoms as well as serum laboratory tests have been shown to have low sensitivity in ruling out infection. Analysis of synovial aspirates may provide additional information to the surgeon, but currently, the value and optimal thresholds of synovial aspirate cell count and neutrophil percentage is unclear and has never been studied in a systematic fashion. Furthermore, the current International Consensus Meeting (ICM) criteria utilizes threshold values from the hip and knee literature. The objective of this study was to utilize data from a multicenter revision shoulder arthroplasty database to determine optimal threshold values for synovial cell count and neutrophil percentage in definite and non-definite shoulder periprosthetic joint infection (PJI).

METHODS:

Methods: Data prospectively collected on consecutive revision shoulder arthroplasty cases from the American Shoulder and Elbow Surgeons (ASES) Revision Shoulder Arthroplasty and PJI Multicenter database was utilized. A standardized approach to intraoperative testing at revision shoulder arthroplasty was agreed upon by all participants and included 1) aspiration of synovial fluid prior to arthrotomy for culture and cell count, 2) collection of multiple deep tissue specimens. Only subjects with finalized synovial aspiration results and a minimum of three deep tissue specimens sent for culture at the time of revision arthroplasty were included in this study. For analysis, “Definite” infections (intra-articular pus, sinus tract, ≥2 cultures positive for virulent bacteria per 2018 ICM criteria) were analyzed separately from “Non-Definite” infections (“Probable,” “Possible,” and “Unlikely” by ICM criteria). For the Non-Definite group, the performance of each diagnostic test in prediction of positive intraoperative cultures was measured using two thresholds, ≥2 positive cultures (“Non-Definite ≥2”) and ≥3 positive cultures (“Non-Definite ≥3”) of the same bacterial species. Receiver operator characteristics curves were constructed and each diagnostic test's area under the curve (AUC), sensitivity, specificity, positive predictive value (PPV), and negative predictive value (NPV) were calculated.

RESULTS:

Results: 209 patients met the inclusion criteria of having a successful intra-operative aspirate. The median age was 68 (IQR, 62-73), and 58% were male. 32 patients (15.3%) met the criteria for a Definite PJI while 177 (84.7%) had Non-Definite PJI (**Table 1**).

Predictive utility using threshold of ≥2 positive cultures: **synovial neutrophil-to-lymphocyte ratio** (AUC=0.669, at threshold sensitivity=0.667 and specificity=0.617), **neutrophil count multiplied by neutrophil percentage** (AUC=0.657, at threshold sensitivity=0.520 and specificity=0.789), and **neutrophil percentage** (AUC=0.654, at threshold sensitivity=0.730 and specificity=0.472) were the most predictive of infection (**Table 2**).

Predictive utility using threshold of ≥3 positive cultures: **neutrophil count multiplied by neutrophil percentage** (AUC=0.780, at threshold sensitivity=0.643 and specificity=0.842), **synovial neutrophil-to-lymphocyte ratio** (AUC=0.690, at threshold sensitivity=0.444 and specificity=0.899), and **neutrophil percentage** (AUC=0.674, at threshold sensitivity=0.545 and specificity=0.779) were the most predictive of PJI.

Synovial aspirate metrics involving neutrophil %, neutrophil count, and neutrophil ratios generally had high negative predictive values (0.853-0.944).

DISCUSSION AND CONCLUSION:

Conclusion: This study presents the first data on optimal thresholds of synovial fluid obtained in a standardized fashion in consecutive revision arthroplasties. Synovial neutrophil percentage, neutrophil-to-lymphocyte ratio, and neutrophil count multiplied by neutrophil percentage had the optimal diagnostic characteristics. Optimized synovial cell count thresholds had high negative predictive values and can assist a surgeon in determining whether interventions aimed at eliminating bacteria (eg, prosthesis explantation, post-operative antibiotics) are necessary at the time of revision shoulder arthroplasty.

Table 1. Demographic characteristics of included patients

Metric	Total [Average (Standard Deviation)]	Definite Infection [Average (Standard Deviation)]	Non-Definite Infection [Average (Standard Deviation)]	p-value*
Sample Size	209	32	177	-
Age	67.5 (9.4)	67.6 (9.5)	67.4 (9.4)	0.944
Male Sex	57.9%	59.4%	57.6%	0.855
Body Mass Index	29.5 (6.3)	29.3 (6.6)	29.6 (6.3)	0.812
History of Tobacco Use	12.2%	22.7%	10.2%	0.051
Current Narcotic Use	29.1%	31.3%	28.7%	0.768
Diabetic Status	14.8%	15.6%	14.7%	0.892
Inflammatory Arthropathy	8.9%	9.7%	8.8%	0.871
Immunosuppressant Medications	11.0%	12.0%	10.9%	0.870
ASA Class	2.7 (0.6)	2.8 (0.5)	2.7 (0.6)	0.614

* = Unpaired student's t-test comparing Definite and Non-Definite Infection cohorts; ASA = American Society of Anesthesiologists Score