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Correlation of Aspiration Results With Periprosthetic Sepsis in Revision Total Hip Arthroplasty

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ABSTRACT

A retrospective chart review was performed of all patients who had undergone revision total hip arthroplasty with a synovial aspiration with greater than 100 WBC since the institution of our electronic medical record. Infection was defined using a combination of criteria. A diagnosis of periprosthetic sepsis was established in 52 of the 253 included hips. No significant differences existed with respect to gender, age, BMI, Deyo–Charlson Comorbidity Index, or the cause of initial hip degeneration. Using receiver-operating characteristic curves accuracy was maximized for WBC of 745 or segmented cell count of 73.5% with a sensitivity of 98%, specificity of 37%, negative predictive value of 99% and accuracy of 50%. Application of the current *American Academy of Orthopaedic Surgery Clinical Practice Guidelines* (AAOS CPG) thresholds revealed a similar accuracy of 49%.

Infection accounts for ~10% of revision total hip arthroplasties performed annually [1]. This complication remains among the most devastating and difficult to treat with varied levels of success [2–6]. Diagnosis can be difficult as patient presentation is often similar to aseptic complications [7,8]. Failure to diagnose periprosthetic sepsis in a timely manner can lead to greater difficulty in eradicating the infection. Therefore, developing an accurate diagnostic methodology is crucial. Previous studies have recommended preoperative synovial aspiration in the setting of an elevated erythrocyte sedimentation rate (ESR) or C-reactive protein (CRP) [9–11]. Laboratory aspirate analysis with cell count, white blood cell (WBC) differential, and culture are then performed [9–11]. Multiple studies have demonstrated that WBC and percent segmented leukocytes in the WBC differential to be sensitive tests for the diagnosis of periprosthetic sepsis [9–13].

Debate remains in the literature as to an optimal threshold value for WBC and segmented cell count at which a given hip should be considered infected [9–13]. While the current *American Academy of Orthopaedic Surgery Clinical Practice Guidelines* (AAOS CPG) suggest a WBC of >1700 cells/μL or a neutrophil percentage of >65% to be the optimal threshold values [14], several additional series have reported other values [9–13]. We retrospectively reviewed revision total hip arthroplasties performed at our institution to determine the optimal WBC and neutrophil percentage threshold values for the diagnosis of periprosthetic sepsis.

Methods

The operative logs of the two senior authors were reviewed after receiving institutional review board approval from our University system. Patients who had undergone revision hip arthroplasty since the institution of our electronic medical record in 2004; patients with an available operative report; patients who had a preoperative or intraoperative synovial aspiration for which cell count, cell differential, and culture were performed; and patients with a synovial WBC count of greater than 100 were included in the study. Patients were excluded if they did not undergo revision from a hip arthroplasty, if no operative report could be located, or if they did not undergo a preoperative or intraoperative synovial aspiration with a cell count, differential, culture, and synovial WBC count of greater than 100. Patients with a synovial WBC count of less than 100 were excluded as it felt that the cell differential analysis would be compromised in these cases.

Data Collection

Data were recorded in a password-protected Excel X (Microsoft, Redmond, WA) spreadsheet. The following data were collected from the medical record: gender, age, body mass index (BMI), medical comorbidities for the calculation of a Deyo–Charlson Comorbidity Index [15–17], etiology of degeneration leading to the initial

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Table 1
Grading Scale for C-Reactive Protein (CRP) and Erythrocyte Sedimentation Rate (ESR) Elevations.

Grade	CRP	Sample Values For Our Laboratory (mg/L)	ESR	Sample Values For Our Laboratory (mm/hr)
Grade 0/Normal	Normal	<5	Normal	<20
Grade I/Mild	0–100% of normal	5–10	0–100% of normal	20–40
Grade II/Moderate	100%–2000% of normal	10–100	100–200% of normal	40–60
Grade III/Severe	>2000% of normal	>100	>200% of normal	>60

arthroplasty, primary presenting symptom, time between the primary arthroplasty and revision, whether the serum CRP was greater or less than the value considered abnormal by the laboratory performing the test, whether the serum ESR was greater or less than the value considered abnormal by the laboratory performing the test, and the appearance of the preoperative radiographs as dictated by the attending surgeon in his preoperative consultation. Because multiple laboratories were utilized in the measurement of serum CRP and ESR, a system was devised to allow comparison between all laboratories with finer gradation than "normal" and "abnormal." Serum CRP and serum ESR elevations were graded by severity as detailed in Table 1 based upon our own experience that 0–100% elevations in both can be spurious and clinical evidence that a 2000% increase in CRP may be a clinically relevant cutoff in the early postoperative period [18]. The results of intraoperative pathologic frozen section were recorded and those that revealed an average of greater than five neutrophils per high-powered field in the five most cellular fields were considered positive [19,20]. The following data were collected regarding the preoperative or intraoperative aspirate: WBC count (cells/μL), red blood cell (RBC) count, percent of segmented WBCs, and final culture results. The preoperative consultation notes and operative reports for each patient were reviewed.

Modes of Failure

The following data were used in combination to determine whether the etiology of failure was periprosthetic sepsis: any patient with bacterial growth from synovial aspirate cultures, a sinus tract or other open communication between a wound and the involved joint, intraoperative purulence, or a combination of three of the four of abnormal ESR, abnormal CRP, synovial WBC count of greater than 3000, or intraoperative frozen section revealing greater than five neutrophils per high-powered field within the five most cellular fields [21]. Cases in which a single broth culture grew a common skin contaminant organism without bacterial growth in any other cultures or clinical signs of infection as above were considered "negative" for the purposes of classification.

Statistical Analysis

All statistical analyses were performed in SPSS 18 (IBM, Armonk, NY). Komolgorov–Smirnov tests were performed and it was determined that none of the numerical data for which analyses were planned were normally distributed ($P < 0.05$ in all cases) with the exception of age, which was normally distributed ($P = 0.128$). All further analyses were therefore performed using nonparametric tests, again with the exception of age for which a *t*-test were performed. Chi-square tests were performed to compare etiology of initial hip degeneration, ESR, CRP, and intraoperative frozen section results between those hips that failed due to periprosthetic sepsis and those hips that failed for all other causes. With regard to demographic data, Mann–Whitney *U* tests were performed to compare BMI, Deyo–Charlson Comorbidity Index, and numbers of years between the primary arthroplasty and the revision procedure between cases of periprosthetic sepsis and failure due to all other causes. With regard to aspirate data, Mann–Whitney *U* tests were performed to compare age, BMI, Deyo–Charlson Comorbidity Index, and numbers of years between the primary arthroplasty and the revision procedure between cases of periprosthetic sepsis and failure due to all other causes.

Receiver-operative characteristic (ROC) curves were created for synovial WBC count and differential segmented cell percentage. Thresholds were adjusted to maximize accuracy and then sensitivity, specificity, positive likelihood ratio (PLR), negative likelihood ratio (NLR), positive predictive value (PPV), negative predictive value (NPV), and accuracy were calculated. In addition these values were also calculated for the thresholds recommended by the current American Academy of Orthopaedic Surgery Clinical Practice Guidelines (AAOS CPG).

Combination tests were similarly tested to determine the optimal algorithm to diagnose periprosthetic sepsis. Two varieties of combinations are possible: combination tests in which the test was considered positive if *both* of the primary tests were positive, which are represented as those combinations separated by "+" signs, and combination tests in which the test was considered positive if *either* of the primary tests were positive, which are represented as those combinations separated by "/" signs. For example, the "WBC + Segmented" test would only be considered positive if both the WBC AND the segmented cell counts exceeded the thresholds for each of those tests—in all other cases the combination test would be considered negative.

Results

Two hundred fifty-three patients met our inclusion and exclusion criteria. Twenty-two patients were excluded as they did not undergo

Table 2
Demographic and Preoperative and Intraoperative Non-Aspirate Data for Periprosthetic Sepsis, Aseptic Failure, and Both Categories Combined.

Diagnosis	*N*	Age (years)	Percent of Female Subjects	BMI	Deyo–Charlson Comorbidity Index	Number of Years Since Primary Arthroplasty	% With OA	% Abnormal CRP	% Abnormal ESR	% Abnormal ESR + CRP	% Frozen Positive
Infection	52	64 ± 13	67	32 ± 9.2	1.1 ± 1.4	6.5 ± 8.2	57	90	88	83%	55
Aseptic failure	201	64 ± 13	59	31 ± 6.7	1.0 ± 1.3	9.9 ± 9.0	67	39	52	29%	6
Total	253	64 ± 13	61	31 ± 7.2	1.0 ± 1.3	9.3 ± 9.0	65	51	62	42	13

Data are reported as arithmetic means ± standard deviations. *N* = number of subjects, BMI = body mass index, OA = osteoarthritis, abnormal CRP = C-reactive protein, abnormal ESR = erythrocyte sedimentation rate, abnormal ESR + CRP = percent of patients with elevations in both erythrocyte sedimentation rate and C-reactive protein, frozen positive = percent of patients with intraoperative frozen section positive for acute inflammation.