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Correlation Between Blood Parameters and Early Detection of Infection in Arthroplasty

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Abstract

Introduction: Few studies have utilized a consistent algorithm to establish the usefulness of the various tests that are available, despite the fact that numerous assays are used to identify the presence of infection at the site of a total hip arthroplasty. The current study's goal was to assess the effectiveness of frequently used assays for detecting periprosthetic infection in patients having revision total hip arthroplasty.

Methods: One of two surgeons analysed 220 patients who underwent 235 consecutive total hip arthroplasties using a standardized approach to detect infection and treated the patients with reoperation. The ideal cut-point values for the white blood cell count and the proportion of polymorphonuclear cells in the intraoperatively aspirated hip synovial fluid were determined using receiver-operating characteristic curve analysis. The following parameters were calculated: sensitivity, specificity, accuracy, negative predictive value, and positive predictive value. Two of the three criteria—a positive intraoperative culture, gross purulence at the time of reoperation, and positive histological findings—were needed for a patient to be diagnosed with an infection.

Results: A total of 201 total hip arthroplasties were left for review after 34 were disqualified due to the presence of a draining sinus, missing information, or a preoperative diagnosis of inflammatory arthritis.

It was determined that 55 hips were infected. No hip in a patient with a differential count of > 80% poly mor phonuclear cells and a preoperative erythrocyte Sedi mentation rate of 4200 white blood cells/mL for the white blood cell count.

The optimal cut-point for the synovial fluid cell count was >3000 white blood cells/mL, which produced the highest combined sensitivity, specificity, positive predictive value, negative predictive value, and accuracy of the tests examined. However, when combined with an elevated erythrocyte sedimentation rate and C-reactive protein level.

Conclusion: In our study, a high preoperative erythrocyte sedimentation rate and C-reactive protein level in patients receiving revision total hip arthroplasty were paired with a synovial fluid cell count of >3000 white blood cells/mL to determine the existence of periprosthetic infection.

Keywords: Arthroplasty, sedimentation, polyethylene

Introduction

Total knee arthroplasty (TKA), which has developed into one of the most successful surgical procedures in medicine over the past 50 years, is expected to have a rise in demand by 2030, which is evidence of the functional and monetary advantages it offers to patients and society. Although reported TKA results are still "good to exceptional," most clinicians will concur that TKA results are not as predictable or good as those of total hip arthroplasty (THA) [1, 2]. Although TKA has been shown to have long-term clinical and radiographic success, many failure-related factors still make it difficult for implants to survive. Component loosening, polyethylene wear, infection, and instability are the most frequent causes of revision TKA; other causes include fracture, osteolysis, and component malposition [3].

Restoring order to the chaos of failure is a requirement of revision knee arthroplasty surgery.

However, elements like infection and bone loss place a tremendous strain on the surgeon's technical skill. Both the patient and the physician must deal with the difficult complication of periprosthetic infection. Infection rates after first total hip arthroplasty have been shown to range from 1% to 2%, and rates following revision hip arthroplasty are considerably higher [4, 5]. This percentage corresponds to a sizable number of patients with periprosthetic hip infections who use a sizable amount of healthcare resources, given the rising number of total hip arthroplasties performed each year. The current study's objective was to assess blood markers and their use in the early diagnosis of infections or arthroplasty revision [6].

Methodology

Between August 2020 and December 2021, 220 patients who had had 220 painful total hip arthroplasties were prospectively reviewed and underwent reoperation. In order to check for infection in the uncomfortable hips, a preoperative and intraoperative protocol was used. During the course of the study, five patients had revision of both hips, and 10 more patients endured several revisions of the same hip (five because of infection, three because of instability, and two because of fracture). The data set was examined twice, once with all but the initial revision for the fifteen non-unique patients who underwent secondary arthroplasties included in the analysis to control for the likelihood of intercorrelated events. Both individuals taking preoperative antibiotics and patients who had undergone a prior resection arthroplasty with or without an antibiotic spacer were excluded from this study.

Data Analysis

A SAS computer programme created specifically for the study was used to calculate the sensitivity, specificity, positive predictive value, negative predictive value, and test accuracy as measured by the Youden's J statistic. A grid search method was used to find the cut-point that produced the highest test accuracy (Youden's J statistic) at a reasonable level of sensitivity, specificity, negative predictive value, and positive predictive value. Statistics were calculated at each distinct value of a variable or composite under evaluation. Using standard errors derived under the binomial assumption and widths obtained using a normal approximation to the binomial distribution, 95 percent confidence limits were estimated for sensitivity, specificity, positive predictive value, negative predictive value, and test accuracy.

Results

Thirty-four of the 235 revision total hip arthroplasties were not included because they had a draining sinus, had insufficient information, or had been diagnosed with inflammatory arthritis prior to surgery, leaving 201 total hip arthroplasties that could be evaluated. The patients' average age at the time of the revision procedure was 64.9 years (range, thirty to ninety-four years). Seventy-three percent (100/27) of the revision arthroplasties were done on female patients. For all hips, the average time between the index procedure and revision surgery was 7.2 years; for infected hips, it was 4.5 years; and for noninfected hips, it was 8.0 years. The explanations for the revision methods are compiled in Table 1.

Table 1: Reason for Revision Procedures

Preoperative Diagnosis	Number of Procedures
Aseptic loosening	79
Chronic infection	35
Instability	34
Acute* infection	
Acute hematogenous	11
Acute postoperative	7
Periprosthetic fracture	14
Implant fracture	10
Polyethylene wear	10
Limb-length discrepancy	1

*Diagnosed less than six weeks after the onset of symptoms.

The mean, range, and standard deviation of the preoperative erythrocyte sedimentation rate and C-reactive protein level, the white blood cell count and the percentage of polymorphonuclear cells in the synovial fluid aspirated from the hip, and the time from the initial procedure to revision for both infected and noninfected hips are summarised in Table II. Between the two groups, every value was significantly different ($p < 0.001$). Additionally, there were significant differences between the infected and noninfected groups in the gross appearance, findings from frozen-section analysis, and final his to pathology findings (p 0.001 for all comparisons).

Table 2: Organisms Isolated in the Fifty-five Infected Hips

Organism	Number of Hips
Staphylococcus aureus	24
Staphylococcus epidermidis	11
Streptococcus species	4
Enterococcus species	2

Haemophilus parainfluenzae	1
Mycobacterium malmoense	1
Proteus mirabilis	1
Pseudomonas aeruginosa	1
Veillonella species	1
Anaerobic Gram-positive cocci*	1
Multiple organisms	1
No organism identified	7

*Unable to be further identified.

Our overall patient cohort's ideal white blood cell count cut-point was 4200 white blood cells/mL. The hip aspirate white blood cell count exhibited an accuracy of 90%, a positive predictive value of 81%, a negative predictive value of 93%, and a sensitivity of 84% at this cut-point. The power and accuracy of the predictive tests increased when the hip aspirate white blood-cell count differential was paired with preoperative erythrocyte sedimentation rate and C-reactive protein status. The optimal cut-point for the white blood-cell count on aspirated fluid when both the erythrocyte sedimentation rate and the C-reactive protein level were elevated remained at 3000 white blood cells/mL, with a sensitivity of 91%, a specificity of 86%, a positive predictive value of 95%, a negative predictive value of 77%, and an accuracy of 88%. The data were reanalyzed after the fifteen secondary procedures on nonunique patients were excluded.

The sensitivity, specificity, positive predictive value, negative predictive value, and accuracy when the erythrocyte sedimentation rate and C-reactive protein level were both elevated above their respective reference ranges were 91%, 91%, 95%, 83%, and 91%, respectively, at the cut-point of 3000 white blood cells/mL, as opposed to 90%, 91%, 95%, 82%, and 90%, respectively, when the erythrocyte sedimentation rate and C-reactive protein level Additionally, when the preoperative erythrocyte sedimentation rate and C-reactive protein level were both 30 mm/hr and 10 mg/dL, respectively, our data showed a 100% specificity for a hip not to be infected.

Discussion and Conclusion

Because the treatment for an infected hip differs significantly from the treatment for a noninfected hip, infection must be ruled out for a successful evaluation of pain at the site of a total hip arthroplasty [7, 8]. On the basis of a comprehensive history, physical exam, and study of plain radiographs, an infection may occasionally be visible. But frequently, imaging techniques and other laboratory testing are required to rule out infection. Tests that are easily accessible to the majority of surgeons in a range of practice settings are required in such situations. Radiologists' knowledge and the skills of specialized laboratory staff are required for advanced nuclear imaging and molecular biologic procedures [9]. We offer diagnostic criteria that are practical for most surgeons to utilise when making preoperative decisions.

The usefulness of the preoperative erythrocyte sedimentation rate and C-reactive protein level in identifying periprosthetic hip infections has been investigated in several studies [10,11]. The erythrocyte sedimentation rate and the C-reactive protein level must be used in conjunction with a thorough history and physical examination because they are nonspecific inflammatory markers. Levels may increase without being a sign of infection in cases of recent surgery and active systemic inflammatory diseases [12]. Patients with an inflammatory arthritis preoperative diagnosis were not included in the current investigation. Similar sensitivity and specificity for the erythrocyte sedimentation rate and the C-reactive protein level were shown in prior studies on the diagnosis of infection prior to revision total joint arthroplasty to those in the current study, though Span Gehl et al. [2] reported a higher specificity for the erythrocyte sedimentation rate. We discovered that this set of preoperative tests provided 100% specificity for excluding infection at the site of a total hip arthroplasty since none of our patients with normal erythrocyte sedimentation rate and C-reactive protein level had an infection. This result is consistent with that of the study by Span Gehl et al. [2], which discovered no periprosthetic infections linked to normal levels of C-reactive protein2 and erythrocyte sedimentation rate. As a reliable, inexpensive screening technique to rule out infection, we advise using a combination of the history, physical examination, a normal erythrocyte sedimentation rate, and a normal C-reactive protein level [13, 14].

Hip aspiration provides a number of benefits when used as a perioperative diagnostic technique to determine the white blood cell count and differential. It can be done either preoperatively or intraoperatively; in our institution, the results are often available in 45 minutes or less when done intraoperatively [15, 16].

In our investigation, the combination of preoperative erythrocyte sedimentation rate and C-reactive protein level with hip aspiration for the assessment of the synovial fluid white blood-cell count was the most predictive perioperative testing modality.

Using our analysis as a guide, we recommend using a cut-point of 3000 white blood cells/ mL when the erythrocyte sedimentation rate and C-reactive protein level are both elevated, and a cut-point of 9000 white blood cells/ mL when either the erythrocyte sedimentation rate or the C-reactive protein level (but not both) is elevated. These cut-points are significantly less stringent than those used in several earlier reports on lower extremity periprosthetic infection, which have used cut-points ranging from 25,000 to 80,000 white blood cells/mL. A recent study on revision total knee arthroplasty by Della Valle et al. [14] determined that 3000 white blood cells per milliliter of aspirated synovial fluid was the ideal cut-point. Additionally, we discovered that when the preoperative erythrocyte sedimentation rate and C-reactive protein level are both high, the white blood cell count differential is highly accurate and beneficial. In the white blood cell differential, the % polymorphonuclear count is a helpful adjunct in the diagnosis of infection.

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