Preoperative Testing for Sepsis Before Revision Total Knee Arthroplasty

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Abstract: One hundred five consecutive painful knee arthroplasties were evaluated by a single surgeon for the presence of infection using a uniform protocol that included an erythrocyte sedimentation rate (ESR), C-reactive protein (CRP), perioperative aspiration with synovial fluid white blood cell (WBC) count and differential, intraoperative frozen section analysis, and culture. A synovial fluid WBC count of greater than 3000 was the most precise test with a sensitivity of 100%, specificity of 98%, and accuracy of 99%. The preoperative use of an ESR and CRP proved to be an excellent screening modality with only one infection identified with both values being normal. A rational approach to perioperative testing for sepsis includes a screening ESR and CRP, and if elevated, aspiration with synovial fluid WBC count or an intraoperative frozen section. **Key words:** total knee arthroplasty, revision, infection, aspiration, synovial fluid white blood cell count.

Infection is a common cause of failure after total knee arthroplasty, and the diagnosis of infection must always be considered when evaluating the patient with a painful knee arthroplasty. The perioperative diagnosis of infection as the cause of failure is important to make both to implement appropriate treatment and, if recognized preoperatively, to counsel patients on the expected treatment plan and outcomes, as the treatment of a deep infection is fundamentally different from treating other modes of failure.

There are a multitude of perioperative tests available to the clinician for diagnosing infection including preoperative laboratory testing (erythrocyte sedimentation rate [ESR] and C-reactive protein [CRP]), plain radiographs, nuclear medicine scans [1-3], intraoperative gram stains [4], intraoperative frozen sections [5-7], and preoperative or intraoperative aspiration with synovial fluid white blood cell (WBC) count and culture [8-10]. The utility of these different tests has been studied by previous authors; however, few studies have specifically examined the utility of perioperative aspiration of the knee with a focus on the use of the WBC count obtained from the aspirated fluid and reported on the utility of this test compared with other testing modalities when multiple tests were implemented in a consistent manner. The aim of this study is to report on the utility of commonly available tests for determining periprosthetic infection of the knee in a consecutive series of revision total knee arthroplasties that all underwent a consistent protocol for evaluating infection with a specific focus on the use of the synovial fluid WBC count.

Materials and Methods

One hundred five consecutive knees in 94 patients underwent perioperative evaluation and revision surgery between September of 2002 and May of 2005 by a single surgeon who implemented a consistent protocol when evaluating painful knee arthroplasties for infection. Of the 11 patients counted more than once, 6 patients underwent a second revision after the first revision procedure in the

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Table 1. Reason for Revision Procedures

Chronic infection	25
Acute hematogenous infection	11
Loosening tibial component	9
Instability	9
Stiffness	7
Patellar maltracking	6
Acute postoperative infection	5
Polyethylene wear	5
Loose femoral component	7
Loose femoral and tibial components	4
Osteolysis	2
Periprosthetic fracture	2
Failed patellofemoral arthroplasty	1
Failed unicompartmental arthroplasty	1
Total	94

same knee, 3 patients underwent revision procedures on both knees, and 1 patient had revisions performed on both knees and a second revision performed in one of the knees. Only patients with a total knee arthroplasty in place (and not those who had previously had a resection arthroplasty) were included in this analysis. Institutional review board approval was obtained for this study.

The protocol used included a preoperative ESR and CRP, aspiration of the knee preoperatively (including a synovial fluid WBC count with differential and aerobic, anaerobic, fungal, and acid fast bacilli cultures), 3 full sets of intraoperative cultures taken from within the knee joint, intraoperative frozen sections taken from synovial tissue adjacent to the implants, and permanent histopathological examination of the same tissues. In knees where no fluid was obtained at the time of the preoperative aspiration, a second aspiration was performed before the skin incision but after prepping and draping at the time of the revision procedure; this was performed in 8 knees.

The following values were considered to be abnormal and potentially indicative of infection based on prior reports: an ESR greater than 30 [11], a CRP greater than 10 mg/dL [11], an average of more than 10 polymorphonuclear cells (PMN) seen within tissue (and not fibrin) in the 5 most cellular fields seen on the frozen sections or the final histopathology [6], and a synovial fluid WBC differential showing more than 65% PMN [9]. The synovial fluid WBC count was assessed at various cutoff points ranging from 1000 to 10 000 WBCs/mL to determine an optimal cutoff value. Cultures were considered positive if organisms grew on the solid media;

Table 2. Procedure Performed

Revision of both components	44
Resection arthroplasty	25
Debridement with exchange of the polyethylene liner	16
Polyethylene liner exchange (aseptic)	6
Tibial component revision	2
Femoral component revision	1
Total	94

Table 3. Infecting Organisms

Staphylococcus aureus	15
Staphylococcus epidermidis	11
Streptococcus species	5
Enterococcus faecalis	2
Escherichia coli	1
Pseudomonas aeruginosa	1
Propionibacterium acnes	1
Multiple organisms	1
No organism identified	4

cultures showing growth in the liquid media only were not considered to be consistent with infection. Intraoperative gram stains were not obtained because prior studies have shown that this testing modality is not useful for identifying periprosthetic infection [4]. Nuclear medicine scans were not routinely ordered as part of the preoperative evaluation. Prophylactic antibiotics were withheld before obtaining operative cultures.

An individual knee was considered to be infected if an organism grew on the solid media from at least 2 of the 3 cultures or if 2 of the following 3 criteria were met: at least one culture was positive, the final histopathology was consistent with infection, or gross purulence was seen at the time of revision surgery. Infections were classified as acute postoperative if they underwent reoperation less than 6 weeks postoperatively and as acute hematogenous if they presented with less than 5 days of acute pain in previously well-functioning knee, met the criteria for infection stated above, and had well-fixed implants.

Sensitivity, specificity, negative predictive value (NPV), positive predictive value (PPV), and accuracy were determined for each test [12]. Statistical analysis was performed using a 2-tailed Student *t* test.

Results

Eleven of the 105 knees were excluded; a draining sinus was found in 4 (and thus the diagnosis of infection was not

Table 4. Mean Testing Values for Infected and Noninfected Knees

Test	Infected	Not Infected	*P*
ESR			
Mean	79.6	26.3	<.001
Range	4-140	1-91	
Standard deviation	34.3	19.4	
CRP			
Mean	123	7.4	<.001
Range	2-464	1-35	
Standard deviation	128.6	8.7	
Synovial fluid WBCs/mL			
Mean	56573	645.0	<.001
Range	8395-179 000	7-4000	
Standard deviation	43 707.80	834.1	
% PMN			
Mean	92	23.0	<.001
Range	49-100	0-90	
Standard deviation	9	28.3	

Table 5. Sensitivity, Specificity, PPV, NPV, and Accuracy for the Perioperative Tests

Test	Sensitivity	Specificity	PPV	NPV	Accuracy
ESR	90.2%	66.0%	67.3%	89.7%	76.6%
CRP	95.1%	75.5%	75.0%	95.2%	84.0%
WBC count*	100.0%	98.1%	97.6%	100.0%	98.9%
Culture aspirate	80.0%	93.3%	94.1%	84.3%	88.2%
% PMN	97.6%	84.9%	83.3%	97.8%	90.4%
Frozen section	87.8%	96.2%	94.7%	91.1%	92.6%

*WBC count = synovial fluid WBC per milliliter.

in question), no fluid was obtained at the time of the aspiration in 3, the aspirated fluid could not be analyzed in 2 (as it was too viscous), and data were incomplete in 2 knees. Reasons for the revision procedures performed in the remaining 94 knees are shown in Table 1, and the procedures performed are shown in Table 2. The mean age at the time of reoperation was 66.6 years (range, 34-89 years), and 56 of the knees were in female patients (59.6%). The index revision was the first in 57 (60.6%), the second in 29 (30.8%), the third in 6 (6.4%), and the fourth and fifth in one each (2.2%).

Forty-one of the 94 knees met the criteria for infection. The organisms identified are shown in Table 3. In 4 of the knees judged to be infected, no organism could be identified. The mean ESR, CRP, cell count, and percentage of PMN for the infected and not infected knees are shown in Table 4; the means for all 4 variables were significantly different in the 2 groups. When tested at various cutoff values ranging from 1000 to 10 000 WBCs/mL, a synovial fluid WBC count of 3000 yielded optimal precision. The sensitivity, specificity, PPV, NPV, and accuracy calculations are shown in Table 5. The synovial fluid WBC count and the intraoperative frozen section analysis proved to be the best testing modalities. When viewed together, the ESR and CRP proved to be a good screening test, with only one infected knee having both a negative ESR and CRP.

Discussion

Multiple tests are presently available for the perioperative identification of deep prosthetic infection. The ideal test should be both sensitive and specific while also being inexpensive, readily available, and simple to perform. Based on the results of this study, we believe perioperative aspiration with a synovial fluid WBC count to be the best test that is presently available for diagnosing infection at the site of a failed knee arthroplasty. Advantages of this test include the ability to perform it either preoperatively or intraoperatively, its low cost, and its ubiquitous nature (no specialized equipment is required). Furthermore, this test is easily accomplished in the office setting and when done preoperatively can also potentially identify the infecting organism to assist with postoperative antibiotic management. When done intraoperatively, the analysis is usually accomplished within 45 minutes, allowing the surgeon to use this as an intraoperative test if desired or if no fluid was obtained at the time of attempted preoperative aspiration.

Our results are in agreement with those of others [9,10] who similarly found the synovial fluid WBC count to be a useful test for identifying periprosthetic sepsis in the setting of revision total knee arthroplasty. Strengths of the present study include the uniform nature of the perioperative testing protocol by a single surgeon and its prospective nature that allows for comparison between the testing modalities studied. The prevalence of infection in this subset of patients at a tertiary care center was however higher than that seen in most practices, and this may have improved the precision of the various tests studied in this report.

We choose to use a value of 3000 WBCs/mL as our cutoff for infection because this yielded optimal sensitivity, specificity, and accuracy. Trampuz et al [9] in a similar study examined the results of 133 knee aspirates and found that a synovial fluid WBC count of 1700/mL was consistent with infection, whereas Mason et al [10] recommended a cutoff value of 2500 WBCs/mL in their study of 86 aspirations. Although these cutoff values differ, it is clear that the threshold for identifying infection in a prosthetic joint is far lower than that of the native knee, where 50 000 WBCs/mL is generally considered to be consistent with infection.

Analysis of intraoperative frozen sections of tissue taken adjacent to the implants was also shown to be a useful test in this study as has been shown by others [5-7]. Although this methodology proved useful in our practice, it does require a dedicated and interested pathologist to gain experience in interpreting the specimens; and such conditions may not be available to all surgeons who perform revision procedures. Furthermore, this test is subjective by nature and subject to sampling error as opposed to the synovial fluid aspirate that is more objective and not subject to sampling error.

The preoperative use of an ESR and CRP as a routine screening test before revision total joint arthroplasty has been advocated because they are easily obtained and have shown high sensitivity for identifying infection [11]. In our series, these 2 testing modalities proved to be an extremely useful screening tool with only one infection having both normal ESR and CRP. Based on this data, a rational approach to evaluation would include the selective use of preoperative aspiration of a painful knee arthroplasty in patients with an elevated ESR or CRP (or if the clinical suspicion for infection is high) combined with an intraoperative aspiration or an intraoperative frozen section of the periprosthetic synovial tissues.

References

1. Merkel KD, Brown ML, Dewanjee MK, et al. Comparison of indium-labeled leukocyte imaging with sequential technetium-gallium scanning in the diagnosis of low-grade musculoskeletal sepsis. A

prospective study. J Bone Joint Surg Am 1985;67: 465.
2. Merkel KD, Brown ML, Fitzgerald Jr RH. Sequential technetium-99m HMDP-gallium-67 citrate imaging for the evaluation of infection in the painful prosthesis. J Nucl Med 1986;27:1413.
3. Scher DM, Pak K, Lonner JH, et al. The predictive value of indium-111 leukocyte scans in the diagnosis of infected total hip, knee, or resection arthroplasties. J Arthroplasty 2000;15:295.
4. Della Valle CJ, Scher DM, Kim YH, et al. The role of intraoperative Gram stain in revision total joint arthroplasty. J Arthroplasty 1999;14:500.
5. Feldman DS, Lonner JH, Desai P, et al. The role of intraoperative frozen sections in revision total joint arthroplasty. J Bone Joint Surg Am 1995;77:1807.
6. Lonner JH, Desai P, Dicesare PE, et al. The reliability of analysis of intraoperative frozen sections for identifying active infection during revision hip or knee arthroplasty. J Bone Joint Surg Am 1996;78:1553.
7. Della Valle CJ, Bogner E, Desai P, et al. Analysis of frozen sections of intraoperative specimens obtained at the time of reoperation after hip or knee resection arthroplasty for the treatment of infection. J Bone Joint Surg Am 1999;81:684.
8. Barrack RL, Jennings RW, Wolfe MW, et al. The Coventry Award. The value of preoperative aspiration before total knee revision. Clin Orthop 1997:8.
9. Trampuz A, Hanssen AD, Osmon DR, et al. Synovial fluid leukocyte count and differential for the diagnosis of prosthetic knee infection. Am J Med 2004;117:556.
10. Mason JB, Fehring TK, Odum SM, et al. The value of white blood cell counts before revision total knee arthroplasty. J Arthroplasty 2003;18:1038.
11. Spangehl MJ, Masri BA, O'Connell JX, Duncan CP. Prospective analysis of preoperative and intraoperative investigations for the diagnosis of infection at the sites of two hundred and two revision total hip arthroplasties. J Bone Joint Surg Am 1999;81: 672.
12. Einhorn TA, Lucas TS, Molinari RW. Conditions affecting orthopaedic surgical practice. Rosemont: American Academy of Orthopaedic Surgeons; 1994.