Diagnosing Infection in Patients Undergoing Conversion of Prior Internal Fixation to Total Hip Arthroplasty

Introduction

Hip fractures accounted for over 340,000 hospital admissions in 2008 and are expected to rise to over 580,000 by 2040 due to an aging population in the United States.\(^1,2\) Patients initially managed with open reduction and internal fixation that result in nonunion, early fixation failure, and post traumatic arthritis can be effectively treated with either revision internal fixation (with or without bone grafting) or conversion to total hip arthroplasty (THA).\(^1-11\) Although conversion THA for failed hip internal fixation has good results, previous reports demonstrate that conversion THA has an increased incidence of superficial and deep infection compared to primary THA.\(^19\)

Periprosthetic joint infection is a devastating complication in THA, resulting in a substantial morbidity to the patient and cost burden to the health care system, and the diagnosis is often unclear.\(^20\)

Currently, there are no recommendations for the diagnosis and management of infection prior to conversion of prior internal fixation to THA. The purpose of this study is to identify the incidence of infection in patients undergoing conversion of prior internal fixation to THA. We investigated several preoperative risk factors for infection and evaluated the utility of preoperative erythrocyte sedimentation rate (ESR) and C-reactive protein (CRP) as screening tools to identify patients with occult infection.

Materials & Methods

This study is an Institutional Review Board approved retrospective review of patients at a single institution who underwent conversion of prior internal fixation to THA from 2009-2014. We searched the hospital’s patient database and identified 33 patients that underwent conversion of prior internal fixation to THA, were greater than 18 years of age, and had laboratory data for ESR and CRP. The study’s primary outcome variable was the presence of infection diagnosed by positive culture results at the time of conversion THA or at short-term follow up. Patients diagnosed with infections preoperatively underwent either removal of hardware with antibiotic cement spacer implantation, staged conversion THA, and 6 weeks of intravenous antibiotics, or single-staged conversion THA with an antibiotic cement-impregnated implant and 6 weeks of intravenous antibiotics. Patients with positive intraoperative cultures that were diagnosed as infected postoperatively were treated with a debridement and/or 6-week course of intravenous antibiotics. After conversion THA or infection treatment, patients were followed for at least 60 days postoperatively (mean follow up of 1 year, range 2-30 months).

An a priori power analysis indicated the need to enroll a minimum of 31 patients to detect a standard large effect size \(w = 0.5\), assuming a type-I error rate of 0.05 and a power of 0.80. Medical co-morbidities, smoking history, body mass index (BMI), prior hip surgery, and preoperative inflammatory markers (ESR and CRP) were documented and analyzed with univariate and multivariate logistic regression analysis (Table 2). Because we could not assume our small sample size was normally distributed, continuous variables were compared using the non-parametric Mann-Whitney U test. Categorical variables were compared using the Chi-square test; when the observed or expected values were less than 5, the Fisher Exact Test was used (Table 1). Receiver operating characteristic (ROC) curves were then generated to determine test performance of traditional inflammatory markers, ESR and CRP. Statistical significance was set at \(p = 0.05\).

Results

The 33 patients in this study included 9 (26%) with a previous intramedullary nail, 8 (23%) with acetabular internal fixation, 2 (6%) with slipped capital femoral epiphysis internal fixation, and 10 (28%) with femoral neck percutaneous screws. There were 16 males and 17 females included in the study with a mean age of 56 years (range 19-88 years). This study included 6 infected patients (18%) and 27 non-infected patients (82%). Logistic regression analysis showed no significant differences in age, BMI, and co-morbidities including diabetes mellitus, cardiac disease, smoking history, obesity, morbid obesity, and advanced age over 70 years between the two groups (Table 2).

Mean ESR and CRP were significantly higher (\(p < 0.05\)) in the infected group (41.6 mm/hr and 2.02 mg/dL) compared to the non-
for ESR.

30mm/hr was 27.66 (95% CI 1.08-705.88) and 3.45 (95% CI 0.23-51.15) for CRP.

1mg/dL. ROC curves assessing the utility of inflammatory markers as a diagnostic tool for infection at the time of conversion THA showed a good fit for both ESR (AUC 0.894) and CRP (AUC 0.891) (Figure 1). Using a CRP.

0.7mg/dL had 100% sensitivity, 80.7% specificity, 100% negative predictive value, and 54.5% positive predictive value. Using an ESR.

30mm/hr had 83.3% sensitivity, 84.6% specificity, 95.6% negative predictive value, and 55.5% positive predictive value. Using a CRP.

0.7mg/dL or an ESR.

30mm/hr had 100% sensitivity, 76.9% specificity, 100% negative predictive value, and 50% positive predictive value. Using both CRP.

0.7mg/dL and ESR > 30mm/hr had 83.3% sensitivity, 88.4% specificity, 95.8% negative predictive value, and 62.5% positive predictive value.

infected group (19.3 mm/hr and 1.27 mg/dL). There was a significant incidence (p < 0.05) of elevated ESR > 30mm/hr and elevated CRP > 1mg/dL in the infected group (84% and 67% respectively) when compared with the non-infected group (15% and 15% respectively). Two (33%) of the infected patients had a CRP that was not elevated (CRP.

1mg/dL) but had an elevated ESR (ESR.

30mm/hr). Of the non-infected patients, 5 (18%) had either an elevated ESR or CRP, but these patients did not develop symptoms of prosthetic joint infection (PJI) during the follow-up period. Univariate analysis demonstrated that ESR > 30mm/hr (OR 28.75 (95% CI 2.62-315.42)) and CRP > 1mg/dL (OR 11.5 (95% CI 0.23-51.15)) were risk factors for the diagnosis of infection at the time of conversion THA. When controlling for confounding variables, multivariate analysis also showed that the odds ratio for ESR > 30mm/hr was 27.66 (95% CI 1.08-705.88) and 3.45 (95% CI 0.23-51.15) for CRP > 1mg/dL.

ROC curves assessing the utility of inflammatory markers as a diagnostic tool for infection at the time of conversion THA showed a good fit for both ESR (AUC = 0.894) and CRP (AUC = 0.891) (Figure 1). Using a CRP > 0.7mg/dL had 100% sensitivity, 80.7% specificity, 100% negative predictive value, and 54.5% positive predictive value. Using an ESR > 30mm/hr had 83.3% sensitivity, 84.6% specificity, 95.6% negative predictive value, and 55.5% positive predictive value. Using a CRP > 0.7mg/dL or an ESR > 30mm/hr had 100% sensitivity, 76.9% specificity, 100% negative predictive value, and 50% positive predictive value. Using both CRP > 0.7mg/dL and ESR > 30mm/hr had 83.3% sensitivity, 88.4% specificity, 95.8% negative predictive value, and 62.5% positive predictive value.

Table 1. Comparison of risk factors of patients undergoing conversion total hip arthroplasty who were both infected and non-infected

<table>
<thead>
<tr>
<th>Risk Factor</th>
<th>Infected (n = 6)</th>
<th>Non-infected (n = 27)</th>
<th>P value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mean Age (years)</td>
<td>66.2</td>
<td>52.5</td>
<td>0.191</td>
</tr>
<tr>
<td>Mean BMI (kg/m2)</td>
<td>29.2</td>
<td>27.3</td>
<td>0.562</td>
</tr>
<tr>
<td>Mean Preoperative ESR (mm/hr)</td>
<td>41.6</td>
<td>19.3</td>
<td>0.003</td>
</tr>
<tr>
<td>Mean Preoperative CRP (mg/dL)</td>
<td>2.02</td>
<td>1.27</td>
<td>0.003</td>
</tr>
<tr>
<td>Diabetes (%)</td>
<td>1 (16)</td>
<td>2 (7)</td>
<td>0.464</td>
</tr>
<tr>
<td>Cardiac disease (%)</td>
<td>1 (16)</td>
<td>5 (19)</td>
<td>1.000</td>
</tr>
<tr>
<td>Smoking history (%)</td>
<td>2 (33)</td>
<td>7 (26)</td>
<td>1.000</td>
</tr>
<tr>
<td>Obesity (%)</td>
<td>1 (16)</td>
<td>3 (11)</td>
<td>1.000</td>
</tr>
<tr>
<td>Morbid Obesity (%)</td>
<td>1 (16)</td>
<td>2 (7)</td>
<td>0.464</td>
</tr>
<tr>
<td>Age &gt; 70 years</td>
<td>3 (50)</td>
<td>6 (22)</td>
<td>0.309</td>
</tr>
<tr>
<td>ESR &gt; 30 (%)</td>
<td>5 (83)</td>
<td>4 (15)</td>
<td>0.007</td>
</tr>
<tr>
<td>CRP &gt; 1 (%)</td>
<td>4 (67)</td>
<td>4 (15)</td>
<td>0.037</td>
</tr>
</tbody>
</table>

Table 2. Univariate and multivariate logistic regression analysis on risk factors for infection at the time of conversion of prior hip surgery to THA

<table>
<thead>
<tr>
<th>Risk Factor</th>
<th>Univariate Analysis</th>
<th>Multivariate Analysis</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Odds Ratio</td>
<td>95% Confidence Interval</td>
</tr>
<tr>
<td>Age &gt; 70 years</td>
<td>3.50</td>
<td>0.55 – 22.20</td>
</tr>
<tr>
<td>Diabetes</td>
<td>2.50</td>
<td>0.18 – 33.17</td>
</tr>
<tr>
<td>Cardiac disease</td>
<td>0.88</td>
<td>0.08 – 9.29</td>
</tr>
<tr>
<td>Smoking history</td>
<td>1.43</td>
<td>0.21 – 9.58</td>
</tr>
<tr>
<td>Obesity</td>
<td>1.60</td>
<td>0.14 – 18.72</td>
</tr>
<tr>
<td>Morbid Obesity</td>
<td>2.50</td>
<td>0.18 – 33.17</td>
</tr>
<tr>
<td>ESR &gt; 30</td>
<td>28.75</td>
<td>2.62 – 315.42</td>
</tr>
<tr>
<td>CRP &gt; 1</td>
<td>11.50</td>
<td>1.55 – 85.15</td>
</tr>
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</table>
We also recognize the limitations of our retrospective chart review with a relatively small sample size ($n = 33$), which is only powered to detect large effect sizes. We risk committing type II error, particularly in the case of variables such as age and diabetes which were associated with increased risk of infection in our series, but not statistically significant. Finally, as a surgical procedure, conversion THA can be quite variable with patients having a variety of demographics, co-morbidities, and types of previous internal fixation procedures. These factors can limit our ability to make specific conclusions regarding the true impact of patient risk factors on infection prior to conversion THA. Nevertheless, given that the case mix of procedures in both groups was similar and comparable, certain generalizations about infection risks in patients undergoing conversion THA can be made.

Conclusions

Given the complexity of conversion THA and morbidity of infection constant vigilance for occult infection must be maintained. The assessment for infection prior to conversion THA should begin with a detailed patient history. Symptoms such as a pain following a pain-free interval after ORIF, nighttime pain, or pain at rest should raise suspicion for infection. A physical examination should be performed and include an assessment of prior hip incisions. Following history and physical examination, routine laboratory studies should include CBC, ESR, and CRP. Elevated inflammatory markers should prompt a preoperative hip aspiration. Synovial fluid analysis including white blood cell count with differential as well as aerobic and anaerobic cultures should be performed.

Elevated ESR and CRP are associated with infection prior to conversion THA. Although elevated ESR and CRP are useful tools to screen for occult infection prior to conversion THA, given the high incidence of discordance in inflammatory markers in this series, patients with both elevated and borderline inflammatory markers should prompt further evaluation with diagnostic hip aspiration including white blood cell count, differential, and culture prior to conversion THA surgery as the results may affect preoperative planning.

Discussion

This study has several limitations. First, we only included patients with inflammatory markers drawn prior to conversion THA. This results in a strong selection bias, as 97 patients who underwent conversion THA did not have an ESR or CRP.

References