The Association of Perioperative Glycemic Control With Postoperative Surgical Site Infection Following Open Carpal Tunnel Release in Patients With Diabetes

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Abstract

Background: The primary goal of the study was to evaluate the association of hemoglobin A1c (HbA1c) levels in diabetic patients with the incidence of surgical site infection (SSI) following open carpal tunnel release (CTR). Our secondary objective was to calculate an HbA1c level in diabetic patients that predicted SSI after open CTR. **Methods:** A national private-payer insurance database was queried for patients who underwent open CTR using Current Procedural Terminology (CPT) code 64721. Patients who underwent concomitant procedures were excluded. Diabetic patients who had their HbA1c level checked within 3 months of surgery were stratified into 6 mutually exclusive groups based on HbA1c levels in 1.0 mg/dL increments from <6.0 to >10 mg/dL. The incidence of SSI was determined for each group by either a diagnosis or procedure for SSI within 1 year using CPT and International Classification of Diseases, 9th Revision (ICD-9) codes. A receiver operating characteristic (ROC) analysis was performed to determine an HbA1c level above which the risk of postoperative SSI was significantly increased. **Results:** 7958 diabetic patients who underwent open CTR and had an HbA1c recorded within 3 months of surgery were assessed. The incidence of SSI within 1 year was associated with HbA1c levels. The inflection point of the ROC curve corresponded to an HbA1c level between 7 and 8 mg/dL. **Conclusions:** Increased HbA1c levels are associated with increased SSI rates in diabetic patients undergoing open CTR. A perioperative HbA1c between 7 and 8 mg/dL could serve as a threshold for an increased risk of SSI following open CTR.

Keywords: carpal tunnel syndrome, carpal tunnel release, diabetes mellitus, hemoglobin A1c, surgical site infection

Introduction

Diabetes mellitus (DM) affects roughly 12% of American adults aged 20 or older and had a reported prevalence in this age group of 7.8 cases per 1000 persons in 2012.²¹ Aside from its direct impact on the health of those it affects, it also increases the risk of surgical site infection (SSI) after numerous types of surgery,³² including reconstruction of the anterior cruciate ligament,² total joint arthroplasty,^{7,14,18} foot and ankle surgery,^{15,31} spinal surgery,^{12,23} and hand surgery.^{3,11} These infections are costly to patients and hospitals both on an inpatient and postdischarge basis and negatively impact quality of life.^{5,25,30}

Diabetes mellitus is also a risk factor in the development of carpal tunnel syndrome (CTS).²⁶ Functional outcomes of carpal tunnel release (CTR) in diabetic patients are comparable with those in nondiabetic patients,^{22,29} and

SSI following CTR is rare, with reported rates ranging from 0.23% to 6.0%.^{1,3,8–10,16,20,28,34} A few studies have examined the influence of DM on the development of SSI following CTR, but no association has been found.^{10,22,34}

However, others have used hemoglobin A1c (HbA1c) in diabetic patients receiving total joint arthroplasty¹⁸ and foot and ankle surgery^{15,31} to stratify them in terms of how well their DM was controlled at the time of surgery and noted an association between increasing HbA1c levels and the risk for SSI. In addition, receiver operating characteristic (ROC)

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analysis has been successfully applied to determine an HbA1c level that could predict SSI in diabetic patients in foot and ankle surgery.¹⁵

In spite of previous reports, the purpose of the present study was to determine whether perioperative HbA1c levels are associated with SSI after open CTR in diabetic patients. We also sought to employ an ROC analysis to determine whether a threshold HbA1c level exists that can identify diabetic patients who are at high risk for SSI after open CTR. We hypothesized that higher HbA1c levels would be associated with a higher incidence of SSI following open CTR and that an HbA1c cutoff point that predicts SSI would therefore be possible to calculate.

Materials and Methods

Data Collection

The PearlDiver Patient Records Database (www.pearliver-inc.com; PearlDiver, Inc, Fort Wayne, Indiana), a for-fee insurance-based database of patient records, was used in the present study to obtain patient data. The database uses International Classification of Diseases, 9th Revision (ICD-9) diagnoses and procedures or Current Procedural Terminology (CPT) codes to report procedural volumes, patient demographics, and average charge information for patients. All of the data are de-identified and anonymous, so the study was exempt from institutional review board approval. A private-payer database within PearlDiver, with patient data between 2007 and 2015, was queried for the present study as it contains laboratory data and values in addition to the above-mentioned demographic and surgical data.

Patients who underwent open CTR in the database were identified with CPT code 64721. Patients who underwent endoscopic CTR were excluded, as were patients who underwent concomitant procedures at the time of open CTR, including concomitant cubital tunnel release, distal radius fracture fixation, and so on. From the remaining patients, all patients with DM who had a perioperative HbA1c level checked within 3 months of surgery were identified. These patients were then stratified into 6 mutually exclusive groups based on their HbA1c in 1.0 mg/dL increments from <6.0 to >10 mg/dL. The incidence of SSI was determined by either a diagnosis or procedure for SSI within 1 year using CPT and ICD-9 codes, and was calculated for each HbA1c group.

Statistical Analysis

A power analysis was performed to assess whether there were sufficient patients included in the database to evaluate the study endpoint comparing infection rates in patients above and below the calculated HbA1c threshold. To detect a 0.6% difference in infection rate between patients above

and below the HbA1c threshold, 7776 patients would be required to achieve 80% power at an $\alpha = 0.05$.

Receiver operating characteristic analysis was performed to determine at which HbA1c level the risk of postoperative SSI was significantly increased. In addition, a multivariate binomial logistic regression analysis was employed to evaluate the independent effect of having an HbA1c level above this determined threshold on infection rates following open CTR. Potential confounding risk factors controlled for were hyperlipidemia, hypertension, peripheral vascular disease, coronary artery disease, congestive heart failure, chronic kidney disease, chronic lung disease, chronic liver disease, hemodialysis use, inflammatory arthritis, depression, hypercoagulable disorders, and hypothyroidism. Diabetes mellitus was not controlled for because all patients included in the study had a diagnosis of DM. An adjusted odds ratio (OR) and 95% confidence interval (CI) were calculated, with $P < .05$ considered statistically significant.

Results

In total, 7958 diabetic patients who underwent open CTR and had a perioperative HbA1c recorded within 3 months of surgery in the database were included in the study. The incidence of SSI within 1 year postoperatively was stratified by HbA1c (Figure 1). Rates of SSI ranged from a low of 0.60% in patients with an HbA1c level of up to 6 mg/dL to a high of 1.7% in patients with an HbA1c level above 11 mg/dL and was significantly associated with increasing HbA1c levels ($P < .0001$). The results of the ROC analysis determined that the inflection point of the curve corresponded to an HbA1c level between 7.0 and 8.0 mg/dL ($P = .027$, specificity = 67%, sensitivity = 44%). Patients in the study with an HbA1c level above 8.0 mg/dL remained at a significantly increased risk for SSI following open CTR after adjusting for several comorbidities through multivariate analysis (OR, 1.77; 95% CI, 1.31-2.39; $P = .006$).

Discussion

Several studies have assessed the influence of DM and glycemic control on the development of SSI, but few have looked at CTR.^{10,20,22,34} However, many reports exist about the incidence of SSI following CTR.^{1,3,8-10,16,20,28,34} The 3 largest studies found infection rates of 0.47%,⁹ 0.37%,¹⁰ and 0.30%.²⁰ These estimates are consistent with the 0.60% infection rate in patients with HbA1c levels up to 6.0 mg/dL, which is lower than the cutoff for clinical DM.¹³

Several mechanisms may contribute to our finding that increased HbA1c levels in diabetic patients increased their risk for SSI following open CTR. Hyperglycemia due to DM causes deficits in leukocytes in both chemotaxis and bactericidal activity.^{4,27} In neutrophils, HbA1c levels are

Figure 1. Postoperative infection risk following open carpal tunnel release stratified by perioperative HbA1c levels.

Note. Patients were divided into 6 groups based on increasing 1.0 mg/dL HbA1c increments, and infection rates were plotted against each HbA1c stratum. HbA1c = hemoglobin A1c; CTR = carpal tunnel release.

inversely related to phagocytic activity.¹⁹ Also, peripheral neuropathy is a common complication in DM, and it impairs neural-mediated vasodilation,²⁴ which in turn impairs the response to injury and wound healing. In a prospective study of 223 diabetic patients receiving foot and ankle surgery,³¹ peripheral neuropathy increased the risk for SSI, and small but long-term studies have shown that HbA1c levels are a marker for decline in peripheral nerve function,^{17,33} including the median nerve.³³ Whether or not these same issues are relevant to open CTR is not clear and should be evaluated in future studies.

While CTR is a fairly superficial procedure, its use in the United States increased 38% from 359 787 to 576 924 cases between 1996 and 2006.⁶ Based on the economic and personal burden of SSI on patients and the health care system,^{5,25,30} understanding contributing factors is critical for any procedure. This is particularly important for CTR and other hand surgeries, as prophylactic antibiotics have not been shown to be effective in preventing SSI in either case.^{3,10} The specificity of our ROC curve was 67%, and as such, HbA1c levels may be a reliable indicator for diabetic patients who have a greater risk for developing SSI following open CTR.

We acknowledge some disagreements between our results and those of previous reports.^{10,20,22,34} However, 3 of these studies did not stratify their diabetic patients based on HbA1c levels.^{10,20,22} Moreover, the low rate of SSI following CTR makes it difficult to assess for differences in SSI

rates between cohorts. Analysis of 3003 CTR patients found respective rates of infection between diabetics and nondiabetics of 0.10% and 0.27%.¹⁰ Similarly, equivalent infection rates of 4.2% in both control and DM groups were found in a study of outcomes of CTR,²² but the groups consisted of 24 diabetic patients and 72 nondiabetic patients. It is possible that any true differences in these studies in terms of SSI were not captured either due to a low incidence of infection in the cohort or due to a small sample size. While a larger study looked at 23 109 CTR cases, they were part of a larger pool of 44 305 hand surgeries.²⁰ These results are therefore not specific to CTR. When 658 CTR cases among 528 diabetic and nondiabetic patients were compared and the diabetic patients stratified on the basis of having an HbA1c level either above or below 7.0%, 27 incidences of SSI developed, and no association with either DM or HbA1c levels was observed.³⁴ This again may have been too small to permit an adequate analysis of these patients.

The strengths of the present study include the large sample size compared with other studies that have assessed the role of DM in SSI rates after CTR and the ability of PearlDiver to access information from patients across the United States. There are of course limitations to our findings that require mention. We did not consider endoscopic CTR in our analysis, and the results cannot be generalized to this form of CTR. Other limitations of the study are inherent to the use of PearlDiver. Because of its retrospective nature, the validity of the analysis is dependent on the quality of the

data. Accuracy of billing codes and miscoding or noncoding by physicians might therefore be sources of error. It is also likely that we excluded many patients with undiagnosed DM because PearlDiver depends on ICD-9 codes. We also can neither assure that our sample represents a true cross-section of the United States nor generalize our findings to patients outside the database. The PearlDiver database consists of de-identified data, limiting the demographic information that is available. In addition, the database identifies infections solely on the basis of diagnosis and procedure codes but does not grant access to patients' medical records, including physical examination data or outcome measures. Further stratification of the infections identified for the study on the basis of their severity is consequently limited.

In spite of these limitations, the association between HbA1c levels and SSI in open CTR and a threshold HbA1c value that can identify patients at a higher risk for SSI could serve as points of discussion between diabetic patients who are candidates for open CTR and their physicians to optimize glycemic control in the months preceding surgery.

Ethical Approval

This study used de-identified patient data and was exempt from institutional review board approval.

Statement of Human and Animal Rights

This article does not contain any studies with human or animal subjects.

Statement of Informed Consent

This article involved the use of a large de-identified patient database, so informed consent was neither necessary nor practical to obtain. There are no figures or tables that contain potentially identifying information for any individual subject in the study.

Declaration of Conflicting Interests

The author(s) declared no potential conflicts of interest with respect to the research, authorship, and/or publication of this article.

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