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ORIGINAL ARTICLE

A novel, validated risk score to predict surgical site infection after pancreaticoduodenectomy

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Abstract

Background: Although pancreaticoduodenectomy (PD) outcomes have improved, complications including surgical site infection (SSI) remain common. We present a stratification tool to predict risk for SSI after PD.

Methods: Data was retrospectively reviewed on all patients undergoing PD at a tertiary hospital (9/2011-8/2014). Potential SSI risk factors identified by univariate analysis were incorporated into a multivariate logistic regression model. The resulting odds ratios were converted into a point system to create an SSI risk score with internal validation.

Results: Six hundred seventy nine patients underwent PD and were chronologically split into derivation (443 patients) and validation (236 patients) groups. There was no difference in demographics or perioperative outcomes between groups. Overall thirty-day SSI was observed in 17.2% (n = 117). Neoadjuvant chemotherapy and/or radiation, intraoperative red blood cell transfusion, operative time greater than 7 h, preoperative bile stent/drain, and vascular resection were associated with SSI in univariate analysis (all $p < 0.05$). On multivariate analysis, preoperative bile stent/drain and neoadjuvant chemotherapy were independent predictors of SSI, each assigned 1 point (both $p < 0.001$). Patients with 0, 1, and 2 points, respectively, had 0%, 32%, and 64% predicted risk of SSI (AUC = 0.73, $R^2 = 0.93$). The model performed equivalently in the validation group (AUC = 0.77, $R^2 = 0.99$).

Conclusion: This novel, validated risk score accurately predicts SSI risk after pancreaticoduodenectomy. Identifying the highest risk patients can help target interventions to reduce SSI.

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Introduction

Pancreatic ductal adenocarcinoma (PDAC) is the fourth leading cause of cancer deaths in the United States with an estimated 40,560 deaths in 2015.[1] Surgical resection remains the best opportunity for cure, and for tumors in the head and neck of the pancreas, this involves performing a pancreaticoduodenectomy (PD).[2,3] Although mortality has improved significantly for patients undergoing pancreatic resection, postoperative morbidity remains high after PD. Surgical site infection (SSI) is one of the most common complications after PD and can lead to delayed time to adjuvant therapy, decreased disease-free survival and decreased overall survival.[2,4–6]

Surgical site infection (SSI) is defined by the Centers for Disease Control (CDC) as an infection involving only the skin or subcutaneous tissue of a surgical incision within 30 days after an operation.[7] It is characterized by erythema, pain, heat, or swelling and may require that the wound be opened.[7] The development of an SSI after abdominal surgery leads to a prolonged hospital length of stay in the majority of patients,

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contributing to dramatically increased post-operative healthcare expenditures.[8–10] Because of the impact SSIs can have on perioperative morbidity and hospital cost as well as disease-free and overall survival, it is important to have a clear understanding of the factors that may contribute to their occurrence. There is limited data on risk factors for SSI in patients who have undergone PD, although previously identified factors include obesity, prolonged operative time, and pancreatic duct diameter.[11] In addition, neoadjuvant chemotherapy has been shown to be a risk factor for SSI in surgical treatment of rectal and breast cancer, but has not previously been definitively associated with SSI after PD.[12,13] Finally, preoperative placement of a biliary stent or drain may increase the risk for an SSI after pancreatic resection. Early studies showed decreased complication rates with preoperative drainage and stenting,[14–16] but more recent studies have yielded equivocal results[17,18] or concluded that biliary stents are associated with increased surgical complications, including SSI.[19–23] Other perioperative measures can be employed to decrease SSI rates including using a laparoscopic approach and prophylactically applying a wound vacuum closure device instead of standard closure.[24]

There is clearly a need for improved SSI risk stratification among patients undergoing PD to allow for preoperative identification of the highest-risk patients and implementation of preventative strategies. This study aimed to identify risk factors associated with an increased risk of SSI after PD and use them to create a risk stratification score.

Methods

Patient selection

All patients who underwent PD at the Johns Hopkins Hospital between September 2011 and August 2014 were included in this study. Prospectively obtained data was analyzed and included patient demographics (age, sex, medical co-morbidities), operative factors, history of chemotherapy or radiation for another malignancy, neoadjuvant or adjuvant therapy for treatment of PDAC, perioperative complications, long-term complications, and tumor histopathology. SSI was identified by retrospective chart review using criteria defined by the Center for Disease Control (CDC).[7] Patients were followed with routine post-operative visits, including a visit approximately two weeks and one month after hospital discharge. This study was carried out with the approval of the Institutional Review Board at the Johns Hopkins Hospital.

Vacuum dressing placement

In a minority of patients, a superficial wound vacuum (VAC) dressing was applied to the wound at the time of surgical closure in a manner previously described.[25] In short, VAC closure involved closure of the dermis using interrupted 3-0 vicryl sutures. Rectangular strips of reticulated open-cell polyurethane white foam (KCI) were cut to size and inserted at 6- to 8-cm intervals through the dermal layer into the subcutaneous space. Exposed areas of skin between the white foam wicks were covered with silver-impregnanted nonadherent dressing (Restore Silver Contact Layer). A negative pressure VAC therapy was applied over the Restore layer, at a continuous pressure of −125 mmHg. The dressing was replaced every 2–3 days until the white foam strips were dry, at which point an SVAC remained in place for two additional days before removal. None of these patients had any evidence of infection at the time of surgery. The VAC dressing was applied at the discretion of the individual surgeon in patients felt to be at higher risk for SSI. This was based on data demonstrating a reduced incidence of SSI and surgical site occurrence (SSO) with prophylactic VAC dressing closure after open ventral hernia repair.[24,25]

Statistical analysis and risk score creation

Summary statistics for patients are presented as percentages for categorical variables and mean values for ranges for continuous variables. Differences between patients with and without SSI were assessed using Fisher's exact test for categorical values and Student's *t*-test for continuous variables. Univariate logistic regression modeling was used to identify individual factors associated with SSI. Covariates with a p-value < 0.20 on univariate analysis met criteria for further analysis and were entered into a multivariable logistic regression model. The Akaike Information Criterion (AIC), Hosmer–Lemeshow goodness-of-fits test and likelihood ratio were used to assess model strength at each step, leading to the derivation of the most parsimonious model. Receiver operator curves were calculated to ensure appropriate sensitivity and specificity of the risk score. Variables significantly associated with SSI by multivariate analysis were assigned point values based on the rounded-off ratios of their relative odds ratios. Weighted linear regression was used to compare observed to predicted rates of SSI based upon the risk score calculated for all patients. Patients were split into derivation and validation cohorts based upon the time period of surgical intervention. The derivation cohort consisted of all patients between September 2012 and August 2014, while the validation cohort consisted all patients between September 2011 and August 2012. Statistical analysis was performed using STATA Version 13.0 (StataCorp, College Station, TX). Significance for all analyses performed was defined as a p-value < 0.05.

Results

Patient characteristics

During the study period, 679 patients underwent pancreaticoduodenectomy and were included for analysis. The average age was 63.7 (range, 19–92 years) and 56% were male. One hundred twenty one patients (18%) were diabetic preoperatively, and 178 patients (26%) presented with weight loss. The average body mass index (BMI) was 26.4 kg/m^2 (range, 15.6–48.4 kg/m^2) and 374 patients (55.1%) were considered overweight with a BMI > 25 kg/

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