https://doi.org/10.1016/j.hpb.2018.01.008 HPB

ORIGINAL ARTICLE

Unique predictors and economic burden of superficial and deep/organ space surgical site infections following pancreatectomy

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Abstract

Background: Surgical site infections (SSIs) are common following pancreatectomy and associated with significant morbidity and economic burden. We sought to identify distinct predictors for superficial versus deep/organ space SSIs and their effects on surgical outcomes.

Methods: ACS-NSQIP targeted pancreatectomy 2014 and 2015 databases were queried. Univariate and multivariate models were developed for both types of SSI, length of stay (LOS), and readmission. Costs were estimated based on Centers for Medicare & Medicaid Services (CMS) recommendations.

Results: Of 8093 patients, there were 422 (5.2%) superficial and 1005 (12.4%) deep/organ space SSIs. On multivariate analyses, preoperative biliary stenting was predictive only for superficial SSI (OR: 2.21), while BMI of 25–29.9 (OR: 1.25) and BMI $\geq$30 kg/m2 (OR: 1.53), pancreatic duct size <3 mm (OR: 1.30), and intermediate (OR: 1.67) versus hard gland texture were predictors of deep/organ-space SSI. Superficial and deep/organ space SSIs were independent predictors of prolonged LOS (OR: 1.74 vs 1.80) and readmission (OR: 2.59 vs 6.57). Additional readmission costs per patient secondary to superficial SSI and deep/organ space SSI were $7661.37 and $18,409.42, respectively.

Conclusion: Deep/organ space SSI contributes more profoundly to prolonged hospital stay, readmission, and additional costs, suggesting that strategies should focus on preferential prevention of deep/organ space infections.

Received 26 June 2017; accepted 4 January 2018

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Background

Surgical site infection (SSI) is a common complication following abdominal surgery. Rates of SSIs as high as 35% after pancreatectomy have been reported,[1,2] which is significantly higher than other major general surgical procedures, such as hepatectomy (3.1%–14%),[3] and colectomy (5%–26%).[4] Differences in SSIs have been established, resulting in the classification by both the United States Centers for Disease Control and Prevention (CDC)[5] and the American College of Surgeons National Surgical Quality Improvement Program (ACS-NSQIP)[6] into three distinct types, based on the level of tissue involvement: superficial incisional, deep incisional, and organ-space.

Studies in other abdominal surgical specialties have shown variations in risk factors among different SSI categories.[3,4,7–9] In addition, surgical outcomes and treatment modalities differ depending on the SSI type, with deep or organ space SSIs often requiring more intensive and invasive interventions compared with superficial SSI. Despite these differences, many studies in pancreatic surgery investigating the risk factors and effects of SSI on patient outcomes have over time grouped all SSI's

☆**Previous Communication**: Mini-oral presentation at the AHPBA Annual Meeting March 29 - 31, 2017.

Please cite this article in press as: Fadayomi AB, et al., Unique predictors and economic burden of superficial and deep/organ space surgical site infections following pancreatectomy, HPB (2018), https://doi.org/10.1016/j.hpb.2018.01.008

together.[1,2,10–13] This may eliminate the opportunity to identify unique modifiable risk factors for proper targeting of quality improvement programs and cost reduction.

This study aims to detect unique predictors for the development of superficial and deep/organ space infections and evaluate their effects on readmission and length of hospital stay, as well as potential cost implications. Our findings hope to provide more granular data and direction for future quality improvement initiatives.

Methods

Data source and study population

A retrospective review of the ACS-NSQIP 2014 and 2015 targeted pancreatectomy participant use data file (PUF) was performed for all adult (age ≥18 years) patients.[6] The ACS-NSQIP is a nationally validated, risk adjusted, peer-controlled registry of patient risk factors and 30-day postoperative outcomes aimed to improve quality of surgical care.[14,15] It is also de-identified and Health Insurance Portability and Accountability Act of 1996 (HIPAA) compliant.[16,17] Inclusion and exclusion criteria, sampling algorithms, and the collected variables with their definitions are publicly available through the American College of Surgeons web page.[6] Institutional Review Board approval was obtained from our institution.

Patient selection

Pancreatic procedures were identified by CPT codes (48120, 48140, 48145, 48146, 48148, 48150, 48152, 48153, 48154, 48155 and 48999). Only inpatients with electively planned pancreatectomies were included. The following groups of patients were excluded from the study: outpatients, disseminated cancer, emergency or non-elective procedures (as defined by the NSQIP manual). Patients with preoperative sepsis within 30 days of surgery, sepsis present at time of surgery (PATOS), septic shock PATOS, superficial SSI PATOS, deep/organ space SSI PATOS, pneumonia PATOS, and urinary tract infection PATOS were excluded (n = 1924) since they may not be considered elective procedures due to another potential underlying etiology. Patients with missing values (height, weight, age, operation time, LOS, unplanned readmission) and unknown values (race, ASA class, radiotherapy, chemotherapy, fistula, vascular resection, operative approach, reason for unplanned readmission) and operation time of zero minutes were also excluded (n = 1202).

Patient characteristics and variables

The baseline, intra-operative and post-operative characteristics of all patients were analyzed. Albumin was categorized according to clinical significance: ≤3 mg/dl or >3 mg/dl and unknown albumin levels were treated as missing values. All patients who were 90 years and older were coded as a maximum of 90 years in NSQIP. Pancreatectomy type was grouped, based on current procedural terminology (CPT) codes as reported in NSQIP, into 1) proximal (48154, 48150, 48153, 48152), 2) distal (48146, 48140, 48145) and 3) others (48155, 48148, 48120, 48999). Days from operation until development of deep incisional SSI complication were used where days from operation until organ-space SSI were missing or unknown. For univariate analysis, age and operative duration were categorized as greater than the median or less than or equal to the median, and modeled as 10-year and 1-h intervals, respectively, for multivariate regression analyses.

Outcomes

Primary outcomes were superficial SSI and deep and/or organ-space SSI within 30-days following pancreatectomy. NSQIP defines superficial SSI as infections involving the skin or subcutaneous tissue of the incision. Deep SSI is defined as an infection involving the deep soft tissues (e.g. fascial and muscle layers) of the incision, while organ-space SSI includes infections involving any part of the anatomy that was opened or manipulated during an operation (other than the incision). The detailed inclusion and exclusion criteria for each SSI are available in the ACS-NSQIP operations manual.[6] Deep and organ-space SSI were grouped together, since infections originating from the organ-space and draining through the surgical incision are labeled as deep SSI in NSQIP, which is also consistent with the CDC definition.[5,6] Patients who developed both a superficial and a deep/organ space SSI were classified as deep/organ-space SSI since it supersedes a superficial SSI in most cases and is consistent with CDC definitions.[5] For analyses, the patient cohort was further divided into two groups: 1) patients with superficial SSI versus no SSI and 2) patients with deep/organ-space versus no SSI.

Secondary outcomes of interest were: 1) length of hospital stay (LOS) measured as days from operation until discharge (modeled as a binary variable; greater than versus less than or equal to the median LOS)[18] and 2) unplanned readmission within 30 days.

Medicare costs

Costs were defined based on recommendations by the Centers for Medicare & Medicaid Services (CMS).[19–23] Readmission costs secondary to SSIs were calculated using Medicare's relative value units (RVUs), hospital and physician fees which are made publicly available on the Centers for Medicare & Medicaid Services (CMS) website.[19,20] The Medicare physician's fee schedule is made available according to current procedural terminology (CPT) codes and the amount paid for a physician's service is the product of three factors: a nationally standardized RVU for work, practice expense, and malpractice; national geographic practice cost index (GPCI); and an annually adjusted dollar conversion factor (2014 Medicare Conversion Factor = $35.8228).[20] The physician fee schedule was calculated using Medicare's formula: physician payment = [(RVU Work × GPCI Work) + (RVU Practice Expense × GPCI Practice Expense) + (RVU Malpractice × GPCI Malpractice)] × Conversion Factor.[21] The

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