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Comparison of skin closure techniques in patients undergoing open pancreaticoduodenectomy: A single center experience

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ABSTRACT

Background: This study evaluated closure techniques and incisional surgical site complications (SSCs) and incisional surgical site infections (SSIs) after pancreaticoduodenectomy (PD).
Methods: Retrospective review of open PDs from 2015 to 2018 was performed. Outcomes were compared among closure techniques (subcuticular + topical skin adhesive (TSA); staples; subcuticular only). SSCs were defined as abscess, cellulitis, seroma, or fat necrosis. SSIs were defined according to the National Surgical Quality Improvement Program (NSQIP).
Results: Patients with subcuticular + TSA (n = 205) were less likely to develop an incisional SSC (9.8%) compared to staples (n = 139) (20.1%) and subcuticular (n = 74) (16.2%) on univariable analysis (P = 0.024). Multivariable analysis revealed no statistically significant difference in incisional SSC between subcuticular + TSA and subcuticular (P = 0.528); a significant difference remained between subcuticular + TSA and staples (P = 0.014). Unadjusted median length of stay (LOS) (days) was significantly longer for staples (9) vs. subcuticular (8) vs. subcuticular + TSA (7); P < 0.001. Incisional SSIs were evaluated separately according to the NSQIP definition. When comparing rates, the subcuticular + TSA group experienced lower incisional SSIs compared to the other two techniques (4.9% vs. 10.1%, 10.8%). However, this difference was not statistically significant by either univariable or multivariable analysis.
Conclusions: Subcuticular suture + TSA reduces the risk of incisional SSCs when compared to staples alone after pancreaticoduodenectomy.

Introduction

Healthcare-associated infections affect 4% of hospitalized patients, and 20% of these are surgical site infections (SSIs), the most common subgroup.[1–3] SSIs continue to be the most common complication in surgical patients, occurring in 2–5% of all inpatient surgeries and as many as 28% of complex gastrointestinal surgeries such as pancreaticoduodenectomy (PD).[4,5] To aid with surveillance of this complication, the National Surgical Quality Improvement Program (NSQIP) has instated strict criteria to define incisional SSIs.[6] Although this definition is broad, it does not encompass *all* postoperative incisional surgical site complications (SSCs), both infectious and non-infectious, that patients or physicians encounter regularly. These postoperative complications affect patient recovery, long-term psychological health, and negatively impact quality metrics like cost and hospital length of stay (LOS).[7,8]

Prior studies evaluating surgical site closure techniques have

Abbreviations: HPB, Hepato-pancreato-biliary; LOS, Length of Stay; NSQIP, National Surgical Quality Improvement Program; PD, Pancreaticoduodenectomy; SSC, Surgical Site Complication; SSI, Surgical Site Infection; TSA, Topical Skin Adhesive.

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shown that topical skin adhesive (TSA) alone and sutures alone were superior in reducing incisional SSIs when compared to staples.[9–12] In a comparison of commonly used TSAs, Dermabond™ (2-Octyl Cyanoacrylate) was proven to be the strongest and most flexible, making it the most desirable for clinical use.[13] Also, Dermabond™ has been shown to inhibit the growth of Gram-positive and Gram-negative organisms, suggesting inherent antimicrobial properties.[14–16] However, studies evaluating the impact of subcutaneous suture combined with TSA on surgical sites after PD are lacking. This study hypothesized that surgical site closure with subcuticular suture and TSA would decrease incisional SSCs after PD and secondarily improve postoperative LOS and healthcare costs.

Materials and methods

Patient population

A retrospective review of all open PDs captured within the institutional NSQIP database between June 2015 and June 2018 was performed. Inclusion criteria included patients 18 years of age or older undergoing nonemergent open PD for any disease diagnosis. To minimize confounders, patients were excluded if an intra-abdominal infection, pancreaticobiliary fistula, or enteric fistula were found intraoperatively. All patients received one dose of parenteral broad-spectrum antibiotics within 60 min of skin incision, and surgical site closures were performed under direct supervision by the attending surgeon or HPB fellow. The study included multiple surgeons who employed a variety of techniques, although one predominantly closed with subcuticular stitches alone. Dermabond™ was the TSA used on patients within this study. The Indiana University Institutional Review Board approved the conduct of this study, and this study was compliant with the Health Insurance Portability and Accountability Act.

Clinical data

Clinical data was augmented by an in-depth review of all medical records and clinical impressions documented by the attending surgeon involved in the individual care of each patient. In addition to standardized NSQIP variables, retrospective variables of interest included surgical site closure technique and postoperative incisional SSCs, as defined below. The surgical site closure technique included subcuticular suture with TSA (subcuticular + TSA), subcuticular suture with steri-strips (subcuticular) only, and staples only (staples). The primary endpoint was the development of an incisional SSCs. Secondary endpoints included postoperative LOS, hospital readmission, and health care costs.

Definitions

Postoperative incisional SSC was defined as the development of one or more of the following complications:

1) Abscess: Purulent fluid from a surgical wound that drains spontaneously or is deliberately expressed with manipulation, with or without opening of the wound, and frequently requires local wound care, and/or antibiotic therapy;
2) Cellulitis: Erythematous, indurated, and inflamed skin that is often tender to touch. Usually noted to arise and spread rapidly and frequently requires antibiotic therapy to treat;
3) Seroma: Excessive serous or serosanguinous fluid draining from the wound that requires local wound care, or deliberate or spontaneous opening of the wound;
4) Fat Necrosis: Erythema, pain, and/or yellow to clear drainage that is more opaque than serous drainage, but not frankly purulent. Treatment may include local wound care, involve spontaneous wound opening, or require the deliberate opening of the wound.

Statistics

Outcomes of interest were compared among the three techniques of surgical site closure. Chi-squared and Kruskal-Wallis tests were used to compare variables among the surgical site closure techniques that had been identified as potential confounders. Significant variables found on univariable analysis were then included in multivariable logistic regressions (for modeling presence/absence of incisional SSCs and incisional SSIs) and a quasipoisson regression (for modeling LOS). The biostatistical analysis was performed by the Indiana University Center for Outcomes Research in Surgery (CORES) using R, version 3.5.0 (Vienna, Austria).

Results

After exclusion criteria were applied, 418 open PDs between June 2015 and June 2018 were included for analysis (subcuticular + TSA, n = 205; staples, n = 139; subcuticular + steri-strips, n = 74). Perioperative variables are shown in Table 1. In summary, patients undergoing surgical site closure with subcuticular suture and TSA had significantly lower albumin, lower hematocrit, and increased rates of preoperative biliary stenting, chemotherapy, and malignant pathology than the other two groups. In patients receiving stapled closure, significant differences were noted in Ioban use, duration of surgery, and estimated blood loss (EBL) on univariable analysis; however, these were controlled for in a multivariable analysis to yield final results.

A total of 60 incisional SSCs developed, including abscess (n = 28, 47%), fat necrosis (n = 16, 27%), seroma (n = 11, 18%), and cellulitis (n = 5, 8%). Baseline demographic and pre-/perioperative clinical characteristics are displayed in Table 2. Patients in the subcuticular + TSA group experienced significantly lower rates of incisional SSCs (9.8%) compared to patients with stapled closure (20.1%) and subcuticular (16.2%) on univariable analysis ($P = 0.024$; Table 3). On multivariable analysis, subcuticular + TSA vs. stapled closure remained significantly different (Table 4) however, sutures + TSA vs. sutures + steri-strips did not.

Incisional SSIs were evaluated separately according to the NSQIP definition. When comparing rates, the subcuticular + TSA group experienced lower incisional SSIs compared to the other two techniques (4.9% vs. 10.1%, 10.8%). However, this difference was not significant by either univariable (Table 3) or multivariable analysis (Table 4).

Unadjusted median LOS was significantly longer for patients within the staples group compared to subcuticular + TSA and subcuticular groups (Table 3). This relationship did not reach statistical significance on multivariable regression analysis (Table 4).

A cost analysis was performed for each surgical site closure technique. Typical laparotomy incisions for open PDs required the following: two packs of absorbable suture + two tubes of TSA (Dermabond™) (subcuticular + TSA), two packs of absorbable suture (subcuticular), or two skin staplers (staples). To determine the overall cost of each closure technique, the price of the materials charged to the hospital was used. Institutional TSA (Dermabond™) is priced at ~$18/tube, each pack of suture costs ~$5, and each skin stapler costs ~$7. In total, the subcuticular + TSA closure technique ($46) is more expensive than the alternatives (subcuticular, $10; Staples, $14).

Table 1
Baseline demographic, pre/perioperative clinical characteristics.

	Staples (N = 139)	Sutures (N = 74)	Sutures + TSA (N = 205)	P - value
	Median [Range] or N (%)	Median [Range] or N (%)	Median [Range] or N (%)	
Variables				
Age (Years)	68.6 [65.5]	65.8 [58.9]	63.7 [78.7]	0.053
Sex (Male)	26 (18.7)	70 (94.6)	113 (55.1)	0.012
Race (Caucasian)	130 (93.5)	70 (94.6)	186 (90.7)	0.512
BMI	27.3 [29.7]	27.1 [29.3]	26.4 [33.8]	0.213
Diabetes	37 (26.6)	27 (36.5)	57 (27.8)	0.286
Tobacco Use	42 (30.2)	20 (27)	52 (25.4)	0.596
Functional Health Status	136 (97.8)	73 (98.6)	200 (97.6)	0.916
Disseminated Cancer	6 (4.3)	0 (0)	6 (2.9)	0.224
Immunosuppression	4 (2.9)	1 (1.4)	8 (3.9)	0.568
Weight Loss (>10%)	39 (28.1)	12 (16.2)	51 (24.9)	0.160
Albumin (g/dL)	3.8 [2.6]	4.2 [2.2]	3.7 [5.0]	<0.001
WBC × 10^9/L	7.8 [33.6]	7.4 [10.9]	7.5 [39.6]	0.400
HCT	37.3 [26.6]	38.6 [17.8]	37.1 [29.8]	0.011
EBL (mL)	500 [3900]	200 [1450]	250 [1950]	<0.001
Ioban	8 (5.8)	70 (94.6)	84 (41)	<0.001
Preoperative Biliary Stenting	75 (54)	16 (21.6)	131 (63.9)	<0.001
Preoperative Chemotherapy	26 (18.7)	4 (5.4)	59 (28.8)	<0.001
Preoperative Radiation	3 (2.2)	2 (2.7)	6 (2.9)	0.922
Wound Protection	126 (90.6)	73 (98.6)	196 (95.6)	0.032
Malignant Pathology	98 (70.5)	32 (43.2)	156 (76.1)	<0.001
Duration of Surgery (min)	244 [608]	302 [290]	258 [429]	<0.001
Organ SSI	11 (7.9)	9 (12.2)	23 (11.2)	0.505

P values for continuous preop/periop variables and outcomes were obtained using the Kruskal-Wallis test, and those for categorical preop/periop variables and outcomes were obtained using the chi-squared test.

Discussion

In the present study, we found that surgical site closure with subcuticular sutures in combination with TSA resulted in significantly fewer incisional SSCs when compared to staple closure. While literature evaluating the technique of PD surgical incision closure does exist,[9–12,17,18] none have examined the three closure techniques simultaneously. In addition, no other studies have expanded their analysis to encompass all incisional complications. Aside from improving patient care and experience, a secondary goal of improving surgical outcomes is to reduce LOS and overall cost. We demonstrated that the cost of closure materials is highest for sutures + TSA; however, based on our data, this up-front investment may be worthwhile. It was shown to reduce incisional SSCs by as much as 6–10% and incisional SSIs by 5%.

The exact mechanism by which subcuticular suture, or particularly subcuticular suture combined with TSA, provides benefit in reducing wound complications is not clear. One theory involves the potential for sutures to provide superior dead-space elimination and sustained blood flow to the incision when compared to staples.[10] Others hypothesize the unique benefits of TSA as an adjunct to surgical wound closure. For example, the use of TSA was found to be superior to adhesive strips in preventing wound separation and reducing complication rates when combined with subcuticular suture for closure after cesarean section.[18] This may be attributed to the antimicrobial properties of TSAs.[14,15,19]

Open PD is an operation associated with one of the highest rates of incisional SSIs (up to 28%).[4,20] There are many risk factors associated with the development of an incisional SSI in HPB surgery that are often difficult or impossible to modify. *Ambiru* et al. evaluated outcomes after complex HPB surgery and found preoperative obstructive jaundice, pancreatobiliary malignancies, number of enteric anastomoses, blood transfusions, and postoperative glucose control to be significant risk factors for the development of incisional SSI.[21] Other series have identified obesity, main pancreatic duct size <3 mm, presence of a pancreatic fistula, ASA>3, increased duration of operation, and hypoalbuminemia to be further risk factors for incisional SSI development.[21–23] Many of these risk factors are non-modifiable, as confirmed in this study.

This series is strengthened by the fact that a higher incidence of incisional SSI risk factors was present in the subcuticular suture with TSA group (i.e., Table 1 poorer nutritional status, more frequent preoperative biliary stenting, preoperative chemotherapy, and malignant pathology). Even in the highest risk patients, combining subcuticular suture with TSA for surgical site closure after PD is associated with the lowest risk of incisional SSI and SSCs. However, it is important to emphasize that the number of incisional SSIs were not statistically significantly different among the groups, yet incisional SSCs were between staples and sutures with TSA.

One limitation of this study is that it is a retrospective review of prospectively gathered data that was not randomized or controlled. We used novel definitions for incisional SSCs, allowing for greater inclusion of all patients who experienced incisional wound complications (infectious and non-infectious); however, this was done

Table 2
Significant risk factors for complications.

Outcome	Risk Factor	OR [95% CI]	P
Seroma	Age	0.95 [0.92–0.99]	0.015
	EBL	1.001 [1.000–1.001]	0.004
Abscess	Wound Closure - Staples (vs. Suture/Bond)	2.42 [1–5.85]	0.049
Fat Necrosis	Preoperative Radiation	5.14 [1.03–25.72]	0.046
Cellulitis	None		

Significant risk factors found for incisional surgical site complications in patients undergoing open PDs.

Table 3
Univariable analysis of closure techniques associated with outcomes.

Outcomes	Staples (N = 139)	Sutures (N = 74)	Sutures + TSA (N = 205)	Overall P - Value
SSCs N (%)	28 (20.1%)	12 (16.2%)	20 (9.8%)	0.024
SSIs N (%)	14 (10.1%)	8 (10.8%)	10 (4.9%)	0.117
LOS (median) (days)	9	8	7	<0.001

P - values for continuous preop/periop variables and outcomes were obtained using the Kruskal-Wallis test, and those for categorical preop/periop variables and outcomes were obtained using the chi-squared test.

Table 4
Adjusted association between closure technique and incisional outcome.

	Odds Ratio	95% CI	P -value
SSCs			
Sutures + TSA (vs Staples)	0.37	0.16–0.81	0.014
Sutures (vs Staples)	0.50	0.16–1.59	0.240
Sutures + TSA (vs Sutures)	0.73	0.28–1.93	0.528
SSIs			
Sutures + TSA (vs Staples)	0.45	0.16–1.27	0.129
Sutures (vs Staples)	1.26	0.29–5.49	0.757
Sutures + TSA (vs Sutures)	0.38	0.11–1.32	0.128
Length of Stay			
Sutures + TSA (vs Staples)	0.90	0.76–1.07	0.280
Sutures (vs Staples)	0.84	0.65–1.10	0.602
Sutures + TSA (vs Sutures)	1.07	0.95–1.34	0.582

Variables included in multivariable analysis: wound closure, age, sex, race, BMI, diabetes, tobacco use, functional health status, disseminated cancer, immunosuppression, weight loss, albumin, WBC, HCT, EBL, ioban, preoperative biliary stenting, preoperative chemotherapy, preoperative radiation, wound protection, malignant pathology, duration of surgery, organ site infection.

through retrospective chart review, leaving the potential for misclassification. Nevertheless, we feel this technique is most appropriate, as standard database definitions have highly selective criteria for incisional SSIs and may exclude or miss complications.

Conclusion

Surgical site closure after pancreaticoduodenectomy using subcuticular suture with a topical skin adhesive significantly reduces incisional surgical site complications compared to staples, but not sutures alone. Further, it is associated with a decreased unadjusted length of stay that is not significant on multivariate analysis. These data and trends justify a prospective randomized trial comparing the techniques.

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Declaration of competing interest

None declared.

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