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SSAT QUICK SHOT PRESENTATION

Early vs Late Readmissions in Pancreaticoduodenectomy Patients: Recognizing Comprehensive Episodic Cost to Help Guide Bundled Payment Plans and Hospital Resource Allocation

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Abstract

Introduction Previous studies on readmission cost in pancreaticoduodenectomy patients use estimated cost data and do not delineate etiology or cost differences between early and late readmissions. We sought to identify relationships between postoperative complication type and readmission timing and cost in pancreaticoduodenectomy patients.

Methods Hospital cost data from date of discharge to postoperative day 90 were merged with 2008–2018 NSQIP data. Early readmission was within 30 days of surgery, and late readmission was 30 to 90 days from surgery. Regression analyses for readmission controlled for patient comorbidities, complications, and surgeon.

Results Of 230 patients included, 58 (25%) were readmitted. The mean early and late readmission costs were $18,365 ± $20,262 and $24,965 ± $34,435, respectively. Early readmission was associated with index stay deep vein thrombosis ($p < 0.01$), delayed gastric emptying ($p < 0.01$), and grade B pancreatic fistula ($p < 0.01$). High-cost early readmission had long hospital stays or invasive procedures. Common late readmission diagnoses were grade B pancreatic fistula requiring drainage ($n = 5$, 14%), failure to thrive ($n = 4$, 14%), and bowel obstruction requiring operation ($n = 3$, 11%). High-cost late readmissions were associated with chronic complications requiring reoperation.

Conclusion Early and late readmissions following pancreaticoduodenectomy differ in both etiology and cost. Early readmission and cost are driven by common complications requiring percutaneous intervention while late readmission and cost are driven by chronic complications and reoperation. Late readmissions are frequent and a significant source of resource utilization. Negotiations of bundled care payment plans should account for significant late readmission resource utilization.

Keywords Pancreaticoduodenectomy · Whipple · Cost · Complication · Readmission · Payment plan · Pancreatic fistula · Delayed gastric emptying · Resource utilization

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Introduction

Pancreas cancer is highly morbid, and post-pancreaticoduodenectomy (PD) care is resource intense. The incidence of postoperative complications can be as high as 60%,[1,2] and the incidence of 30- and 90-day readmissions is 30–37% and 42%, respectively.[2–4] Pancreatic fistula (PF) and delayed gastric emptying (DGE) are highly associated with prolonged hospitalization and 30-day readmission.[5] It is generally understood that postoperative complications drive readmission, which in turn increases the cost of care. However, the true cost of care in the perioperative period remains difficult to define.

Attempts to understand the true cost of cancer care in the US healthcare system are obscured by lack of access to actual costs incurred by hospitals and lack of centralized cost data. The best available cost studies report *estimated* costs, derived from Medicare-based Surveillance Epidemiology and End Results (SEER) reimbursement data.[6–8] These studies demonstrate that the highest estimated cost of pancreas cancer care is associated with treatment that includes surgery, which is more than double that of systemic therapy alone.[6–8] These estimated cost derivations do not reflect true and specific costs of care delivery. In particular, they do not elucidate the actual cost of specific postoperative complications and readmission-associated care, especially for readmission that occurs outside of the 30-day postoperative period.[6–8] Given that post-PD complications and readmission can continue to occur even months after surgery,[3] the impact of this missing data has potentially profound implications on planning and payment/reimbursement negotiations by hospital fiscal systems.

To address this gap in the literature, we sought to delineate the relationship between different types of postoperative complications, the etiologies of early and late readmissions, and the true cost of early versus late readmissions in patients undergoing PD in an academic cancer center.

Methods

Patient Outcome and Fiscal Terminology

This was a single institution retrospective study. Hospital cost data from day of discharge to postoperative day 90 were merged with NSQIP data from day of discharge to postoperative day 90, from 2008 to 2018. Only patients with complete NSQIP and cost data were included in the final analysis.

Total hospital cost was the sum of indirect and direct variables and fixed costs. Direct fixed cost is static, and material costs are associated with running a hospital (buildings, equipment). Direct variable costs are costs that depend on specific patient care (medications, procedures). Indirect costs reflect hospital infrastructure (financial services, information technology).[9] This cost data does not include physician professional fees. All cost data were generated directly from the electronic medical record system and reflect actual costs incurred by the hospital. High-cost care was defined as per-patient episodic cost within the top quartile of all cost data. Early readmission was defined as occurring within 30 days of surgery, and late readmission was defined as occurring between 30 and 90 days from surgery. NSQIP definitions were used to categorize delayed gastric emptying (DGE),[10] and International Study Group on Pancreatic Fistula (ISGPF) definitions were used to characterize pancreatic fistula (PF).[11]

Statistical Analyses

This analysis focused on identifying risk factors for early and late readmissions and identifying readmission diagnoses associated with high cost. Bivariate analysis of risk factors for early and late readmissions was based on preoperative patient factors, surgeon, and type of postoperative index stay complication. Preoperative patient factors included in the analysis were age, gender, body mass index (BMI), preoperative albumin, American Society of Anesthesia Physical Classification Status (ASA), any history of hypertension, chronic obstructive pulmonary disease (COPD), renal failure, preoperative weight loss greater than 10% body weight, and reduced functional status. Index stay postoperative complications included in the analysis were wound infection, organ space infection, wound dehiscence, urinary tract infection (UTI), *Clostridium difficile* infection, pneumonia, pulmonary embolism, stroke, myocardial infarction, cardiac arrest, postoperative bleeding, deep vein thrombosis, DGE, PF, and Clavien-Dindo score.[12] There was a significant and consistent correlation between complication diagnosis and Clavien-Dindo score. For example, all UTIs presented as benign complications (Clavien-Dindo 2), whereas all postoperative pneumonia presented as severe complications (Clavien-Dindo 4b-5). Therefore, to perform complication-specific analysis, complication diagnosis rather than severity was used in final regression analyses. All patients with index stay mortality were excluded from analysis. Bivariate analyses included Student's *t* test, chi-square test, Fischer's exact test, and ANOVA.

Multivariable logistic regression was conducted for early and late readmissions. Only independent variables identified on bivariate analysis as significant risk factors for early or late readmission were included in the final multivariable regression analysis. All analyses were conducted with SAS version 9.4 (SAS institute, Inc., Cary NC, USA), and a p value < 0.05 was considered significant.

Results

Of 305 available patients, 2 patients had an index stay mortality and were excluded; 230 had complete NSQIP and cost data

and were included in the final analysis. Patient demographics were similar for readmitted patients and non-readmitted patients aside from a higher prevalence of COPD in readmitted patients (Table 1). Fifty-eight patients (25%) were readmitted: 30 (13%) as early readmissions, 17 (7%) as late readmissions, and 11 (5%) as both early and late readmissions. The mean early readmission cost was $18,365 ± $20,262, and the mean late readmission cost was $24,965 ± $34,435 per patient.

Early Readmission

Forty-one patients were readmitted within 30 days. On bivariate analysis, postoperative organ space infection ($p < 0.006$), deep vein thrombosis (DVT) ($p = 0.002$), uncontrolled grade B PF ($p < 0.0001$), and DGE ($p < 0.0001$) were associated with early readmission. Importantly, early readmission was not associated with any specific patient comorbidities or surgeon. Multivariable analysis demonstrated that early readmission was associated with postoperative DVT ($p = 0.01$), DGE ($p < 0.01$), and inadequately drained grade B PF ($p < 0.01$) but not postoperative organ space infection ($p = 0.5$) (Table 2).

The most common early readmission diagnoses were DGE ($n = 12$, 29% of early readmissions) and inadequately drained grade B PF ($n = 11$, 26% of early readmission) (Fig. 1). On subset analysis, patients with pancreatic biochemical leaks or adequately drained grade B PFs did not demonstrate an increased risk of readmission compared to patients without PFs or postoperative complications ($p > 0.05$ across all analysis iterations).

The mean early readmission cost per patient was $18,365 ± $20,262. As depicted in Fig. 1, the most common early readmission diagnoses were not always associated with the highest readmission costs; rather, high early readmission cost occurred with long hospital stays and/or an invasive procedure (Fig. 1; Table 3). All patients readmitted with partial small bowel obstructions or GI bleeding were in the top cost quartile. In contrast, only 33% of patients readmitted with organ space infections, grade B PFs, or DVT treatment–related coagulopathy were in the top cost quartile. Only 25% of patients readmitted with DGE were in the top cost quartile (Table 3).

Table 1 Patient demographics and comorbidities

Patient characteristics	No readmission ($n = 172$)	Any readmission ($n = 58$)	p value
Gender, *n* (%)			
Female	76 (44%)	21 (36%)	0.29
Male	96 (56%)	37 (64%)	
Age			
Mean ± std dev	66.1 ± 11.7	66.2 ± 9.3	0.89
Range	23–88	39–85	
BMI			
Mean ± std dev	27.3 ± 6.1	27.8 ± 5.6	0.49
Range	16.6–52.3	18.8–45.7	
Albumin			
Mean ± std dev	3.5 ± 0.5	3.6 ± 0.5	015
Range	1.7–4.8	2.1–4.6	
ASA class, *n* (%)			
1	1 (< 1%)	0 (0%)	0.77
2	82 (48%)	26 (45%)	
3	82 (48%)	31 (53%)	
4	4 (2%)	1 (2%)	
Missing	3 (1000%)	0 (0%)	
COP D, *n* (%)	2 (1%)	6 (10%)	0.02
Smoker, *n* (%)	29 (17%)	6 (10%)	0.23
Diabetes	35 (20%)	12 (21%)	0.96
Hypertension, *n* (%)	92 (53%)	34 (59%)	0.50
Renal failure, *n* (%)	0 (0%)	1 (2%)	0.08
Immunosuppresion, *n* (%)	5 (3%)	5 (9%)	0.11
Weight loss, *n* (%)	32 (20%)	6 (10%)	0.14
FHS, *n* (%)	2 (1%)	1 (2%)	0.74

Abbrevations: *FHS* reduced functional health status, *COPD* chronic obstrutive pulmonary disease, *ASA* American Society of Anesthesiology Physical Status, *BMI* body mass index

*p values refer to differences between incidence of variable in readmitted vs not readmitted groups

Table 2 Multivariable analysis of early and late readmissions

Early readmission			Late readmission		
Variable	Estimate ± std error	*p* value	Variable	Estimate ± std error	*p* value
DVT	0.34 ± 0.13	0.01	Readmission within 30 days	0.14 ± 0.06	0.01
DGE	0.22 ± 0.05	< 0.01	Wound infection	0.13 ± 0.06	0.05
PF grade B w/ IR drain	0.54 ± 0.13	< 0.01	Organ space infection	0.22 ± 0.07	< 0.01
Organ space infection	− 0.08 ± 0.1	0.46	Postoperative bleeding	0.13 ± 0.06	0.03

Abbreviations: *DVT* deep vein thrombosis requiring treatment, *DGE* delayed gastric emptying, *PF* pancreatic fistula

Late Readmission

Twenty-eight patients were readmitted between postoperative days 30 and 90. On bivariate analysis, late readmission was associated with previous readmission ($p < 0.01$), index stay diagnosis of organ space infections ($p < 0.01$), postoperative bleeding ($p = 0.04$), and index stay wound infection ($p = 0.03$). Of note, late readmission was not associated with any specific patient comorbidities or surgeon. On multivariable analysis, previous readmission, organ space infection, bleeding, and wound infection all remained associated with late readmission (Table 2).

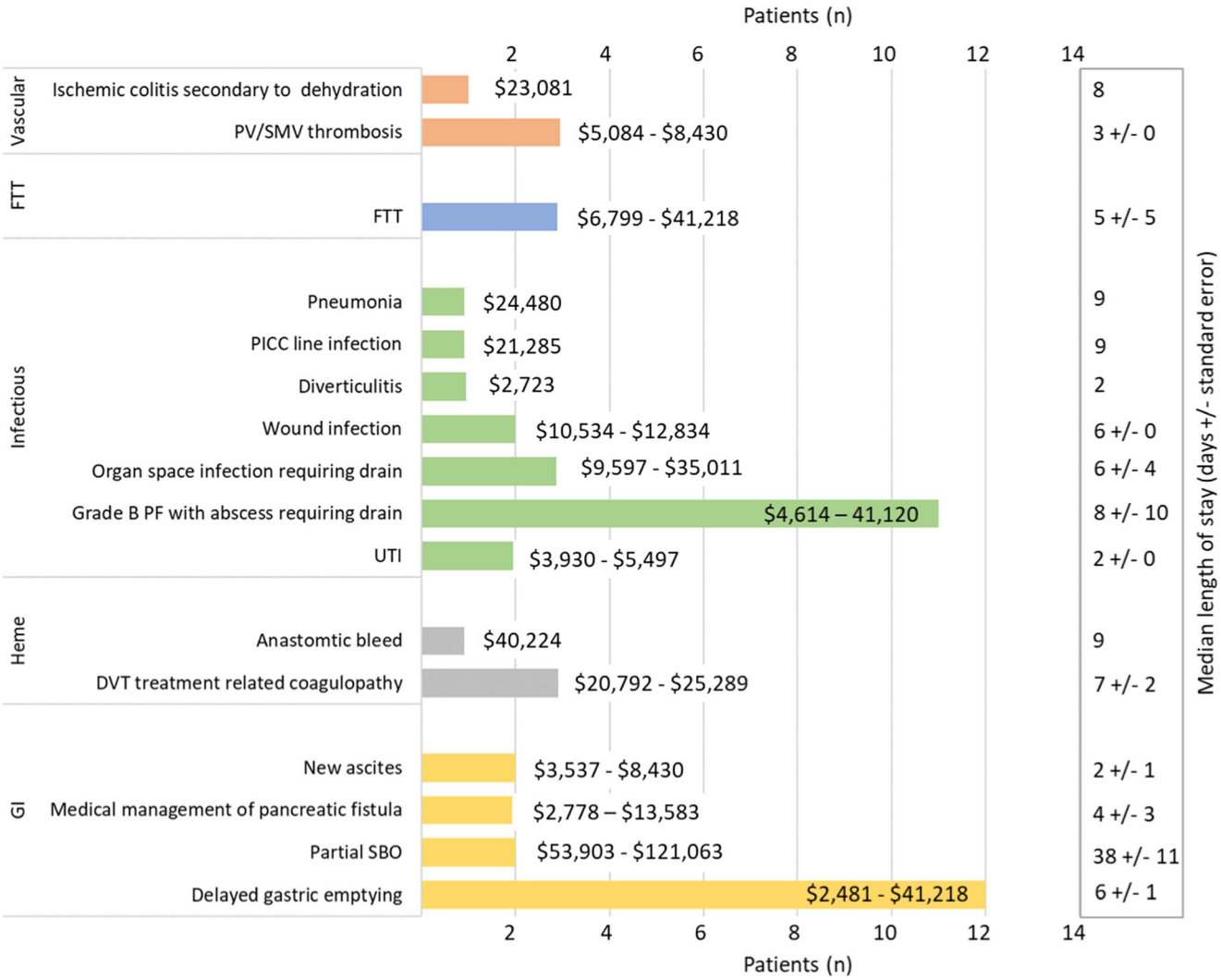

Fig. 1 Early readmission diagnoses: frequency and cost range. PV portal vein, SMV superior mesenteric vein, FTT failure to thrive, PF pancreatic fistula, UTI urinary tract infection, DVT deep vein thrombosis, SBO small bowel obstruction

Table 3 Top quartile costs for early and late readmissions and associated length of stay range

	Number	Cost range	LOS range (days)
Early readmission diagnosis			
Partial SBO	2	$53,900–$121,100	29–36
Anastomotic bleed	1	$40,224	18
Grade B PF requiring drainage	3	$24,450–$41,120	9–12
DGE management	3	$23,600–$41,218	8–17
Organ space infection requiring intervention	1	$35,011	6
DVT treatment related coagulopathy	1	$25,289	7
Late readmission diagnosis			
SBO requiring operation	2	$69,600–$138,400	28–62
DGE	1	$134,445	12
ECF management	1	$45,802	22
Organ space infection requiring intervention	3	$24,199–$24,600	9

Abbreviations: *SBO* small bowel obstruction, *PF* pancreatic fistula, *DGE* delayed gastric emptying, *DVT* deep vein thrombosis, *ECF* enterocutaneous fistula, *LOS* length of stay

The most common late readmission diagnoses were inadequately drained grade B PF requiring intervention ($n = 4$, 14%), failure to thrive ($n = 4$, 14%), small bowel obstruction requiring operation ($n = 3$, 11%), and organ space infection requiring intervention ($n = 3$, 11%) (Fig. 2).

The mean late readmission cost per patient was $24,965 ± $34,435. The high-cost late readmissions were related to time-dependent or chronic postoperative issues, some of which required reoperation: recurrent small bowel obstruction requiring reoperation, DGE, PF-related enterocutaneous fistula, and organ space infection requiring invasive intervention (Fig. 2, Table 3).

There were 11 patients who had both early and late readmissions. Of these 11 patients, 8 patients had related early and late readmission diagnoses. Four out of 11 patients were in the top early readmission cost quartile, and 3 out of 11 were in the top late readmission cost quartile.

Discussion

This study is novel in that we quantify the *true cost* of early and late readmissions and demonstrate the persistent and currently unrecognized fiscal impacts of late readmission after PD. Early readmission occurred secondary to the most common postoperative complications (DGE and PF), but these complications did not always incur high costs. In contrast, late readmission occurred secondary to complications that required time to manifest into an intervenable issue (time-dependent complications: recurrent partial small bowel obstruction evolving into complete small bowel obstruction, failure to thrive, non-healing chronic wounds). Late readmission cost was less varied within individual diagnoses, but when high costs occurred, they were exorbitant.

Much effort has been dedicated to predicting and preventing post-PD complciations, primarily to benefit patients but also to reduce cost of care. These efforts have centered on preoperative patient optimization, postoperative complication reduction, or improved transitions of care. Despite these efforts, reducing common postoperative complications and readmissions has been difficult in PD patients. This suggests that some post-PD complications and readmissions may be inevitable.

For example, preoperative cardiac disease and hypertension are patient-dependent risk factors associated with readmission.[13,14] Prehabilitation programs designed to optimize cardiovascular comorbidities, however, have unclear impacts on postoperative morbidity and readmission. Small randomized trials examining the impact of prehabilitation programs have not demonstrated reduction in perioperative morbidity or readmission[15] while results from larger trials are pending.[16]

There has also been little progress in preventing common and often costly post-PD complications. Meta-analysis and multi-institutional studies demonstrate that infectious complications, failure to thrive, DGE, and complication severity drive readmission[13,14,17,18] and therefore represent cost saving opportunities.[5,8] Despite this knowledge, there has been little progress in the preventing or improving treatment of the most common post-PD complications. For example, results from studies examining prevention and improved management of DGE through operation type or postoperative erythromycin have conflicting results.[19–25] Similarly, studies examining operative strategies to prevent PF have failed to delineate evidence-based recommendations.[22,26–28] While the efficacy of somatostatin analogues to treat PF may be improving with the use of pasireotide, promising results have not been reproduced and pharmacologic intervention is costly.[29–31]

Efforts have also been made to reduce post-PD readmissions through transitional care programs. Although

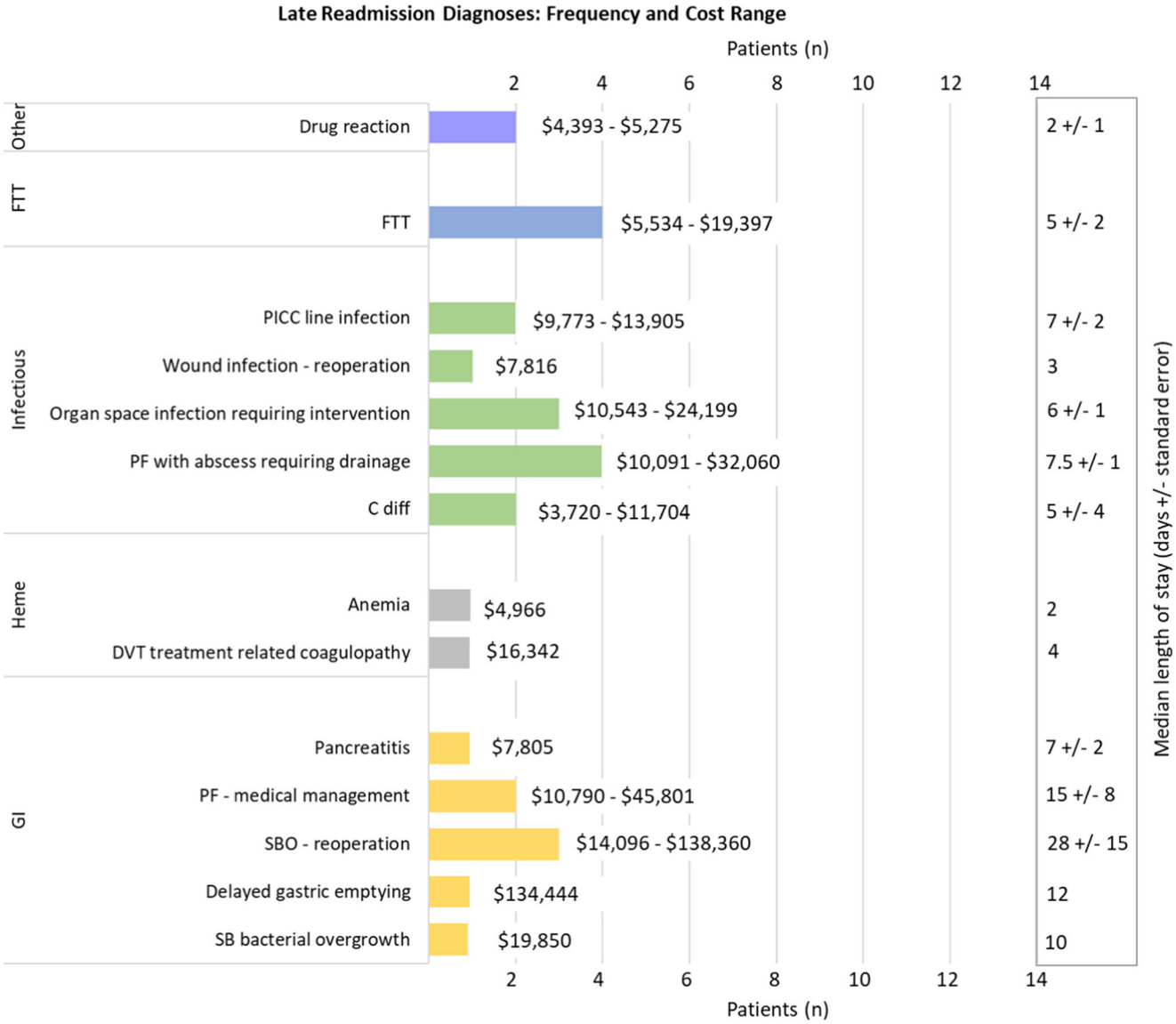

Fig. 2 Late readmission diagnoses: frequency and cost range. FTT failure to thrive, PF pancreatic fistula, C. Diff *Clostridium difficile* infection, DVT deep vein thrombosis, SBO small bowel obstruction, SB small bowel

these programs have shown promise in some surgical populations, their efficacy in PD patients is less clear.[32] One retrospective study reviewed trends in postoperative morbidity and readmission over a 5-year period during which discharge coordination and patient education efforts were standardized; these data demonstrated a 10% reduction in morbidity and a 50% reduction in 30-day readmissions over this period.[33] However, these results are inherently biased by study design and conflict with more recent results from a prospectively designed transitional care program.[34–36] This study was designed to mitigate known clinical and patient-identified risk factors for readmission but failed to demonstrate a reduction in post-PD readmissions within 30 days.[34–36]

These cumulative scenarios suggest that some post-PD complications may be inevitable, at least within current treatment paradigms. It is therefore important for hospital systems to acknowledge that post-PD complication–associated costs can remain significant for months after surgery.

The cost trends presented in our study prompt further discussion of the potential for cost containment interventions despite the inevitability of post-PD complications. As apparent in Figs. 1 and 2, there is a wide range in cost for similar readmission diagnoses, which should be further examined for cost containment potential. For example, while postoperative PF and DGE were associated with early readmission, they did not always incur high cost. Readmission-associated cost of an inadequately drained grade B PF ranged from $4614 to $41,120 while that of DGE ranged from $2481 to $41,218. Undoubtedly, severity of PF and DGE is relevant to the cost of care; however, the range in cost could also reflect surgeon-

specific management strategies and different thresholds for intervention or outpatient management. Additionally, late readmission cost of small bowel obstruction requiring reoperation ranged from $14,096 to $138,360. Again, disease severity could explain the difference in cost but other factors should also be considered. The two highest cost patients had recurrent partial small bowel obstructions requiring multiple readmissions before definitive surgical management of complete small bowel obstructions. Although the disease course of these patients may have been inevitable, their multiple readmissions before definitive management represent an opportunity for internal review and discussion of management optimization and cost containment strategies. Alternatively, in the event that exorbitant cost is non-preventable, these cost data could be used to promote cost-containment standards of care across similar hospital systems. This may help internally and externally regulate PD-specific healthcare costs among hospitals caring for PD patients and provide data for negotiation of bundled payment plans.

Central to efforts to contain perioperative costs is an understanding that cost can be greatly influenced by not only the cumulative effect of relatively low-cost frequent complications *but also* the stand-alone effect of high-cost infrequent complications. Patients with infrequent complications but exorbitant cost, or "super-users," represent between 1 and 5% of the population but are responsible for 20–50% of national healthcare expenditures.[37,38] Researchers and policymakers have therefore debated whether mitigation of high-cost infrequent complications should be prioritized over that of low-cost frequent complications.[39] Our analysis demonstrates that within the PD population, both can have a profound impact on the fiscal stability of hospital systems.

This is a retrospective small study; however, the trends in complications and readmissions align with findings from larger studies. It was not possible to decipher the breakdown of operative, supportive, or intervention-based costs within the readmission data which made it difficult to determine the cost distribution within a patient's hospital stay. Only the cost of inpatient care was obtainable for this analysis; therefore, the total cost of care is underestimated due to lack of outpatient care costs. Additionally, only readmissions to the index hospital were captured and the readmission incidence was therefore likely underestimated.

Conclusion

Early and late readmissions following pancreaticoduodenectomy vary in both etiology and cost. In our studied population, early readmission and cost were driven by common complications requiring intervention. Late readmission is driven by time-dependent complications, and cost is driven by reoperation and complex medical management requiring long hospital stays. As hospital systems and insurers work toward bundled payment plans for comprehensive episodes of care, it must be recognized that late readmissions for PD occur frequently and are a significant source of resource utilization. Additionally, hospital systems should invest in comprehensive, longitudinal cost accounting systems to understand opportunities to prevent exorbitant cost within similar diagnoses. In the event that exorbitant cost is non-preventable, these cost data should be used to promote cost containment standards of care or goals.

Authors' Contributions Alexandra W. Acher MD: Concept design, data acquisition, analysis and interpretation, manuscript writing and critical revision, final approval, final accountability agreement.

James R. Barrett MD: Analysis interpretation, manuscript critical revision, final approval, final accountability agreement.

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Daniel E. Abbott MD: Concept design, analysis interpretation, manuscript critical revision, final approval, final accountability agreement.

Compliance with Ethical Standards

Conflict of Interest The authors declare that they have no conflict of interest.

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Presentation at Scientific Meeting

The abstract for this work was selected for Quick Shot Presentation at the 2020 SSAT/DDW Conference, Chicago, IL, May 2, 2020 and will be presented electronically due to Covid-19 related conference disruption.