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Pancreaticoduodenectomy Hospital Resource Utilization in Octogenarians

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Abstract

Background—Although pancreaticoduodenectomy (PD) is feasible in patients ≥ 80 years, little is known about the potential strain on resource utilization.

Methods—Outcomes and inpatient charges were compared across age cohorts (I: ≥ 70, II: 71 – 79, III: ≥ 80 years) in 99 patients who underwent PD (2005–2013) at our institution. The generalized linear modeling approach was used to estimate the impact of age.

Results—Perioperative complications were equivalent among cohorts. Increasing age was associated with ICU use, increased length of stay (LOS) and the likelihood of discharge to a skilled facility. After controlling for covariates, hospital charges were significantly higher in Cohort-III (P=0.006) and Cohort-II (P=0.035) when compared to Cohort-I. However, hospital charges between Cohorts-II and III were equivalent (P=0.374). Complications (P=0.005) and LOS (P<0.001) were associated with higher hospital charges.

Conclusions—Increasing age was associated with increased ICU, LOS and discharge to skilled facilities. However, octogenarians had equivalent PD charges and outcome measures when compared to septuagenarians and future studies should validate these findings in larger national studies.

Keywords

Whipple; octogenarian; age disparity; surgical cost analysis

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Introduction

The proportion of individuals over the age of 80 years within the United States is projected to increase exponentially (up to 350%) between the years 2000 and 2050 [1]. This projected expansion may have significant implications on the current healthcare system since 70% of cancers are expected to occur in older persons [2]. In fact, between 2004 and 2008 the median age at the time of diagnosis of pancreatic cancer was 72 years with 42% of patient's 75 years of age [3]. Older adults represent a susceptible cohort for increased adverse operative events following major cancer surgery due to their comorbidities and potential frailties [4]. Given that the incidence of cancer increases with age, the burden and cost of cancer care should likewise increase[5]. Although the safety and feasibility of PD in older persons has previously been established, the impact of performing this technically complex procedure in octogenarians on hospital resource utilization remains notably absent [2, 6]. Current Medicare data suggest the aggregate 5-year net costs of cancer care to be approximately \$21.1 billion dollars for elderly cancer patients (>65 years) diagnosed in 2004 [5]. With growing pressure to reduce hospital costs, it is imperative to identify, understand and modify factors that contribute to elevated resource use.

Pancreatic ductal adenocarcinoma (PDA) portends a poor prognosis at all ages and accounts for 7% of all cancer related deaths [7]. Unfortunately, overall survival from PDA remains inferior to that of other malignancies, and resection remains the only chance for long-term survival. Following resection, median survival reaches 26 months with 25% of resected patients surviving 5 years [8, 9]. With the potential for limited healthcare resources in the future due to an expanding elderly population, the marginal increase in survival afforded by PD may come under scrutiny by health policy officials regarding octogenarians. Therefore, it is imperative to identify, understand and mitigate the drivers of the potential increased costs and identify whether or not they are age-related. We postulate that PD surgical hospitalization resource use will increase linearly with age. Herein we assess perioperative outcomes and inpatient charges (as a proxy for medical care resource use) for the PD hospitalization in cohorts of increasing age in order to elucidate the extent to which age drives / impacts potential differences in resource utilization.

Methods

A retrospective review of a prospectively maintained pancreatic resection database within the MedStar Georgetown University Hospital, Department of Surgery identified 99 patients who underwent PD between 2005 and 2013. All clinicopathologic data was obtained following approval from the Georgetown University Investigational Review Board (study #2010-354). We attempted to include all patients over the age of 80 years during our study period. There were a total of 36 consecutive patients identified however 3 patients had to be excluded due to the lack of complete medical records. Three non-randomized patient cohorts were then created which were matched for histology and stratified by age: 70 years, 71–79 years, and 80 years. Traditional perioperative outcome measures were compared among cohorts. In this particular analysis we have chosen to report 60-day readmission rates. Because of the possible extended impact of pancreaticoduodenectomy on operative

outcomes beyond 30-days, we extended our analysis to the 60-day time-point since we do not believe the 30-day time point accurately captures outcomes data. Pancreatic fistula is defined at our institution as an elevated Jackson-Pratt amylase level three times the upper limit of normal serum amylase on or after post-operative day 4 and follows data from the International Study Group for Pancreatic Fistula.

Charges were derived from the MedStar Georgetown University Hospital charge-master, which collected all charges incurred during the hospitalization in which the PD was performed. The charge-master was obtained from the hospital finance department and adjusted for inflation to 2013 dollars by the General Hospital Producer Price Index from the Bureau of Labor Statistics. Charges for individual service units were aggregated into operating room charges and hospital charges. Operating room charges included anesthesia, operating room services, recover room, supplies and devices and sterile supply. Hospital charges included supplies and devices, cardiology, diagnostics, miscellaneous, ICU, non-ICU room, laboratory, pharmacy and therapeutic services.

Statistical Analysis

Bi-variate analysis was performed to investigate the association between age group and patient characteristics. Fisher's exact test was used for categorical variables, while the Mann-Whitney U test was used for continuous variables. Additional pairwise comparison analyses were performed by Fisher's exact tests for categorical variables or by Dwass, Steel, Critchlow-Fligner method for continuous variables.

The generalized linear modeling (GLM) approach was used to estimate the impact of age on the charge amounts of health services. The Box-Cox transformation technique was used to determine the link function in the GLM models. The Modified Park test was used to determine the appropriate variance structure of the model [10]. P-values from Wald Chi-square testing for each coefficient estimate in the GLM models were used to determine significance. The goodness of fit for the final models were examined using Pregibon's Link [11]. Separate models were developed for operating room charges and hospital charges. Predictors for the model of operating room charges included age cohort, gender, co-morbidity, malignancy, tumor size, blood loss and year of admission. For modeling hospital charge, additional predictors of length of stay (LOS), and complications were considered. Potential endogeneity of LOS in the hospital charge model was addressed with instrumental variable method, using the predicted LOS generated from the GLM with the patient's age, complication, year of admission, and readmission status as predictors. After the model selection, we used the GLM with inverse Gaussian distribution and the reciprocal link ($\lambda = -1$) were used to obtain the predicted LOS. Finally, we applied the recycled prediction method to obtain the mean difference of the charge amount with the original scale for the categorical predictors [12].

Results

Patient Characteristics

99 patients were identified and stratified into three non-randomized cohorts of increasing age: Cohort I (36/99), II (30/99) and III (33/99) (Table 1). Patients were not stratified by comorbidities. The overall age range was 34 to 87 years. Median age per cohort was I: 62 years (range, 34 – 70 years), II: 73 years (range, 71 – 79 years) and III: 83 years (range, 80 – 87 years). Pathologic diagnosis per cohort included PDA (I: 21/36, II: 18/30, III: 20/33), cholangiocarcinoma (I: 1/36, II: 1/30, III: 2/33), ampullary carcinoma (I: 3/36, II: 3/30, III: 3/33), duodenal carcinoma (I: 0/36, II: 2/30, III: 2/33), pancreatic neuroendocrine tumor (I: 2/36, II: 1/30, III: 2/33) and benign lesions (I: 9/36, II: 5/30, III: 4/33).

Perioperative Outcomes

As depicted in Table 1, estimated blood loss (I: 400mL, II: 350mL, III: 500mL; $P=0.345$), rates of postoperative pancreatic fistula (I: 27.8%, II: 33.3%, III: 18.2%; $P=0.392$) and 60-day readmission rates (I: 19.4%, II: 26.7%, III: 24.2%; $P=0.796$) were not significantly different among cohorts. Median stage for PDA patients was IIB. Median LOS differed between Cohorts I and II (7 vs. 10 days; $P=0.028$) and between Cohorts I and III (7 vs. 11 days; $P=0.015$) but did not differ significantly between Cohorts II and III (10 vs 11 days). Increasing age was also associated with higher rates of ICU stay (I: 16.7%, II: 26.7%, III: 51.5%; $P=0.007$) and discharge to SNF (I: 5.6%, II: 13.8%, III: 27.3%; $P=0.046$). However, Cohorts I and II did not differ significantly when directly compared in rates of ICU stay ($P=0.32$) or SNF discharge ($P=0.40$), nor did Cohorts II and III differ in rates of SNF discharge ($P=0.221$). Factors associated with an increased LOS included pancreatic fistula ($P<0.001$), ICU use ($P<0.001$) and discharge to SNF ($P<0.001$). In all of these categories, median LOS increased by 6.5 days.

Charges

Charges derived from the institutional charge-master were obtained for the PD index hospitalization and individual service units and aggregated into operating room charges and hospital charges. Results of the generalized linear models for operation and hospital charges are represented in Table 2. For modeling the operating room charges, an inverse Gaussian distribution with a link function of 0.11 power was used, based on the Box-Cox test ($\lambda=0.11$; 95%CI: $-0.04, 0.28$). The model of hospital charge fit the inverse Gaussian distribution for $\lambda=-0.43$ (95%CI: $-0.66, -0.22$). The result of Pregibon's Link test indicated that the link function for each model was appropriately chosen ($P=0.997$ for the operating room charges model and $P=0.897$ for the hospital charge model).

Results from the operating room charges model found Cohort I to have significantly lower operating room charges than Cohort II ($P=0.048$) after controlling for other factors (Table 2). There was no statistical difference in operating room charges between Cohorts I and III ($P=0.091$) or between Cohorts II and III ($P=0.799$). Gender, co-morbidities, malignancy, tumor size, and blood loss during the operation were not predictive factors. However, cohort I was found to have fewer charges in the supplies and devices category as well as the sterile supply category. Outside of this we cannot explain the observed trend.

Results from the hospital charge model found Cohort III ($P=0.006$) and Cohort II ($P=0.035$) to have significantly higher charge as compared to Cohort I after controlling for other factors (Table 2). There was no significant difference in hospital charges between Cohorts II and III ($P=0.374$). Patients in Cohort I were estimated to have \$22,073 lower hospital charges than those in Cohort II and \$34,373 lower than those in Cohort III. The presence of complications ($P=0.005$) and the length of stay ($P<0.001$) were significantly associated with higher hospital charges. Gender, co-morbidities, malignancy, tumor size, and blood loss during the operation were not predictive factors.

Discussion

We investigated potential differences in health care utilization and charges incurred during hospitalization for PD in cohorts of increasing age. Charges were used as a proxy for medical care resource use and were aggregated into operating room charges and overall inpatient charges (Hospital Charge). For operating room charges we found a significant difference between patients 70 and those 71 – 79; however no difference was observed between other cohorts. With respect to hospital charges, the youngest cohort (I) incurred significantly less charges than both the middle (II) and oldest cohorts (III). However, there was no difference in hospital charges between cohorts II and III. Sex, comorbidities, operative blood loss and pathology were not associated with charges; however complications and LOS were predictive. Operating room charges comprised approximately half of the total charges. However, operating room charges only differed between cohorts I and II despite the fact that cohort III incurred the highest overall charges. This suggests that the drivers of increased charges lay in non-OR departments, which corresponded to results shown in previous literature where total charges were not directly related to OR charges [1, 13, 14].

Our results of complications, specifically pancreatic fistula rates, were equivalent across cohorts and matched previously published work [15, 16]. However, we found increasing age to be associated with ICU use, increased LOS and the likelihood of discharge to a skilled facility; all of which are also concordant with previously published work [17, 18]. Moreover, Gerstenhaber *et al* found elderly patients more likely than their younger counterparts to be post-operatively admitted to an ICU even following uneventful surgeries [2]. This particular finding may be a cause of unnecessary charges and a hospital-level factor, which has the potential for mitigation. Interestingly, we found LOS to differ between Cohorts I and II and between Cohorts I and III, but not between Cohorts II and III. Increased LOS may potentially correspond with increased charges, a finding that is supported by the fact that Cohorts II and III had equivalent LOS and equivalent charges. This reflects the linear relationship shown in previous literature between LOS and resource utilization [13, 14, 19–21]. Moreover, in a prospective cost analysis study of LOS following PD, a 7-day increase in LOS increased ward costs by 76% [13]. This rise in costs were due to a uniform increase in the consumption of resources with no particular department was responsible for the higher costs [13]. LOS may therefore be considered a proxy for costs, as more resources are consumed the longer a patient stays. Therefore, perioperative care for the elderly should focus on safely decreasing LOS in order to control inpatient charges.

In addition to LOS, several studies have shown a strong relationship between complications and costs [13, 14, 19, 20]. Enestvedt *et al.* found that complications nearly doubled charges in a network of community-based teaching hospitals following PD, especially in pharmacy charges [19]. Topal *et al.* likewise showed that complications were associated with increased LOS and higher hospital costs for those undergoing PD [14]. In our study, complications increased total charges by over 50%. Specifically, we found the median charge total for those with complications to be \$38,898.96 greater than for those without (\$112,654.20 vs. \$73,755.24). Of note, we postulate that increased care given to pancreatic fistula patients was a major driver of increased hospital charges related to complications. We did not find age to be predictive of complications. Additionally, younger patients with complications incurred significantly higher median charges than an octogenarian without complications.

In disagreement with our findings, others have found increasing age to be associated with inferior post-operative outcome measures [18, 22–25]. In a meta-analysis of over 5000 patients, those over the age of 74 years had significant increases in the incidence of mortality and post-operative pneumonia [3]. Additionally, those over 80 years observed general increases in post-operative complications (57% vs. 41% in younger counterparts) and an increased LOS [3, 22]. Unlike our population, their LOS was driven by complications [3]. In a general analysis of complex abdominopelvic surgery in older adults, patients 65 years and older who were discharged to an institutional care facility rather than home were 3.5 times more likely to die within the first year [26]. Future endeavors should explore this data since we found 27% of our octogenarian PD population discharged to a SNF.

The current study has several limitations. First, it is an observational, retrospective study of a single institution with a small sample size. Additionally there are clear shortcomings to our database such as the lack of data on the reason for transfer or admission to the ICU. Second, we used inpatient charges as a proxy for cost, which assumed that hospital charges reflected resource consumption, and that greater resource consumption corresponded to higher cost. In general, we caution readers that charges are not always representative of true costs and are instead subject to market forces regarding payer-provider interactions. Lastly, there is a potential selection bias that our PD octogenarians may have less comorbidities and higher performance status than the general octogenarian population. As this was a pilot / hypothesis generating platform study, a power analysis was not performed therefore we acknowledge that our findings are exploratory and best serve as hypothesis- generating for future studies using nationally representative surgical data sets.

Nevertheless, our findings are filling a gap in the literature and have several policy and research implications. First, although referring physicians may be hesitant to refer their octogenarian patients for PD, our institutional results add to mounting data to reassure them. Additionally, we believe this to be the first cost center analysis to directly compare cohorts of increasing age. It is presumed that the projected expansion of our elderly population may have significant implications for the current healthcare system. However, we found similar costs of PD for all patients over the age of 70. Moving forward, we now must focus on mitigating the drivers of potential increased costs (LOS) for our elderly patients. Lastly, the impact of PD within patients over the age of 80 years on other cancer care metrics such as

the cost of outpatient care, patient reported outcomes, quality of life and the completion of adjuvant systemic therapies should also be assessed.

Conclusion

With the potential for limited healthcare resources in the future, it is imperative to attempt to find, understand and mitigate factors, which drive perioperative complications and costs. Although one would presume that surgical morbidity and mortality increase and the feasibility and effectiveness of available treatment methods decrease with advanced age we found no differences in perioperative complications across our cohorts. Although increasing age was associated with increased intensive care use, length of stay and discharge to skilled facilities, octogenarians had equivalent PD charges and outcome measures as compared to their septuagenarian counterparts. Future studies should validate these findings in a wider range of settings.

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Table 1

Patient characteristics and perioperative outcomes following PD

Characteristics	Cohort I 70 years	Cohort II 71 – 79 years	Cohort III 80 years	P-value
Number of patients	36	30	33	
Median Age (range)	62 (34–70)	73 (71–79)	83 (80–87)	
Pathology				
- Ductal Cancer	21	18	20	
- Cholangio Cancer	1	1	2	
- Ampullary Cancer	3	3	3	
- Duodenal Cancer	0	2	2	
- PNET [†]	2	1	2	
- Benign	9	5	4	
Estimated blood loss (mL) [‡]	400 (200,900)	350 (200,938)	500 (200,1200)	0.345
Pancreatic fistula rates [#]	27.8%	33.3%	18.2%	0.392
Any Complication (60-days) [#]	47.2%	60.0%	51.5%	0.589
60-day Readmission [#]	19.4%	26.7%	24.2%	0.796
ICU use at index hospitalization [#]	16.7%	26.7%	51.5%	0.007 ^c
Length of Stay (days) [‡]	7 (5,14)	10 (6,19)	11 (6,25)	0.015 ^c
Discharge to skilled facility [#]	5.6%	13.8%	27.3%	0.046 ^c

Note:

[†] PNET: pancreatic neuroendocrine tumor.[‡]For this variable, the result presents median with 10th percentile and 90th percentile in the parenthesis for each cohort. The p-value was obtained by Mann–Whitney U test.[#]For this variable, the p-value was obtained by Fisher's exact test.^cIt denotes that a significant relationship (p<0.05) was detected between cohort 1 and cohort 3. It was done by Fisher's exact test for categorical variable, or by Dwass, Steel, Critchlow-Fligner method for continuous variables. No other significant result was obtained from the pairwise comparison analyses.

Table 2

Difference in estimated charge amount for selected predictors, adjusted by other factors in generalized linear models

Predictors	Operating Room Charge		Hospital Charge	
	Estimated difference (\$)	P-value	Estimated difference (\$)	P-value
Cohort2 vs. Cohort1	10,122	0.048	22,073	0.035
Cohort3 vs. Cohort1	8,771	0.091	34,373	0.006
Female vs. Male	907	0.822	17,549	0.101
Malignant vs. Benign	-2,517	0.617	-22,561	0.147
Co-morbidity vs. None	-97	0.983	15,505	0.142
Complication vs. None	n/a	n/a	33,688	0.005

Note: Age groups were as follows, Cohort I: 70 years, Cohort II:71–79 years, Cohort III: 80 years. Models were controlled by cohort, gender, malignancy, comorbidity, blood loss during surgery (data not show), tumor size (data not show), complication, and length of stay (data not show).