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Hospital-Level Resource Use by the Oldest-Old for Pancreaticoduodenectomy at High Volume Hospitals

Russell C. Langan, MD^{1,2}, Chaoyi Zheng, MS^{1,2}, Katherine Harris, PhD^{1,2,3}, Richard Verstraete, RN¹, Waddah B. Al-Refaie, MD, FACS^{1,2,4}, and Lynt B. Johnson, MD, MBA, FACS^{1,2,4}

¹Department of Surgery at Georgetown University Hospital

²MedStar-Georgetown Surgical Outcomes Research Center

³MedStar Health Research Institute

⁴Lombardi Comprehensive Cancer Center

Abstract

Introduction—Due to limited data on hospital resources consumed in caring for the oldest-old, we examined the use of pancreaticoduodenectomy (PD)-relevant hospital resources in patients of increasing age treated in high-volume-hospitals (HVH) participating in the University HealthSystem Consortium (UHC).

Methods—Perioperative outcomes, resource use and direct costs were compared across increasing age groups in 12,766 PDs (< 70 years n=8,564, 70-79 years n=3,302, 80 years n=900) performed in 79 HVHs between 2010 and 2014. Linear regression models with and without covariate adjustments were used to assess the impact of older age.

Results—The oldest-old experienced fewer readmissions and had equivalent ICU-use and mortality rates compared to both younger cohorts. However, those 80-years experienced more complications, blood transfusions, greater TPN use, longer LOS and higher direct hospital costs compared to those < 70 years (Table 2). No differences were found between patients 80-years and those 70–79 years with respect to the administration of blood products, TPN or the direct cost of PD.

Conclusion—Our findings suggest the ability to deliver quality pancreatic surgical care to an aging population without strong associations to increased resource utilization. As the number of octogenarians undergoing PD continues to grow, the impact of this technically complex procedure

Corresponding Author: Lynt B. Johnson, MD, FACS, Chairman, Department of Surgery, Georgetown University Hospital, Lombardi Comprehensive Cancer Center, 3800 Reservoir Rd NW, 4 PHC, Washington, DC 20007, Tel: 202-444-4557, Fax: 202-444-7304, JOHNSOL3@gunet.georgetown.edu.

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on other important cancer care metrics including patient reported outcomes and quality of life requires further assessment.

Keywords

Cost pancreaticoduodenectomy; resource use pancreaticoduodenectomy; elderly pancreaticoduodenectomy

Introduction

It is well known that patients of advanced age are more susceptible to adverse peri-operative events [1]. With a looming, predicted expansion of 350% over the next 30 years for those 80 years, the consumption of healthcare resources may similarly increase [2]. Medicare data suggests aggregate 5-year net costs of cancer care for patients over 65 years of age to be greater than \$21 billion dollars [3]. Pancreatic malignancy remains a serious disease, which places strains and financial burdens on our healthcare system [4]. Currently, the median age at the time of diagnosis of pancreatic ductal adenocarcinoma (PDA) is 72 years with 42% of patient's being 75 years [5]. Pancreaticoduodenectomy (PD) remains the only curative treatment modality with a median overall survival following resection of approximately 26 months with only 25% of resected patients surviving 5 years [6-8]. We speculate that with the growing pressure to deliver high level, quality cancer care while simultaneously containing costs, the marginal increase in survival afforded by PD for octogenarians may come under scrutiny by health policy officials.

Despite considerable data focused on the morbidity of PD, a paucity of data remains on the financial impact of this technically complex surgery. According to the National Inpatient Sample and Healthcare Cost and Utilization Project databases for 2005, the average hospital charge for a patient who underwent PD was greater than \$100,000 [4]. Although this value incorporates diagnostic exams and may not truly depict the cost of care delivered, it is certainly not insignificant [4]. In addition to this value, the costs of adjuvant therapy, skilled care facilities and end of life care can exponentially increase the overall cost of resected pancreatic cancer [4]. Quality and cost remain two of the most prominent forces driving decision making in healthcare policy today. The future potential for resource limitations has led payers to challenge physicians to deliver care that is both effective and efficient [4]. Therefore, it is imperative to identify, understand and mitigate the drivers of potential increased costs and identify whether or not they are age-related.

Although the safety and efficacy of performing complex pancreatic resections in patients older than 80-years is still a controversial topic, there remains a paucity of data on the hospital resources consumed and the cost of care for the oldest-old [1, 9]. Therefore, we previously examined post-PD outcomes and resource use in cohorts of increasing age at our own institution and found perioperative outcomes and complications comparable between all age groups and the total charge differential equal between septuagenarians and octogenarians. Herein, we sought to expand this preliminary, single academic high volume hospital (HVH) study to a large, diverse sample of HVHs in order to improve understanding of age as a driver of resource utilization. Based on our prior preliminary work, we postulate

that PD surgical hospitalization resource use would be higher among patients 80 years at HVH's

Methods

The Georgetown University Hospital Institutional Review Board reviewed and approved this study (study #2010-354). The data used in this study was extracted from a large, clinical database maintained by the University Healthcare Consortium (UHC). UHC is a multihospital cooperative that collects and compiles discharge data submitted by members on a quarterly basis. UHC then makes standardized diagnostic, resource utilization and cost data aggregated at the hospital-level available to members through a secure, interactive, web-based interface. We used the database to identify 83 high-volume (HV) hospitals performing a total of 44 or more PDs between 2010 and 2014 identified based on the International Classification of Diseases, Ninth Revision procedure code 527. We defined very high-volume (VHV) hospitals as those performing a number equal to or greater than the median number of PDs performed by HV hospitals in our sample during our study period, which was 130 PDs.

For each hospital in the sample, we extracted aggregated data on patient comorbidities, outcomes and resource use for PD patients stratified into three age categories (< 70 years, 70-79 years, 80 years). We employed UHC's standardized, AHRQ-based measure of the mean number of comorbidities per patient in each group of patients of a given hospital that were in the same age cohort [10]. Our outcome measures included proportions of patients experiencing six different peri- and post-operative complications as identified by ICD-9 diagnostic codes; 7-, 14-, and 30-day rates of readmission to the index (i.e., discharging) hospital; and seven-day mortality rates. Our resource measures included the proportion of patients using total parental nutrition (TPN) and blood transfusions (as identified based on ICD-9 procedure codes listed in Table 1), the proportion using an intensive care unit (ICU) and average length of stay (LOS). Direct cost of care was calculated by UHC based on detailed charges and cost-to-charge ratios reported to UHC by member hospitals and excluded overhead costs associated with hospital operations that do not vary by patient. We excluded from our analysis hospitals that reported < 5% of their PD patients having used TPN as a proxy for poor data quality. Our final sample included a total of 79 HV hospitals.

We estimated linear regression models to measure the strength and statistical significance of hospital-level associations between age and resource use and outcomes of care. We weighted our analysis based on the number of patients represented in a given hospital-age cell. We used robust regression to account for unequal variance induced by differences in the number of patients in each hospital-age cell. We estimated models with and without controls for the mean number of comorbidities present at admission within a given cell and an indicator of being a VHV hospital. To account for multiple testing, we adjusted all p-values using Holm's method with R 3.1.0 (R Foundation for Statistical Computing, Vienna, Austria). All other analyses were performed using STATA 13.0 (Stata Corporation, College Station, TX).

Results

Descriptive results

The 79 HV hospitals in our sample performed 12,766 PDs over the five-year study period with 67.1% of all PDs performed on patients < 70 years of age, 25.9% on patients 70-79 years and 7.0% on patients ≥ 80 years of age (**Table 1**). On average, HV hospitals in our sample performed roughly two and a half times as many PDs during our study period on patients younger than age 70 than on patients aged 70 - 79 (111.2 vs. 45.9) and roughly eight times as many than on patients aged 80 and older (111.2 vs. 14.8). Compared with patients ≥ 80 years, the average number of comorbidities at admission was lower in patients < 70 years (2.1 vs 2.6, $p < 0.001$), but not significantly different in those 70 – 79 years (2.5 vs 2.6, $p = 0.2$). VHV hospitals were similar to non-VHV hospitals in terms of the age distributions of PDs they performed and comorbidity burden of the patients they treated (**Table 1**).

Multivariate results

Patients < 70 years vs. ≥ 80 years—Overall, we found several age-related differences in PD-related outcomes (**Table 2**). Our unadjusted results suggested that compared to patients ≥ 80 years, patients < 70 years were 16.9 % ($p < 0.01$) less likely on average to experience any complication. Specifically, patients < 70 years were on average 13.3 % less likely ($p < 0.01$) to experience cardio-pulmonary complications, 6.1 % less likely ($p < 0.01$) to experience infections, 11.5 % less likely ($p < 0.01$) to experience genitourinary complications, 7.4 % less likely ($p < 0.01$) to use TPN and 10.7 % less likely ($p < 0.01$) to receive blood transfusions. Moreover, patients < 70 years of age stayed an average of 2.8 fewer days ($p < 0.01$) in the hospital and incurred \$4,914 less in direct costs of care ($p < 0.05$). However, as compared to those ≥ 80 years, we found the youngest cohort to be on average 4.1 and 5.4 % more likely ($p < 0.01$) to be readmitted at 14 and 30 days post-discharge, respectively. There was no difference observed in rates of mortality.

Following adjustments for covariates (hospital-wide PD volume and average number of comorbidities), the age-related differences in PD-related complications and resource use largely remained unchanged. However, two notable exceptions were (1) the lack of statistical significance in adjusted differences in the proportion of patients receiving blood transfusions and the direct cost of care for patients ≥ 80 years and those < 70 years and (2) the significance of the adjusted difference in the 7-day readmission for patients ≥ 80 years and those < 70 years (**Table 2**).

Patients 70 – 79 years vs. ≥ 80 years—On unadjusted comparisons, those aged 70 – 79 years, were 7.2 ($p < 0.05$) percent less likely on average to experience any complication, however significance was not reached for any particular complication sub-category. However, patients aged 70 - 79 were 3.9 and 4.9 percent more likely ($p < 0.01$) to be readmitted at 14 and 30 days post-discharge and stayed in the hospital 1.6 fewer days ($p < 0.05$) as compared to patients ≥ 80 years. Unlike the youngest cohort, there were no differences observed in the use of ICU, TPN, administration of blood products or the direct cost of PD care between patients 70 – 79 and those ≥ 80 years. There was no difference observed in rates of mortality (**Table 2**).

Discussion

In this large, diverse, study of HVHs we observed that the oldest-old (> 80 years) experienced more complications following PD than both younger cohorts. However, they had equivalent resource use and direct costs as compared to septuagenarians. Moreover, when compared to the youngest cohort, following adjustments for hospital volume and comorbidities, the oldest-old also had an equivalent cost of PD. These findings point toward the ability to deliver quality pancreatic surgical care to an aging population with minimal increases in resource utilization. Traditionally, referring physicians and surgeons alike have been hesitant to offer PD to the oldest-old (> 80 years) [11, 12]. However, there has been a recent paradigm shift due to the improved management of medical comorbidities, improved surgical techniques and advancements in perioperative care [13]. Additionally, as our US elderly population has rapidly expanded, there has been an increased demand to operate on an older patient demographic [13]. Although it has been documented that PD can be performed safely in the oldest-old with acceptable survival rates, a paucity of data currently remains on the relationship between age and resource utilization [9]. Therefore, we set out to determine 1) the relationship between age and PD peri-operative outcome measures and 2) the effect age has on PD resource utilization and the direct cost of PD, using the oldest-old (> 80 years) as our reference category. Of note, we believe this to be the largest PD resource use analysis to directly compare cohorts of increasing age.

In order to identify potential drivers of costs, others have analyzed PD charges and have found strong direct relationships between complications and LOS [4, 14-16]. In an analysis of hospital costs per cost category following PD, complications (specifically postoperative pancreatic fistula) were associated with increased LOS and in effect higher hospital costs [15]. The authors concluded that any measure to decrease the incidence and severity of complications after PD would ultimately decrease overall costs [15]. This was also corroborated by a review of 144 patients undergoing PD and found that complications nearly doubled charges [4]. The independent predictors of increased cost included: reoperation, sepsis, pancreatic fistula, bile leak, delayed gastric emptying and pulmonary, renal and thromboembolic complications. In their cost center analysis of patients with major complications, charges increased significantly in blood bank, clinical laboratory, computer tomography and diagnostic imaging [4]. However, although we did not statistically analyze the impact of complications on costs, a unique finding to our analysis was the lack of a direct relationship between complications and resource use / direct cost. Although we found clear differences in the complication profile between patients < 70 years and those > 80 years and much less difference in the complication profile between those 70 – 79 years and those > 80 years, our adjusted analysis found direct costs to be equivalent across all cohorts despite these differences in complication profiles. Therefore we speculate that although the 80-year group had more complications it did not appear to result in increased resources consumed.

In order to decrease inpatient costs, inpatient length of stay (LOS) is currently a priority health policy topic [4, 14-17]. Our results were consistent with previous studies and demonstrated a longer LOS in patients over 80 years of age [18, 19]. Specifically, we found LOS to be significantly longer for patients > 80 as compared to both younger cohorts.

However, unique to our study, those over 80 years were significantly less likely to be readmitted at 30-days. Therefore, patients ≥ 80 may not accrue additional long-term charges or utilize more resources, overall.

Additional distinctive findings within our analysis were the lack of difference in resource utilization and direct costs observed between septuagenarians and those over the age of 80 years. Similarly, a recent NSQIP study compared peri-operative outcomes between 475 PD patients ≥ 80 to 4,102 patients < 80 and supported this finding. Their subgroup analysis found septuagenarians to have a similar odds ratio of experiencing mortality or complications as compared with octogenarians, whereas those patients < 70 years were at a significantly lower risk [20]. Dissimilar to our study however, they found octogenarians to have an increased risk for mortality compared with patients < 80 years [20]. One reason for this finding may have been our use of HV institutions, since the regionalization of complex care was first proposed approximately 20 years ago, numerous studies have shown higher hospital volume to be associated with lower postoperative morbidity and mortality [21]. Additionally, following adjustments for hospital-wide PD volume and the average number of comorbidities, the difference in the direct cost of PD between patients ≥ 80 and those < 70 was abrogated. Therefore, age may not be associated with increased costs but rather patient comorbidity and hospital volume, as previously published [21].

In today's current healthcare market, providers are under increasing pressure to control costs while simultaneously improving outcomes [22]. Therefore, it will be imperative to identify, understand and mitigate the drivers of potential increased costs. Enhanced recovery pathways have recently been identified as cost saving measures. In a PD pre- and post-pathway charge analysis of 135 patients at a single institution, mean charges for PD went from \$240,242 to \$126,566 after introduction of the clinical pathway [22]. Moreover, their post-pathway patients had a significantly shorter LOS (13 vs 7 days) and operative times were also less [22]. This analysis has implications for better use of resources and overall cost containment and should be extrapolated to the expanding elderly population. Future endeavors should focus on the development of standardized perioperative PD pathways for patients > 70 years.

Our study has several limitations including the inherent retrospective design. Additionally, further limitations were partially related to the shortcomings of the UHC database. UHC does not directly collect data on pancreatic fistulas although up to 20% of patients experience pancreatic fistula following PD [23]. Therefore, our assessment of complications is not complete. Additionally, UHC does not report national discharge data (skilled nursing facility or home health care). Of note, during our institutional pilot study we found discharges to skilled facilities to be associated with increasing age, therefore, our observation that patients > 80 years were readmitted less as compared to their younger counterparts may be due to their discharge to a skilled facility or their use of home health care agencies. Also, our patients were not stratified by disease type therefore; it is unclear what role the indication (malignancy vs. benign pathology) for resection plays in the outcomes of patients undergoing PD. , The bias of patient selection (elderly patients undergoing major cancer surgery) may also have played a role in our analysis. Elderly cancer patients must 1) have the appropriate performance status to undergo such an

operation and 2) have to be referred for surgical consultation. Therefore our patient population may be a highly selected one. Lastly, due to our focus on HV hospitals it is unclear whether our results can be readily replicated at non-specialized centers. Despite these limitations, this study encompassed a large patient population using a national representative dataset. Moreover, we believe we are filling a knowledge gap and to our knowledge, this is the largest study in the literature evaluating post-PD healthcare resource utilization in cohorts of increasing age.

We acknowledge that our findings have limitations and serve as hypothesis generating for future studies to better understand and potentially mitigate the drivers of increased resource use and costs of cancer care. Nevertheless, our findings have several research and policy implications. First, our findings allude to the ability to deliver quality pancreatic surgical care to an aging population with minimal increases in resource utilization. Therefore, patients over the age of 80 who have appropriate performance status should be referred for PD. Second, since it is presumed that the projected expansion of our elderly population may have significant implications for the current healthcare system, the effects of age on other technically complex procedures and further drivers of increased resource utilization and cost should also be examined. Finally, as the number of octogenarians undergoing PD continues to grow, the impact of this technically complex procedure on other important cancer care metrics including patient reported outcomes and quality of life requires further assessment.

Conclusion

With growing pressure to control and reduce hospital costs, it is imperative to identify, understand, and modify factors that contribute to elevated resource use both within the hospitals and post-discharge. We found the oldest-old to have comparable mortality, intensive care use and fewer readmissions to all younger patients and as compared to septuagenarians the oldest-old had no differences in TPN-use or direct costs. Moreover, following adjustments for hospital volume and comorbidities the differences in the direct cost of PD between the youngest and oldest cohort were abrogated. Our findings suggest that despite increases in complications the oldest-old had comparable clinical outcomes. PD in the oldest of old may not exert additional healthcare resources or increase the index cost of PD.

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Table 1

Number and Percent of Pancreaticoduodenectomy Procedures by Age Group and Hospital Type, 2010-2014

Hospital type	<70 years	70-79 years	80 years	All Ages
All High Volume Hospitals (n=79)				
Total PDs	8,564	3,302	900	12,766
% of patients	67.10%	25.90%	7.00%	100.00%
Per hospital average number of PDs (SD)	111.2 (86.2)	45.9 (34.4)	14.8 (11.7)	60.8 (69.1)
Weighted per hospital average number of comorbidities at admission (SD)	2.1 (0.3) ***	2.5 (0.4)	2.6 (0.5)	2.2 (0.4)
High Volume Hospitals (n=39)^a				
Total PDs	2,036	818	180	3,034
% of patients	67.10%	27.00%	5.90%	100.00%
Per hospital average number of PDs (SD)	55.0 (18.9)	23.4 (8.4)	7.8 (3.7)	31.9 (23.4)
Weighted per hospital average number of comorbidities at admission (SD)	2.1 (0.4) **	2.5 (0.5)	2.5 (0.7)	2.3 (0.5)
Very High Volume Hospitals (n=40)				
Total PDs	6,528	2,484	720	9,732
% of patients	67.10%	25.50%	7.40%	100.00%
Per hospital average number of PDs (SD)	163.2 (91.5)	67.1 (36.2)	18.9 (12.9)	84.6 (83.9)
Average # of comorbidities at admission	2.1 (0.3) ***	2.5 (0.3)	2.6 (0.4)	2.2 (0.4)

Note:

**
p < 0.01, compared with 80 years old age group***
p < 0.001, compared with 80 years old age group^aNon-VHV hospitals.

Table 2

Estimated Mean and Percentage Point Differences in Pancreaticoduodenectomy Outcomes by Age Category, 2010-2014

Outcomes	Baseline Mean and Percent for Patients Aged 80	Mean and Percentage Point Differences			
		Unadjusted		Adjusted ¹	
		< 70 years	70-79 years	< 70 years	70-79 years
% Mortality	6.3	-4.8	-4.1	-4.4	-4.0
Complications					
% Any Complication	54.7	-16.9 **	-7.2 *	-13.8 **	-6.9 *
% Cardio-pulmonary	29.7	-13.3 **	-5.9	-10.4 **	-5.4
% Neurologic	0.8	-0.5	-0.4	-0.6	-0.4
% Wound	4.3	-1.0	0.0	-1.1	-0.1
% Infection	23.6	-6.1 **	-3.3	-6.4 *	-3.5
% Vascular	2.2	-0.8	-0.6	-0.3	-0.5
% Genitourinary	25.7	-11.5 **	-5.0	-8.9 **	-4.6
% Using ICU ²	66.3	-12.9	-9.6	-0.3	-7.6
% Using TPN ³	22.7	-7.4 **	-3.1	-6.9 **	-3.2
% Receiving Blood	32.0	-10.7 **	-6.5	-9.0	-6.5
Mean Length of Stay	14.1	-2.8 **	-1.6 **	-2.8 **	-1.7 *
Readmission					
% Readmitted within 7 Days	2.1	2.4	2.2	2.4 *	2.2
% Readmitted within 14 Days	2.8	4.1 **	3.9 **	3.8 **	3.8 **
% Readmitted within 30 Days	3.4	5.4 **	4.9 **	5.0 **	4.8 **
Mean Direct Cost	29,830	-4,914 *	-2,849	-4,610	-2,736

Key:

* Holm-adjusted p-value < 0.05

** Holm-adjusted p-value < 0.01

¹ Adjusted for hospital-wide PD volume and average number of comorbidities within each hospital-age cell

² Intensive Care Unit

³ Total Parental Nutrition