Author Manuscript Author Manuscript Author Manuscript Author Manuscript

HHS Public Access
Author manuscript
J Gastrointest Surg. Author manuscript; available in PMC 2018 September 01.

Published in final edited form as:
J Gastrointest Surg. 2017 September ; 21(9): 1404–1410. doi:10.1007/s11605-017-3466-2.

Analysis of the Cost Effectiveness of Laparoscopic Pancreatoduodenectomy

Michael H Gerber[a], **Daniel Delitto**[a], **Cristina J Crippen**[a], **Thomas J George Jr**[b], **Kevin E Behrns**[a], **Jose G Trevino**[a], **Jessica L Cioffi**[a], and **Steven J Hughes**[a,*]

[a]Department of Surgery, University of Florida College of Medicine, Gainesville, FL 32610

[b]Department of Medicine, University of Florida College of Medicine, Gainesville, FL 32610

Abstract

OBJECTIVE—We sought to determine if laparoscopic pancreatoduodenectomy (LPD) is a cost effective alternative to open pancreatoduodenectomy (OPD).

METHODS—Hospital cost data, discharge disposition, readmission rates, and readmission costs from periampullary cancer patient cohorts of LPD and OPD were compared. The surgical cohorts over a 40 month period were clinically similar, consisting of 52 and 50 patients in the LPD and OPD groups, respectively.

RESULTS—The total operating room costs were higher in the LPD group as compared to the OPD group (median: $12,290 vs $11,299; $P = 0.05$) due to increased costs for laparoscopic equipment and regional nerve blocks ($P \leq 0.0001$). Although hospital length of stay was shorter in the LPD group (median: 7 vs 8 days; $P = 0.025$), the average hospital cost was not significantly decreased compared to the OPD group (median: $28,496 vs $28,623). Surgery-related readmission rates and associated costs did not differ between groups. Compared to OPD patients, significantly more LPD patients were discharged directly home rather than to other healthcare facilities (88% vs 72%; $P = 0.047$).

CONCLUSION—For the index hospitalization, the cost of LPD is equivalent to OPD. Total episode-of-care costs may favor LPD via reduced post-hospital needs for skilled nursing and rehabilitation.

Keywords

Laparoscopic; minimally invasive; pancreaticoduodenectomy; pancreatic cancer; pancreatic surgery

Introduction

Laparoscopic pancreatoduodenectomy (LPD) is emerging as a safe and effective option compared to open pancreatoduodenectomy (OPD), but still remains an area of significant controversy [1–4]. Several retrospective studies have shown LPD to be non-inferior in

*__Corresponding Author__: Steven J. Hughes, Department of Surgery, University of Florida College of Medicine, 1600 SW Archer Rd, Room 6165, PO Box 100109, Gainesville, FL 32610. steven.hughes@surgery.ufl.edu; Tel: 352-265-0761 Fax: 352-265-1060.

Author Manuscript Author Manuscript Author Manuscript Author Manuscript

regards to morbidity and mortality when compared to OPD [5–12]. Collectively, these studies have identified potential benefits to LPD including decreased blood loss, delayed gastric emptying rates, hospital length of stay, wound infection rates, and utilization of intensive care services, while facilitating larger percentages of patients proceeding on to adjuvant therapy [6–11]. These benefits even appear to be realized during the institutions early experience with LPD [6, 13, 14]. Further, there does not appear to be a clinically meaningful difference between the approaches with respect to surrogate markers of oncologic adequacy including positive margin rates [6, 8–10] and number of resected lymph nodes [6, 8–10, 13]. Recently, we and others have reported similar long term oncologic outcomes between the approaches including disease free and overall survival [10, 15]. Taken together, these data suggest that LPD is equivalent to OPD with respect to most clinical outcome measures, and may have some small benefits over OPD.

While LPD might have small benefits compared to OPD, what are the financial implications of a LPD? Only a limited number of small studies have published comparative cost data between LPD and OPD [6, 7, 13, 16]. These studies evaluated hospital costs associated with the surgical procedure and index hospitalization, showing increased operative costs are recouped by reduction in other costs (i.e. length of stay), but they did not evaluate the potential value of LPD in the context of the total episode of care. Thus, we hypothesized that episode of care costs favor LPD over OPD for patients with periampullary malignancy. To gain a better representation of the total costs associated with these operations, we analyzed healthcare needs related to the surgical procedure, evaluating costs associated with readmissions and utilization rates for skilled nursing facilities (SNF), long term acute care (LTAC), physical rehabilitation, and home health care (HHC).

Methods

This study was approved by the University of Florida Institutional Review Board (IRB). A prospectively maintained clinical database identified all patients who underwent a PD from November 2010 to February 2014. This allowed for a minimum post-operative follow-up time of 12 months, enabling evaluation of itemized hospital cost data as well as post-discharge healthcare needs for periampullary cancer patient cohorts following LPD or OPD. The LPD was performed by a single surgeon who was already experienced with LPD. The OPD was performed by a group of experienced pancreatic surgeons.

The inclusion and exclusion criteria and clinical outcomes for these cohorts were previously described and reported in Delitto et al. [8]. Briefly, the cohorts represented consecutive patients with the diagnosis of a periampullary malignancy from November 2010 to February 2014 (excluding neuroendocrine neoplasms) that met the National Comprehensive Cancer Network (NCCN) criteria for resectable disease [8, 17]. Contraindications for enrollment included borderline resectable or locally advanced disease, morbid obesity (BMI>40), rare aberrant organ anatomy, and prior surgeries with documentation stating an extensive amount of adhesive disease (Supplementary Figure 1). The LPD and OPD cohorts were previously reported to be clinically similar with two exceptions; the median primary tumor size in greatest diameter was significantly larger in the OPD group (median (IQR) 2.5 (1.9–3.0) cm vs 2.7 (2.0–3.5) cm, $P = 0.046$) and the R1 resection rate in the OPD group was significantly

Author Manuscript Author Manuscript Author Manuscript Author Manuscript

higher (26% versus 9.6%, p = 0.030) [8] (Supplementary Tables 1 and 2). The laparoscopic techniques employed have also been previously described [14, 18].

All patients in the study received care in a single intensive care unit, a single regular care medical/surgical ward, and by a single discharge coordinator, social worker, and physician assistant, and a rotating team of residents. Post-operative care was highly proscribed by an Early Recovery After Surgery (ERAS) protocol that aimed for discharge on post-operative day five. Items that are regulated by this and other ICU-specific protocols include: pulmonary toilet, fluid resuscitation, blood transfusion triggers, nasogastric tube management, initiation and progression of oral intake, initiation of tube feeds or total parental nutrition, physical activity and use of physical therapy consultation, glucose monitoring and management, and diabetic education.

The cost data was abstracted from University of Florida Health's data repository that includes direct and indirect costs. Total costs were calculated from the sum of the direct and indirect costs for specified categories including hospital salaries, supplies, and overhead. Physician professional billing was not included in the costs as these are not part of the institution's data repository. All costs were abstracted and applied to each patient in identical fashion. Readmissions, lengths of stay, and discharge dispositions were also abstracted from University of Florida Health's data repository. Readmissions were evaluated for attribution to surgical care versus other causes (i.e. neutropenia or electrolyte abnormalities associated with chemotherapy) at 30, 60, 90, 180, and 360 days.

All statistical analyses were performed using the SPSS version 22.0 statistical software package (IBM SPSS statistics for Windows; IBM Corp). Continuous variables were analyzed using the independent samples *t*-test. Differences between categorical variables were analyzed using χ^2 coefficients and Fischer's exact test, as appropriate. Significance was considered for $P < 0.05$.

Results

During the study dates from November 2010 to February 2014, our institution performed 236 PDs of which 91 (39%) were LPD. Of these patients, 138 met the inclusion criteria of a periampullary malignancy; 7 patients were excluded as not being candidates for LPD for reasons not related to the neoplasm [8]. Patients were further excluded if preoperative imaging or intraoperative findings identified disease burden beyond NCCN criteria for "resectable" disease. Of the 61 OPD patients and 70 LPD patients with periampullary adenocarcinoma, 11 and 18 patients, respectively were excluded due to the presence of borderline resectable tumors. Thus, the OPD and LPD cohorts represented 50 and 52 patients, respectively. Of the 52 LPD patients, 2 required conversion to OPD but were included in the LPD arm as an intention to treat analysis.

The comparison of operating room (OR) costs between the cohorts found the LPD to have significantly higher total costs (median (IQR) of $12,290 ($11,387–13,475) for LPD vs $11,299 ($9,053–12,968) for OPD; $P = 0.05$). When itemized, LPD had greater costs of laparoscopic equipment and regional nerve blocks (Table 1). The differences in total OR cost

Author Manuscript Author Manuscript Author Manuscript Author Manuscript

can be attributed to these two categories. No significant differences in costs associated with surgical staplers, electrosurgical devices, sutures, or room charges were observed between the two cohorts.

While the hospital length of stay was significantly shorter for LPD (median (IQR) of 7 (6–11.5) vs 8 (7–12) days; $P = 0.025$) [8] (Supplementary Table 3), this was not associated with statistically significant savings in any non-OR category of care-related costs including room- or ICU-costs. However, trends in savings in the LPD cohort in these and several other categories led to the observation that total costs of the initial hospital stay were not significantly different between LPD and OPD (Table 2). Thus, non-specific savings in postoperative care costs negated the increased costs of the OR in the LPD cohort.

Another source of variability in the overall cost of PD that has not been previously evaluated is post-discharge costs directly attributable to recovery from the surgical procedure. These include expenses associated with home health care (HHC), skilled nursing facilities (SNF), long term acute care hospitals (LTAC), and rehabilitation facilities. We found that LPD patients were more likely to be discharged home compared to the OPD patients ($P = 0.047$) (Table 3). When this was subcategorized between those who went home with HHC and those who went home without HHC, there was also a trend for more LPD patients going home without HHC ($P = 0.064$). Further, more patients were discharged to a healthcare facility in the OPD group compared to the LPD group, respectively 26% vs 10% ($P = 0.038$). No patients in the LPD cohort were discharged to rehabilitation facilities ($P = 0.054$) or to an LTAC ($P = 0.24$).

Readmissions were evaluated for attribution to surgical care versus other etiologies (i.e. neutropenia or electrolyte abnormalities associated with chemotherapy) at 30, 60, 90, 180, and 360 days. No readmissions occurred due to surgery-related complications after 60 days, but readmissions related to chemotherapy toxicity were identified between 60 and 90 days (data not shown). Thus, all readmissions within 60 days of the surgical procedure were analyzed for potential cost differences. No differences in the total numbers of readmissions between LPD and OPD were found, 23% vs 30%, respectively ($P = 0.43$) (Table 4). No patient was readmitted more than one time in the 60 days from discharge. The total number of readmission hospital days in the OPD group was 186 vs 90 in the LPD group. However, the average length of stay per patient was not statistically significant between the groups. Ultimately, total costs associated with readmissions were not significantly different between the groups. Even when costs were itemized into categories (Table 5), no specific differences in costs were observed between the groups.

Discussion

To determine if the LPD is an effective cost alternative to OPD, we retrospectively evaluated total episode of care costs for patients undergoing PD. This entailed compiling the costs of the initial hospitalization, readmissions related to the surgery, and disposition from the hospital. We show there is no difference between costs of the index admission or readmissions, except for a statistically significant, but only marginally relevant procedure specific OR cost. However, we observed a significant difference in disposition from the

Author Manuscript

Author Manuscript

Author Manuscript

Author Manuscript

hospital following the index admission. Although we could not obtain costs of the rehabilitation facilities, LTACs, and SNFs, or length of stay data, it is reasonable to assume the overall cost burden would be decreased in the LPD group as a result of these disposition differences.

Our data regarding costs of the index hospitalization are consistent with the reports of others. However, one report did identify that OPD surgical costs are significantly less than the LPD [6, 7, 16]. Our data expand upon these earlier studies, identifying that LPD results in a significant number of patients going directly home rather than to an LTAC, rehabilitation facility, or SNF as compared to OPD. We also analyzed the total number of readmissions attributable to the surgical procedure and the associated hospital days and costs of those readmissions for both the LPD and OPD cohorts. The data show no significant difference in the number of readmissions and no differences in the length of stay per patient. The total costs of the readmissions are also not statistically different between the groups, nor are there any differences in the subcategories, suggesting that LPD does not confer a benefit via reduction in readmission rates or the associated costs of those readmissions.

As expected, when comparing the OR costs, we identified a statistically significant total cost difference favoring OPD. There was not a difference between groups in costs associated with staplers, energy devices, or overall room charges. Rather, this difference was attributable to significant differences in the regional nerve block and laparoscopic equipment categories. The LPD group received bilateral paravertebral catheters while the OPD group received an epidural catheter at the time of surgery, and this doubled the LPD cost in that category. Thus, should the LPD group receive epidural catheter analgesia moving forward, the total cost of the LPD is decreased by $630 per patient and this would eliminate the OR cost benefit of OPD (*P* value = 0.40). Given that the total index admission cost of care was equitable between the two groups, for bundled payment models, these discrete categorical differences may not be relevant in the future.

Of note, all patients in this study were subjected to the same ERAS protocol; a practice that has become standard in most tertiary pancreatic surgery centers. The rationale for these protocols is to standardize care and thus drive reductions in complications and length of stay [20, 21]. This consistency between cohorts strengthens the validity of our observations, but prohibits our ability to assess the impact of ERAS protocols upon costs or the potential decrease in cost that can be realized by implementing ERAS protocols.

This study is subject to a number of limitations. It reflects the results of a single LPD surgeon compared to multiple surgeons performing OPD within the experience of a single institution, and like all retrospective analyses, it is at risk for selection bias. Although the selection criteria was for resectable disease only, the cohorts did in fact have a difference in R1 resection with 26% of patients in the OPD having an R1 resection while only 9.6% in the LPD had an R1 resection. But, the median tumor size in the OPD group was also larger (2.5 (IQR 1.9–3.0) cm vs 2.7 (IQR 2.0–3.5) cm, p = 0.046), thus this certainly could be a confounding factor. Studies aimed at assessing the potential value of LPD with respect to obtaining negative retroperitoneal margin may be warranted. Further, this study does not account for the impact of a learning curve when implementing LPD that associates with

Author Manuscript Author Manuscript Author Manuscript Author Manuscript

increased OR time, but not necessarily increased complications [6, 13, 19, 22]. Specific to increased OR time that would impact cost, this learning curve is realized somewhere between ten and fifty cases [6]. Thus, the time frame analyzed represents a period significantly beyond our institutions LPD learning curve. As OR times are longer during this learning curve, associated cost increases should be expected. Finally, our study is also limited by our lack of data regarding robotic pancreatoduodenectomy (RPD) and we cannot provide cost data to support the increasing use of RPD [2, 5, 11] or the impact of costs during the associated learning curve of RPD [23, 24]. Similar to LPD, the literature does suggest that RPD may offer some clinical outcome advantages over OPD [2, 5, 25, 26]. Thus, our finding of reduced health care needs upon discharge following LPD may suggest this benefit will also be realized with RPD. Taken together, the translation of our findings to other high volume pancreatic surgery programs should be limited.

In summary, the study suggests that the cost of the index hospitalization for LPD is equivalent to OPD. However, total episode of care costs may favor LPD via reduced post-hospital needs for skilled nursing and rehabilitation.

Supplementary Material

Refer to Web version on PubMed Central for supplementary material.

Acknowledgments

Supported in part by training grant NCI 5T32CA106493-09 (D.D.), funds from the Cracchiolo Foundation (D.D.) and the Frederick A. Coller Surgical Society (D.D.)

Michael H Gerber – contributed to conception of the work, design of the work, acquisition, analysis and interpretation of data for the work, drafting the work, revising the work critically for important intellectual content, and have agreed to the final version to be published

Daniel Delitto – contributed to design of the work, acquisition, analysis and interpretation of data for the work, drafting the work, revising the work critically for important intellectual content, and have agreed to the final version to be published

Cristina J Crippen – contributed to the acquisition, analysis and interpretation of data for the work, revising the work critically for important intellectual content, and have agreed to the final version to be published

Thomas J George Jr – contributed to the acquisition, analysis and interpretation of data for the work, revising the work critically for important intellectual content, and have agreed to the final version to be published

Kevin E Behrns – contributed to the acquisition, analysis and interpretation of data for the work, revising the work critically for important intellectual content, and have agreed to the final version to be published

Jose G Trevino – contributed to the acquisition, analysis and interpretation of data for the work, revising the work critically for important intellectual content, and have agreed to the final version to be published

Jessica L Cioffi – contributed to the acquisition, analysis and interpretation of data for the work, revising the work critically for important intellectual content, and have agreed to the final version to be published

Steven J Hughes – contributed to conception of the work design of the work, acquisition, analysis and interpretation of data for the work, drafting the work, revising the work critically for important intellectual content, and have agreed to the final version to be published

Author Manuscript

Author Manuscript

Author Manuscript

Author Manuscript

References

1. Alsfasser G, Hermeneit S, Rau BM, Klar E. Minimally Invasive Surgery for Pancreatic Disease - Current Status. Digestive surgery. 2016; 33(4):276–83. DOI: 10.1159/000445007 [PubMed: 27216738]
2. Correa-Gallego C, Dinkelspiel HE, Sulimanoff I, Fisher S, Vinuela EF, Kingham TP, Fong Y, DeMatteo RP, D'Angelica MI, Jarnagin WR, Allen PJ. Minimally-invasive vs open pancreaticoduodenectomy: systematic review and meta-analysis. Journal of the American College of Surgeons. 2014; 218(1):129–39. DOI: 10.1016/j.jamcollsurg.2013.09.005 [PubMed: 24275074]
3. Doula C, Kostakis ID, Damaskos C, Machairas N, Vardakostas DV, Feretis T, Felekouras E. Comparison Between Minimally Invasive and Open Pancreaticoduodenectomy: A Systematic Review. Surgical laparoscopy, endoscopy & percutaneous techniques. 2016; 26(1):6–16. DOI: 10.1097/sle.0000000000000228
4. Nappo G, Perinel J, El Bechwaty M, Adham M. Minimally Invasive Pancreatic Resection: Is It Really the Future? Digestive surgery. 2016; 33(4):284–9. DOI: 10.1159/000445012 [PubMed: 27216850]
5. Boggi U, Amorese G, Vistoli F, Caniglia F, De Lio N, Perrone V, Barbarello L, Belluomini M, Signori S, Mosca F. Laparoscopic pancreaticoduodenectomy: a systematic literature review. Surgical endoscopy. 2015; 29(1):9–23. DOI: 10.1007/s00464-014-3670-z [PubMed: 25125092]
6. Speicher PJ, Nussbaum DP, White RR, Zani S, Mosca PJ, Blazer DG 3rd, Clary BM, Pappas TN, Tyler DS, Perez A. Defining the learning curve for team-based laparoscopic pancreaticoduodenectomy. Annals of surgical oncology. 2014; 21(12):4014–9. DOI: 10.1245/s10434-014-3839-7 [PubMed: 24923222]
7. Mesleh MG, Stauffer JA, Bowers SP, Asbun HJ. Cost analysis of open and laparoscopic pancreaticoduodenectomy: a single institution comparison. Surgical endoscopy. 2013; 27(12):4518–23. DOI: 10.1007/s00464-013-3101-6 [PubMed: 23943116]
8. Delitto D, Luckhurst CM, Black BS, Beck JL, George TJ Jr, Sarosi GA, Thomas RM, Trevino JG, Behrns KE, Hughes SJ. Oncologic and Perioperative Outcomes Following Selective Application of Laparoscopic Pancreaticoduodenectomy for Periampullary Malignancies. Journal of gastrointestinal surgery : official journal of the Society for Surgery of the Alimentary Tract. 2016; 20(7):1343–9. DOI: 10.1007/s11605-016-3136-9 [PubMed: 27142633]
9. Asbun HJ, Stauffer JA. Laparoscopic vs open pancreaticoduodenectomy: overall outcomes and severity of complications using the Accordion Severity Grading System. Journal of the American College of Surgeons. 2012; 215(6):810–9. DOI: 10.1016/j.jamcollsurg.2012.08.006 [PubMed: 22999327]
10. Croome KP, Farnell MB, Que FG, Reid-Lombardo KM, Truty MJ, Nagorney DM, Kendrick ML. Total laparoscopic pancreaticoduodenectomy for pancreatic ductal adenocarcinoma: oncologic advantages over open approaches? Annals of surgery. 2014; 260(4):633–8. discussion 8–40. DOI: 10.1097/sla.0000000000000937 [PubMed: 25203880]
11. Zhang H, Wu X, Zhu F, Shen M, Tian R, Shi C, Wang X, Xiao G, Guo X, Wang M, Qin R. Systematic review and meta-analysis of minimally invasive versus open approach for pancreaticoduodenectomy. Surgical endoscopy. 2016; 30(12):5173–84. DOI: 10.1007/s00464-016-4864-3 [PubMed: 27005287]
12. Stauffer JA, Coppola A, Villacreses D, Mody K, Johnson E, Li Z, Asbun HJ. Laparoscopic versus open pancreaticoduodenectomy for pancreatic adenocarcinoma: long-term results at a single institution. Surgical endoscopy. 2016; doi: 10.1007/s00464-016-5222-1
13. Tan CL, Zhang H, Peng B, Li KZ. Outcome and costs of laparoscopic pancreaticoduodenectomy during the initial learning curve vs laparotomy. World journal of gastroenterology. 2015; 21(17):5311–9. DOI: 10.3748/wjg.v21.i17.5311 [PubMed: 25954105]
14. Zureikat AH, Breaux JA, Steel JL, Hughes SJ. Can laparoscopic pancreaticoduodenectomy be safely implemented? Journal of gastrointestinal surgery : official journal of the Society for Surgery of the Alimentary Tract. 2011; 15(7):1151–7. DOI: 10.1007/s11605-011-1530-x [PubMed: 21538192]
15. Delitto D, Black BS, Cunningham HB, Sliesoraitis S, Lu X, Liu C, Sarosi GA, Thomas RM, Trevino JG, Hughes SJ, George TJ Jr, Behrns KE. Standardization of surgical care in a high-

Author Manuscript
Author Manuscript
Author Manuscript
Author Manuscript

volume center improves survival in resected pancreatic head cancer. American journal of surgery. 2016; 212(2):195–201.e1. DOI: 10.1016/j.amjsurg.2016.03.001 [PubMed: 27260793]

16. Fox AM, Pitzul K, Bhojani F, Kaplan M, Moulton CA, Wei AC, McGilvray I, Cleary S, Okrainec A. Comparison of outcomes and costs between laparoscopic distal pancreatectomy and open resection at a single center. Surgical endoscopy. 2012; 26(5):1220–30. DOI: 10.1007/s00464-011-2061-y [PubMed: 22179451]
17. Tempero MA, Malafa MP, Behrman SW, Benson AB 3rd, Casper ES, Chiorean EG, Chung V, Cohen SJ, Czito B, Engebretson A, Feng M, Hawkins WG, Herman J, Hoffman JP, Ko A, Komanduri S, Koong A, Lowy AM, Ma WW, Merchant NB, Mulvihill SJ, Muscarella P 2nd, Nakakura EK, Obando J, Pitman MB, Reddy S, Sasson AR, Thayer SP, Weekes CD, Wolff RA, Wolpin BM, Burns JL, Freedman-Cass DA. Pancreatic adenocarcinoma, version 2.2014: featured updates to the NCCN guidelines. Journal of the National Comprehensive Cancer Network : JNCCN. 2014; 12(8):1083–93. [PubMed: 25099441]
18. Hughes SJ, Neichoy B, Behrns KE. Laparoscopic intussuscepting pancreaticojejunostomy. Journal of gastrointestinal surgery : official journal of the Society for Surgery of the Alimentary Tract. 2014; 18(1):208–12. DOI: 10.1007/s11605-013-2308-0 [PubMed: 23929187]
19. Kim SC, Song KB, Jung YS, Kim YH, Park DH, Lee SS, Seo DW, Lee SK, Kim MH, Park KM, Lee YJ. Short-term clinical outcomes for 100 consecutive cases of laparoscopic pylorus-preserving pancreatoduodenectomy: improvement with surgical experience. Surgical endoscopy. 2013; 27(1): 95–103. DOI: 10.1007/s00464-012-2427-9 [PubMed: 22752284]
20. Pecorelli N, Nobile S, Partelli S, Cardinali L, Crippa S, Balzano G, Beretta L, Falconi M. Enhanced recovery pathways in pancreatic surgery: State of the art. World journal of gastroenterology. 2016; 22(28):6456–68. DOI: 10.3748/wjg.v22.i28.6456 [PubMed: 27605881]
21. Lassen K, Coolsen MM, Slim K, Carli F, de Aguilar-Nascimento JE, Schafer M, Parks RW, Fearon KC, Lobo DN, Demartines N, Braga M, Ljungqvist O, Dejong CH. Guidelines for perioperative care for pancreaticoduodenectomy: Enhanced Recovery After Surgery (ERAS(R)) Society recommendations. World journal of surgery. 2013; 37(2):240–58. DOI: 10.1007/s00268-012-1771 [PubMed: 22956014]
22. Paniccia A, Schulick RD, Edil BH. Total Laparoscopic Pancreaticoduodenectomy: A Single-Institutional Experience. Annals of surgical oncology. 2015; 22(13):4380–1. DOI: 10.1245/s10434-015-4450-2 [PubMed: 25893407]
23. Boone BA, Zenati M, Hogg ME, Steve J, Moser AJ, Bartlett DL, Zeh HJ, Zureikat AH. Assessment of quality outcomes for robotic pancreaticoduodenectomy: identification of the learning curve. JAMA surgery. 2015; 150(5):416–22. DOI: 10.1001/jamasurg.2015.17 [PubMed: 25761143]
24. Shakir M, Boone BA, Polanco PM, Zenati MS, Hogg ME, Tsung A, Choudry HA, Moser AJ, Bartlett DL, Zeh HJ, Zureikat AH. The learning curve for robotic distal pancreatectomy: an analysis of outcomes of the first 100 consecutive cases at a high-volume pancreatic centre. HPB : the official journal of the International Hepato Pancreato Biliary Association. 2015; 17(7):580–6. DOI: 10.1111/hpb.12412 [PubMed: 25906690]
25. Zhang J, Wu WM, You L, Zhao YP. Robotic versus open pancreatectomy: a systematic review and meta-analysis. Annals of surgical oncology. 2013; 20(6):1774–80. DOI: 10.1245/s10434-012-2823-3 [PubMed: 23504140]
26. Zureikat AH, Postlewait LM, Liu Y, Gillespie TW, Weber SM, Abbott DE, Ahmad SA, Maithel SK, Hogg ME, Zenati M, Cho CS, Salem A, Xia B, Steve J, Nguyen TK, Keshava HB, Chalikonda S, Walsh RM, Talamonti MS, Stocker SJ, Bentrem DJ, Lumpkin S, Kim HJ, Zeh HJ 3rd, Kooby DA. A Multi-institutional Comparison of Perioperative Outcomes of Robotic and Open Pancreaticoduodenectomy. Annals of surgery. 2016; 264(4):640–9. DOI: 10.1097/sla.0000000000001869 [PubMed: 27433907]

Author Manuscript Author Manuscript Author Manuscript Author Manuscript

Table 1

Itemized OR costs

	LPD (*n*=52)	OPD (*n*=50)	*P* value
Electrosurgical, median (IQR)	$ 640 (559 – 724)	$ 503 (390 – 643)	0.25
Laparoscopic, median (IQR)	$ 446 (251 – 626)	$ 0 (0 - 0)	<0.001*
Room, median (IQR)	$ 7,315 (6,427 – 8,627)	$ 7,164 (6,284 – 8,237)	0.52
Other, median (IQR)	$ 348 (259 – 407)	$ 192 (102 – 307)	0.55
Regional block, median (IQR)	$ 1,510 (515 – 1,912)	$ 718 (164 – 1,361)	<0.001*
Staplers/Clips, median (IQR)	$ 1,591 (1,355 – 2,273)	$ 1,886 (519 – 2,794)	0.98
Suture, median (IQR)	$ 244 (0 – 464)	$ 212 (0 – 513)	0.92
Total cost, median (IQR)	$ 12,290 (11,387 – 13,475)	$ 11,299 (9,053 – 12,968)	0.05*

P values were calculated using the unpaired *t* test

IQR interquartile range

Author Manuscript Author Manuscript Author Manuscript Author Manuscript

Table 2

Itemized Hospital costs

	LPD (*n*=52)	OPD (*n*=50)	*P* value
Hospital Bed, median (IQR)	$ 5,634 (3,858 – 8,641)	$ 5,711 (3,756 – 9,816)	0.66
Anesthesia, median (IQR)	$ 1,444 (1,344 – 1,577)	$ 1,495 (1,321 – 1,626)	0.80
Anesthesia Pre-op, median (IQR)	$ 0 (0 - 0)	$ 0 (0 - 0)	0.17
Blood, median (IQR)	$ 119 (41 – 175)	$ 159 (111 – 324)	0.97
Dietary, median (IQR)	$ 0 (0 - 0)	$ 0 (0 – 67)	0.41
ER, median (IQR)	$ 0 (0 - 0)	$ 0 (0 - 0)	0.08
ICU, median (IQR)	$ 3,206 (1,697 – 5,700)	$ 5,262 (3,606 – 8,572)	0.23
Lab, median (IQR)	$ 1,262 (1,042 – 1,702)	$ 1,987 (1,522 – 2,517)	0.17
OR, median (IQR)	$ 12,958 (12,052 – 14,565)	$ 11,442 (9,053 – 13,039)	0.02*
OT, median (IQR)	$ 0 (0 - 0)	$ 0 (0 – 126)	0.47
Other Therapy, median (IQR)	$ 0 (0 – 327)	$ 0 (0 – 209)	0.98
Pharmacy, median (IQR)	$ 2,256 (1,534 – 3,057)	$ 1,936 (1,481 – 4,412)	0.75
PT, median (IQR)	$ 222 (83 – 396)	$ 311 (188 – 473)	0.22
Radiology, median (IQR)	$ 220 (75 – 827)	$ 353 (159 – 1,171)	0.75
RT, median (IQR)	$ 253 (89 – 681)	$ 261 (82 – 1,685)	0.45
Supplies, median (IQR)	$ 279 (212 – 486)	$ 394 (287 – 805)	0.93
Total Cost, median (IQR)	$ 28,496 (25.913 – 35,464)	$ 28,623 (25,717 – 46,241)	0.61

P values were calculated using the unpaired *t* test

IQR interquartile range, ER emergency room, ICU intensive care unit, OR operating room, OT occupational therapy, PT physical therapy, RT respiratory therapy

Author Manuscript Author Manuscript Author Manuscript Author Manuscript

Table 3

Disposition at Initial Discharge

	LPD (*n*=52)	OPD (*n*=50)	*P* value
Expired	1 (2%)	1 (2%)	1
To home (with or without HHC)	46 (88%)	36 (72%)	0.047*
To home with HHC	23 (44%)	23 (46%)	1
To home without HHC	23 (44%)	13 (26%)	0.064
To facility	5 (10%)	13 (26%)	0.038*
To long term acute care	0 (0%)	2 (4%)	0.24
To rehabilitation center	0 (0%)	4 (8%)	0.054
To skilled nursing facility	5 (10%)	7 (14%)	0.55

P values were calculated using Fisher's exact test

HHC home health care

Author Manuscript
Author Manuscript
Author Manuscript
Author Manuscript

Table 4

60 Day Readmissions

	LPD	OPD	*P* value
Readmissions within 60 days (SEM)	12 (23%)	15 (30%)	0.43
Total hospital days during readmissions	90	186	
Average length of stay per readmission, days (SEM)	7.5 (1.76)	12.4 (4.72)	0.38

P values were calculated using χ^2 coefficients

SEM standard error of the mean

Author Manuscript Author Manuscript Author Manuscript Author Manuscript

Table 5

Itemized Hospital Costs of Readmissions

	LPD (*n*=52)	OPD (*n*=50)	*P* value
Acute Care, median (IQR)	$ 2,176 (1,101 – 4,993)	$ 3,756 (1,421 – 7,566)	0.12
Anesthesia Pre-Op, median (IQR)	$ 0 (0 - 0)	$ 0 (0 - 0)	0.31
Anesthesiology, median (IQR)	$ 0 (0 - 0)	$ 0 (0 - 0)	0.69
Blood, median (IQR)	$ 0 (0 – 85)	$ 0 (0 – 112)	0.21
Dietary, median (IQR)	$ 0 (0 - 0)	$ 0 (0 – 118)	0.11
ER, median (IQR)	$ 0 (0 – 475)	$ 0 (0 – 453)	0.40
ICU, median (IQR)	$ 0 (0 - 0)	$ 0 (0 - 0)	0.34
Lab, median (IQR)	$ 380 (181 – 860)	$ 414 (219 – 1,213)	0.31
OR, median (IQR)	$ 0 (0 - 0)	$ 0 (0 - 0)	0.26
OT, median (IQR)	$ 0 (0 - 0)	$ 0 (0 - 0)	0.47
Other Therapy, median (IQR)	$ 0 (0 – 624)	$ 0 (0 – 542)	0.52
Outpatient Surgery, median (IQR)	$ 0 (0 - 0)	$ 0 (0 - 0)	0.43
Pharmacy, median (IQR)	$ 506 (346 – 2,216)	$ 917 (269 – 1,826)	0.64
PT, median (IQR)	$ 0 (0 – 206)	$ 0 (0 – 233)	0.53
Radiology, median (IQR)	$ 513 (90 – 2,868)	$ 1,034 (258 – 2,109)	0.58
RT, median (IQR)	$ 0 (0 – 140)	$ 0 (0 – 75)	0.34
Supplies, median (IQR)	$ 84 (48 – 254)	$ 167 (62 – 295)	0.32
Total Cost, median (IQR)	$ 6,714 (3,824 – 21,305)	$ 8,796 (5,081 – 20,920)	0.42

P values were calculated using the unpaired *t* test

IQR interquartile range, ER emergency room, ICU intensive care unit, OR operating room, OT occupational therapy, PT physical therapy, RT respiratory therapy