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Old Dogs and New Techniques: Comparing Complete Robotic Adoption to Laparoscopic Surgery-A Single Institution Experience with Distal Pancreatectomies

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Abstract

The laparoscopic distal pancreatectomy (LDP) is superior to the open approach; however, proximal dissection, hand-assisted (HA) approaches and conversion to open resection can be improved upon. Robotic distal pancreatectomy (RDP) addresses the limitations of LDP with better optics (3D), magnification, instrument/visual stabilization and dexterity of the instrumentation. We sought to investigate RDP vs. LDP and to introduce a new variable, tumor distance from the superior mesenteric vein (SMV), to assess how proximal the dissection was performed. A consecutive sample of 45 patients who underwent minimally invasive distal pancreas resection between 2/1/2012 to 6/30/2018 was completed. Typical demographics and clinicopathologic variables were collected, including outcomes. Overall, 22 LDPs and 23 RDPs, were evaluated. No demographics, comorbidities, or ASA score were significantly different between the cohorts. Neither differences in tumor size (LDP: 3.4cm +/- 2.8, RDP: 3.1cm +/- 1.9; p=0.80) or distance from the SMV (LDP: 4.1cm +/- 3.0, RDP: 3.9 cm+/- 2.9; p = 0.89) were significantly different. Positive margins were similar between groups; lymph nodes were less with LDP than RDP (mean 6.4 and 10, respectively; p=0.09). Post-operative complications and length of stay (mean 5.4 and 5.3 days, respectively) were similar between groups (p=0.27; p=0.94). We show that converting to an entirely robotic approach for distal pancreatectomies is safe, effective, with potentially better lymph node dissection and a learning curve that demonstrates adoption at any level of post residency training. Additionally, tumor distance from the SMV/portal vein confluence could help quantify the theoretical technical advantages of robotic distal pancreatectomy.

Introduction

A complex and challenging procedure, distal pancreatectomy (DP) has traditionally been performed via an open approach [1]. With advancements in technology, the first laparoscopic distal pancreatectomy (LDP) was performed in 1994 by Cuschieri [2]. Compared to open surgery, LDP is associated with a reduction in hospital stay, analgesic requirements, and blood loss [3-5]. Despite the benefits of a minimally invasive approach, LDP has limitations. The presence of large vascular structures, the retroperitoneal location, and the concern for an inadequate margin clearance create obstacles for surgeons who choose LDP, sometimes forcing them to convert to a HA or open approach [5,6].

Robotic surgery represents the latest innovation in minimally invasive surgery. Melvin et al. reported the first robotic distal pancreatectomy (RDP) in 2003, the same year Giulianotti et al. published their series of robotic pancreas resections [7,8]. Robotic surgery has allowed surgeons to overcome the limitations of LDP, while maintaining a minimally invasive approach. Most notably, a robotic approach provides a larger range of motion due to an internal articulated endo-wrist. Robotics also offer a three-dimensional high-definition surgical view and tremor filtration, which can significantly improve ergonomics for the surgeon [9]. Theoretically, these technical advantages should afford the surgeon greater precision, possibly providing them more access to tumors that would be not considered for a laparoscopic approach and thus relegated to a HA or open method.

Despite the benefits of robotic surgery, the adoption of RDP has been slow. For veteran surgeons, adopting new surgical approaches can be daunting. This hesitation is often due to the loss of tactile feedback with robotics, which relies on "visual haptics," and concerns over increased operating time during the early learning curve as well as possible increased cost associated with robotic surgery [1]. Furthermore, the adoption of a new surgical approach can be hindered by a lack of training/experience, comfort with old approaches, and concerns regarding outcomes. A growing body of literature has arisen to compare the outcomes of LDP and RDP [1,5,10-13]. Meta-analyses by Gavriilidis (2016) and Zhou (2016) investigate the findings of 8 retrospective studies and 2 prospective studies comparing LDP and RDP [14,15]. RDP was found to be a safe and comparable alternative to LDP, with no differences found between the two approaches.

The aim of this study was to investigate the effectiveness of converting to an entirely robotic platform for distal pancreatectomies by a veteran surgeon (old dog) and to introduce a new variable, tumor distance from the superior mesenteric vein (SMV), as a measure of precisely assessing how proximal the dissection was performed.

Methods

Following IRB approval, a retrospective analysis from 2/1/2012 to 6/30/2018 of 45 consecutive patients who underwent minimally invasive distal pancreas resection at our tertiary institution was

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completed. Patients with multiple other operations, those without followed up at our institution, and patients for whom complete records were not available were excluded. All procedures were performed by a single surgeon. The LDP population consisted of patients who received treatment before robotic resection was available at our institution (2/1/2012 to 4/30/2016). The LDP cohort included those resections that involved hand assistance as well as those requiring conversion to HAL. The RDP population consisted of patients treated following the introduction of robotic resection after 4/30/2016. This cohort included patients resected with robotic technology only and those surgeries that were converted from robotics to an open resection.

Robotic surgeries were completed using the DaVinci® Robotics (Intuitive, Sunnyvale, CA).

Preoperative imaging noted tumor size and distance from the SMV/portal vein confluence as a comparison of the perceived difficulty of the resection and appropriate use of surgical technique (LDP+/- HAL; RDP conversion to open). For the purposes of our study, we considered any patient that was started or changed to HAL as an indication of a case outside a straight MIS approach.

All data were retrospectively collected and obtained from the institution's electronic medical records. The following data were extracted: cohort characteristics, tumor location, intraoperative outcomes (operative time, estimated blood loss, conversion rate, complications), postoperative recovery (length of stay (LOS), post-operative complications), and pathological outcomes (margin status by frozen section and/or permanent section, tumor size, histologic grade, lymph nodes harvested). Tumor location and distance from the SMV were identified using pre-operative CT scans to trace the SMV/portal vein confluence to the proximal edge of the tumor. The shorter the distance the more proximal the dissection necessary for resection and in principle; more challenging the surgery. Postoperative complications were categorized according to the Dindo–Clavien classification [16].

Data were stratified into LDP and RDP cohorts for statistical analyses. The welch two sample t-tests were used to compare mean age, BMI, length of stay, tumor size and location, console time, estimated blood loss, and number of nodes examined. Fisher's exact test was used to compare categorical variables to include race, gender, insurance status, ASA score, comorbidities, and post-operative complications.

Results

Following application of the exclusion criteria, 45 patients, 22 LDPs and 23 RDPs, were included in the study. In regards to demographics, the two cohorts were not significantly different for age (mean 59.9 and 63.1 years, respectively), race, gender, BMI (mean 29.6 and 27.7, respectively) and insurance status. The most frequent American Society of Anesthesiologist's score (ASA) in the cohorts was 3; however, this was also not significantly different (Table 1). No significant differences in comorbidities, previous cancer, or previous surgery were observed between the two groups (data not shown). Interestingly, there were no significant differences for tumor size (LDP: 3.4cm +/- 2.8, RDP: 3.1cm +/- 1.9; p=0.80) or distance from the SMV (LDP: 4.1cm +/- 3.0, RDP: 3.9 cm+/- 2.9; p = 0.89) between cohorts (Table 2). When considering conversions, HALS/open were

Table 1: Demographics.

	Total	Laparoscopic	Robotic	p-value
	n = 45	n = 22	n = 23	α = 0.05
Age (Years)				
Mean	61.5	59.9	63.1	0.39
Range	25 - 84	25 - 84	39 - 80	
Race				0.22
White	35 (78%)	16 (73%)	19 (83%)	
Black	6 (13%)	5 (23%)	1 (4%)	
Hispanic	4 (9%)	1 (5%)	3 (13%)	
Gender				0.54
Female	28 (62%)	15 (68%)	13 (57%)	
Male	17 (38%)	7 (32%)	10 (43%)	
Insurance				0.8
Private		17	19	
Medicare		2	3	
Medicaid		2	1	
None		1	0	
BMI				
Mean	28.6	29.6	27.7	0.4
Range	15.9 - 54.6	22.6 - 44.5	15.9 - 54. 6	
ASA Score				0.8
1	1 (2%)	0 (0%)	1 (4%)	
2	8 (18%)	5 (23%)	3 (13%)	
3	31 (69%)	15 (68%)	16 (70%)	
4	5 (11%)	2 (9%)	3 (13%)	

Table 2: Surgical Variable.

	Laparoscopic	Robotic	p-value
	n = 22	n = 23	α = 0.05
Tumor Size			0.8
Mean	3.35	3.15	
Distance from SMV			0.89
Mean	4.1	3.9	
Range	0 - 9.4	0 - 9.0	
Conversions*			
Open	2 (9%)	3 (13%)	0.16
HALS	5 (23%)	0 (0%)	
Positive Margins	1	1	
Nodes Examined			
Mean	6.4	10	**0.05**
Console Time			0.1
Mean	225	259	
Range	139 - 364	144 - 426	
EBL			
Mean	152	214	0.34
Range	5 - 800	10 - 900	
Post Op Complications			0.27
0	5 (23%)	10 (43%)	
1	13 (59%)	7 (30%)	
2	3 (14%)	4 (17%)	
3b	0 (0%)	1 (4%)	
3a	1 (4%)	1 (4%)	
LOS			
Mean	5.4	5.3	0.94
Range	3 - 14	1 - 13	

*Open, HAL, HAL conversions were considered additively for LDP; RDP only had open conversions.

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combined for each cohort; overall, while the LDP cohort had more conversions than the RDP cohort (LDP 32%; RDP 13%), this was not significantly different (p=0.16; Table 2). Overall, five LDP resections included a hand assist port (25%), two were converted to open (9%), while 13% of RDP were converted to open (Table 2).

Additionally, while both cohorts had 5% of resections with positive margins, LDP harvested less lymph nodes than RDP (mean 6.4 and 10, respectively); this was not significantly different (p=0.09; Table 2). The estimated blood loss between the cohorts was also not significantly different (p=0.34) nor was the console time (p=0.10; Table 2). Post-operative complications and length of stay (mean 5.4 and 5.3 days, respectively) were similar between groups (p=0.27; p=0.94).

The most common diagnosis for the LDP cohort was a mucinous cystic neoplasm in five patients (23%). Serous cystic neoplasm was the most common diagnosis for the RDP cohort, representing seven patients (30%).

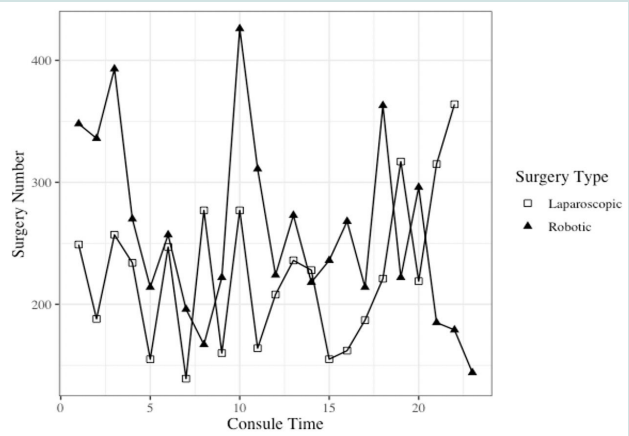

Figure 1: Consule times for a single surgeon's first 23 robotics cases compared to his last 22 laparoscopic cases. Squares represent laparoscopic cases; filled triangles represent robotic cases.

Discussion

As surgical techniques evolve and medical technology advances, established approaches are replaced with more innovative procedures that promise better outcomes. Yet before widespread adoption, the safety, efficacy, and feasibility of these approaches must be confirmed. Laparoscopic distal pancreatectomy has been shown to safely improve patient outcomes when compared to a traditional open approach; however, technical limitations remain [6]. A robotic approach provides a solution to these technical limitations with its internal articulation (seven degrees of freedom), 3D perspective, 10X optics and tremor filtration [10].

The outcomes of LDP and RDP have been compared by numerous retrospectivestudies. Meta analyses of the literature have concluded that there is essentially no difference between LDP and RDP regarding operative time, conversion rate, major morbidity, or post-operative fistula [14,17]. In our study, we aimed to not only assess these measures but also the feasibility of adopting a total robotic platform for a senior surgeon. Anecdotally, adoption of new techniques can be hindered by a lack of training/experience, comfort with established approaches and concerns regarding outcomes. To these points, three important findings were demonstrated in our study. First, within the early learning phase (20 cases) the senior surgeon was able to match his laparoscopic outcomes with no increase in operative time, morbidity or other post-operative complications. Thus, demonstrating that an "old dog" can safely learn a disruptive technology without sacrificing outcomes. A comparison of the first 20 RDP compared to our last 20 LDP highlight this (Figure 1). It is interesting to see that while there was variability in the RDP times there was also a fair amount in the LDP, despite these being our established experience (greater than 15 years of LDP resections). Few others have investigated the robotic learning curve for distal pancreatectomy. Our outcomes mirrored similar studies. A study comparing a single institution's first 20 robotic cases with their later 17 cases found no significant difference in operative time or conversion rate [1]. Another study assessed the robotic learning curve over a single institution's first 55 robotic cases using a cumulative sum method and found that operative time improved only over the first ten patients [19].

While our study did not elucidate any significant differences between the LDP and RDP cohorts, once distal pancreatectomies were done robotically, LDP was no longer a surgical option at our institution. Thus, surgeon selection bias was eliminated. Like Daouodi [5], we sought to minimize this bias by evaluating LDP and RDP cohorts based on time and not on patient or surgeon preference. Since all DP performed at our institution were laparoscopic before November 2016 and all DP performed after November 2016 were robotic, we were able to reduce the effect of treatment selection bias. Our results add to the growing evidence that RDP can be safely adopted with proper training and preparation, especially by surgeons with extensive LDP experience.

Second, while the conversion rates for LDP and RDP were not significantly different in our study, the overall conversion rate for LDP was greater than RDP (31% versus 13%), suggesting that this phenomenon will continue with continued acquisition of skill and more resection experience. Daouodi described a reduced conversion rate for RDP and Duran concluded that RDP reduced morbidity [5,12]. In hindsight this is not surprising when one considers the improved optics (10x magnification), instrument degrees of freedom (7 robotic vs 4 laparoscopic) and 3D visualization.

Third, in oncologic outcomes, the number of lymph nodes resected has become a surrogate for completeness of resection and improved prognostication [18]. We demonstrated that with RDP the number of lymph nodes resected was greater than in LDP, 10 vs 6.4 nodes (p=0.09). Again, although we are in the early phase of our adoption of this approach, we have nonetheless been able to not only show equivalence but even improvement in some measures of successful outcomes.

One of the reasons we elected to adopt robotics was the potential ability to perform a more proximal dissection (toward the SMV/ portal vein confluence). For LDP, the closer to the SMV/portal vein the lesion was, the more likely we were to use a HALs approach or dissect the tail and then make a midline incision (limited open) to complete the resection at the neck. How to define and assess this proximal dissection is difficult, outside of anecdotal experience and

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therefore we present a new variable that is potentially less subjective. Tumor distance from the SMV/portal vein confluence was evaluated in an attempt to quantify the anecdotal evidence for robotic surgery facilitating more proximal dissections. We hypothesized that RDP might allow surgeons to operate on tumors closer to the SMV/portal vein confluence, but ultimately found no significant difference in this metric. A confounding issue in this variable may have been the resolution of imaging prior to resection regarding the ability to recreate a 3D-high resolution map of the pancreas and its relationship to the SMV/portal vein confluence. With more precise measurements, 3D modeling and larger sample size, tumor distance from the SMV/portal vein confluence might be a valuable variable for future studies.

While the robotic approach has been shown to be a safe, feasible, and an effective alternative to LDP, its widespread adoption has likely been hindered by physicians' comfort with laparoscopic techniques, the relative lack of data on the RDP learning curve, and the initial cost of robotics systems [Napoli, 2015]. We present a single senior surgeon's transition from laparoscopic to robotic distal pancreatectomies to demonstrate that "old dogs" can safely learn "new tricks". Given that the surgeon had the greatest experience with LDP and the least experience with RDP highlights and the lack of difference in outcomes is remarkable and encouraging for other surgeons.

Conclusion

Our experience suggests that converting to an entirely robotic approach for distal pancreatectomies is safe, and effective, with potentially better lymph node dissection and a learning curve that demonstrates adoption at any level of post-residency training, even if that is years later. The superiority of the robotic approach over a more traditional laparoscopic approach continues to be debated; however, the introduction of a new variable, tumor distance from the SMV/portal vein confluence, could help quantify the theoretical technical advantages of robotic distal pancreatectomy. As the technology continues to evolve and more data are presented, it will be important to continue these investigations in larger, randomized clinical trials, especially with regard to long-term outcomes and physician learning curves.

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The datasets generated during and/or analyzed during the current study are not publicly available, but are available from the corresponding author on reasonable request and the procurement of a data sharing agreement with Prisma Health Upstate.

Ethics

This research study was conducted retrospectively from data obtained for clinical purposes. We consulted extensively with the IRB of Health Sciences SC who determined that our study did not need ethical approval. An IRB official waiver of ethical approval was granted from the IRB of Health Sciences SC and Prisma Health Upstate.

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