REVIEW ARTICLE

Is Robotic Pancreatic Surgery expected Access by the Minimal Access Pancreatic Surgeons?

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ABSTRACT

Objectives: Many surgeons have demonstrated the feasibility of laparoscopic pancreatoduodenectomies (PD), but benefits comparable to or even more prominent than those of an open procedure has not been clinically proven. Robotic surgery has improved some aspects of the laparoscopic approach. We compare both types of approach for PD.

Methods: The literature was systematically reviewed to find all the PD procedures totally performed by a laparoscopic or by a robotic approach.

Results: Between 1996 and 2012, 192 patients underwent a total laparoscopic PD and 109 a total robotic PD. The mean operating room time and mean estimated blood loss was 388.8 minutes and 178.7 ml for LG and 397.4 minutes and 319.06 ml for RG. Morbidity was found in 18 cases of RG and in 69 of LG. Mortality and conversion rates were similars in both arms.

Conclusion: This review can not find clear difference between both groups in spite of the short literature available.

Keywords: Laparoscopic, Robotic, Pancreatoduodenectomy, Whipple.

INTRODUCTION

Even in unresectable pancreatic neoplasms, staging or palliation can be accomplished by laparoscopic means. It is well known that the morbidity of a large laparotomy, which is required for an adequate exposure, can be avoided with laparoscopic examination and ultrasonography for staging, laparoscopic palliative bypass surgery or thoracoscopic splanchnicectomy for pain control.

But, what about minimal access pancreatic resection for pancreatic cancer? Surgical resection in nonadvanced pancreatic neoplasms represents the only hope of cure. The definitive surgical procedure for carcinoma of the head of the pancreas is the Whipple pancreaticoduodenectomy (PD), and for some time now, pylorus-preserving PD is replacing standard Whipple PD because a better gastric emptying may result in better nutrition and weight gain. Although debate continues, the open approach continues to enjoy decreasing rates of morbidity and mortality around the world, of course,

when the procedure is performed by experienced surgeons in referral centers.

At the same time, minimal access techniques are in a high-speed development day by day, minute by minute and second by second. Once a surgical technique is not fully demonstrated yet, another new access technique approach or even instrument is born. In pancreatic surgery there is increasing interest in the feasibility of minimal access techniques in an attempt to decrease morbidity. But, the difficulty of performing these complex resections and reconstructions without the whole freedom of movement of the open surgery can cast doubt on the suitability of the laparoscopic approach.

Robotic surgery, an unstoppable field of the minimal access surgery, has improved some limitations of standard laparoscopic surgery such, among other things, ergonomic, precision suturing and of course tha lack of three-dimensional visualization. So, is robotic surgery the step we were expecting for minimal access PD?

In this review, we present the current evidence available on minimal access PD comparing both techniques to sort out this question.

METHODS

Search Strategy

The PubMed database was searched electronically from 1996 up to January 2011 (inclusive). Search terms used included: Laparoscopic, robotic, Whipple procedure, pancreaticoduodenectomy, pancreatoduodenectomy. Terms were searched both in isolation and in combination. Search limits were applied to include articles published in English or in Spanish languages and human studies only. Articles published in abstract form only, single case reports, review articles or reporting less than five cases were not included for the final analysis. Cases describing hand assistance as part of the procedure or hybrid approaches are also excluded in this study because were not considered as just one pure approach (total laparoscopic or total robotic PDs). For authors or institutions who republished their results with larger series, only the most recent article and larger series were included. To achieve a more homogeneous data collecting, series of patients from multicentric studies were taken, when the information reported allowed, as independent series according to the institution. Flow chart

outlines the search history and the total number of publications included in this review.

The variables studied were as follows: Mean operating room time, mean estimated blood loss, morbidity, bleeding, fistulas rates, mortality and conversion rates.

RESULTS

The initial search identified 658 articles. After exclusion of repeated articles 228 and items not published in English or Spanish languages or no humans studies, 44, 184 publications were selected. All identified articles were examined, and manuscripts with one or more exclusion criteria were not taken into account—review articles 68, single case reports 37, lack of relevance 62, data duplication 4.

During the process of data collection, we found an article with a large series of 35 patients[1] in which there were not reported most of the variables examined, therefore, we finally excluded it in spite of it is mentioned and used in other review articles.[2] At the end, a total of 12 articles were full examined.

In the examined publications, there were no randomized controlled trials and a total of 326 patients were included in from all articles; 217 patients for the laparoscopic group (LG) and 109 for the robotic group (RG). In 25 patients (LG), an additional assistance was necessary as a minilaparotomy or a hand-port to perform the whole reconstruction, so these patients were excluded of the study. Of the remaining 301 patients the conversión rates were 29 (9.6%; LG = 16 (8.3%); RG = 13 (12%)) and were taken as technique fails.
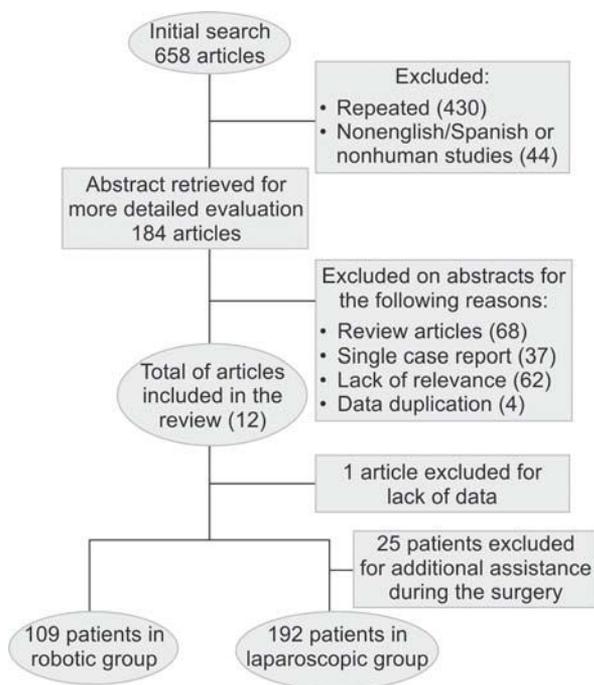
Flow Chart 1: The search history and total number of publications included

A weighted average (WA), utilized also by Gumbs et al in a recent review, is used to calculate a statistical weighted mean of all the differents means collected in the examined publications:

$$WA = (w_1x_1 + w_2x_2 + \ldots + w_nx_n)/(w_1 + w_2 + \ldots + w_n)$$

where w is the number of cases in a publication and x is the mean of an specific variable.

Tables 1 and 2 summarise the outcomes of total laparoscopic and total robotic PD respectively.

PERIOPERATIVE FACTORS

Mean operation time ranged from 287 to 628 minutes in LG and from 312 to 718 minutes in RG, with a WA of 389 (LG) and 394 minutes (RG). Mean estimated blood loss ranged from 74 to 770 ml in LG, but this variable was not reported in 10 cases (5%) which were not taken into account in the analysis. Notice that the lowest estimated blood loss is in the largest series as Palanivelu's series and most of them are under 300 ml of blood loss. WA calculated was 178.7 ml. In the robotic arm WA was 319 ml with a range from 153 to 389 ml. All of the groups reported hospital stay. Average length of stay in LG ranged from 7 to 22.3 days with a WA of 10 days. The lowest limits of this range is from the group of Minnesota, the largest and one of the most recent series in this analysis. In RG, we found a considerable increase in the length of stay, ranged from 9 to 22 days and with a WA of 15 and 31 days.

Morbidity

Perioperative complications occurred in LG in 69 patients (36%). We have stressed the importance of two specific types of morbidity: Bleeding and fistulas and we have not paid attention to gastric emptying because we are not going to differentiate standard Whipple´s procedure with pylorus-preserving PD. It is important to enhance that in RG total morbidity is not representative because of the absence of the largest series data (60 patients; 55%).

Bleeding

Bleeding is considered as an unexpected blood loss during the surgery or the whole postoperative hospital stay which required any surgical or medical management and is not directly derivated from another medical or nonmedical intervention. Anemia as incidental finding was not considered as bleeding although blood transfusions were required. Just one group did not report this data (42 patients; 26.4%) but we decided to count it as if they did not suffer any bleeding because of the fact that the author reported a detailled morbidity without the necessity of mention this parameter.[3] Bleeding was identified in eight (4%) of 192 of the patients of the LG and in nine cases (9%) of 101 patients

Study	Year	Patients	Mean operative time (min)	Mean estimated blood loss (ml)	Mean hospital stay (days)	Morbidity cases	Mortality cases	Conversion cases
Gagner[12]	1997	10	510	NR	22	3	NR	4
Dulucq[21]	2006	16	287	107	16	4	1	3
Lu[22]	2006	5	528	770	NR	2	1	1
Palanivelu[3]	2007	75	357	74	8	20	1	0
Pugliese[23]	2008	12	461	180	19	4	0	6
Kendrick[13]	2010	54	368	240	7	26	1	0
Ammori[14]	2011	6	628	350	11	2	0	0
Zureikat[24]	2011	14	456	300	8	8	1	2
Total/mean		192	388.8	178.7	9.9	69 (35.9%)	5 (2.7%)	16 (8.3%)

Table 1: Total laparoscopic pancreaticoduodenectomies (NR: Nonreported)

Study	Year	Patients	Mean operative time (min)	Mean estimated blood loss (ml)	Mean hospital stay (days)	Morbidity cases	Mortality cases	Conversion cases
Buchs[17]	2010	41	430	389	13	16	1	2
Giulianotti (IT)[4]	2010	36	312	261	22	NR	1	9
Giulianotti (USA)[4]	2010	24	351	342	9	NR	1	2
Zhou[25]	2011	8	718	153	16	2	0	0
Total/mean		109	394.77	319.06	15.31	18 (21%)	3 (3%)	13 (12%)

Table 2: Total robotic pancreaticoduodenectomies (NR: Nonreported)

reported in RG with a good control in all of the cases in both arms.

Fistula

We do not use an specific international definition of postoperative pancreatic fistula (PPF) due to the varied definitions used by the differents authors, although most of them adopted the international study group on pancreatic fistula definition. Furthermore, to emphasize the difficulty of the reconstruction, we joined all the anastomosis leaks (pancreatic, biliary and digestive) in just one variable for the final analysis. The most common fistula reported was PPF. We identified 28 cases (14.5%) from the LG and 33 (30%) in RG in which at least one total intracorporeal anastomosis presented a leak.

Mortality

Operative mortality was defined as death within the period of time from the surgery until the discharge. All the studies reported their mortality apart from one with 10 cases which were not taken into account in the analysis. We found five patients (2.7%) who died during the hospital stay, most of them due to an advanced septicemia condition secondary to pancreatic fistula in LG. In the robotic arm, we identified three patients (3%) who died, one of them secondary to esophageal rupture at 85 days after primary resection.[4]

Conversion

Conversion was understood as an impossibility to perform the total laparoscopic approach, both technical difficulties

or medical necessity. In 16 patients (8.3%) of LG and in 13 cases (12%) of RG the surgery was converted to an open procedure.

DISCUSSION

For many pancreatic disorders surgical resection offers the only chance for a cure, and surgery also plays a very important role in the symptom's palliation of unresectable pancreatics neoplasms.

Since the first laparoscopic staging for pancreatic cancer described by Dr Bernheim at the Johns Hopkins Hospital in 1911,[5] up to date, laparoscopic procedures for staging with laparoscopic intraoperative ultrasonography seem to be well accepted by the scientific community due to its higher sensitivity for identifying intraabdominal metastasis and facilitating biopsy and superior specificity for predicting unresectability, compared with CT scan.[6-8]

During the last 20 years many authors have reported large series of minimal access pancreatic surgery with multiple procedures, from distal pancreatectomies with or without splenic-preserving to pancreaticoduodenectomies (Whipple's procedure or even pylorus-preserving PD), including enucleations and central resections. In contrast to laparoscopic PD, laparoscopic distal pancreatectomies have been reported with increasing frequency. The main reasons are the easier surgical technique of the procedure without the need of an anastomosis and, of course, the well-known advantages of laparoscopy in general. But, minimal access PD is considered by many surgeons, most

of them nonlaparoscopic surgeons, as an experimental procedure due to the associated morbidity and the very difficult surgical technique of this particular surgery.[9]

In the open approach, when the procedure is performed by significant expertise in pancreatic surgery, rates of morbidity and mortality are prone to decrease (morbidity = 18-54%; mortality = 1-4%). From the first description of the Whipple's procedure,[10] the technique has suffered some modifications and surgeons have to develop their surgical skills day by day until reach the morbidity and mortality rates of this era. Whenever the minimal access approach (laparoscopic and robotic) was between certain security limits, it must suffer a similar development as open approach.

Robotic surgery improves many of the shortcomings of laparoscopy. The dizzying development of the surgical industry, makes possible in robotic surgery binocular three-dimensional imaging, 360º movement of surgical instruments and a better comfort and precision, without the physiologic tremor, of the surgeon. These advances allow to perform complex procedures with nearly identical principles to open surgery making robotic surgery the probable expected step in minimal access pancreatic surgery.

Gagner et al[11] described the first laparoscopic pancreaticoduodenectomy in 1994 and reported a large series of 10 patients some years later[12] with a mean operative time of 510 minutes. From this series to the most recent ones, there is a significant decrease in the operating room time. Kendrick et al published in 2010[13] a series of 54 patients with a mean operative time of 368 minutes and state that their initially long operation time decreased from a mean of 7.7 hours in the first 10 patients to 5.3 hours in the last 10; on the other hand, Ammori et al[14] recently reported a small series of six patients with a mean operating room time of 628 minutes. Surprisingly, in RG, the WA was 394.77 minutes, practically the same as in LG (388.8 mins), in spite operative times usually remain significantly longer in robotic surgery than in other approaches.

Many publications report numerous potential benefits of robotic surgery over the traditional approach: Less pain, less risk of infection, less blood loss and transfusions, less scarring, faster recovery and quicker return to normal activities.[15,16] But, in this case, we found clear differences in mean estimated blood loss and mean hospital stay between both groups in favor of LG. The WA of the estimated blood loss was 178.7 ml for LG and 319.06 ml for RG. We can not explicate this difference and we would need a more thorough analysis to get conclusions. In the other hand the WA of the hospital stay was 9.9 days (LG) and 15.31 days (RG). This variations in the length of hospital stay can be explained by the differences in the health systems between

Europe and North America as Giulanotti et al[4] expose in their article. The authors explain that the length of hospital stay of their series, divided in this article into two independent series according to the institution where the procedure was performed, varied depending if the patient was operated in Europe or in America. In the Italian group the mean hospital stay was 22 days and in the US group, was 9 days. They stress that Europeans patients do not go home if they have a drain in place but american patients were discharged at the 9th day (mean), with or without drain, to reduce the price of the procedure. We realized that this series is a large one which has a big influence in the final analysis, so we also suggest this as the main reason why the WA of the hospital stay is higher in RG than in LG.

Rates of perioperive morbidity in laparoscopic PD in series of high-volume range between 26 and 40%. In this review, we identified 69 morbidity cases (36%) in LG and 18 (21%) in RG, but these data are not very reliable because of two series of RG (60 patients; 55%) did not specifically report this variable. Although we did not take in count this cases for the final analysis we did not want to compare both groups due to the high difference in their sizes.

PPF is the most frequent and one of the most dangerous specific major complication after pancreatic resection. There is a huge variation between series in the reported rates, probably because of the different definitions of PPF used. In spite of the robotic surgery allows a better freedom of movement to perform an anastomosis, we found a higher percentage of fistula in RG (30%) than in LG (14.5%) when we compared both arms. Probably this finding could be caused because more than 50% of the patients of the Buchs et al publication[17] had pancreatic stump sclerosis, where small pancreatic leaks are common. The other article in which data showed a high incidence of pancreatic fistula was the Giulanotti et al publication.[4] They attribute this high incidence also to the subgroup of patient who followed injection sclerosis of the duct but do not rule out a surgical technique fail. However, similar rates of bleeding (RG: 9%; LG: 4%) and conversion (LG: 8.3%; RG: 12%) were found in both groups. Conversion rates was compared favorably with that in the literature (11.5%).

We can find similar rates of motality in high-volume centers for open PD (1 to 4%) and for minimal access PD (0 to 5%). We found five cases in the whole series of LG (2.7%) and three in the RG (3%) which is in keeping with the literature reviewed. In the article of Buchs et al,[17] there was one death as a result of a fatal cardiac arrhythmia in a patient over 70 years old. In spite of this death, the authors conclude that a totally robotic approach for PD can be performed safely in an elderly population, with similar results compared with younger patients. The other two cases reported by Giulanotti et al[4] were due to sepsis following

Boerhaave syndrome and from colonic ischemia at 85 days after primary resection and on day 20 respectively. These two last cases were not strictly secondary to the first surgery but to avoid personal opinions which could be a deciding factor in the comparison between the two groups, we decided to take them in count.

Hybrid approaches have been reported during the last years.[18-20] The initial approach is made by laparoscopy and the reconstruction with the anastomosis is performed with a surgical robot system. The outcomes are acceptable in safety and maintenance of the standard of care for the management of the disease process. In spite of a very few experience, (five patients in one series and 24 patients in other) this hybrid approach showed the feasibility of performing complex pancreatic resections and offers the possibility to improve along the learning curve with both approaches.

CONCLUSION

This is the first review in the literature which compares total laparoscopic PD with total robotic PD and can not demonstrate any clear differences between both in spite of the scant literature available. The use of robotics in this patient population is limited, making it difficult to get the possibility of prospective or randomized trials. However one might expect that the different groups would improve their outcomes once past the learning curve, and minimal access pancreatic surgery would clearly demonstrate its real face with regard to open approach.

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