ΜΕΤΑΠΤΥΧΙΑΚΟ ΠΡΟΓΡΑΜΜΑ ΣΠΟΥΔΩΝ:
‘‘ΕΛΑΧΙΣΤΑ ΕΠΕΜΒΑΤΙΚΗ ΧΕΙΡΟΥΡΓΙΚΗ,
ΡΟΜΠΟΤΙΚΗ ΧΕΙΡΟΥΡΓΙΚΗ ΚΑΙ ΤΗΛΕΧΕΙΡΟΥΡΓΙΚΗ’’

ΕΘΝΙΚΟ ΚΑΙ ΚΑΠΟΔΙΣΤΡΙΑΚΟ ΠΑΝΕΠΙΣΤΗΜΙΟ ΑΘΗΝΩΝ

ΙΑΤΡΙΚΗ ΣΧΟΛΗ

ΔΙΠΛΩΜΑΤΙΚΗ ΕΡΓΑΣΙΑ
ΘΕΜΑ:

ROBOTIC PANCREATICODUODENECTOMY

ΜΕΤΑΠΤΥΧΙΑΚΟΣ ΦΟΙΤΗΤΗΣ:
ΚΟΡΝΑΡΟΠΟΥΛΟΣ ΜΙΧΑΗΛ

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ΠΡΑΚΤΙΚΟ ΚΡΙΣΕΩΣ

ΤΗΣ ΣΥΝΕΔΡΙΑΣΗΣ ΤΗΣ ΤΡΙΜΕΛΟΥΣ ΕΞΕΤΑΣΤΙΚΗΣ ΕΠΙΤΡΟΠΗΣ

ΓΙΑ ΤΗΝ ΑΞΙΟΛΟΓΗΣΗ ΤΗΣ ΔΙΠΛΩΜΑΤΙΚΗΣ ΕΡΓΑΣΙΑΣ

Του μεταπτυχιακού φοιτητή ΚΟΡΝΑΡΟΠΟΥΛΟΥ ΜΙΧΑΗΛ

Εξεταστική Επιτροπή

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Η Τριμελής Εξεταστική Επιτροπή η οποία ορίσθηκε από την ΓΣΕΣ της Ιατρικής Σχολής του Παν. Αθηνών Συνεδρίαση της.....ης .... 20.... για την αξιολόγηση και εξέταση του υποψηφίου κου Κορναρόπουλου Μιχαήλ, συνεδρίασε σήμερα .../.../....

Η Επιτροπή διαπίστωσε ότι η Διπλωματική Εργασία του κου Κορνρόπουλου Μιχαήλ με τίτλο: *«Robotic Pancreaticoduodenectoymy»,* είναι πρωτότυπη, επιστημονικά και τεχνικά άρτια και η βιβλιογραφική πληροφορία ολοκληρωμένη και εμπεριστατωμένη.

Η εξεταστική επιτροπή αφού έλαβε υπ' όψιν το περιεχόμενο της εργασίας και τη συμβολή της στην επιστήμη, με ψήφους .... προτείνει την απονομή του Μεταπτυχιακού Διπλώματος Ειδίκευσης (Master's Degree), στον παραπάνω Μεταπτυχιακό Φοιτητή.

Στην ψηφοφορία για την βαθμολογία ο υποψήφιος έλαβε για τον βαθμό «ΑΡΙΣΤΑ» ψήφους ...., για τον βαθμό «ΛΙΑΝ ΚΑΛΩΣ» ψήφους ...., και για τον βαθμό «ΚΑΛΩΣ» ψήφους .... Κατά συνέπεια, απονέμεται ο βαθμός «.....................».

Τα Μέλη της Εξεταστικής Επιτροπής

- Αλέξανδρος Παπαλάμπρος **(Επιβλέπων)** (Υπογραφή) ____________
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INTRODUCTION

Pancreatic cancer is widely recognized as one of the most aggressive solid tumors and one of the most lethal in Western society. Despite considerable oncological and surgical advances over the last 50 years, the median survival is still only approximately 21-24 months and the 5-year survival for all patients is only 5% (1). Furthermore, only a minority of patients presenting with pancreatic cancer are candidates for surgical therapy due to the presence of either distant metastasis or locally invasive disease.

Pancreaticoduodenectomy (PD) has been universally accepted as the only chance for cure for patients with cancerous tumors on the head of the pancreas, periampullary malignant tumors, cholangiocarcinoma (cancer of the pancreatic end of the duct), cancer of duodenum and malignant or premalignant cystic pancreatic neoplasms such as intraductal papillary mucinous neoplasms (IPMN) or neuroendocrine pancreatic tumors (PNT) when indicated {2}. It was first described by Allessandro Codivilla in 1898 {3} and later popularized by Allen O. Whipple in 1935 {4} and is considered one of the most complex operations of the alimentary track owing to the combined challenge of careful dissection in close proximity to multiple major vessels and the restoration of enteric continuity with three anastomosis (pancreaticojejunostomy, hepaticojejunostomy and gastrojejunostomy). No surprising, the surgery has a high perioperative morbidity of 30-40% and mortality rate of 1-6% even at the highest volume centers {5}.

In an effort to reduce the high historically rate of perioperative morbidity minimally invasive surgical (MIS) approaches were applied to the field of pancreatic surgery. Gagner and Pomp described the first laparoscopic PPD over 20 years ago {6}, however it has not gained widespread popularity {7}. This has been attributed to the retroperitoneal location of the pancreas, its closed relationship with major vascular structures and the tedious nature of the dissection required to optimize oncological margins in pancreatic cancer. Perhaps the largest barrier of all the laparoscopic PD is the challenge of reconstruction since three separate anastomosis are required.

The development of the Da Vinci robotic platform (Intuitive Surgical ®, CA, USA) has completely changed the paradigm of minimal invasive pancreatic surgery. The Da Vinci ® surgical system consist of a three or four-armed robot which is operated by the surgeon who sits at a separate console. The robotic platform overcomes many of the key shortcomings of the traditional laparoscopy that include monocular vision, limited degrees of freedom and the effects of pivot and fulcrum, which make suturing in particular difficult to master. In contrast, the robotic approach affords the surgeon a three-dimensional stereoscopic view of the operating field and restores hand-eye coordination. The Endowrist ® instrumentation replicates the movements of the human hand with seven degrees of freedom and eliminates hand tremor. The ease and precision of dissection and suturing represents a real advance over the traditional laparoscopic approach.

Since the development of the robotic platform, the challenge of pancreatic surgery has been taken up with renewed enthusiasm, with the result that in the number of reports

on robotic-assisted (RA) pancreatic surgery has been on the rise. The aim of the present review is to evaluate the current state on total robotic PD.

Material and Methods

The Preferred Reporting Items for Systematic Reviews and Meta-analysis (PRISMA) statements were followed to conduct this systematic {8}.

Literature search

A systematic literature search was performed in PubMed, Embase, Cochrane Central of Controlled Trials, and BioMed Central from January 1st 2003 to July 31st July 2016. The following terms were used to perform the bibliographic research: “robotic” OR “robotics” OR “da Vinci” OR “minimally invasive” AND “pancreaticoduodenectomy” OR “Whipple procedure” OR “pancreatic surgery”. Among the considered studies, all titles and abstracts were analyzed to select those concerning robotic PD. Subsequently, full text papers of the selected studies were independently screened by 2 authors for eligibility. When multiple articles were published by the same study group and no difference in the study period was described, only the most recent article was considered to avoid double counting.

Selection of the studies

In this review were considered for inclusion only studies written in English, covering human studies, who reported at least one of the outcomes of interest on PDs performed for various types of pancreatic pathology and in which all the surgical steps were robotically performed (resection and reconstruction). Both comparative studies, including randomized controlled trials (RCTs) and non-randomized controlled trials (non-RCTs) were considered. Comparative studies were included irrespective to the type of surgical approach used in the comparator group (laparoscopic or open). Non-comparative studies, such as case reports and case series, irrespective of their size, bearing the outcomes of interest were also considered. Studies in which the outcomes of interest were neither reported nor directly or indirectly inferable were excluded.

Data extraction and outcomes of interest

One reviewer (M.K.) evaluated all retrieved studies to determine if they met the criteria, to assess study quality and extract data. The study team resolved all the disagreements through discussion to reach a consensus. All the studies were reviewed for the following data:

- (I) Author’s surname and year of publication, origin of study, study design and length in time, type of robotic system
- (II) Patient’s characteristics : number of patients, age, BMI, sex, tumor size
- (III) Operative outcomes : technical details of robotic PD (pancreatic stump treatment, anastomosis techniques), operative time (defined as the time from skin incision to completion of the surgical dressing), estimated blood loss (EBL), length of hospital stay (LHS), conversion to laparotomy, transfusion, reoperation rate
- (IV) Complications : bleeding, number and grade of pancreatic fistula, biliary leak, delayed gastric emptying, mortality
- (V) Oncologic outcomes : number of harvested lymph nodes, number of incomplete resection (R1)
- (VI) Costs

Quality Assessment of Literature

The (modified) Newcastle-Ottawa Quality Assessment star scoring system was used to evaluate the quality of all the included studies. The scale is comprised of seven elements that assess patient population and selection, study comparability, follow-up and outcome of interest. In assessing comparability between groups, focus was on the variables that might affect primary endpoints such as, patient age, pathologic tumor-node-metastasis stage, type of PD, resection margin, tumor size, histologic type and reconstruction. Studies were scored using an ordinary star scale so as to compare their quality, with higher scores representing higher quality. A maximum of one star was awarded to a study for each numbered item within the selection and outcome assessment. A maximum of two stars was awarded for the comparability of the two groups. The total score was 9 stars and the quality of each article was graded as level 1/low quality (0-5 stars) or level 2/high quality (6-9 stars).

Results

The PRISMA flow diagram for systematic review is presented in **Fig 1**. The initial search yielded 56 potentially relevant articles. After the titles and abstracts screening for relevance, 28 remaining articles were further assessed for eligibility. Finally, 13 studies, which characteristics are reported in Table 1, were included in the systematic review.

Study quality

The quality of all 13 non-RCTs was level 2 (6-9 stars) on the modified Newcastle-Ottawa scale and good for the RCT according to the Jadad composite scale.

Characteristics of the included studies

All included studies were non-RCTs and published between 2000 and today.
The systematic review included a total of 738 patients who were planned to undergo total robotic PD. Overall, the procedure was successfully performed in 692 patients (93%). In all, 523 patients were operated in United States, 88 China, 119 Italy, 5 Brazil and 3 in Japan.
The majority of PD were classic Whipple operations, fewer were pylorus-preserving PD (PPPD). The management of the pancreatic stump was described in most cases: mainly end-to side pancreaticojejunostomy {9-21}, fewer pancreaticogastrostomy {9} and a fibrin glue occlusion of the main pancreatic duct {9}.
Table 1 shows the results of the current review of totally robotic PD studies reported. A total of 738 patients were retrieved from 13 studies available {9-21}.

Publication	*Study design*	*Country*	*Study period*	*Number of patients*	*Type of PD (dissection–resection-reconstruction)*
Baker {14}	Retrospactive cohort analysis	Charlotte,USA	2012-2014	32	completely robotic
Guilianotti {9}	Retrospactive case series	Chicago, USA/Grosseto, Italy	2000-2009	60	completely robotic
Lai {10}	Nonrandomized comparative study-Retrospactive case series	Hong Kong, China	2000-2012	20	completely robotic
Zhou {11}	Retrospective, case matched study	Beijing, China	2009	8	completely robotic
Chen {15}	Non-Randomized study	Shanghai, China	2010-2013	60	completely robotic
Cunninham {16}	Cohort comparative study	Pittsburg, USA	2014-2015	96	completely robotic
Polanco {17}	Prospectively study	Pittsburg, USA	2008-2013	150	completely robotic
Boggi {18}	Retrospactive case series	Pisa, Italy	2008-2014	83	completely robotic
De Vasconcelos Macedo {13}	Retrospactive case series	Sao Paolo, Brasil	2011	5	completely robotic
Radhid{19}	Retrospactive case series	Florida,USA	2012-2013	21	completely robotic
MacKenzie {21}	Technical note	Minneapolis, USA	2010		completely robotic
Boone {20}	Retrospactive case series	Pittsburgh, USA	2008-2014	200	completely robotic
Horiguchi {12}	Case series	Japan	2009-2010	3	completely robotic
Total	**13**			**738**	**completely robotic**

Table 1. Characteristics of the included studies

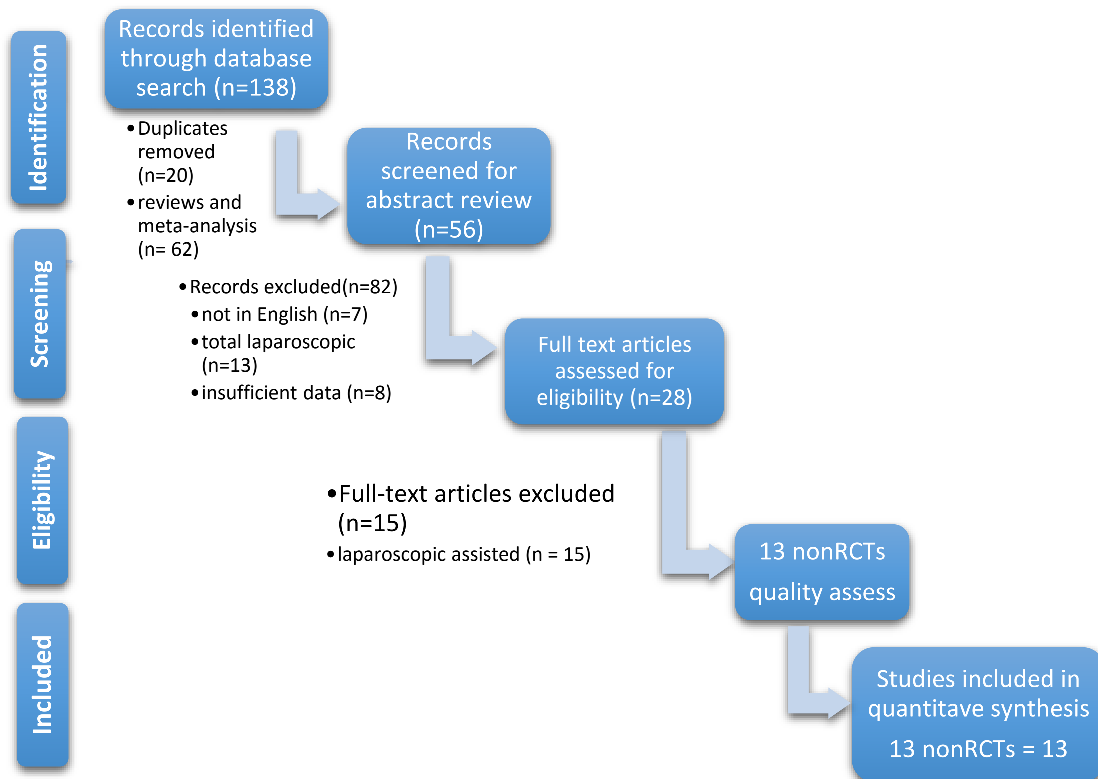

Fig 1. Flow chart of the identification and inclusion of studies

Publication	*Study design*	*Country*	*Study period*	*N of patients (RPD)*	*Type of PD (dissection–resection-reconstruction)*	*Reason for exclusion*
Chalikonda {24}	Retrospactive cohort analysis	Cleveland, USA	2009-2010	30	Lap resection-robotic reconstruction	The procedure was not total robotic
Guilianotti {22+23}	Retrospactive case series	Grosseto, Italy	2000-2003	8	completely robotic	The article was published by the same study group and no difference was described {9}
Zeh {27+28}	Retrospective review	Pittsburg, USA	2008-2010	50	completely robotic	The article was published by the same study group and no difference was described {20}
Buchs {26}	Cct-R	Chicago, USA	2002-2010	44	completely robotic	The article was published by the same study group and no difference was described {9}
Zureikat {25}	Non-Randomized study	Pittsburg, USA	2008-2012	132	completely robotic	The article was published by the same study group and no difference was described {20}
Chan {30}	Retrospactive case series	Hong Kong, China	2009-2010	55	completely robotic	The article was published by the same study group and no difference was described {10}
Bao {31}	Prospectively study	Stony Brook, USA	2009-2011	56	Lap resection-robotic reconstruction	The procedure was not total robotic
Boggi {29}	Retrospactive case series	Pisa, Italy	2013	34	completely robotic	The article was published by the same study group and no difference was described {18}

Table 2. Characteristics of excluded studies

Results

Intraoperative outcomes

Operative time (OT). All studies reported the median OT. Except from Zhou{11+26} and Boggi{18+29 } none of the studies specified whether the OT included the setup, the draping and the docking phase. The mean OT varies between 356 and 718 min, with a longer operative time reported mainly at the beginning of the experience. Boone {20} study demonstrated that there was an important difference in mean OT between the first 80 RPD and the last 120 (581 min vs 417 min). In the comparative studies the OT was significantly longer in compared to open PD {14+10+11+15+21+18}.
Estimated blood loss (EBL). EBL was available also in all 13 studies. The analysis of the comparative studies found that the robotic approach would significantly minimize blood loss when compared with the open group {14+10+11}.
Conversion rate. Regarding the feasibility of the robotic approach the overall rate of conversion to laparotomy ranged from 0% to 18.3%. The most common reported causes were failure to progress, hemorrhage and unexpected vascular involvement {14+9}. Boone showed that after 20 procedures the convention rate dropped from 33% to 3.3% {20}.

Overall perioperative complications

Morbidity
The overall morbidity rates that reported in the most comparative studies to open PD ranged from 25% to 73%. The most compelling contrast was in Zhou's {11} and Baker's {14} study (25% RPD vs 75% OPD and 40% rpd vs 67% OPD). It is important to enhance that in RPD, total morbidity is not represented because of the absence of data from large series.
Pancreatic Fistula
Based on ISGPF {32} PF is described as a drain output of any measurable volume of fluid on or after postoperative day 3 with an amylase content over 3 times the serum amylase activity**.** Except the comparative study of Lai {10} (35% RPD vs 17% OPD) and Boggi {18} (33% RPD vs 16% OPD), PF rates were comparable between minimally invasive and open groups.
Delayed gastric emptying, Postoperative Hemorrhage and Bile leak
Delayed gastric emptying is defined by ISGPS {33} as need for maintenance of nasogastric tube for 3 days or the need to reinsert the nasogastric tube for persistent vomiting after POD 3, or inability to tolerate a solid diet by POD 7.
Postoperative hemorrhage was available in 6{9+10+11+15+18+13} studies and bile leak in 4 studies {9+10+15+17+13+19}.
The results showed that the postoperative hemorrhage and bile leak rates were comparable, but the robotic group tended to fewer incidence of delayed gastric emptying {14+9+10+15+18}.
Reoperation and Mortality
Ten studies {14+9+10+11+17+18} reported incidence of mortality, it ranged from 1 to 12.5% and it turned out comparable with OPD. Most of the postoperative deaths reported were related to hemorrhagic complication of pancreatic fistula or cardiac event.

Eight studies {9+10+11+15+16+18+13+12} reported incidence of reoperation, main reason was intra-abdominal hemorrhage and severe pancreatic fistula (Grade C) {9}. Overall, no significant differences were found.

Length of stay (LOS)
Pooling data from 12 studies including 588 patients of hospital stay showed a difference favoring the robotic PD. In Lai's {10} and Zhou's {11} CCT the robotic group had a significantly shorter hospital stay compared to the open group (mean 13.7 vs 25.8 and 16.38 vs 24 respectively).

Operative oncologic outcomes
Most RPD were performed for malignant diseases. The most frequent malignancy was pancreatic adenocarcinoma, followed by ampullary adenocarcinoma and distal cholangiocarcinoma. Eight studies reported the number of harvested lymph nodes (Table 4). The number of the lymph node harvested and Ro ratio are related to the prognosis. The results manifested that the number of lymph node was comparable, but the minimally invasive group tended to have less margin involved. In Lai's {10} study the R1 ratio were R PD 26% O PD 64%, whereas in Boggi's {18} trial R1 was 12.5% in R PD and 45% in O PD.

Publication	*Age*	*BMI*	*Operative Time*	*Ebl*	*LOS*	*Cost*	*Conversions to laparotomy*
Baker {14}	63,6+-9,8 *(OP 35+12,9)*	26.8 +-4.3 *(OP 26,7+-5,5)*	527,4+-87,7 *(OP 391+-141)*	466,7+-452,3 *(OP 866,8+-931)*	10,1+-5,8 *(OP 11,5+-7,1)*	Operative 50,535 *(OP 32,309)* Inpatient 141,581 *(OP 136,246)* Follow up 283 *(OP 519)* Total 142,149 *(OP 150,473)*	5 (15%)
Guilianotti {9}	58(25-86)		421(240-660)	394(80-1500)	22(5-85)		11(18,3%)
Lai {10}	66,4+-1,9 *(OP 62+-11,2)*		491,5+-94 *(OP264+-63)*	247 *(OP 774)*	13,7+_6,1 *(OP25,8+-23)*		1(5%)
Zhou {11}	64,38 *(OP59,38)*		718,75+-186 *(OP420+-127)*	153,75+-43,4 *(OP 210+-53)*	16.38+-4.14 *(OP24+-7)*		0
Chen {15}	53,6 *(OP53,8)*	23,2 *(OP22,6)*	445(40)=340(20) *(OP 322)*	500+200 *(OP 500)*	20 *(OP 25)*	19,755 *(OP12,111)*	1
Cunninham {16}	65,56-66,11	28,63-28,19	356,6-363,5	150-225	7,7-6,8	23,933-19,516	
Polanco {17}	67,4+-12,2	27,2+-5,37	515,1+-106	300 (150-500)	9 (4-87){22}		11(7,3%)
Boggi {18}	62 *(OP64)*	23,8 *(OP 23.4)*	527,2(+-166) (60'' for IT *(OP 425.3)*	2 Units *(OP2)*	17(14-26) *(OP 14(13-27)*	6193	3
De Vasconcelos Macedo {13}	64,5		640 (435-790)	1/5	25,8(12-52)		1/5
Radhid{19}	69	29,1	621	200	8(4-34)		
MacKenzie {21}			8h(5,9-9,6) (OP5,4)		6,2(5,2-18,8) (OP 7,9)		
Boone {20}	67	28	483	250(150-500)	9 (7-14)		13(6,5%)
Horiguchi {12}			703+-141	118+-72	26+-12		0

Table 2. Main intraoperative outcomes of studies

Publication	***Overall morbidity***	***Postoperative hemorrhage***	***Pancreatic Fistula Grade I-II-III***	***Delayed gastric emptying***	***Bile leakage***	***Mortality(30d)***	***Reoperation***
Baker {14}	11/27 (40,7%) *(OP 33/49 (67%)*		2 (7,4%) *(OP 6/49 12%)*	4(14,4%) *(OP 30.6)*		0 *OP2/49*	
Guilianotti {9}		0	19/60 (31.3%)	3	1 *OP2***{26}**	2 (3,3%)	4 (6.6%)
Lai {10}		2(10%) *OP34.5%)*	7(35%) *OP12(17%)*	1(5%) *OP(11.9%)*	3(15%) *OP4(6%)*	0 *OP2(3%)*	2(10%)op(4.5%)
Zhou {11}	25% *OP75%*	0 *OP1*	5a (62,5%) *OP3a*			1 (12,5%) *OP1*	0 op1
Chen {15}	21 (35%) *OP48 (40%)*	4 *OP9/120*	8 (3a5b) (13.3%) *OP29/120(A11B14C4)*	5 (8.3%) *OP18/120 (15%)*	5 (8.3%) *OP8/120 (6.6)*	1 (1.6%) *OP3/120*	2 (3.3%) OP 4/120
Cunninham {16}			19 7a12b (20%)			1 (1%)	6 (6.3%)
Polanco {17}			26(17.3%) a13,b7,c6		2% **{26}**		
Boggi {18}	61(73%) 53%GRADE I-II *OP 28(79%)*	7	28(33%) a13b13c2 *OP(16.7%)a4b2*	46(55%)a3b25c18 *OP 22(61%)*		1 (1.2%) *OP 0*	9(11.1%) op4(11%)
De Vasconcelos Macedo {13}		1	1		1		1
Radhid{19}					1 (4.7%)		
MacKenzie {21}			1b			0	
Boone {20}	134(67%)		34(17%)A17,B10,C7			3.3%	
Horiguchi {12}						0	0

Table 3. Main postoperative outcomes of studies

Publication	*Robotic PD for malignant neoplams*	*Tumor Size*	*Lymph node harvested*	*R1 (N of patints)*
Baker {14}	22(81,6%) *OP40/49*	3 +-1.2 *OP3,6+-2,5*	15 *OP30*	6(26%) *OP14/49* (28,5%)
Guilianotti {9}	45/60	21-36	21-14 (18,2)	5/45 (11%)
Lai {10}	15/20 OP53/67	2,1+-0,7 *OP2,9+-2,3*	10+-6 *OP10+-8*	9(26%) *OP33(64%)*
Zhou {11}	8			0 *OP1*
Chen {15}	38/60 *OP766/120*	2,6	13,6 OP12,5	1/46(2,4%) OP88/92
Cunninham {16}	43	2,8-2,4		
Polanco {17}	123	2,76+-1,5	17-26	
Boggi {18}	71		37(28,8-45,3) OP 36	2(12,5%) OP6(45%)
De Vasconcelos Macedo {13}	4			
Radhid{19}	17	2.3	16(2-23)	0
MacKenzie {21}			11(7-18)	0
Boone {20}	166	2.7	22	16(8%)
Horiguchi {12}	2			0

Table 4. Pathological details of RPD

Discussion

Allen Oldfather Whipple is the uncontested father of North American pancreatic surgery. Although both Alessandro Codivilla in Italy and Walter Kausch in Germany had performed pancreatoduodenectomy decades before {3} Whipple's presentation at the American Surgical Association meeting in 1935 of 3 patients who underwent a 2-staged operations and his successful performance of a 1-stage pancreatoduodenectomy 5 years later set the stage for further development of this operation in the United States and Canada {4}. The current version of the operation that bears his name is now performed throughout the world and, although still fraught with potential serious complications, is a common operation in many major medical centers.

In an effort to reduce the high historically rate of postoperative morbidity, pancreatic surgeries have challenged for over twenty years the field of minimally invasive surgery. Despite the fact that in the field of pancreatic surgery laparoscopic distal pancreatectomy and enucleations have gained rapid acceptance and been described in large series of pancreatic surgery the last years {34+35}, when it comes to laparoscopic PD, only limited series and case reports have been published. In 1994 Gagner et al. {6} described the first lap PD, but the level of evidence concerning such technique is still low as only less than 300 cases performed were identified by review studies {36+37}. It is the complexity and the high skill required for such intracorporeal anastomosis that has led to a growing interest in robotic-assisted surgery.

Robotic surgery assist the surgeon in overcoming many of the obstacles to the widespread application of laparoscopic pancreatic surgery. The superior visualization, the improved 3-dimensional imaging, the enhanced dexterity, the improved ergonomics and the restoration of hand-eye coordination help surgeons to complete such complex procedures and reconstructions, with at least equivalent results to the open approach.
In the current literature the definition of robotic PD has not yet been standardized, since in many studies the technique is defined as robotic, robotic-assisted, robotic-assisted laparoscopic and robotic hybrid, according to the different steps PD, resection and reconstruction. The current review aims to evaluate the current state of total robotic PD, both resection and reconstruction.

Safety and feasibility of the new surgical approach is of paramount importance. The findings in this study indicate that robotic PD is a feasible procedure, with some high volume centers reporting a noteworthy 6.5% and 7.8% conversion rate {17+20}. The Pittsburg group reported a steep decline after 20 procedures (35% vs 3.3%) {17}.
Minimally invasive surgery has always been associated with longer operative times when compared to open technique. The overall duration of RPD was significantly longer in all studies compared with OPD. Time for setup, draping and docking the robot impacts largely the overall OT, and whether the documented OT include these factors or just the pure procedure is not defined in most studies. Nonetheless, such lengthy operative times observed In RPD can be mentally and physically exhausting for the surgical team. Again, the Pittsburg team showed the important factor of learning curve regarding OT, reporting reduction in the mean OT from 581 min for cases 0-80, to 417 min for cases 81-200 {16+17+25+27}.

Operative blood loss was shown to be lower in RPD when compared to OPD {14+11+10}, especially after consolidation of the learning curve {15}. This may be attributed to the magnified view of small vessels that robotic camera allows for, particularly during dissection of the plane between the uncinate process and the superior mesenteric vessels. This finding indicate that the robotic approach owns advantage without compromising safety.

Analyzing morbidity after PD, no major difference was evidenced in literature {10+20} between open and minimally invasive approach. Theoretically, robotic procedure guarantees less postoperative complications in terms of fast recovery, reduced respiratory complications, wound infections and shorter post-operative stay compered to open surgery {10+20}. The postoperative morbidity rate ranged between 20-73% when mentioned and suggests that RPD could be considered as safe as open. Severe complications requiring reoperations ranged between 3-11%, in high volume centers such as Pittsburg {16+17+25+27} Zureikat reports 4 re-operations after 132 RPD, Boggi in Piza {18} reported 9 reoperations after 83 RPD mainly because of PO hemorrhage. The reoperations rate of 3-11% after RPD is higher respect of the 3% reported in high volume centers after OPD {38}.

Delayed gastric emptying was reported in 4 comparative studies indicating an important advantage favoring RPD comparing OPD. Regarding bile leak, Lai {10} reported a difference between the different approaches in 20 patients (RPD 15% vs 6% OPD), but Chen, Zureikat and Guilianotti (270 patients) did not mentioned any major difference between the two approaches.

Pancreatic fistula is the most common postoperative complication after PD and the inciting event for many downstream complications that result in longer length of stay, need for reinterventions, readmissions and deaths. Variations in the precise definition of POPF has historically led to widely different rates of reported leak rates, from as low as 2% to more than 35% {27}. In this study, the overall rate of POPF after RPD was 20-32%, comparing favorably to most OPD series that report fistulae in the post-ISGPF era {27+28+39}; most of them had low-output and were conservatively managed (Grade A). Larger series of RPD {17} with documented risk factors of POPF (pancreatic texture, pancreatic duct size, ASA score, EBL, OT, tumor size, BMI) will allow to determine whether Braga and Callery score {40+41} for OPD apply to RPD.

The mortality rate was surprisingly low (1.6%), similar with mortality rates of high volume centers for open PD (1-4%) {9+17+18}. This might be explained by the fact that robotic PD is performed only in very high volume hospitals {42} and in highly selected patients.

As far as length of hospital stay is concerned, the outcomes had a very wide range in patients undergoing RPD. One could expect that robotic surgeries reduce hospital stay, however this is not observed in the majority of the series. This might be explained by the different national health systems and the hospital policies of discharging patients in a nearby facility with drains-in-situ and continued medical care to reduce the overall cost {9}. It is very likely that the overall LHS is similar between RPD and OPD in most centers, with a slight advantage in RPD {10+11}.

Oncological outcome is the major concern arising from RPD among patients suffering from malignancies. R0 resections and lymph node retrieved are two indicators of the oncologic adequacy of RPD. Microscopic infiltration of the pancreatic stump (R1) was considerably low (10%) for patient undergoing RPD, lower rate comparing large series of OPD {43}. Again, one possible explanation for this outcome could be the preoperative selection of low-risk patients for positive margin status. The collected lymph nodes reported was very broad, ranged from 10 to 35, the highest number being reported in the studies with the largest number of RPD 9+17+18+14+20}. All these considered, plus the utility of MIS in decreasing the pro-inflammatory and immunologic response to surgical trauma {44} and quicker adjuvant therapy, RPD seems to be at least comparable and perhaps better to OPD for malignancies, but long-term outcomes are as yet unknown.

One important question surrounding the use of MIS is whether or not the benefits will offset the significantly increased operative costs. The robotic platform is

expensive with an initial capital cost of $ 1-2,5 million; annual maintenance liabilities well over $ 100000, and many instruments are single use only {45}. Four studies {14+18+15+16} have attempted to address this question. Not surprisingly, all found operating room costs to be greater for RPD. However, when the total hospital costs were taken into account (including costs of hospital stay and readmission) the robotic approach tended to be less expensive than their open approach. Baker {14} showed that there was no significant difference in overall cost (176,931$ RPD vs 182,552$ OPD) in 71 PD and in another study {46} for 76 patients total robotic costs were 150,473$ while open approach 142,149$. Chen's {15} overall costs results for 180 patients demonstrate that RPD was more expensive than OPD (RPD 19,755$vs 12,11$OPD) but a significantly lower postoperative cost (8529 R vs 10,559 O) although it should be noted that average length of hospital stay in China was approximate 3-4 weeks and the patients usually opted to discharge after full recovery. Boggi in Pisa {18} documented excess mean operative cost compared with open resection 6193 euros, whereas Cunningham {16} concluded that a standard policy of omitting a postoperative ICU admission on postoperative day 0 after RPD can result in overall savings in total hospital costs. These data demonstrate that robotic related costs can be cushioned by the shorter stay and faster recovery of patients. What is more, as far as the number of robotic procedures increase, the costs of technology are likely to proportionally decrease.

In summary, it is rational to conclude that robotic PD is safe and feasible in an high-volume institution where surgeon are experienced and medical staff are appropriately trained. Randomized controlled trials are certainly the best way to investigate all the aspects. Data on cost analysis and long-term oncological outcomes are needed to evaluate the cost-effectiveness of the robotic approach in comparison to open technique.

Abstract

Background: Pancreaticoduodenectomy (PD) is considered one of the most complex operations in surgery, with high perioperative morbidity and mortality even in the highest volume centers. Since the development of the robotic platform, the number of reports on robotic-assisted (RA) pancreatic surgery has been on the rise. This article reviews the current status of total robotic pancreaticoduodenectomy.

Method: A systematic literature search was performed from January 2000 and July 2016 for studies which reported PDs and in which all the procedures steps (dissection, resection and reconstruction) was robotically performed.

Results: Thirteen studies met the inclusion criteria with total number of 738 patients. Data regarding perioperative outcomes such as operative time, blood loss, mortality, morbidity, conversion and oncological outcomes were analyzed. No major differences were observed in mortality, morbidity and oncological parameters, the operative time was longer in robotic approach, whereas the estimated blood loss was lower in RPD. The conversion rate to laparotomy was 6,5% to 7,8%.

Conclusions: Robotic pancreaticoduodenectomy are safe and feasible in a high-volume institution where surgeon are experienced and medical staff are appropriately trained. Randomized controlled trials are required to investigate all the aspects. Data on cost analysis and long-term oncological outcomes are needed to evaluate the cost-effectiveness of the robotic approach in comparison to open technique.

Περίληψη

Εισαγωγή: Η παγκρεατοδωδεκαδακτυλεκτομή (επέμβαση Whipple) θεωρείται μια από τις πιο απαιτητικές επεμβάσεις στην γενική χειρουργική, με μεγάλη περιεγχειρητική νοσηρότητα και θνητότητα ακόμα και σε μεγάλα εξειδικευμένα κέντρα. Με την ανάπτυξη της ρομποτικής χειρουργικής, ο αριθμός των αναφορών στην ρομποτική χειρουργική του παγκρέατος ολοένα και αυξάνεται. Η συγκεκριμένη μελέτη επικεντρώνεται στην τρέχουσα κατάσταση της εξ ολοκλήρου ρομποτικής παγκρεατοδωδεκαδακτυλεκτομής.

Μέθοδος : Πραγματοποιήθηκε συστηματική αναδρομική μελέτη στην υπάρχουσα βιβλιογραφία από τον Ιανουάριο του 2000 έως τον Ιούλιο του 2016 αναφορικά με άρθρα που σχετίζονται με την παγκρεατοδωδεκαδακτυλεκτομη στην οποία όλοι οι χειρουργικοί χρόνοι (παρασκευή, εκτομή και ανακατασκευή) πραγματοποιήθηκαν ρομποτικά.

Αποτελέσματα : Δεκατρία άρθρα πληρούσαν τα κριτήρια της μελέτης με συνολικό αριθμό ασθενών 738. Τα δεδομένα σχετικά με την περιεγχειρητική περίοδο όπως ο συνολικός χρόνος επέμβασης, η απώλεια αίματος, η θνητότητα, η νοσηρότητα, η μετατροπή σε λαπαροτομία και τα ογκολογικά αποτελέσματα συγκεντρώθηκαν και αναλύθηκαν. Δεν παρατηρήθηκε σημαντική διαφορά στην θνητότητα, την νοσηρότητα και τα ογκολογικά αποτελέσματα, ο συνολικός χρόνος της επέμβασης ήταν μεγαλύτερος, ενώ η διεγχειρητική απώλεια αίματος ήταν μικρότερη στην ρομποτική προσέγγιση. Τα ποσοστά μετατροπής σε ανοικτή επέμβαση ήταν 6,5% με 7,8%.

Συμπεράσματα : Η ρομποτική παγκρεατοδωδεκαδακτυλεκτομή είναι ασφαλής και εφικτή μέθοδος σε εξειδικευμένα κέντρα από έμπειρους χειρουργούς και με εκπαιδευμένο προσωπικό. Τυχαιοποιημένες ελεγχόμενες μελέτες χρειάζονται για να ερευνηθούν όλοι οι παράγοντες της επέμβασης. Επίσης, δεδομένα σχετικά με το κόστος της επέμβασης και μακροπρόθεσμα ογκολογικά αποτελέσματα είναι απαραίτητα για να τεκμηριωθεί αν η ρομποτική προσέγγιση υπερτερεί συνολικά της ανοικτής.

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