The Benefit of Advanced Age on Survival in Patients Undergoing Laparoscopic Pancreaticodoudenectomy, A Multi-Center, Comparative study-Cohort Study

Maher Hendi
Zhejiang University School of Medicine

Yiping Mou (853440660@qq.com)
Zhejiang provincial people's hospital

Chao Lu
Zhejiang Provincial People's Hospital

Bin Zhang
Zhejiang University School of Medicine Sir Run Run Shaw Hospital

Xiaowu Xu
Fudan University Shanghai Cancer Center

Renchao Zhang
Zhejiang Provincial People's Hospital

Zhouyu cheng
Zhejiang Provincial People's Hospital

Ke Chen
Zhejiang University School of Medicine Sir Run Run Shaw Hospital

---

Research

Keywords: Comparative study, Laparoscopic pancreaticoduodenectomy, Short-term outcomes, Surgical operation, Safety, Elderly

Posted Date: April 20th, 2020

DOI: https://doi.org/10.21203/rs.3.rs-21406/v1

Abstract

Background: Management of malignant diseases in elderly patients has become a global clinical issue because of the increased life expectancy worldwide. The advancements in surgical techniques and perioperative management have reduced age-related contraindications for LPD. Past papers have reported that elderly patients undergoing laproscopic pancreatoduodenectomy (LPD) are at an increased risk compared to non-elderly patients. The aim of this paper is to compare a single centre risk of LPD in elderly and non-elderly patients.

Methods: Retrospective review (n = 237) of perisurgical outcomes in patients undergoing LPD during the months of September 2012–December 2017. Outcomes in elderly patients (aged ≥75 years) were compared with those in non-elderly patients.

Results: In elderly patients, transfer to ICU was more frequent (odds ratio [OR] 6.49, P = 0.001) and mean hospital stay was lengthier (21.4 days compared with 16.6 days, *P = 0.0033*) than for non-elderly patients. There was no statistically significant difference in operation time (*P=0.494*), estimated blood loss (*P=0.0519*), blood transfusion (*P=0.863*), decreased gastric emptying (DGE) (P=0.397), abdominal pain (*P=0.454*), food intake (P=0.241), time to self ambulation (*P=1*), reoperation (*P=0.543*), postoperative pancreatic fistula (POPF) grade A (*P=0.454*), POPF grade B (*P=0.736*), POPF grade C (*P=0.164*), hemorrhage (*P=0.319*), bile leakage (*P=0.428*), infection (*P=0.259*), GI bleeding (*P=0.286*), morbidity (*P=0.272*) or mortality (*P=0.449*) between the two groups.

Conclusions: Elderly patients who underwent LPD in this study had significantly good overall survival after LPD and similar to young patients . The perioperative and long term outcomes of LPD are not worse .The Both rate of ICU admission and hospital stay increased in elderly patients undergoing LPD when compared with non-elderly ones. LPD can be performed on elderly patients with similar outcomes as younger patients; therefore Age it self should not be a contraindication to LPD for pancreatic cancer, but it suggests that elderly patients with comorbidities should be more stringently selected for surgery.

Introduction

Management of malignant diseases in elderly patients has become a global clinical issue because of the increased life expectancy in many countries.(26-27)Laparoscopic pancreatoduodenectomy (LPD) was introduced in 1994(24) In recent years, this approach has been shown to be safe and feasible when performed by experienced surgeons in high volume centers.(25)Laparoscopic surgery is now a widely utilized technique for the treatment of a variety of both benign and malignant diseases, because it is associated with a lower degree of invasion, less pain and shortened postoperative hospital stay than open surgery. Laparoscopic surgery bestows several advantages when compared to open surgery in elderly patients undergoing pancreatoduodenectomy (PD)[1,2,3,4].In addition,the two have similar oncological results[1,4,5]. Laparoscopic surgery has, in a number of studies, been shown to result in less postoperative pain, fewer wound complications, shorter hospital stays, decreased pancreatic fistula rates

and decreased surgical morbidity and mortality[1,6,7,8]. However, those selected for laparoscopic PD are predominantly otherwise healthy patients under the age of 75, with good performance status; thus, the extrapolation of results from such trials to daily practice necessitates careful consideration. Longer operation times and higher incidences of organ injury [9,10,11,12], are of particular concern when considering LPD surgery for elderly patients [13]. One retrospective analysis of Robot-assisted PDs concluded that the procedure can be performed safely in elderly patients with mortality, morbidity, and outcomes comparable to those in younger patients[14]. Sperti et al. showed that outcomes after pancreatectomy were not markedly different in octogenarians than in younger patients[15] and Maehara et al. found no statistically significant difference in the mortality rate or overall morbidity rate in patients undergoing PD for periampullary tumors above and below the age of 75[16].

In our department centre, 237 patients underwent LPD in a relatively short period 5 years to be exact. Patients aged 75 years and above comprised nearly 26 percent of the analysis, which is comparable to the age distribution of the world's population and the increasing age at which pancreatic cancer is now being diagnosed. Following this, a retrospective review (n = 237) of perisurgical outcomes for elderly (aged ≥75 years) and non-elderly LPD patients was carried out.

Our centre favours a laparoscopic approach for pancreatic cancer resection, regardless of patient age. However, a huge body mass is a contraindication for the procedure. Consequently, approximately 80% of our pancreatic cancer patients underwent laparoscopic surgery, minimizing surgical approach selection bias in this study

Aim: This study aimed to evaluate the safety of LPD for elderly patients with pancreatic disease by retrospectively analyzing the medical records of elderly patients aged ≥75 years that underwent surgery between September 2012 and December 2016 in our centre

Materials And Methods

Patients Selection

We analyzed data for 237 consecutive patients who underwent LPD in two centres between September 2012 to December 2017. Zhejiang University Sir Run Run Shaw Hospital and Zhejiang Provincial People's Hospital, of which 61 were elderly (aged≥75 years). The collected data were retrieved from prospectively maintained databases and included baseline patients characteristics. Results of pathological examinations were used as an indicator of preoperative factors, based on the assumption that preoperative findings would correlate with postoperative staging. This study was approved by the Institutional Review of Zhejiang Provincial People's Hospital and Zhejiang University.

The patients were prospectively followed up at institution . Most of the patients were traditionally observed according to a protocol similar to the Chinese guidelines,(28-29).The commonly used imaging modalities in suspected pancreatic carcinoma include ultrasonography, Novel imaging modalities

including MRI (13.9%), PET/CT (1.8%), and EUS (5.6%) were not widely used in our population. Only 39.7% of cases were histologically verifified (surgery with histologic diagnosis 31.0%, cytological diagnosis 8.7%, surgery without histologic diagnosis 12.1%, and clinical diagnosis 48.2%). Overall, 30.0% of patients underwent curative-intent operation, and only 9.8% of patients received comprehensive treatment.The prognosis of all registered patients was followed until confirmation of death. All these data were collected and registered with the approval of each institution.

Surgical procedure

Most of the operations were performed by one experienced surgeon Professor. ***Yiping Mou ,***with the rest being carried out by surgeons with sufficient experience of laparoscopic pancreatic surgery under supervision. Our surgical procedures called (***Wu Kong Zi***) have been previously described[17]. The procedures for patients with resectable PD, wereperformed using general anesthesia with the patient in the supine position and legs apart. “Five Trocars”[17], were used for the procedure. The trocars were placed as follows; one initial 10mm trocar was placed below the umbilicus for laparoscopy. The other four trocars, one 12mm in diameter and three 5mm in diameter, were inserted into the left upper flank, left flank, right upper flank and right flank quadrants, respectively. The five trocars were arranged in a V formation. However, for patients who had SMV encasement which made creating the retro-pancreatic tunnel difficult (borderline resectable pancreatic cancer), we used the “Easy First” strategy to perform LPD[18]**.** The definition of mesopancreas used was; the soft connective tissue along the celiac axis, superior mesenteric vessels and the uncinate process of pancreas, especially the lymphatic and nervous structures of retroperitoneal margin, as has been previously reported[19].After the specimens were removed from the enlarged umbilical port, a frozen section was sent off to confirm the negative margins. Child’s reconstruction was then performed in a complete laparoscopic manner following individual construction. Laparoscopic pancreaticojejunostomy (LPJ) was performed using the duct-to-mucosa method. If the diameter of MPD was between 2 and 5 mm, LPJ was carried out using interrupted sutures of 4–6 stitches with stents of the proper diameter. As for MPDs larger than 5 mm, running sutures were uesed without stents, and non-absorbable sutures were used instead of absorbable sutures. Laparoscopic choledochojejunostomy was performed with running sutures if the CBD was larger than 8 mm or with interrupted sutures if CBDs were less than 8 mm. As for the laparoscopic gastrojejunostomy, we used an endoscopic linear stapler to perform a side-to-side anastomosis with running sutures to close the opening

Definition of the Difficulty

Difficulty of LPD in both groups was categorized into 2 steps.Resections, and Reconstruction. Surgeons who frequently perform LPD may handle reconstruction difficulty surgical cases. More experienced surgeons who regularly perform reconstruction difficulty LPD can perform high-difficulty LPD cases. The operative time, total intraoperative blood loss, and Re-operation rate were evaluated to address surgical difficulty with a certain degree of objectivity, because surgical difficulty can be reflected in a combination of these intraoperative factors.

Statistical analysis

A comparison of baseline and post treatment levels of each variable was carried out to identify statistically significant differences between elderly and non-elderly patients. Continuous data was expressed as mean (SD) or mean (SEM) or median (interquartile range, IQR), and the means were compared using two independent samples of Student's *t* test. Categorical data was compared using the Chi-squared test or Fisher's exact probability test. The Mann-Whitney U test was used for abnormally distributed variables. Statistical significance was defined at the level of 0.05. All analyses were performed using statistical software SPSS 19.0 (SPSS Inc, Chicago, IL, USA).

Histopathological analysis

Operative details are shown in Table .Tumour size of >5cm and the rate of R0 resection were similar in the two groups 98.7 % vs 98.8 % (***Table 1*****).** The mean number of lymph nodes removed was similar in the two groups, lymph nodes retrieved in the LPD Non-elderly group and LPD elderly groups were (21.3±10.9 vs 20.3±11.9) respectively (*P* =1). Median pancreatic duct diameter was >5mm (*P* =1).The histoPath outcomes can be seen in.

Table 1 Histopathology data

Outcome	Non-Elderly (n=176)	Elderly Patients (n=61)	P-value
Type of pancreatic Cancer			
Pancreatic Ductal Adenocarcinoma	32 (18%)	12(19%)	0.796
Ampullary	45 (26%)	10(16%)	0.144
Duodenum Adenocarcioma	8 (5%)	5(8%)	0.328
CBD Adencarcinoma	13 (7%)	3(5%)	0.768
Pancreatic head	56(31%)	17(28%)	0.903
Pancreatitis	6 (4%)	3(5%)	0.698
IPMN	12(7%)	9(15%)	0.791
Duodenal GIST	2(1%)	1(2%)	1
Others	2 (1%)	1(2%)	1
Laparoscopic resection and reconstruction, n (%)	100 %	100 %	-
Laparoscopic resection and open reconstruction[1], n (%)	None	None	-
Tumor size cm, median	(2.3+-3.9 cm)	(2.4+-3.8)cm	0.8622
Malignant disease n (%)	141	22	<0.0001
R0 resection	98.7 %	98.8 %	1
No.of lymph nodes retrieved	21.3+-10.9	20.3+-11.9	1
Pancreatic duct diameter (mm)	2-5 mm	2-5mm	1

Values are *mean(s.d.) and †median (range). χ2 test, except Student's *t* test and Fisher's exact test

IPMN: Intraductal papillary mucinous neoplasm. **GIST**: Gastrointestinal stromal tumor. **CBD**: Common bile duct

Patients who underwent PD resection for both benign and malignant disease during the study period were included. All individuals were offered surgery following a consensus decision by the GI&Pancreas Multidisciplinary Team (MDT) meeting. And the respectively review of all cases consecutively performed we can seen it in ***Figure 1***.

Results

Patients

A total of **237** patients underwent LPD in our centers between 2012 and 2017, of which **61 (25.74%)** were elderly patients. All procedures were performed in a purely minimally invasive fashion. All operations were initiated laparoscopically. There were 144 male and 93 female patients with a median age of 73 (range 19 - 92) years and a median body mass index of 22.65 Kg/m(2). however comorbidities were more common in elderly (68.9%) than in non-elderly patients (34.6%) (odds ratio [OR] 4.17, P = 0.0001). Basic demographics for the entire cohort are summarized in Table 1.

Table 2: Baseline characteristics of entire patients cohort

Variable	Entire Study (n=237)	Age <75 (non elderly) (n=176)	Age ≥75 (elderly) (n=61)	P-value
Basic demographics				
Age, Years, mean±SD	65.73±7.87	55.75±10.76	75.72±4.984	<0.0001
< 75 (19-74), n (%)	176 (74.3 %)			
≥75(75-92), n (%)	61 (25.7 %)			
Gender (%)		0.89		
Male	144 (60.7 %)	107 (60.1 %)	37 (60.1 %)	
Female	93 (39.3%)	69 (39.2%)	24 (39.4 %)	
BMI Kg/m(2), mean±SD	22.65±3.35	23.1±3.5	22.2±3.2	0.0783
Comorbidities n(%)	103 (43.5 %)	61 (34.6 %)	42 (68.9 %)	0.0001
Hypertension	64 (27.0%)	39 (22.2%)	25(41.0%)	0.007
Congestive heart disease	6 (2.5%)	2 (1.1%)	4(6.6%)	0.0396
Arrhythmia	10 (4.2%)	8(4.6%)	2(3.3%)	1
Jaundice	89 (37.6 %)	64 (36.4%)	25 (41.0 %)	0.542
ASA score				
Grade I	85 (35.9%)	73(41.5%)	12(19.7%)	0.002
Grade II	135 (57.0%)	97(55.1%)	38(62.3%)	0.3697
Grade III	17 (7.2%)	6(3.4%)	11(18.0%)	0.0005
Grade IV	0 (0%)	0(0%)	0(0%)	1

ASA, American Society of Anesthesiologists; **BMI**, body mass index;**SD**, standard deviation;

Operative Outcomes

Operative details are shown in both ***Table 1 and Table 3 and Table 4***.The definition of mortality we used in this paper was either death before being discharged from the hospital or within 30 days of surgery. Surgical morbidity was also measured for 30 days after the operation and was based on hospital records, readmissions, and routine follow-up information. Wound infection was defined by any superficial, deep, or organ space infection with or without an associated wound and/or fascial dehiscence. Complications

were graded on severity according to the Clavien–Dindo classification. Major morbidity was defined as a complication of Clavien–Dindo Grade IIIb or higher. DGE, post-pancreatectomy haemorrhage (PPH) and POPF were classified based on the International Study Group of Pancreatic Surgery definitions[20,21,22]. Reoperations and readmissions were defined as those occurring within 30 days of surgery. Reoperations and re-admissions outside the study institution were confirmed through outside institutional charts that were also reviewed to capture additional morbidity information related to these occurrences. Records of any unplanned admissions to the ICU of either the index hospital admission or readmission were also obtained. Postoperative blood transfusion was defined as any receipt of packed red blood cells (PRBC) during the course of hospitalization. Length of stay was the duration of hospitalization from the date of surgery until the time of index discharge.There were no statistically significant differences in operation time (*P=0.494*), estimated blood loss (*P=0.0519*) or blood transfusion (*P=0.863*). Intraoperative outcomes can be seen in

Table 3 : Intraoperative Outcomes for elderly versus non-elderly patients

Outcome	Non-Elderly (n=176)	Elderly Patients (n=61)	P-value
Age, years mean±SD	55.75±10.76	75.72±4.984	<0.0001
Operative time, mean±SD	367.9±60.0	373.8 ± 51.3	0.4935
EBL,ml,mean,±SD	189.8±132.8	230 ± 153.8	0.0519
Transfusion	28 (15.9 %)	16 (26.2 %)	0.863

EBL, estimated blood loss ,. **SD**, standard deviation;

In-hospitality mortality rate was 0.84 % (n = 2). Postoperative complications occurred in 79 patients (33 %). Urgent reoperation was required in 15 patients (6 %). Bile leakage occurred in 8 patients the rate was 3% (n=8). In elderly patients, transfers to the ICU were more frequent (odds ratio [OR] 6.49, *P = 0.001*) and mean hospital stay was prolonged (21.4 days compared with 16.6 days, (*P = 0.0033*) when compared with that of non-elderly patients. There was no statistically significant difference in DGE (*P=0.397*), abdominal pain (*P=0.454*), food intake (*P=0.241*), time to self ambulation (P=1), reoperation (*P=0.543*), POPF grade A (*P=0.454)*, POPF grade B (*P=0.736*), POPF grade C (*P=0.164*), hemorrhage (*P=0.319*), bile leakage (*P=0.428*), infection (*P=0.259*), GI bleeding (*P=0.286*), morbidity (*P=0.272*) and mortality (*P=0.449*) between the two groups. Postoperative outcomes can be seen in

Table 4 : Postoperative outcomes for elderly patients versus non-elderly patients

Outcome	Non-Elderly (n=176)	Elderly Patients (n=61)	P-value
Mortality	1 (0.56 %)	1 (1.64 %)	0.4493
LOS, days	16.6±9.1	21.4±14.9	0.0033
ICU admission	16 (9.1 %)	24 (39.3 %)	0.001
No Symptoms	22 (12.5 %)	7 (11.5 %)	0.8251
Bowel movement	4.0±1.7 (2.3 %)	3.8±1.2 (6.2 %)	0.3973
Abdominal pain	77 (43.7 %)	23 (37.7 %)	0.4539
Intake	5.4±5.1 (3.1 %)	4.6±2.5 (7.5 %)	0.2408
Mobilisation	2.0±1.2 (1.13 %)	2.3±0.9 (3.77 %)	1
Re-operation	10 (5.9 %)	5 (8.2 %)	0.543
Morbidity	55 (31.2 %)	24 (39.3 %)	0.2717
POPF Grade A	19 (10.8 %)	4 (6.6 %)	0.4541
POPF Grade B	10 (5.7 %)	2 (3.3 %)	0.7357
POPF Grade C	1 (0.57 %)	2 (3.3%)	0.1635
POH hemorrhage	15 (8.5 %)	8 (13.1 %)	0.3186
Bile Leakage	5 (2.8 %)	3(4.9 %)	0.4275
Infection	11 (6.2 %)	7 (11.5 %)	0.259
GI Bleeding	6 (3.4%)	4 (6.6 %)	0.2857

ICU, intensive care unit,. **POPF**, postoperative pancreatic fistula,. **LOS** length of postoperative hospital stay,. **POH hemorrhage** postoperative hemorrhage.

Discussion

In an increasingly aging society, laparoscopic surgery is being employed more frequently on elderly patients. However, only a limited number of studies have been conducted on laparoscopic surgery in elderly patients with pancreatic cancer. Compared to younger patients, elderly patients are more likely to have existing conditions when undergoing surgery, as well as reduced major organ function and reduced functional reserves for invasive surgery. This study showed that other than an increase in ICU transfer rate (OR 6.49, P = 0.001) and an extended length of hospital stay (21.4 days versus 16.6 days; P = 0.0033, elderly versus non-elderly), there were no significant statistical differences in any of the other outcomes, including morbidity and mortality, between elderly and non-elderly patients. These results are supported by those of a number of studies in relation to both postoperative morbidity and mortality [1,8,16]. However, other papers have reported an increase in postoperative mortality and complications in elderly

patients[3,14,23]. A recent meta-analysis of over 5000 patients demonstrated that patients 76 to 80 years old undergoing PD had increased postoperative mortality rates compared with younger patients[23]. In addition elderly patients (when defined as aged >80 years) were found to have an increased risk for postoperative complications compared with non-elderly patients[23]. Elderly patients (aged >75 years) were also found to have increased risk for pulmonary complications compared with non-elderly patients[23]. One possible reason for this disparity could be the higher age of elderly patient definition used in the aforementioned papers. However, another retrospective review, which defined elderly as over 70, found elderly pancreatoduodenectomy patients (n = 860) were more likely to experience postoperative cardiorespiratory complications[1]. This difference could be due to our study cohort being of insufficient size, and hence underpowered, to reveal statistically significant differences for such rare events. Total mortality, for example, in our study was just 0.84%. It is possible that this very low mortality rate may also reflect an increase in skill of laproscopic surgeons in recent years. Our study demonstrated an increased risk of ICU admission and an increased length of hospital stay for elderly patients. However, this could be due to the fact that admission to ICU and hospital discharge decisions are made partly in accordance withthe patient's age, which would make it a confounding factor. Our study supported Buchs et al comparison of elderly patients (defined as those aged >70 years) and non-elderly patients undergoing robotic PD in that it identified no statistically significant differences in operative time, blood loss, postoperative mortality or overall morbidity between the two groups[14]. Limitations of our study and previous ones executed in a similar manner are their retrospective nature, which makes them susceptible to selection bias.

Conclusion

In our conclusion, we report here our experience over 5years with 237 cases included ur experience during the last 461 cases over than 75 years laparoscopic resections. And this is an extremely challenging task to perform such complicated procedures like laparoscopic pancreatoduodenectomy whether young or older patients safely and without compromising outcomes, but our paper suggests that neither morbidity nor mortality increased in elderly LPD patients when compared to non-elderly patients. Elderly LPD patients experienced a higher admittance rate to ICU and a longer hospital stay post operation. No statistically significant differences were found in any other complications assessed in this study.Therefore Age it self should not be a contraindication to LPD for pancreatic cancer, but it suggests that elderly patients with comorbidities should be more stringently selected for surgery.

Abbreviations

LPD:laparoscopic pancreaticoduodenectomy, PD:pancreaticoduodenectomy, PPH: post-pancreatectomy haemorrhage, POPF:postoperative pancreatic fifistula, GI:Gastric-intestinal, BMI: body mass index,

Declarations

Ethics approval and consent to participate

This study was approved by the Ethics Committee of Zhejiang Provincial Peoples Hospital and Zhejiang University. Written consent was obtained from every patient prior to surgery.

Consent for publication

Not applicable

Availability of data and materials

The datasets generated and/or analyzed during the current study are not publicly available due to data privacy according to the license for the current study, but are available from the corresponding author on reasonable request.

Competing interests

The authors declare that they have no competing interests

Funding

This research was supported by Scientific and Technological Project of Zhejiang Province (Grant No. 2015C03049). The funders had no role in study design, data collection and analysis, interpretation of data and preparation of the manuscript.

Authors' contributions

MH,YPM wrote the manuscript, YPM,XWX,RCZ,YCZ performed the operations, CL,CK,BZ reviewed the medical records and collected data,all authors read and approved the final manuscript.

Acknowledgments

Not applicable.

References

1. Tee, M. C. *et al.* Laparoscopic pancreatoduodenectomy does not completely mitigate increased perioperative risks in elderly patients. *HPB (Oxford).* **17,** 909–918 (2015).
2. Zhou, J. *et al.* Laparoscopic pancreaticoduodenectomy in A-92-older Chinese patient for cancer of head of the pancreas: A Case report. *Medicine (Baltimore).* **96,** e5962 (2017).
3. Lightner, A. M. *et al.* Pancreatic resection in the elderly1 1No competing interests declared. *Am. Coll. Surg.* **198,** 697–706 (2004).

4. Croome, K. P. *et al.* Total Laparoscopic Pancreaticoduodenectomy for Pancreatic Ductal Adenocarcinoma: Oncologic Advantages Over Open Approaches? *Surg.* **260,** 633–640 (2014).
5. Asbun, H. J. & Stauffer, J. A. Laparoscopic vs open pancreaticoduodenectomy: overall outcomes and severity of complications using the Accordion Severity Grading System. *Am. Coll. Surg.* **215,** 810–819 (2012).
6. Winter, J. M. *et al.* 1423 pancreaticoduodenectomies for pancreatic cancer: A single-institution experience. *Gastrointest. Surg.* **10,** 1191–1199 (2006).
7. Crist, D. W., Sitzmann, J. V & Cameron, J. L. Improved hospital morbidity, mortality, and survival after the Whipple procedure. *Surg.* **206,** 358–365 (1987).
8. Tani, M. *et al.* A pancreaticoduodenectomy is acceptable for periampullary tumors in the elderly, even in patients over 80 years of age. *Hepatobiliary. Pancreat. Surg.* **16,** 675–680 (2009).
9. Jin, W. *et al.* [Early experience of laparoscopic pancreaticoduodenectomy on 66 cases]. *Zhonghua Wai Ke Za Zhi* **54,** 84–88 (2016).
10. Spencer, M. P., Sarr, M. G. & Nagorney, D. M. Radical pancreatectomy for pancreatic cancer in the elderly. Is it safe and justified? *Surg.* **212,** 140–143 (1990).
11. Hatzaras, I. *et al.* Pancreatic resection in the octogenarian: a safe option for pancreatic malignancy. *Am. Coll. Surg.* **212,** 373–377 (2011).
12. Wiltberger, G. *et al.* Pancreaticoduodenectomy in the Elderly Patient: Age-Adapted Risk Assessment. *Surg.* **34,** 43–51 (2017).
13. Ansari, D., Aronsson, L., Fredriksson, J., Andersson, B. & Andersson, R. Safety of pancreatic resection in the elderly: a retrospective analysis of 556 patients. *Gastroenterol.* **29,** 221–225 (2016).
14. Buchs, N. C. *et al.* Outcomes of robot-assisted pancreaticoduodenectomy in patients older than 70 years: a comparative study. *World J. Surg.* **34,** 2109–2114 (2010).
15. Beltrame, V. *et al.* Outcome of pancreaticoduodenectomy in octogenarians: Single institution's experience and review of the literature. *Visc. Surg.* **152,** 279–284 (2015).
16. Yamashita, Y.-I. *et al.* Surgical outcomes of pancreaticoduodenectomy for periampullary tumors in elderly *Langenbeck's Arch. Surg.* **398,** 539–545 (2013).
17. Jin WW, Zhang RC, M. Y. et al. Modified operative approach for laparoscopic pancreaticoduodenectomy. *Chin J Hepat Surg* 338–40 (2014).
18. Ren F, Jin WW, Lu C, et al. Clinical efficacy of 'Easy First' strategy in laparoscopic pancreaticoduodenectomy for borderline resectable pancreatic cancer. *Chin J Dig Surg* 644–7 (2014).
19. Cameron, J. L. & He, J. Two thousand consecutive pancreaticoduodenectomies. *Am. Coll. Surg.* **220,** 530–536 (2015).
20. Wente, M. N. *et al.* Delayed gastric emptying (DGE) after pancreatic surgery: a suggested definition by the International Study Group of Pancreatic Surgery (ISGPS). *Surgery* **142,** 761–768 (2007).

21. Wente, M. N. *et al.* Postpancreatectomy hemorrhage (PPH): an International Study Group of Pancreatic Surgery (ISGPS) definition. *Surgery* **142,** 20–25 (2007).
22. Baker, M. S. *et al.* Using a modification of the Clavien-Dindo system accounting for readmissions and multiple interventions: defining quality for pancreaticoduodenectomy. *Surg. Oncol.* **110,** 400–406 (2014).
23. Sukharamwala, P., Thoens, J., Szuchmacher, M., Smith, J. & DeVito, P. Advanced age is a risk factor for post-operative complications and mortality after a pancreaticoduodenectomy: a meta-analysis and systematic review. *HPB (Oxford).* **14,** 649–657 (2012).
24. Gagner M, Pomp A. Laparoscopic pylorus-preserving pancreatoduodenectomy. *Surg Endosc.*1994 ;8:408–410.
25. Kendrick ML, van Hilst J, Boggi U, et al.Minimally Invasive Pancreatic Resection Organizing Minimally invasive pancreatoduodenectomy.*HPB (Oxford*). 2017;19:215–224.
26. Weir HK, Thompson TD, Soman A, et al. The past, present, and future of cancer incidence in the United States: 1975 through 2020. Cancer. 2015;121:1827–1837.
27. Smetana K Jr, Lacina L, Szabo P, et al. Ageing as an important risk factor for cancer. Anticancer Res. 2016;36:5009–5017.
28. Guo, Z. Cui, Current diagnosis and treatment of pancreatic cancer in China, Pancreas 31 (2005) 13–22.Cancer statistics:
29. J-Long, G-Luo, Z-Xiao, Z-Liu, M-Guo, L-Liu, C-Liu, J-Xu, Y-Gao, Y-Zheng, C-Wu, Q-Ni , M-Li , X-YuCurrent diagnosis and treatment of pancreatic cancer in Shanghai, Cancer Letters-11 January 2014

Figures

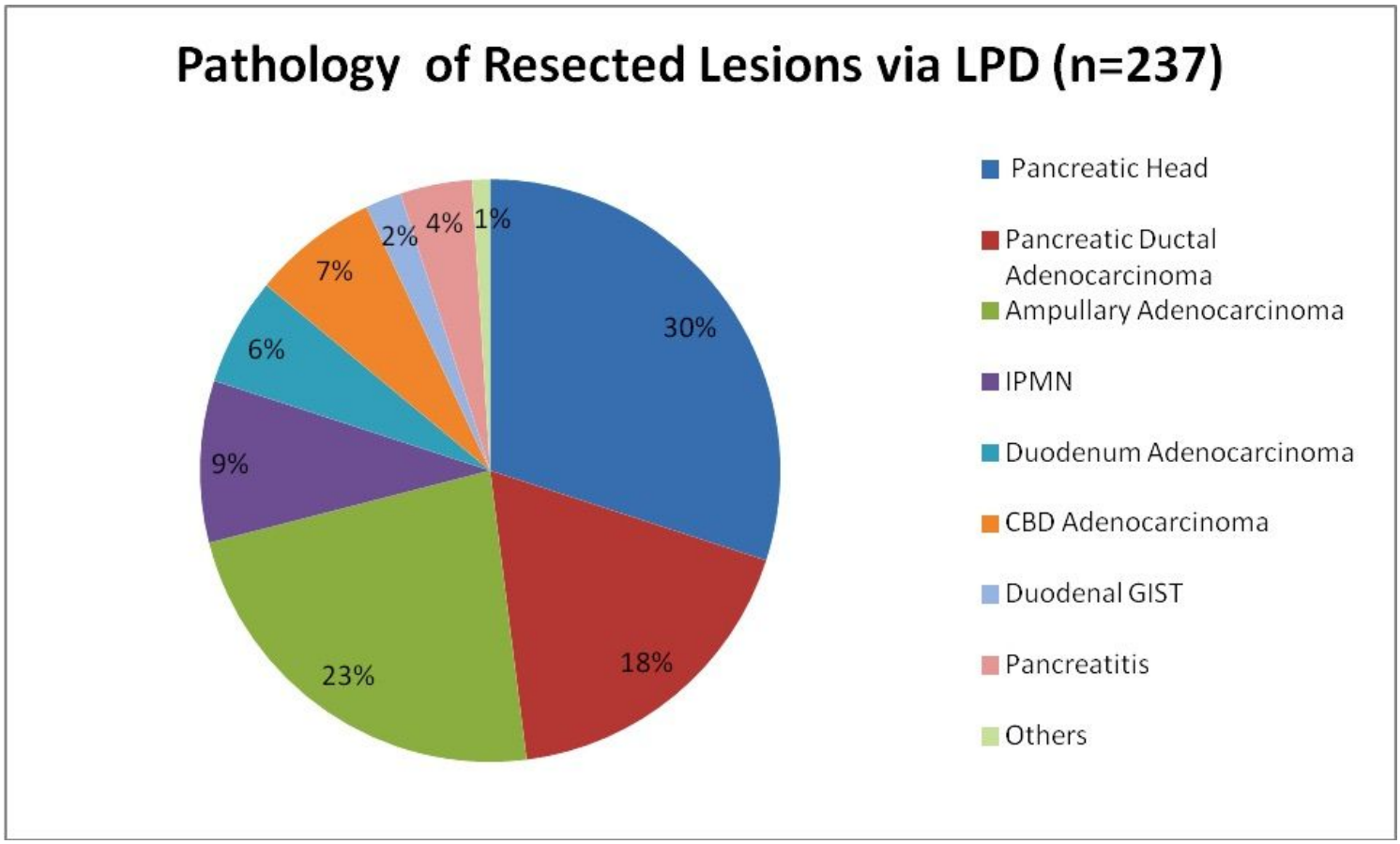

Figure 1

Pathology of resected lesions via LPD (n=237)