Original Paper

Cattel and Blumgart Anastomosis: Comparison of Pancreatojejunostomy Techniques in Patients with Pancreatic Cancer

SERGIO ISIDRO GAMBOA-HOIL[1], RICARDO GAMBOA-GUTIERREZ[2], PATRICIA BOLADO-GARCIA[3], ALEJANDRO MEDINA-CAMPOS[3]

[1]Surgical oncology, Department of Oncology, Unidad Médica de Alta Especialidad Yucatán, Instituto Mexicano del Seguro Social

[2]Surgical oncology, Head of the Oncology Department, Unidad Médica de Alta Especialidad Yucatán, Instituto Mexicano del Seguro Social

[3]Department of Investigation, Unidad Médica de Alta Especialidad Yucatán, Instituto Mexicano del Seguro Social

ABSTRACT: Backround. Pancreaticojejunal anastomosis has a high risk of pancreatic leakage, which several surgical techniques have been described. Our main objective is to determine what is the association of postoperative pancreatic leakage in patients undergoing pancreaticoduodenectomy according to the pancreaticojejunal anastomosis technique used (Cattel vs Blumgart)? Material and methods. Historical cohort, all cancer patients undergoing pancreaticoduodenectomy were included. From April 2020 to May 2021, Cattel technique was used; from June 2021 to June 2022, Blumgart technique was used. All procedures were performed by a single board-certified surgical oncologist at Oncology Hospital. Results. 24 patients (11 men and 13 women). The first 9 procedures were performed with the Cattel technique, starting from procedure 10, the Blumgart technique was used. No differences were observed regarding the consistency of the pancreas (p=0.28) or the size of the duct (p=0.51) between the two groups. Pancreatic leakage was observed in 100% with the Cattel technique and in 6.7% with the Blumgart technique (p= 0.0001). An amylase value was observed in the left drainage at 6 days > 200 U/L with the Cattel technique and < 200 U/L with Blumgart (p=0.0001). Intraoperative bleeding (Cattel 1200 ml vs. Blumgart 400 ml, p= 0.03) and 90-day mortality (Cattel 33.3% vs. Blumgart 0%, Log-Rank: 0.022) also showed a difference in favor of Blumgart technique. Blumgart technique is a protective factor for the presence of pancreatic leakage (RR 0.06, 95% CI 0.01-0.44, p=0.0001). Discussion. A lower risk of pancreatic leakage was found using the Blumgart technique, compared to the Cattel technique.

KEYWORDS: *Blumgart anastomosis, cattel anastomosis, pancreatic leakage, pancreaticojejunostomy, pancreatic anastomosis, pancreaticoduodenectomy.*

Introduction

The pancreatic-jejunum anastomosis has a high complexity and a high risk of pancreatic leakage [1,2].

In high-volume centers, morbidity of up to 50% has been reported [3-6].

Several techniques have been described to reduce the risk of post-surgical pancreatic leakage, including the duct-mucosal anastomosis technique, such as the one described in 1956 by Cattel-Warren and the one described in 2010 by Blumgart [7-12].

Currently, it seems that the anastomosis should be considered individually, according to the patient's characteristics and the surgeon's preferences [8-10].

Our main objective is to determine what is the association of postoperative pancreatic leakage in patients undergoing pancreaticoduodenectomy according to the pancreaticojejunal anastomosis technique used (Cattel vs Blumgart)?

Material and methods

Study population

This protocol was approved by the institution's ethics committee (R-2023-3203-001), and each patient gave written informed consent regarding their participation in the study.

From April 2020 to June 2022, 24 patients underwent pancreaticoduodenectomy in our Oncology Hospital, Unidad Médica de Alta Especialidad of the Instituto Mexicano del Seguro Social. All patients were included in this historical cohort.

Surgical technique

The surgical procedure was performed under general anesthesia through a supra-transumbilical incision in all cases. Classic or pylorus-preserving technique was performed according to the extension of the tumor towards the pyloric region. Clinical characteristics of the pancreas were measured after resection. All procedures were performed by the same board-certified surgical oncologist, with support from a general

10.12865/CHSJ.50.01.03

surgeon and/or general surgery residents. The technique used during the historical cohort was Cattel or Blumgart. After pancreatic section, the mobilization of the pancreas was 4 cm.

The loop of jejunum was sectioned using a GYA 55 mm linear stapler and the section edge was not invaginated using stitches.

Subsequently, the first anastomosis (hepatic-jejunum) was performed 20 cm from the ascended loop.

The second anastomosis (pancreatic-jejunum) was performed 5 cm from the ascended loop. For the second anastomosis, electrocautery was used to open and evert 8 to 10 mm of the jejunal mucosa and 4 cardinal points were placed with 3-0 prolene. An end-to-side anastomosis was performed, according to the Cattel or Blumgart technique.

Cattel

Prolene 3-0 was used to place 4 stitches on the posterior surface of the pancreas, approached the posterior wall of the jejunum and tied (Figure 1).

Subsequently, 4 points were placed in the respective quadrants of the circumference of the sectioned pancreatic duct, before tying, a stake was placed inside the pancreatic-jejunum duct (5 or 8 fr nasoenteral tube between 8 and 10 cm).

Subsequently, 4 stitches were placed on the anterior surface of the pancreas and jejunum, and tied [11].

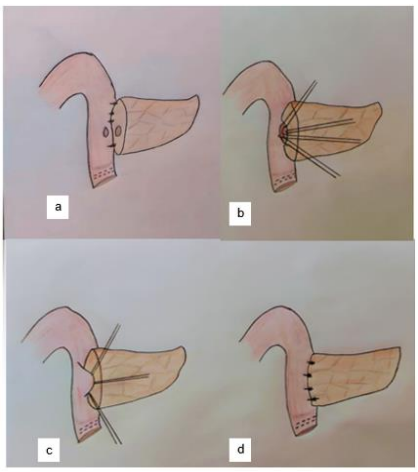

Figure 1. Pancreaticojejunostomy using Cattel technique. a) 4 stitches were placed on the posterior surface of the pancreas to approximate it to the posterior wall of the jejunum. b) 4 points were placed in the respective quadrants of the circumference of the sectioned pancreatic duct and a stake was placed inside the pancreatic duct-jejunum (the stake is not shown in the figure). c) The 4 points of the respective quadrants of the circumference of the pancreatic duct were tied. d) Subsequently, 4 stitches were placed on the anterior surface of the pancreas and jejunum and tied.

Blumgart

Prolene 3.0 was used, 4 full thickness stitches were placed (3 stitches above the pancreatic duct and 1 stitch below the pancreatic duct) from the anterior surface of the pancreas to the posterior one, subsequently seromuscular stitches were placed on the posterior wall of the jejunum and, back, full thickness points to pancreas from posterior to anterior surface (Figure 2).

Before tying it, 4 stitches were placed in the respective quadrants of the circumference of the sectioned pancreatic duct as well as a stake was placed inside the pancreatic jejunum duct (5 or 8 fr nasoenteral tube measuring between 8 to 10 cm).

First the duct-mucosa stitches were tied and then the full thickness stitches of the pancreas were tied.

Once the full thickness stitches were tied, with the same suture the stitches were placed from the anterior surface (knotted) of the pancreas to the anterior seromuscular surface of the jejunum and tied again [12].

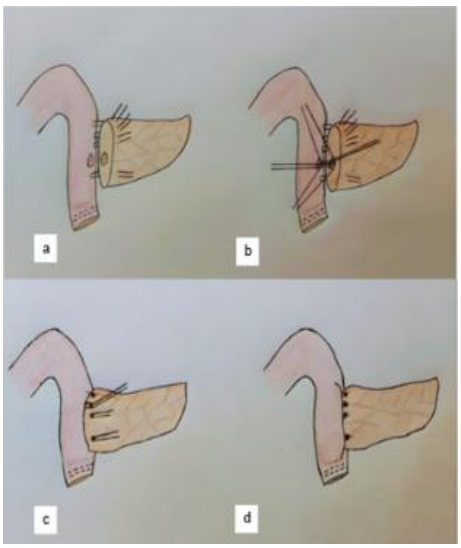

Figure 2. Pancreaticojejunostomy using Blumgart technique. a) 4 full thickness stitches (3 stitches above the pancreatic duct and 1 stitch below the pancreatic duct) were placed from the anterior to the posterior surface of the pancreas, then seromuscular stitches were placed on the posterior wall of the jejunum and back, stitches full thickness from the posterior to the anterior surface of the pancreas, b) 4 stitches were placed in the respective quadrants of the circumference of the sectioned pancreatic duct, as well as a stake was placed inside the pancreatic duct-jejunum (not shown in the figure), c) The full thickness stitches of the pancreas were tied, d) With the same suture, the stitches were placed from the anterior surface of the pancreas (knotted) to the anterior seromuscular surface of the jejunum and, tied again.

The gastric-jejunum anastomosis was performed 20 cm from the hepatic-jejunum anastomosis.

In both techniques, 2 drains were placed (19 or 20 fr endopleural probe), a right one towards the hepatic-jejunum anastomosis and a left one towards the pancreatic-jejunum anastomosis.

Postoperative management

After the surgical event, all patients were managed in the intensive care service. All patients were managed with octreotide at a dose of 200 micrograms every 8 hours after surgery and until the start of the diet.

Response variable

Pancreatic leakage was defined based on the amylase value of the left drainage fluid between the fourth and sixth postoperative day. A value greater than 200 U/L was considered a pancreatic leakage [13].

Statistical analysis

Descriptive statistics were performed with measures of central tendency and dispersion according to the distribution of the variables, whether normal or free. Quantitative variables were compared using Mann-Whitney U or student T depending on the distribution. Qualitative variables were compared using chi square or Fisher's exact test if the assumptions of the former were not met. Relative Risk was used as a measure of association with a 95% confidence interval. The results were considered significant with $p \leq 0.05$.

Results

From April 2020 to June 2022, 24 patients (11 men and 13 women) underwent pancreatoduodenectomy in our hospital. From April 2020 to May 2021, the Cattell technique was used, from June 2021 to June 2022, the Blumgart technique was used. As this is a historical cohort, the first 9 surgical procedures were performed using the Cattel technique, Starting with procedure 10, it will be performed using the Blumgart technique.

The median age at diagnosis was 64 years (31 to 78). Ampulla of Vater was the most common site of the tumor (45.8%). Adenocarcinoma histology was the most frequent (83.3%). Median tumor size was 3 cm (1 to 9.5). Characteristics of the population according to the Cattel or Blumgart technique are presented in Table 1.

The median pancreatic duct was 3 mm (2 to 4 mm). Semi-soft consistency of the pancreas was observed in 75%, the soft consistency in 16.7% and the fibrous consistency in 8.3%, Table 2.

Table 1. Characteristics of the population.

Variable		Cattel (9)	Blumgart (15)	p value *
Sex n (%)	Male	6 (66.7)	5 (33.3)	0.20
	Female	3 (33.3)	10 (66.7)	
Age	Younger	48	31	
	Older age	78	75	
65 years old group (%)	Less than 65	4 (44.4)	9 (60.0)	0.67
	Over 65 years old	5 (55.6)	6 (40.0)	
Comorbidities n (%)	Mellitus diabetes	1 (11.1)	2 (13.3)	0.99
	Systemic arterial hypertension	2 (22.2)	10 (66.7)	0.89
	Heart disease	0 (0)	2 (8.3)	0.72
Tumor location n (%)	Ampulla of Vater	7 (77.8)	4 (26.7)	
	Pancreas	0 (0)	8 (53.3)	**0.008**
	Duodenum	1 (11.1)	3 (20.0)	
	Hepatic duct	1 (11.1)	0 (0)	
Histology n (%)	Adenocarcinoma	8 (88.9)	12 (80.0)	
	Solid pseudopapillary neoplasm	0 (0)	2 (13.3)	0.44
	Gist	0 (0)	1 (6.7)	
	Sclerosing cholangitis	1 (11.1)	0 (0)	
Size in cm	Minor	1.0	1.5	
	Greater	6.0	9.5	
T n (%)	T1b	0 (0)	2 (13.3)	
	T1c	0 (0)	4 (26.7)	
	T2	0 (0)	4 (26.7)	**0.005**
	T3	1 (11.1)	0 (0)	
	T3a	7 (77.8)	2 (13.3)	
	T4	0 (0)	1 (6.7)	
	Others	1 (11.1)	2 (13.3)	
N n (%)	N0	8 (88.9)	11 (73.4)	
	N+	0 (0)	2 (13.3)	0.50
	Others	1 (11.1)	2 (13.3)	
M n (%)	M0	8 (88.9)	13 (86.7)	0.82
	M+	0 (0)	0 (0)	
	Others	1 (11.1)	2 (13.3)	
Clinical stage n (%)	I	0 (0)	3 (20.1)	
	IA	0 (0)	2 (13.3)	
	IB	0 (0)	3 (20.1)	**0.004**
	IIA	8 (88.9)	2 (13.3)	
	IIB	0 (0)	1 (6.6)	
	III	0 (0)	2 (13.3)	

10.12865/CHSJ.50.01.03

	Others	1 (11.1)	2 (13.3)	
Margin n (%)	Negative	9 (100.0)	14 (93.3)	0.99
	Positive	0 (0)	1 (6.7)	
Neural invasion n (%)	Positive	2 (22.2)	3 (20.0)	0.99
	Negative	7 (77.8)	12 (80.0)	
Lymphovascular invasion n (%)	Positive	2 (22.2)	3 (20.0)	0.99
	Negative	7 (77.8)	12 (80.0)	
Grade n (%)	I	0 (0)	1 (6.7)	
	II	6 (66.7)	9 (60.0)	0.99
	III	2 (22.2)	3 (20.0)	
	Others not malignant	1 (11.1)	2 (13.3)	
Lymph nodes n (%)	Positive	0 (0)	2 (13.3)	0.51
	Negative	9 (100.0)	13 (86.7)	

Note: * Fisher's exact test

Table 2. Characteristics of the surgical procedure.

Variable		Cattel (9)	Blumgart (15)	p value
Pancreaticoduodenectomy n (%)	Classic	1 (11.1)	9 (60.0)	0.03*
	Pylorus-sparing	8 (88.9)	6 (40.0)	
Pancreatic duct in mm	2	5 (55.6)	5 (33.3)	
	3	2 (22.2)	7 (46.7)	0.49*
	4	2 (22.2)	3 (20.0)	
Pancreatic duct	Median	2	3	0.51++
Consistency of the pancreas n (%)	Soft	3 (33.3)	1 (6.7)	
	Semi-soft	6 (66.7)	12 (80.0)	0.28*
	Fibrous	0 (0)	2 (13.3)	
Intraoperative bleeding	300	1 (11.1)	2 (13.3)	
in ml n (%)	350	0 (0)	4 (26.7)	
	400	1 (11.1)	3 (20.0)	
	500	1 (11.1)	1 (6.7)	
	600	1 (11.1)	0 (0)	
	800	0 (0)	2 (13.3)	**0.008***
	1000	0 (0)	3 (20.0)	
	1200	1 (11.1)	0 (0)	
	1500	4 (44.5)	0 (0)	
Intraoperative bleeding	Median	1200	400	**0.035 ++**
Intraoperative hemotransfusion	0	1 (11.1)	5 (33.3)	
blood units n (%)	1	3 (33.3)	5 (33.3)	
	2	0 (0)	3 (20.1)	.087*
	3	4 (44.5)	2 (13.3)	
	4	1 (11.1)	0 (0)	
Intraoperative hemotransfusion blood units	Median	3	1	0.09++
Reintervention n (%)	Yes	1 (11.1)	0 (0)	0.37*
		8 (88.9)	15 (100)	
Pancreatic leakage (%)	Yes	9 (100.0)	1 (6.7)	**0.0001***
	No	0 (0)	14 (93.3)	
Bile leakage n (%)	Si	3 (33.3)	0 (0)	**0.042***
	No	6 (66.7)	15 (100)	
Amylase in drain U/L	Minor	Greater than 200	30	
	Greater	Greater than 200	3263	
Amylase in drain n (%)	Less than 200	0 (0)	14 (93.3)	**0.0001***
	Greater than 200	9 (100)	1 (6.7)	
Days of amylase measurement n (%)	4	--	6 (40.0)	
	5	--	6 (40.0)	
	6	--	3 (20.0)	
	Others	Greater than 200	0 (0)	
Plasma albumin g/dL	Minum	2.6	2.4	
	Greater	4.0	5.4	
Plasma albumin (standard deviation)	Median	3.05 (0.43)	3.6 (0.74)	0.058¥
Delayed gastric emptying n (%)	Yes	0 (0)	7 (46.7)	**0.022***
	No	9 (100.0)	8 (53.3)	
Gastric emptying resolution in weeks n (%)	6	NA	2 (28.6)	
	7	NA	5 (71.4)	
Mortality in 90 days n (%)	Yes	3 (33.3)	0 (0)	**0.04***
	No	6 (66.7)	15 (100.0)	
Hospital stay	Median	50 days	6 days	

Note: * Fisher's exact test. ++ Mann-Whitney U. ¥ t student

Postoperative morbidity and mortality

Pancreatic leakage occurred in 100% of the patients operated on using Cattell and in 6.7% (1 patient) of those operated on with the Blumgart technique (p=0.0001).

Postoperative amylase values measured from the left drainage after day 6 were greater than 200 U/L when Cattel technique was used, while Blumgart technique, 93.3% presented values less than 200 U/L in the first 6 days after surgery (p=0.0001), with a trend towards a shorter hospital stay with a median of 6 days.

11% of patients underwent surgical reintervention when Cattel technique was used, with the Blumgart technique 0% were surgical reintervention (p=0.37). 90-day mortality was of 33.3% with the Cattel technique, while 0% with

the Blumgart technique (Log-Rank: 0.022) (Figure 3).

Overall survival until the closure of this study is 55.6% for the Cattel technique and 86.7% for the Blumgart technique (Log-Rank: 0.30) (Figure 4).

However, if we consider both techniques, 41.7% of the population presented pancreatic leakage, with a 90-day mortality of 12.5%, requiring 4.1% surgical reintervention.

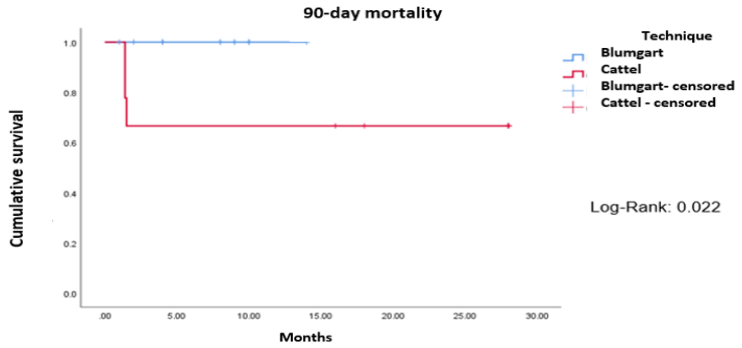

Figure 3. Mortality at 90 days, depending on the technique used.

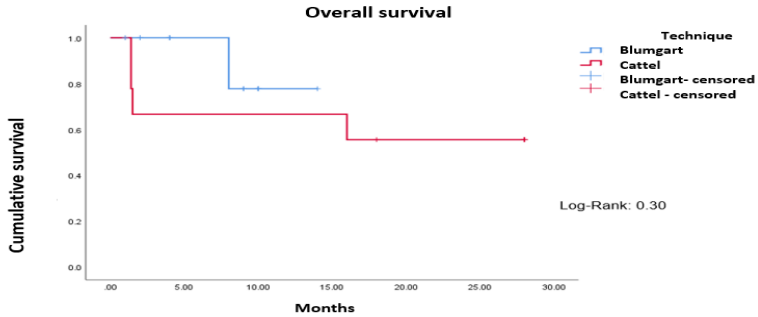

Figure 4. Overall survival according to the technique used.

Perioperative differences between both techniques

Median size of the pancreatic duct for the Cattel technique was 2mm, while median for the Blumgart technique was 3mm, although without a statistically significant difference (p=0.51), added to the fact that 100% of the patients operated on with the Cattel technique presented pancreatic leakage. Semi-soft consistency of the pancreas was the most frequent in both (p=0.28).

Median intraoperative bleeding was 1200 ml for the Cattel technique and 400 ml for the Blumgart technique (p=0.03), median number of red blood cells transfused was 4 with the Cattel technique and 0 to 1 with the Blumgart technique (p=0.09).

Adjuvant treatment

No statistically significant difference was found between both surgical techniques and treatment with adjuvant chemo or radiotherapy.

However, a statistically significant difference was observed regarding the weeks of initiation of adjuvant chemotherapy, starting 6 weeks earlier, when the Blumgart technique was used (p=0.01), Table 3.

Table 3. Distribution of adjuvant treatment.

Variable		Cattel (9)	Blumgart (15)	p value
Adjuvant chemotherapy n (%)	Yes	4 (44.4)	8 (53.3)	0.99*
	No	5 (55.6)	7 (46.7)	
Start of chemotherapy in weeks n (%)	4	0 (0)	2 (40.0)	
	7	0 (0)	3 (60.0)	**0.01***
	11	1 (25.0)	0 (0)	
	12	2 (50.2)	0 (0)	
	13	1 (25.0)	0 (0)	
Start of chemotherapy (standard deviation)	Median	12 (0.81)	5.8 (1.64)	**<0.01 ¥**
Adjuvant radiotherapy n (%)	Yes	0 (0)	2 (13.3)	0.51*
	No	9 (100.0)	13 (86.7)	
Start of radiotherapy in weeks n (%)	6	0	2 (100)	

Note: * Fisher's exact test. ¥ t student

10.12865/CHSJ.50.01.03

Recurrence

No statistically significant difference was observed regarding surgical technique and disease recurrence (Log-Rank 0.93) (Figure 5).

All recurrences were treated with chemotherapy, Table 4.

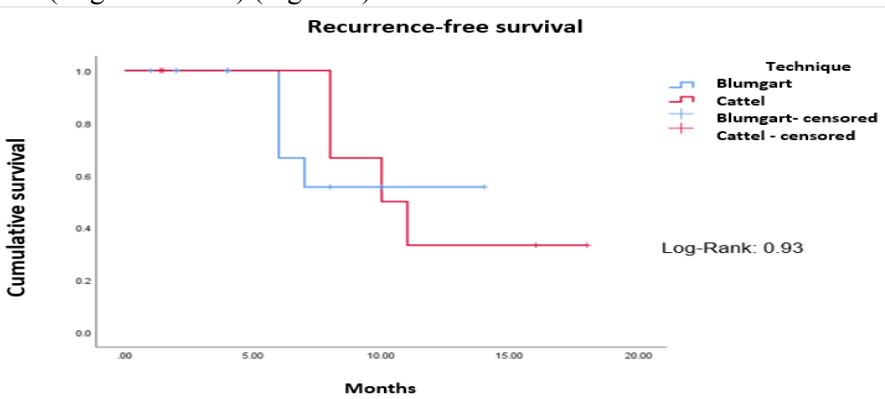

Figure 5. Recurrence-free survival according to the technique used.

Table 4. Recurrence and survival.

Variable		Cattel (9)	Blumgart (15)	p value
Recurrence n (%)	Yes	4 (44.4)	4 (26.7)	0.41*
	No	5 (55.6)	11 (73.3)	
Recurrence site n (%)	Local	0 (0)	2 (50.0)	0.06*
	Local, liver	2 (50.0)	0 (0)	
	Local, liver, lung	2 (50.0)	2 (50.0)	
Recurrence in months n (%)	6	0 (0)	3 (75.0)	
	7	0 (0)	1 (25.0)	**0.01***
	8	2 (50.0)	0 (0)	
	10	2 (50.0)	0 (0)	
Recurrence (standard deviation)	Median	9 (1.15)	6.5 (0.57)	**<0.01 ¥**
Recurrence treatment	Chemotherapy	4 (100.0)	4 (100.0)	
Stay alive	Yes	5 (55.6)	13 (86.7)	0.15*
	No	4 (44.4)	2 (13.3)	

Note: * Fisher's exact test. ¥ t student

Factors associated with pancreatic leakage

In the analysis of the variables, we observed that systemic arterial hypertension was a protective factor for the presence of pancreatic leakage. Location of the tumor other than the head of the pancreas increased the risk of developing pancreatic leakage, similarly, the risk increased in tumors larger than T1, especially T3 tumors (according to the classification corresponding to each tumor) [14].

Regarding the surgical technique, the Blumgart anastomosis technique was a protective factor for the presence of pancreatic leakage. Table 5.

Table 5. Factors associated with pancreatic leakage

Variable	Leakage n(%)	RR (CI 95%)	p value*
Systemic arterial hypertension	2/ 10 (20)	0.1 (0.01 – 0.69)	0.02
Location other than the pancreas	10/ 10 (100)	2.6 (1.4- 5.0)	0.006
Greater than T1	9/9 (90)	2.5 (1.3- 4.6)	0.019
T3	8/9 (88)	40 (3.04- 524.8)	0.002
No biliary leakage	7/10 (70)	3 (1-6- 5.4)	0.059
Blumgart	1/10 (10)	0.06 (0.01- 0.44)	0.0001

Note: RR: Relative risk, CI confidence interval. * Fisher's exact test

Discussion

In our study population, sex contrasts with the literature, which is more frequently observed in men (52 to 61%) [3,4,15-20], the median age was similar to that observed in the publications (60 to 68 years), the location of the tumor in our study also contrasts with the articles, where pancreatic cancer is the most frequent (28 to 63%) [2, 4,15-17,20], while in fewer articles the location of the ampulla of Vater has been more frequent (67 to 72%) [8].

Comparing the above, it could be due to the fact that in our population the majority of male patients seek medical attention with greater symptoms and therefore with more advanced disease, therefore, they are not candidates for surgical treatment. 70% of our population had comorbidities, a higher percentage than reported in the literature (13 to 20%) [2,15,19].

Regarding pylorus-preserving pancreatoduodenectomy, Kleespies et al, comparing the Cattel vs Blumgart technique, reported preserving the pylorus in 14.8% of ampulla of Vater [15].

Meanwhile, Marcus S, et al and Berger A, et al, reported higher percentages in their publications (64 and 87% respectively) [4,6].

Compared to Kleespies et al [15], in our population we preserved the pylorus in patients with ampulla of Vater by 100%, while we did compare both groups, in general the pyloric preservation was f 25%, a lower percentage than those reported by Marcus S, et al and Berger A, et al [5,6].

Soft consistency of the pancreas has been reported between 45 to 51%, however, this differs from our study population where soft consistency was observed in only 16% [6,16,17].

Several studies have reported a pancreatic duct measurement greater than 3 mm (50-60%) [6, 16, 20], which is similar to those observed in our patients (58%), as Kojima et al, we did not observe statistically significant differences between the size of the pancreatic duct of both groups (p=0.51) [20].

Several publications have reported intraoperative bleeding with a median of 450 to 1150 ml [4,15-17,19,20], which does not differ from our population, where the median intraoperative bleeding was 500 ml, however, where we observed contrast with the literature was in transsurgical hemotransfusions, reported in the literature between 36 to 48%, while in our population it was 75%, with a median of 1 globular unit (from 0 to 6 according to international publications) [4,6].

Surgical reinterventions have been reported between 1 to 8.3%, in our population it was of 4.2% [3 6,17]. Surgical reintervention when the Blumgart technique was used in our study was 0%, in contrast to Grobmyer et al, Fujii et al and Kawakatsu et al (5.3, 1 and 2% respectively) [12,17,19].

Albumin value measured pre-surgery was slightly lower than that reported in the literature, which was greater than 3 g/dl in 70% of our population (92% internationally) [2].

Biliary leakage occurred in 12.5% of our population, a higher percentage than reported (1.6-2.4%) [3,8,15,17,20].

It is striking that in our study we did find significant differences between the biliary leakage group and the surgical technique group (p=0.04), which differs from what was observed by Kleespies et al. and Kojima et al [15, 20].

The delay in gastric emptying with the Blumgart technique was 46.7%, a percentage higher than that reported in the literature which is 2% [17,20].

Pancreatic leakage occurred in 41.7% of our population, similar to that reported by other studies (2.2+42.7%) [3,5,8,15,19-21].

However, in our population, in the pancreatic leakage according to the Cattel (100%) vs. Blumgart (6.7%) groups, we observed a statistically significant difference (p=0.0001) in favor of the Blumgart technique, similar to that observed by Kleespies et al. and Kojima et al [15,20].

Post-surgical amylase values, Fujii et al, reported a median of 129 IU/L on the third day of drainage (day 3 p=0.003), in patients without pancreatic leakage, in our study in patients without pancreatic leakage using the Blumgart technique, the median amylase was 171 IU/L (30-136 IU/L) between the 4th and 6th postoperative day [17].

Shrikhande et al, reported a percentage of pancreatic leakage of 3.2% with the duct-mucosal technique (p=0.0005) [8].

Kleespies et al, compared the Cattel technique vs. Blumgart technique, observed pancreatic leakage in 13% and 4% respectively (p=0·032) [15].

In our study, when comparing both Cattel and Blumgart techniques, we obtained a lower percentage of pancreatic leakage with the Blumgart technique (p=0.0001), similar to what was reported by Grobmyer S et al, where pancreatic leakage was observed in 6.9% [12].

The research by Berger et al was carried out in two institutions with several surgeons performing the same procedure. The research by Grobmyer et al was carried out by three surgeons at two institutions, and in the research by Kleespies et al, the procedures were performed by or under the supervision of one of three expert pancreatic surgeons, all of the above could impact the results. In our study, the procedures were performed by the same surgical oncologist at the same institution.

Regarding risk factors, comorbidities other than pancreatic cancer were significant for pancreatic leakage in our study (RR 2.6, 95% CI 1.4-5.0, p=0.006). Fujii et al, reported a significant result in the univariate analysis (OR 2.27, 95% CI 1.18–4.35, p= 0.012), but not in the multivariate analysis (HR 1.82, 95% CI 0.71-4.71, p=0.214) [17].

It is striking in our study that patients who did not present a biliary leakage had a tendency

10.12865/CHSJ.50.01.03

towards a higher risk of pancreatic leakage (RR 3, 95% CI 1-6-5.4, p=0.059). Which could be related to the location of the tumor.

Soft consistency of the pancreas has been reported as a risk factor for pancreatic leakage (Berger et al, OR 3.7, 95% CI 1.5-8.8, p= 0.003, Fujii et al, OR 6.10, 95% CI 2.30–17.36, p=<0.001) [6,17].

Globmyer et al, reported an association of patients with a pancreatic duct smaller than 3 mm and a higher risk for the development of pancreatic leakage compared to those larger than 3 mm (p=0.008) [12], both variables were not significant in our population.

Cattel anastomosis (vs. Blumgart) has been associated with a higher risk of pancreatic leakage (Kleespies et al, p=0·032) [15].

Fujii et al, reported the Blumgart anastomosis technique as a protective factor compared to the Cattel technique (HR 0.02, 95% CI 0.01-0.08, p=<0.001) [17].

Similar results were observed in our study, where the Blumgart technique was a protective factor for developing pancreatic leakage (RR 0.06, 95% CI 0.01 – 0.44, p=0.0001).

Other variables such as systemic arterial hypertension (RR 0.1, 95% CI 0.01-0.69, p=0.02) and tumors larger than T1 (RR 2.5, 95% CI 1.3-4.6, p=0.019), were significant in our study. It is important to rule out that the observed data represent the specific population studied, as reported by Berger et al, even in their prospective, randomized study, it is possible to find significant differences between two institutions (p=0.04) [6].

With the mucosal duct technique, a shorter median in-hospital stay has been observed, data that agree with our study where the median stay in patients after surgery with the Blumgart technique is 6 days [6,8,17].

Kojima et al, reported a statistically significant difference in favour of the Blumgart technique in relation to the Cattel technique (22 days (11-90) vs 34 (15-134), p= <0.001) [20].

Periods of long hospital stay could affect the start of adjuvant treatment in patients with oncological pathology, as observed in our study where patients treated with the Blumgart technique started adjuvant chemotherapy 6 weeks earlier compared to the Cattel technique (p=<0.01). 90-day mortality reported with the Blumgart technique is less than 3%, similar to that observed in our study (0%) [15,18].

Although the Blumgart technique is used in international publications, these could be modifications to it, Hiroro et al. compared the Blumgart technique vs. modification of the Blumgart technique, pancreatic leakage were reported in 6.3% with the Blumgart technique and 10.3% with the modified Blumgart technique, but without statistically significant differences (P=0.367) [18].

According to Shrikhande et al, it seems that the standardized practice of an anastomosis technique could help reduce the incidence of complications after pancreaticoduodenectomy, [22] as observed in our study, a lower percentage of pancreatic leakage was found using the Blumgart technique.

Limitations of the study

As limitations to our study, we can mention that it is a historical cohort and the number of patients included, variables that could limit the results obtained.

Conclusion

In our study, a decreased risk of pancreatic leakage was found using the Blumgart technique, additionally, with the Blumgart technique, less intraoperative bleeding was observed and a lower amylase value measured in the drainage in the first 6 days after surgery, 90-day mortality was lower and adjuvant chemotherapy was started 6 weeks earlier compared to the Cattel technique.

Conflict of interests

None to declare.

References

1. Kennedy EP, Yeo CJ. Dunking pancreaticojejunostomy versus duct-to-mucosa anastomosis. J Hepatobiliary Pancreat Sci, 2011, 18(6):769-774.
2. Gouma DJ, van Geenen RC, van Gulik TM, de Haan RJ, de Wit LT, Busch OR, Obertop H. Rates of complications and death after pancreaticoduodenectomy: risk factors and the impact of hospital volume. Ann Surg, 2000, 232(6):786-795.
3. Narayanan S, Martin AN, Turrentine FE, Bauer TW, Adams RB, Zaydfudim VM. Mortality after pancreaticoduodenectomy: assessing early and late causes of patient death. J Surg Res, 2018, 231:304-308.
4. Marcus SG, Cohen H, Ranson JH. Optimal management of the pancreatic remnant after pancreaticoduodenectomy. Ann Surg, 1995, 221(6):635-645.
5. Bassi C, Falconi M, Molinari E, Mantovani W, Butturini G, Gumbs AA, Salvia R, Pederzoli P. Duct-to-mucosa versus end-to-side pancreaticojejunostomy reconstruction after pancreaticoduodenectomy: results of a prospective randomized trial. Surgery, 2003, 134(5):766-771.

6. Berger AC, Howard TJ, Kennedy EP, Sauter PK, Bower-Cherry M, Dutkevitch S, Hyslop T, Schmidt CM, Rosato EL, Lavu H, Nakeeb A, Pitt HA, Lillemoe KD, Yeo CJ. Does type of pancreaticojejunostomy after pancreaticoduodenectomy decrease rate of pancreatic fistula? A randomized, prospective, dual-institution trial. J Am Coll Surg, 2009, 208(5):738-747.
7. Kakita A, Yoshida M, Takahashi T. History of pancreaticojejunostomy in pancreaticoduodenectomy: development of a more reliable anastomosis technique. J Hepatobiliary Pancreat Surg, 2001, 8(3):230-237.
8. Shrikhande SV, Barreto G, Shukla PJ. Pancreatic fistula after pancreaticoduodenectomy: the impact of a standardized technique of pancreaticojejunostomy. Langenbecks Arch Surg, 2008,393(1):87-91.
9. Pedrazzoli S. Pancreatoduodenectomy (PD) and postoperative pancreatic fistula (POPF): A systematic review and analysis of the POPF-related mortality rate in 60,739 patients retrieved from the English literature published between 1990 and 2015. Medicine (Baltimore), 2017,96(19):e6858.
10. Olakowski M, Grudzi?ska E, Mrowiec S. Pancreaticojejunostomy-a review of modern techniques. Langenbecks Arch Surg, 2020, 405(1):13-22.
11. Warren Kw, Cattell Rb. Basic techniques in pancreatic surgery. Surg Clin North Am, 1956,36(3):707-724.
12. Grobmyer SR, Kooby D, Blumgart LH, Hochwald SN. Novel pancreaticojejunostomy with a low rate of anastomotic failure-related complications. J Am Coll Surg, 2010, 210(1):54-59.
13. Molinari E, Bassi C, Salvia R, Butturini G, Crippa S, Talamini G, Falconi M, Pederzoli P. Amylase value in drains after pancreatic resection as predictive factor of postoperative pancreatic fistula: results of a prospective study in 137 patients. Ann Surg, 2007, 246(2):281-287.
14. Hermán J, Pawlik T. Cancer Stanging. In: Amin M (Eds): American Cancer Society, Springer, 2017, USA, 327-360.
15. Kleespies A, Rentsch M, Seeliger H, Albertsmeier M, Jauch KW, Bruns CJ. Blumgart anastomosis for pancreaticojejunostomy minimizes severe complications after pancreatic head resection. Br J Surg, 2009, 96(7):741-750.
16. Senda Y, Shimizu Y, Natsume S, Ito S, Komori K, Abe T, Matsuo K, Sano T. Randomized clinical trial of duct-to-mucosa versus invagination pancreaticojejunostomy after pancreatoduodenectomy. Br J Surg, 2018, 105(1):48-57.
17. Fujii T, Sugimoto H, Yamada S, Kanda M, Suenaga M, Takami H, Hattori M, Inokawa Y, Nomoto S, Fujiwara M, Kodera Y. Modified Blumgart anastomosis for pancreaticojejunostomy: technical improvement in matched historical control study. J Gastrointest Surg, 2014,18(6):1108-1115.
18. Hirono S, Kawai M, Okada KI, Miyazawa M, Kitahata Y, Hayami S, Ueno M, Yamaue H. Modified Blumgart Mattress Suture Versus Conventional Interrupted Suture in Pancreaticojejunostomy During Pancreaticoduodenectomy: Randomized Controlled Trial. Ann Surg, 2019, 269(2):243-251.
19. Kawakatsu S, Inoue Y, Mise Y, Ishizawa T, Ito H, Takahashi Y, Saiura A. Comparison of pancreatojejunostomy techniques in patients with a soft pancreas: Kakita anastomosis and Blumgart anastomosis. BMC Surg, 2018, 18(1):88.
20. Kojima T, Niguma T, Watanabe N, Sakata T, Mimura T. Modified Blumgart anastomosis with the "complete packing method" reduces the incidence of pancreatic fistula and complications after resection of the head of the pancreas. Am J Surg, 2018, 216(5):941-948.
21. Kawaida H, Kono H, Hosomura N, Amemiya H, Itakura J, Fujii H, Ichikawa D. Surgical techniques and postoperative management to prevent postoperative pancreatic fistula after pancreatic surgery. World J Gastroenterol, 2019, 28;25(28):3722-3737.
22. Shrikhande SV, Sivasanker M, Vollmer CM, Friess H, Besselink MG, Fingerhut A, Yeo CJ, Fernandez-delCastillo C, Dervenis C, Halloran C, Gouma DJ, Radenkovic D, Asbun HJ, Neoptolemos JP, Izbicki JR, Lillemoe KD, Conlon KC, Fernandez-Cruz L, Montorsi M, Bockhorn M, Adham M, Charnley R, Carter R, Hackert T, Hartwig W, Miao Y, Sarr M, Bassi C, Büchler MW; International Study Group of Pancreatic Surgery (ISGPS). Pancreatic anastomosis after pancreatoduodenectomy: A position statement by the International Study Group of Pancreatic Surgery (ISGPS). Surgery, 2017, 161(5):1221-1234.

Corresponding Author: Sergio Isidro Gamboa-Hoil, Surgical oncology, Department of Oncology, Unidad Médica de Alta Especialidad Yucatán, Instituto Mexicano del Seguro Social
e-mail: sergio_gamboa@hotmail.com

10.12865/CHSJ.50.01.03