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Laparoscopic Pancreatic Surgery for Islet Cell Tumors of the Pancreas

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Abstract. The experience with laparoscopic pancreatic surgery (LPS) in general, and pancreatic islet cell tumors (ICTs) in particular, is still limited. Because insulinoma is the most prevalent tumor and is mostly benign, single, and curable with surgical excision, it comprises most of the cases. Our experience with 17 cases (10 insulinomas, 2 gastrinomas, 1 nesidioblastoma, 4 nonfunctioning tumors) and those recorded in the literature (93 cases) show that laparoscopic surgery for small, solitary benign islet cell tumors located in the body and tail is feasible and safe and can result in rapid postoperative recuperation and a complication rate comparable or lower than that achieved with open surgery. It duplicates the success rate seen with conventional surgery regarding intraoperative localization and cure of disease. The main morbidity continues to be the occurrence of a fistula (18%), most often after enucleation, but the clinical course is benign in most instances. Preoperative imaging studies are required for localization, and the combined use of biphasic helical computed tomography and endoscopic ultrasonography (US) seems to be cost-effective. The use of laparoscopic US is an integral part of the laparoscopic procedure, and the information achieved is valuable for both confirming localization and decision making concerning the most appropriate surgical procedure. In cases of distal pancreatectomy, splenic salvage, preferably with preservation of splenic vessels, is feasible albeit more demanding and can be achieved in most cases.

Laparoscopic surgery for digestive diseases achieved marked advances over the last decade. However, laparoscopic pancreatic surgery (LPS) is still uncommon because of the anatomic location of the pancreas, technical difficulties of pancreatic resection, the relative rarity of surgical pancreatic disorders, the requirements for highly experienced, skillful laparoscopic surgeons and the need for complicated techniques and technologic advances. Therefore the experience worldwide is still limited, a fact well reflected in the literature describing mainly small series and case reports. In fact, LPS is still at its evaluation stage and is considered experimental by many surgeons. Since Gagner and Pomp first described pancreaticoduodenectomy and distal pancreatectomy for chronic pancreatitis and islet cell tumors during the early 1990s [1, 2], various laparoscopic pancreatic procedures have been performed, including laparoscopic distal pancreatectomy (LDP), laparoscopic enucleation (LE), laparoscopic pancreaticoduodenectomy, laparoscopic cyst gastrostomy, and necrosectomy for infected necrosis [3–11].

Endocrine pancreatic tumors, or islet cell tumors (ICTs), are rare neoplasms with an annual incidence of 0.1 to 0.4 per 100,000; and in 70% to 80% of individuals they are slow-growing and of a benign nature [7, 12]. Insulinomas represent up to 70% to 80% of clinically symptomatic ICTs (one to six cases per million population annually) and occur in all age groups, with a peak incidence during the third to fifth decades. They are usually < 2 cm at presentation; approximately 90% are solitary and benign; and a female predominance of 60% to 75% is evident. Because of the characteristic clinical presentation of hypoglycemia, they are usually diagnosed when they are still small and resectable. Multicentric tumors are usually associated with multiple endocrine neoplasia type 1 (MEN-1). These tumors are located predominantly (65–80%) in the body and the tail of the pancreas [7, 12]. These favorable features make insulinomas the main ICT amenable to the laparoscopic approach. The most effective treatment is surgical excision, with surgical cure of benign insulinomas being achieved in more than 90% of patients [13–16].

In contrast, gastrinomas are much less prevalent, and in more than half are extrapancreatic. Tumors in the pancreas tend to be > 2 cm, and up to 60% to 70% exhibit metastasis at the time of diagnosis. These characteristics make gastrinomas unsuitable for laparoscopic approach. Similarly, glucagonomas and vasoactive intestinal peptide-producing tumors (VIPomas) are rare, and 80% and 60%, respectively, are malignant at presentation. Somatostatinomas are found mainly in the pancreatic head or periampullary region as large malignant neoplasms (70%), with signs of a mass lesion rather than hormone production [12]. Resectable nonmetastatic, nonfunctioning ICTs are considered candidates for surgery [17], with small tumors located in the body or tail of the pancreas being suitable for the laparoscopic approach [2]. Herein, we present our experience and that published in the literature with laparoscopic surgery for ICT with emphasis on the indications, complications, and limitations.

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Patients and Methods

Patients

The personal experience in laparoscopy for ICTs of the pancreas of the senior author (M.G.) during the period between January 1992 and December 2000 is presented [2, 8]. These patients were operated on at the Hotel-Dieu de Montreal (Montreal) and the Mount Sinai Medical Center (New York).

A thorough review of the world literature dealing with laparoscopy of ICTs of the pancreas using the Medline database covering the period January 1966 to October 2003 was undertaken. Manual cross-referencing was also performed to find further relevant articles. Series duplicating previously published data from the same author or institution were excluded from the final analysis.

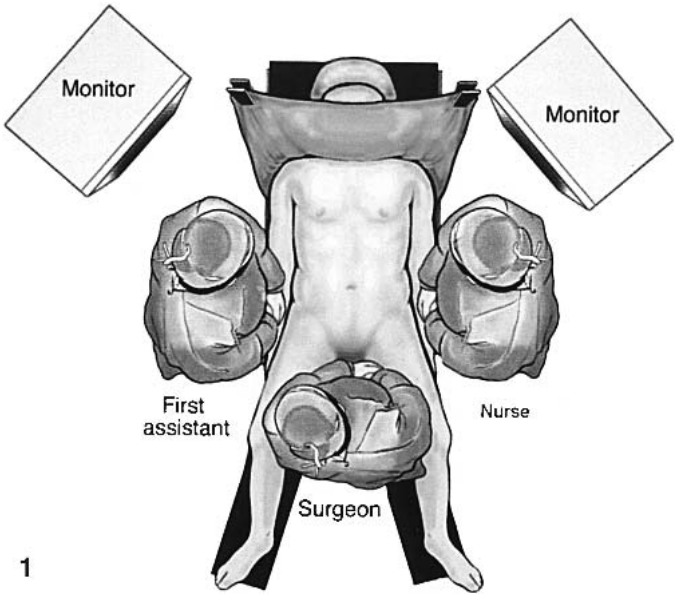
Surgical Technique

Patients are placed supine on a rotating table in a modified lithotomy position where an anti-Trendelenburg position and a tilt to the right can be achieved. A roll is placed under the left flank. The surgeon stands between the legs of the patient, with the first assistant and the nurse on the left and right side of the table, respectively (Fig. 1). Laparoscopic distal pancreatectomy requires a total of four trocars, although an additional fifth 5 mm trocar is inserted in the epigastrium if additional retraction or exposure is needed (Fig. 2). The body and tail of the pancreas are exposed anteriorly through a window in the gastrocolic ligament, which is created with 5 mm ultrasonic shears. An 8- to 10-cm window is needed to allow inspection and evaluation with laparoscopic ultrasonography (LUS) of the entire body and tail of the gland to the hilum of the spleen (Fig. 3). If salvage of the spleen is considered, care should be taken not to divide the short gastric vessels at this stage. The greater curvature of the stomach is retracted with a Babcock or soft bowel clamp inserted through the epigastric port. A laparoscopic 10 mm ultrasonography (US) probe with 7.5 MHz frequency is then inserted and applied anteriorly to the body and tail. The US scan is split with the video to provide a "picture in picture" view (Fig. 4). Placing the probe in contact with the gland at the duodenal sweep allows imaging of the head.

Once the lesion has been localized and its resectability confirmed, a decision is made to perform either enucleation or distal pancreatectomy with or without spleen salvage based on the pathology and location of the lesion in the gland and its relation to the pancreatic duct and the portal and splenic vessels.

If enucleation is planned, dissection under LUS guidance is carried out with ultrasonic shears along the capsule of the adenoma between the tumor and the parenchyma. The vessels are coagulated or ligated with clips. The tumor bed is then carefully inspected for pancreatic leaks or bleeding. Fibrin glue is applied to the tumor bed, and the tumor is extracted in a small sterile bag through a 12 mm port. A closed suction drain is placed in the lesser sac at the enucleation site.

With distal pancreatectomy, the posterior peritoneum is incised along the inferior and superior border of the body and tail, and a plane is created posterior to the pancreas with blunt and sharp dissection through the relatively avascular space on the superior aspect of the splenic vessels. If splenectomy is planned, the short gastric vessels are divided to enlarge the gastrocolic window, and the splenic flexure is mobilized to expose the inferior aspect of the spleen. Next the lateral aspect of the spleen is mobilized up to the left crus of the diaphragm. A linear stapler (45 × 3.5 mm) is used to transect the pancreatic parenchyma through the already created retropancreatic window (Fig. 5). The transection can be done to include the splenic vessels; alternatively, these vessels can be divided separately (Fig. 6). In our experience, the pancreatic duct is closed adequately with a linear stapler, but small arterial arcades



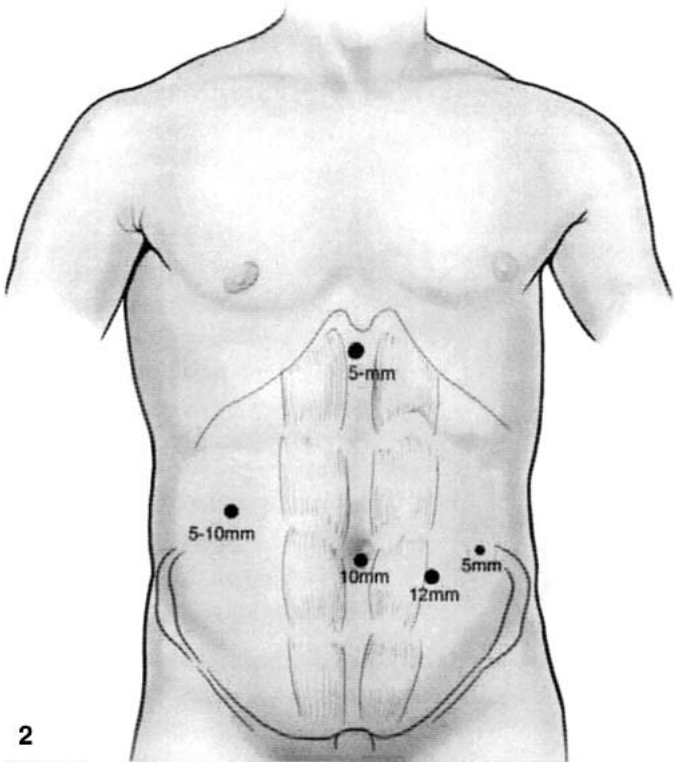


Fig. 1. Room layout.

Fig. 2. Port placement.

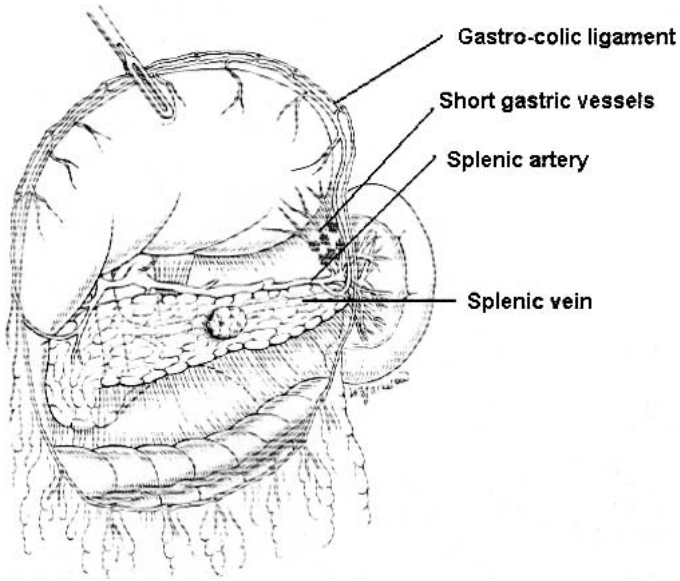


Fig. 3. Exposure of the pancreas after dividing the gastrocolic ligament and some short gastric vessels.

Fig. 4. Laparoscopic ultrasonography scan.

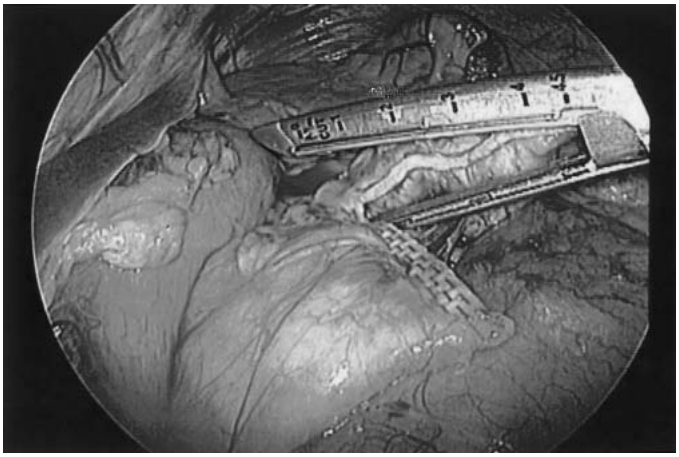


Fig. 5. Transection of the pancreas.-

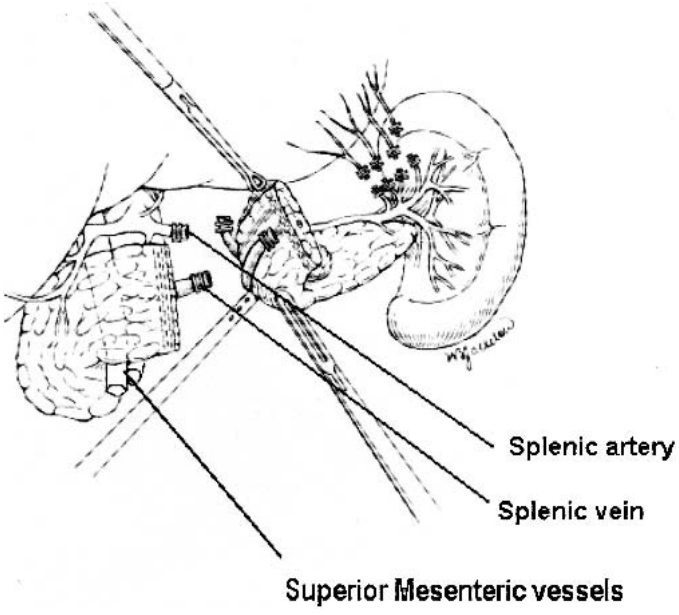


Fig. 6. Division of the splenic artery, vein, and pancreas. The tail is dissected from the retroperitoneum from the medial to lateral direction.

may need to be clipped or sutured. The proximal stump of the pancreas is inspected for hemostasis and to ensure secure closure of the pancreatic duct. Oversewing of the stump with fine nonabsorbable sutures or fibrin glue can be applied at the discretion of the surgeon.

The pancreas is then mobilized from body to tail in a retrograde fashion, and the specimen is placed in a rigid plastic bag for extraction. The opening of the bag is delivered through a minimally enlarged umbilical incision, and the pancreatic specimen is removed intact. The spleen is then morcellated within the bag and removed as a separate specimen. If splenic salvage is entertained, after transection of the pancreatic parenchyma (excluding the vessels) the distal pancreas and tail are held with an atraumatic grasper so the transverse branches of the splenic artery and vein are individually dissected and divided with clips (Fig. 7) or ultrasonic shears. Alternatively, the splenic vessels can be transected using the short gastric vessels as the sole supply of blood for the spleen. In this case, the vessels should be ligated proximally, thereby avoiding meticulous dissection of the short transverse branches. A closed suction drain is placed in the lesser sac in the pancreatic bed.

Results

Our results (Table 1) showed that laparoscopic enucleation or resection for benign islet cell tumors of the pancreas was feasible and safe. Although the initial experience [2] was associated with a relatively high conversion rate (40%), this was mainly due to invasive and metastatic malignant gastrinomas and a large nesidioblastoma located deep in the head of the pancreas. Two insulinomas were not localized by LUS but were detected by open US in the retroportal neck and the body. Our later experience [8] demonstrated no conversions or missed tumors using LUS. The laparoscopic intervention resulted in an easy, short recovery (4 days for enucleations and 5 for LDP).

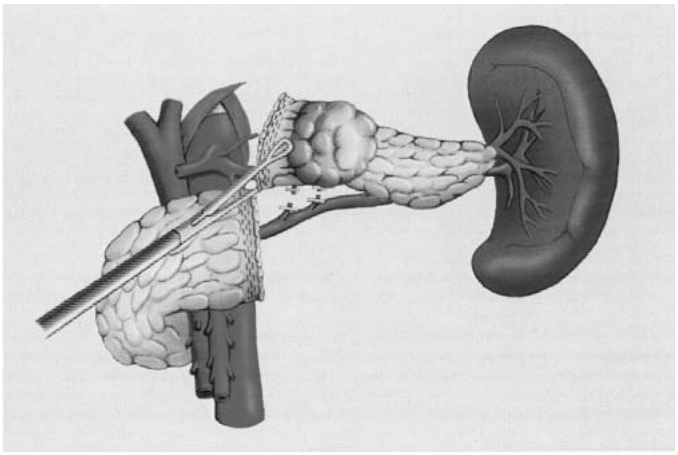


Fig. 7. Pancreatic resection with preservation of splenic vessels.

The complication rate (23%) is comparable to that of open surgery as well as for fistula formation (15.3%), which were managed conservatively with drainage alone. Splenic salvage with preservation of the splenic vessels was achieved in all six cases of LDP. There was no mortality and no recurrence of the benign insulinomas and nonfunctioning tumors.

Review of the literature [2–4, 6, 8, 10, 18–36] revealed a total of 93 reported cases (Table 2). After excluding duplications, the largest experiences from the same institution constitutes of no more than 10 patients, a fact reflecting the rarity of these procedures. Insulinoma was the most prevalent diagnosis, comprising 87% of all cases. Other ICTs were rare, with three gastrinomas (two of them metastatic and therefore converted), one malignant VIPoma (also converted), and seven unspecified "other" and nonfunctioning ICTs. The laparoscopic procedures performed were equally divided between LDP and enucleation (39 cases each), with 15 converted cases (16.1%). The reasons for conversion were proximity to the pancreatic duct or the portal vein (or both) (six cases), inability to detect the tumor with LUS (five cases), large invasive malignant tumors (three cases), and tumor located deep in the head of the pancreas (one case). The mean operating time for LDP was 3.7 hours (range 1.7–5.5 hours) and for enucleation 2.8 hours (range 2.0–3.5 hours). The mean blood loss for LDP was 425 ml (range 20–733 ml) and that for enucleation 199 ml (range 20–575 ml). The length of the hospital stay after LDP was 6.4 days (range 4.1–14.0 days) and after enucleation 5.5 days (range 3–7 days).

The overall complication rate for the completed laparoscopic procedures was 28.2% (range 0–57%). There was no mortality. Pancreatic fistula occurred in 14 cases (17.9%) and constituted 64% of the morbidity. Interestingly, the incidence of fistulas was much higher after enucleation (12/39, 30.7%) than after LDP (2/39, 5.1%). Most of these fistulas were successfully managed conservatively with drainage (11/14), one with a combination of drainage and endoscopic retrograde cholangiopancreatography (ERCP) with pancreatic duct stenting [19]; two required open operations for salvage [21, 22]. Other complications included bleeding from the splenic vein, pleural effusion, intraabdominal fluid collections, wound infection, and urinary retention. No mortality was reported, and there was no recurrence of disease during the short-term follow-up (range 3–48 months).

Splenic salvage (Table 3) was achieved in 23 of 27 cases of LDP (85%). Data were lacking or unclear in several reports. Twenty procedures were performed with splenic vessel preservation and three without (spleen left on short gastric vessels). However, one splenic infarction (managed conservatively) was reported in a case where the spleen was preserved with division of its main vessels [31].

Laparoscopic ultrasonography (LUS) was utilized in 47 cases, with correct localization in 42 (89.3%) (Table 4). The missed tumors were detected during open or hand-assisted laparoscopic surgery [3] by US and palpation. Missed tumors were located mainly in the retroportal neck, deep in the head and body, and at the inferior border of the gland. Multiple tumors were not reported.

Discussion

Few surgeons have experience with open pancreatic surgery, fewer master advanced laparoscopic techniques, and even fewer have experience in both. The result, considering the rarity of pancreatic ICTs, is well reflected in the literature, where the experience is still limited with short-term follow-up, being based on small series of patients or single case reports. Because insulinoma is the most prevalent, mostly benign, and single and is curable with surgical excision, it comprises most of that experience. Nevertheless, this important, yet immature, experience with this entity demonstrates the feasibility and safety of laparoscopic surgery and its advantages in terms of reduced patient discomfort and fast recovery.

The presence of a solitary adenoma and its precise localization on preoperative imaging are required before considering laparoscopic surgery for an insulinoma because successful management relies on accurate localization and appropriate surgical technique. There is no consensus as to the extent of the preoperative localization studies that should be used or if the laparoscopic approach should replace common practice.

The average accuracy of many imaging modalities, including US (transabdominal), conventional CT scanning, MRI, angiography, somatostatin receptor scintigraphy, and portal venous sampling, remains relatively low (up to 70%) [37]. Two preoperative modalities have proved to have higher accuracy rates: endoscopic ultrasonography (EUS) and arterially stimulated venous sampling (ASVS). EUS appears to be emerging as one of the best preoperative studies to identify insulinomas > 5 mm [38–41]. However, it requires considerable specialized expertise, is operator-dependent, and may miss tumors located in the tail [42]. It has a sensitivity of 80% to 88% and a specificity of 95%. When EUS was combined with biphasic helical CT scanning (with thin slices of the pancreas), the diagnostic accuracy increased to 97% [37]. Furthermore, helical CT scanning allows recognition of ectopic insulinomas, peripancreatic lymph nodes, invasiveness, and liver metastasis in cases of malignancy. Accurate regionalization, but not localization, has been achieved by means of ASVS in 90% of cases [43]. Obviously, this invasive modality has all the disadvantages of angiography, is operator-dependent, and is not available in many centers.

At open surgery, because of the high failure rate of preoperative studies during the 1980s and early 1990s, it has been emphasized that careful palpation of the pancreas combined with intraoperative ultrasonography (IOUS) was the most sensitive method for detecting insulinomas [44, 45]. However, it requires full exploration of the pancreas and is not practical during laparoscopic surgery, which lacks tactile sense. During surgery, the most effective method for localizing an insulinoma is IOUS [40]. This modality detects 90% to 95% of insulinomas and is especially useful for tumors in the head [46, 47]. This imaging procedure is particularly accurate for delin-

Table 1. Personal experience with laparoscopy for islet cell tumors of the pancreas.

No. of pts.	Diagnosis	Type of procedure	Conversions	Complications	Spleen salvage (in LDP)
17					
10	Insulinoma	5 Enucleations	4/17	3/17 (18%)	6/8 (with splenic vessels preservation)
2	Gastrinoma	8 LDP	23.5%; 2 Malignant gastrinomas	1 Bleeding 2 Fistulas (1 E, 1 LDP)	
1	Nesidioblastoma		1 large nesidioblastoma (in the head)		
4	Nonfunctioning	4 Explorations	1 undetected insulinoma		

Data are from Gagner et al. [2] and Patterson et al. [8].
E: enucleation; LDP: laparoscopic distal pancreatectomy.

eating the anatomic relationship of the tumor with the pancreatic duct, common bile duct, and portal and splenic veins. Laparoscopy and LUS provide information similar to that obtained by means of open IOUS and duplicates its success with accuracy approximating 90% (Table 4). Furthermore, the valuable information provided by LUS aided in the surgical decision making as to the appropriate surgical procedure (laparoscopic versus open and enucleation versus distal pancreatectomy), and it was used during enucleation to assess the resection margins, especially in relation to the pancreatic duct (see references in Table 4). Laparoscopic enucleation is reserved for benign solitary small tumors (< 2 cm) located on the surface of the pancreas and not in contact with splenic vessels or the portal vein or main pancreatic duct. If these conditions are not met, distal pancreatectomy is the best choice. Some believe that in selected cases of insulinoma in the pancreatic tail, LDP is preferable to enucleation, as in this location it could be technically difficult [37]. Similarly, enucleation from the head is more technically challenging—if possible at all. Hellman et al., in a large series of 65 patients with insulinomas managed by open surgery, showed that resection, especially in the head of the pancreas, was associated with lower complication rates than enucleation [14].

In light of the encouraging results of laparoscopic surgery and LUS, a cost-effective strategy for the use of preoperative localization studies remains to be determined. It appears that if a lesion is localized by more than one noninvasive study, such as biphasic CT scan and MRI, it is reasonable to explore the patient laparoscopically [23]. If noninvasive studies are equivocal, EUS and ASVS should be considered and selectively performed depending on the local expertise [23, 47].

Although no cases of hormonal failure were reported with the laparoscopic approach, despite all the efforts, an occult insulinoma may still be encountered and not detected by LUS. Moreover, a second adenoma exists in about 10% of cases. Therefore it has been suggested that the efficacy of laparoscopic management of insulinomas may improve with intraoperative monitoring of serum glucose and insulin levels by serial blood measurements [37]. An increase in glucose levels is observed in about 75% of cases, and insulin levels are expected to return to normal within 20 minutes of resection [37]. Open surgery with IOUS or perhaps hand-assisted laparoscopic surgery [3], which allows manual palpation and better exploration of the head and neck, will continue to play a role in cases of detection failure by LUS.

The results of laparoscopic management for ICT (primarily for insulinomas), as reflected in the available literature (Table 2), compare favorably with open surgery, despite the fact that this represents the initial limited experience. Table 5 summarizes the experience gained with open surgery in cases of insulinoma in four large series, including 154 cases reported during the last decade [13–16]. More enucleations were performed during open surgery than with laparoscopy (60% vs. 50%). The mean complication rate in the laparoscopic series of 24% compares favorably with the 32% rate seen with open surgery.

Interestingly, a lower overall fistula rate was noted in the laparoscopic experience: 17.9% compared to 21.0% for open surgery. The incidence of fistula after enucleation was higher than after distal pancreatectomy for both approaches: 30.7% with laparoscopy and 28.8% with open surgery versus 5.1% and 12.5%, respectively. Perhaps the inability to recognize and secure smaller ducts or injuries to the pancreatic duct accounts for this higher occurrence after enucleation. Chapuis and Dousset advocated the use of intraoperative secretin to facilitate recognition of pancreatic leaks at the tumor bed of the enucleated insulinoma [37]. Nevertheless, pancreatic fistulas appear to be less frequent after laparoscopy than previously thought, even though it continues to represent the main major morbidity after pancreatic surgery, whether laparoscopic or open. However, the course of these fistulas after laparoscopy was generally benign, and they were managed conservatively with drainage in most cases, although open salvage reoperations were reported on two occasions [15, 22]. Therefore, the contention that laparoscopic surgery is associated with a higher risk for fistulas is not substantially supported. To date, there is no "magic bullet" for preventing pancreatic fistulas after pancreatectomy. Several maneuvers have been described, but none has proven to be "the best." Notwithstanding all these methods, pancreatic fistula still occurs.

The way in which the surgeon approaches the pancreatic transection seems to be important. A useful ergonomic consideration is that the stapler used to transect the pancreas must be introduced through a trocar far away from the pancreas [8] (left paramedian location). This may avoid disruption of the gland, which could happen if the stapler approximating the pancreas is in a perpendicular position. Oversewing the stapled end of the stump with a nonabsorbable suture is one of those "preventive" measures intended to secure the staple line [3, 18, 48]. Using this method, Park and Heniford, in their series of 25 LDPs, encountered just one fistula [3]. Some believe that, if the pancreatic parenchyma is thick and fibrotic, dividing the isthmus with ultrasonic shears and separately suturing the pancreatic duct would be helpful [5]. Others do that routinely if they visualize the duct after transection [8]. Perioperative somatostatin analogs have been described as another method for preventing fistula formation or accelerating its closure [8]. However, administration of this drug has not been statistically proved to be helpful [49, 50]. Similarly, despite the lack of confir-

Table 2. Worldwide experience with laparoscopic surgery in islet cell tumors of the pancreas.

Study	Year	No. of pts.	Diagnosis	Procedure	Conversions	Operating time (hours)	Blood loss (ml)	LOS (days)	Complications
Gagner [2]	1996	10							
		6	Insulinoma	1 E	4/10	3 E	NA	4 E	1 Bleeding
		2	Gastrinoma	5 LDP		4.5 LDP		5 LDP	
		1	Nesidioblastoma						
		1	Nonfunctioning						
Fernandez-Cruz [6]	2002	10							
		6	Insulinoma	4 E	2/10	3.4 E	200 E	5 E	2 Fistulas (E)
		1	MEN-1 insulinoma	4 LDP		5 LDP		5 LDP	
		2	Nonfunctioning				500 LDP		
		1	VIPoma						
Berends [19]	2000	10							
		10	Insulinoma	5 E; 1 LDP	4/10	3	100	7	2 Fistulas (E)
Park [3]	2002	9							
		7	Insulinoma	2 E	1/9	3.7 LDP	273 LDP	4.1	2 Bleeding
		2	Other	7 LDP					1 Wound infection
									1 Fistula
Gramatica [18]	2002	9	Insulinomas	4 E; 5 LDP	0	2 E; 4 LDP	NA	5-E 5-LDP	1 Fistula (E)
									1 Pleural effusion
									1 Abscess
Patterson [8]	2001	7			0				
		4	Insulinoma	4 E		4.4 (median, E+LDP)	200 (median, E+LDP)	6 (E+ LDP)	2 Fistulas (1-E, 1-LDP)
		3	Nonfunctioning	3 LDP					
Iihara [23]	2001	7	Insulinoma	4 E; 2 LDP	1/7	2.5 E; 3.5 LDP	20	NA	4 Fistula (3 E, 1 LDP)
Chapuis [22]	1998	5	Insulinoma	3 E; 1 LDP	1/5	2.6 E; 1.6 LDP	200 E; 600 LDP	5 E; 5 LDP	1 Fistula (E)
Cuschieri [24]	1998	4	Insulinoma	3 E; 1 LDP	1/4	NA	400	7.1	NA
Mahon [20]	2002	3	Insulinoma	3 LDP	0	1.7	733	4.7	1 Urinary retention
Lo [21]	2000	3	Insulinoma	1 E; 1 LDP	1/3	NA	NA	6-LDP	1 Fistula (E)
Tagaya [25]	2003	2	Insulinoma	1 E; 1 LDP	0	3.5 E; 5.5 LDP	100 E; 450 LDP	7 E; 14 LDP	
Spitz [26]	2000	2	Insulinoma	1 E	1/2	NA	NA	3	0
VanNieuwenhove [27]	1999	2							
		1	Insulinoma	2 E	0	2.5 E	575	7	0
		1	Gastrinoma						
Case reports [28–36]		10	Insulinoma	5 E; 5 LDP	0	4.5	85	4.75	1 Splenic infarction
Total/mean		93							
		81	Insulinoma	39 E	15/93	2.8 E	200 E	5.5 E	22/78 (28.2%)
		3	Gastrinoma	39 LDP	(16%)	3.7 LDP	425 LDP	6.4 LDP	14 fistula (17.9%, 12 E, 2 LDP)
		1	VIPoma						
		7	Other/ nonfunctioning						

NA: not assessed; LOS: length of stay; MEN-1: multiple endocrine neoplasia type 1; VIPoma: vasoactive intestinal peptide-producing tumor.

matory evidence, fibrin glue has been used after resections and enucleations [18, 37, 51].

As with open surgery, splenic preservation in these benign entities is encouraged whenever it is technically feasible. In cases of hilar fibrosis and scarring due to past inflammation or abscess formation, splenic preservation should be avoided [48], and laparoscopic en bloc pancreaticosplenectomy is the safest technique. In the largest series to date (reporting 25 LDPs by Park and Heniford [3]), it was noted that insulinomas in close proximity to the splenic vein frequently have an intense desmoplastic reaction, making separation from the vessels difficult and possibly causing significant bleeding, thereby precluding preservation of the spleen. In most LDP series, splenic salvage was successfully achieved in 50% to

Table 3. Spleen salvage with laparoscopic distal pancreatectomy for islet cell tumors.

Study	Rate of spleen salvage	Method of spleen salvage
Gagner [2]	3/3	Classic[a]
Fernandez-Cruz [6]	4/4	Classic
Gramatica [18]	4/5	2 Classic; 2 division of vessels
Iihara [23]	1/2	Classic
Mahon [20]	2/3	Classic
Chapuis [22]	1/1	Classic
Berends [19]	1/1	Classic
Park [3]	5/7	Classic
Tagaya [25]	1/1	Division of vessels
Total	23/27	20 Classic; 3 division of vessels

[a]Classic: splenic vessel preservation.

Table 4. Experience with laparoscopic ultrasonography in pancreatic resections for islet cell tumors.

Study	Use of LUS (no. of cases)	Localization success	Location of missed tumors	Method for detecting missed tumors
Gagner [2]	8	6/8	1 Retroportal neck 1 body	Open surgery with IOUS
Fernandez-Cruz [6]	10	9/10	1 inferior border of the pancreas	Open surgery
Park [3]	7	5/7	Unspecified	1 open surgery 1 hand-assisted laparoscopy
Mahon [20]	3	3/3		
Lo [21]	3	3/3		
Iihara [23]	7	7/7		
Tagaya [25]	2	2/2		
Gramatica [18]	7	7/7		
Total	47	42/47(89.3%)		

Table 5. LUS: laparoscopic ultrasonography; IOUS: intraoperative ultrasonography.Experience with open surgery for insulinoma.

Study	No. of patients	Type of procedure	Complications	Fistula	Mortality
Geoghegan [13]	34				
	18	E	10/34 (29.4%)	3/13 DP (23%)	0
	13	DP	2/18 E		
	2	Negative exploration	8/13 DP		
Huai [16]	28				
	18	E	4/28 (14.3%)	4/18 E (14.3%)	0
	10	DP			
Hellman [14]	65				
	37	E	26/65 (40.0%)	20 (30.7%): 17 E (46.0%)	1
	21	DP	Unspecified for E/DP	3 DP (14.2%)	
	4	E+DP		3 Reoperations	
	2	PD			
Lo [15]	27				
	20	E	9/27 (33%)	5/26 (19.2%)	1
	6	DP	Unspecified for E/DP	3 Reoperations	
	1	PD			
Total/mean	154				
	93	E	32.3%	21%	2/154
	54	DP		28.8% E	(1.3%)
	3	PD		12.5% DP	

DP: distal pancreatectomy; PD: pancreaticoduodenectomy.

100% of patients [3–5]. With LDP for ICTs, the rate of splenic salvage approached 85%, and most of the operations were performed with splenic vessel preservation.

Two techniques known from open surgery were integrated into laparoscopic pancreatic surgery: LDP with splenic vessel preservation and LDP with splenic vessel ligation. The former requires a longer operating time and laparoscopic surgical expertise [4, 5, 25]. The magnified view using laparoscopy facilitates separating the splenic vessels from the pancreas as well as dissecting, ligating, and dividing the branching arteries and veins feeding the pancreas [3, 4]. The spleen-preserving distal pancreatectomy with splenic vessel ligation requires ligation and transection of the splenic vessels at the level of the pancreatic section and at the splenic hilum. The spleen subsequently receives a vascular supply from the short gastric vessels. This technique, less demanding technically, is applied in cases of malignancy (adequate lymph node sampling) and during uncontrollable bleeding from the splenic vessels along the upper edge of the pancreas. The experience gained to date with this technique showed that it is associated with a low risk of splenic infarction, and that it has several advantages regarding duration of surgery and blood loss. In fact, only two splenic infarctions not necessitating splenectomy [31, 52] and one abscess culminating in splenectomy [4] have been reported in the literature.

Conclusions

Our experience and that accumulated in the literature show that laparoscopic surgery for small, solitary benign islet cell tumors, mainly insulinomas, located in the body and tail, is feasible and safe. Moreover, it can result in rapid postoperative recuperation with no mortality and a complication rate comparable or lower than that seen with open surgery. It duplicates the success rate achieved with conventional surgery regarding intraoperative localization and cure of disease. The main morbidity continues to be the occurrence of a fistula, more often after enucleation, but the clinical course is benign in most instances.

Preoperative imaging studies are still required for localization. The combined use of biphasic helical CT scans and EUS seems to be cost-effective. The use of LUS is an integral part of the laparoscopic procedure, and the information achieved is valuable for both confirming localization and decision making concerning the most appropriate surgical procedure. Splenic salvage with or without preservation of the splenic vessels is feasible and can be achieved in most cases. Obviously, laparoscopic pancreatic surgery should be performed only by surgeons experienced in both pancreatic and advanced laparoscopic surgery. Further experience is needed for maturation of laparoscopic techniques in pancreatic surgery.

Résumé. De façon générale, et particulièrement pour les tumeurs Langheransiennes (cellules béta) du pancréas, l'expérience de la chirurgie pancréatique par laparoscopie (CPL) est encore très limitée. L'insulinome est la tumeur la plus fréquemment rencontrée: souvent bénigne et isolée, cette tumeur est curable au plan thérapeutique par simple excision chirurgicale. Notre expérience laparoscopique comprends actuellement 17 cas: 10 insulinomes, 2 gastrinomes, 1 nésidioblastome et 4 tumeurs non-fonctionnelles. En associant cette expérience personnelle à celle de la littérature (93 cas), on voit que pour de petites tumeurs insulaires, isolées, bénignes, localisées dans le corps et la queue du pancréas, la chirurgie laparoscopique est faisable, sûre et peut donner lieu à une récupération postopératoire rapide avec un taux de complication comparable ou plus bas que celui observé pour la chirurgie traditionnelle. En ce qui concerne la localisation per-opératoire et la cure de la maladie, les taux de succès sont similaires à ceux obtenus par la chirurgie traditionnelle. La morbidité principale continue d'être la fistule (18%) qui se voit plus souvent après énucléation, mais l'évolution clinique est dans la plupart des cas bénigne. L'imagerie préopératoire est nécessaire pour localiser ces tumeurs, et l'utilisation de la tomodensitométrie hélicoïdale biphasique associée à l'écho endoscopie est pour le moment la démarche la plus intéressante en ce qui concerne le coût-efficacité. L'utilisation de l'écho endoscopie peropératoire fait également partie du procédé laparoscopique: l'information obtenue est valable pour confirmer la localisation et pour prendre les décisions en ce qui concerne le procédé chirurgical le plus approprié. En cas de pancréatectomie distale, la conservation splénique avec conservation vasculaire, bien que plus difficile, peut être accomplie dans la plupart des cas.

Resumen. Las intervenciones quirúrgicas del páncreas por vía laparoscópica, especialmente por lo que al tratamiento de los tumores procedentes de los islotes de Langerhans (ICI) se refiere, son todavía poco frecuentes. Dado que el insulinoma constituye la neoplasia más frecuente y que la mayoría de las veces es un tumor benigno, único y curable tras extirpación quirúrgica, han sido estas neoplasias las que más frecuentemente se han tratado mediante cirugía laparoscópica. Nuestra casuística ($n = 17$; 10 insulinomas, 2 gastrinomas, 1 nesidioblastoma y 4 incidentalomas) junto con la publicada en la literatura al respecto (93 casos) demuestra que la cirugía laparoscópica, para tumores benignos únicos, localizados en el cuerpo o cola del páncreas es factible y segura, proporcionando una rápida recuperación postoperatoria y cursando con la misma tasa de complicaciones que las de la cirugía convencional. Además, la cirugía laparoscópica duplica, con respecto a la convencional, el número de casos localizados durante la operación así como el número de curaciones. La causa más frecuente de morbilidad viene dada por la fístula pancreática (18%) que se observa sobre todo tras enucleación tumoral, pero que tiene, en la mayoría de los casos, una evolución benigna. Son imprescindibles los estudios preoperatorios de imagen para el diagnóstico topográfico previo. En relación, al coste-eficacia los mejores resultados los proporciona la tomografía axial computerizada bifásica y helicoidal así como la ecografía endoscópica. La utilización de la ecografía laparoscópica constituye parte integral del procedimiento laparoscópico y es fundamental tanto para la localización del tumor como para elegir la estrategia quirúrgica adecuada. En casos de pancreatectomía distal conviene conservar el bazo para lo que es necesario no lesionar los vasos esplénicos, lo que es posible en la mayoría de los casos.

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