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EXPERIMENTAL LAB RESEARCH

WILEY

Laparoscopic partial pancreatectomy of the left limb using a harmonic scalpel in nine cats

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Abstract

Objective: To describe a laparoscopic technique and outcome for partial pancreatectomy in cats.

Study design: Prospective cohort study.

Animals: Nine cats.

Methods: Laparoscopic pancreatectomy was performed using a single incision laparoscopic surgery port and an additional 5.5 mm port. The left pancreatic limb was dissected, sealed and divided at the level of the splenic vein insertion to the portal vein using a harmonic device. Surgical time and complications were recorded. The weight and length of the resected pancreatic limb was recorded. Pre- and postoperative trypsin-like immunoreactivity (TLI), pancreatic lipase immunoreactivity (PLI), and hemoglobin A1C were documented.

Results: Laparoscopic partial pancreatectomy was performed successfully in all cats. One grade 1 intraoperative complication occurred (1/9; 11%) resulting in minor hemorrhage from a caudal splenic vein branch. A grade 2 postoperative complication occurred within 3 days after surgery in one cat (1/9; 11%), involving localized, sterile peritonitis in the region of the pancreatic angle. Signs resolved with conservative management. No cats exhibited signs of pancreatitis postoperatively. Long-term, mean TLI decreased by 37% ± 38% ($p = .03$) following partial pancreatectomy, while PLI and A1C were unchanged. All cats were alive and clinically well at last follow-up 250 to 446 days following surgery.

Conclusions: Laparoscopic partial pancreatectomy using a harmonic device is effective in cats, and offers a minimally-invasive alternative to open surgical pancreatectomy techniques. Laparoscopic pancreatectomy of the left limb results in adequate exocrine and endocrine function in the long-term.

1 | INTRODUCTION

The use of laparoscopy in the treatment of feline pancreatic disease is limited to a case report describing omentalization of a pancreatic cyst, and very recently resection of an exocrine carcinoma.[1,2] Similarly, in dogs, one report exists describing the use of laparoscopy

Abbreviations: IQR, interquartile range; LPP, laparoscopic partial pancreatectomy; PLI, pancreatic lipase immunoreactivity; SILS, single incision laparoscopic surgery; TLI, trypsin-like immunoreactivity.

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to resect a pancreatic beta cell tumor.[3] While the application of laparoscopic surgery in veterinary medicine has become common place for a wide array of diseases, reports on its use for pancreatic resection are virtually nonexistent. This may be due to the rare nature of pancreatic neoplasia[4] or possibly because only limited technical descriptions exist in the veterinary literature.[1–5] A recent report describing the clinical outcome following open pancreatic resection for insulinoma in 20 cats suggests that there is a population of cats that would benefit from having a minimally invasive surgical option for partial pancreatectomy.[6] In this report, most cats underwent partial pancreatectomy using a suture guillotine technique, but one cat was reported to have undergone partial pancreatectomy using a harmonic scalpel. Currently, no technical descriptions of laparoscopic partial pancreatectomy (LPP), using an ultrasonic energy device exist in the veterinary literature. Thus, the efficacy and safety of LPP using a harmonic scalpel are also unknown.

The objectives of this report were to describe a laparoscopic technique for partial pancreatectomy using an ultrasonic energy device, and to describe the clinical outcome in a group of cats. Our hypothesis was that laparoscopic resection of the left pancreatic limb using an ultrasonic energy device would be safe and effective; and that pancreatic function would be adequate following removal of the left limb.

2 | MATERIALS AND METHODS

2.1 | Case selection

Nine healthy purpose-bred domestic shorthair cats (5 male, 4 female) were included. Cats were group-housed in facilities accredited by the Association for Assessment and Accreditation of Laboratory Animal Care (AAALAC) International. All cats were socialized and acclimatized to catheter bandages and routine handling and restraint for at least 3 months prior to the start of the study. Extensive environmental enrichment was provided, including 1–3 h of daily human interaction and 24-h access to various toys and climbing apparatus. Cats were fed commercial dry cat food (Envigo 2060 Teklad Global Cat Diet) ad libitum in sufficient amount to maintain bodyweight. Cats were deemed healthy based on routine weekly physical examinations, annual systemic bloodwork (complete blood count and serum biochemistry panels), and the absence of clinical signs of disease. The cats were involved in a companion study to isolate pancreatic islet cells. The study was approved by the Institutional Animal Care and Use Committee (IACUC#202011101).

2.2 | Procedure

Hemoglobin A1c (A1Care, Baycom Diagnostics, Tallahasee, Florida), serum feline trypsin-like immunoreactivity (fTLI, Texas A&M University GI lab, College Station, Texas) and serum feline pancreatic lipase immunoreactivity (fPLI, Texas A&M University GI Lab, College Station, Texas) were measured before and approximately 3 months after LPP. In the interim, no treatments or medications that might affect fTLI, fPLI or A1C were administered. Whole blood was obtained and placed on ice immediately. The samples were then centrifuged at −4°C and the plasma stored in a −80°C freezer if analysis did not occur right away.

Anesthesia protocols were determined by the Animal Care and Use Veterinarian and consisted of premedication using ketamine 2.5 mcg/kg, dexmedetomidine 10 mcg/kg, and butorphanol 0.2 mg/kg IM. Once sedated, cats underwent endotracheal intubation. Inhaled isoflurane was administered if needed to facilitate intubation. Cats were maintained under anesthesia with inhaled isoflurane in 100% oxygen. Cats were then positioned in dorsal recumbency and the entire ventral abdomen clipped and aseptically prepared using standard technique. The abdomen was isolated using standard four-quarter drapes and a large patient drape.

A 25 mm incision was made in the skin centered on the ventral midline, just caudal to the umbilicus. The subcutaneous tissue was dissected using Metzenbaum scissors. An Adson forceps was used to grasp the linea and a number 15 scalpel blade was used to make a stab through the rectus sheath. The incision was extended to 25 mm using the blade. A SILS port (Medtronic, Minneapolis, Minnesota) was then placed in the linea in routine fashion. An additional threaded 5.5 mm port (KARL STORZ Endoscopy-America, El Segundo, California) was placed in the left craniolateral abdomen. The abdomen was insufflated using CO_2 to a max pressure of 8 mmHg.

A 30-degree, 5 mm laparoscope (Karl Storz Endoscopy-America, El Segundo, California) was used to briefly explore the abdomen. Next, a 5 mm laparoscopic Babcock forceps (Karl Storz Endoscopy-America) was used to grasp the parietal gastric surface for retraction towards the ventral abdominal wall. Two transabdominal sutures (3–0 Monocryl, Ethicon, Somerville, New Jersey) were placed through the seromuscular layer of the stomach to create ventral suspension of the stomach. A 5 mm ultrasonic energy device (Sonicision, Medtronic) was used to incise the superficial leaf of the greater omentum along the greater curvature of the stomach to expose the left limb of the pancreas (Figure 1A). The spleen was retracted and displaced using a blunt probe and/or alteration of the cat into slight oblique

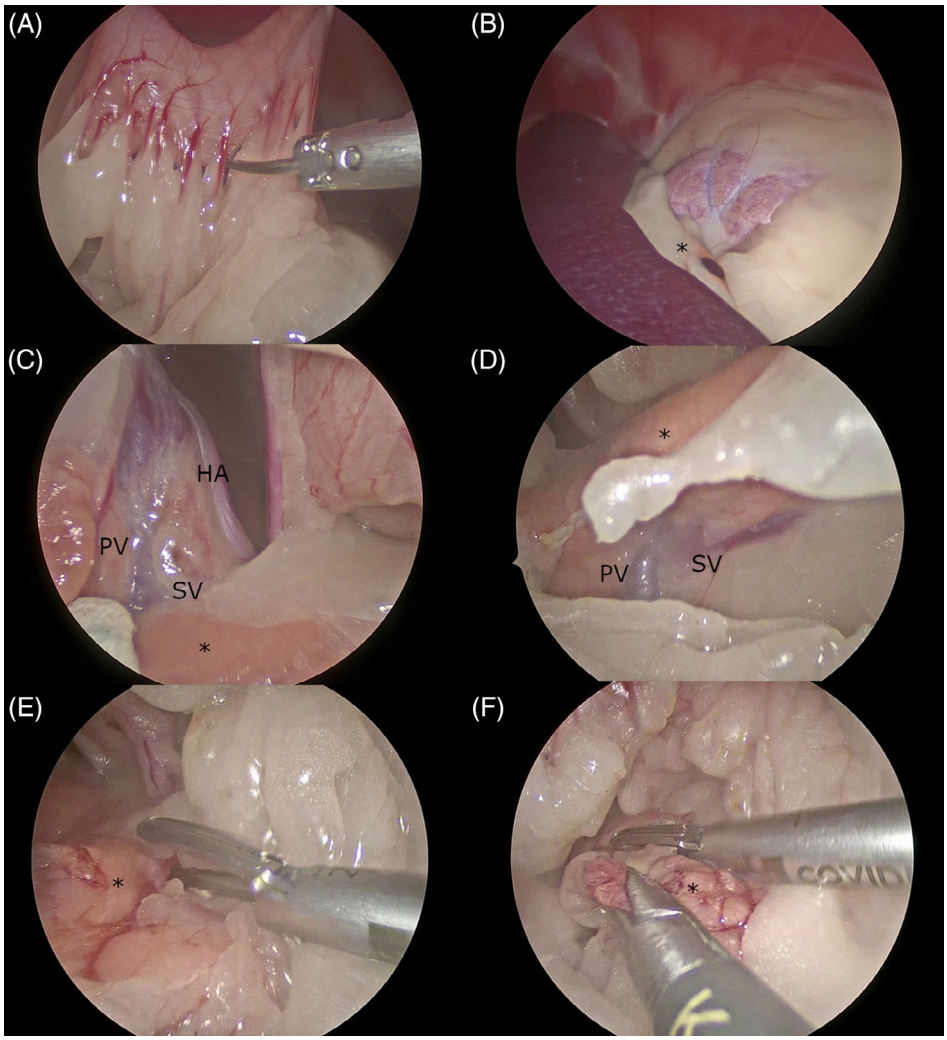

FIGURE 1 (A) Temporary percutaneous, ventral retraction of the stomach. The harmonic scalpel is being used to dissect the superficial leaf of the greater omental bursa. (B) The tail of the left pancreatic limb (*) is observed extending between the spleen and the left kidney. Notice the ectopic spleen present. (C) Within the omental bursa demonstrating the body of the pancreas (*), portal vein (PV), splenic vein (SV) and hepatic artery (HA). (D) Dissection through the deep leaf of the omentum, caudal to the left pancreatic limb (*), demonstrating the critical view at the junction of the splenic vein (SV) and portal vein (PV). Note the intimate association of the splenic vein with the left limb prior to entry to the main portal vein. (E) Dissection through the deep leaf of the omentum, cranial to the left pancreatic limb (*) in preparation for transection of the left limb. Steps D and E are critical to ensure that the splenic vein is not inadvertently sealed and divided. (F) Positioning of the harmonic scalpel across the pancreas (*) just prior to transection. The left limb is grasped with atraumatic endoscopic graspers to provide retraction during dissection.

position as needed (Figure 1B). The epiploic foramen, left pancreatic limb, regional pancreatic- and peripancreatic vasculature were explored (Figure 1C). A mixture of blunt dissection using laparoscopic Kelly forceps (Karl Storz Endoscopy-America) and endoscopic cotton-tipped rods (EndoPeanut; Medtronic) were utilized along with ultrasonic dissection to separate the left limb of the pancreas from the deep omental leaf and splenic vein branches (Figure 1D). Small pancreatic branches from the splenic vein and splenic artery were sealed and divided using the ultrasonic energy device. The left pancreatic limb was isolated to the level of the main portal vein and then transected at the pancreatic body using the ultrasonic device (Figure 1E,F). The dissection was completed by grasping the cut edge of the pancreatic body to apply gentle medial and ventral retraction (Figure 2A–C). This facilitated continued dissection of the distal left pancreatic limb using the ultrasonic device. The pancreatic tissue was retrieved from the abdomen once the SILS port was removed (Figure 2D). The length (cm) and weight (grams) of the resected pancreas was recorded. The external rectus sheath was closed using monofilament suture (3–0 PDS, Ethicon). The subcutaneous and intradermal tissue was closed with monofilament suture (3–0 Monocryl, Ethicon). Surgical and postoperative complications were documented

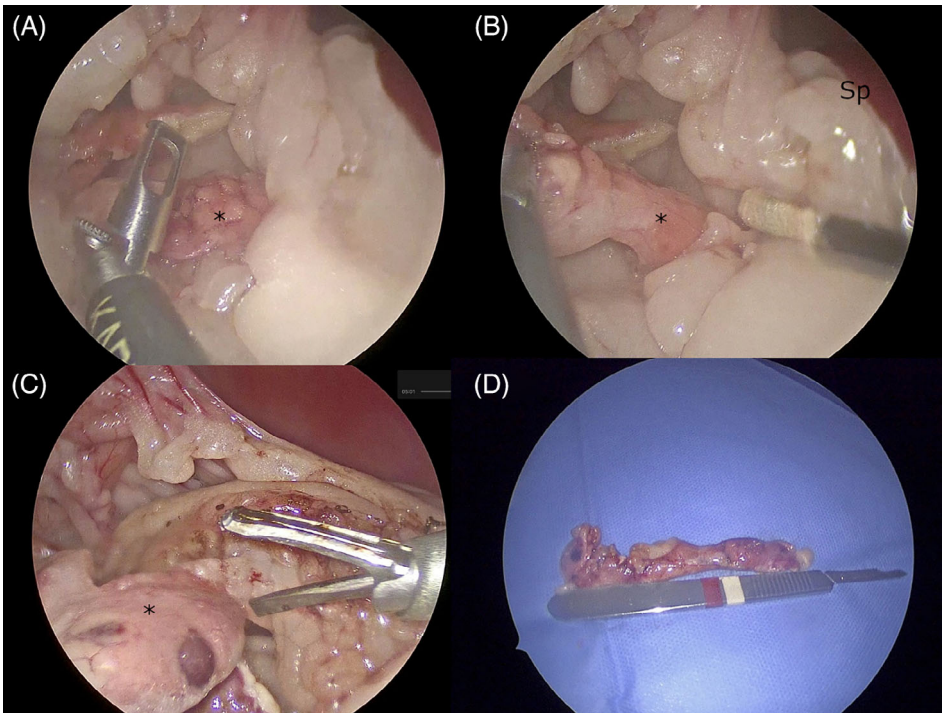

FIGURE 2 (A) Following transection of the pancreatic limb (*), the graspers are then used to retract the tissue medially and ventrally to facilitate dissection of the distal limb. (B) The pancreas (*) is being retracted medially and the endoscopic blunt dissector is being used to retract the spleen (Sp) laterally to further expose the distal pancreatic limb. (C) Dissection around the distal end of the pancreas (*) to complete the left limb pancreatectomy. (D) Extracorporeal image of the excised left limb of the pancreas.

and graded using a standard scoring scheme.[7] Briefly, grade 1 complications are those that represent any deviation from the normal course without requiring pharmacological intervention whereas grade 2 complications are those that require pharmacological treatment.

2.3 | Postoperative care

All cats were recovered and monitored following surgery by the Animal Care Services team under the direction of the lead veterinarian according to the approved IACUC. Postoperatively, each cat underwent twice daily assessments for 5 days following surgery. A physical examination included mentation, temperature, heart rate, respiratory rate, and incision evaluation. Frequency and character of appetite, defecation and urination were also monitored and documented. All cats received 0.3 mg/kg meloxicam and extended-release buprenorphine at 0.12 mg/kg, subcutaneously at the conclusion of surgery. Maropitant was administered at 1 mg/kg, subcutaneously for 2 days following surgery. All cats were returned to indefinite housing at the conclusion of the study. The date of last follow-up was documented for each cat.

2.4 | Statistical analysis

Summary statistics were performed using JMP (9.0.2, SAS Institute Inc). Categorical variables were summarized by frequencies and percentages. The Shapiro–Wilk test was performed for all numerical, continuous variables to assess for normality. Continuous variables that did not follow a normal distribution were summarized using median and interquartile range or range in the case of fPLI, whereas normally-distributed data were summarized using mean and standard deviation. The paired *t*-test was used to compare normally distributed data and the Wilcoxon signed rank test was used to compare non-parametric clinicopathological data before and after pancreatectomy. A p-value $<.05$ was considered statistically significant.

3 | RESULTS

Nine cats that underwent laparoscopic pancreatectomy of the left limb were included. Four cats were spayed females and five castrated males. Bodyweight was 5.3 ± 0.9 kg, and body condition score was 6 (IQR 5–7; reference range 1–9). Median age at the time of surgery was 5.5 (IQR 5.4–5.7 years).

For all cats, preoperative complete blood count and serum biochemistry revealed no significant abnormalities. Further, fTLI, and A1C were within the normal reference intervals (Table 1). In two cats, preoperative serum fPLI was increased above the reference interval (5.1, 3.9).

The mean procedure time for laparoscopic pancreatectomy was 59.7 ± 16.2 min. Mean anesthesia time was

	Preoperative	Postoperative	*p*-value
TLI µg/L (REF 12–82)	43.7 ± 16.2	32.8 ± 9.7	.03*
PLI µg/L (REF <3.5)	2.5 (1.9–5.1)	2.4 (2.2–3.0)	.82
A1C (REF 0–3.5)	2.7 ± 0.27	2.8 ± 0.37	.58

TABLE 1 Pre- and postoperative trypsin-like immunoreactivity (TLI), pancreatic lipase immunoreactivity (PLI) and A1C values in nine cats following laparoscopic partial pancreatectomy (LPP). The mean ± SD is presented for TLI and A1C whereas the median and range are reported for PLI.

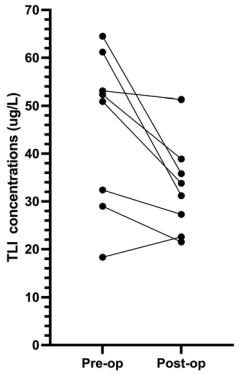

FIGURE 3 Pre- and postoperative trypsin-like immunoreactivity (TLI) values for cats following partial pancreatectomy.

106.3 ± 16.9 min. Mean weight of pancreatic tissue resected was 3.0 ± 1.4 g.

One grade-1 intraoperative complication occurred (1/9; 11%) in which minor hemorrhage from a caudal splenic vein branch developed during dissection of the pancreatic limb. The hemorrhage was easily controlled using the ultrasonic device. A grade-2 post-operative complication occurred in one cat. The cat developed abdominal discomfort and hyporexia 5 days following surgery. Abdominal CT revealed abdominal effusion and a consolidated mass of omentum in the region of the pancreatic body. Fluid analysis and cytology revealed a sterile exudate, which was attributed to possible leakage of enzymes from the pancreatic duct. The cat was initially treated with a single dose of meloxicam at 0.1 mg/kg and maropitant 1 mg/kg, subcutaneously for 3 days. Abdominal discomfort improved initially, but returned after 5 days. Dexamethasone 0.05 mg/kg subcutaneously was administered once daily for 7 days, then once every other day for 7 days, followed by once every 3 days for 7 days. Abdominal discomfort and the peritoneal effusion resolved over the course of treatment. No other postoperative complications occurred and no cats developed clinical signs consistent with pancreatitis.

Postoperative serum biochemical analysis was performed between 102 and 147 days (median 107 days). Postoperative fTLI was lower than preoperative fTLI ($p = .03$), by 37% ± 38% but remained within the normal reference interval for all cats (Table 1, Figure 3). There were no significant differences between pre- and postoperative fPLI and A1C (Table 1). Follow-up time for all cats ranged from 250 to 446 days (median 252 days). At the time of last follow-up, all cats were alive and clinically healthy.

4 | DISCUSSION

We have demonstrated that a laparoscopic approach for left limb partial pancreatectomy is feasible and safe using an ultrasonic energy device in cats. Further, removal of the left limb appears to be well tolerated and results in adequate pancreatic function. Although one cat developed postoperative aseptic peritonitis, this complication resolved with conservative management. It is unknown why this complication occurred, but incomplete sealing of the pancreatic ductal tissue is considered the most likely cause.

Postoperative pancreatic duct leak and fistula formation are reported complications of pancreatectomy in people and have been areas of research given the increased use of energy-based sealing devices, especially with laparoscopic surgery.[8,9] There is contradictory evidence in human surgery regarding the risk of pancreatic duct leak when using instruments like the ultrasonic energy device. In some cases, with more proximal resections, the risk of duct leak appears to be higher with an ultrasonic device when compared to electrosurgical scalpels.[10] Conversely, in other studies with more distal resections, the risk is consistent with techniques like stapling.[11] In our study, cats had proximal resections, but the pancreatic tissue and duct diameter are significantly smaller than that of humans.[12,13] The feline maximal pancreatic duct diameter is 1.5–1.7 mm whereas the human pancreatic duct diameter in the body of the pancreas is 2.5–3.0 mm. Conversely, the pancreatic duct diameter in the tail of the human is closer to the cat measuring 2.0 mm on average. Thus, the region of resection of the feline pancreas in our study was presumably less than that of the tail of the human pancreas, which provides

conceptual support for the use of ultrasonic sealing in pancreatic resection in cats. It is worth noting that, in this study, all cats had grossly normal pancreatic tissue at the site of surgery, which may not be the case in many clinical situations. For example, it has been demonstrated that cats with pancreatitis have larger pancreatic ducts (2.4 mm) so extrapolating our results to diseased pancreatic tissue in cats might not be justified.[12] In the one cat in which suspected leakage occurred, fPLI was well within the reference interval prior to surgery, suggesting no active pancreatitis at the time of the procedure. This cat also had more pancreatic tissue resected compared to all other cats (5.3 g). Further studies are indicated to assess the efficacy of ultrasonic pancreatic resection in cats with clinical disease. Interestingly, following completion of the present study, the use of a bipolar vessel sealing device to perform LPP in a cat with an exocrine pancreatic carcinoma was reported with good results.[2] Comparison between ultrasonic and bipolar vessel sealing devices for partial pancreatectomy in cats has not been performed to the author's knowledge.

Postoperative pancreatitis is a known complication of feline pancreatic surgery.[6] In a recent report of partial pancreatectomy in cats with insulinoma, a complication rate of 25% was reported with pancreatitis developing in at least one of the cats.[6] Pancreatitis might have contributed to postoperative morbidity in the one cat in the present study that developed abdominal discomfort, hyporexia and a sterile peritoneal exudate. However, none of the other cats developed clinical evidence of acute necrotizing pancreatitis and all cats had PLI values within the normal range, which did not differ from preoperative levels. Ideally, PLI would have also been measured within the first week following surgery, but this was not done in the study. It is possible that some degree of subclinical pancreatitis may have occurred and gone undetected, but this is unknown. The use of laparoscopy may have influenced these results as laparoscopic surgery generally results in less tissue trauma and manipulation when compared to open techniques. Additionally, the use of an ultrasonic energy device for LPP may be desirable as the degree of collateral thermal injury is less than other types of bipolar vessel sealing devices and electrosurgical scalpels.[14,15] Whether or not these factors influenced our results is unknown.

The left limb was selected for resection in our study for a few reasons. First, the left limb appears to be the most common location for neoplastic disease in cats with 16 of 20 insulinomas occurring in the left limb in one study.[6] Second, the left limb may be challenging to access via laparoscopy as it is contained within the omental bursa and is positioned dorsal to the stomach and spleen. Additionally, a laparoscopic approach for biopsy of the right limb has been described previously.[16] Subjectively, the laparoscopic approach was moderately challenging. Access to the omental bursa required retraction with transabdominal sutures and dissection of the greater omentum. Additionally, alteration of the cats' position and manipulation of the spleen was often required to complete dissection of the distal left limb. Most importantly, the cats in this study were overweight and all possessed a moderate-to-severe amount of peripancreatic fat. This made identification of the splenic and pancreatic vessels, a challenge. We found that blunt dissection using the endoscopic peanuts was especially useful to isolate these vessels from the surrounding adipose tissue without causing iatrogenic lacerations. Once these vessels were accurately identified, the fine tips of the ultrasonic device facilitated safe and precise dissection.

Procedure time in our study was under 1 h which was considered to be reasonably short and may be partially related to the use of an ultrasonic energy device to facilitate dissection, the normal pancreatic anatomy in these healthy cats, and the previous experience of the surgeons in laparoscopic surgery.

Although the endocrine pancreas contributes approximately 2% to the entirety of pancreatic mass, in people, relative pancreatic volume is significantly decreased in patients suffering from diabetes (early onset), prediabetes, and their first-degree relatives.[17] This correlates with reduction in serum trypsinogen as well as a decrease in numbers of acinar cells in diabetic people.[18,19] The reduction of serum fTLI post LPP in our study is not surprising, although the magnitude of this reduction was more than we expected considering the amount of tissue removed. Two cats had fPLI results that were slightly above normal preoperatively, potentially indicating subclinical pancreatitis that could have increased their TLI relative to their normal (while not increasing it enough to exceed population RI). Resolution of pancreatitis resulting in a decrease in fTLI in these two cats might have contributed to the overall change in fTLI in the group which could contribute to the greater than expected reduction of fTLI in the group. It remains to be seen if fTLI would be reduced in feline diabetics as well. Hemoglobin A1C, a sensitive marker of early dysglycemia in people,[20] was unaffected by reduction in pancreatic mass in our study.

Relevant limitations of this study are the small number of cats included and the lack of naturally occurring disease. Obviously, disease can affect the technical aspect of surgical dissection as well as the character of tissues, which may alter the response to energy-based sealing devices. Consequently, interpretation of our data must be done within the context of healthy tissue.

In conclusion, laparoscopic pancreatectomy of the left limb using a harmonic scalpel in cats is feasible and results in adequate endocrine and exocrine pancreatic function. Future studies investigating laparoscopic pancreatectomy in cats with clinical disease are indicated.

AUTHOR CONTRIBUTIONS

Brad Case J, DVM, MS, DACVS: Drafting of work, conception of study design, performance of surgical procedures, acquisition analysis and interpretation of data, final approval of all work. Adin C, DVM, DACVS: Drafting of work, conception of study design, performance of surgical procedures, acquisition analysis and interpretation of data, final approval of all work. Crews C, MS, BS: Drafting of work, coordination of medical procedures for all cats, acquisition analysis and interpretation of data, final approval of all work. Gilor C, DVM, DACVIM: Drafting of work, conception of study design, acquisition, analysis and interpretation of data, final approval of all work.

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CONFLICT OF INTEREST STATEMENT

The authors declare no conflicts of interest related to this report.

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