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Role of laparoscopic ultrasonography in intraoperative localization of pancreatic insulinoma

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Abstract
Background: A combination of digital palpation and ultrasonography plays an important role in locating insulinomas intraoperatively. Laparoscopic resection of insulinomas has been described recently, but experience in locating insulinomas during laparoscopy is lacking.
Methods: From January 1998 to January 1999, three patients with pancreatic insulinomas underwent laparoscopy and laparoscopic ultrasonography aimed at intraoperative localization and potential resection. The role of laparoscopy and laparoscopic ultrasonography in locating insulinomas is evaluated.
Results: Preoperative localization studies were routinely performed, and two patients had an occult tumor before laparoscopy. None of the tumors was detected by laparoscopic examination, but laparoscopic ultrasonography identified solitary tumors located at the body and tail of the pancreas. Conversion to laparotomy was performed in one patient as a planned procedure. One patient underwent laparoscopic enucleation, whereas the other had a laparoscopic distal pancreatectomy.
Conclusions: Laparoscopic ultrasonography seems to be sensitive in locating insulinomas at the body and tail of the pancreas. It optimizes and facilitates resection of insulinomas through a minimally invasive approach.

Key words: Insulinoma — Laparoscopic ultrasonography — Laparoscopy — Localization — Treatment

Insulinomas usually are small benign tumors evenly distributed in the pancreas. Ideally, all tumors should be located before exploration to facilitate and expedite surgical removal [15]. However, none of the preoperative imaging methods have been shown to be superior to a combination of digital palpation and intraoperative ultrasonography by experienced surgeons during surgical exploration [11].

Laparoscopic resection of the pancreas has been reported for insulinomas [5, 14, 16] and other benign pancreatic diseases [4, 8, 16]. Laparoscopic resection of islet cell tumors, including insulinomas, has been described as a good alternative to open surgery [7]. Laparoscopic ultrasound has been used frequently during laparoscopic resection of pancreatic insulinomas [7] even when the tumors were located before the operation began [5, 14]. We describe three patients with insulinomas located by laparoscopic ultrasonography (LUSG) and evaluate the possible roles during minimally invasive surgery for insulinoma.

Materials and methods

From January 1998 to January 1999, we evaluated prospectively the role of laparoscopy and LUSG in intraoperative location of pancreatic insulinomas with an aim of potential laparoscopic resection. Standard preoperative localization studies including computed tomography (CT) scan, magnetic resonance imaging (MRI), and endoscopic ultrasonography (EUS) were performed in all patients. Intra-arterial calcium stimulation with hepatic vein sampling for insulin gradients (ASVS) preceded by selective angiography also was performed for regionalization of insulinomas.

Laparoscopy and LUSG were performed before consideration of definitive surgical treatment. Three patients (2 men and 1 woman) ages 29, 49, and 35 years with confirmed hyperinsulinemia were included. Two of the patients had an occult tumor before laparoscopy.

Technique

The patient was placed in a supine position with a nasogastric tube and an indwelling urinary catheter inserted. Three 11-mm ports were inserted. A 30° angled 10-mm laparoscope through the subumbilical trocar was used for laparoscopy and inspection of the anterior surface of the pancreas. By lifting the greater curvature of the stomach with a babcock forceps through the epigastric trocar, the neck, body, and tail of the pancreas were exposed and examined through a window in the gastrocolic ligament.

The window was created by ligating and dividing branches of gastroepiploic arcade with clips and scissors or by making use of an ultrasonic dissector (Ultracision, Johnson & Johnson, Cincinnati, Ohio, USA) through a trocar at the left upper quadrant of the abdomen. An ultrasound

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Table 1. Summary of three patients undergoing laparoscopy and laparoscopic ultrasonography for location of insulinoma

	Case 1	Case 2	Case 3
Preoperative			
Glucose (mmol/l) (N: 3.8–5.9 mmol/l)	1.2	1.6	1.9
Insulin (mIU/l) (N: <23 mIU/l)	13	18	18
Localization			
CT scan	−	+	−
MRI	−	+	−
EUS	−	+	−
ASVS	−	+	+[a]
Size (cm)	1.5	1.5	1.5
Location	Body	Tail	Tail
Procedure	Conversion + distal pancreatecomy	Laparoscopic enucleation	Laparoscopic distal pancreatectomy
Immediate outcome	Discharged at day 10	Pancreatic fistula	Discharged at day 6
Postoperative			
Glucose (mmol/l)	5.6	5.2	5.9
Insulin (mIU/l)	2.3	6.0	2.7
Follow−up (months)	11	9	6

[a] Operating surgeons were blinded to the results
CT scan, computed tomography; MRI, magnetic resonance imaging; EUS, endoscopic ultrasonography; ASVS, arterially stimulated venous sampling

probe 10 mm in diameter with a frequency of 8 MHz (Sharplan, Honeyclave Medical, NJ, USA) was then used. The probe was applied directly in contact with the anterior surface of the pancreatic neck, body, and tail for LUSG.

Once the tumor had been located and the decision for laparoscopic pancreatic resection had been made, the patient was rotated laterally 45° with the left side up in the reverse Tredelenburg position. An additional port was inserted in the left side of the abdomen as a working channel. For enucleation, dissection was performed using a combination of hook cautery and ligaclips. When it was decided to perform distal resection, the inferior and superior borders of the pancreas were dissected from the retroperitoneal fat until the gland was mobile posteriorly. The splenic artery, identified in a position superior to the gland, was doubly clipped and ligated proximally to the proposed line of transection. The ligation at proximal stump was reinforced with a preform suture loop. The pancreas was transected proximally to the tumor together with the splenic vein by an endoscopic linear stapler (45 mm in length and 18 mm in diameter; Ethicon, Johnson & Johnson). Laparoscopic ultrasonography was used frequently to guide the extent of resection proximal to the located tumor. Short gastric vessels were ligated and divided with ligaclips and the ultrasonic dissector.

With retraction on the transected pancreas laterally and inferiorly, dissection was completed with division of the splenorenal ligament. The specimen was placed in a sterile plastic bag and retrieved after the spleen was morcelated through the subumbilical port, which was enlarged slightly. A Jackson-Pratt drain was left in the lesser sac.

Results

Table 1 summarizes the biochemical parameters, localization studies, operative details, and outcome of the patients.

Case 1

A 29-year-old Chinese man had repeated attacks of hypoglycemia for 4 years. Hyperinsulinemia was confirmed with fasting hypoglycemic test. However, the tumor remained occult despite all preoperative imagings. The patient was referred for ASVS, which also failed to locate the tumor. In the absence of preoperative localization, the patient was reluctant for any surgical procedure to be performed, but accepted the idea of diagnostic laparoscopy and LUSG for localization of the tumor before definitive surgery.

Infragastric laparoscopic examination of the body and tail of the pancreas revealed no tumor, but LUSG showed a hypoechoic nodule located at the midbody of the pancreas in close proximity to the pancreatic duct. Laparotomy was performed, and the tumor was palpable at the corresponding position. Intraoperative ultrasound confirmed the proximity of the tumor to the main pancreatic duct. Distal pancreatectomy with splenectomy was performed. The patient recovered uneventfully without complications and was discharged 10 days after surgery.

Case 2

A 49-year-old Indian woman was referred with 3 months history of decreased sensorium attributed to hypoglycemia and hyperinsulinemia. Both CT scan and MRI revealed a 1.5-cm lesion at the tail of the pancreas. Endoscopic ultrasonography confirmed the location of the tumor, whereas ASVS regionalized the tumor to the tail of pancreas. Laparoscopic resection of the tumor was planned. During laparoscopy, no tumor can be visualized at the position expected by preoperative localization, but LUSG revealed a hypoechoic lesion at the inferior border of the pancreas tail (Fig. 1). Laparoscopic enucleation was performed because of the tumor's favorable location.

The immediate postoperative course was uneventful with minimal pain and analgesic requirement. However, persistent drainage of amylase-rich fluid indicated pancreatic fistulation. Despite conservative treatment with sandostatin (Sandoz Pharma., Basle, Switzerland) and total parenteral nutrition for 2 months, the fistula persisted. Open distal pancreatectomy with splenectomy was performed for salvage, and the patient was discharged 3 weeks after the second operation.

Case 3

A 35-year-old Chinese man with mental illness was admitted with frequent episodes of dizziness and fainting attacks caused by hypoglycemia. Hypoglycemic test results were positive at 4 h of fasting, with a concomitant inappropriately elevated insulin level. Localization studies with CT scan, MRI and EUS all were negative. An ASVS was performed, and more than a twofold increase in insulin level was recorded in the hepatic vein blood sample at 60 s after splenic artery injection, suggesting an insulinoma located at the tail. The result of the ASVS was not disclosed to the operating surgeons in an effort to evaluate the accuracy of intraoperative localization by LUSG.

During laparoscopic infagastric examination of the pancreas, no tumor was identified, but LUSG revealed a hypoechoic tumor measuring 1.5 cm located at the distal tail of the pancreas. It was decided to perform distal pancreatectomy with the assistance of LUSG to guide the proximal extent

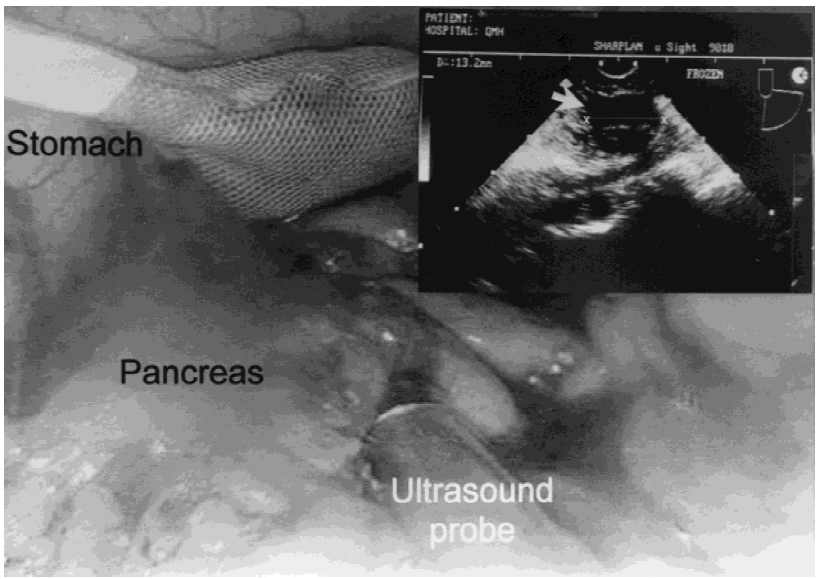

Fig. 1. Laparoscopic ultrasonography (8-MHz) of the pancreatic tail demonstrates a 13-mm hypoechoic insulinoma (*arrow*).

of resection (Fig. 2). The postoperative course was smooth. The man resumed a normal diet 2 days after the operation and was fully mobilized on postoperative day 4. Analgesic requirement was minimal, and he was discharged home on postoperative day 6 (Fig. 3).

Discussion

The average accuracy of current imaging technology, including ultrasonography, CT scan, MRI, angiography, and somatostatin receptor scintigraphy for location of insulinomas, remains low [11]. Endoscopic ultrasonography is sensitive in detecting insulinomas but likely to miss tumors located at the tail [13]. Arterially stimulated venous sampling is the most sensitive preoperative test for locating insulinomas [6]. However, considerable doubt exists in recommending its routine use for locating insulinomas preoperatively [1]. Even when an insulinoma is located preoperatively, it is possible that preoperative studies identify tumors readily found at surgery and miss those that elude the surgeons' fingers [1]. A combination of digital palpation and intraoperative ultrasonography by an experienced surgeon remains the most sensitive method for locating insulinomas during surgical exploration [1, 9, 11, 15].

New technology has facilitated the application of various open surgical procedures to their equivalents in a minimally invasive fashion. With the advent of laparoscopic pancreatic resection [4, 7, 8, 14], it has been suggested that accurate preoperative location of tumors may play an increasingly important role in the care of patients with insulinomas [2]. The dissectable pancreatic surface can be examined visually, but the laparoscopic surgeon has a decreased tactile sensation of the pancreas. Laparoscopic resection of insulinoma may depend on an accurate preoperative localization [7]. However, with the exception of ASVS, this may not be easily achieved [2]. Despite all preoperative localization, 36% of the islet cell tumors were not identified before laparoscopy, and inability to locate the tumor intraoperatively can lead to conversion [7].

Because LUSG enhances minimal invasive surgery, it has been adopted frequently during preoperative diagnostic and staging for pancreatic malignancy [3, 12]. For insulinoma, it has been suggested that LUSG facilitates intraoperative location of the tumor and constitutes the first important step in treatment of insulinoma in a minimally invasive fashion [10]. The availability of LUSG was recommended during laparoscopic resections of islet cell tumors [7]. It also was suggested that laparoscopy combined with LUSG is an alternative to open exploration [16].

Our results show that LUSG can achieve a high sensitivity for tumors located at the body and tail of the pancreas. Two tumors were occult before laparoscopy because all available preoperative localization results failed to identify the location of the tumor. However, these tumors were located at the body and tail of the pancreas expeditiously during examination with LUSG.

Most of the insulinomas are less than 1.5 cm in size and seldom visible to the naked eye. However, most of the tumors are palpable [15]. In our current report, examination of the anterior surface of the pancreas failed to identify any tumor during laparoscopy. Even though the tumor is located preoperatively, it may not be identified easily by laparoscopic surgery in the absence of tactile sensation.

The ASVS is the most sensitive preoperative localization test. It allows a focused pancreatic exploration with a combination of palpation and intraoperative ultrasonography during open surgery [2]. Like its counterpart during the open procedure, LUSG is important in confirming the exact location of the tumor regionalized by ASVS and in obviating a blind pancreatic resection based on results of preoperative localization studies. Two of the three tumors regionalized by ASVS required LUSG for their localization, whereas the one tumor missed by ASVS was located by LUSG intraoperatively.

Although we do not have any experience with laparoscopy for tumors located at the head and neck of the pancreas, these areas also can be accessed and evaluated by LUSG. A laparoscopic Kocher maneuver has been described, and the laparoscopic probe can be positioned behind the uncinate process to evaluate this relatively blind area [7]. Even if visualization of these areas is poor, a com-

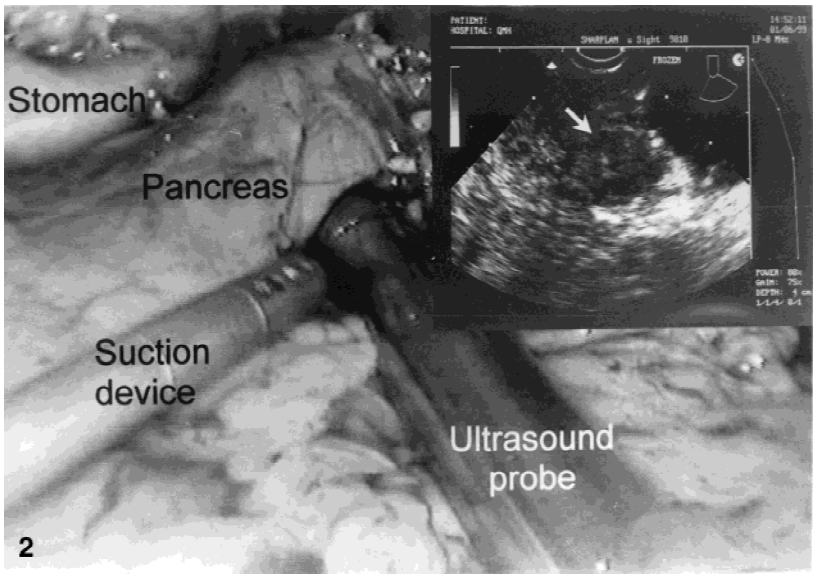

Fig. 2. Laparoscopic ultrasonography confirms the position of a hypoechoic insulinoma at the tail of the pancreas (*arrow*) before distal resection. Note that the irrigation and suction device is used to provide a pool of water as a contact media to facilitate ultrasonographic examination.

Fig. 3. Position of trocar sites as illustrated by the appearance of the abdomen 6 days after laparoscopic distal pancreatectomy.

bination of EUS, which is sensitive for tumors located at the head of the pancreas [13], can achieve a precise location of insulinomas intraoperatively.

Laparoscopic distal pancreatectomy with splenectomy has been described in patients with chronic pancreatitis [4]. On the other hand, laparoscopic distal pancreatectomy combined with splenic preservation has been described in selected patients with islet cell tumors by dissection of the splenic vessels [7] or in patients with distal pancreatic tumors by preservation of the blood supply from the short gastric vessels [16].

As in open surgery, splenic preservation is worthwhile if it can be achieved safely. Splenic function can be preserved either by tumor enucleation or splenic-preservation distal pancreatectomy. Our patients underwent concomitant splenectomy because of technical difficulty encountered during dissection of splenic vessels. Splenic preservation on the vasa brevia during laparoscopic left pancreatectomy should be feasible and regarded as an alternative [16]. In addition, successful laparoscopic enucleation of pancreatic insulinoma has been reported twice [5, 7]. In open surgery, simple enucleation is preferred to resection, and this crucial decision has been facilitated by the routine use of intraoperative ultrasonography [15]. In our current report, laparoscopic enucleation was complicated with pancreatic fistula and required distal pancreatectomy for salvage. Although pancreatic fistula is not an uncommon morbidity after pancreatic surgery [15], the safety of laparoscopic enucleation for pancreatic insulinoma and the usefulness of LUSG in guiding this decision need further evaluation.

It seems that LUSG is as sensitive as open ultrasonography in locating an insulinoma at the body and tail of the pancreas. It confirms the position of the tumor and optimizes resection by the minimally invasive technique. Therefore, LUSG should be available during attempted laparoscopic resection of pancreatic insulinomas.

References

1. Axelord L (1995) Insulinoma: cost-effective in patients with a rare disease. Ann Intern Med 123: 311–312
2. Brown CK, Bartlett DL, Doppman JL, Gordon P, Libutti SK, Fraker DL, Shawker TH, Skarulis MC, Alexander HR (1997) Intra-arterial calcium stimulation and intraoperative ultrasonography in the localization and resection of insulinomas. Surgery 122: 1189–1194
3. Callery MP, Strasberg SM, Doherty GM, Soper NJ, Norton JA (1997) Staging laparoscopy with laparoscopic ultrasonography: optimizing resectability in hepatobiliary and pancreatic malignancy. J Am Coll Surg 185: 33–39
4. Cushieri A, Jakimowicz JJ, van Spreeuwel J (1996) Laparoscopic distal 70% pancreatectomy and splenectomy for chronic pancreatitis. Ann Surg 223: 280–285
5. Dexter SPL, Martin IG, Leindler L, Fowler R, McMahon MJ (1999) Laparoscopic enucleation of a solitary pancreatic insulinoma. Surg Endosc 13: 406–408 DOI: 10.1007/s004649901000
6. Doppman JL, Chang R, Fraker DL, Norton JA, Alexander HR, Miller DL (1995) Localization of insulinomas to regions of the pancreas by intra-arterial stimulation with calcium. Ann Intern Med 123: 269–273
7. Gagner M, Pomp A, Herrera M (1996) Early experience with laparoscopic resections of islet cell tumors. Surgery 120: 1051–1054
8. Klingler PJ, Hinder RA, Menke DM, Smith SL (1998) Hand-assisted laparoscopic distal pancreatectomy for pancreatic cystadenoma. Surg Laparosc Endosc 8: 180–184
9. Lo CY, Lam KY, Kung WC, Lam KSL, Tung PHM, Fan ST (1997) Pancreatic insulinomia: a 15-year experience. Arch Surg 132: 926–930
10. Pietrabissa A, Shimi SM, Vander VG, Cushieri A (1993) Localization

of insulinoma by laparoscopic infragastric inspection of the pancreas and contact ultrasonography. Surg Oncol 2: 83–86
11. Rothmund R (1994) Localization of endocrine pancreatic tumours. Br J Surg 81: 164–166
12. Schirmer B (1994) Laparoscopic ultrasonography: enhancing minimally invasive surgery. Ann Surg 220: 709–710
13. Schumacher B, Lubke HJ, Frieling T, Strohmeyer G, Starke AAR (1996) Prospective study on the detection of insulinomas by endoscopic ultrasonography. Endoscopy 28: 273–276
14. Sussman LA, Christie R, Whittle DE (1996) Laparoscopic excision of distal pancreas including insulinoma. Aust N Z J Surg 66: 414–416
15. van Heerden JA, Lo CY (1996) Pancreatic endocrine disease In: Carter DC, Russell RCG (eds) Rob & Smith operative surgery Chapman and Hall, pp 624–632
16. Vezakis A, Davides D, Larvin M, McMahon MJ (1999) Laparoscopic surgery combined with preservation of the spleen for distal pancreatic tumors. Surg Endosc 13: 26–29 DOI: 10.1007/s004649900891