



Robotic spleen-preserving distal pancreatectomy

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Abstract: Along the last decade minimally invasive distal pancreatectomy (DP) is gaining wide diffusion in clinical practice due to a number of advantages as compared to the conventional open resection. When the procedure is performed with the intent to preserve the spleen, robotic surgery has shown some advantages over conventional laparoscopy. By describing the case of a patient with pancreatic neuroendocrine tumor, herein we present our robotic technique of DP with preservation of the spleen and splenic vessels according to Kimura.

Keywords: Minimally invasive surgery (MIS); distal pancreatectomy (DP); robotic surgery

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Introduction

Nearly 25 years after its first introduction in clinical practice, minimally invasive surgery (MIS) of the pancreas is gaining momentum, also as a result of increased experience in this field and the availability of innovative technologies (1-3). With distal pancreatectomy (DP) in particular, the application of MIS (both laparoscopic and robotic surgery) has shown a number of clinical advantages over conventional surgery, especially with reference to enhanced postoperative recovery (4-6).

At the same time, although more technically demanding and more time-consuming as compared to conventional DP with splenectomy, spleen-preserving procedures are gaining wide diffusion in selected patients (7-10). In particular, minimally invasive spleen-preserving DP is regarded as a demanding intervention, for which there is still no consensus on the optimal surgical procedure. Herein we report our technique of robotic spleen-preserving DP, as performed to treat a patient with a low-grade neuroendocrine tumor of the pancreas.

Case presentation and surgical technique

A 44-year old, otherwise healthy male was referred to the surgical department for further investigation of an incidentally discovered pancreatic nodule at abdominal ultrasonography. Physical examination was unremarkable. Routine blood investigations were substantially normal. Computed tomography and magnetic resonance imaging confirmed the presence of a solid nodule measuring 20 millimeters in diameter within the body of the pancreas (*Figure 1*). Endoscopic ultrasound-guided fine-needle aspiration biopsy was suggestive of pancreatic neuroendocrine tumor. The expression of Ki67 was <2%. The patient was scheduled to receive robotic DP with preservation of the spleen and splenic vessels.

A fourth generation, four-arm Da Vinci Surgical Robot (Da Vinci Xi, Intuitive Surgical, Sunnyvale, CA, USA) is employed. The patient is placed in the supine position, with the legs apart. An anti-Trendelenburg, left-side up position is given. Pneumoperitoneum is obtained using the Veress needle in the left hypochondrium. One laparoscopic assistant

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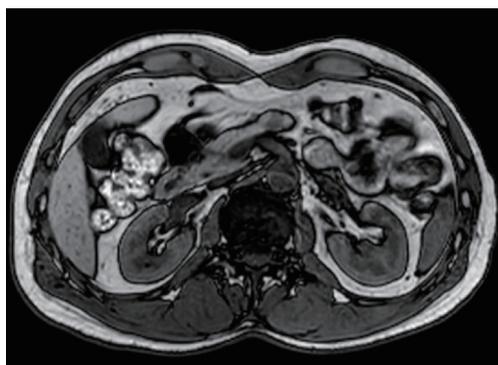


Figure 1 Abdominal MRI revealing a solid mass in the pancreatic body.

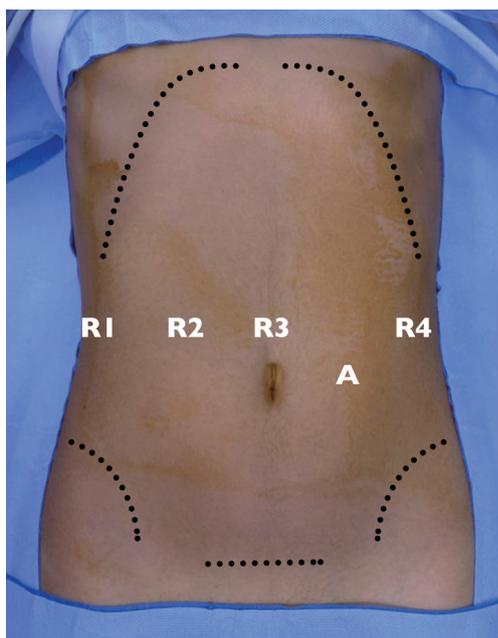


Figure 2 Ports placement for robotic DP with spleen and splenic vessels preservation. The robot is docked on the right side of the patient. R1–R4: robotic ports, A: standard laparoscopic assistant port. The endoscope is installed on R3. DP, distal pancreatectomy.

port and four standard robotic ports are thus placed. Ports placement strategy is depicted in *Figure 2*. The procedure commences with conventional laparoscopic exploration of the abdominal cavity. The peritoneum, omentum, mesentery and viscera are inspected for signs of peritoneal disease. The stomach is retracted upward and to the right by the third arm. The gastrocolic ligament is thus divided below the gastroepiploic arcade and the lesser omentum is

accessed. The dissection is carried to the origin of the right gastroepiploic artery. When present, adhesions between the posterior wall of the stomach and the anterior layer of the pancreatic capsule (supramesocolic fascia) are divided. A robot-integrated ultrasound inspection follows (11), to confirm the exact location of the tumor and evaluate its relationship with the main pancreatic duct and splenic vessels. The splenic artery is thus identified and dissected at the upper edge of the pancreas. Once the first tract of splenic artery is dissected circumferentially, it is encircled with a silicon loop, to allow rapid control in the case of vascular injury and bleeding. The peritoneum overlying the inferior border of the pancreas is incised transversely to reach the avascular plane on the pre-adrenal fascia. From the inferior border of the pancreas, the pancreatic neck is dissected off the superior mesenteric vein (SMV) and the portal vein (PV). The pancreatic parenchyma is now dissected from the splenic vein and divided using the Harmonic[®] scalpel and monopolar scissors (*Video 1*). During pancreatic division, the main pancreatic duct of Wirsung is identified and suture-ligated with monofilament suture. Once the pancreas is completely divided at its neck, it is gently rotated laterally, to facilitate the meticulous dissection required to separate the parenchyma from the splenic artery and vein. The dissection proceeds from medial to lateral, in the direction of the splenic hilum. All communicating branches between the pancreas and the splenic vessels are divided between ties or carefully cauterized until the pancreas is completely freed from the remaining attachments of the lienorenal ligament. The specimen is thus retrieved through a protected Pfannenstiel incision. The viability of the spleen is now appraised with extemporaneous fluorescence-angiography (FireflyTM) by injecting intravenously a small bolus of indocyanine green (*Figure 3*). A closed-suction drain is left adjacent to the pancreatic bed. The patient had an uneventful postoperative course and was discharged home on the 7th postoperative day. Final pathology confirmed the diagnosis of a neuroendocrine tumor 19 millimeters in diameter with 24 harvested lymph nodes.

Discussion

In the case of benign or premalignant conditions, DP can be performed with conservation of the spleen to avoid the well-known postsplenectomy sequelae on immunologic and hematologic function (3,4,12,13). Traditionally,

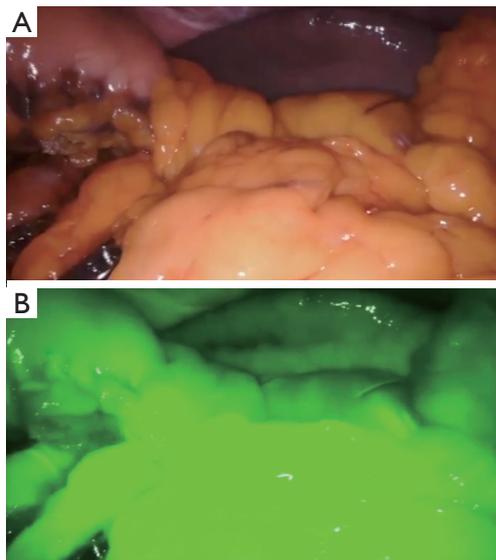


Figure 3 At the end of the procedure, the operative field is viewed under standard (A) and fluorescent (B) light to assess splenic perfusion after intravenous indocyanine green injection.

spleen-preserving DP is regarded as a more demanding procedure compared with the conventional DP with splenectomy (4). Actually, meticulous and time-consuming dissection is usually required due to a higher risk of vascular injury and bleeding (4). When the spleen is to be conserved, DP can be performed either with preservation (SVP, also known as the Kimura technique) either with sacrifice of the splenic vessels [also known as the Warshaw technique (WT)]. Currently, both SVP and the WT are considered safe and effective techniques to perform DP. Nevertheless, there are several reports suggesting that SVP should be preferred to reduce postoperative morbidity (10,12). Song *et al.* recently aggregated the available data from the literature comparing the WT *vs.* SVP technique of spleen-preserving DP. The authors meta-analyzed the outcomes of more than 1,000 patients from 18 studies, mostly reporting on MIS (>90%) (12). Despite a significantly higher amount of estimated blood loss, and a tendency toward increased operation time, the SVP technique was superior to the WT with regard to clinically relevant postoperative pancreatic fistula, splenic infarct, intra/postoperative splenectomy and gastric varices.

As for the method of surgical approach, the application of MIS to DP, has shown some advantages over open surgery in terms of postoperative recovery, length of hospital stay,

and quality of life (4,6,13). In order to evaluate possible differences on the rate of spleen preservation, we recently analyzed the data provided in an elegant meta-analysis by Mehrabi *et al.* comparing laparoscopic versus open DP for the treatment of benign and malignant pancreatic lesions (3,13). Were considered only those studies in which both laparoscopic and conventional DPs were well-matched for benign and malignant disease, including the data of 950 patients derived from 14 studies. Overall, the rate of spleen preservation was 23%, with significant difference between laparoscopic and conventional surgery (34% and 12%, respectively, $P < 0.01$). Interestingly, in the specific subgroup of patients receiving surgery for benign or premalignant disease, the rate of spleen preservation was 43% and 14%, respectively. This data is consistent with that observed by Xie *et al.* in a recent, well-conducted meta-analysis comparing the relative results of open *vs.* laparoscopic DP on more than 1,300 patients from 9 studies (14). The open and laparoscopic groups were homogeneously distributed for the relative proportions of benign conditions and malignancies Overall, there was a significant difference (risk ratio, 2.38) in the rate of spleen preservation favoring MIS over conventional surgery (13% *vs.* 30%, respectively).

Currently, minimally invasive spleen-preserving DP is performed at specialized centers both by conventional laparoscopy and robotic surgery. However, a number of reports, including meta-analyses have shown possible advantages associated with the application of robotic platform on the rate of spleen preservation and conversion to open surgery as compared to conventional laparoscopy (15-20). Hong *et al.* recently evaluated a consecutive series of minimally invasive DP performed by a single, experienced surgeon (4). The difference in the percentage of spleen-conserving procedures between robotic and laparoscopic PD was analyzed on an intent-to-treat basis for splenic preservation. Overall, there was a significantly higher rate of splenic preservation favoring the robot (96.8%) over conventional laparoscopy (82.5%). This finding was already observed by two recent reviews by Guerrini *et al.* (20), and Røsok *et al.* (2) comparing robotic and laparoscopic PD. Overall, the meta-analysis of data showed a significantly higher proportion of spleen-preservation and a lower rate of conversion to laparotomy for the robotic group.

Actually, minimally invasive spleen-preserving DP, and especially the SVP technique is regarded as a technically highly-demanding surgery (3,4,13,16). Several crucial maneuvers, such as pancreatic dissection, and especially

splenic vessels dissection are likely facilitated by the use of the robotic system (4,16,17). The magnified 3D-view and the augmented dexterity enable not only easier dissection and suture, but also simplify the management of intraoperative complications such as vascular injuries, which are main factors increasing the rate of conversion to open surgery (2,17,20).

Conclusions

The relative lack of high-level studies still preclude definitive conclusions on the argument. However, increasing evidence is supporting the role of the robot in performing minimally invasive DP, especially when surgery is performed with the intent to preserve the spleen. As shown in the present report, the technology of the robotic system is a valid option to perform minimally invasive DP with preservation of the spleen and splenic vessels competently.

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Footnote

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Ethical Statement: The authors are accountable for all aspects of the work in ensuring that questions related to the accuracy or integrity of any part of the work are appropriately investigated and resolved. All procedures performed in studies involving human participants were in accordance with the ethical standards of the institutional and/or national research committee(s) and with the Helsinki Declaration (as revised in 2013). Written informed consent was obtained from the patient.

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1. Dr. Giovanni Battista Levi Sandri: Did authors had conversion during robotic pancreatectomy? If yes, it was an elective conversion for an unfavorable intraoperative finding or an emergency conversion secondary to an unfavorable intraoperative event?

Authors' answer:

Over the last years our group has reached a significant experience on robotic pancreatectomy made up of about 150 cases including pancreaticoduodenectomies, distal pancreatectomies (with or without splenectomy) and enucleations. In the case of pancreaticoduodenectomy, 12% of conversion to an open procedure were recently reported by our group concerning the recent experience with the technique. These cases were converted to laparotomy mainly in relation with severe peritoneal adhesions or the presence of advanced disease. There was one procedure which was converted due to an uncontrolled bleeding from the splenic vein. With regard to distal pancreatectomy and pancreatic enucleation, all surgeries were completed with the robot and no conversion to open surgery occurred.

2. Dr. Giovanni Battista Levi Sandri: It is necessary a learning curve of previous distal pancreatectomy with splenectomy?

Authors' answer:

It is quite difficult to assess the actual learning curve of surgical procedures which are relatively uncommon such as robotic distal pancreatectomy with preservation of the spleen. Conventionally, certain endpoints of pancreatic surgery such as intraoperative blood loss, operating time, length of postoperative hospital stay, the rate of postoperative morbidity and particularly POPF are considered as primary measures of interest. Nevertheless, to define a reliable learning process for distal pancreatectomy with preservation of the spleen, other crucial factors are to be taken into account beside the specific experience of the operating surgeon. Among these, patients clinical characteristics, the rate of splenic vessels preservation, and, importantly, the level of training of the entire surgical team are to be considered. With specific reference to the surgical procedure, in the early period non-experienced surgeons must consider cases requiring splenectomy or, theoretically, the Warshaw technique in those where the spleen should be preserved.