Minimally invasive distal pancreatectomy: mapping surgical maneuvers towards operative standardization

Ann Ital Chir, 2022 93, 1: 122-129
pii: S0003469X21036150
Online ahead of print 2021 - Oct. 13
free reading: www.annitalchir.com

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Minimally invasive distal pancreatectomy: Mapping surgical maneuvers towards operative standardization

AIM: *To analyze the minimally invasive surgical maneuvers currently performed to remove pancreatic tail, with or without preservation of the spleen, for benign and borderline malignant neoplasms.*
MATERIAL AND METHODS: *We described operative steps and technical pitfalls encountered during laparoscopic and robotic distal pancreatectomy. The methodology of research focused on recruitment of evidence-based surgical strategies and critical analysis of modern minimally invasive techniques.*
RESULTS: *Laparoscopic and robotic distal pancreatectomy have gradually accepted by pancreatic surgeons and clinical evidences document its growing interest. The choice of patient positioning, port placement, surgical dissection and operative techniques used for pancreatic parenchymal transection is not codified and changes according to personal preference. The technical variability in minimally invasive approach to pancreatic surgery strongly depends depends on surgeon's training and to limited application of these procedures in single institutions.*
CONCLUSIONS: *Pancreatic surgeons worldwide accept laparoscopic and robotic distal pancreatectomy but the best intraoperative praxis is not defined in clinical routine. To date, the pancreatic resection adopts hybrid techniques and the conduction of minimally invasive resection depends to surgeon's experience, patient body habitus and location of pancreatic lesion. Although several technical variations have described, no standardization of the operative minimally invasive surgical method is convincingly built.*

KEY WORDS: Laparoscopy, Minimally invasive surgery, Pancreas, Robotic pancreatectomy

Introduction

Laparoscopic distal pancreatectomy (LDP) is performed by 79% of the surgeons and its success varies between 10.8 to 46.6% [1]. In selected patients affected by benign and borderline distal pancreatic tumors, LDP is a feasible and effective alternative to laparotomy but technically more demanding than conventional surgery [2-4]. The lack of standardization of LDP depends to the limited diffusion of LDP in single institutions and to surgeon's preference [5,6]. The LEOPARD study reports that LDP is statistically significant associated with less blood loss, longer operative time, shorter hospital stay and faster functional recovery [1]. LDP remains a difficult operation with a high conversion rate that varies between 0-34% and it is related to surgeon's learning curve [1,3-8]. Splenectomy is often associated with LDP for technical reasons, such as vascular involvement, or potentially because the spleen preservation may be challenging [3]. In 1988, Warshaw introduces a spleen-preserving distal pancreatectomy with transection of the splenic vessels and preservation of short gastric and left gastroepiploic vessels [9]. In 1996, Kimura describes a technique of spleen-

Pervenuto in Redazione Marzo 2021. Accettato per la pubblicazione Marzo 2021
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preserving distal pancreatectomy, including preservation of the splenic artery and vein [10]. In 1996, Cuscheri performs the first LDP and, more recently, Melvin performs robotic distal pancreatectomy (RDP) [11]. After this period, a growing number of studies documented the feasibility of RDP and the continuous interest in minimally invasive pancreatectomy [6,12.] RDP is the evolution of minimally invasive concept and it has the potential to overcome the limitations of LDP, in terms of better dexterity and three-dimensional visualization [13]. However, there is no consensus on which approach is better, because both LDP and RDP appear equivalent [13].
The aim of this article is to focus on the emerging operative maneuvers performed during LDP and RDP with discussion of operative steps.

Technical Notes

Several techniques have proposed to remove pancreatic tail and encouraged results have more recently reported [5,14]. Pancreatic resection techniques adopt a "medial to lateral", a "lateral to medial" or a "hybrid technique" [6]. The prograde pancreatectomy, by transecting the pancreatic body first and then moving up towards the spleen, is the most widespread technique [7,15]. The retrograde pancreatectomy, on the contrary, consists of initial mobilization of the pancreatic tail from the splenic hilum and dissection of the distal margin of the gland to look for the splenic vein and artery [16].
After the induction of general anaesthesia, LPD is performed in a supine or in a right lateral position [17]. In laparoscopic and robotic approaches, the pneumoperitoneum is established via open technique, through periumbilical incision under direct vision or closed technique with Veress needle in the left upper quadrant [18]. Although the choice of trocar's position during LDP or RDP is personal and changes by surgeons, it is important to respect the triangulation of trocars with at least 5 cm distance to have a sufficient range of motion. Conceptually, the trocars are located according to patient's body habitus and pancreatic lesion.[18]
Commonly four trocars are used and the patients are in reverse Trendelenburg position (30 degree) [19,20]. The trocar's position follows this sequence: a supra-umbilical port, a left hemi-abdomen port, a subcostal left lateral trocar, and an epigastric 5 mm trocar to the right of the midline [19,20]. Hu and colleagues use four trocars with the followed operative positioning [2]. A 30° laparoscope is inserted in a 10-mm trocar below the umbilicus; the primary port is located on the left midclavicular line and on the midline between the xiphoid process and the umbilicus; the secondary port is located on the lateral margin of the left rectus abdominis muscle and a third trocar is placed on the left midaxillary line. In case of obese patients, trocar positioning is moved higher to facilitate the reach of the superior pole of the spleen. In conclusion, we can deduce that a comfortable and advantageous setting is the position of trocars according to a semi-circular fashion centered on an umbilical camera [3]. In the French experience, the patient is placed in a modified lithotomy position and the operating surgeon between the patient's legs. In semi-lateral decubitus position, the surgeon is placed to the patient's right. While the French position is useful in case of exposure of the body and neck of the pancreas, the second option is indicated for lesions of the tail of the pancreas [5]. The patient can be positioned either supine or in a right lateral decubitus according to the preference of surgeon, with the advantages that the supine setting is suited for anterograde dissection (right to left), and offers the possibility of a rapid conversion in case of uncontrolled bleeding. On the other site, the right lateral decubitus is preferred for retrograde dissection (left to right). This technique is associated with an easier mobilization of the spleno-pancreatic block .[21]
To avoid injury of the pancreas and obtain adequate margins, a Penrose drain is brought around the pancreas as a "lasso" for atraumatic manipulation [22]. Using the Penrose drain, the pancreas is retracted away from the retroperitoneum, and the retropancreatic dissection may be finally completed. The "lasso" technique reduces the risk of pancreatic parenchyma disruption, the percentage of bleeding and peritoneal seeding from the tumor [22]. In 2017, a modified "lasso" technique is proposed with the aim of reducing the post-operative bleeding from splenic artery [23]. Three LDP methods are nowadays reported. In conventional LDP, the splenic artery and vein are separately ligated and divided, and the pancreatic parenchyma is divided with a stapler. The original "lasso" technique consists in the division of vessels and pancreatic parenchyma using a laparoscopic mechanical stapler. In the modified "lasso" technique, the splenic artery is ligated using ties or clips and a mechanical stapler is used to divide the pancreas together with the splenic artery and vein in the distal part [23]. Several strategies are proposed but no agreement is still reached on the best surgical management of splenic vessels closure.
Surjan and colleagues develop an innovative technique to retract the stomach during LDP. They use equally four trocars (sub-xiphoid 5-mm trocar, transumbilical 10-mm trocar; left anterior axillary 12-mm trocar and one right midclavicuar 5-mm trocar) and a gastric retraction with a polyester tape through the sub-xiphoid trocar incision. This atraumatic manoeuvre allows the assistant to help surgeon by retracting the stomach and by making the 5-mm sub-xiphoid port a multi-task access [24].
With an Intuitive DaVinci Xi system, eight trocars are used for instrument arms, the supra-umbilical trocar for camera, and the 12 mm left para-median trocar for stapling device [26].
The trocar placement is similar to those used in LDP and a combination of 5, 8 and 12 mm in diameter is commonly used [26]. The feasibility of RDP is well estab-

lished and the cost-effectiveness, on the contrary, remains a matter of an ongoing debate [27,28].

In case of difficult identification of splenic vein, one suggestion coming from pancreatic surgeons is to identify the splenic vein-portal vein junction under the pancreatic neck, and subsequently follow the splenic vein toward the spleen. While the splenic vein is situated posterior to the pancreas and lying deeply in the pancreatic gland, the splenic artery is located along the superior border of the pancreas [25]. The modern minimally invasive techniques of the pancreas have to be inevitably built on key anatomical landmarks.

Excellent outcome is reported after LDP with a clockwise approach for dissection, combined with the progressive stepwise compression technique for pancreatic transection [4]. This surgical procedure includes the mobilization of the proximal descending colon along Toldt fascia with transection of the short gastric vessels; the dissection along the inferior edge of the pancreas; the pancreatic transection and ligation of splenic vessels; the dissection along the superior edge of the pancreas, the mobilization of the spleen and, finally the specimen removal [4].

In the experience of Southampton General Hospital, the LDP steps consist on division of the gastro-colic ligament up to the splenic flexure and adhesions between posterior stomach wall and the pancreas. The stomach is lifted via the epigastric port. The pancreatic dissection starts by mobilizing the lower margin 2 cm proximal to the lesion and then the superior pancreatic margin to permit the placement of a nylon tape around the pancreas. The transection of parenchyma requires the use of an endoscopic stapler [6].

Hasselgren and colleagues propose the following techniques for LDP: mobilization of the left colonic flexure with division of the spleno-colic and gastro-colic ligament with the exposure of the lower border of the pancreas [29]. Kudsi and co-workers follow these manoeuvres: transection of gastro-colic ligament to open the lesser sac, ligation of short gastric vessels and mobilization of the splenic flexure by dividing the spleno-colic ligament, dissection of the inferior border of the pancreas and creation of a window below the pancreatic edge and the retroperitoneum for pancreatic mobilization. Before pancreatic transection, the parenchyma is retraced superiorly and anteriorly. An en-bloc transection of the splenic artery and vein together with pancreatic parenchyma is finally performed [30]. First experiences on LDP report the use of large metallic clips in ligation of splenic vein and artery. In selected cases, a vascular endo-GIA is preferred due to the splenic vein diameter [15,31]. Surgeons report wide heterogeneity in this practice and any standardized technique of vascular closure is still reached.

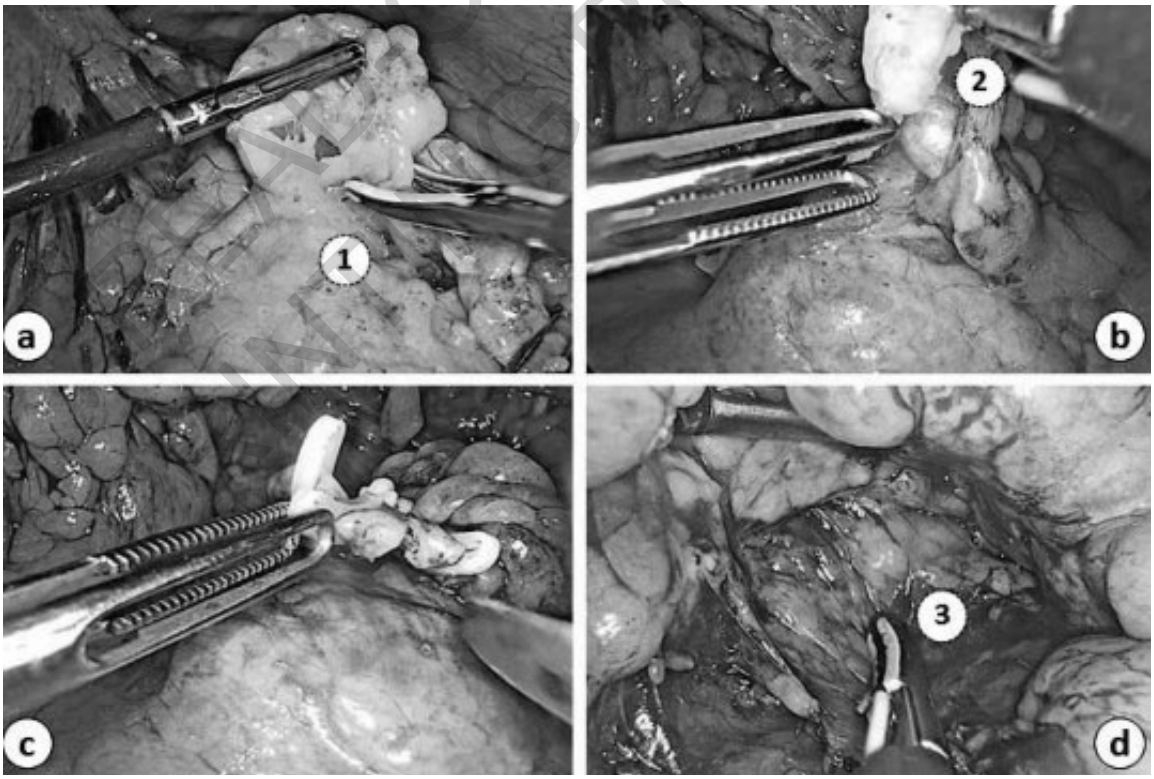

Fig. 1: Operative field view of LDP (photos of personal experience); a) Lesser sac exposure; b) Isolation of splenic artery on superior border of the pancreas; c) Division of splenic artery with Hem-o-lok clip; d) Dissection of the inferior border of the pancreas, by developing an avascular posterior plane between the pancreas and the retroperitoneum.

After the division of the gastro-colic omentum and the retraction of the stomach anteriorly and superiorly, the dissection of the splenic artery is the recommended first step of LDP [5]. The splenic artery is divided in the site of the planned resection of the pancreas. After the division of the posterior peritoneum along the inferior margin of the pancreas, it is useful to proceed with the identification of the inferior mesenteric vein as a guide of splenic vein dissection [5]. After splenic artery and vein division, the pancreas is transected and the stump is elevated anteriorly and laterally to complete the pancreatic dissection and the spleen. In accordance with these considerations, the experience of French Hepatobiliary Surgeons recommends first the splenic artery control, the use of linear stapler for parenchyma transection, the splenic vein control and preservation of splenic vessels when possible [21]. De Rooij and colleagues suggest that during LDP the best option is to first transect the pancreas and then separate the splenic vessels. The splenic artery is identified at the superior margin of the pancreas and slung with a vessel loop which is secured with a Hem-o-lok clip (Telefrex Medical, Weck Drive, Research Triangle Park, NC, USA)[32].

The ligation of splenic artery should be the first surgical step following by ligation of the vein and the transection of the pancreatic parenchyma (Fig. 1). The advantages of ligation and division of the splenic artery are based on the better control of intraoperative bleeding and splenic rupture. We prefer to use Hem-o-lok clips to titanium clips, but no clinical evidences have been reported in terms of better outcome or intraoperative advances. After splenic artery division, we prefer to closure splenic vein with the same methods, and then proceeding to parenchyma transection with vascular stapler (Fig. 2). The selected ligation and division of splenic vessels are probably more useful in controlling the postoperative complications of pancreatic fistula development, because the vessels are separately closed with non-absorbable materials rather than bipolar coagulation.

Many techniques for resection and closure of the pancreatic remnant have proposed: hand-sewn suture techniques or stapled closure, usually an Endo-GIA™ Tri-staple™ (Covidien, Medtronic) and purple reload, 60 or 45 mm and the use of a bioabsorble staple line reinforcement (GORE® SEAMGUARD® Bioabsorbable Staple Line Reinforcement) or a combination of both [14,33,34]. An alternative way to transect the parenchyma is to use ultrasonic devices or even simple scissors, followed by the placement of interrupted stitches to achieve hemostasis and to close the main pancreatic duct. The pancreatic stump might be treated with the apposition of fibrin glue [30,31]. The DISPACT trial, designed to assess

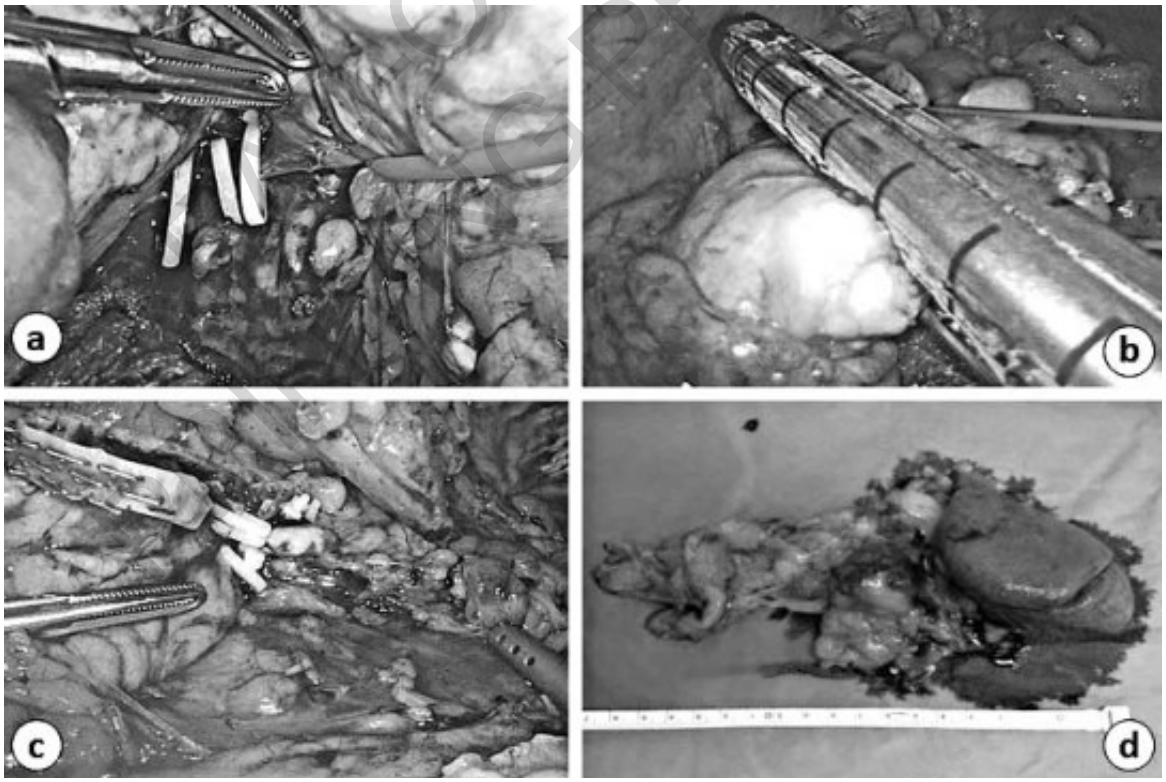

Fig. 2: Operative field view of LDP (photos of personal experience); a) Isolation of splenic vein and its division with Hem-o-lok clip; b) Pancreatic transection with an articulated rotational endoscopic 60-mm linear stapler with preloaded buttress material; c) Dissection of the spleno-pancreatic block (medial to lateral); d) Surgical specimen (pathological confirmation of neuroendocrine tumor).

the effect of stapler versus hand-sewn closure on formation of postoperative pancreatic fistula (POPF) after distal pancreatectomy, concludes that both stapler and hand-sewn closure were equally safe after distal pancreatectomy [35]. Furthermore, gradual closing of the stapler over the course of about the 2-3 minutes could reduce POPF rates, as reported by Asbun [4]. Transection is performed by an endostapler (Endo Echelon 60 mm stapler with gold cartridge; Johnson & Johnson; Ethicon Endo surgery or EndoGIA; EndoGIA -II 45-4.8 stapler with purple cartridge; Tyco Healthcare, Norwalk, CT, USA) with a prolonged peri-firing compression of 5 minutes, and a continuous suture (4-0 nylon, Johnson & Johnson; Ethicon Endo surgery) just proximal to the stapler line [36]. The combination of linear stapling, peri-firing compression plus continuous suture prevents the occurrence of POPF [36]. Recent evidences show that utilization of a stapler for transection of the pancreas is the most popular method, more commonly applied in North-America than in Europe/Africa/Middle East [37,38,39]. Interestingly, dividing the pancreas using 2.5 mm vascular stapler might significantly decrease the rate of POPF compared with 4.5 mm stale cartridges [3]. Round ligament closure is considered an additional method of patch closure followed by seromuscolar patch closure [40]. Concerning the current techniques of parenchyma transection, no consensus is still reached on the best surgical method.

The traditional approach of left-to-right pancreatic distal resection plus splenectomy is associated with a high positive tangential margin. For this reason, the research group of Washington University in St. Louis has introduced the approach called radical antegrade modular pancreatosplenectomy (RAMPS), that allows a more comprensive lymphadenectomy of the N1 nodes and reduces the risk of positive posterior resection margins [25]. During RAMPS, the pancreatic dissection starts from right-to-left with early division of the neck of the pancreas and splenic vessels and a celiac node dissection. The RAMPS is modular and the dissection ca be anterior, along a more superficial plane, directly on the left adrenal gland and Gerota' fascia surface or posterior to adrenal and Gerota' fascia, along the surface of the left kidney [41]. The indication of this technique, anterior or posterior, is based on the presence of a rim of normal pancreas posterior to the tumor.

When the trocars are inserted as described both in LDP and in RDP, an extended incision between the two trocars of the left upper quadrant might be useful to extract the resected specimen using a disposable sterile endobag [2]. In other cases, the Pfannenstiel incision is used to extract the specimen [6]. The drain is advocated with the aim to be placed in the pancreatic stump area and it is used since most fistula can be managed conservatively [2,6,7]. The technical conduction of LDP is determined by individual surgeons and additional results are necessary to determine the best minimally invasive approach [17].

By using robotic platform, the operation continues by following the same steps of LDP, with opening the lasser sac and with tunnelisation of the pancreas. Splenic

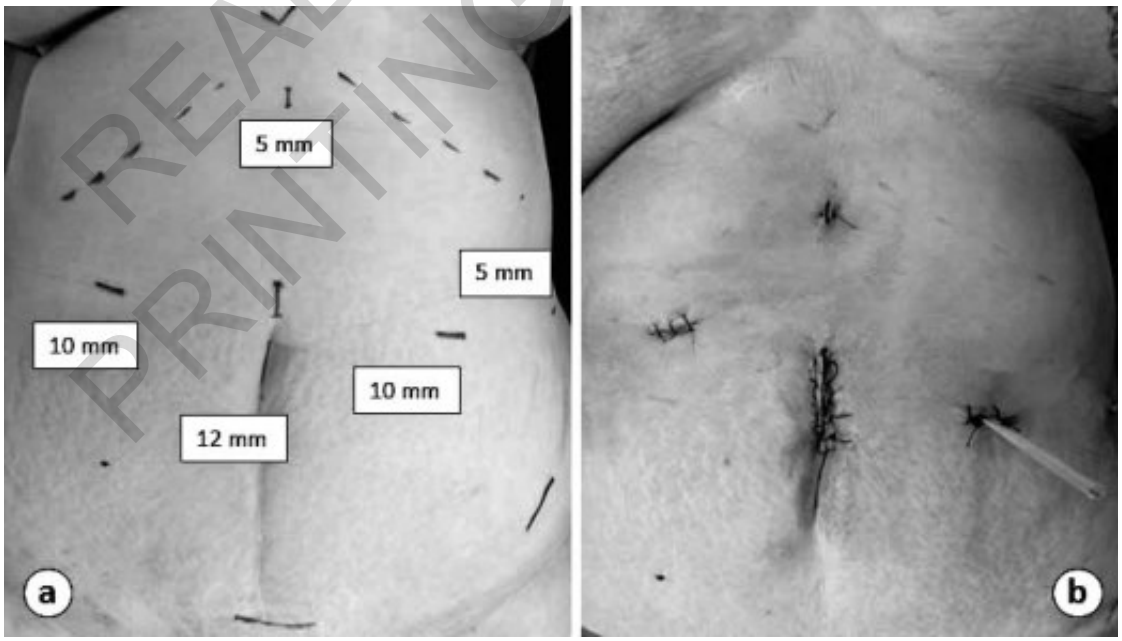

Fig. 3: Operative field view of LDP (photos of personal experience); a) Patient is in a supine position with legs apart. One 12-mm (optical), two 10-mm and two 5-mm trocars are introduced; b) Cosmetic results after LDP. The specimen is took out of abdomen through a 4-5 cm incision in periumbilical area. One drainage tube is placed near the pancreatic stump.

vessels are preserved or divided according to the need of spleen preservation [12]. A liver retractor is placed through epigastric port site [26]. During RDP, the splenic artery is divided using surgical clips or a vascular stapler, as well as splenic vein after its dissection on the posterior aspect of pancreatic body [26]. In retrospective review of 102 consecutive RDP and LPD, RDP is performed using three robotic arms (2 left, and 1 right), and the robotic camera system. The bedside assistant uses conventional laparoscopic suckers, bowel graspers, and endostapler (in a 12-mm trocar placed in the left iliac fossa) [13]. According to the clinical experience, the pancreatic dissection proceeded from the medial to lateral position with exception of distal pancreatic tail lesions.

The really advantages of RDP are the increased percentage of spleen salvation, a lower rate of conversion to open, and the ability of performing technically complex maneuvers, especially during resection of gastroduodenal and infra-pancreatic lymphonodes [11,12,26,42]. No significant difference in the perioperative outcome such as transfusion rates, postoperative length of stay and mortality rate is reported between RDP and LDP [13].

Discussion

Pancreatic surgeons accept LDP and RDP worldwide but the best operative praxis has not been defined in clinical routine. The choice of trocar's position during LDP and RDP is heterogeneous and it depends to patient's habitus and location of pancreatic lesion. It is important to respect the trocar's triangulation to have a range of motion. According to these observations, it is very difficult to standardize this operative step. The direction of dissection remains a matter of different points of view during LDP or RDP and it depends to surgeon's preference and anatomical landmarks. To accomplish this aspect, a good knowledge of anatomy is necessary to perform a safe and oncologically surgical dissection along the embryological planes, by preventing surgical pitfalls. Experience coming from evidence-based surgical practice recommends performing primary control of the splenic artery to reduce the risk of uncontrolled intraoperative bleeding. This is a meticulous surgical maneuvers and the choice of stapler or clips for closure of splenic vessels depends to operator. The technique of parenchyma transection is an additional crucial step but still displays significant variability due to the scarcity of solid evidences in reducing POPF rate. Minimally invasive surgical procedures performed to remove pancreatic tail are not standardized operations. The minimally invasive technique is strongly influenced by surgeon's training and presents significant personal variability. Although several technical variations have described during LDP and RDP, no agreement is conclusively reached on the adoption of the best advisable and reproducible surgical method.

Riassunto

Obiettivo: Analizzare le manovre chirurgiche mininvasive attualmente in uso e necessarie per asportare la coda del pancreas, con o senza la tecnica di preservazione della milza, nei casi di neoplasie pancreatiche benigne e borderline.

Materiale e Metodi: riportiamo la descrizione dei tempi operatori e la valutazione delle difficoltà tecniche riscontrate durante la pancreasectomia distale laparoscopica e robotica. Il metodo di ricerca si focalizza sul reclutamento delle strategie chirurgiche più attuali e basate sull'evidenza clinica, oltre che sull'analisi critica delle moderne tecniche mininvasive.

Risultati: La pancreasectomia distale laparoscopica e robotica sono state gradualmente accettate dai chirurghi del pancreas e le evidenze cliniche dimostrano il dilagante interesse scientifico. La scelta della posizione operatoria del paziente, la disposizione dei trocars sulla parete addominale, la scelta delle tecniche operatorie di dissezione e la condotta chirurgica di resezione del parenchima pancreatico non sono state codificate e variano secondo l'esperienza del chirurgo. La variabilità dell'approccio mininvasivo dipende notevolmente dal training del chirurgo e dalle limitate applicazioni della metodica stessa nei singoli centri.

Discussione: In tutto il mondo i chirurgi del pancreas hanno accettato le tecniche di pancreasectomia distale laparoscopica e robotica ma la strategia chirurgica operatoria non è stata codificata nella pratica clinica. Ad oggi la resezione del pancreas viene condotta con tecniche ibride e la variabilità dell'approccio chirurgico mininvasivo dipende in modo significativo dall'esperienza del chirurgo, dall'abitus del paziente e dalla localizzazione della lesione pancreatica. Nonostante le numerose variazioni di tecnica chirurgica finora descritte durante l'intervento di pancreasectomia distale, nessuna standardizzazione del metodo operatorio mininvasivo è stato definito in modo convincente.

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