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HOW-I-DO-IT ARTICLE

Left kidney mobilization technique during radical antegrade modular pancreatosplenectomy (RAMPS)

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Abstract

Purpose Radical antegrade modular pancreatosplenectomy (RAMPS) has been accepted as a standard operation for distal pancreatic cancer. While enbloc retroperitoneal dissection in the "medial to lateral" direction is one of the most important steps in this oncologic procedure, it is technically challenging due to the depth of organs under the left costal margin, and poor exposure of the resecting organs in this area will increase the risk of incomplete oncologic dissection.

Methods To improve exposure of the left upper quadrant organs, left kidney was completely mobilized during RAMPS, and all the left upper quadrant organs were elevated and medialized by lap sponges packed in the retrorenal space. The operative and oncologic outcomes for patients who underwent our modified RAMPS with left kidney mobilization were evaluated.

Results One hundred and forty-four patients with distal pancreatic cancer underwent this procedure from 2005 through 2016. The median operation time was 310 min (range, 132–899), and blood loss was 440 ml (25–2430). There was no complication associated to left kidney mobilization. The median number of harvested lymph nodes was 27 (3–87). While 77% of the tumors had microscopic retroperitoneal invasion, 96% of patients achieved negative retroperitoneal margin.

Conclusions Left kidney mobilization is useful for safe and oncologically sound lateral retroperitoneal dissection during RAMPS for distal pancreatic cancer.

Keywords Radical antegrade modular pancreatosplenectomy · Kidney mobilization · Surgical technique · Distal pancreatic cancer

Introduction

Radical antegrade modular pancreatosplenectomy (RAMPS), first reported (in English) by Strasberg et al. in 2003 [1], has been accepted as a standard oncological operation for distal pancreatic cancer. This operation is characterized by dissection of the distal pancreas with retroperitoneal tissue enbloc in "medial to lateral" direction, which can provide better chance of negative tangential margin compared with the traditional distal pancreatectomy with "lateral to medial" dissection [2, 3]. However, the step of lateral retroperitoneal dissection during RAMPS is often challenging because of poor exposure of the dissection plane around the deep organs under the rib cage, particularly for deep-chested or obese patients.

Herein, we illustrate our modified RAMPS with left kidney mobilization for patients with distal pancreatic cancer. This simple trick can provide better exposure of the organs at the left upper quadrant abdomen, and it would not only make the lateral retroperitoneal dissection easier and safer but also enhance the oncologic clearance because of more precise complete retroperitoneal resection.

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Methods

Detail of the procedure

Step 1. *Dissection of left renal vein from the right*

Initial several steps for our modified RAMPS procedure are similar to the original RAMPS proposed by Strasberg et al. [1]. After confirmation for absence of distant metastasis, the operation is commenced with formal Kocher's maneuver to mobilize the pancreas head and the duodenum. The para-aortic lymph nodes can be sampled at this point for staging purpose, and the anterior surface of left renal vein was dissected free as medial as possible beyond the superior mesenteric artery. When metastasis to the para-aortic lymph nodes is confirmed by frozen section, the resection should be aborted (Fig. 1a).

Step 2. *Lymphadenectomy around the celiac axis and division of pancreatic neck*

The lessor sac is entered by incising the gastrocolic ligament, and the pancreas is exposed widely. The neck of the pancreas is elevated off the superior mesenteric vein and portal vein from below. The superior border of the pancreas is dissected, and the lymph nodes left to the proper hepatic artery and around the common hepatic artery are swept medially toward the specimen. The splenic, left gastric, and celiac arteries are subsequently skeletonized, and the left gastric vein is divided. The left gastric artery can be preserved unless it needs to be removed to ensure the oncologic margin. The splenic artery is then ligated and divided at its root. The portal vein is exposed behind the gastroduodenal artery, and the tunnel between the neck of the pancreas and portal vein is completed. The pancreatic neck is then divided with a stapling device, and the splenic vein is suture ligated and divided near the confluence. The inferior mesenteric vein is also divided when it is necessary. The left side of the superior mesenteric artery is dissected down to the retroperitoneum until the left renal vein is seen. The identification of left renal vein is facilitated as the left renal vein has been dissected off the retroperitoneal fat from the right-side during step 1. This anterior surface of the left renal vein would be the posterior end of the retroperitoneal dissection (Fig. 1b).

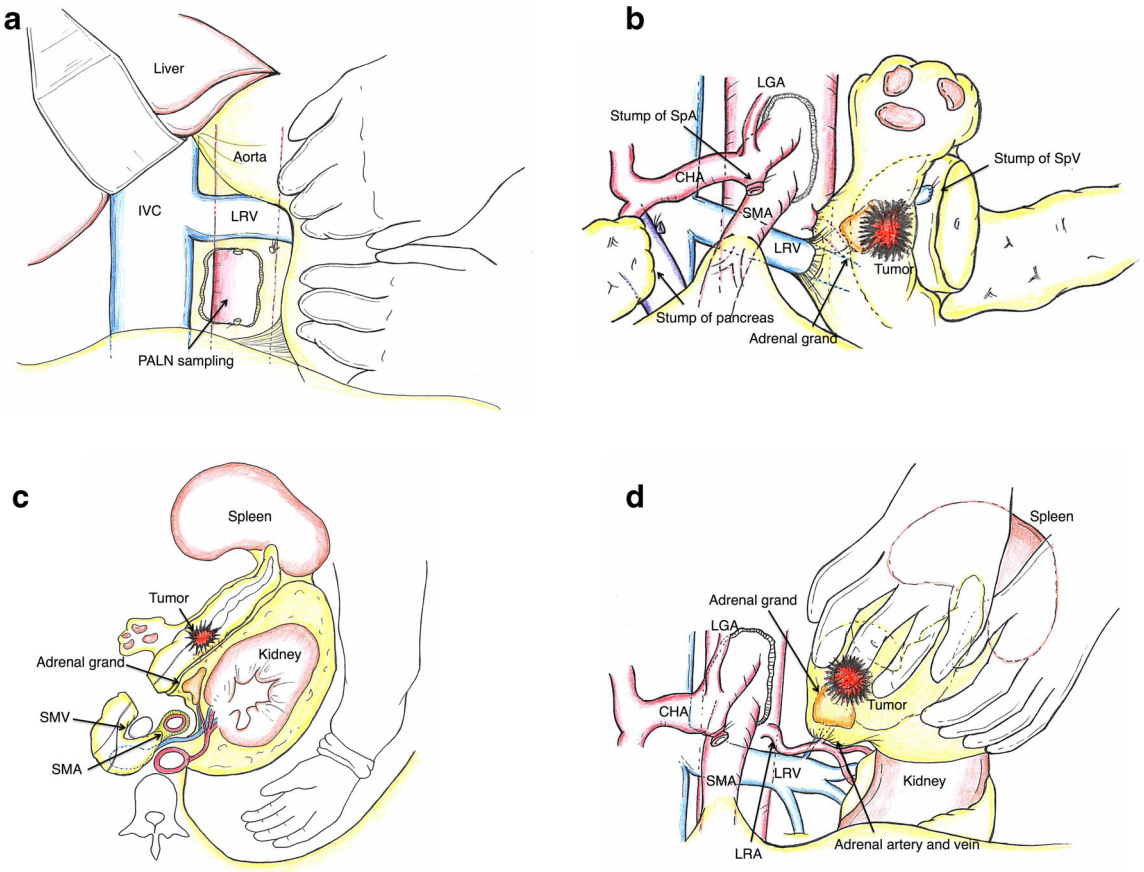

Fig. 1 The key steps of modified RAMPS were illustrated. **a** Kocher's maneuver and dissection of anterior surface of left renal vein. **b** Lymphadenectomy around the celiac axis and division of pancreatic neck. **c** Left kidney mobilization. **d** Left to right retroperitoneal dissection with or without adrenal resection

Step 3. *Mobilization of left kidney*

The small intestine is pulled out from the left upper quadrant and packed to the right by lap sponges. The parietal peritoneum at the left lateral gutter is incised, and the space between the kidney and the psoas muscle is entered. This plane behind the kidney is always avascular and easily dissectable with the operator's finger up to the diaphragm superiorly and the aorta medially (Fig. 1c). Once the dissected space is packed with lap sponges, all the organs at the left upper quadrant including spleen, pancreas, and kidney are lift up to the anteromedial surgical field, and the rest of the dissection becomes much easier and safer. The short gastric vessels are divided, and the splenic flexure is taken down.

Step 4. *Left to right retroperitoneal dissection with or without adrenal resection*

The final step of this procedure is to complete the retroperitoneal dissection. The lateral retroperitoneum was incised down until the surface of the left kidney is exposed. The retroperitoneal tissue is dissected off the kidney with the Gerota's fascia from left to right with skeletonizing the renal vein and artery. As the left adrenal gland is located at the plane above the Gerota's fascia, when the adrenal is to be preserved (for anterior RAMPS), the dissection plane needs to be switched to one layer up by incising the anterior renal fascia, and some retroperitoneal tissue would inevitably be left behind around the adrenal. When the adrenal gland is to be resected (for posterior RAMPS), the adrenal artery and vein are ligated and divided and the all the retroperitoneal fatty tissue above the renal vein can be resected enbloc (Fig. 1d). When the medial and lateral sides of the posterior dissection planes are connected, the specimen can be removed. Figure 2 shows the conclusion of our dissection for posterior RAMPS. Of note, the roots of the celiac artery and the superior mesenteric artery and the entire length of left renal vein are visible representing complete regional lymphadenectomy and retroperitoneal tissue dissection.

It has been our standard to slice the specimen transversely and evaluate/report microscopic superior, inferior, and posterior margin addition to the pancreas stump margin status. We highly recommend to ink the posterior retroperitoneal margin to ensure accurate histologic evaluation.

Results

From 2005 to 2016, we performed modified RAMPS on 144 patients with pancreatic cancer at the body and tail. Table 1 summarized the demographics of our patients and their short-term outcomes. Most of our patients had large tumor (median 3.5 cm (range, 0.6–13 cm)) with 40% of T3 disease (> 4 cm) according to the 8th UICC staging system. One hundred and one patients (70%) underwent posterior RAMPS, and 22 patients (15%) underwent additional organ resection other than adrenal gland. The median operative time was 310 min (132–899 min), and the median blood loss was 440 ml (25–2430 ml). Transfusion was necessary only for seven patients (5%). Morbidity rate for grade 3 or higher by Clavien-Dindo classification was 13%, and 39% of patients developed pancreatic fistula (grade B, 37% and grade C, 2%).

The median number of lymph nodes removed was 27 (3–87), and 65% of patients had metastasis in the resected regional lymph nodes. The invasion into the retroperitoneum was

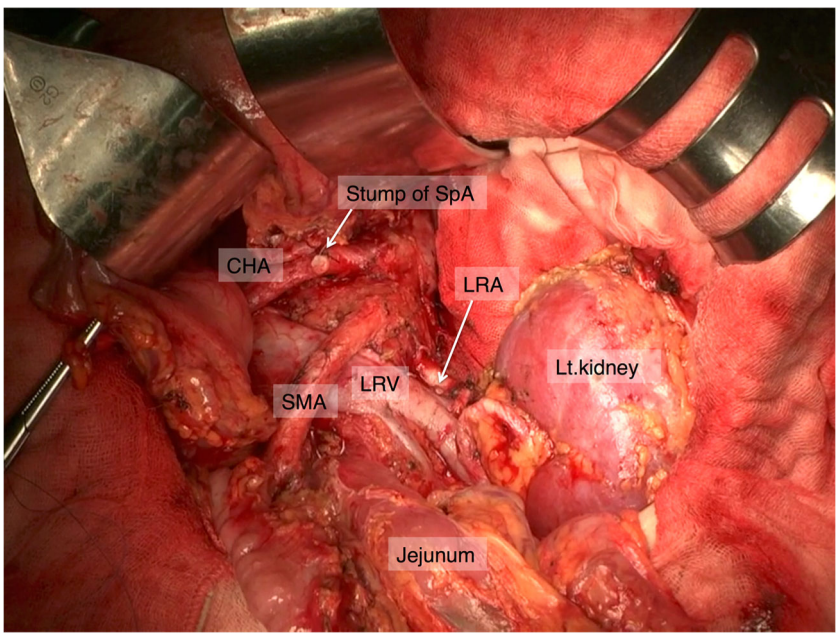

Fig. 2 The completion of posterior RAMPS. The left renal vein and artery were skeletonized, and all retroperitoneal tissue was removed. Abbreviation: *IVC*: inferior vena cava, *LRA*: left renal artery, *LRV*: left renal vein, *PALN*: para-aortic lymph node, *LGA*: left gastric artery, *SpA*: splenic artery, *SpV*: splenic vein, *CHA*: common hepatic artery, *SMA*: superior mesenteric artery, *SMV*: superior mesenteric vein

Table 1 Demographics of our patients who underwent modified RAMPS and the short-term outcomes ($n = 144$)

Characteristics	Value
Age, years	68 (36–89)
Sex, male, *n* (%)	95 (66.0)
BMI, kg/m^2	22.0 (16.0–28.2)
CEA, ng/ml	3.0 (0.5–76)
CA19–9, ng/ml	96.9 (2–50,000)
Preoperative chemotherapy, *n* (%)	1 (0.7)
Combined resection, *n* (%)	105 (73)
Left adrenal grand	101 (70)
Stomach	7 (5)
Transverse colon	8 (6)
Portal vein	8 (6)
Operation time, min	310 (132–899)
Blood loss, ml	440 (25–2430)
Transfusion, *n* (%)	7 (5)
Tumor size, cm	3.5 (0.6–13)
pT stage, *n* (%)	
T1	19 (13)
T2	67 (47)
T3	58 (40)
T4	0 (0)
# harvested LNs, *n*	27 (3–87)
LN metastases, *n* (%)	94 (65)
Retroperitoneal infiltration, *n* (%)	111 (77)
Tangenital margin negative, *n* (%)	138 (96)
R0 resection, n (%)	130 (90)
Morbidity (Clavien-Dindo ≥ III), *n* (%)	19 (13)
Intra-abdominal abscess	5 (3)
Intra-abdominal bleeding	4 (3)
Intra-abdominal fluid collection	2 (1)
Chylous ascites	1 (0.7)
Sepsis	1 (0.7)
Delayed gastric emptying	1 (0.7)
Pleural effusion	1 (0.7)
Wound infection	1 (0.7)
Perforation of small intestine	1 (0.7)
Self-removal of drain tube	1 (0.7)
Cardiac arrest	1 (0.7)
Pancreatic fistula, *n* (%)	
Grade B	53 (37)
Grade C	3 (2)
Mortality, *n* (%)	1 (0.7)
Adjuvant chemotherapy, *n* (%)	110 (76)
Continuous data was expressed as median (range)	

noted in 111 patients (77%), and the negative retroperitoneal (or posterior) margin was obtained in 138 patients (96%).

Discussion

In this brief report, we described the technical details of our modified RAMPS procedure for patients with distal pancreatic cancer. This small trick of left kidney mobilization provides much superior view of the deepest area at the retroperitoneum during the retroperitoneal dissection than the original RAMPS described by Strasberg et al. [1], and it enhances the surgical and oncological safety of this complex operation.

It has been reported that distal pancreatic cancer is less often operable than pancreatic head cancer due to late presentation of patients with distal tumor [4]. Moreover, among patients with resectable cancer, R0 resection is often difficult to achieve by the traditional "left to right" distal pancreatosplenectomy because of the tumor infiltration into the retroperitoneum. While radical distal pancreatectomy with enbloc retroperitoneal dissection had been reported from a Japanese center many years before [5], Strasberg first describe a "right to left" approach featured with complete central lymphadenectomy and enbloc retroperitoneal resection as a systematic manner in 2003. His group reported that the negative tangential margin rate was 89–94% [6–9], compared with 72 to 85% in the many other series in which the traditional left to right distal pancreatectomy used [10–15]. Though our cohort was slightly skewed as most of the patients had advanced disease, the findings of 77% of retroperitoneal infiltration and 65% of regional lymph node metastasis among the resected specimens highlight the importance of systematic lymphadenectomy and retroperitoneal dissection for curative resection for distal pancreatic cancer.

Medialization of left upper quadrant organs by left kidney mobilization was described in the old surgical atlas written by T. Kajitani in 1992 [16] as a technical trick to facilitate left upper quadrant total visceral resection for locally advanced gastric cancer, and we applied this technique to radical distal pancreatectomy. In our modification, enbloc retroperitoneal resection in left to right fashion following left kidney mobilization allows a more precise and safe dissection, while the oncologic principle remains the same as the original RAMPS procedure. Despite of much larger tumor size and more advanced tumor stage in our series, R0 resection rate was higher than the one reported from the group of Strasberg [9] (90% vs 85%) with posterior RAMPS (enbloc resection of adrenal gland) or other organ resection applied more often. Although majority of our patients underwent posterior RAMPS due to the proximity of the tumor to the adrenal grand, the oncologic benefit of posterior RAMPS over anterior RAMPS was not documented in any previous studies [15, 17, 18], and, in fact, R1 resection rate for our patients who underwent posterior RAMPS was not statistically significant for those who underwent anterior RAMPS (12% vs 5%, $p = 0.18$). Thus, we recommend against routine posterior RAMPS for all patients with distal pancreatic cancer.

The technical ease provided by kidney mobilization was evidenced by relatively small amount of intraoperative blood loss. The median blood loss for our patients was 440 ml compared with 629 ml in the series from the group of Strasberg [9]. The medialization of left upper quadrant organs can minimize the chance of splenic capsule tear by the retraction during the retroperitoneal dissection and allow better control of bleeding from the perigastric vessels or renal vessels if it happens. Indeed, only 5% of our patients received blood transfusion, and it is very important as perioperative blood transfusion has been shown to be associated with worse oncologic long-term outcomes by meta-analysis [19].

In contrast to the previously reported series from US or European centers, our cohort patients tended to be lean with median BMI of 22, and none had BMI greater than 30. As BMI likely affects the outcomes following pancreatic resection, a simple comparison for the perioperative outcomes following our modified RAMPS in our series and those following standard RAMPS for other series with greater BMI needs to be interpreted cautiously. Although it is difficult to draw any conclusion from our observation for benefits of our modified RAMPS for obese patients with BMI greater than 30, it intuitively makes sense that our technique is more advantageous for obese patients than lean patients like ours as one of the major operative challenges for obese patients is a poor exposure of the deep organs in the abdomen and left kidney mobilization can improve it.

Conclusion

We described our modified RAMPS procedure using left kidney mobilization and its short-term outcomes for our patients with distal pancreatic cancer. Further study to evaluate the long-term oncologic outcomes for the patients underwent this procedure is warranted.

Authors' contributions GW—conception or design of the work AND drafting of the work.

HI—conception or design of the work AND drafting AND critical revision of the work.

TS—conception or design of the work AND critical revision of the work.

YO—conception or design of the work AND critical revision of the work.

YM—conception or design of the work AND critical revision of the work.

YI—conception or design of the work AND critical revision of the work.

TI—conception or design of the work AND critical revision of the work.

YT—conception or design of the work AND critical revision of the work.

AS—conception or design of the work AND critical revision of the work.

All authors approved the version of the manuscript to be published and agreed to be accountable for all aspects of the work. None of the authors have any actual or potential conflict of interest in relation to the submission of this article.

Compliance with ethical standards

Conflict of interest The authors declare that there is no conflict of interest.

Ethical approval All procedures performed in studies involving human participants were in accordance with the ethical standards of the institutional and/or national research committee and with the 1964 Helsinki declaration and its later amendments or comparable ethical standards.

Informed consent Informed consent was obtained from all individual patients included in the study.

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