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# Surgical Strategies to Approaching the Splenic Artery in Robotic Distal Pancreatectomy

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**Abstract.** *Background/Aim: Understanding different surgical approaches and anatomical landmarks adjacent to the splenic artery (SpA) is important for safe robotic distal pancreatectomy (RDP). Herein, we propose our standardized RDP techniques, focusing on these issues. Patients and Methods: Between April 2021 and April 2022, 19 patients who underwent RDP at our Institution were reviewed. Anatomical patterns of the SpA were classified into three types: Type 1, no pancreatic parenchyma on the root of the SpA; type 2, any pancreatic parenchyma on the root of the SpA; and type 3, dorsal pancreatic artery around the bifurcation of the common hepatic artery and SpA. Next, the surgical strategy for approaching the SPA was determined according to the location of the pancreatic transection line: On the superior mesenteric vein (SMV) or on the left side of the root of the SpA. Results: There were seven cases of type 1, nine cases of type 2, and three cases of type 3. When transecting the pancreas on the SMV, the SpA-first ligation technique was used for type 1 SpA anatomy, and the pancreas-first division technique was applied for types 2 and 3. In patients in whom the pancreas was transected at the left side of the root of the SpA, the SpA-first ligation technique was used. Conclusion: Our standardized surgical strategy based on anatomical landmarks and focusing on the approach to the SpA in RDP is demonstrated. Our strategy should help trainees approach the SpA and perform RDP safely.*

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The importance of understanding surgical approaches for minimally invasive distal pancreatectomy (DP) has been emphasized (1). However, the surgical approaches in laparoscopic and robotic surgery are different. In laparoscopic DP, an operator usually stands on the right side of the patient and approaches the root of the splenic artery (SpA) from right to left. In contrast, in robotic distal pancreatectomy (RDP), the operator approaches the SpA caudally and moves in the cranial direction. Therefore, it is important to understand the different approaches to the root of the SpA in robotic and laparoscopic surgery (Figure 1). Another issue is the safe isolation of the root of the SpA because this is a technically challenging but unavoidable step in RDP (1). Several studies have described surgical techniques focusing on the SpA in laparoscopic DP (2-5). However, few studies have reported surgical strategies for approaching the SpA during RDP. Therefore, as it is essential to understand robot-specific surgical approaches and anatomical landmarks to perform RDP safely, in this article, we propose our standardized RDP techniques, focusing on surgical approaches to the SpA with anatomical landmarks in mind.

## Patients and Methods

*Patients*. We retrospectively reviewed 19 patients who underwent RDP at Okayama University Hospital (Okayama, Japan) between April 2021 and April 2022, with regard to anatomical variations and surgical approaches to SpA. The study protocol was approved by the Ethics Committee of our Institution (approval number 2110-002) and conducted according to the Declaration of Helsinki.

*Robotic platform*. A da Vinci Si or Xi robotic system (Intuitive Surgical, Sunnyvale, CA, USA) was used. The patient was positioned in a reverse Trendelenburg position and slightly tilted to the left. Four robotic trocars at the umbilical level and two trocars for an assistant between the robotic trocars were inserted as previously described (6). A robotic arm, including fenestrated bipolar, Maryland bipolar forceps, Cadiere forceps, and ultrasonic shears (Ligasure) were employed.

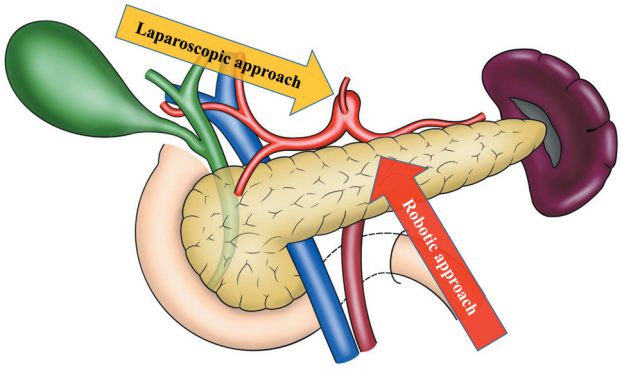


Figure 1. *Different approaches to the root of the splenic artery in robotic and laparoscopic distal pancreatectomy.*

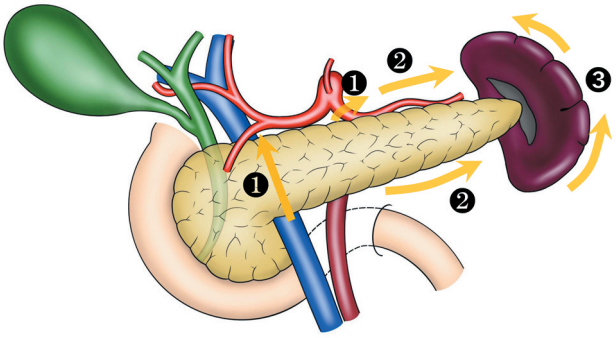


Figure 2. *The overview of the division of the pancreas and splenic vessels (step 3), and mobilization of the pancreas using a medial approach (step 4). Firstly, the pancreas or splenic vessels are divided according to our surgical strategy for approaching the splenic artery. Secondly, the pancreas is mobilized using a medial approach. Thirdly, the mobilization around the spleen is performed.*

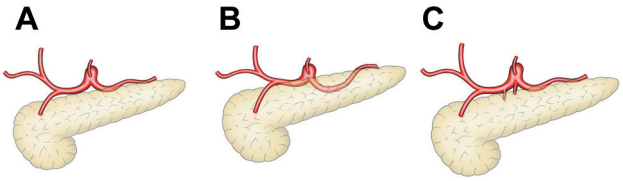


Figure 3. *Anatomical landmarks of the splenic artery (SpA). A: Type 1, no pancreatic parenchyma on the root of the SpA. B: Type 2, any pancreatic parenchyma on the root of the SpA. C: Type 3, the dorsal pancreatic artery around the bifurcation of the common hepatic artery and SpA.*

*Surgical techniques*. Briefly, our standardized surgical techniques for RDP can be categorized into the following four steps: Step 1, division of the gastrocolic ligament; step 2, dissection around the pancreas; step 3, division of the pancreas and splenic vessels; and step 4, mobilization of the pancreas using a medial approach (7). An overview of steps 3 and 4 is shown in Figure 2.

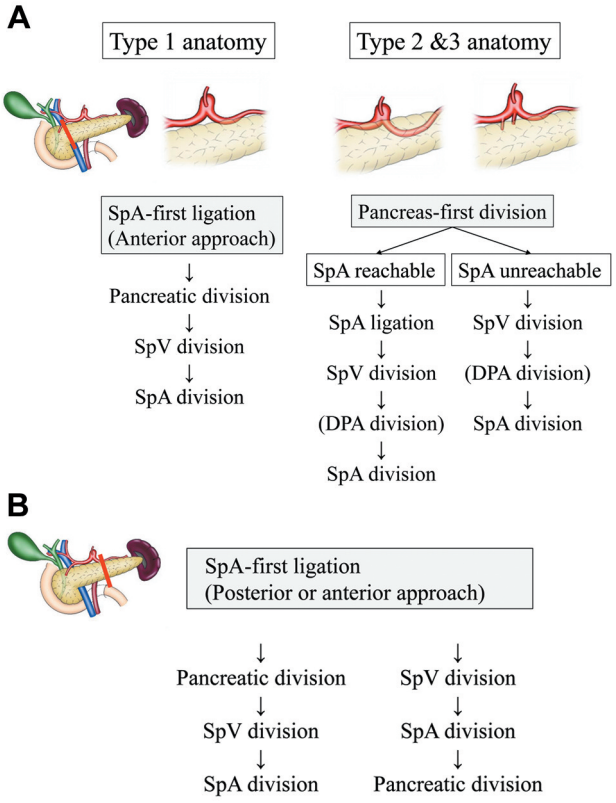


Figure 4. *The overview of the surgical strategy for approaching the splenic artery (SpA), depending on the pancreatic transection line. A: In cases where the pancreatic transection line was on the superior mesenteric vein, the SpA-first ligation with an anterior approach was performed for Type 1 SpA anatomy. In Type 2 and 3 SpA anatomy, the pancreas-first division technique was used. Next, the accessibility to the SpA was evaluated. B: In cases where the pancreatic transection line was at the left side of the root of the SpA, the SpA-first ligation technique was used with an anterior or posterior approach.*

In patients with resectable pancreatic cancer, retroperitoneal dissection with radical antegrade modular pancreatosplenectomy (RAMPS) was performed during step 4 (6, 8).

In robotic spleen-preserving DP (SPDP), the pancreatic body and tail were dissected using a medial approach, splenic vessel-sacrificing approach (Warshaw technique), or splenic vessel-preserving approach (Kimura technique) (9).

*Anatomical consideration of the SpA*. The relationship between the pancreatic parenchyma and root of the SpA should be carefully evaluated using preoperative computed tomography images. Three types of anatomical variations should be considered when approaching the root of the SpA. Type 1 includes no pancreatic parenchyma at the root of the SpA (Figure 3A). Type 2 involves any pancreatic parenchyma at the root of the SpA (Figure 3B). In addition, Type 3 are cases in which the dorsal pancreatic artery (DPA) is situated around the bifurcation of the common hepatic artery and SpA (Figure 3C).

Table I. *Characteristics of patients who underwent robotic distal pancreatectomy.*

| Case | Age, years/ sex | Disease | Procedure | PTL | Anatomy | Approach, first target | Order of division of the pancreas and splenic vessels | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | 1st | 2nd | 3rd | 4th | 5th |
| 1 | 75/F | PDAC | RDP | SMV | Type 1 | SpA | SpA ligation, anterior | Pancreatic division | SpV division | SpA division | |
| 2 | 50/F | MCN | RDP | SMV | Type 1 | SpA | SpA ligation, anterior | Pancreatic division | SpV division | SpA division | |
| 3 | 77/F | PDAC | RDP | SMV | Type 1 | SpA | SpA ligation, anterior | Pancreatic division | SpV division | SpA division | |
| 5 | 73/M | PDAC | RDP | SMV | Type 1 | SpA | SpA ligation, anterior | SpV division | Pancreatic division | SpA division | |
| 4 | 53/F | PNET | R-SPDP, Warshaw | SMV | Type 1 | SpA | SpA ligation, anterior | Pancreatic division | SpV division | SpA division | |
| 6 | 53/F | Cyst | R-SPDP, Kimura | SMV | Type 1 | | Pancreatic division | | | | |
| 7 | 65/F | PNET | R-SPDP, Kimura | SMV | Type 1 | | Pancreatic division | | | | |
| 8 | 76/F | IPMN | R-SPDP, Warshaw | SMV | Type 2 | Pancreas | Pancreatic division | SpA ligation | SpV division | SpA division | |
| 9 | 74/M | IPMN | RDP | SMV | Type 2 | Pancreas | Pancreatic division | SpV division | SpA division | | |
| 10 | 75/M | PDAC | RDP | SMV | Type 2 | Pancreas | Pancreatic division | SpV division | SpA division | | |
| 11 | 76/M | PDAC | RDP | SMV | Type 2 | Pancreas | Pancreatic division | SpV division | SpA division | | |
| 12 | 72/M | PDAC | R-SPDP, Warshaw | SMV | Type 2 | Pancreas | Pancreatic division | SpV division | SpA division | | |
| 13 | 70/F | PDAC | RDP | SMV | Type 3 | Pancreas | Pancreatic division | SpA ligation | SpV division | DPA division | SpA division |
| 14 | 79/F | PDAC | RDP | SMV | Type 3 | Pancreas | Pancreatic division | SpV division | SpA ligation | DPA division | SpA division |
| 15 | 69/F | PDAC | RDP | SMV | Type 3 | Pancreas | Pancreatic division | DPA division | SpA ligation | SpV division | SpA division |
| 16 | 51/F | PNET | RDP | Pb | Type 2 | SpA | SpA ligation, anterior | SpV division | SpA division | Pancreatic division | |
| 17 | 78/F | PDAC | RDP | Pb | Type 2 | SpA | SpA ligation, posterior | SpV division | SpA division | Pancreatic division | |
| 18 | 57/F | SPN | R-SPDP, Warshaw | Pb | Type 2 | SpA | SpA ligation, posterior | Pancreatic division | SpV division | SpA division | |
| 19 | 69/M | PanIN | R-SPDP, Warshaw | Pb | Type 2 | SpA | SpA ligation, posterior | SpV division | Pancreatic division | SpA division | |

DPA: Dorsal pancreatic artery; F: female; IPMN: intraductal papillary-mucinous neoplasm; M: male; MCN: mucinous cystic neoplasm; PanIN: pancreatic intraepithelial neoplasia; Pb pancreatic body (on the left side of the root of the splenic artery); PDAC: pancreatic ductal adenocarcinoma; PNET: pancreatic neuroendocrine tumor; PTL: pancreatic transection line.; RDP: robotic distal pancreatectomy; R-SPDP: robotic spleen-preserving distal pancreatectomy; SMV: superior mesenteric vein; SpA: splenic artery; SPN: solid-pseudopapillary neoplasm.

*Approaches to the SpA*. Surgical approaches to SpA should be in accordance with the transection line of the pancreas and anatomical variations. Our strategy for approaching the SpA is shown in Figure 4.

When the transection line of the pancreas is on the superior mesenteric vein (SMV), we propose two different approaches to the SpA based on its anatomical landmarks (Figure 4A). In type 1 SpA anatomy, the root of the SpA can be encircled with an anterior approach, and this should be ligated first (the SpA-first ligation technique). Thereafter, the pancreas is divided on the SMV, followed by division of the splenic vein and SpA. In contrast, the SpA-first ligation technique is difficult in type 2 and 3 SpA anatomies. Therefore, we first divide the pancreas on the SMV (pancreas-first division technique). The division of the pancreas facilitates access to the splenic vessels. If the root of the SpA is reachable, it is ligated, and then the SpV and SpA are divided. If the root of the SpA is not reachable, the SpV is divided; thereafter, the SpA is transected.

When the transection line of the pancreas is on the left side of the root of the SpA, the SpA-first ligation technique is applied (Figure 4B). Firstly, the SpA is encircled using a posterior or anterior approach and then it is ligated at the pancreatic transection line. Subsequently, transection of the pancreas, SpV, and SpA is performed.

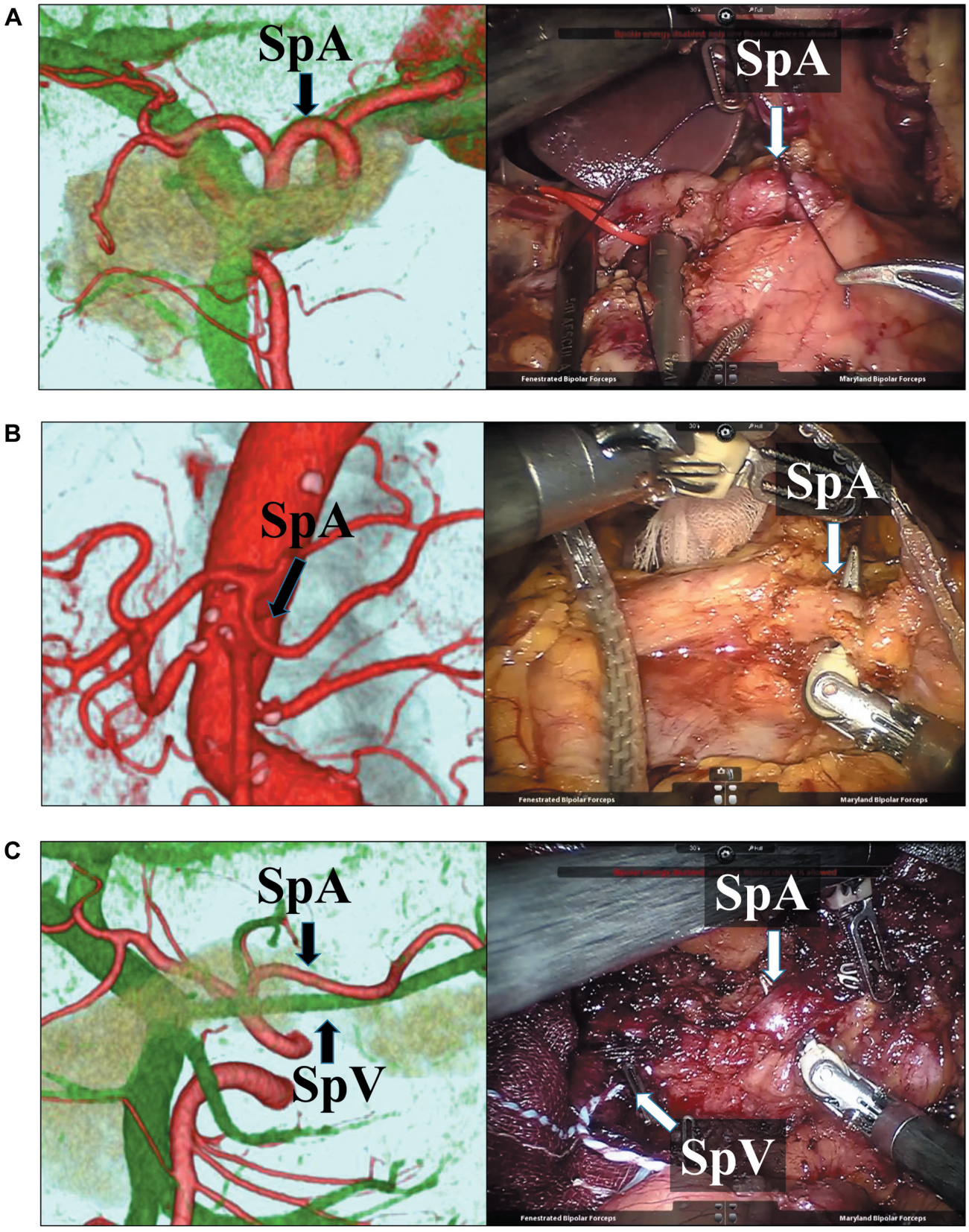


Figure 5. *Continued*

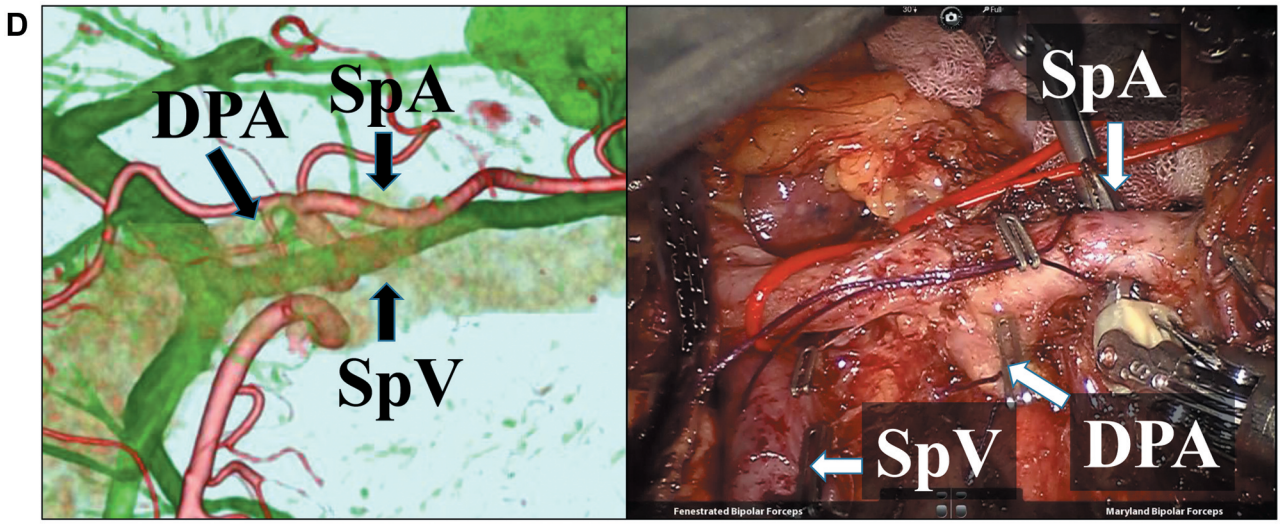


Figure 5. *Individual cases with type 1, 2, and 3 anatomy. A: In type 1 SpA anatomy, the root of the splenic artery (SpA) is encircled and ligated prior to the division of the pancreas (the SpA-first ligation technique). B: In type 2 SpA anatomy, the root of the SpA can be dissected (SpA reachable type) following the division of the pancreas (the pancreas-first division technique). C: In type 2 SpA anatomy, the root of the SpA can be dissected following the division of the pancreas as well as the splenic vein (SpV) (SpA unreachable type). D: In type 3 SpA anatomy, the root of the SpA can be dissected following the division of the pancreas, the SpV, and dorsal pancreatic artery (DPA).*

## Results

The characteristics and surgical details of the 19 patients who underwent RDP are summarized in Table I. The median age was 72 years (interquartile range=57-76 years), including six men and 13 women. Out of 19 patients, 10 were of pancreatic cancer. Surgical outcomes included median operative time and estimated blood loss, which were 239 min (interquartile range=217-266 min) and 10 ml (interquartile range=0-10 ml), respectively. Regarding the type of procedure, two patients underwent robotic SPDP with the Kimura technique, and the others underwent RDP, including robotic RAMPS or robotic SPDP with the Warshaw technique. With regard to anatomical patterns, there were seven cases of type 1, nine of type 2, and three of type 3. The transection line of the pancreas was on the SMV in 15 patients and on the left side of the root of the SpA in the other four.

In patients with type 1 anatomy, where the transection line of the pancreas was on the SMV, SpA-first ligation with an anterior approach was performed. This facilitated identification and exposure of the root of the SpA (type 1 anatomy) (Figure 5A). Following SpA ligation, the pancreas, SpV, and SpA were divided.

The pancreas-first division technique was applied to patients with type 2 anatomy. Accessibility of the root of the SpA was evaluated following division of the pancreas on the SMV. In patients in whom the root of the SpA was reachable, the SpA was ligated (Figure 5B), followed by division of the SpV and SpA. In contrast, in cases where the root of the SpA was inaccessible, the SpV was divided first, and the SpA was identified and divided thereafter (Figure 5C).

The pancreas-first division technique was applied to patients with type 3 anatomy. Following pancreatic transection of the SMV, accessibility to the root of the DPA and SpA was confirmed. When the roots of DPA or SpA were accessible, they were divided or ligated (Figure 5D). The SpV and SpA were transected next.

In patients in whom the pancreatic transection line was on the left side of the root of the SpA, the SpA-first ligation technique was used with an anterior or posterior approach first, and the pancreas and splenic vessels were divided next.

## Discussion

The present study demonstrated our standardized surgical strategy, focusing on the SpA approach in RDP. Although the technical difficulty of RDP depends on the type of procedure, such as standard RDP, SPDP, and RAMPS, anatomical variations are also important factors affecting technical difficulty (2). Furthermore, we need to understand the differences between laparoscopic and robotic surgical approaches (Figure 1). Therefore, we believe our surgical strategy to approaching the SpA with anatomical landmarks should help in performing RDP.

With respect to surgical strategy, it is necessary to understand that the surgical approach to the SpA differs depending on the pancreatic transection line, as demonstrated in Figure 4. In cases

where the pancreatic transection line is on the SMV, our policy for approaching the SpA is to consider the artery-first approach in order to reduce intraoperative blood loss. Considering the anatomical landmarks, type 1 SpA anatomy would be suitable for application of the SpA-first ligation technique. In contrast, the technique of pancreas-first division should be considered instead of the artery-first approach in cases where the root of the SpA is concealed by the pancreatic parenchyma. Although the posterior approach for the SpA might be optional, the pancreas-first division makes it easier to access the splenic vessels. Therefore, we used the pancreas-first division technique for those with type 2 SpA anatomy. Following the division of the pancreas, we evaluated the accessibility to SpA. When dissection of the SpA is possible, it should be ligated for inflow control. However, in cases where the SpA is not reachable, we divide the SpV first and then the SpA. Although SpV division prior to SpA division might cause congestion, short-term congestion is not a serious problem. In type 3 SpA anatomy, special attention must be paid to the DPA. In fact, we need to confirm the root of the DPA as well as the SpA carefully, using the pancreas-first division approach. By dividing the DPA, we could create sufficient room for the root of the SpA.

In cases where the pancreatic transection line is on the left side of the root of the SpA, the splenic vessels must be dissected from the pancreatic parenchyma at the transection line. Our strategy includes the adoption of the SpA-first ligation technique to control inflow from the SpA. Thereafter, the pancreas and splenic vessels are divided.

We believe that the safe implementation of RDP can be achieved by standardizing the surgical strategy and recognizing anatomical landmarks. The surgical strategy for RDP should be developed by considering anatomical variations of the splenic vessels. Therefore, our strategy focusing on the approach to SpA can help trainees shorten the learning curve and perform RDP safely.

## Conclusion

We propose a standardized surgical strategy for approaching the SpA in RDP with anatomical landmarks. Our strategy, which takes into consideration anatomical variations, should help trainees approach the SpA and perform RDP safely.

## Conflicts of Interest

The Authors declare no conflicts of interest regarding this study.

## Authors' Contributions

K.T. contributed to the study conception and design, the acquisition of data, the development of the protocol, and the drafting of the article. K. K., Y. U., R. Y., T. F., K. Y., T. Y., and T.F. contributed to the development of the protocol and the critical revising of the final draft. All Authors approved the final version.

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