A new manoeuvre of vascular control in laparoscopic spleen-preserving distal pancreatectomy: Retrospective review for a modified Kimura’s method

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INTRODUCTION

The splenic vessels are closely related to the pancreatic body and tail, so the conventional view was that they were an anatomical unit and were usually excised together. However, with the understanding of the anti-infection and immune function of the spleen, many surgeons advocate the preservation of the spleen to avoid ‘innocent splenectomy’. Inappropriate splenectomy made patients post-operative high blood coagulation, thrombosis, and increased the possibility of low immunity also did not accord with the modern surgery trends of minimally invasive and quick recovery. Historically, in 1943, spleen-preserving distal pancreatectomy (SPDP) was first described by Mallet-Guy and Vachon. In 1988, Warshaw...
published a technique of SPDP, in which splenic vessels were ligated, leaving the spleen to survive on collateral blood flow through the short gastric and left gastroepiploic vessels. Due to its simplicity, Warshaw technique is faster and is associated with less intraoperative blood loss, and has gained the favour of some surgeons, particularly for use during laparoscopic resections. Later, in 1996, Japanese researcher Kimura et al. described an alternative SPDP by sparing the splenic artery and vein, and ligation of the multiple small, short vascular connections to the body and tail of the pancreas, which assures increased blood supply to the spleen.[6] At the present stage, laparoscopic SPDP (LSPDP) has also become more and more used worldwide.[7-9]

We improved the surgical method based on the Kimura method, compared to which, we achieved less blood loss and shorter operation time after ten cases of practice. This study was retrospectively analysed and now, we present as follows.

**MATERIALS AND METHODS**

**Patients selection**
This was a retrospective study in patients from January 2013 to December 2018, a total of 63 patients were undertook LSPDP who were diagnosed with benign pancreatic tumours. From January 2010 to September 2018, we performed laparoscopic Kimura technique (which was carried out since 2003 in our hospital) for 33 cases and from October 2014 to December 2018 we performed modified Kimura technique for 30 cases. Among 30 modified Kimura technique cases, we divided them into the first series for ten cases, the second series for ten cases and the last series for ten cases. Pre-operative investigations included routine blood, urine, and stool tests, neoplastic markers, chest radiographs, upper abdominal ultrasound, computed tomography scan, magnetic resonance imaging and gastroscopy.

**Ethical work**
The study was approved by the Ningbo Medical Center of Lihuili Hospital ethical committee. Written informed consent was obtained from the patients. Contraindications to laparoscopy were severe cardiorespiratory disease, use of anticoagulant drugs; American Society of Anaesthesiologists score ≥4; distant metastases; serious electrolyte disorders, and inability to perform endotracheal intubation.

**Surgical process**
All operations were performed by the same surgeon. The patient was intubated in a supine position with a 20° head-up tilt. After undergoing tracheal intubation and induction of general anaesthesia, a CO$_2$ pneumoperitoneum was created via an open veress-assisted technique. A 30° telescope was used to inspect the peritoneal cavity. Five trocars were used: a 10-mm telescope trocar in the midline above the umbilical incision; two cranially placed 5-mm ports in the left and right anterior axillary lines, and two cranially placed ports 5 mm to the left and 12 mm to the right of the rectus muscles at the level of the umbilicus [Figure 1].

**Kimura technique**
First, we opened the gastrocolic ligament and the gastroplenic ligament, fully disclosed the pancreatic body and tail. Dissected and exposure the splenic artery and vein under the pancreatic neck. The pancreas was cut-off 2 cm from the left proximal end of the nidus by ENDO-GIA. After that, the apocoptic pancreatic neck was pulled toward pancreatic tail to reveal the splenic artery and vein by using ultrasonic knife, as carefully as possible to ensure splenic blood flow. Then removed the specimen, and a drainage tube was placed at the incisal margin, and the whole surgery was completed.

**Modified Kimura technique**
First, we opened the gastrocolic ligament and the gastroplenic ligament, fully disclosed the pancreatic body and tail. Dissecting from the lower margin of the pancreatic body and tail to the anterior renal fascia, which was an avascular area we dissociated the entire pancreatic tail. The superior mesenteric vein was exposed among the adipose tissue under the lower margin of the pancreatic neck, creating a tunnel between the superior mesenteric vein, portal vein, splenic vein, and the pancreatic neck. At this point, the pancreatic neck, splenic artery, and vein were completely divided [Figure 2a]. After that, we placed a blockage band (usually an 8F catheter) or a bulldog clamps (Aesculap Inc., Center Valley, PA, USA) through pancreatic body and tail, respectively. The blood flow of the pancreatic tail was blocked first, and then blocked the pancreatic body’s blood flow, at that time, we obtained an environment of total splenic artery and vein blocked [Figure 2b-d]. The splenic artery was first dissected from the pancreatic body to tail, and then the splenic vein was also dissected, the large vessels were severed by a hem-o-lok and divided by ultrasonic knife [Figure 3a and b]. The blockage band or bulldog clamps at the pancreatic tail was first released. At this point, the returned blood flow would form bleeding points when it encountered the blood vessel rupture. According to the bleeding points, we would use 5-0 prolene needle to repair the blood vessel [Figure 3c]. Then, we released the blockage of the pancreatic body, ending the blockage of
total blood flow. The pancreas was cut-off 2 cm from the proximal end of the nidus by ENDO-GIA (Johnson and Johnson, New Jersey, USA). Then removed the specimen, and a drainage tube was placed at the incisal margin, and completed the whole surgery [Figure 3d].

**Followed up**
Patients were followed up by phone or outpatient until February 2019.

**Statistical analysis**
Data were analysed using the SPSS for Windows version 20 (IBM Ltd., Armonk, NY, USA). Qualitative variables were analysed by calculating absolutely and relative frequencies were compared with the χ² test. Quantitative variables were expressed as mean or median and standard deviation and were compared with the Student’s t-test. Differences in continuous variables were analysed using one-way ANOVA or Kruskal–Wallis test. Statistical significance was considered for P < 0.05.

**RESULTS**
All the operations were carried out smoothly. In the analysis of the pre-operative data, the mean age was 55.6 ± 8.1 in Kimura technique, 57.2 ± 8.2 in the first series, 61.8 ± 11.7 in the second series and 56.4 ± 12.4 in last series. Male patients were 16 in Kimura technique, 3 in the first series, 5 in the second series and 6 in the last series. Body mass index score was 22.1 ± 1.8 in Kimura technique, 21.8 ± 1.9 in the first series, 21.6 ± 2 in the second series and 20.9 ± 1.7 in the last series. There were no statistically significant differences in these data, which are summarised in Table 1.

In the intra-operative outcomes, the operation time (from CO₂ pneumoperitoneum was established to its end) was 188.8 ± 17.5 in Kimura technique, 176.4 ± 14.7 in the first series, 171.6 ± 17 in the second series and 161.5 ± 21.7 in the last series. Compared to Kimura technique group, the operation time was decreased 12 min, 17 min, and

d
27 min, respectively, and the first series’ operation time had no statistically significant differences ($P = 0.055$), while the second series ($P = 0.009$) and last series’ ($P = 0.000$) data had statistically significant [Figure 4a]. The blood loss was $212.3 \pm 65.4$ in Kimura technique, $204.7 \pm 66.8$ in the first series, $162.3 \pm 61.3$ in second series and $104.3 \pm 29.3$ in the last series. Compared to Kimura technique group, the blood loss was decreased 8 ml, 50 ml and 108 ml, respectively, and the first series’ blood loss had no statistically significant differences ($P = 0.729$), while the second series ($P = 0.025$) and last series’ ($P = 0.000$) data had statistically significant [Figure 4b]. Conversion to open was happened in 3 patients in Kimura technique, 1 patient in first series, 0 in second series and 0 in last series ($P = 0.388$). Spleen resection was 6 patients in Kimura technique, 1 patient in first series, 0 patient in second series and 0 patient in last series ($P = 0.104$). The above is summarised in Table 2.

In the analysis of post-operative complications, post-operative haemorrhage was occurred in four patients in Kimura technique, whereas one patient in first series, one patient in second series and one patient in last series ($P = 0.523$). Two Kimura technique patients were found splenic vein branch haemorrhage in the open operation, and the rest were cured by puncture drainage under B-ultrasound localisation, all the patients were recovered smoothly. As for post-operative pancreatic fistula, in Kimura technique group, there were 22 patients with higher than normal amylase level in the abdominal drainage tube after surgery, 13 of them (Grade A pancreatic fistula) showed transient elevation of amylase level without systemic symptoms, eight cases (Grade B pancreatic fistula) leucocyte or body temperature were increased and recovered after adjustment of drainage tube, unobstructed drainage, and using of antibiotics, and three cases (Grade C pancreatic fistula) were cured by fasting, parenteral nutrition, somatostatin and puncture drainage. In the first series, the Grade A pancreatic fistula was happened in four cases, the Grade B pancreatic fistula in two cases and the Grade C pancreatic fistula in one case. In the second series, the Grade A pancreatic fistula was happened in three cases, the Grade B pancreatic fistula in two cases and the Grade C pancreatic fistula in one case. The above is summarised in Table 3.

### DISCUSSION

The spleen plays an important role in maintaining haematological stability, and the retention of the spleen could prevent platelet increasing due to splenectomy. Meanwhile, as an important immune organ, the spleen plays an irreplaceable role in anti-infection and anti-tumour. Studies have shown that after splenectomy, the risk of infection, deep vein thrombosis, pulmonary

### Table 1: Patients’ preoperative data

|                      | Kimura technique | Modified Kimura technique | $P$  |
|----------------------|------------------|---------------------------|------|
|                      | First series     | Second series             | Last series |
| Age                  | 55.6±8.1         | 57.2±8.2                  | 61.8±11.7 | 56.4±12.4 | 0.345 |
| Gender               |                  |                           |      |
| Male                 | 16               | 5                         | 6    |          |      |
| Female               | 17               | 7                         | 5    | 4        | 0.576 |
| BMI                  | 22.1±1.8         | 21.8±1.9                  | 21.6±2.0 | 20.9±1.7 | 0.380 |

BMI: Body mass index

### Table 2: Comparison of each groups’ intra-operative data

|                      | Kimura technique | Modified Kimura technique | $P$  |
|----------------------|------------------|---------------------------|------|
|                      | First series     | Second series             | Last series |
| Operation time       | 188.8±17.5       | 176.4±14.7                | 171.6±17.0 | 161.5±21.7 | 0.000 |
| Blood loss           | 212.3±65.4       | 204.7±66.8                | 162.3±61.3 | 104.3±29.3 | 0.000 |
| Conversion to open   |                  |                           |      |
| Yes                  | 3                | 1                         | 0    | 0        | 0.388 |
| No                   | 30               | 9                         | 10   | 10       |      |
| Spleen resection     |                  |                           |      |
| Yes                  | 6                | 1                         | 0    | 0        | 0.104 |
| No                   | 27               | 9                         | 10   | 10       |      |

### Table 3: Comparison of each groups’ post-operative data

|                      | Kimura technique | Modified Kimura technique | $P$  |
|----------------------|------------------|---------------------------|------|
|                      | First series     | Second series             | Last series |
| Post-operative haemorrhage |                  |                           |      |
| Yes                  | 4                | 1                         | 1    | 0        | 0.523 |
| No                   |                  |                           |      |
| Post-operative pancreatic fistula |              |                           |      |
| Grade A              | 13               | 4                         | 4    | 3        | 0.316 |
| Grade B              | 6                | 2                         | 3    | 2        | 0.632 |
| Grade C              | 3                | 1                         | 1    | 1        | 0.225 |
Jie, et al.: A new manoeuvre of laparoscopic spleen-preserving distal pancreatectomy

Pancreatectomy combined with splenectomy was mainly used in the following two cases. First, the splenectomy was to ensure the thoroughness of tumour treatment for the aim of R0 resection. Second, the lesion affected the blood supply of the spleen and surgeons had to undergo splenectomy. For the cases who had pre-operative diagnosis of benign tumours and whose lesions not invasive splenic hilum and splenic arteriovenous, we considered to perform LSPDP. In this study, we only performed with benign tumours, and post-operative routine pathology also verified this.

Currently, SPDP can be divided into the Kimura method and the Warshaw method. The Kimura method preserves both spleen and splenic arteriovenous, ensuring the normal blood supply of the spleen. This operation is much more difficult and challenging under laparoscopy. Warshaw method does not retain the splenic arteriovenous, but only keeps the short stomach and the left gastroepiploic vein. This operation is relatively simple but may occur different levels of the post-operative splenic infarction. Therefore, for patients undergoing LSPDP, the Kimura method should be tried first.

The separation of the splenic arteriovenous and the pancreatic parenchymal is the key point of the Kimura method, which are high requirements for laparoscopic operators. Surgeons often need to repeatedly identify the anatomical relationships between major vascular or use intra-operative ultrasonography to clarify the vascular abnormality, resulting in greater psychological pressure for operators and prolonged operation time. Meanwhile, the prevention of haemorrhage is another key point of laparoscopic pancreas surgery. Laparoscopic surgery should make full use of its good lighting and clear vision, and bleeding will influence operating field. The splenic vein branch wall is thin, short, dispersed and crowded. In some patients, the splenic vein is wrapped in the pancreatic tissue, which is easy to cause bleeding when separating, affecting the surgical field of vision and even increasing the convert rate. In this study, based on Kimura method, we blocked total blood flow of the pancreas, and when separating the arteriovenous vein of the spleen, even if there was vascular damage, it rarely caused massive bleeding. After completely isolated splenic arteriovenous, first to loosen the pancreatic block at the end of the pancreatic body, the backflow of blood will form bleeding points when it encountered the blood vessel rupture. According to the bleeding points, we would use 5–0 prolene line to repair the blood vessel. Such a small amount of bleeding not only is helpful to identify the bleed point but also would not influence surgical field. When repairs were difficult, we would re-block the splenic artery/vein. In our experience, blocking within 30 min can be considered safe, when it is over 30 min, we would choose to release blocking, given a certain amount of blood flow reperfusion, after that the splenic artery and vein could be blocked again. The intra-operative colour changes of the spleen could be observed to understand the spleen's blood supply. Complete splenic arteriovenous occlusion has no strict limitation on occlusion time, which is different from hepatic portal occlusion.

Special attention should be paid to: (1) The operation must be gentle, due to the lack of direct hand sensation in the operation under the laparoscopy, the action force is excessively enlarged by the action of lever, which would easily cause bleeding. (2) Be calm when facing bleeding. Splenic artery haemorrhage, such as clear a bleed point, first, use the separating pliers to grip the crevasse of blood vessels, second use the attractor drained the blood to expose the operation field, thirdly use titanium clip to clamp the grip the crevasse of blood vessels, after that use a use 5–0 prolene line to repair the blood vessel, then remove the titanium clip. If the bleeding point is not clear, for a small amount of bleeding, the gauze can be used to compress the bleeding point firstly. If the bleeding volume is large, the bleeding point cannot be exposed and controlled, or the blood vessel is seriously ruptured, there should be converted to open surgery in time. (3) High precision endoscopic operation requires the tacit cooperation between the main knife and the assistant. When bleeding occurs, skilled cooperation can timely and accurately expose bleeding points, saving valuable time for controlling bleeding. (4) The upper, lower and surrounding tissues of the pancreatic tail should be fully dissociated, and the lateral side of the pancreas were separated in the superficial layer of Gerota fascia. The pancreatic tail should be widely dissociated to make it easily to the placement of the blocking band or bulldog clamp. (5) The ‘arterial first’ could be considered. Dissociating the splenic artery along the superior edge of the pancreas till to the splenic hilum, then dissociating the splenic vein. Because the splenic vein once haemorrhage is easier to control. Under the condition of releasing occlusion, sometimes the small bleeding point can be stopped by pressing with gauze, without forcing to find the bleeding point and suture. (6) During the operation, the colour and blood supply of the spleen should be observed throughout the operation. If the colour of the spleen turns deep, it should be release the bandage or bulldog clamp.
**CONCLUSION**

After ten cases of practice, the modified Kimura technique with the characteristics of simple and safe can shorten the operation time, can reduce intra-operative bleeding, can enhance the spleen preservation rate and is worthy of popularisation and application.

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**Conflicts of interest**

There are no conflicts of interest.

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