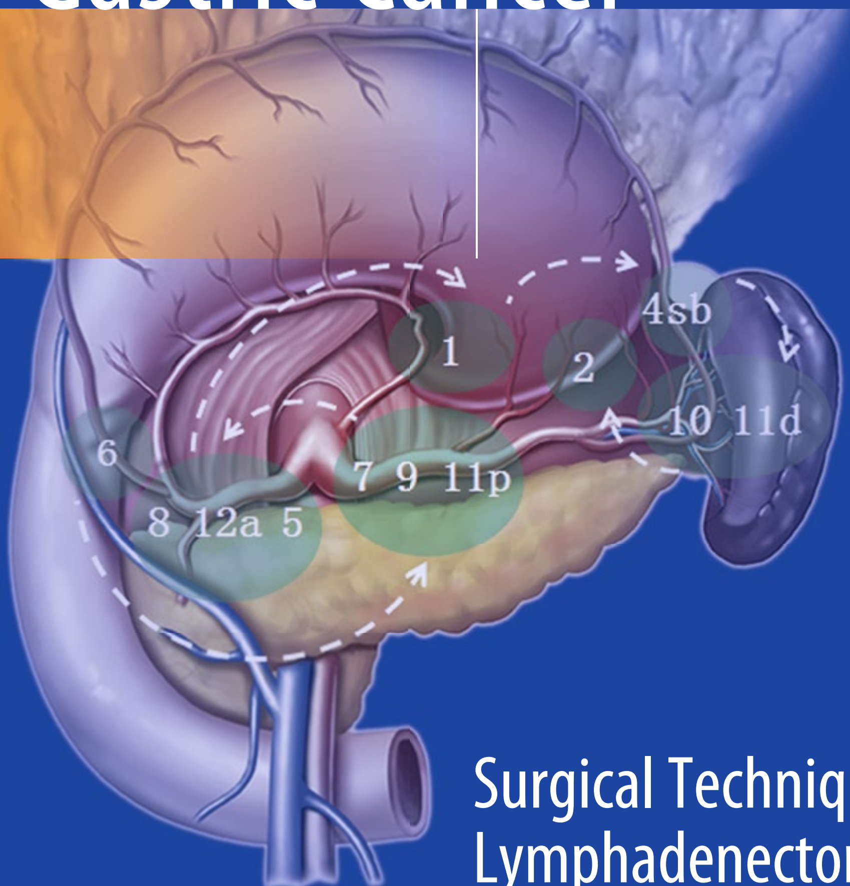
Chang-Ming Huang
Chao-Hui Zheng
Editors

Laparoscopic Gastrectomy for Gastric Cancer



Surgical Technique and Lymphadenectomy

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Editors
Chang-Ming Huang
Department of Gastric Surgery
Fujian Medical University Union Hospital
Fuzhou
China

Chao-Hui Zheng
Department of Gastric Surgery
Fujian Medical University Union Hospital
Fuzhou
China

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Preface

We are delighted to witness the publication of the English edition of *Laparoscopic Gastrectomy for Gastric Cancer: Surgical Technique and Lymphadenectomy*.

Gastric cancer is the fourth most common malignancy and second most common cause of cancer-related death worldwide. Surgical treatment has proven to be an important approach to improve the long-term prognosis, and radical gastrectomy with D2 lymphadenectomy has become the standard surgery for advanced gastric cancer. Since laparoscopic gastrectomy (LG) for early gastric cancer was initially reported by Kitano et al. in 1994, laparoscopic techniques for early gastric cancer have gradually developed and progressed worldwide in the past 20 years. Moreover, the therapeutic range of these laparoscopic techniques has been extended to include locally advanced gastric cancer. Surgical treatment for gastric cancer has gradually stepped into the era of minimal invasiveness.

The incidence of gastric cancer is relatively high in China, and most affected patients develop advanced disease. Successful performance of LG for advanced gastric cancer requires not only proficient surgical techniques, but also standardized and programmed surgical procedures. We first began to perform LG 7 years ago and have continuously summarized the experiences of the practice in our untiring pursuit to establish a standardized and programmed strategy for this surgery. To date, we have performed more than 2500 LG procedures for gastric cancer and have thus gained extensive experience. In 2010, we completed the first laparoscopic spleen-preserving splenic hilar lymphadenectomy, and we are now able to routinely perform this procedure for advanced middle- or upper-third gastric cancer. We also summarized the operative procedure as Huang's three-step maneuver, allowing increasingly more surgeons to easily master this technique. In 2012, delta-shaped gastroduodenostomy following totally laparoscopic distal gastrectomy was first performed in China in our center, and we have performed the largest number of these surgeries in China.

We herein summarize and share our 7-year experience of LG without reservation. This academic monograph can be used for clinical practice, scientific research, and education. This book contains a large amount of comprehensive material, and areas of particular importance are highlighted. Wonderful pictures are included to enhance understanding and interest. All material is original and based on clinical practice. The text describes our understanding about what we have gained and lost from massive surgeries and summarizes our accumulated experience throughout years of clinical practice. We particularly focus on both the common and rare anatomy around the stomach in minimally invasive surgery, describe in detail the procedures and issues that require attention during the performance of radical LG for gastric cancer, and present the techniques of lymphadenectomy with both text and graphics. This information is both clinically useful and innovative. We hope that this book will eventually provide new inspirations and become a standard source of knowledge for all of our colleagues who have devoted themselves to the surgical treatment for gastric cancer, and that it will facilitate the promotion and development of LG.

This book is written by the team members of the Department of Gastric Surgery in Fujian Medical University Union Hospital, China. I would like to thank everyone in my team, who has heavy clinical work and academic activities but still sacrificed plenty of his or her spare time to put an incredible effort into publishing this book.

Fuzhou, China Chang-Ming Huang
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Contents

Contributors

Editors

Chang-Ming Huang Department of Gastric Surgery, Fujian Medical University Union Hospital, Fuzhou, China

Chao-Hui Zheng Department of Gastric Surgery, Fujian Medical University Union Hospital, Fuzhou, China

Deputy Editors

Ping Li Department of Gastric Surgery, Fujian Medical University Union Hospital, Fuzhou, China

Jian-Wei Xie Department of Gastric Surgery, Fujian Medical University Union Hospital, Fuzhou, China

Contributors

Jia-Bin Wang Department of Gastric Surgery, Fujian Medical University Union Hospital, Fuzhou, China

Jian-Xian Lin Department of Gastric Surgery, Fujian Medical University Union Hospital, Fuzhou, China

Jun Lu Department of Gastric Surgery, Fujian Medical University Union Hospital, Fuzhou, China

Qi-Yue Chen Department of Gastric Surgery, Fujian Medical University Union Hospital, Fuzhou, China

Long-Long Cao Department of Gastric Surgery, Fujian Medical University Union Hospital, Fuzhou, China

Mi Lin Department of Gastric Surgery, Fujian Medical University Union Hospital, Fuzhou, China

Min Shao Department of Gastric Surgery, Fujian Medical University Union Hospital, Fuzhou, China

Mu Xu Department of Gastric Surgery, Fujian Medical University Union Hospital, Fuzhou, China

Ru-Hong Tu Department of Gastric Surgery, Fujian Medical University Union Hospital, Fuzhou, China

Rui-Fu Chen Department of Gastric Surgery, Fujian Medical University Union Hospital, Fuzhou, China

Tan Chen Department of Gastric Surgery, Fujian Medical University Union Hospital, Fuzhou, China

Chen-Bin Lv Department of Gastric Surgery, Fujian Medical University Union Hospital, Fuzhou, China

Jun-Rong Zhang Department of Gastric Surgery, Fujian Medical University Union Hospital, Fuzhou, China

Qian Yu Department of Gastric Surgery, Fujian Medical University Union Hospital, Fuzhou, China

Xin-Tao Yang, Department of Gastric Surgery, Fujian Medical University Union Hospital, Fuzhou, China

Guang-Tan Lin Department of Gastric Surgery, Fujian Medical University Union Hospital, Fuzhou, China

Hui-Zhong Lin Department of Gastric Surgery, Fujian Medical University Union Hospital, Fuzhou, China

Xi Lin Department of Gastric Surgery, Fujian Medical University Union Hospital, Fuzhou, China

Introduction of Chief Editors

Professor Chang-Ming Huang, chief physician, doctoral supervisor, an expert entitled to Government Special Allowance (GSA) the Director of Department of Gastric Surgery of Fujian Medical University Union Hospital, China, is the vice-chairman of Surgical Oncology Committee of Surgery Branch of China Medical Doctor Association, a member of the standing committee of Gastric Cancer Profession of China Anti-Cancer Association, and a member of the Minimally Invasive Surgery Committee of Surgery Branch of China Medical Doctor Association. He is also an editorial board member of *Chinese Journal of Gastrointestinal Surgery*, a corresponding editor of *Chinese Journal of Surgery*, and a reviewer of *Chinese Medical Journal*, *Chinese Medical Journal: English edition* and *World Journal of Gastroenterology*. Till now, he has published more than 100 articles in the source of SCI journals, Chinese medicine magazines and other professional journals. As an editor-in-chief, he compiled *Laparoscopic Radical Gastrectomy for Gastric Cancer: Technique of Lymphadenectomy*. Moreover, he has been awarded Fujian Provincial Science and Technology Achievement Award many times and is undertaking currently a number of national and provincial scientific research projects.

Chao-Hui Zheng, associate professor, associate chief physician, at present works in the Department of Gastric Surgery of Fujian Medical University Union Hospital, China. He is a member of the youth committee of Gastric Cancer Profession of China Anti-Cancer Association, Surgical Oncology Committee of Surgery Branch of China Medical Doctor Association, and Obesity and Diabetes Surgery Committee of Surgery Branch of China Medical Doctor Association. Till now he has published more than 10 articles in the source of SCI journals, Chinese medicine magazines and other professional journals. He is also the deputy editor of *Laparoscopic Radical Gastrectomy for Gastric Cancer: Technique of Lymphadenectomy*. He has won Fujian Provincial Science and Technology Achievement Award many times and is undertaking currently a number of national and provincial scientific research projects.

Our team: Department of Gastric Surgery, Fujian Medical University Union Hospital, China.

Left→Right: Long-Long Cao, Ping Li, Jia-Bin Wang, Jun Lu, Chang-Ming Huang, Qi-Yue Chen, Chao-Hui Zheng, Jian-Wei Xie, Jian-Xian Lin, Mi Lin

1 Summary of Anatomy and Physiology of Perigastric Lymphatic System

Abstract

At the end of the nineteenth century, the medical community realized that lymph node metastasis (LNM) is the most common pattern of metastatic spread in gastric cancer. Satisfactory results will not be achieved if gastrectomy alone is performed for patients with gastric cancer. Many European and American researchers began to study the lymphatic flow of the stomach and explore the characteristics of LNM. Dissection of the relevant lymph nodes (LNs) revealed that metastasis was not limited to the LNs around the stomach. Those located at the superior border of the pancreas and other sites were also frequently involved. In 1944, Kajitani indicated that LNs positioned along the celiac artery system were closely involved in metastasis of gastric cancer according to the outcomes of 166 patients with gastric cancer who underwent lymph node dissection. He also proposed the concepts of systemic lymph node dissection. According to these concepts, Kajitani led the Japanese Research Society in the first detailed anatomical study of gastric cancer, in which the researchers divided the perigastric LNs into groups and described the lymphatic drainage routes of the stomach. He then observed the distribution of the metastatic LNs and studied the tendencies of LNM from a histological viewpoint. These discoveries helped to establish the theory supporting systemic lymph node dissection for gastric cancer. This anatomical description of the lymphatic system of the stomach by Japanese researchers was a key step in the study of LNM in gastric cancer.

1.1 Lymphatic Drainage Routes of the Stomach

At the end of the nineteenth century, the medical community realized that lymph node metastasis (LNM) is the most common pattern of metastatic spread in gastric cancer. Satisfactory results will not be achieved if gastrectomy alone is performed for patients with gastric cancer. Many European and American researchers began to study the lymphatic flow of the stomach and explore the characteristics of LNM. Dissection of the relevant

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lymph nodes (LNs) revealed that metastasis was not limited to the LNs around the stomach. Those located at the superior border of the pancreas and other sites were also frequently involved. In 1944, Kajitani indicated that LNs positioned along the celiac artery system were closely involved in metastasis of gastric cancer according to the outcomes of 166 patients with gastric cancer who underwent lymph node dissection. He also proposed the concepts of systemic lymph node dissection. According to these concepts, Kajitani led the Japanese Research Society in the first detailed anatomical study of gastric cancer, in which the researchers divided the perigastric LNs into groups and described the lymphatic drainage routes of the stomach. He then observed the distribution of the metastatic LNs and studied the tendencies of LNM from a histological viewpoint. These discoveries helped to establish the theory supporting systemic lymph node dissection for gastric cancer. This anatomical description of the lymphatic system of the stomach by Japanese researchers was a key step in the study of LNM in gastric cancer.

The lymphatic networks in the gastric walls communicate with one another and flow in a certain direction, draining into the perigastric lymphatic system in close proximity to the corresponding veins. However, lymphadenectomy is performed along the corresponding arteries, and the perigastric LNs are grouped and named according to the arteries. Therefore, the lymphatic drainage of the stomach is customarily divided into four areas according to the four feeding arteries of the gastric walls.

District I (right gastroepiploic artery (RGEA) group): This lymphatic network mainly drains the greater curvature of the lower half of the gastric body and the pylorus. Lymphatic vessels are abundant in this area. They drain into the infrapyloric LNs along the RGEA. Their efferent lymphatic vessels drain into the retropyloric and suprapyloric LNs, then into the hepatic LNs, and finally into the celiac artery LNs. Some of the lymphatic vessels along the gastroepiploic veins in front of the pancreatic head drain into the LNs located at the root of the middle colic vein (MCV) and superior mesenteric vein (SMV).

District II (left gastroepiploic and short gastric arteries group): This lymphatic network mainly drains the greater curvature of the left half of the gastric fundus and the greater curvature of the upper half of the gastric body. Lymphatic vessels are rare in this area. They drain into the splenic hilar LNs and pancreaticosplenic LNs located at the pancreatic tail along the gastrosplenic ligament. Most lymphatic vessels of the left half of the gastric fundus flow left and drain into the splenic hilar LNs, while those located at the posterior wall of the gastric fundus flow directly into the pancreaticosplenic LNs. Most lymphatic vessels of the left half of the gastric body at the greater curvature turn left along the left gastroepiploic artery (LGEA) and drain directly into the splenic hilar LNs. A few lymphatic vessels drain into the inferior left gastric LNs, then into the splenic hilar LNs, and finally into the celiac artery LNs.

District III (left gastric artery (LGA) group): This lymphatic network mainly drains the right half of the fundus, left half of the lesser curvature, and cardia of the stomach. Most lymphatic vessels of the right half of the gastric fundus drain into the paracardial and pericardial LNs, while a few lymphatic vessels flow into the retrocardial and pancreaticogastric LNs. They occasionally flow into the left diaphragmatic LNs. Most lymphatic vessels of the left half of the lesser curvature of the stomach drain into the superior gastric LNs, while a few drain directly into the pancreaticogastric LNs. The lymphatic vessels of the gastric cardia mostly drain into the paracardial, retrocardial, and pericardial LNs, while a few flow into the superior gastric and pancreaticogastric LNs. The paracardial, retrocardial, pericardial, and superior gastric LNs all drain into the pancreaticogastric LNs, then into the celiac artery LNs. This area plays an important role in the lymphatic drainage of the stomach.

District IV (right gastric artery (RGA) group): The RGA is thin and contains little blood. Lymphatic vessels are rare in this area, and few suprapyloric LNs are present along the RGA. This area mainly drains the lesser curvature of the gastric pylorus, and a few lymphatic vessels drain into the hepatic portal LNs along the hepatoduodenal ligament (HDL) in a reverse direction. However, most lymphatic vessels drain into the LNs around the common hepatic artery (CHA), then into the celiac artery LNs.

The lymph drainage routes differ between gastric stump cancer and general gastric cancer because these drainage routes and the anatomic structure of the remnant stomach are changed by the first operation. First, the LGA and/or its descending branch at the lesser gastric curvature is transected. This causes the flow of the lymph vessels along the LGA to change and course toward the right cardia, then drain into the celiac artery LNs. The lymph vessels at the greater curvature of the stomach mainly drain into the splenic hilar LNs and splenic artery LNs. Additionally, the lymph vessels in the remnant stomach communicate with one another and the surrounding organs. Lymph vessels of the gastric cardia and fundus can drain into the lower esophagus through the esophagogastric junction. Those in the distal gastric stump drain into the duodenal wall (Billroth I anastomosis) or jejunal wall (Billroth II anastomosis). Cancer cells can invade the LNs in the mesentery of the anastomotic site and metastasize to LNs located at the root of the mesentery, especially when distal gastrectomy with Billroth II anastomosis is performed. Studies have shown that if the LGA is preserved during the primary surgery, the lymph drainage routes of gastric stump cancer are identical to those of primary upper-third gastric cancer. The main lymph drainage of the remnant stomach begins at the lesser curvature of the stomach along the LGA. However, if the LGA is transected during the primary surgery, the lymph drainage of the remnant stomach mainly follows the greater curvature of the stomach instead of following the original route.

The lymph drainage of gastric stump cancer is classified into three routes: (1) The lymph drainage is along the LGA, posterior gastric artery, and splenic artery (SpA). (2) The lymph vessels drain into the duodenal wall or jejunal wall. (3) The lymph vessels drain into the intrathoracic LNs.

1.2 Lymph Node Groups in Gastric Cancer

The Japanese Research Society for the Study of Gastric Cancer anatomically divided the perigastric LNs into 16 nodal groups, as shown in the following table:

No.	Group/designation	Definition
1	Right paracardial LNs	LNs along the first branch of the ascending limb of the LGA and those located on the anterior and right sides of the gastric cardia
2	Left paracardial LNs	LNs along the esophagocardiac branch of the left subphrenic artery and its root, including left and posterior paracardial LNs
3	Lesser curvature LNs	LNs included in the two layers of the lesser omentum at the gastric lesser curvature, along the branches of the LGA and distal part of the RGA
4sa	Left greater curvature LNs along the short gastric arteries	LNs along the short gastric arteries and their roots
4sb	Left greater curvature LNs along the LGEA	LNs along the LGEA and its first branch feeding the gastric wall
4d	Right greater curvature LNs along the RGEA	LNs along the second branch and distal part of the RGEA
5	Suprapyloric LNs	LNs along the first branch and proximal part of the RGA
6	Infrapyloric LNs	LNs along the first branch and proximal part of the RGEA down to the confluence of the right gastroepiploic vein (RGEV) and anterosuperior pancreaticoduodenal vein (ASPDV)
7	LNs along the LGA	LNs along the trunk of the LGA between its root and the origin of its ascending branch

No.	Group/designation	Definition
8a	Anterosuperior LNs along the CHA	LNs anterosuperior to the CHA (from the origin to the root of the gastroduodenal artery)
8p	Posterior LNs along the CHA	LNs posterior to the CHA (No. 8p is continuous with No. 12p and No. 16a2)
9	Celiac artery LNs	LNs around the celiac artery including those located at the roots of the LGA, CHA, and SpA
10	Splenic hilar LNs	LNs adjacent to the SpA distal to the pancreatic tail, those on the roots of the short gastric arteries, and those along the LGEA proximal to its first gastric branch
11p	Proximal splenic artery LNs	LNs from the origin of the SpA to halfway between its origin and the pancreatic tail end
11d	Distal splenic artery LNs	LNs from halfway between the origin of the SpA and the pancreatic tail end to the end of the pancreatic tail
12a	HDL LNs along the proper hepatic artery	LNs along the proper hepatic artery, in the caudal half between the confluence of the right and left hepatic ducts and the upper border of the pancreas
12b	HDL LNs along the bile duct	LNs along the bile duct, in the caudal half between the confluence of the right and left hepatic ducts and the upper border of the pancreas
12p	HDL LNs along the portal vein	LNs along the portal vein, in the caudal half between the confluence of the right and left hepatic ducts and the upper border of the pancreas
13	LNs on the posterior surface of the pancreatic head	LNs on the posterior surface of the pancreatic head cranial to the duodenal papilla
14v	LNs along the SMV	LNs in front of the SMV, lying within the following boundaries: lower edge of the pancreas (upper border), left side of the confluence of the RGEV and ASPDV (right border), left edge of the SMV (left border), and furcation of the MCV (lower border)
14a	LNs along the superior mesenteric artery	LNs along the superior mesenteric artery
15	LNs along the middle colic vessels	LNs along the middle colic vessels
16a1	Para-aortic LNs, a1	Para-aortic LNs in the diaphragmatic aortic hiatus (in the range of 4–5 cm, encircled by the diaphragmatic crus)
16a2	Para-aortic LNs, a2	Para-aortic LNs between the upper margin of the origin of the celiac artery and lower border of the left renal vein
16b1	Para-aortic LNs, b1	Para-aortic LNs between the lower border of the left renal vein and upper border of the origin of the inferior mesenteric artery
16b2	Para-aortic LNs, b2	Para-aortic LNs between the upper border of the origin of the inferior mesenteric artery and aortic bifurcation

1.3 Pattern of Metastatic Spread and Characteristics of Metastatic LNs in Gastric Cancer

LNM is the most common pattern of metastatic spread in gastric cancer. The reported frequency of LNM in gastric cancer ranges from 75.0 to 90.0 %. Lymphatic networks are abundant in each layer of the gastric wall, especially in the submucosa and subserosa, which facilitates LNM.

Examination of tissue specimens and metastatic LNs has revealed the following LNM process in gastric cancer:

Cancer cells invade the lymph vessels. Cancer cells released from the cancerous tissue invade the lymphatic capillaries near the tumor. The process by which this occurs involves the cancer cells first passing through the basilar membrane of the epithelial cells and the connective tissue space until they are in close contact with the endothelial cells. They then pass through the endothelial intercellular space using much the same type of amoeboid movement and invade the lymphatics or are simply pushed into open lymphatic capillaries under the strong lymphatic flow.

Cancer cells migrate within the lymph vessels. The cancer cells migrate in the direction of the lymph flow after entering the lymph vessels. Two migration patterns have been identified: The cancer cells either form a continuous cancer embolus by continuous proliferation or spread within the lymph vessels or they form a floating cancer embolus in a decentralized fashion. Different cancer emboli may exhibit different cancer cell characteristics. The viscosity of continuous cancer emboli is stronger than that of floating cancer emboli, which readily separate and metastasize. Different lymphatic cancer emboli may also be associated with different growth and infiltration patterns among the cancer cells. Continuous cancer emboli are more typically seen in nest-type or mass-type gastric cancer, while floating cancer emboli are always found in diffuse-type gastric cancer (signet-ring cell cancer or poorly differentiated adenocarcinoma).

Cancer cells form metastatic foci within LNs. When cancer emboli reach the regional LNs, they first come together in the marginal sinus. They then grow and multiply to break the structure of the LNs, finally forming a metastatic focus within the LNs.

LNM in gastric cancer is generally associated with the location of the primary tumor, and metastasis follows the lymphatic drainage routes from the shallower to the deeper and from the near to the more distant LNs. For example, lower gastric cancer frequently metastasizes to No. 3, No. 4, No. 5, and No. 6 LNs; then to No. 7, No. 8, and No. 9 LNs; and finally to No. 12, No. 13, and No. 16 LNs. Upper gastric cancer mostly metastasizes to No. 1, No. 2, No. 3, and No. 4 LNs, then to No. 7, No. 8, No. 9, No. 10, and No. 11 LNs.

Metastatic spread patterns in the lymph vessels are divided into two types: continuous spread and discontinuous spread. Continuous spread refers to the progressive proliferation of gastric cancer cells within the lymph vessels and their continuous spread to subordinate LNs or retroactive spread along the lymph vessels. They eventually reach the LNs in the lymphatic drainage area. This metastatic spread pattern is primarily found in nest-type gastric cancer. Abundant lymphatics filled with solid cancer emboli are found in the submucosa or subserosa of the tissue surrounding the carcinoma. If solid cancer emboli form within the serosa, the lymph vessels may become obstructed and expanded, leading to lymphatic deposition. In such cases, lymphatic vesicles in a row or gray fine-grained spots or bands can be seen on the serosal surface of the gastric wall. These lymph vessels are known as tumor lymphatics.

Discontinuous spread refers to the movement of gastric cancer cells into the lymph vessels without the formation of a continuous band. The cells float dispersedly or migrate within the lymph vessels, exit the lymph vessels using amoeboid movement, or invade the LNs by following the lymphatic flow. Even when the cancer cells reach the LNs, they spread unceasingly by floating within the lymphatic sinus. This metastatic spread pattern is frequently found in poorly differentiated adenocarcinoma or diffuse signet-ring cell carcinoma. Although gastric cancer of this type has a more widespread LNM pattern, cancer cells sometimes invade the omental tissue around the LNs before the occurrence of LNM. Furthermore, normal LNs enclosed by the invaded omental tissue can be seen. This phenomenon indicates that cancer cells spread more rapidly within the loose mesenchyme.

The two above-described metastatic spread patterns are not isolated. In particular, when cancer cells spread continuously within the lymph vessels, they may only migrate a certain distance before moving into the lymph vessels to spread by another pattern.

1.4 Types and Characteristics of Metastatic LNs in Gastric Cancer

Macroscopic types. (1) Fused large nodule type: LNs are obviously enlarged and may reach the size of an egg. Some LNs fuse together to form a mass surrounded by an envelope with a necrotic center. (2) Isolated small nodule type: LNs are not very obviously enlarged. They are generally scattered and smaller than a soya bean. Therefore, it is easy to mistake them for normal LNs. (3) General type: LNs are round, hard, and slightly enlarged to a size somewhere between the two extremes, often as large as a pinkie finger.

The fused large nodule type has the lowest metastatic rate and the lowest mean number of metastatic LNs. In contrast, the isolated small nodule type has the highest metastatic rate and the highest mean number of metastatic LNs. The general type falls between these two extremes.

Histological types. (1) Early metastasis: Few cancer cells can be seen, and they are only present in the marginal sinus. (2) Massive metastasis: Large cancerous LNs extend from the marginal sinus to the medulla, and the surrounding tissue is compressed. (3) Diffuse metastasis: The structures of the LNs are either preserved or broken, and cancer cells are diffusely scattered in the cortex and/or medulla.

LNM in gastric cancer generally progresses from the near to the distant and the shallower to the deeper LNs based on the lymphatic drainage routes. If the lymphatic streams are obstructed, retrograde metastasis may occur. In some cases, second-tier LNM without first-tier LNM occurs. This is known as a skip metastasis. These phenomena indicate that it is important for clinicians to examine the LNs to determine the optimal extent of lymph node dissection during the operation.

In addition to the general LNM pattern via the lymph vessels, some particular LNM patterns may occur as follows:

Retrograde metastasis: The lymph vessels among different districts communicate with one another, and retrograde motion may exist even under normal conditions. Additionally, cancer emboli may obstruct the lymphatic vessels or LNs, increasing the risk of retrograde movement. Thus, retrograde metastasis of LNs frequently occurs in gastric cancer.

Skip metastasis: LNM does not always occur sequentially from the shallower to deeper LNs. Metastatic spread may skip regional draining LNs to form distant nodal metastases via the collateral branches of the lymph vessels. Therefore, it is important for the surgeon to dissect the distal LNs during surgery.

Virchow's metastasis: The epigastric organs, including the liver, pancreas, and spleen, surround the stomach and duodenum. These organs have a common lymphatic drainage unit. Their efferent lymph vessels finally drain into the celiac artery LNs. The celiac artery LNs drain into the intestinal lymphatic trunk with the LNs located at the root of the mesentery (terminal LNs of the intestinal tract). This portion of the intestinal lymphatic trunk communicates with the lumbar lymphatic trunk or para-aortic LNs. The majority of the lymphatic fluid drains into the thoracic duct through the cisterna chyli. The supraclavicular LNs are located at the point at which the thoracic duct drains into the left jugular vein. Metastasis of these LNs is called Virchow's metastasis. Metastasis of Virchow's node is considered to be strongly indicative of the presence of extensive metastasis in the retroperitoneal tissue around the abdominal aorta.

Many studies have identified numerous factors associated with LNM in gastric cancer, including the depth of invasion, tumor morphology, tumor size, and histological type of cancer. Deeper invasion, a larger tumor diameter, a more advanced stage, and greater differentiation are associated with a higher incidence of LNM. However, there is no definitive evidence of a relationship between LNM and the tumor location or the patient's age or sex. However, tumor location is closely related to the group distribution of LNM. LNM is an important biological characteristic and prognostic factor of gastric cancer. Radical gastrectomy for gastric cancer is based on lymphadenectomy, and complete dissection of metastatic LNs is not only vital, but difficult to perform. Only with a clear understanding of the biological behavior and characteristics of LNM can a surgeon choose the optimal surgical method and thus increase the extent of radical resection.

2 The Current Status and Development of Lymph Node Dissection for Gastric Cancer

Abstract

In 1962, according to the results concluding from specimens of gastric cancer, the Japanese Gastric Cancer Association produced the first edition of Japanese Classification of Gastric Carcinoma (JCGC), in which lymph nodes (LNs) associated with metastasis of gastric cancer (GC) were anatomically divided into groups. This clarified the gastric lymphatic circulation system in detail. The classification laid the theoretical foundation of systematic lymph node dissection for GC and also propelled its surgical treatment into a new era. Researchers in Japan had worked to ensure that the standard set by the JCGC realistically reflected the approach and extent of lymph node metastasis (LNM), to guide the reasonable extent of lymph node dissection. The JCGC has been steadily revised since 1962 with new understandings from continuously practices by Japanese researchers; they kept observing and summarizing the regularities of the distribution of positive metastatic LNs. In 2010 the 14th edition of the JCGC was published. It described the lymphatic system of the stomach from the perspective of anatomy and further revealed the regularity of LNM of GC and the method for evaluating the extent of LNM. Moreover, it established the integrated theoretical framework for systemic lymphadenectomy, in which the extent of lymph node dissection was verified by the stage of cancer. The TNM staging system of the Union for International Cancer Control (UICC) is another important international appraisal system for GC, which evaluates the extent of metastasis with only the number of metastatic LNs. It reflected the relationship between the number of metastatic LNs and the prognosis of the patient. However, with respect to the regularity of LNM, this system cannot reflect well. It can only be regarded as a way for assessing the post-

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Keywords
Lymphadenectomy • Gastric cancer • Laparoscopic surgery

In 1962, according to the results concluding from specimens of gastric cancer, the Japanese Gastric Cancer Association produced the first edition of Japanese Classification of Gastric Carcinoma (JCGC), in which lymph nodes (LNs) associated with metastasis of gastric cancer (GC) were anatomically divided into groups. This clarified the gastric lymphatic circulation system in detail. The classification laid the theoretical foundation of systematic lymph node dissection for GC and also propelled its surgical treatment into a new era. Researchers in Japan had worked to ensure that the standard set by the JCGC realistically reflected the approach and extent of lymph node metastasis (LNM), to guide the reasonable extent of lymph node dissection. The JCGC has been steadily revised since 1962 with new understandings from continuously practices by Japanese researchers; they kept observing and summarizing the regularities of the distribution of positive metastatic LNs. In 2010 the 14th edition of the JCGC was published. It described the lymphatic system of the stomach from the perspective of anatomy and further revealed the regularity of LNM of GC and the method for evaluating the extent of LNM. Moreover, it established the integrated theoretical framework for systemic lymphadenectomy, in which the extent of lymph node dissection was verified by the stage of cancer. The TNM staging system of the Union for International Cancer Control (UICC) is another important international appraisal system for GC, which evaluates the extent of metastasis with only the number of metastatic LNs. It reflected the relationship between the number of metastatic LNs and the prognosis of the patient. However, with respect to the regularity of LNM, this system cannot reflect well. It can only be regarded as a way for assessing the postoperative outcomes but not as a guide for determining the extent of surgery. Therefore, controversies on the extent of lymphadenectomy for GC almost center on the JCGC.

2.1 The Extent of Lymphadenectomy in Early Gastric Cancer (EGC)

The rate of EGC gradually increased in recent years, probably owing to improved detection [1–3]. More than 50.0 % of patients with GC in Japan, and more than 40.0 % of those in Korea, were diagnosed as EGC. These rates are expected to increase further as diagnostic techniques and public awareness of GC improve. Therefore, the correct surgical approach for EGC is especially important. Reportedly, among patients with EGC, only 2.4–16.7 % have metastatic nodes when the primary lesion is confined to the mucosa. However, if the tumor has invaded the submucosa, the rate increases to 16.0–46.7 % [2]. Therefore, if lymphadenectomy is not performed in patients with EGC, the risk of postoperative tumor residual and recurrence increases [4]. However, a D2 lymphadenectomy in accordance with radical gastrectomy for GC may be considered overtreatment. The most recent studies support limited (D1) dissection in EGC, as its 5-year survival rate is 98.0 %. Additionally, D2 dissections, when compared with D1 lymph node dissection, do not increase the overall 10-year survival rate or reduce the recurrence rate in EGC [5, 6]. The third edition of Japanese Gastric Cancer Treatment Guidelines [7] recommends the extent of lymphadenectomy for EGC as follows: (1) A D1 lymphadenectomy is indicated for cT1aN0 tumors that do not meet the criteria for endoscopic mucosal resection/endoscopic submucosal resection and for tumors that are histologically of differentiated type and ≤1.5 cm in diameter. (2) A D1+ lymphadenectomy is indicated for cT1N0 tumors other than the above. (3) A D2 lymphadenectomy is indicated for cT1N+ tumors.

2.2 The Extent of Lymphadenectomy for Advanced Gastric Cancer

For advanced gastric cancer, Japanese researchers have recommended extended lymph node dissection (D2) for GC according to the study of lymphatic circulation system in JCGC since the 1960s. This recommendation was thereafter followed in Korea and China. Although most Asian researchers considered the D2 dissection was designed according to the feature of lymphatic drainage in GC, in which potentially metastatic LNs were removed to a great extent, it was also a relatively safe and effective radical treatment for GC. However, reports in Western countries were not so positive. In the 1980s, a multicenter prospective randomized controlled trial (RCT) of D1 and D2 lymphadenectomy for GC from Britain and the Netherlands found postoperative complications and in-hospital mortality of D2 lymphadenectomy to be higher than those of D1 procedures, but with similar survival rates. Therefore, D2 lymphadenectomy was regarded as unsafe [8, 9]. Nevertheless, the reasons of this result were various and complicated for some Western scholars in the early years. The Dutch trial involved 331 patients who underwent D2 dissection in 80 medical centers between August 1989 and July 1993; for a mean of 1.2 D2 lymphadenectomies per center, per year, the interval of each operation was too long, and the quality of operation was not well controlled. Besides, if doctors lacked experience of managing patients with D2 lymphadenectomy during the perioperative period, it also affected the recovery of patients. Therefore, Italian researchers in cooperation with Japanese researchers provided thorough training and strict control of surgeons' operating quality and found outcomes of D2 lymphadenectomies were closer to those of Asian reports [10]. The operative morbidity rate was 20.9 %, the postoperative in-hospital mortality was 3.1 %, and the postoperative 5-year survival rate was 65.9 %. Since then, Asian and Western researchers have continuously improved their technique for D2 lymphadenectomy through live surgical demonstrations and exchange of experience. Later RCTs which were scientific and well designed in Western countries showed that D2 and D1 lymphadenectomy did not significantly differ in postoperative morbidity or in-hospital mortality, but the postoperative 5-year survival rate of D2 lymphadenectomy was obviously higher than that of D1. A 15-year follow-up of the Dutch research reported in 2010 showed D2 lymphadenectomy to be superior to D1 in postoperative survival rate, morbidity, and recurrence rate [11]. However, Asian and Western researchers have not yet reached a complete consensus. The NCCN2010 GC guidelines point out that D2 dissection for GC should be performed by surgeons with significant degree of training and expertise. And it is considered a recommended but not required surgery. Thus the acceptance of D2 lymphadenectomy as a standard procedure for stage II and III GC is occurring gradually. The guidelines defined a standard gastrectomy as resection of at least two-thirds of the stomach with a D2 lymph node dissection.

Extensive lymphadenectomy beyond D2 is controversial. Although Sano T et al. suggested that D2 plus No. 16 lymph node dissection would not increase major surgical complications [12], the JCOG9501 study in 2008 denied that preventative No. 16 lymph node dissection had a curative effect [13]. The study additionally reported that although patients with No. 16 LNM or those with no other non-radical factors could undergo R0 resection, their prognosis remains poor.

A consensus as to whether No. 14v LNs are regional has not been formed. Although in the past No. 14v LNs were divided into N3 LNs and were not dissected in standard radical gastrectomy in the JCGC of the edition before 13th, they were thereafter placed within the extent of D2 procedures in the 13th edition. Then in the 14th edition, they were once again placed outside of D2 procedures, as patients with No. 14v LNM were thought to have a worse survival rate. However, No. 14v lymph node dissection is recommended for patients with GC with potential distal No. 6 LNM.

2.3 The Application of Laparoscopic Techniques in Lymphadenectomy

Through the aforementioned discussion about the extent of lymphadenectomy, laparoscopic radical gastrectomy (LRG) would be a standard surgical mode for GC, if it can follow the rules of open curative resection to achieve the goal of thorough lymph node dissection. In EGC, LRG can meet the requirements of negative margins and can determine the extent of systematic lymphadenectomy according to the depth of tumor invasion. Since the first report of its use by Kitano in 1994 [14], LRG for EGC has become widely used all over the world. Currently, LRG is considered a standard procedure with a maturing technique and is associated with good outcomes in EGC [15, 16]. In 1997, Goh et al. [17] first reported laparoscopy-assisted gastrectomy (LAG) with D2 lymphadenectomy for advanced GC, and the safety and feasibility of which have been shown in multiple studies [18–21]. However, indications for laparoscopic approaches are controversial. Although techniques in LRG with D2 lymphadenectomy continue to develop, most of the surgeons accept that one of the indications is the advanced tumor that has not perforated the visceral peritoneum [22]. Some surgeons suggest that LRG has similar curative resection and oncologic outcomes to open approaches and LRG with D2 lymphadenectomy can be performed exploratively for tumors that penetrate the visceral peritoneum $\leq 10\ \text{cm}^2$ [23]. Improper manipulations in laparoscopic surgery may be associated with increased risk of the tumor spreading to the abdominal wall, immune function disturbance, and changes in the peritoneal structure. These increased the risk of tumor cell distribution and implantation metastasis at the incision [24, 25]. Thus LAG was unsuitable for GC that penetrated the visceral peritoneum $>10\ \text{cm}^2$, LNM surrounding important vessels, or when there is extensive invasion of adjacent structures. LRG is also not suited for extremely complicated lymphadenectomies, such as LNM that requires super extended (D3) lymphadenectomy.

Although the most striking feature of LRG was its minimal invasiveness [20, 26–29], its oncologic outcomes are the focus of our attention. The number of dissected LNs was the most important surrogate marker of the "radical surgery." Miura et al. [30] reported that significantly fewer LNs were harvested by an LRG than by conventional open surgery, particularly for No. 4, 6, 9, and 11 LNs. However, Huscher et al. [31] reported that the two methods did not significantly differ in lymph node retrieval. Song et al. [18] compared surgical outcomes of LRG with D2 dissection and conventional open gastrectomy (OG) for patients with EGC (75 patients, of whom 44 underwent LAG and 31 underwent OG) and found no significant differences in the total number of retrieved LNs (37.2 vs. 42.4; $P>0.05$) or node stations ($P>0.05$) between the two groups. We found that skilled laparoscopic surgical technique and thorough palpation of anatomical layers under laparoscopy are the key to lymph node dissection. Laparoscopic amplification elaborately shows the finer structures of the vasculature, nerves, and fascia, which helps the surgeon identify specific fascial planes and facilitates lymph node dissection within the vascular sheath. Furthermore, the ultrasonic scalpel is an effective instrument for cutting, providing hemostasis, and minimizing damage to surrounding tissues, which is suitable for vascular separation and lymph node dissection. We previously reported a study that compared 506 patients who received LRG with 428 who received OG. The mean number of dissected LNs was 29.1 ± 10.4 per patient, showing that there were no significant differences between LRG group and OG group ($P<0.05$). However, significantly more No. 7 and 8 LNs were retrieved in the LRG group than in the OG group. And no significant difference in other groups of LNs was observed [19]. We also performed a retrospective matched-cohort study to compare LRG and OG for advanced GC without serosa invasion ($n=83$ for both groups). We found no significant difference in the number of dissected LNs between these two groups during the same period [32]. Hence, LRG for GC is apparently as curative as the open approach.

Long-term outcomes are an important measure of curative effect. In Korea and Japan, the proportion of LRG for EGC has increased. Some retrospective analyses and small sample RCTs reported that long-term outcomes from laparoscopic surgery for EGC are similar with those from open surgery. Mochiki et al. [33] reported a retrospective study of 89 patients who underwent LRG, compared with 60 who underwent conventional OG; the two groups did not significantly differ in their 5-year survival rates (98.0 % vs. 95.0 %). A multicenter study of oncologic outcomes after laparoscopic surgery for early gastric cancer in Japan [34] showed that among 1,294 patients who were treated curatively (median follow-up: 36 months), only six cases were of recurred disease; the 5-year disease-free survival rate was 99.8 % for stage IA disease, 98.7 % for stage IB disease, and 85.7 % for stage II disease; the results indicated that laparoscopic surgery treatment for early gastric cancer has a good long-term outcomes. Although few studies focus on long-term outcomes of patients with advanced GC, reports of results from laparoscopic surgery for advanced GC were not inferior to those from open surgery. Shuang et al. [35] reported a case-control study of laparoscopy-assisted and open distal gastrectomy for advanced GC. Cumulative survival of the two groups was similar after 50 months of follow-up. Ibanez et al. [36] and Azagra et al. [37] reported that laparoscopy-assisted gastrectomy for locally advanced cancer is equivalent to laparotomy as far as long-term oncological results are concerned. Recently, a study to verify the long-term safety of laparoscopic gastrectomy for GC compared with open conventional gastrectomy was conducted across multiple institutions in Korea. The researchers analyzed long-term follow-up data of a large number of patients and found, after matching with a propensity scoring system, that overall survival, disease-specific survival, and recurrence-free survival rates did not significantly differ at each stage (median follow-up period: 70.8 months) [38]. However, all of the aforementioned results should be confirmed by large well-designed prospective RCTs. Currently, some countries such as China, Japan, and Korea have carried out RCTs focused on the efficacy of laparoscopic and open conventional surgery for patients with advanced GC. These RCTs will offer strong evidence of evidence-based medicine for the further application of laparoscopic surgery for gastric cancer.

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3 Preoperative Notes of Laparoscopic Lymph Node Dissection for Gastric Cancer

3.1 Instruments

3.1.1 Routine Devices

A high-definition camera and display systems, a pneumoperitoneum machine, irrigation and suction devices, and video and image storage devices should be available, as well as routine laparoscopy equipment, such as 5–12-mm trocars, Maryland forceps, noninvasive grasping forceps, intestinal forceps, an aspirator, scissors, a needle holder, vascular clamps, an absorbable clip applier, a titanium clip applier, and small gauzes (Figs. 3.1, 3.2, and 3.3).

3.1.2 Special Devices

Ultracision, LigaSure™ vessel sealing system, bi-active coagulation set, and all varieties of intestinal Endo-GIA and circular staplers should be at the ready.

3.2 Patient's Position

Appropriate patient positioning is important for intraoperative exposure during laparoscopic gastrectomy for gastric cancer. The patient is usually placed in the supine position with legs separated. The surgical table is declined about 10–20° into the reverse Trendelenburg position. Therefore, the patient's upper body is elevated. This causes the intestine to move toward the lower abdomen, thus helping to expose the upper abdomen (Fig. 3.4). When dissection of the splenic hilar lymph nodes (LNs) is performed, the patient's upper body is elevated about 10–20°, and the left side of the body is tilted up about 20–30° (Fig. 3.5), allowing the intestine and omentum to move toward the right lower abdomen. This helps expose the splenic hilar area.

3.3 Surgeons' Locations

Generally, the surgeon stands on the patient's left side, the assistant is on the right side, and the camera operator is between the patient's legs (Fig. 3.6), while during dissection of the splenic hilar LNs, the surgeon stands between the patient's legs, with the assistant and camera operator both on the patient's right (Fig. 3.7).

3.4 Location of Trocars

The 5-port method is generally used (Figs. 3.8 and 3.9). A 10-mm trocar is inserted 1 cm below the umbilicus as an observation port. Another 12-mm trocar is introduced in the left preaxillary line 2 cm below the costal margin as a major hand port. A 5-mm trocar is then inserted in the left midclavicular line 2 cm above the umbilicus

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Fig. 3.1 Small gauzes

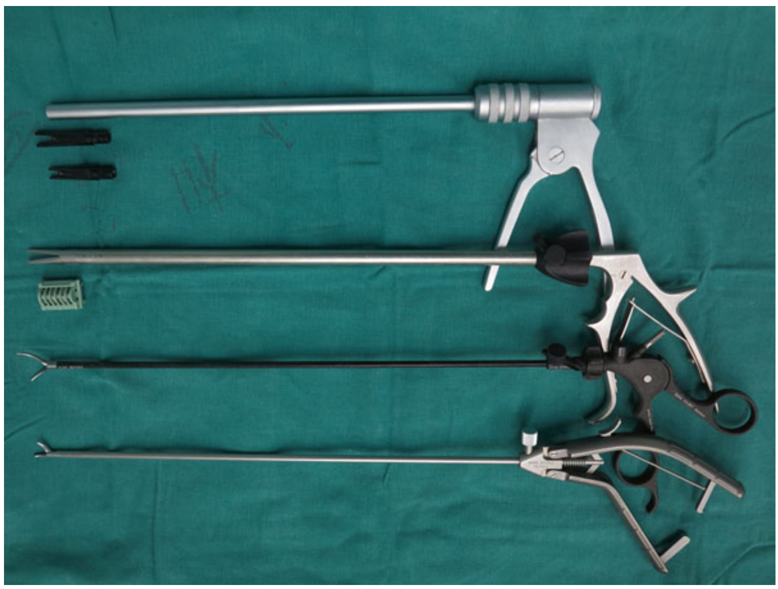


Fig. 3.2 An absorbable clip applier, a titanium clip applier, Maryland forceps, and a needle holder

as a tractive port. Two 5-mm trocars are severally placed in the right midclavicular line 2 cm above the umbilicus and in the right preaxillary line 2 cm below the costal margin as two accessory ports. The observation port is usually inserted first. For this insertion, an approximately 1.5-cm-long incision is made, and the abdominal wall is raised with towel forceps. When inserting the trocar, the operator should rotate it left and right and move it forward slowly. The sensation of the breakthrough "pop" indicates that the trocar has entered the abdominal cavity and the puncture sleeve is removed. Pneumoperitoneum should be established after trocar insertion is confirmed by laparoscopy to avoid subcutaneous emphysema. The remaining trocars should be inserted into the ports under the laparoscopic image.

Fig. 3.3 Gastric forceps, intestinal forceps, and an aspirator

Fig. 3.4 The patient is in the supine and reverse Trendelenburg position

The possibility of a poor seal should be routinely checked after placing the trocars, with particular regard to two situations: (a) a broken flap or switch cap on the trocar and (b) the incision that is too large for a good seal. In the former case, the trocar needs to be changed. In the latter case, a skin suture after the placement of trocar can prevent a gas leak.

Sudden movements are unfavorable when inserting the trocars and may injure the mesentery or bowel (Fig. 3.10). Patients with histories of abdominal surgery often have adhesions of the small intestine near the lower part of the incision, which may be injured if the trocar is pushed through the operative scar (Fig. 3.11).

Fig. 3.5 The patient is in the reverse Trendelenburg and right lateral position

Fig. 3.6 Surgeons' general locations

3.5 Establishment of Pneumoperitoneum

The formation of a visual field and operation space depends on pneumoperitoneum during laparoscopic surgery. CO_2 is commonly used, as it is chemically stable, nonflammable, readily accessible, and nontoxic. Additionally, it can be exhaled from the lungs through the normal carbonate metabolic pathway after absorption by the body. After establishing pneumoperitoneum, intra-abdominal pressure is maintained between 12 and 15 mmHg, although for elderly patients or patients with pulmonary disease, intra-abdominal pressure should be maintained at a reduced level. Sometimes, to reduce spray produced by

Fig. 3.7 Surgeons' locations during the splenic hilar lymph node dissection

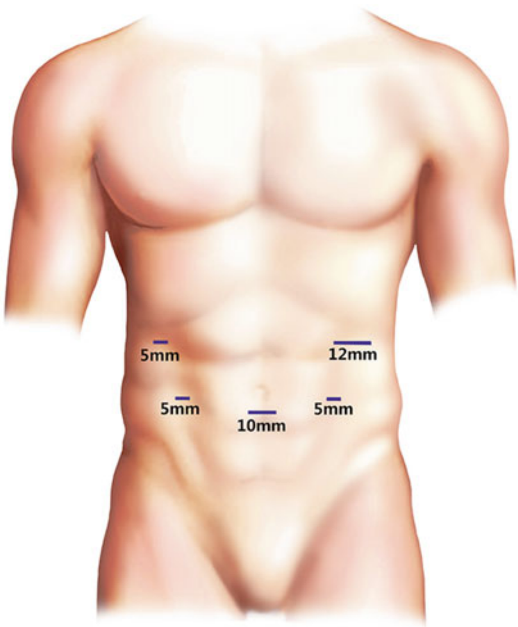


Fig. 3.8 Diagram of the trocars' locations

ultrasonic scalpel during surgery, a small-flow vacuum suction set can be connected to the trocar at the major hand port. In this case, the pneumoperitoneum machine pressure should be raised appropriately to make the spray diffuse quickly to maintain clear vision (Fig. 3.12).

3.6 Preoperative Exploration

As surgery begins, the camera lens may fog from the change in temperature as it enters the abdomen for the first time. This can be solved by soaking the camera lens in warm (≥60 °C) physiological saline for about 10 s and then wiping it clean with dry lens gauze and inserting it promptly into the abdominal cavity. Meanwhile, room temperature should be regulated to 24 °C. When the temperature is too high, the surgeons may feel uncomfortable, whereas a lower temperature would cause the camera lens to fog during insertion.

When a high-volume stomach is found during exploration, the circulating nurse should suction away as much intragastric liquid and gas as possible, so that it is easier to adjust and expose during the surgery.

Accurate preoperative TNM staging guides cancer management decisions. Laparoscopic exploration is used for preoperative staging, especially to assess intra-abdominal metastasis, which can reduce unnecessary laparotomy for gastric cancer. NCCN treatment guidelines also propose using diagnostic laparoscopy to evaluate gastric cancer metastasis and thus improve the

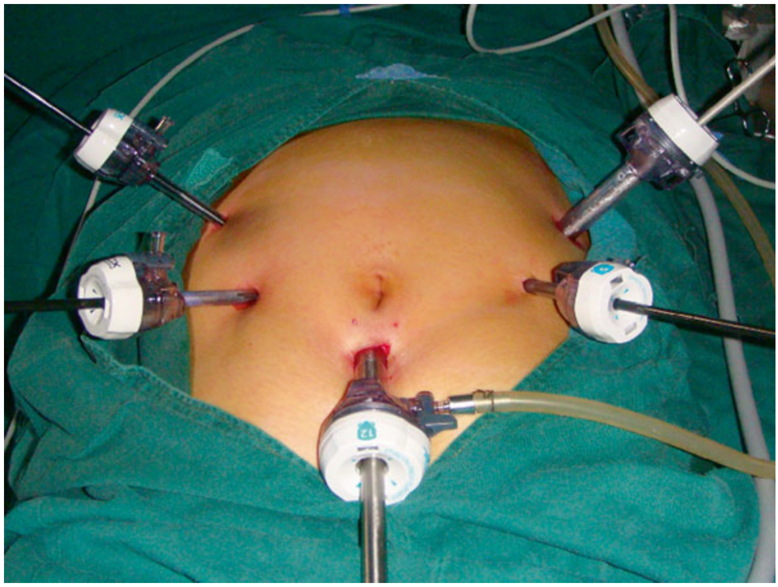


Fig. 3.9 Locations of the trocars

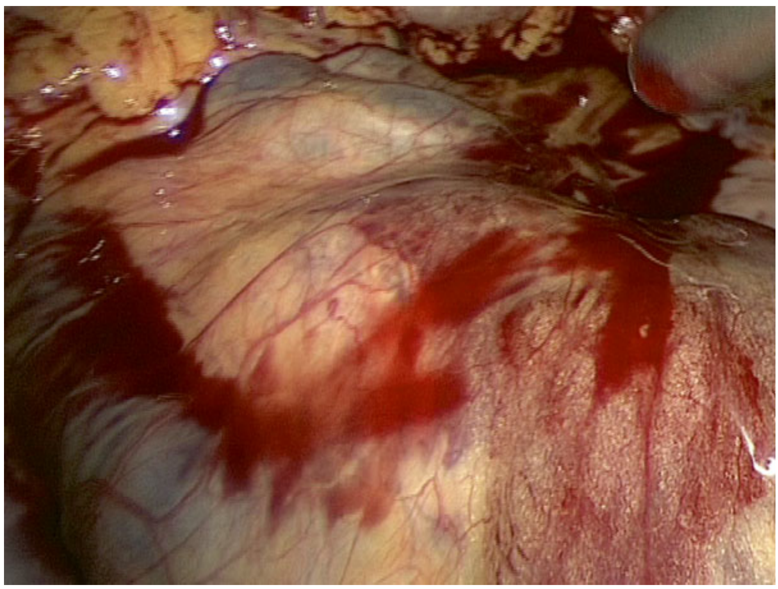


Fig. 3.10 Mesenteric hematoma caused by excessive puncture strength

accuracy of preoperative gastric cancer staging. Preoperative diagnostic laparoscopies can identify the primary tumor's location, extent and depth of invasion, lymph node metastasis (LNM) or abdominal metastasis, ascites, and invasion of adjacent structures (Figs. 3.13, 3.14, 3.15, 3.16, 3.17, 3.18, and 3.19).

3.7 Sequence of a Lymphadenectomy

In principle, the sequence of a lymphadenectomy is from top to bottom, right to left, and greater to lesser curvature, with the duodenum and esophagus resected at the conclusion.

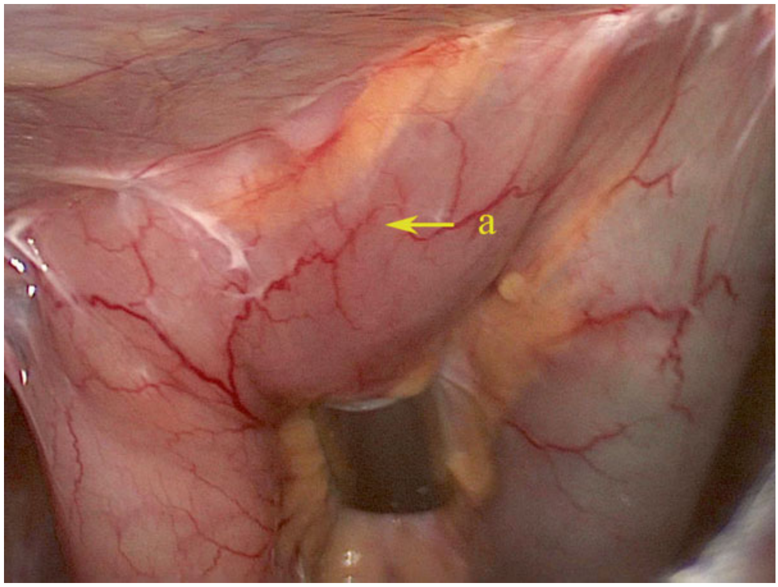


Fig. 3.11 Small intestine adhesion (*a*) in the lower part of the incision is punctured

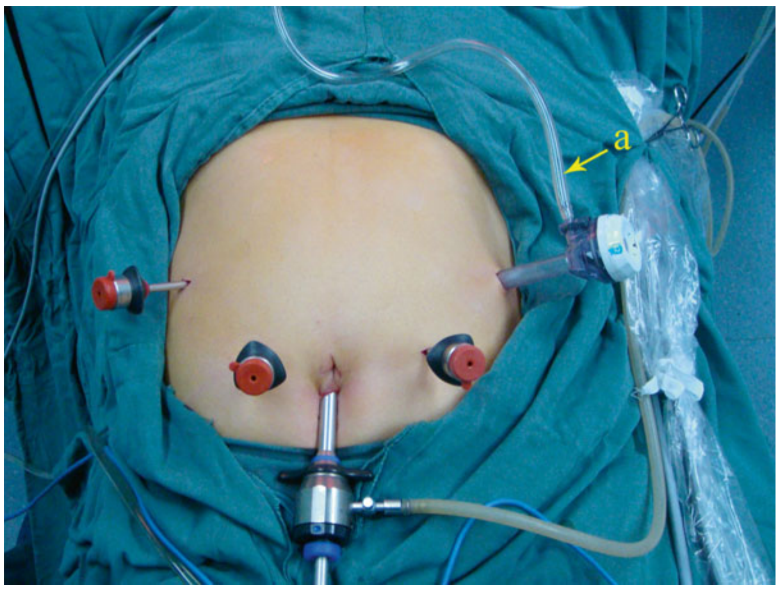


Fig. 3.12 Major hand port is connected to a small-flow vacuum suction set (*a*)

The specific steps are as follows: (1) distal gastrectomy, No. 6 → No. 7, 9, 11p → No. 3, 1 → No. 8a, 12a, 5 → No. 4sb (Fig. 3.20), and (2) total gastrectomy, No. 6 → No. 7, 9, 11p → No. 8a, 12a, 5 → No. 1 → No. 4sb → No. 10, 11d → No. 2 (Fig. 3.21).

The advantages of this sequence are (a) the operative position does not need to change, (b) the clamping of lesion tissue on the gastric wall is less frequent, (c) the surgery field exposure is better, and (d) the tissue to be resected can be connected from top to bottom and, to the extent possible, resected en bloc.

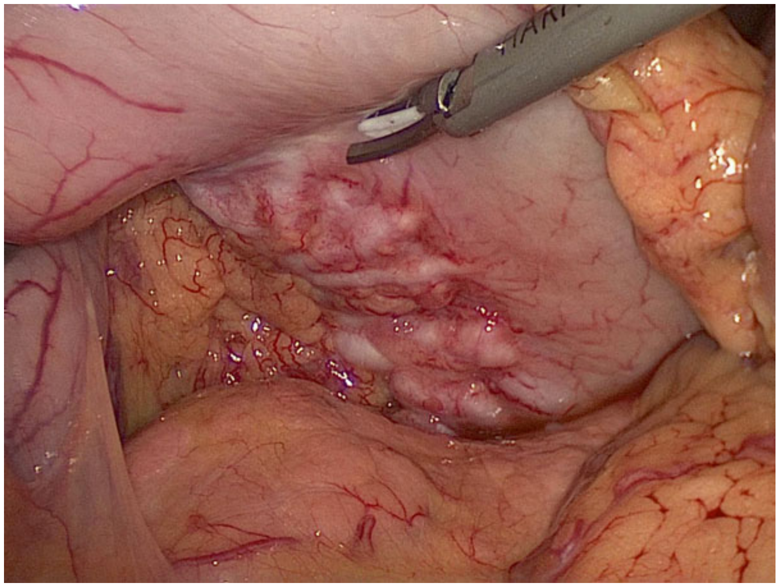


Fig. 3.13 Tumor located on the posterior gastric wall invades the serosal layer

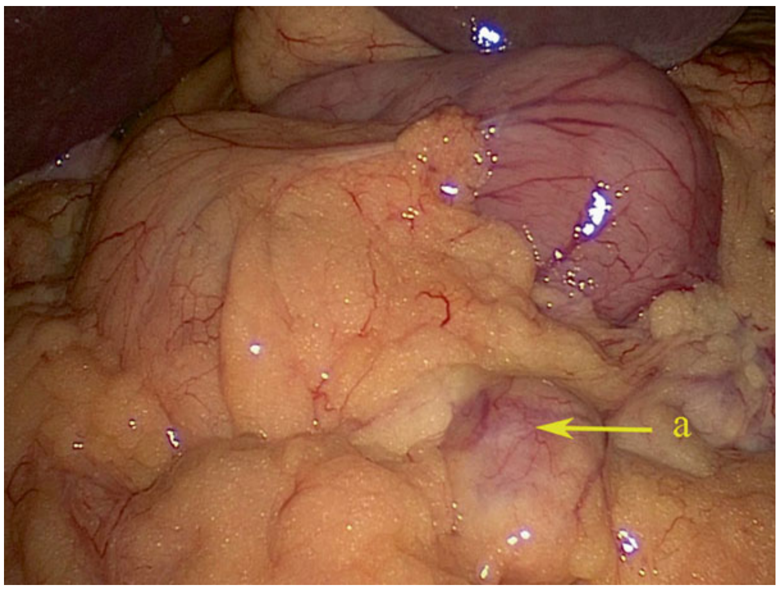


Fig. 3.14 LNM (*a*) of gastric greater curvature

3.8 Nursing Cooperation

Laparoscopic gastrectomy should be performed with close cooperation between surgeons and nurses because of its diverse surgical methods, various surgical instruments, and complex operative process. Adequate preoperative preparation, familiarity with the operative procedure and surgeon's operation habits, and a high reaction capability are required for nursing staff members. All of these factors help to ensure the successful performance of laparoscopic surgery with shorter operation times.

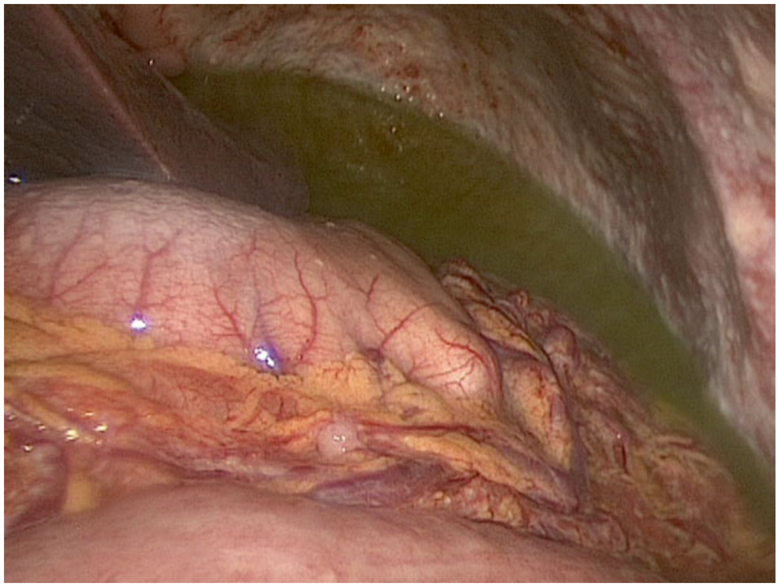


Fig. 3.15 Gastric cancer with intra-abdominal extensive metastasis and ascites

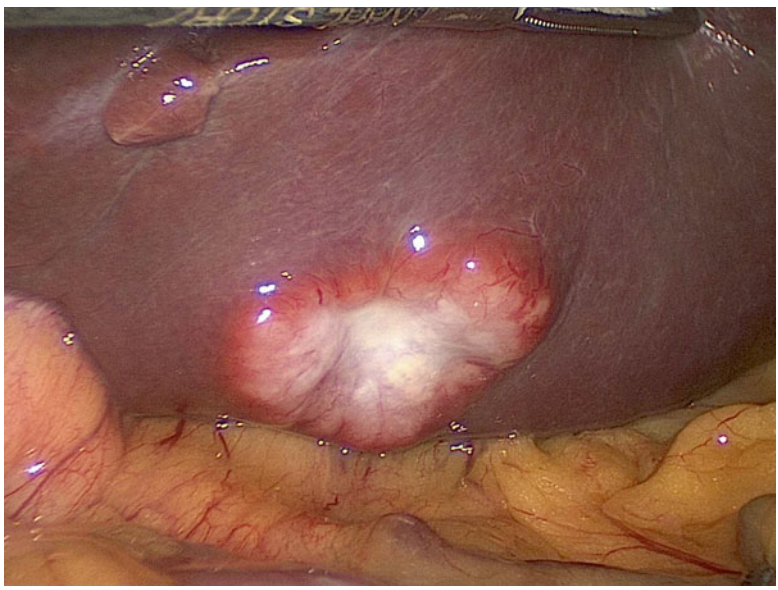


Fig. 3.16 Gastric cancer with liver metastasis

3.8.1 Preoperative Visit

After receiving notification of surgery, a circulating nurse should visit the patient in the ward, introduce the surgical methods, and explain the advantages of laparoscopic surgery the day before the surgery. The nurse should also help the patient and his or her relatives to relieve mental stress and enhance confidence. This allows the patients to face the surgery under optimal conditions. The conditions of diseases should be kept secret to the patients if they are not suitable to know.

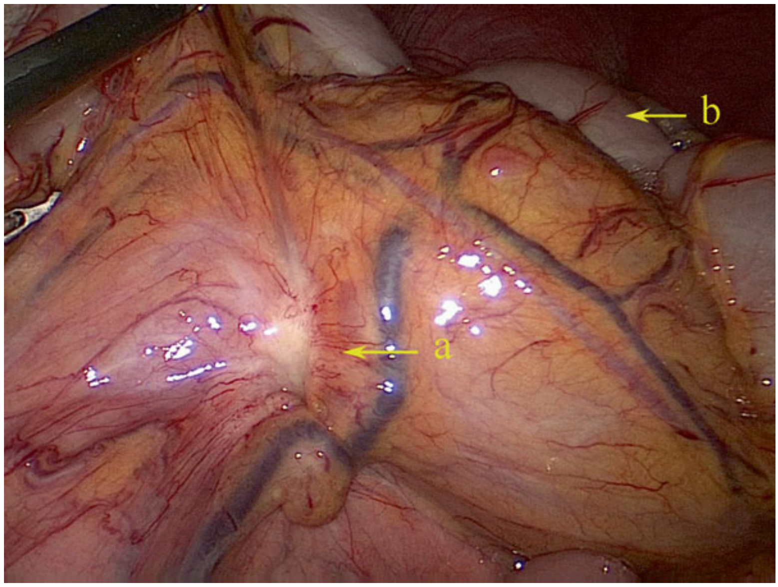


Fig. 3.17 Gastric cancer invades the transverse mesocolon (*a*) and transverse colon (*b*)

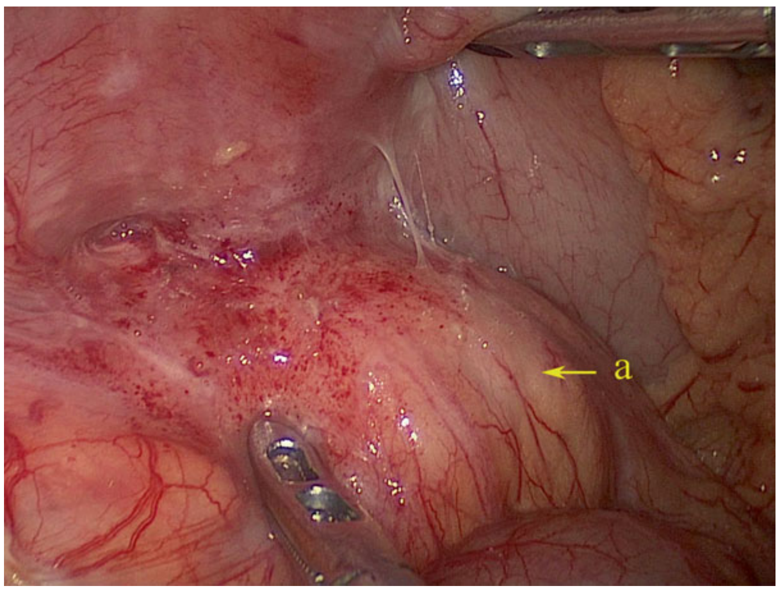


Fig. 3.18 The pancreas is invaded by a tumor located on the gastric posterior wall (*a*)

3.8.2 Preparation of Instruments

The surgical instruments used for laparoscopic gastrectomy include a basic package for open surgery, laparoscopic camera systems, routine laparoscopic equipment, and the instruments used for reconstruction of the digestive tract.

3.8.3 Preparation of Operating Room

The surgery should be performed in a clean laminar flow operating room; visitors and staff should be restricted from frequently walking in and out of the operating room. The relative humidity and

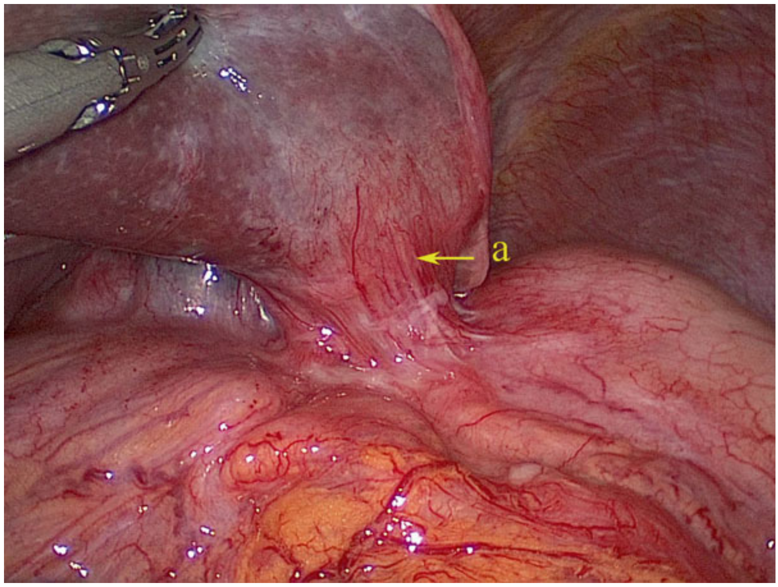


Fig. 3.19 Left external lobe of the liver (*a*) is invaded by gastric cancer

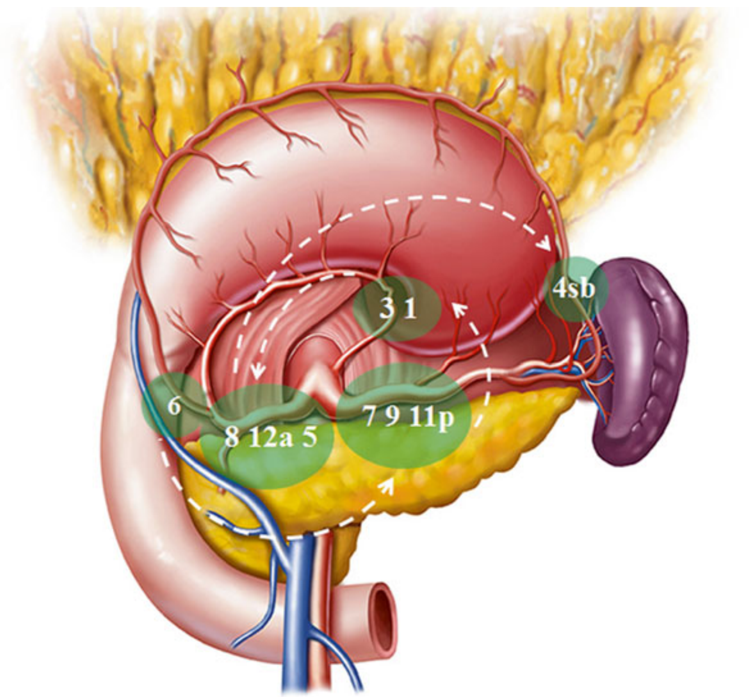


Fig. 3.20 Sequence of a lymphadenectomy for laparoscopic distal gastrectomy

temperature should generally be maintained at 40.0–60.0 % and 24 °C, respectively. Light music can be played to help the patient relax.

The main laparoscopic system should be placed on the left side of the patient, while two monitors are placed at the patient's head part. The monitors should be adjusted to obtain the proper angle to prevent reflection of light and allow for the best operating view for both the chief surgeon and assistant. Also, the camera system, insufflation machine, and Ultracision should be correctly connected.

The scrub nurse stands on the left side of the patient, and the instrument table should be placed at the distal one-third of the left leg board (Fig. 3.22). The surgeon should wear an additional sterile waistcoat, or pad a sterile towel on his/her back over the surgical gown to keep the instruments clean and the instrument table sterilized during the process of passing the instruments.

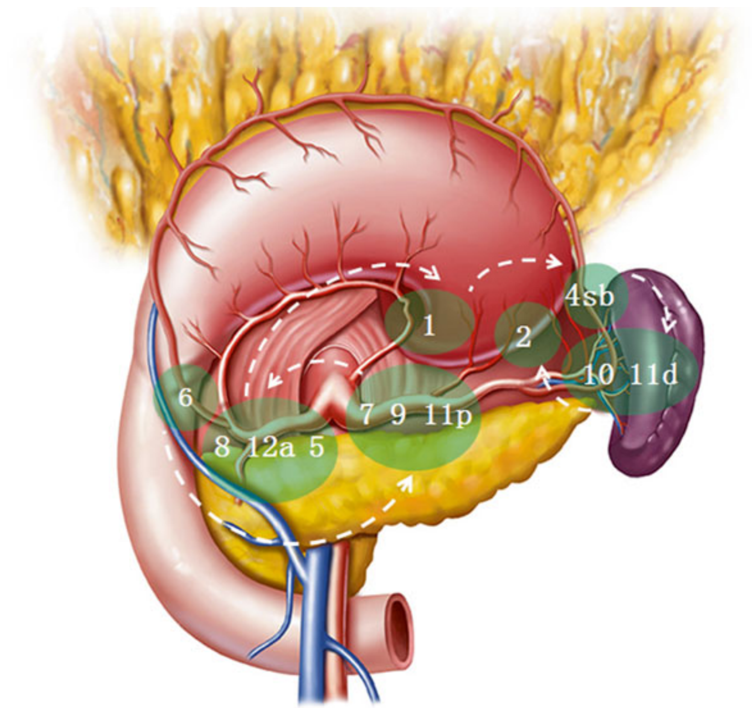


Fig. 3.21 Sequence of a lymphadenectomy for laparoscopic total gastrectomy

Fig. 3.22 Positions of the instrument table (*a*) and scrub nurse (*b*)

Laparoscopic Infrapyloric Area Lymph Node Dissection for Gastric Cancer

4

4.1 Review of Laparoscopic Infrapyloric Area Lymph Node Dissection for Gastric Cancer

Lymph node dissection in the infrapyloric area is an important procedure during laparoscopic radical gastrectomy for gastric cancer, which mainly involves dissection of the No. 6 lymph nodes (LNs) (the infrapyloric LNs) and the No. 14v LNs [LNs located at the root of the superior mesenteric vein (SMV)] (Fig. 4.1).

The frequency of No. 6 lymph node metastasis (LNM) varied between 26.0 % and 34.0 % [1, 2], while the 5-year survival rate among patients with No. 6 LNM was 23.0 % [2]. No. 6 LNM was correlated with tumor location, depth of invasion, and other factors [3]. The metastatic rates of No. 6 LNs in early middle and lower gastric cancer were found to be 1.7 % and 7.6 %, respectively [4], while in advanced middle and lower gastric cancer, the incidence of No. 6 LNM varied between 34.2 % and 41.0 % [1, 5], which is the highest incidence of LNM compared with other groups [6, 7]. However, the incidence of No. 6 LNM in early upper gastric cancer was low. Xu et al. [8] reported that No. 6 LNM was not observed in patients with early proximal gastric cancer after total gastrectomy. Ishikawa et al. [9] analyzed the clinical data of 127 cases with proximal gastric cancer and showed that No. 6 LNM was negative in the early stages. However, the frequency of No. 6 LNM was up to 8.6 % in advanced proximal gastric cancer [10]. Consequently, No. 6 LNs should be routinely removed during curative treatment for middle and lower gastric cancer or advanced proximal gastric cancer according to the 3rd edition of the Japanese Gastric Cancer Treatment Guidelines [11]. However, it is unnecessary to dissect No. 6 LNs for early upper gastric cancer during radical proximal subtotal gastrectomy.

Metastasis of the No. 14v LNs acts as an important prognostic factor for patients with gastric cancer. Although the incidence of No. 14v LNM was lower (0.0–1.3 %) in early gastric cancer, it rose to 19.7 % in advanced gastric cancer [1, 8, 12, 13]. The frequency of No. 14v LNM was also associated with various factors including tumor location, tumor size, depth of invasion, N staging, and whether there was invasion in the surrounding organs and tissues [12, 14, 15]. Zhu et al. [1] considered that the No. 14v LNM rate itself was low, while the anatomy here was complicated and it was easy to damage the gastrocolic trunk, middle colonic vein, and SMV, leading to uncontrollable bleeding. These factors increase the difficulty and risk in dissecting No. 14v LNs. In addition, No. 14v LNM is mostly evident in patients with advanced cancer. These patients have deeper depth of invasion and more positive LNs. Thus, patients with positive No. 14v LNs have a poor prognosis even when dissection is performed. Hence, routine dissection of No. 14v

C.-M. Huang, C.-H. Zheng (eds.), *Laparoscopic Gastrectomy for Gastric Cancer: Surgical Technique and Lymphadenectomy*, DOI 10.1007/978-94-017-9873-0_4,

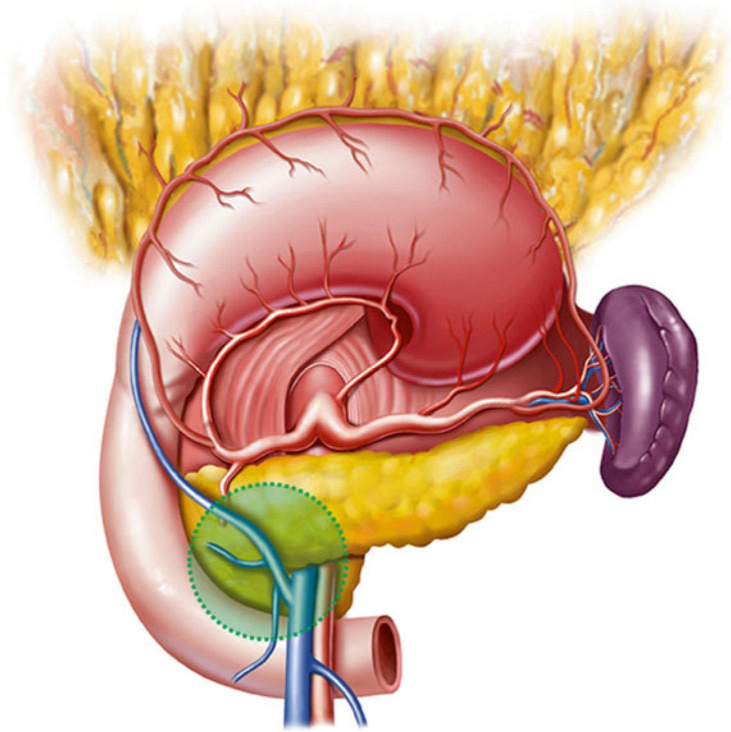


Fig. 4.1 Infrapyloric area

LNs is not recommended in lower gastric cancer. Moreover, an analysis of 1,104 patients who underwent gastrectomy including No. 14v lymph node dissection by An et al. [14] showed that the metastatic rate of No. 14v LNs was only 6.6 %, and three-quarters of patients with No. 14v-positive disease suffered stage IV cancer. In patients with stage II and III gastric cancer, the frequency of No. 14v LNM was only 2.4 % and 4.1 %, respectively. Patients with No. 14v-positive gastric cancer had a poor prognosis similar to that of patients with distant metastasis. The 3- and 5-year survival rates of patients with No. 14v-positive disease were demonstrated as 24.0 % and 9.0 %, respectively. Therefore, An et al. [14] suggested that the No. 14v LNs should be regarded as the extra-perigastric LNs, and whether it should be removed during D2 lymphadenectomy for distal gastric cancer was worth consideration. Hence, routine resection of No. 14v LNs is not recommended, which coincides with the stipulation that the No. 14v LNs is excluded from D2 lymphadenectomy according to the 3rd edition of Japanese Gastric Cancer Treatment Guidelines [11].

However, some scholars indicated that there was a tendency of LNM from No. 6 LNs to No. 14v LNs based on the anatomical structure and the lymphatic drainage pathway in the gastric antrum [7, 12]. Moreover, there is more of a propensity for No. 6 LNM in lower gastric cancer, and the status of No. 6 LNs is an independent variable affecting No. 14v LNM. Hence, on the premise that the surgeon is skillful to achieve a radical treatment, it is reasonable to dissect No. 14v LNs for advanced lower gastric cancer when positive No. 6 LNs are suspected. Liang et al. [16] revealed that metastasis of No. 14v was an independent prognostic factor for advanced gastric cancer after D2 lymphadenectomy. Patients with No. 14v LNM after curative surgery demonstrated a significant lower survival rate than those without it (5-year overall survival rate, 8.3 % vs. 37.8 %, $P<0.01$). For patients with advanced middle and lower gastric cancer, particularly those with a larger size of tumor, serosal invasion, and the possibility of No. 6 LNM, it was necessary to remove the No. 14v LNs.

4.2 Anatomy Associated with Lymph Node Dissection in the Infrapyloric Area

4.2.1 Fascia and Intrafascial Space in the Infrapyloric Area

4.2.1.1 Greater Omentum

The greater omentum is derived from the downward continuation of the embryonic anterior layer of the dorsal mesogastrium (DM). Its right border extends as far as the commencement of the duodenum, and its left border is continuous with the gastrosplenic ligament (GSL). The greater omentum is a four-layered fold of peritoneum. The two anterior layers, which originate at the greater curvature of the stomach and the commencement of the duodenum, descend a considerable distance and return upward to form the two posterior layers, which reach as far as the transverse colon. The posterior layers then enclose the transverse colon to form the transverse mesocolon (TM), and they eventually attach to the posterior abdominal wall. If the two anterior layers attach to the transverse colon when they pass it, this portion is called the gastrocolic ligament (GCL). In some cases, this attachment is not present and there is no actual GCL (Figs. 4.2, 4.3, and 4.4).

4.2.1.2 Gastrocolic Intrafascial Space (GIS)

The two posterior layers of the greater omentum and the TM fuse together near the pylorus to form a latent space called the GIS, which is an avascular zone full of loose connective tissue and some adipose tissue.

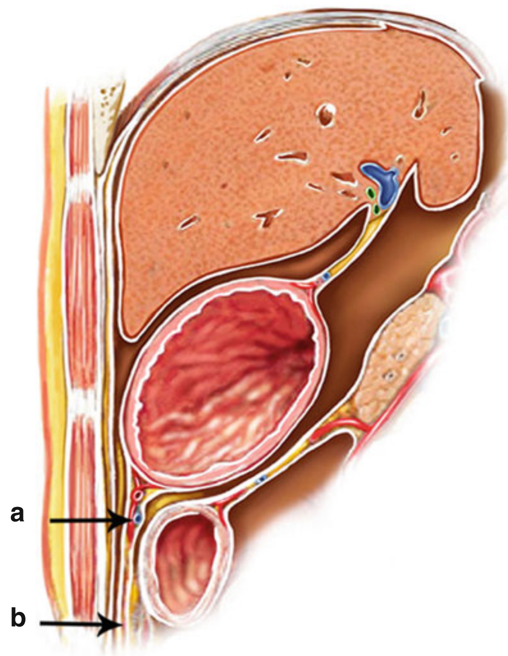


Fig. 4.2 GCL (*a*) and greater omentum (*b*)

Fig. 4.3 Greater omentum (in autopsy) (the *arrow* represents the whole greater omentum)

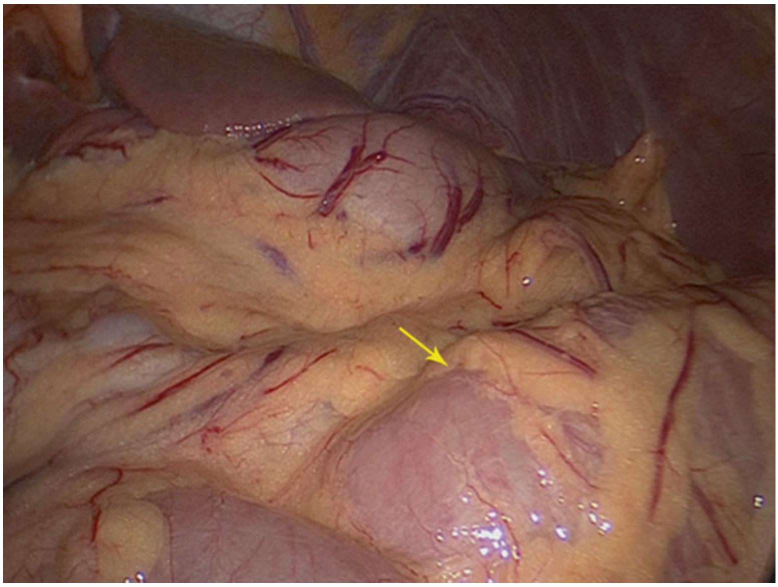


Fig. 4.4 Intraoperative view of the greater omentum (the *arrow* represents the whole greater omentum)

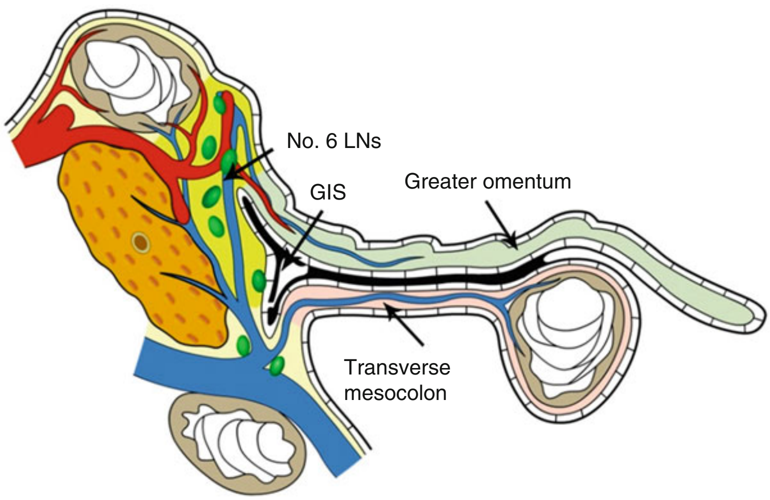


Fig. 4.5 The schematic figure of the GIS

The right gastroepiploic and infrapyloric vessels can be exposed by opening this space. Thus, the No. 6 LNs can be dissected (Figs. 4.5, 4.6, and 4.7).

4.2.1.3 TM

The two posterior layers of the greater omentum separate to surround the transverse colon, then continue upward to the posterior wall of the abdomen to form the TM. This is a broad fold of the peritoneum, attaching from the hepatic flexure and extending across the middle of the right kidney, the descending part of the duodenum, the pancreas, and the front of the left kidney to end at the splenic flexure. Both ends of the TM are relatively fixed, while the middle part is longer and more mobile. The TM is composed of anterior and posterior lobes. Between them, there is a fusion space that is easily separated because of the loose connective tissue in it. The vessels, nerves, lymphatics, and LNs of the transverse colon are included in this space (Figs. 4.8, 4.9, and 4.10). The middle colic vessels (MCVs) within the space can be exposed by opening the anterior lobe of the TM. The anterior pancreatic space, which is linked with the TM fusion space, can be entered by opening the anterior pancreatic fascia along the MCVs toward their roots.

Fig. 4.6 GIS under the pylorus (in autopsy) (the *arrow* represents the GIS)

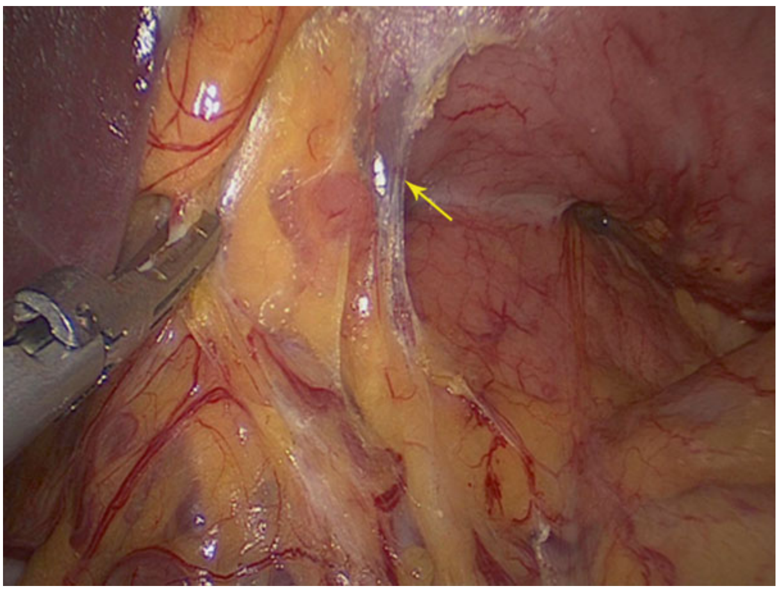


Fig. 4.7 GIS (the *arrow* represents the GIS)

4.2.1.4 Pancreaticoduodenal Fascia (PDF) and Its Intrafascial Space

The PDF is derived from the posterior layer of the DM. It encloses the pancreatic head and the second part of the duodenum, and it fuses with the ascending mesocolon. The intrafascial space between the posterior PDF and the inherent pancreatic fascia is called the posterior pancreaticoduodenal space (PPDS), which contains the SMV, portal vein (PV), and No. 14v LNs (Figs. 4.11 and 4.12).

4.2.2 Vascular Anatomy Associated with Lymph Node Dissection in the Infrapyloric Area

4.2.2.1 Arteries Associated with Lymph Node Dissection in the Infrapyloric Area

Right Gastroepiploic Artery (REGA)

The RGEA with the larger diameter is the main arterial supply of the gastric antrum area. It is the

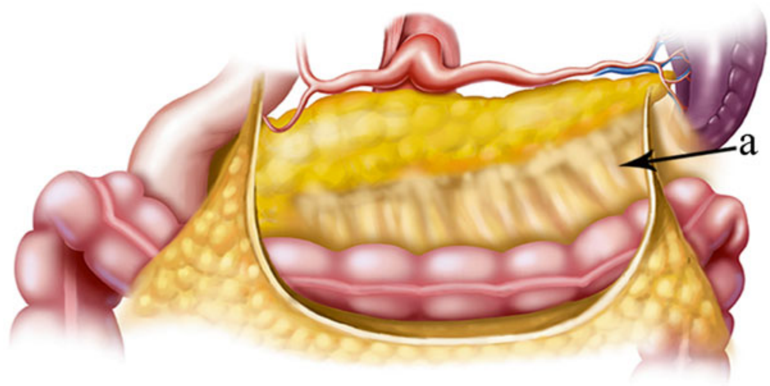


Fig. 4.8 TM (*a*)

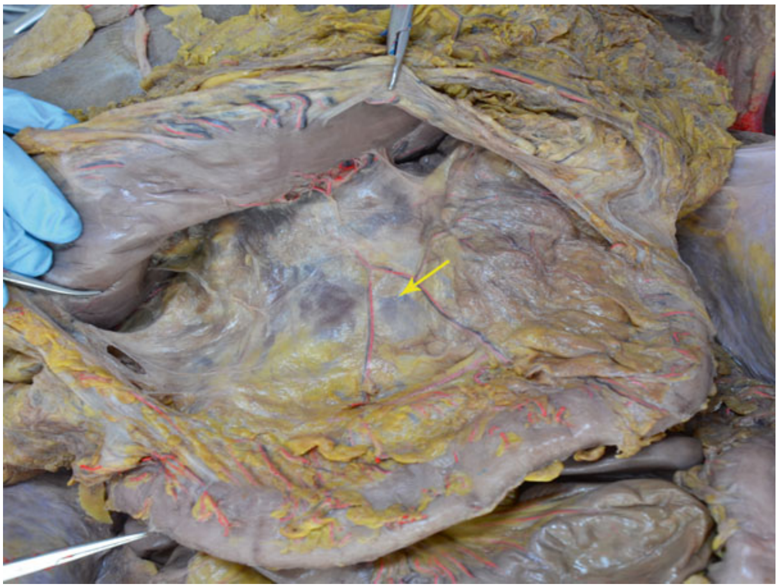


Fig. 4.9 TM (in autopsy) (the *arrow* represents the TM)

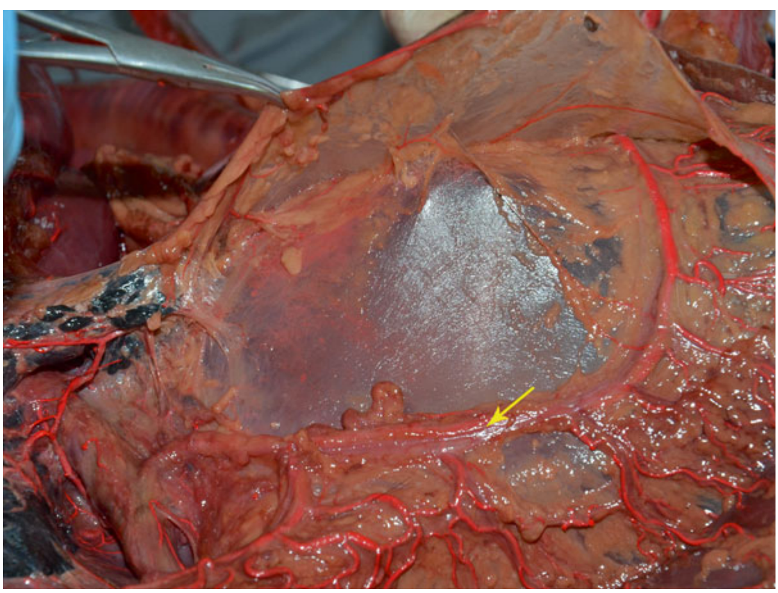


Fig. 4.10 Vessels in the TM fusion space (in autopsy) (the *arrow* represents vessels)

Fig. 4.11 PPDS (in autopsy)

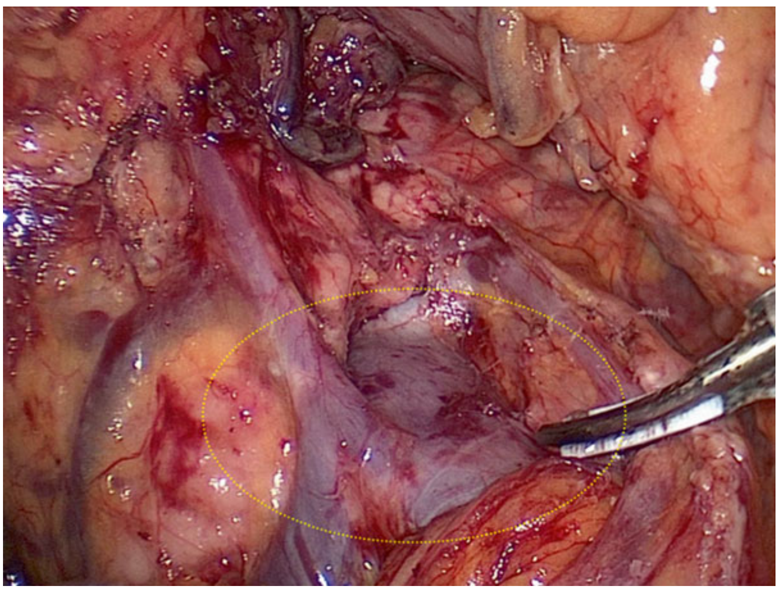


Fig. 4.12 Intraoperative view of the PPDS

largest terminal branch of the gastroduodenal artery (GDA) issued under the pylorus. After arising from the GDA, it runs to the left along the greater curvature of the stomach (between the anterior two layers of the greater omentum) and joins the left gastroepiploic artery (LGEA) to form the arterial arch of the gastric greater curvature, supplying the anterior and posterior walls of the stomach and the greater omentum. The RGEA and its branches are distributed within the greater curvature side of the gastric central axis: the upper border is the confluence of the RGEA and LGEA, and the lower border is the pylorus. Anatomical variations of the RGEA are very rare. Its root can generally be identified by confirming and dissecting along the GDA (Figs. 4.13, 4.14, and 4.15).

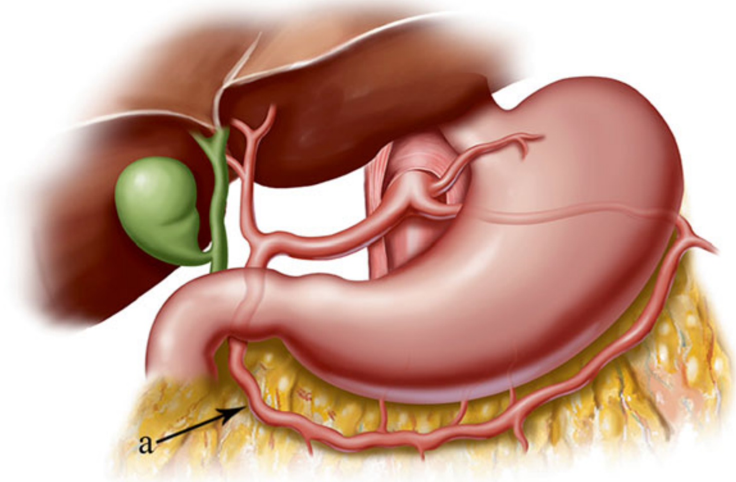


Fig. 4.13 The distributing range of the RGEA (*a*)

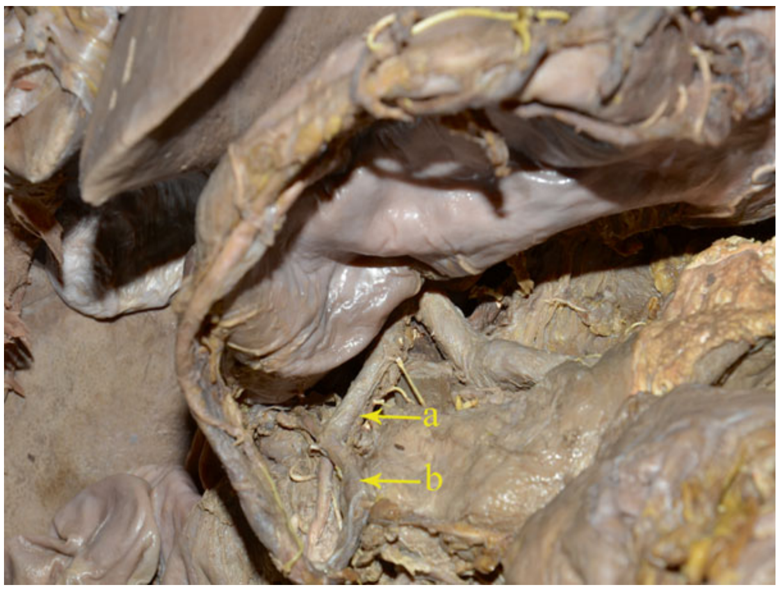


Fig. 4.14 The GDA (*a*) branches out the RGEA (*b*) (in autopsy)

Infrapyloric Artery (IPA)

The IPA arises from the GDA in approximately 85.0 % of cases (Figs. 4.16, 4.17, and 4.18). It branches from the RGEA in approximately 15.0 % of cases (Figs. 4.19 and 4.20). It mainly supplies the pylorus, and it gives off three to four small radial branches near its root. During pylorus-preserving gastrectomy or pylorus-preserving radical gastrectomy for early gastric cancer, the IPA should be left intact. However, if metastasis is judged to be present in the No. 6 LNs by the naked eye, it should be severed.

Superior Pancreaticoduodenal Artery (SPDA)

At the lower border of the pylorus, two terminal branches, the RGEA and the SPDA, are formed from the GDA (Figs. 4.21 and 4.22). The latter gives off anterior and posterior branches (Fig. 4.23), which pass down the anterior and posterior grooves between the pancreatic head

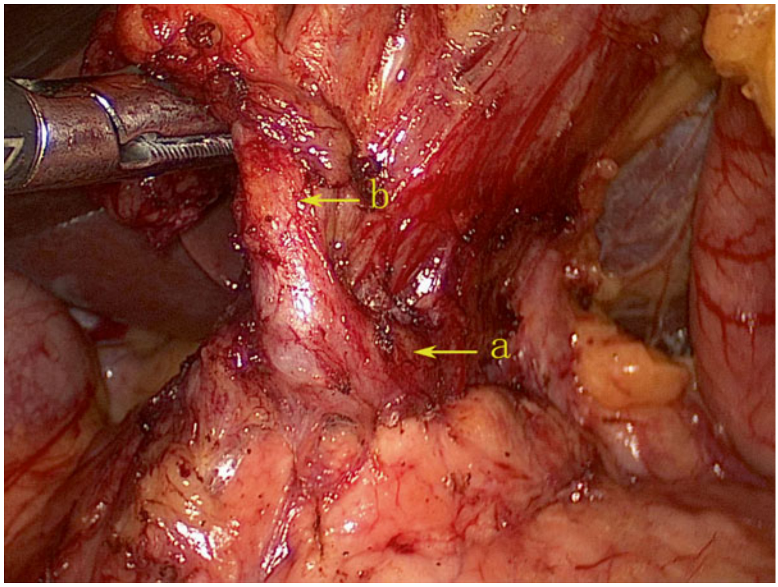


Fig. 4.15 The GDA (*a*) branches out the RGEA (*b*)

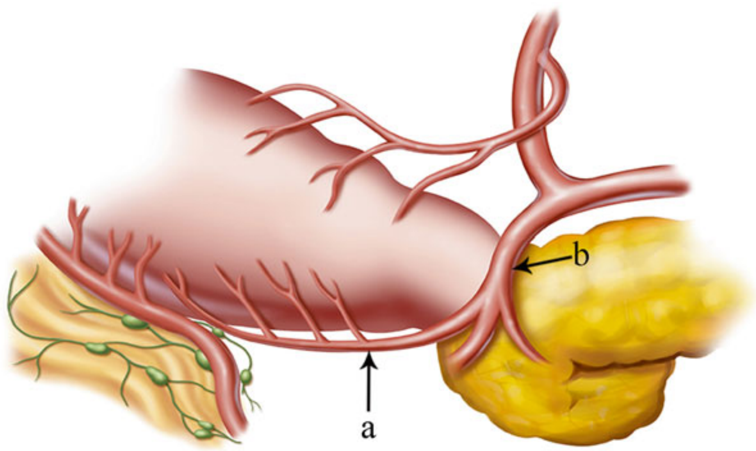


Fig. 4.16 The IPA (*a*) arises from the GDA (*b*)

and the duodenum, respectively, and join similar branches of the inferior pancreaticoduodenal artery, a branch of the superior mesenteric artery (SMA). These branches supply blood to the pancreas and duodenum (Figs. 4.24 and 4.25).

4.2.2.2 Veins Associated with Lymph Node Dissection in the Infrapyloric Area

Right Gastroepiploic Vein (RGEV)

The RGEV runs parallel with the corresponding artery but diverges under the pylorus. At this point, the vein turns downward over the front of the pancreatic head to join the anterior superior pancreaticoduodenal vein (ASPDV) and form the gastroduodenal vein (GDV). The GDV forms Henle's trunk together with the right or accessory right colic vein (RCV or ARCV), flows into the SMV, and finally drains into the portal system (Fig. 4.26).

SMV

The SMV lies to the right of the corresponding artery within the mesentery. At its termination behind the neck of the pancreas, the vein

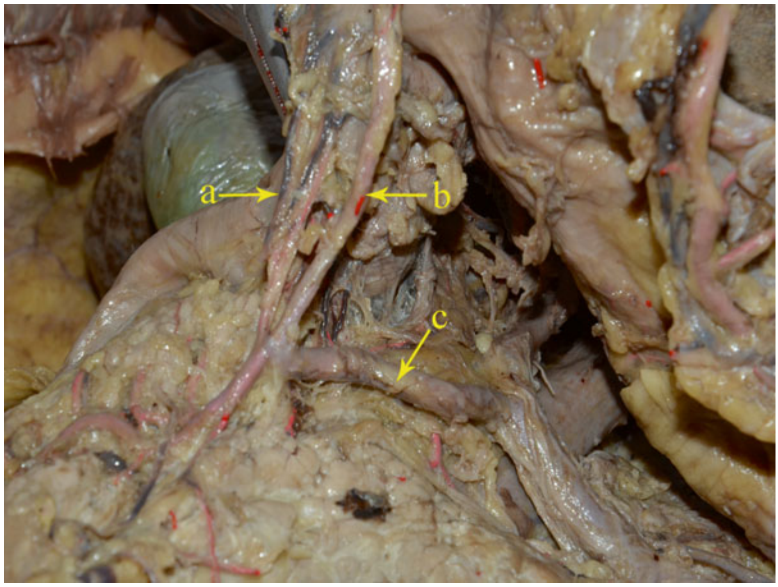


Fig. 4.17 The IPA (*a*) and the RGEA (*b*), respectively, arises from the GDA (*c*) (in autopsy)

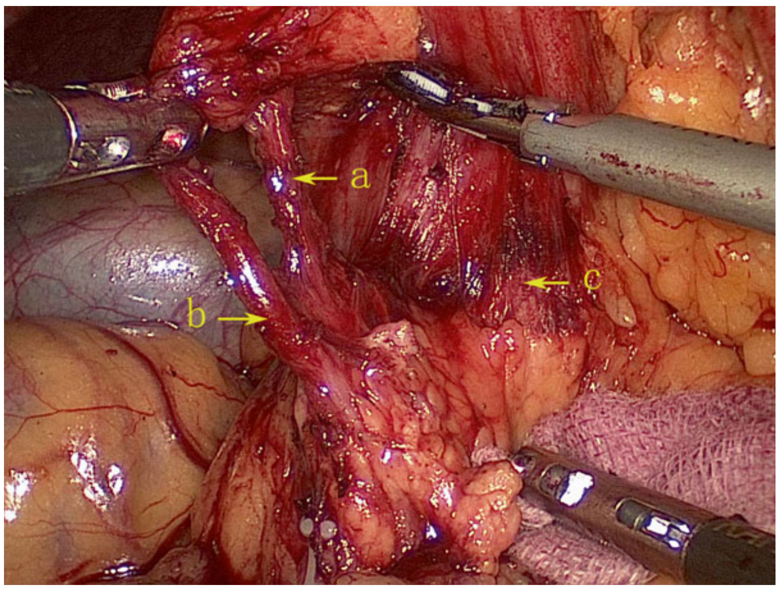


Fig. 4.18 The IPA (*a*) and the RGEA (*b*), respectively, arises from the GDA (*c*)

combines with the splenic vein (SpV) to form the PV. It receives venous blood from the tributaries that correspond to the branches of the SMA and the RGEA. These main tributaries are the RGEV, ASPDV, RCV or ARCV, and the MCV (Figs. 4.27 and 4.28).

There are six branching patterns of the SMV:

1. The RGEV combines with the ASPDV to form the SMV (Fig. 4.29).
2. The RGEV directly drains into the SMV (Fig. 4.30).
3. The RGEV joins the ASPDV to form Henle's trunk together with the RCV or ARCV, which finally flows into the SMV (Fig. 4.31).
4. The RGEV joins the SMV around the confluence of the ASPDV and RCV (Fig. 4.32).
5. The RGEV combines with the RCV to flow into the SMV (Fig. 4.33).

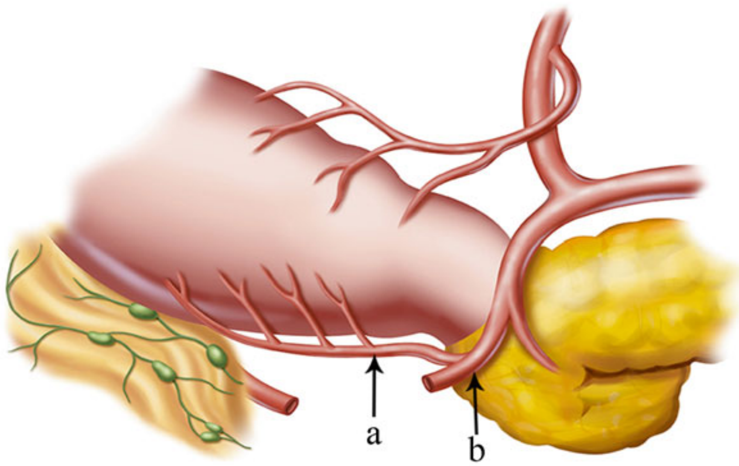


Fig. 4.19 The IPA (*a*) branches from the RGEA (*b*)

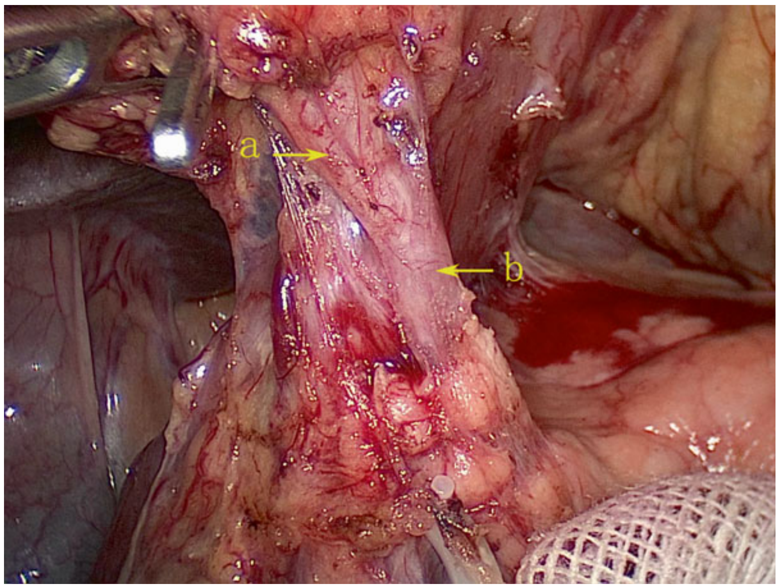


Fig. 4.20 The IPA (*a*) branches from the RGEA (*b*)

6. The confluence of the RGEV and ASPDV forms Henle's trunk together with the RCV and the ARCV, which finally flows into the SMV (Fig. 4.34).

MCV

The MCV follows the path of its corresponding artery. It is an important anatomic landmark for finding the SMV during the operation. There are four variations of the convergence:

1. The MCV directly drains into the SMV (Fig. 4.35).
2. The RCV unites with the MCV to drain into the SMV (Fig. 4.36).
3. The MCV directly drains into the SpV (Fig. 4.37).
4. The MCV joins Henle's trunk to flow into the SMV (Fig. 4.38).

4.2.3 Lymph Node Anatomy of the Infrapyloric Area

4.2.3.1 The No. 6 LNs (Infrapyloric LNs)

Definition of the No. 6 LNs

The No. 6 LNs are included in the two layers of the mesogastrium along the greater curvature of the stomach under the pylorus. This group

Fig. 4.21 The GDA (*a*) gives off the RGEA (*b*) and SPDA (*c*) (in autopsy)

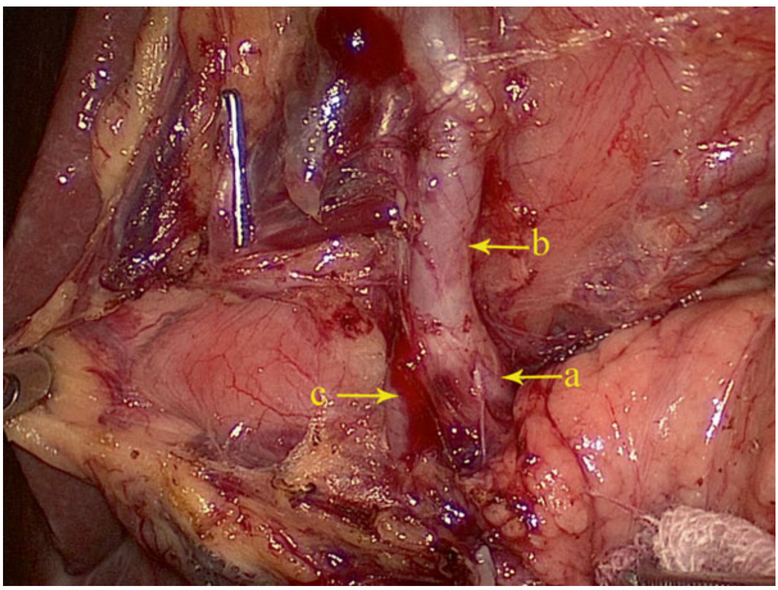


Fig. 4.22 The GDA (*a*) gives off the RGEA (*b*) and SPDA (*c*)

includes the LNs along the infrapyloric vessels (the infrapyloric and retropyloric LNs) and those located at the confluence of the RGEV and ASPDV (Figs. 4.39, 4.40, and 4.41).

The No. 6 LNs are separated from the No. 4d LNs by the first branch of the RGEA that feeds the gastric walls. The No. 6 LNs are on the right side of the artery and the No. 4d LNs are on the left. During the dissection of the No. 6 LNs and the exposure of the RGEV, the united veins should be confirmed, and the RGEV should be ligated and transected above the confluence of the ASPDV.

Cases of No. 6 LNM

Case one: Figs. 4.42 and 4.43

Case two: Views of the No. 6 LNs before and after neoadjuvant chemotherapy (Figs. 4.44, 4.45, 4.46, and 4.47)

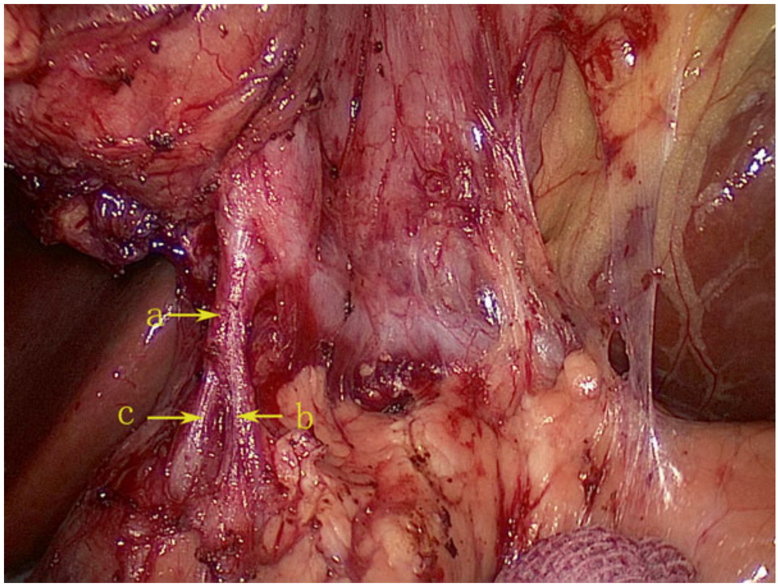


Fig. 4.23 The SPDA (*a*) divides into the anterior (*b*) and posterior (*c*) branches

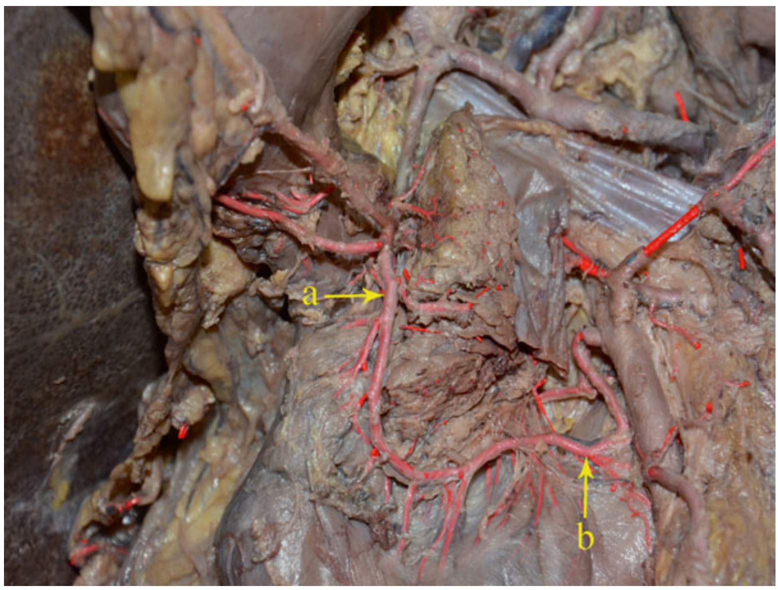


Fig. 4.24 The SPDA (*a*) anastomoses with the IPDA (*b*) (in autopsy)

4.2.3.2 The No. 14v LNs (LNs Located at the Root of the SMV)

Definition of the No. 14v LNs

The No. 14v LNs fall within the superior mesenteric LNs, which drain the lymphatic flow from the SMVs and their branches. The LNs located in front of the root of the SMV are called the No. 14v LNs, and they lie within the following boundaries: the lower edge of the pancreas (upper border), the left side of the confluence of the RGEV and ASPDV (right border), the left edge of the SMV (left border), and the furcation of the MCV (lower border) (Figs. 4.48, 4.49, and 4.50).

Cases of No. 14v LNM

Case one: Figs. 4.51 and 4.52
Case two: Figs. 4.53 and 4.54
Case three: Views of the No. 14v LNs before and after neoadjuvant chemotherapy (Figs. 4.55, 4.56, 4.57, and 4.58)

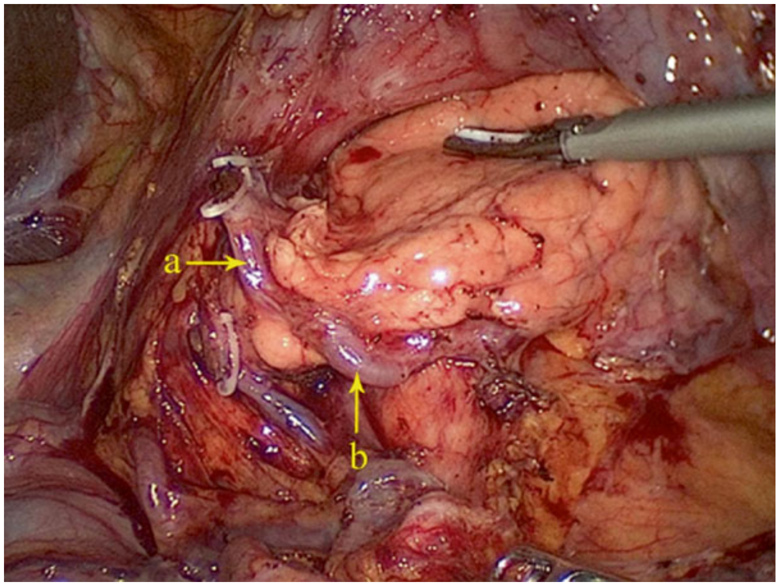


Fig. 4.25 The SPDA (*a*) anastomoses with the IPDA (*b*)

4.3 Procedures for Lymph Node Dissection in the Infrapyloric Area

4.3.1 Removing the Greater Omentum and Peeling the Anterior Lobe of the Transverse Mesocolon (ATM)

4.3.1.1 Removing the Greater Omentum

Operative Approach

The approach for removing the greater omentum is from the superior border of the transverse colon near its midpoint (Fig. 4.59), an avascular area where the greater omentum is thinnest.

Exposure Methods

First, the greater omentum covering the hypogastric area is repositioned above the transverse colon and the anterior wall of the stomach by the assistant. Next, it is lifted up and unfolded on both sides using two atraumatic graspers positioned 3–5 cm away from the superior border of the transverse colon. Subsequently, the surgeon presses the transverse colon down (counteraction) to create triangle traction, keeping the greater omentum under tension (Fig. 4.60). During this process, the assistant alternates lifting the front and back portions of the greater omentum using two graspers in both hands to keep a certain tension, which facilitates division of the greater omentum with the ultrasonic scalpel.

Operative Procedures

Using the ultrasonic scalpel, the greater omentum is divided in the avascular area starting from the superior border of the transverse colon near its midpoint (Fig. 4.61). Next, the division is extended toward the left and then toward the right. The surgeon first divides it toward the left until reaching the splenic flexure of the colon (Fig. 4.62), then divides it toward the right until the hepatic flexure is reached (Fig. 4.63). In this way, the attachment of the greater omentum and transverse colon is completely severed. Subsequently, the assistant places the free greater omentum on the left upper side of the abdomen in front of the gastric fundus and body to create a good operating field for the infrapyloric area. This facilitates the subsequent separation of the ATM and the dissection of the infrapyloric LNs.

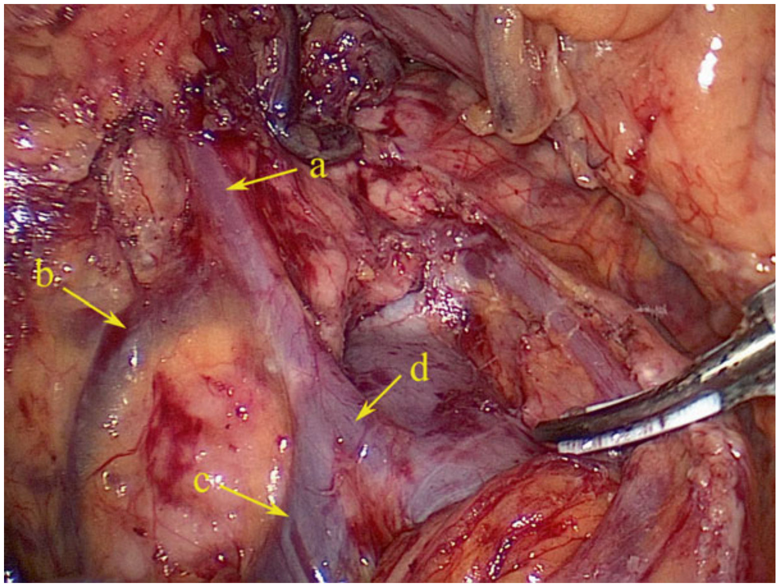


Fig. 4.26 The RGEV (*a*) joins the ASPDV (*b*) to form Henle's trunk (*d*) together with the RCV or ARCV (*c*)

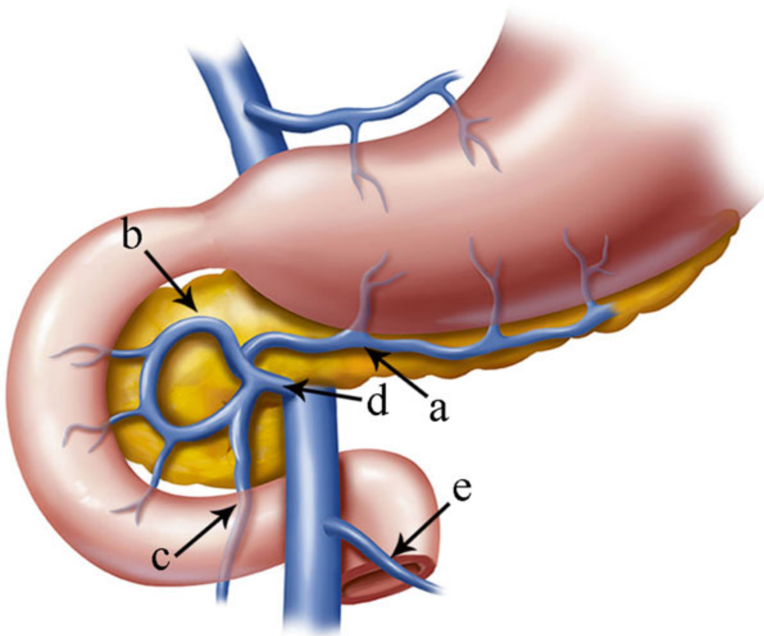


Fig. 4.27 The tributaries of the SMA are the RGEV (*a*), ASPDV (*b*), RCV or ARCV (*c*), gastrocolic trunk (*d*), and MCV (*e*)

4.3.1.2 Peeling the ATM

Operative Approach

The approach is from the superior border of the right transverse colon (Fig. 4.64). The tissues here, in the fusion space between the ATM and posterior lobes of the TM (PTM), are the loosest and no great vessels are present. Accordingly, it is convenient to peel the ATM from this site, where there is less risk of hemorrhage.

Exposure Methods

Using an atraumatic left-handed grasper, the assistant pulls up the greater omentum at the greater curvature of the gastric antrum (Fig. 4.65)

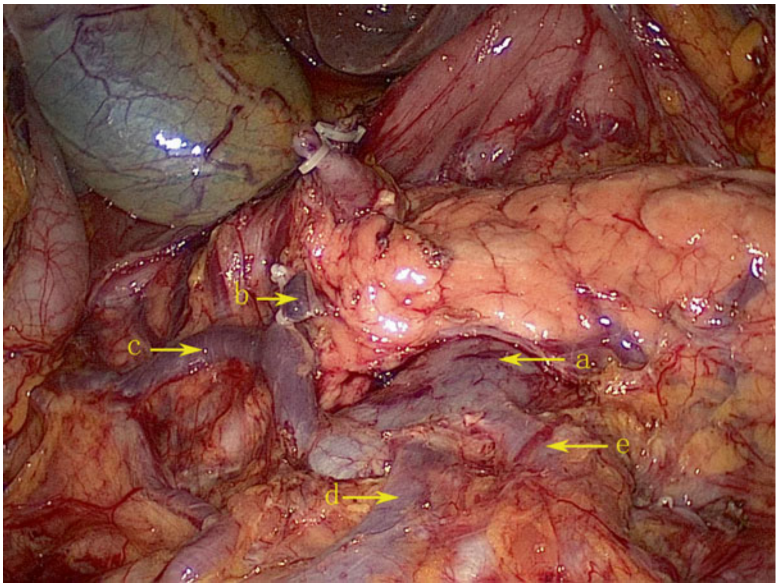


Fig. 4.28 The tributaries of the SMV (*a*) are the RGEV (*b*), ASPDV (*c*), RCV (*d*), and MCV (*e*)

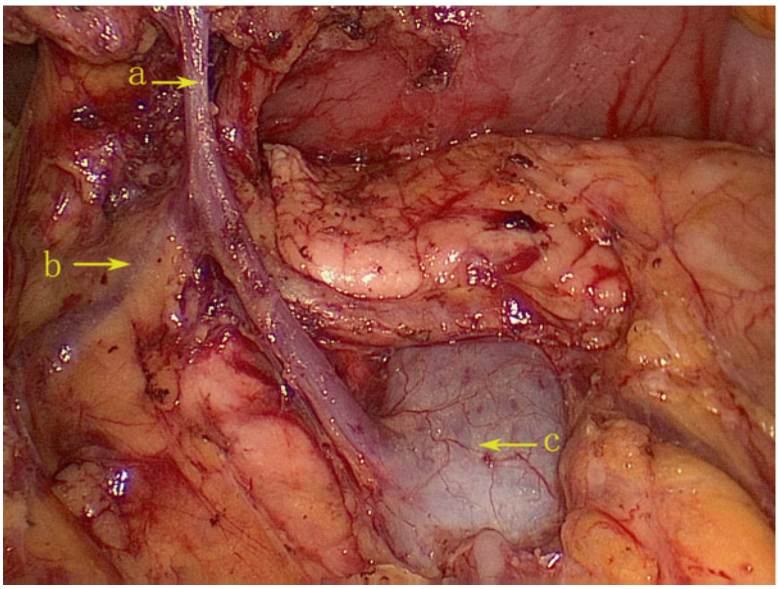


Fig. 4.29 The RGEV (*a*) combines with the ASPDV (*b*) to form the SMV (*c*)

and gently lifts up the ATM (Fig. 4.66) with a right-handed grasper. Meanwhile, the surgeon's left hand presses the TM down to create a certain tension and reveal the fusion space between the ATM and PTM (Fig. 4.67), which is full of loose connective tissue. During the peeling of the ATM, the assistant should gently push the ATM up and PTM down along the fusion space to help the surgeon separate it (Figs. 4.68 and 4.69).

Operative Procedures

The dissection is initiated from the superior border of the right transverse colon using the ultrasonic scalpel (Fig. 4.70). Alternating blunt and sharp dissection of the ATM is performed along the fusion space (Figs. 4.71 and 4.72). The dissection is continued toward the right up to the medial border of the descending duodenum (Fig. 4.73) and is continued upward to the lower border of the pancreas (Fig. 4.74).

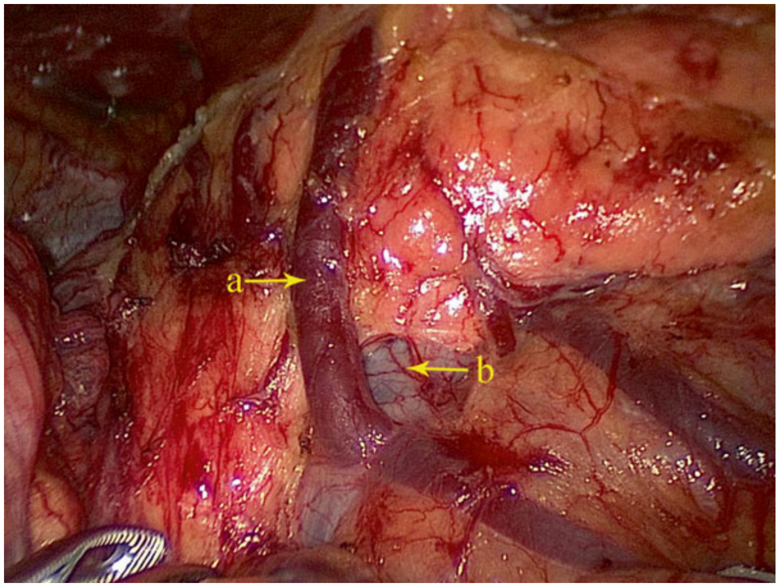


Fig. 4.30 The RGEV (*a*) directly drains into the SMV (*b*)

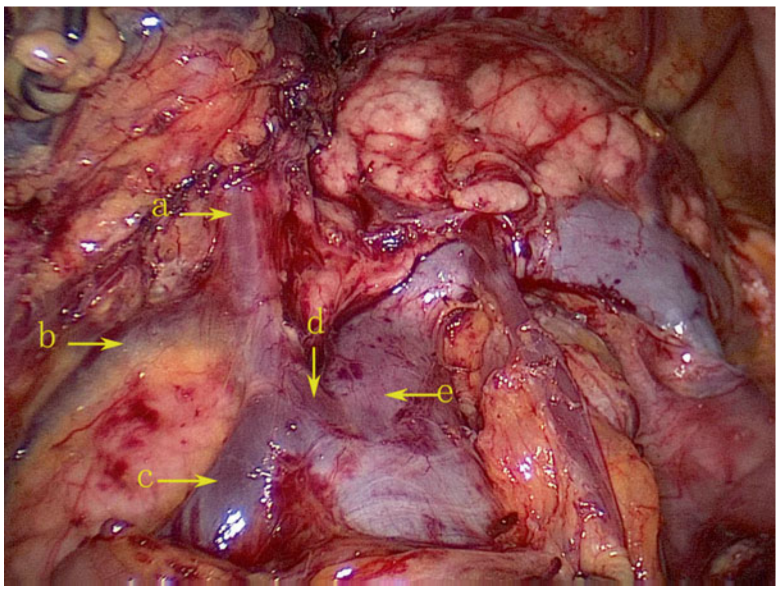


Fig. 4.31 The RGEV (*a*) joins the ASPDV (*b*) to form Henle's trunk (*d*) together with the RCV or ARCV (*c*), which finally flows into the SMV (*e*)

4.3.2 Dissection of the No. 14v LNs

4.3.2.1 Operative Approach

The favored starting point for this dissection is the MCV (Fig. 4.75), which is one of the intraoperative anatomical landmarks for locating the SMV, along with the inferior border of the pancreatic neck. The inferior segment of the SMV can be found within posterior pancreaticoduodenal space (PPDS) by following the MCV proximally up to the inferior border of the pancreatic neck.

4.3.2.2 Exposure Methods

The assistant continues to lift the greater omentum at the greater curvature of the gastric antrum with the left hand, while pulling up the detached ATM with the other hand. Meanwhile, the surgeon presses PTM to create proper tension and

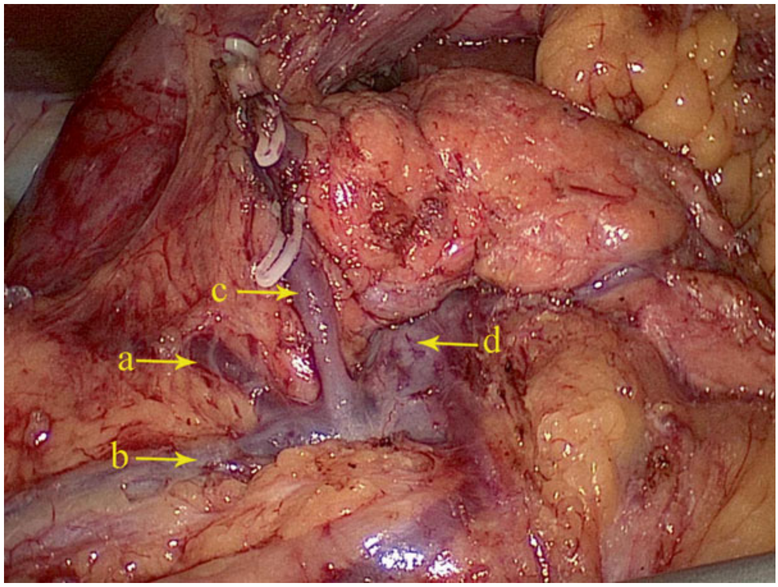


Fig. 4.32 The confluence of the ASPDV (*a*) and RCV (*b*) joins the RGEV (*c*) to drain into the SMV (*d*)

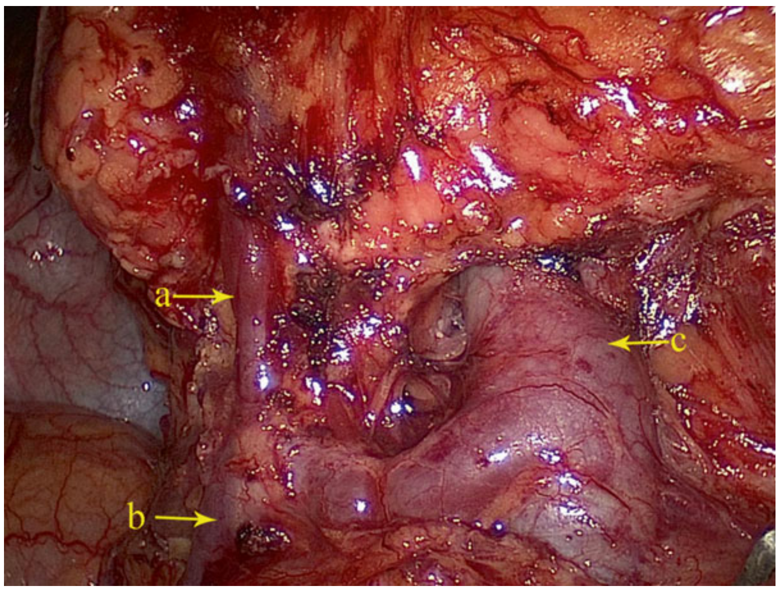


Fig. 4.33 The RGEV (*a*) combines with the RCV (*b*) to flow into the SMV (*c*)

expose the MCV and the root of the SMV (Fig. 4.76). The tissue should not be stretched too tightly, as this can tear the veins and cause intra-operative bleeding during the exposure. The camera operator should focus the laparoscope on the near field and move the lens slowly forward to clearly expose the operating field around the root of the SMV.

4.3.2.3 Operative Procedures

The assistant lifts up the fatty connective tissue on the surface of the MCV with the right hand, while the surgeon uses the nonfunctional surface of the ultrasonic scalpel to dissect these tissues along the vein (Fig. 4.77) toward the inferior border of the pancreas. The confluence of the MCV and the SMV can then be exposed (Fig. 4.78). The dissection is

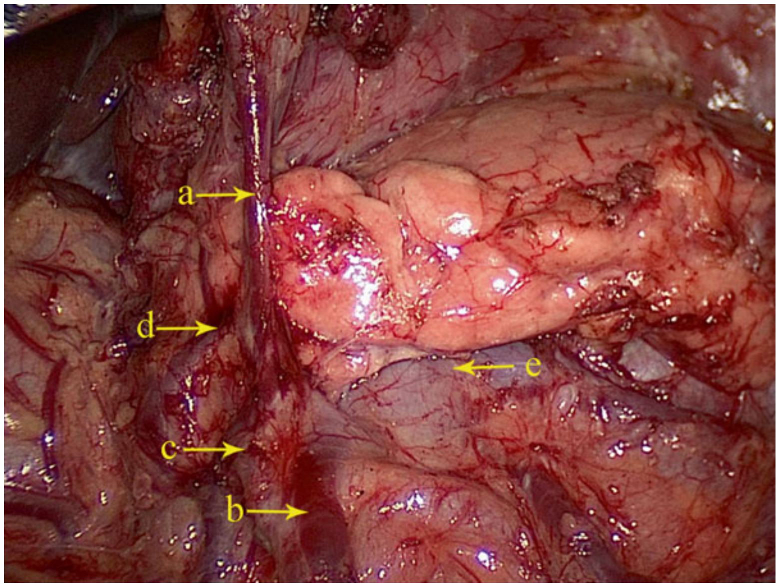


Fig. 4.34 The confluence of the RGEV (*a*) and ASPDV (*b*) forms Henle's trunk with the RCV (*c*) and the ARCV (*d*), which finally flows into the SMV (*e*)

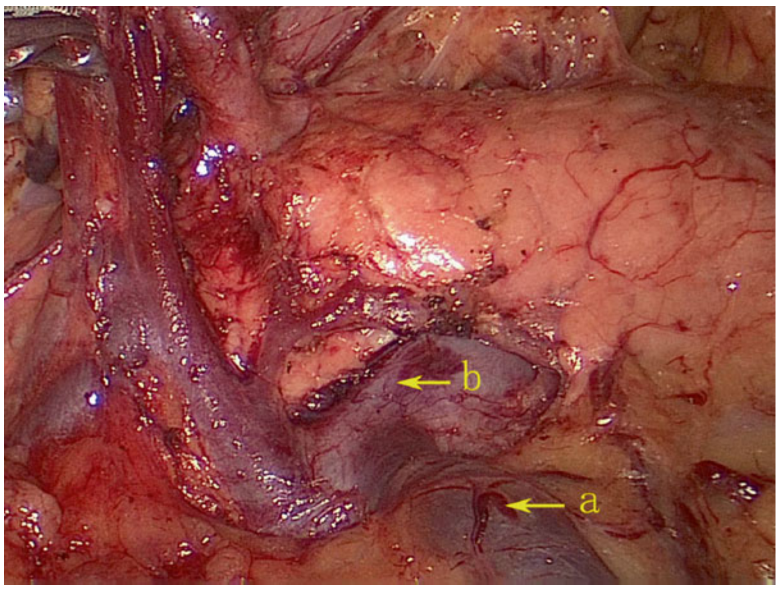


Fig. 4.35 The MCV (*a*) directly drains into the SMV (*b*)

continued upward along the anatomical space on the surface of the SMV until the inferior border of the pancreas is reached and the PPDS is entered (Fig. 4.79). Next, the dissection is continued toward the left up to the left margin of the SMV and toward the right up to the point where Henle's trunk flows into the SMV (Fig. 4.80). Subsequently, the surgeon dissects toward the right along the anatomical space on the surface of Henle's trunk to reach the confluence of the RGEV and the ARCV or RCV (Fig. 4.81), where the GDV can be exposed. Finally, the dissection is extended to the confluence of the RGEV and the ASPDV (Fig. 4.82). The fatty lymphatic tissue around Henle's trunk and the SMV is completely removed. The dissection of No. 14v LNs is then accomplished (Fig. 4.83).

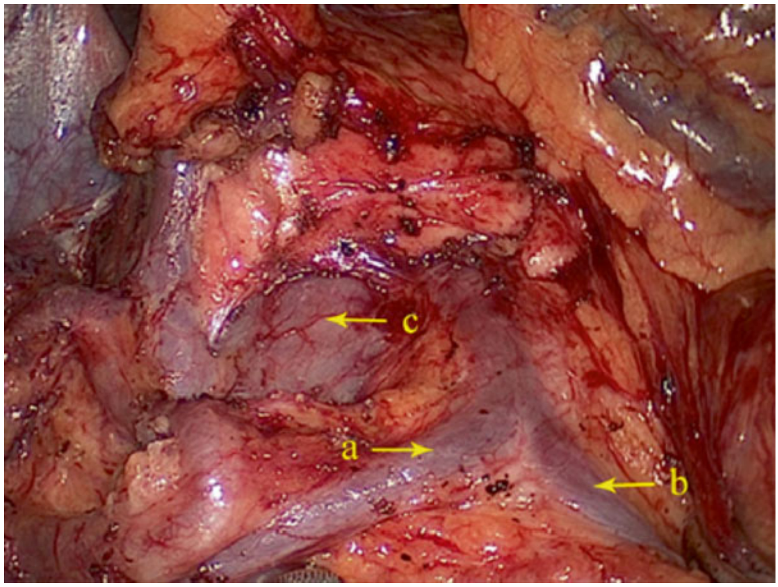


Fig. 4.36 The RCV (*a*) unites with the MCV (*b*) to drain into the SMV (*c*)

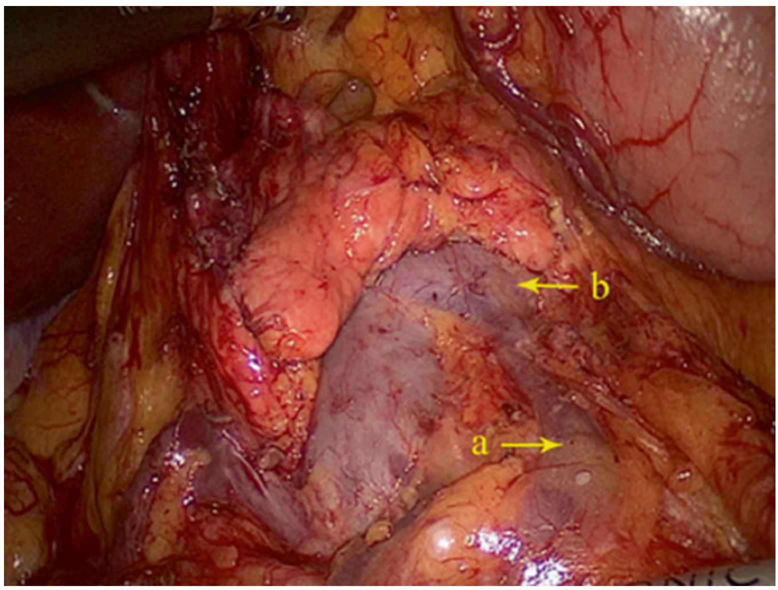


Fig. 4.37 The MCV (*a*) directly drains into the SpV (*b*)

4.3.3 Dissection of the No. 6 LNs

4.3.3.1 Operative Approach

The approach to the No. 6 lymph node dissection is from the GIS (Fig. 4.84). The confluence of the RGEV and SPDV is the starting point of the dissection. The GDA and the root of the RGEA can be further exposed by dissecting upward along the RGEV.

4.3.3.2 Exposure Methods

The assistant lifts up the posterior wall of the gastric antrum with a left-handed grasper and applies traction to the fatty lymphatic tissue on the surface of the vessels with a right-handed grasper. Meanwhile, the surgeon uses a left-handed atraumatic grasper and gauze to press down on the root of the TM (counteraction) at the lower border of the pancreas, exposing the infrapyloric

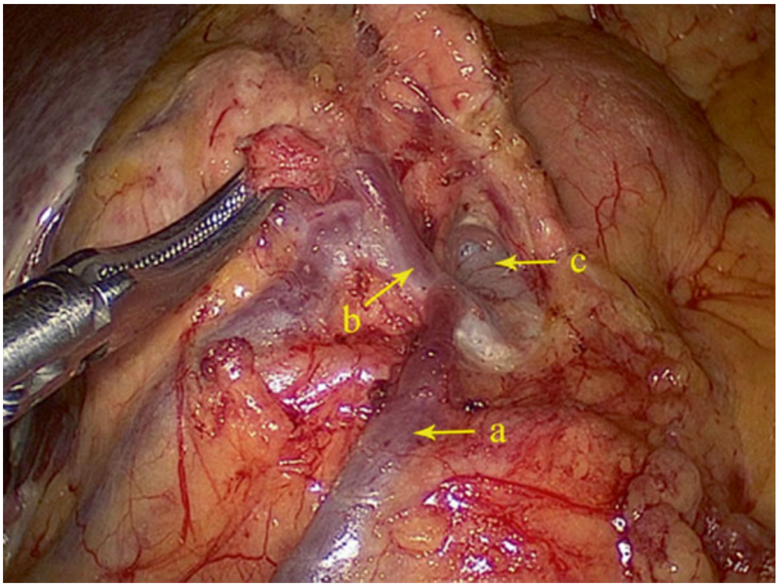


Fig. 4.38 The MCV (*a*) joins Henle's trunk (*b*) to flow into the SMV (*c*)

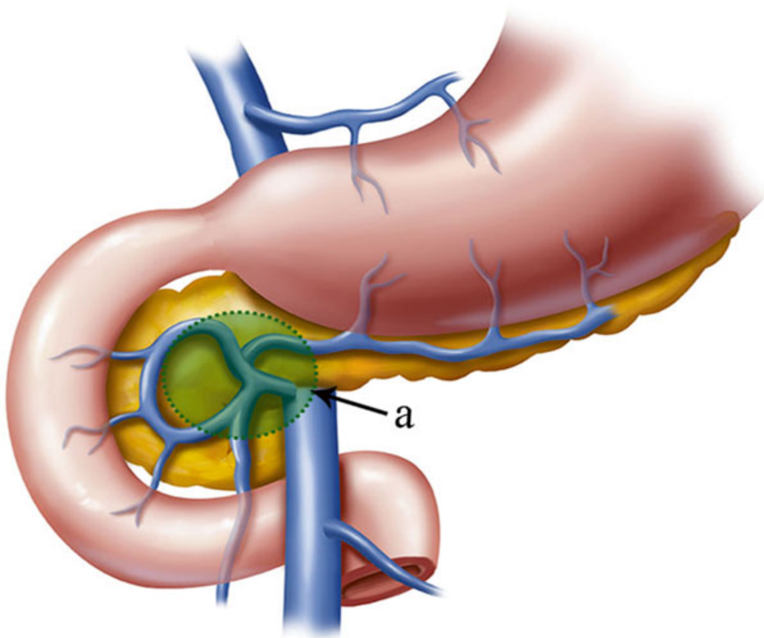


Fig. 4.39 The scope of the No. 6 LNs (*a*)

area. In this way, a good operating field and proper tension can be provided for the dissection of the No. 6 LNs (Fig. 4.85).

4.3.3.3 Operative Procedures

The assistant pulls up or retracts the lymphatic, fat, and connective tissues on the surface of the RGEV with the right hand. Taking its confluence with the SPDV as a starting point, the surgeon uses the nonfunctional face of the ultrasonic scalpel to dissect these lymphatic tissues along the vein distally up to the superior border of the pancreatic head (Fig. 4.86). After the RGEV is vascularized, the assistant pulls on the RGEV,

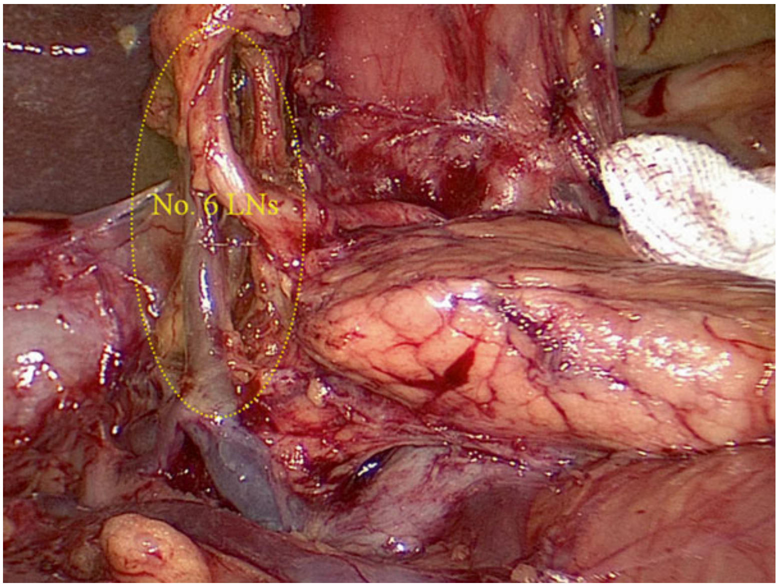


Fig. 4.40 The scope of the No. 6 LNs

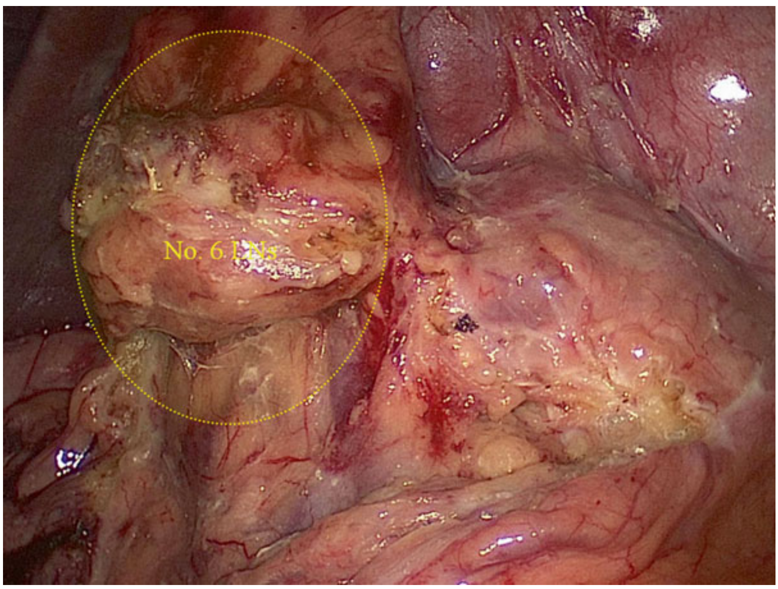


Fig. 4.41 No. 6 LNs

separating it from the pancreas, and the surgeon divides it with clamps above the confluence (Fig. 4.87). Next, the assistant continues to lift up the posterior wall of the gastric antrum with the left hand and pushes the duodenal bulb out with the right hand. With the left hand, the surgeon gently presses down on the pancreas using gauze to expose the groove between the pancreatic head and the duodenum (Fig. 4.88). The GDA can then be exposed and separated (Fig. 4.89), and the root of the RGEA can be exposed along the terminal segment of the GDA (Fig. 4.90). At this point, the assistant pulls up the fatty lymphatic tissue on the surface of the RGEA, and the surgeon uses the ultrasonic scalpel to dissect these tissues along the anatomical space on the surface of the artery toward the pylorus. Next, the root of the artery is vascularized (Fig. 4.91) and divided (Fig. 4.92). The IPA, which arises from the GDA, should usually be divided as well. During the dissection,

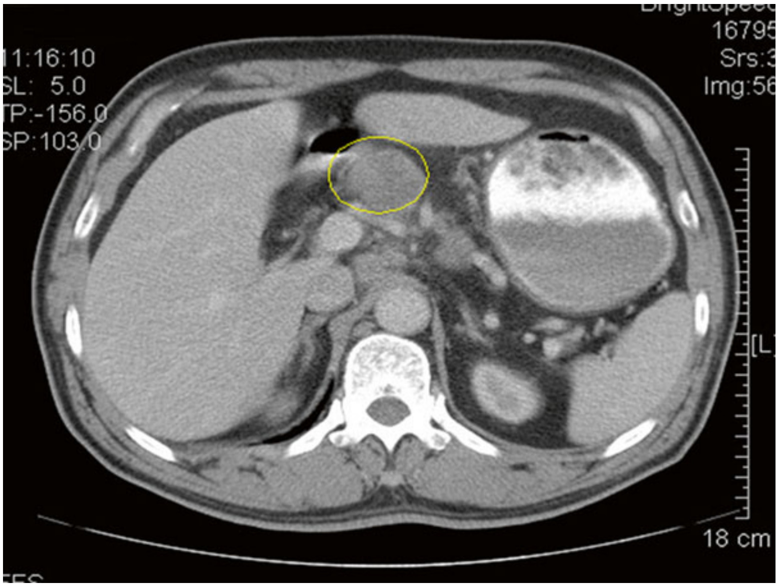


Fig. 4.42 Computed tomography (CT) scan showing No. 6 LNM (the circle represents the swollen No. 6 LNs)

care should be taken to avoid injuring it and causing bleeding. Subsequently, taking the division of the RGEA as a starting point, the surgeon uses the nonfunctional face of the ultrasonic scalpel to dissect along the duodenum toward the pylorus, until the pylorus is reached (Fig. 4.93). The lymphatic and fatty tissue in the infrapyloric area is dissected and removed en bloc. The No. 6 LNs are then dissected (Fig. 4.94). This completes the lymph node dissection within the infrapyloric area (Fig. 4.95).

4.4 Common Situations Encountered and Surgical Techniques Utilized During the Dissection of the Infrapyloric Region

4.4.1 Surgical Techniques Utilized in Resection of the Greater Omentum and Division of the ATM

4.4.1.1 Excision of the Greater Omentum

Surgical Techniques Involved in Division

Before separating the greater omentum, it is important to use the laparoscope to survey the abdominal cavity. Adhesions always exist in patients with a previous surgical history and may even be encountered in some without such a history (Fig. 4.96). If resistance is encountered when pulling on the greater omentum during exploration, the presence of an adhesion should be considered. In this case, it is important to carefully look for the adhesive site and to divide the adhesion at its root. Otherwise, ischemic necrosis of the residual omental tissue or even intra-abdominal infection could result. The surgical approach for entering the omental bursa should be from the middle of the greater omentum, where it is the thinnest and is almost avascular. Dissection should be conducted close to the superior border of the transverse colon, the landmark for division of the greater omentum. When this approach is not available (in some obese patients or those with adhesions), the adhesions between the omentum should first be divided along the superior margin of the transverse colon toward the left, continuing until the posterior gastric wall is detected. Under these circumstances, the surgical plane lies in the omental bursa, and the greater omentum can be divided en bloc. When exposing the greater omentum, the assistant should elevate the omental tissues using grasping forceps in both hands. The grasping sites should be located at a distance of 3–5 cm

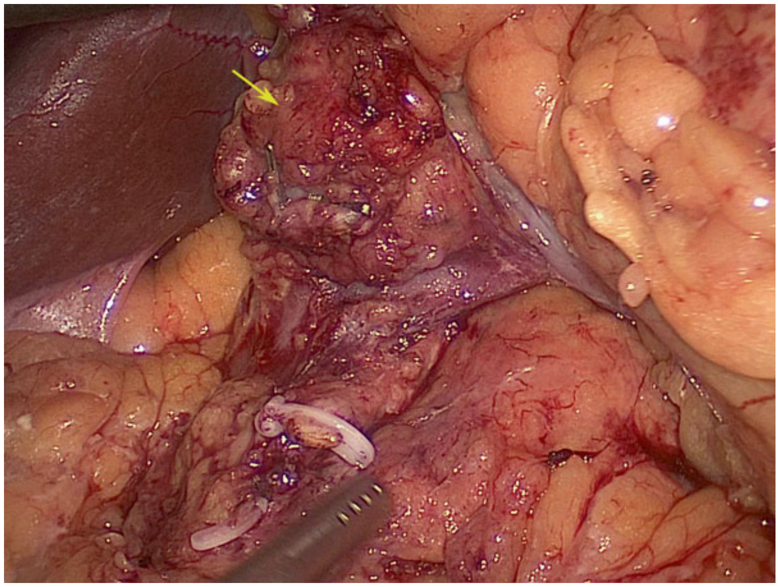


Fig. 4.43 Intraoperative view of No. 6 LNM (the *arrow* represents the swollen No. 6 LNs)

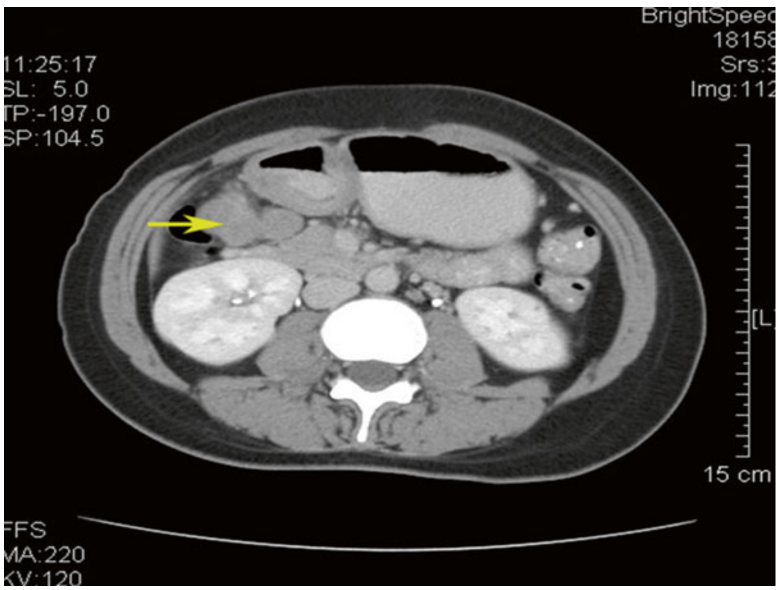


Fig. 4.44 CT scan image of No. 6 LNM before neoadjuvant chemotherapy (the *arrow* represents the swollen No. 6 LNs)

from the superior border of the transverse colon. If the grasping site is too far from the colon, it is difficult to keep appropriate tension, but the operating field can be affected if the site is too close. Meanwhile, the operator should gently grasp the transverse colon and push it downward, creating triangle traction together with the assistant. Under these conditions, the greater omentum close to the transverse colon becomes tense and flat. Additionally, the assistant must flexibly change the grasping sites during the entire process of division. The two grasping forceps should be alternately moved to create favorable planes for division to realize rapid division.

Prevention of Damage to Adjacent Tissues and Organs

Obese patients have a thick, rich greater omentum and always have adhesions. The transverse colon is always wrapped in the omentum and is difficult to

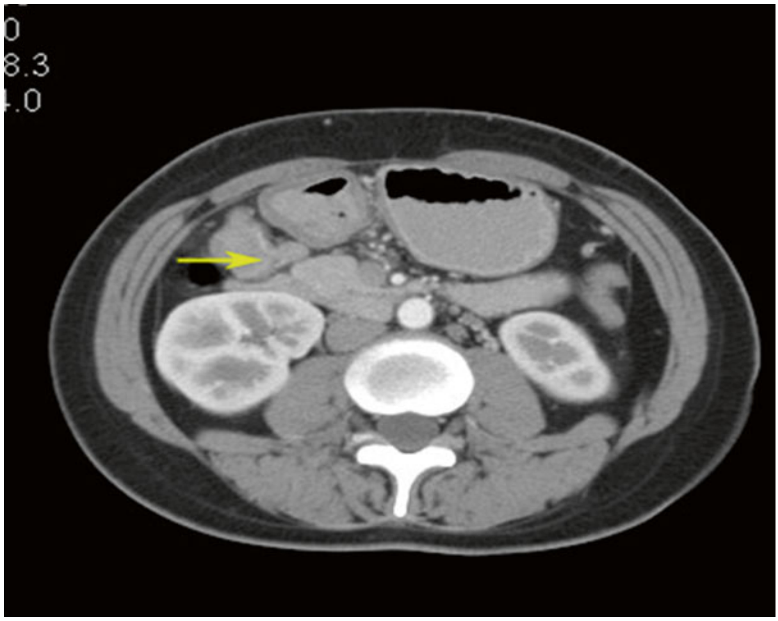


Fig. 4.45 CT scan image of No. 6 LNM after neoadjuvant chemotherapy (the *arrow* represents the No. 6 LNs)

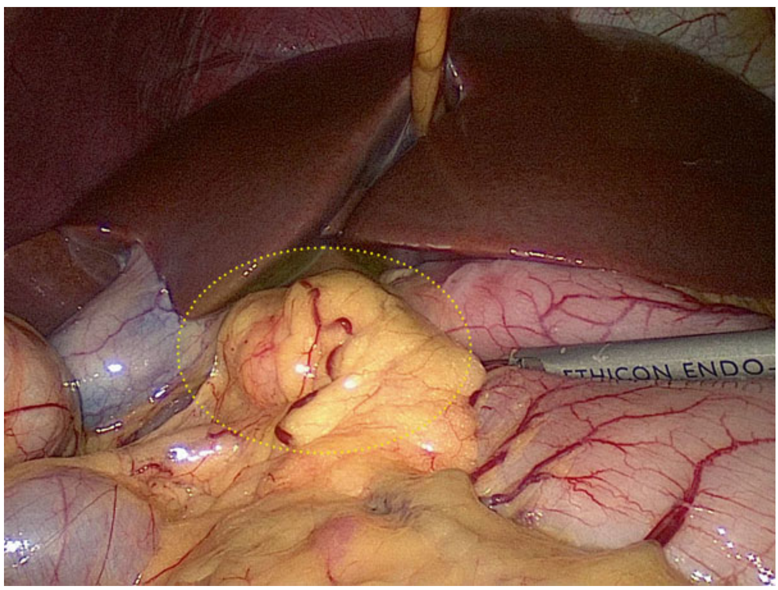


Fig. 4.46 Intraoperative view of the swollen No. 6 LNs

expose. When separating it, meticulous sharp and blunt dissection should be alternately used to avoid injuring the colon (Fig. 4.97). The superior margin of the transverse colon should serve as the landmark for division. During the dissection of the greater omentum at the splenic flexure of the colon, it can be difficult to expose the spleen because of adhesions between the greater omentum and the spleen as well as fusion and overlap between the greater omentum and the splenocolic ligament. Accordingly, dissection of this area should be very cautious to avoid injury to the colon and the spleen. Additionally, the assistant should apply proper tension to the greater omentum here to avoid rupturing the spleen. The duodenum is always proximal to the hepatic flexure of the colon, with adipose tissue wrapped around it. Because the colon is relatively dissociated, it is easy to find the hepatic flexure

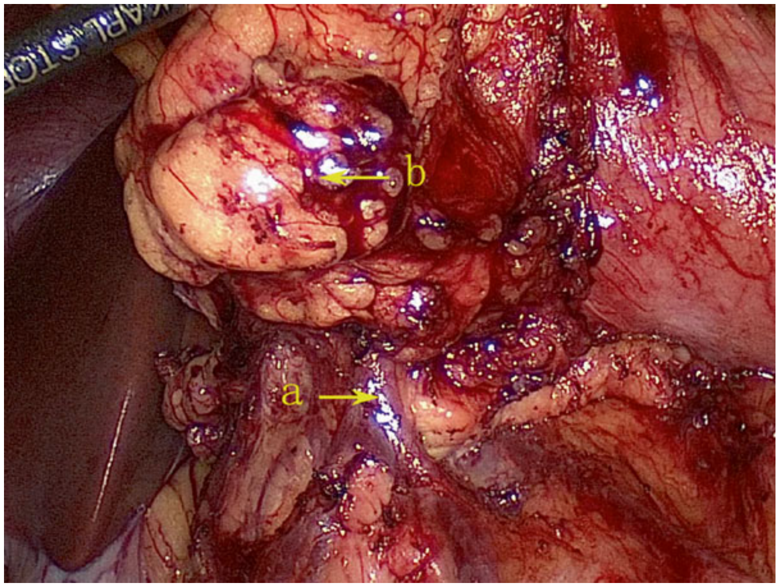


Fig. 4.47 Appearance after the No. 6 lymph node dissection. RGEV (*a*). No. 6 LNs (*b*)

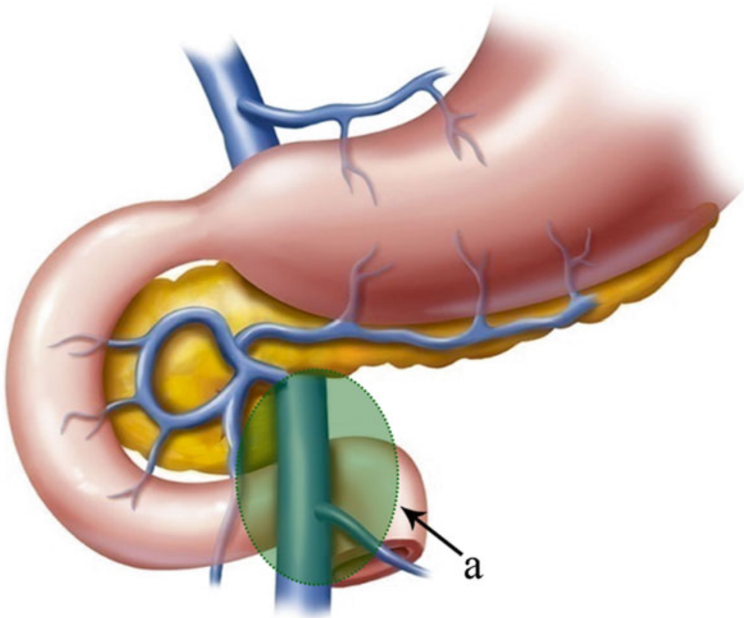


Fig. 4.48 The scope of No. 14v LNs (*a*)

when separating the tissue along the transverse colon. Pulling the hepatic flexure outward allows for smooth exposure of the duodenum (Fig. 4.98). If the duodenum is exposed first, not only may the operating field be limited, but the colon may also be susceptible to injury. If accidental injury to the colon occurs, the surgeon should stop the current operation and carefully examine the injured site. Subsequently, the surgeon should either repair it immediately or mark the injured site with a titanic clip, enabling later identification and repair of the injury (Fig. 4.99).

Prevention of Vascular Injury

Generally, no great vessels are required to be broken during division of the greater omentum. Consequently, if great vessels are encountered during the dissection procedure, the surgeon

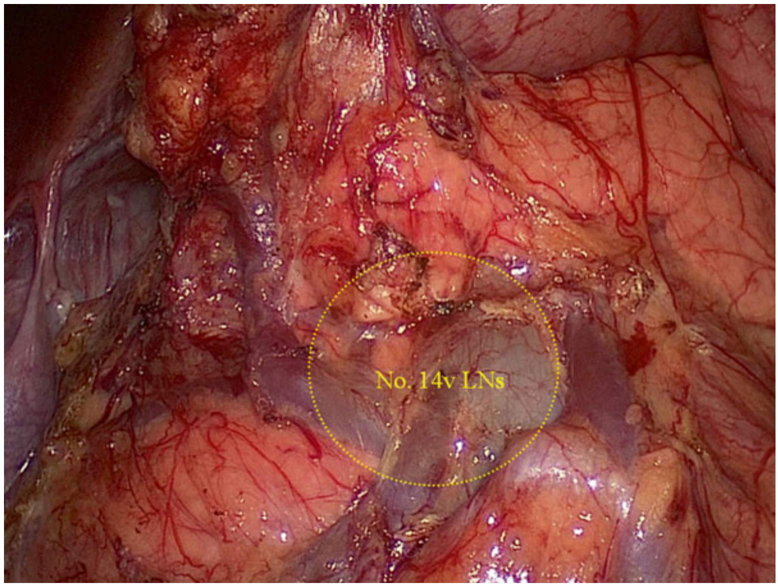


Fig. 4.49 The scope of No. 14v LNs

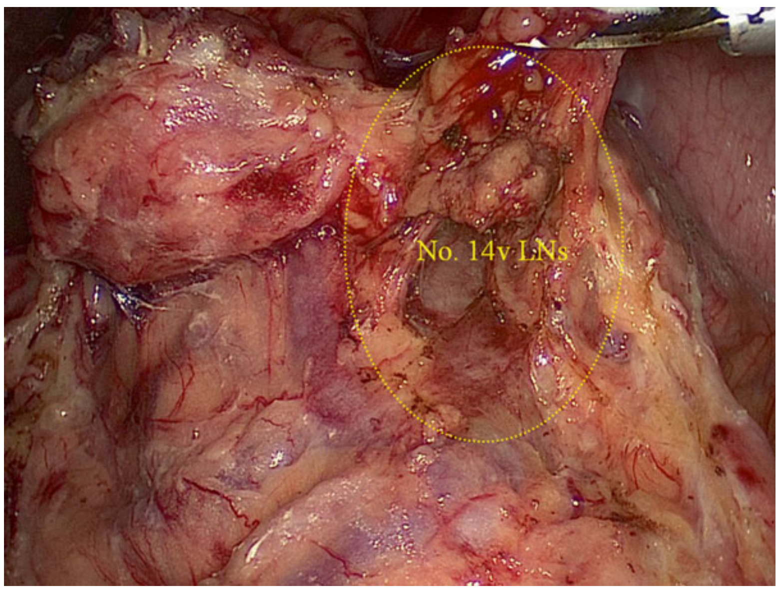


Fig. 4.50 No. 14v LNs

should carefully identify them to avoid injuring any important vessels (such as the vessels of the transverse colon).

4.4.1.2 Division of the ATM

Surgical Techniques Involved in Division

The closer to the pancreas, the looser the space formed between the ATM and PTM. Division should be conducted from left to right, shallow to deep, and layer by layer. When dividing the anterior lobe close to the inferior margin of the pancreas, the assistant should lift the gastric antrum in an anterior direction while the operator pulls the TM downward. Here, the planes between the ATM and PTM form an obtuse angle, and many loose connective tissues exist in this area. This space is the surgical plane (Fig. 4.100). If the anatomic space is not clearly exposed, the assistant can use the right grasping forceps to bluntly dissect inferior of the pancreatic head to

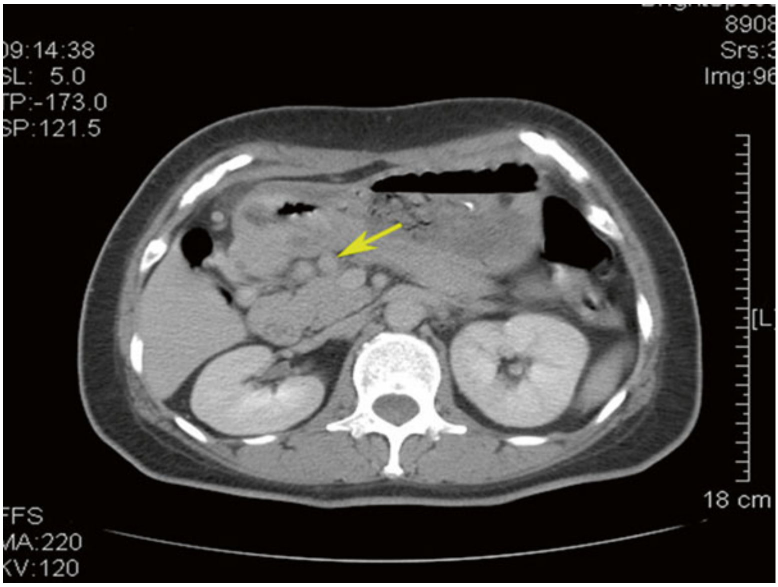


Fig. 4.51 Preoperative CT scan image of No. 14v LNM (the *arrow* represents the swollen No. 14v LNs)

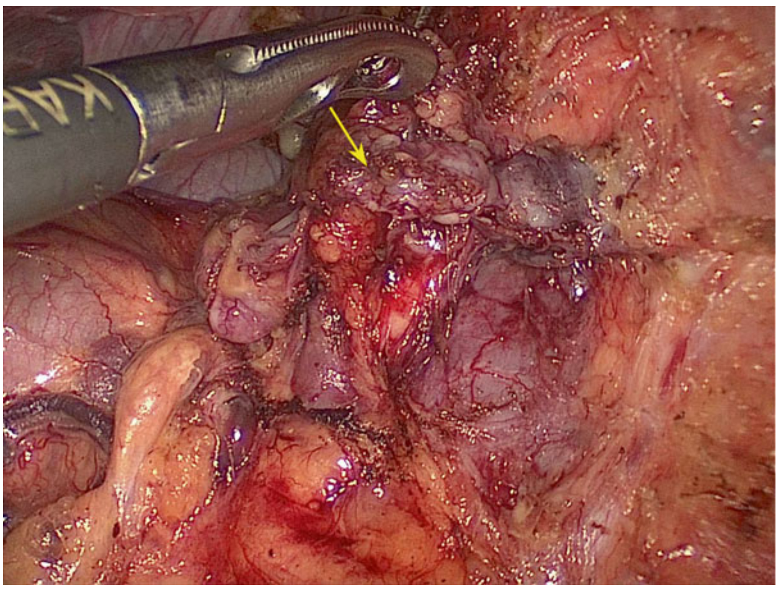


Fig. 4.52 Intraoperative view of No. 14v LNM (the *arrow* represents the swollen No. 14v LNs)

help expose the space (Fig. 4.101). Because the intrafascial space between the ATM and PTM is avascular, it has a low risk of bleeding and is easily divided. If repeated bleeding of small vessels is encountered during division, the possibility that the division plane is too deep or shallow should be taken into consideration. In this case, it is appropriate to search for the anatomic plane again (Fig. 4.102). The interior margin of the duodenum is the right border of the ATM. Division should continue to this border so that the ATM is completely dissected. The adhesions between the duodenal bulb, descending portion of the duodenum, and the hepatic flexure of the colon should be sufficiently divided. This is beneficial for the assistant lifting the gastric antrum and makes division within the infrapyloric region easier (Fig. 4.103).

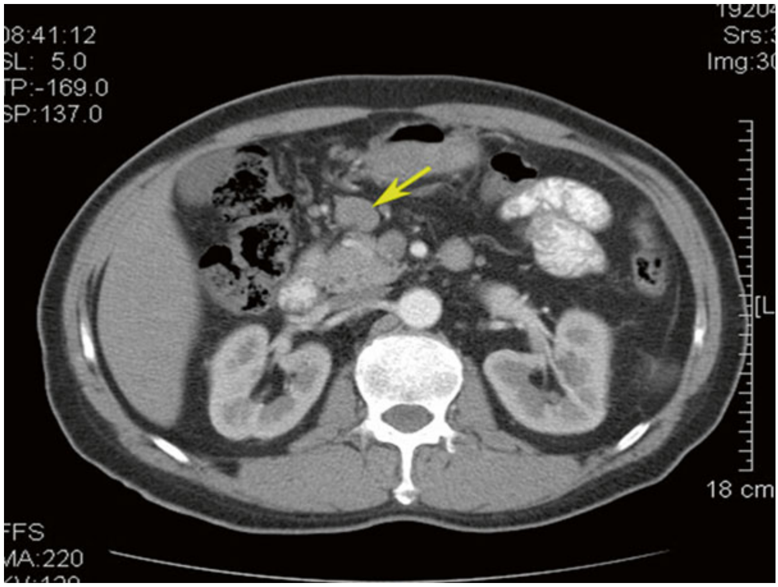


Fig. 4.53 Preoperative CT image demonstrating No. 14v LNM (the *arrow* represents the swollen No. 14v LNs)

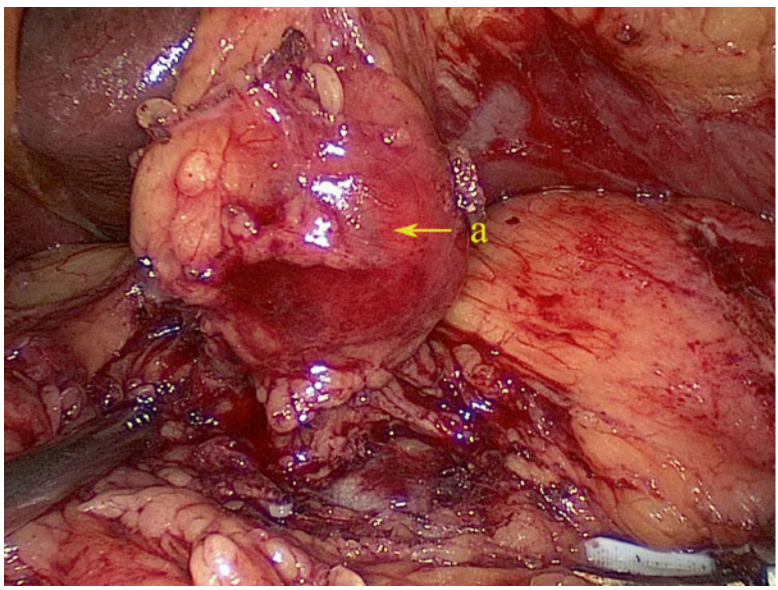


Fig. 4.54 Intraoperative view of No. 14v LNM (*a*)

Prevention of Damage to Adjacent Tissues and Organs

Entering the plane too deeply (which can occur in some patients with an unapparent anatomic space) may cause rupture of the mesentery during separation of the ATM. This appears as a broken hole in the mesentery, through which the small intestine behind it can be seen (Fig. 4.104). In this case, the position and extent of the broken mesentery should be checked, and the colonic vessels should be examined for injury. Subsequently, the operative plane should be readjusted to find the correct anatomic space.

Prevention of Vascular Injury

The separated space between the ATM and PTM can change because of adhesions or excessive traction by the assistant. When the gastric antrum

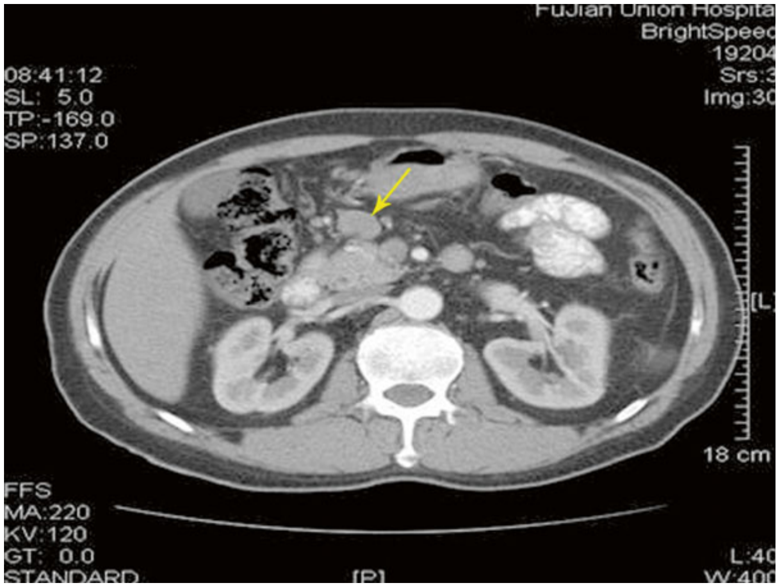


Fig. 4.55 CT image of No. 14v LNM before neoadjuvant chemotherapy

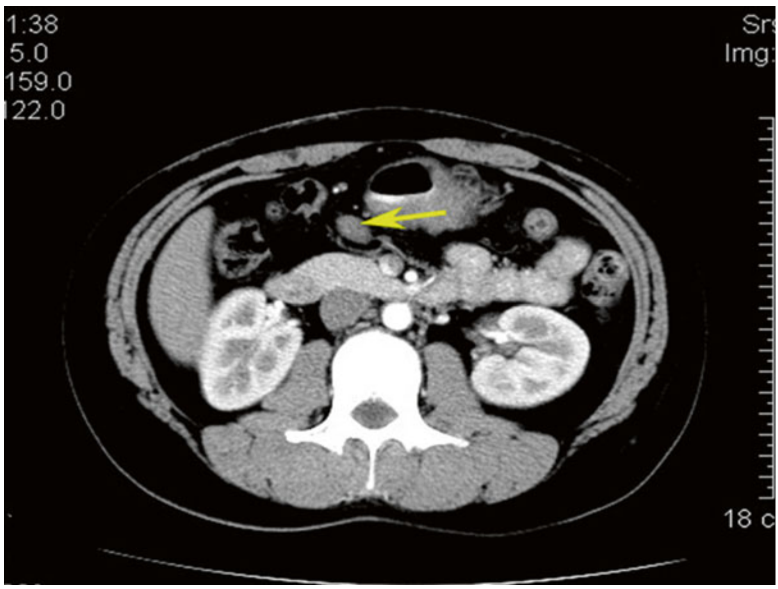


Fig. 4.56 CT image of No. 14v LNM after neoadjuvant chemotherapy

is lifted, the TM is drawn with it, which may cause the lifted vessels to be incorrectly identified as the right gastroepiploic vessels and to be severed (Fig. 4.105). Thus, in this situation, dissection should take place on the side closest to the stomach, and the correct anatomic plane should be identified to avoid injuring the TM and its vessels (Fig. 4.106).

4.4.2 Surgical Techniques Involved in Dissection of the No. 14v LNs

4.4.2.1 Surgical Techniques Involved in Dissection

When exploring and exposing the anatomic space, the assistant should lift the posterior wall of the gastric antrum upward with one grasper,

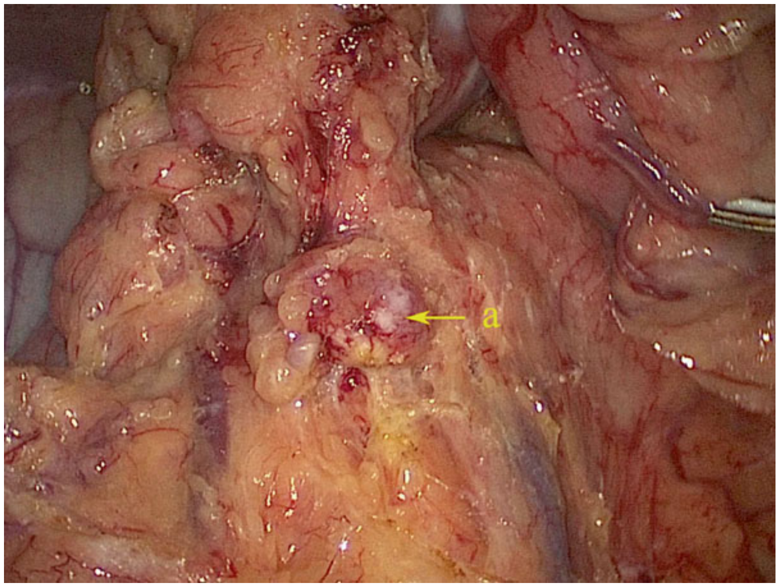


Fig. 4.57 Intraoperative view of No. 14v LNs (*a*)

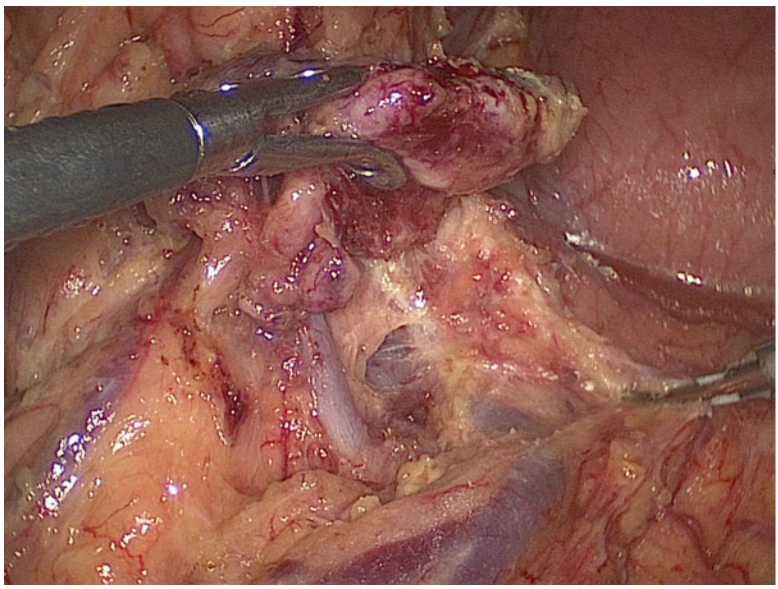


Fig. 4.58 Appearance after dissection of the No. 14v LNs

while using another to keep the tissue that needs to be separated under tension together with the operator's grasper opposite. This facilitates exposure of the anatomical space and the use of ultrasonic scalpels (Fig. 4.107). Before exposing the SMV, the ATM should first be separated to reveal the MCV, which can be used to detect the SMV. Sometimes, fairly thick connective tissues may be located in front of the middle colic vessels, so the dissection plane should be close to the surface of the vessels to avoid entering the plane too high or too low. For obese patients or those whose MCV is too deep to be exposed, it is proper to explore the RGEV on the inferior margin of the pancreas. Subsequently, dissection should be along the course of the RGEV and the

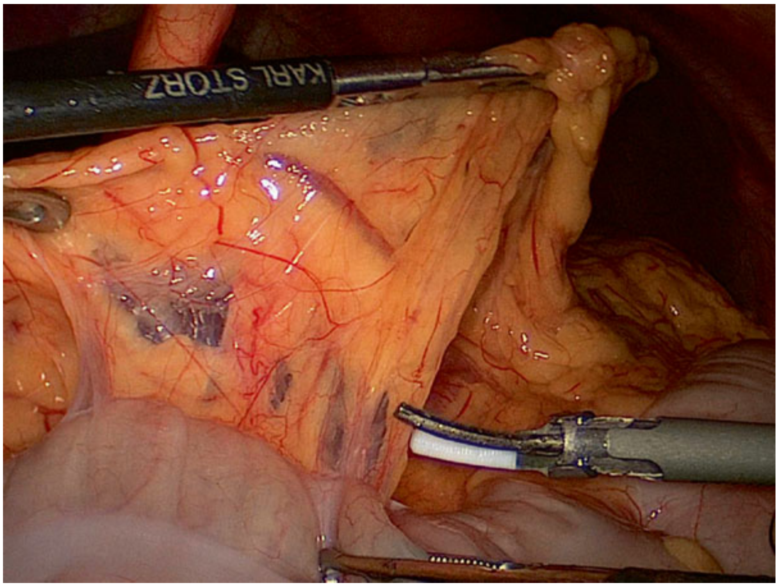


Fig. 4.59 The approach is from the superior border of the transverse colon near its midpoint

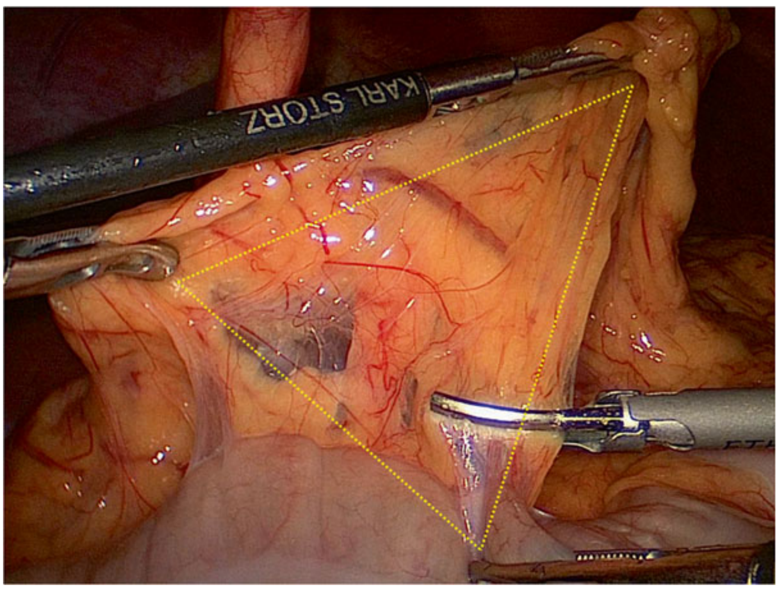


Fig. 4.60 Triangle traction keeps the greater omentum under tension

MCV to expose the part of the SMV into which the two veins drain. The SMV is then exposed after entering the retropancreatic space from this site (Fig. 4.108).

4.4.2.2 Prevention of Damage to Adjacent Tissues and Organs

In obese patients, adipose and lymphoid tissues are always difficult to distinguish from pancreatic tissues. Consequently, when dissecting the LNs around the root of the SMV up to the inferior margin of the pancreas, careful identification of the different tissues and meticulous dissection of the LNs along the surface of the pancreas are required to avoid injury to the pancreas, which might cause postoperative pancreatic fistula. When the No. 14v LNs are obviously swollen, it is important to expose the space between the basilar aspect of the LNs and the SMV. If the dissection plane is too shallow, the ultrasonic scalpel

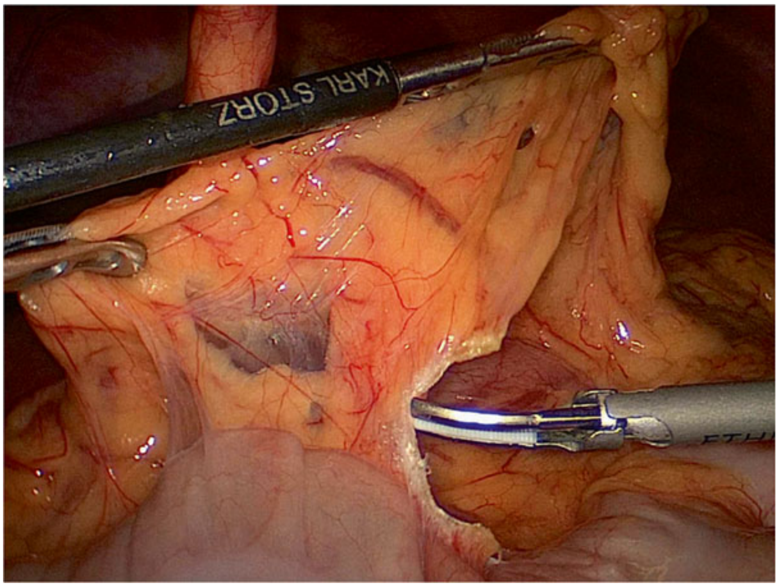


Fig. 4.61 The greater omentum is divided in the avascular area at the superior border of the transverse colon

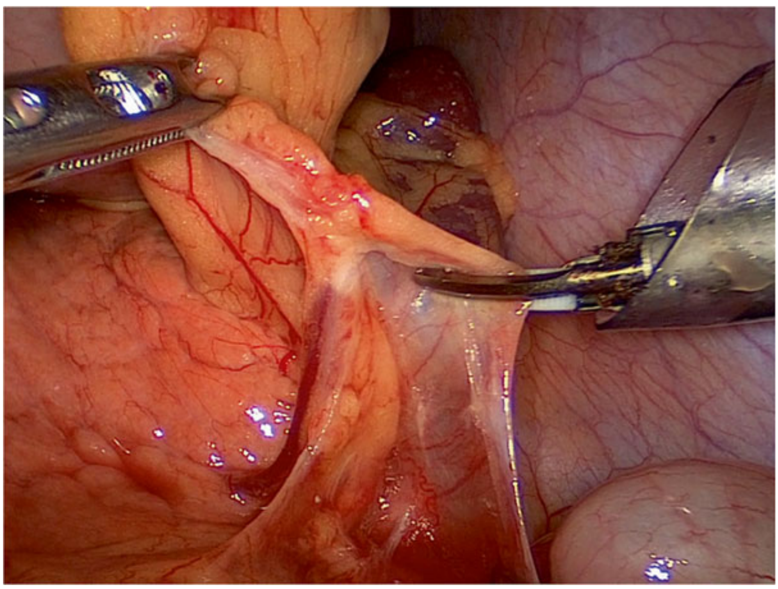


Fig. 4.62 Divide the greater omentum until reaching the splenic flexure of the colon

may harm the LNs and cause bleeding (Fig. 4.109) while it may damage the SMV and result in massive hemorrhage if the plane is too deep.

4.4.2.3 Prevention of Vascular Injury

During the process of exposing the SMV, the surgeon should not simply dissect it along the surface of the MCV, because this will lead to a too narrow operative field, potentially leading to injury of the mesenteric vein where it is difficult to achieve hemostasis after injury. To avoid these complications, the surgical plane around the MCV should be sufficiently expanded. The SMV will be naturally exposed during the process of separating ATM (Fig. 4.110). There is a thin layer of fascia in front of the SMV, the extension of the anterior PDF. This fascia should be opened when dissecting the No. 14v LNs to ensure adequate exposure of the SMV. The assistant should help to lift the adipose and lymphoid tissues in

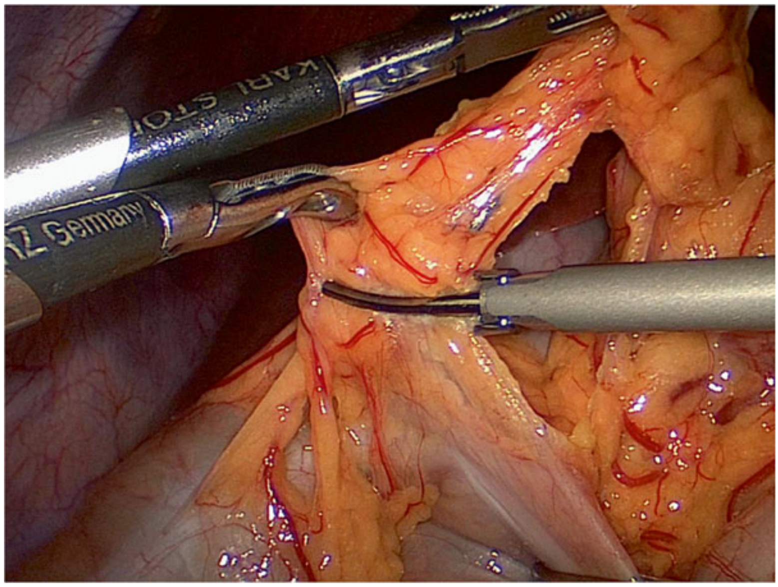


Fig. 4.63 Divide the greater omentum until the hepatic flexure of the colon

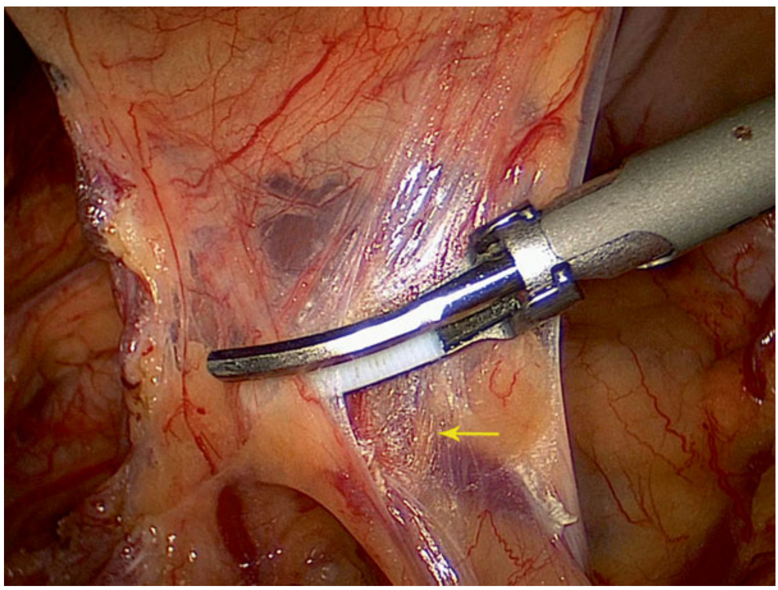


Fig. 4.64 The approach is from the superior border of the right transverse colon (the *arrow* represents superior border of the right transverse colon)

front of the vein while the surgeon draws the middle colic vessels and the TM downward to expose the space between these tissues and the vessels. These manipulations enable convenient dissection with ultrasonic scalpel (Fig. 4.111). Because the venous wall is thin, the dissection on the surface of the SMV should be gentle. It is appropriate to dissect directly with ultrasonic scalpels rather than using blunt dissection. Throughout the dissection, the nonfunctional face of the ultrasonic scalpel should be positioned close to the venous wall to prevent hemorrhage caused by vascular injury (Fig. 4.112). Some venules directly drain into the SMV at the inferior margin of the pancreas (Fig. 4.113), and transection of these should be avoided when dissecting the No. 14v LNs. Because of the relatively high pressure in the SMV and the thin venous wall, a broken venule can easily bleed. If it is necessary for a vessel to be divided, it should be completely occluded with the ultrasonic scalpel and then severed using the minimum speed.

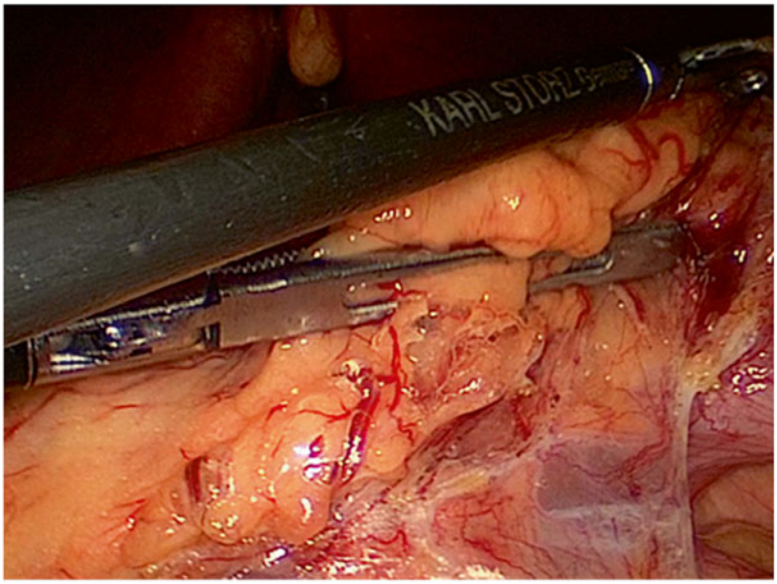


Fig. 4.65 The assistant pulls up the greater omentum at the greater curvature of the gastric antrum using an atraumatic left-handed grasper

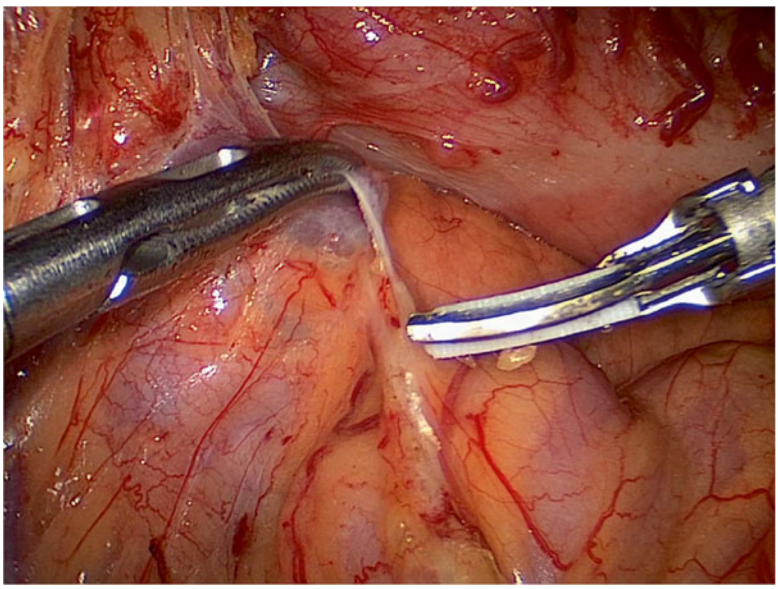


Fig. 4.66 The assistant lifts up the ATM with a right-handed grasper

However, if bleeding occurs, it is appropriate to apply compression with gauze to stop it rather than using the ultrasonic scalpel, because a blind maneuver may cause uncontrollable massive hemorrhage. Because of the variation in convergence patterns of the branches of the SMV, careful identification of the convergence is required. Thus, dissection in this region should be carefully visualized, and the use of ultrasonic scalpel should be limited. The No. 14v LNs should be removed on the surface of the venous branches to avoid injuring the vessels. In some patients, the right colic artery (RCA), which is located 1–2 cm beneath Henle's trunk, runs across the ventral side of the SMV. In this case, division of the TM should be conducted from the surface of the RCA to the retropancreatic space (rather than along the inferior margin of the RCA) to avoid injuring the artery (Fig. 4.114). Moreover, the surgeon should exercise caution when an unusual artery is found in the infrapyloric region. To avoid ischemia of the colon, an artery that is

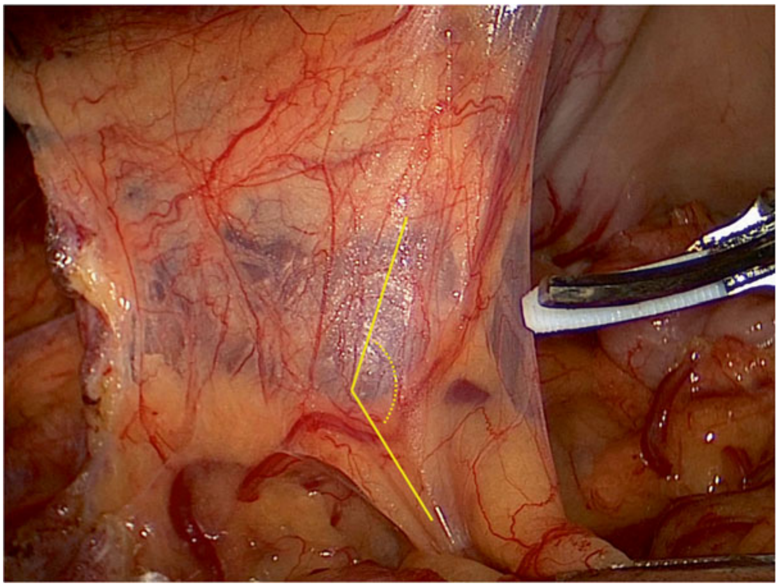


Fig. 4.67 The fusion space between the ATM and PTM is revealed

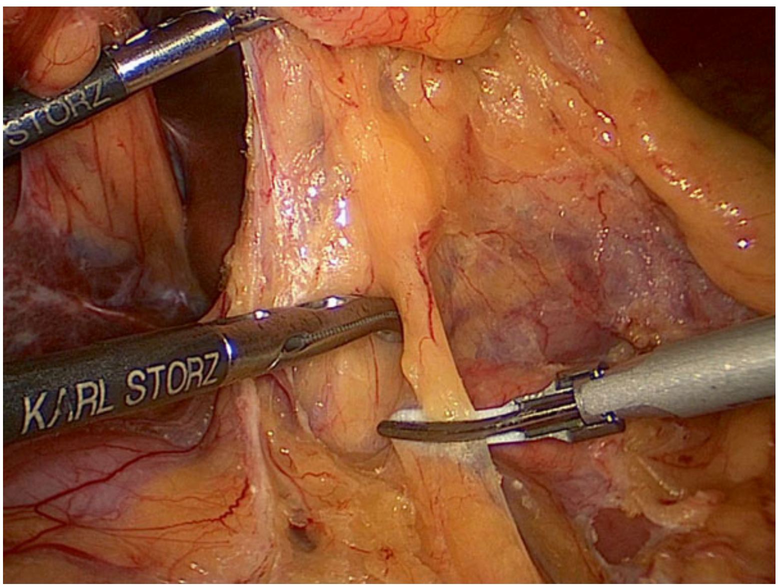


Fig. 4.68 The assistant pushes the ATM up along the fusion space

suspected to be a variant RCA should be sufficiently dissected to track it and identify its origin and terminus (Figs. 4.115, 4.116, 4.117, and 4.118). In a few patients, the SPDA gives off several superficial branches which lie on the surface of the pancreas. Thus, the surgeon should take care to avoid injuring these vessels when dissecting the pancreatic membrane and the No. 14v LNs (Fig. 4.119).

4.4.3 Surgical Techniques Involved in Dissection of the No. 6 LNs

4.4.3.1 Surgical Techniques Involved in Dissection

Before dissecting the No. 6 LNs, the adhesions around the duodenum should be sufficiently divided. To adequately expose the region during dissection, it is important to maintain proper

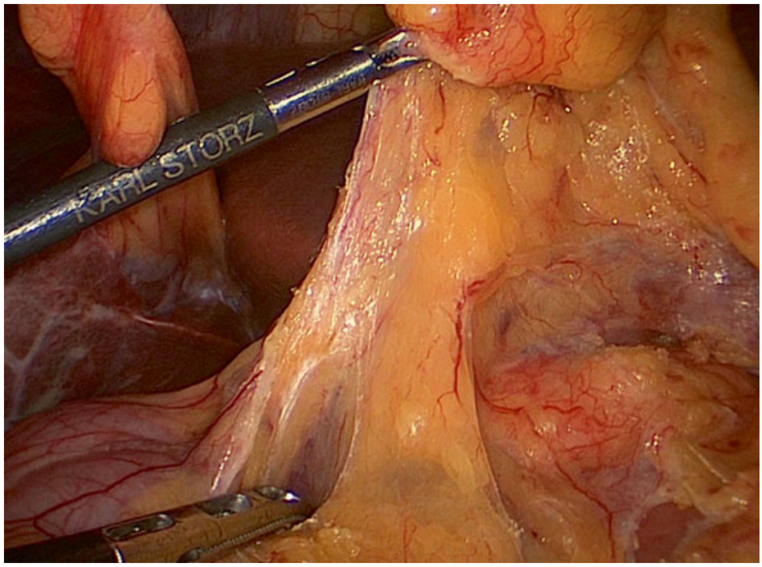


Fig. 4.69 The assistant pushes the PTM down along the fusion space

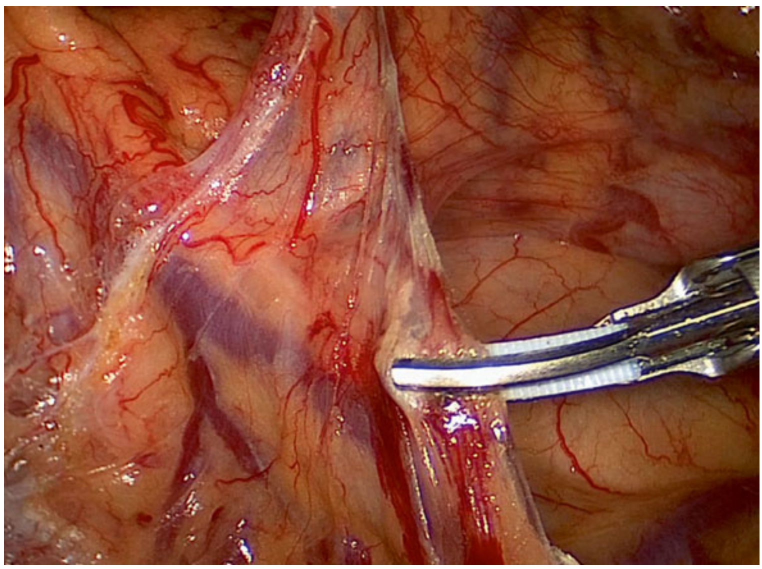


Fig. 4.70 The dissection is initiated from the superior border of the right transverse colon

tension. If the tumor at the gastric antrum is too large to grasp, the assistant can use atraumatic grasping forceps to hold the stomach by lifting the posterior wall of the gastric antrum or grasping more omental tissue (Fig. 4.120). To adequately expose the infrapyloric region in the presence of a large amount of adipose and lymphoid tissue, a piece of gauze can be used to fix the dropping adipose tissue between the liver and the duodenum (Figs. 4.121 and 4.122). It is often difficult to confirm the surgical approach at the convergence of the RGEV and the ASPDV in obese patients or those with swollen No. 6 LNs. Therefore, the proper procedure is to first expose the SMV and Henle's trunk, then to expose the origin of the RGEV along the surface of the pancreatic head from inferior to superior (Fig. 4.123). The pancreatic head is an important anatomic landmark for the dissection of the No. 6 LNs, particularly in patients with too much adipose tissue in this region. The dissection procedure can proceed from the surface of

Fig. 4.71 Sharp dissection of the ATM using the ultrasonic scalpel

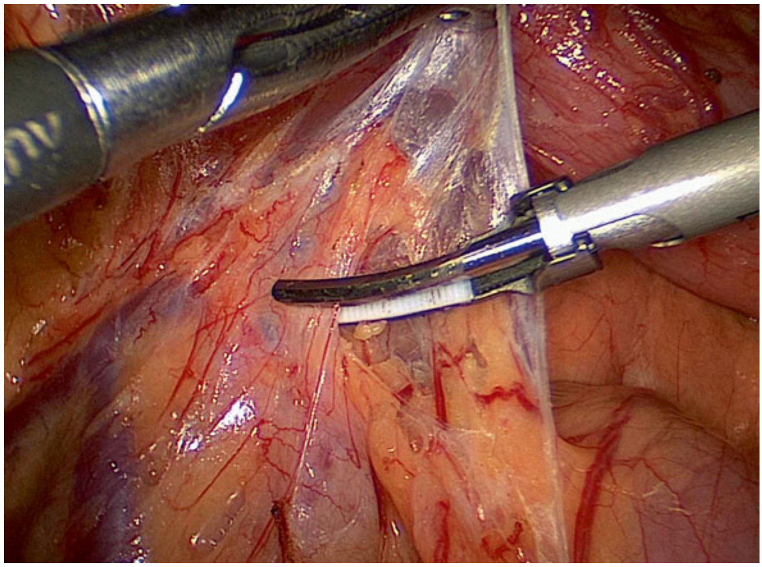
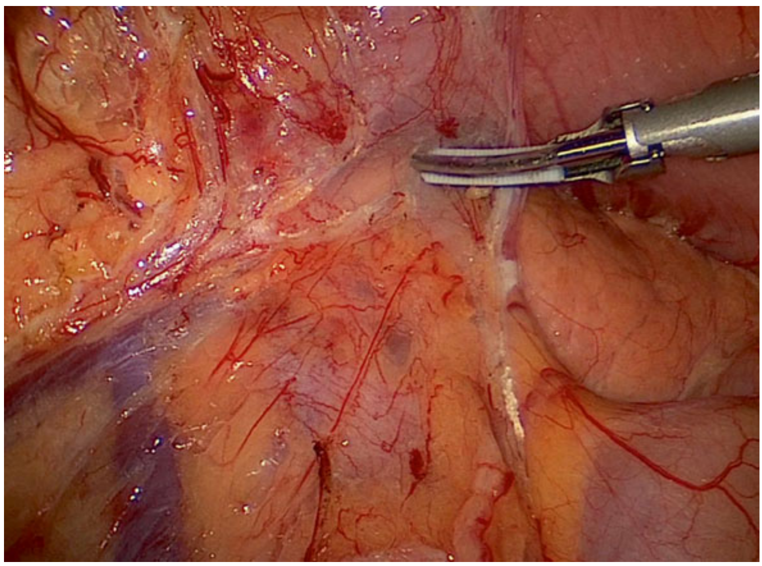


Fig. 4.72 Blunt dissection of the ATM using the ultrasonic scalpel



the pancreatic head to the groove between the duodenum and the head of the pancreas. After exposing the GDA, it is easy to look for the root of the RGEA along the course of the GDA. The vessels at the gastric pylorus give off branches into the gastric wall in the shape of a claw. If these vessels are encountered, it means that mobilizing of the duodenum has progressed to the pylorus.

4.4.3.2 Prevention of Damage to Adjacent Tissues and Organs

The boundaries between different tissues should be taken into account to avoid the accidental injury of other organs (e.g., gall bladder, colon, pancreas) when mobilizing the duodenum. The assistant must apply proper tension when retracting the omental tissue to avoid tearing it and causing bleeding during the process of exposure

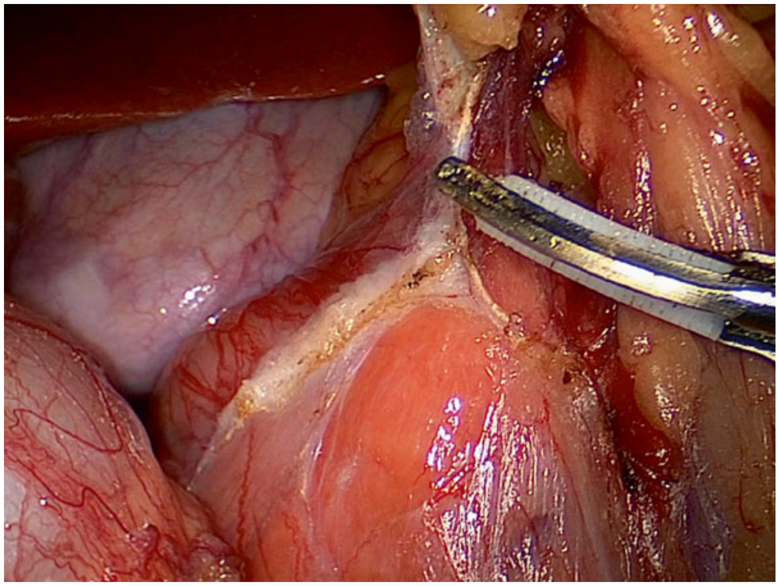


Fig. 4.73 The dissection of the ATM is continued toward the right up to the medial border of the descending duodenum

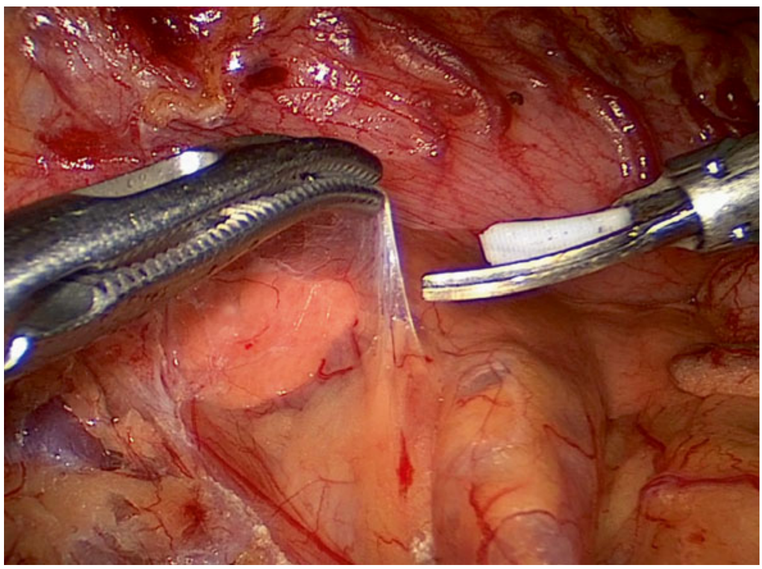


Fig. 4.74 The dissection of the ATM is continued upward to the lower border of the pancreas

(Fig. 4.124). It is best to use the dissecting function of the ultrasonic scalpel to resect adipose tissue around the RGEV, alternating between the horizontal axis and the vertical axis. This technique enables sufficient dissociation of the dorsal side of the RGEV (Figs. 4.125 and 4.126). In some patients, aberrant pancreatic tissue and/or lobes of heterogenic pancreatic tissue can exist in the infrapyloric region, which may look like swollen infrapyloric LNs and adipose tissue. Considering the risk of postoperative pancreatic fistula, these tissues should be carefully identified during the operation; the former can be dissected, while the latter should be preserved (Figs. 4.127, 4.128, and 4.129). When mobilizing the duodenum after dissecting the No. 6 LNs, the

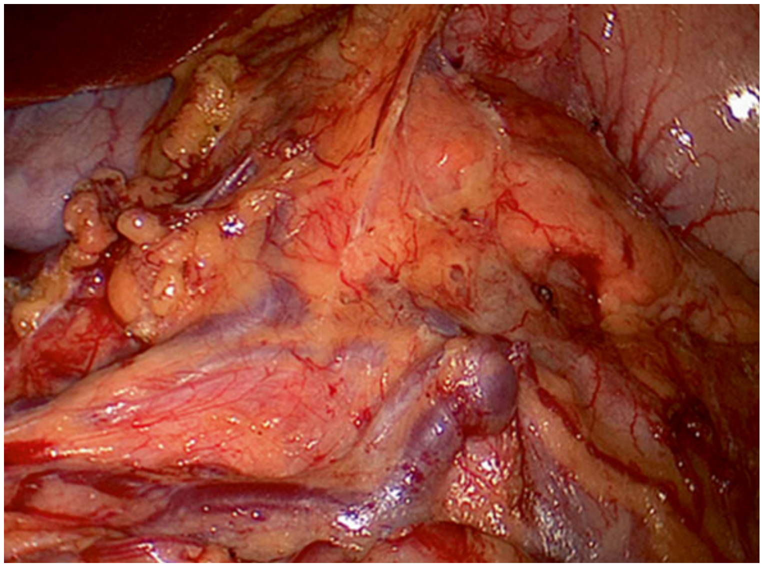


Fig. 4.75 The approach is from the MCV

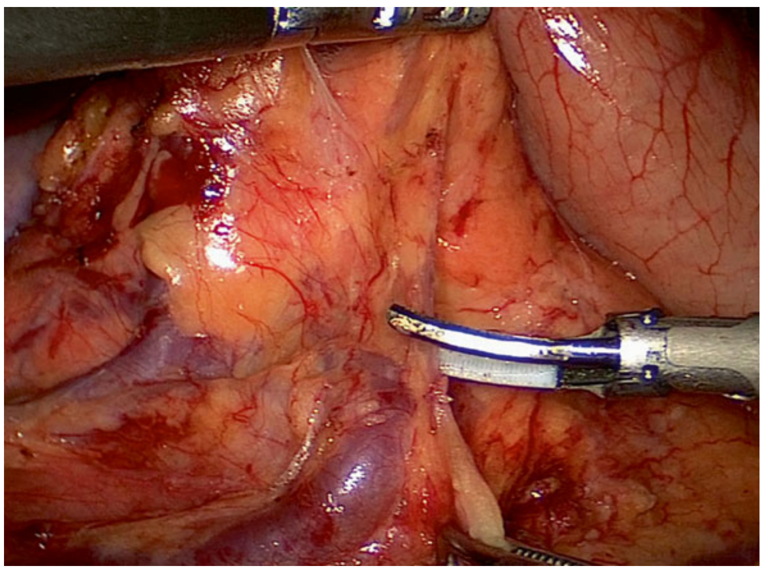


Fig. 4.76 The exposure of the root of the SMV

ultrasonic scalpel should proceed along the tangential direction of the duodenal wall, with its nonfunctional face close to the duodenum to avoid injury to the wall.

4.4.3.3 Prevention of Vascular Injury

Generally, a large amount of adipose tissue surrounds the RGEV in obese patients. Additionally, a vessel under traction can be too thin to identify because of a lack of blood flow. To avoid vascular injury, the assistant should appropriately loosen the left hand when lifting the tissues to allow for perfusion of the vessels, making them easier to distinguish and enhancing the effect of occlusion with a vascular clip. Because the area drained by the No. 6 LNs lies between the RGEV and RGEA, the division plane of the RGEA is above the surface of the pancreatic head, while the division plane of the RGEV is below it. Hence, the two vessels should be severed at different positions, and the RGEV should be ligated and transected first to avoid tearing and bleeding (Figs. 4.130 and 4.131).

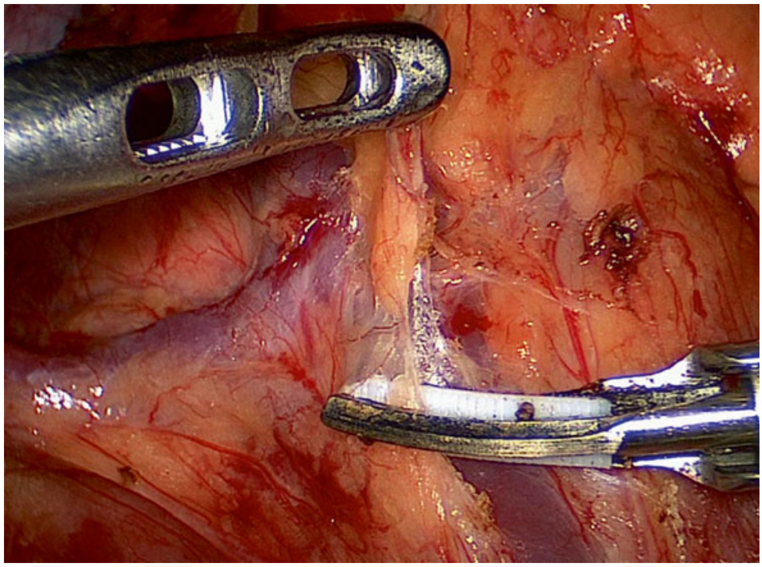


Fig. 4.77 The surgeon uses the nonfunctional surface of the ultrasonic scalpel to dissect these tissues along the vein

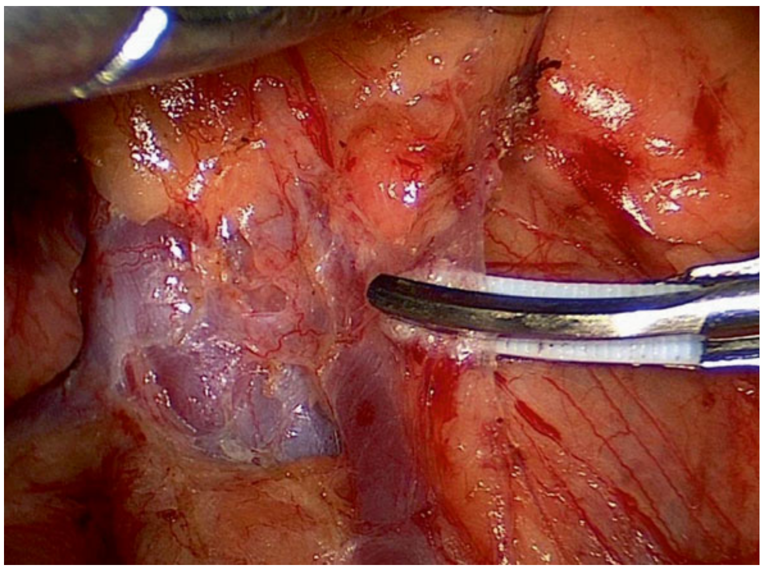


Fig. 4.78 The reveal of the confluence of the MCV and the SMV

The dissection plane of the RGEV should be above the confluence with the ASPDV. Therefore, when dissecting the RGEV, the location of the ASPDV (coming from the right, backward of the pancreatic head) should be noted (Fig. 4.132). If the RGEV converges directly into the SMV, the vessel should be dissected at the inferior margin of the pancreas (Fig. 4.133). When the RGEV, the ASPDV, and the RCV form Henle's trunk at the right side of the SMV, Henle's trunk or the ASPDV should not be ligated and severed if the root of the RGEV has not been sufficiently exposed (Figs. 4.134 and 4.135). After dividing the RGEV, when the assistant pulls the RGEA upward, the GDA and the SPDA will also be lifted together. The surgeon should sever the RGEA at its root, after the GDA gives off the SPDA. If the plane of ligation is too low, the SPDA may be ligated by mistake, causing ischemia of local tissues (Figs. 4.136 and 4.137). The IPA, which always originates from the GDA behind the RGEA, is thin and has many branches, making it difficult to

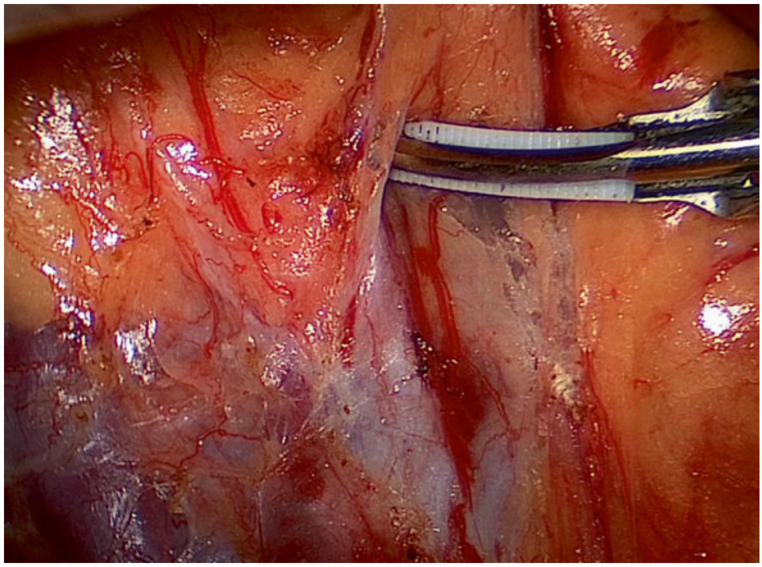


Fig. 4.79 The dissection is continued upward until the inferior border of the pancreas is reached and the PPDS is entered

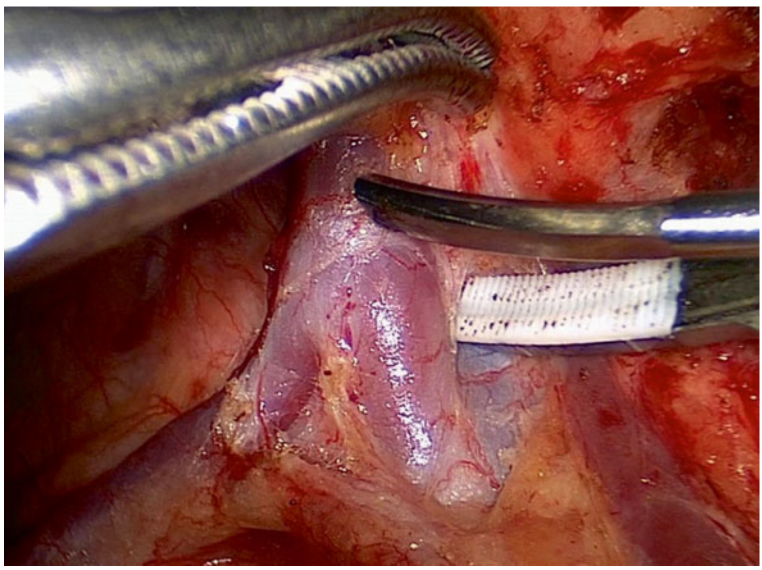


Fig. 4.80 Henle's trunk is vascularized

denude. After dividing the RGEA, the surgeon should focus on this artery. It is appropriate to ligate it and then divide it using the minimum speed of the ultrasonic scalpel (Fig. 4.138). The GDA always gives off some branches to the posterior wall of the duodenum. Considering that these branches are difficult to expose and that it is difficult to stop them from bleeding once injured, the division here should be handled after dissection of the superior margin of the pancreas.

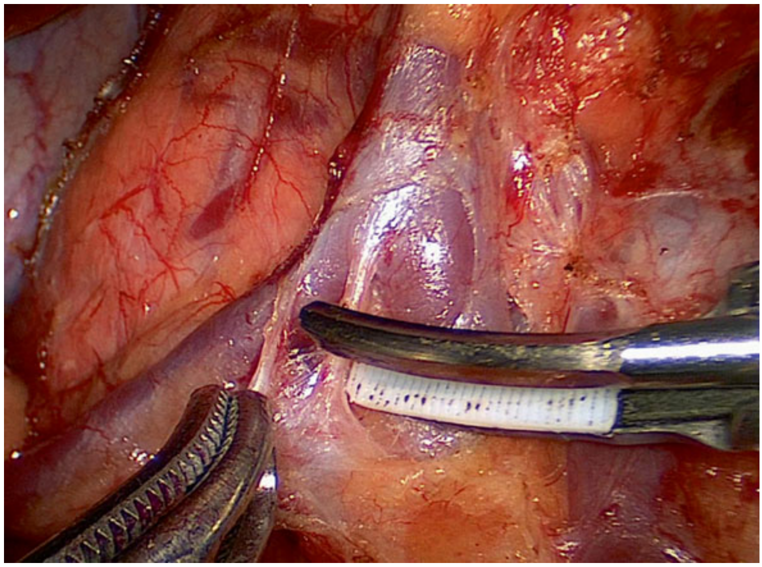


Fig. 4.81 The separation and exposure of the confluence of the RGEV and RCV or ARCV

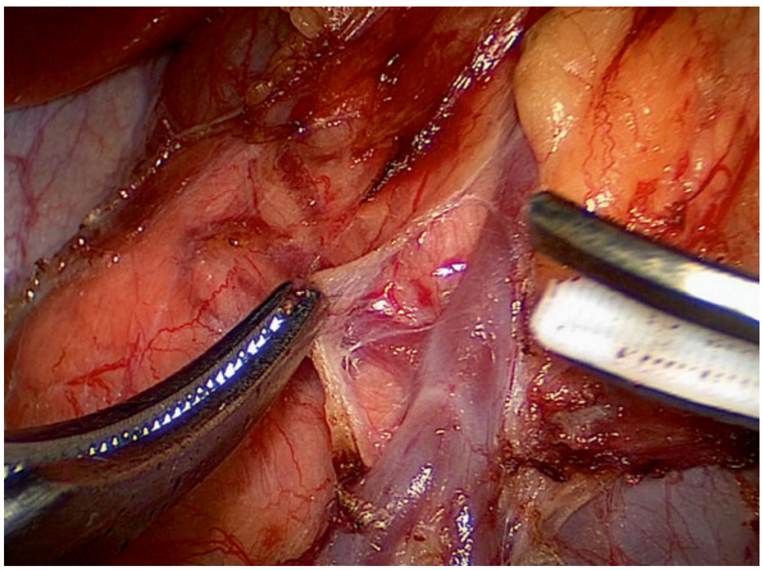


Fig. 4.82 The separation and exposure of the confluence of the RGEV and ASPDV

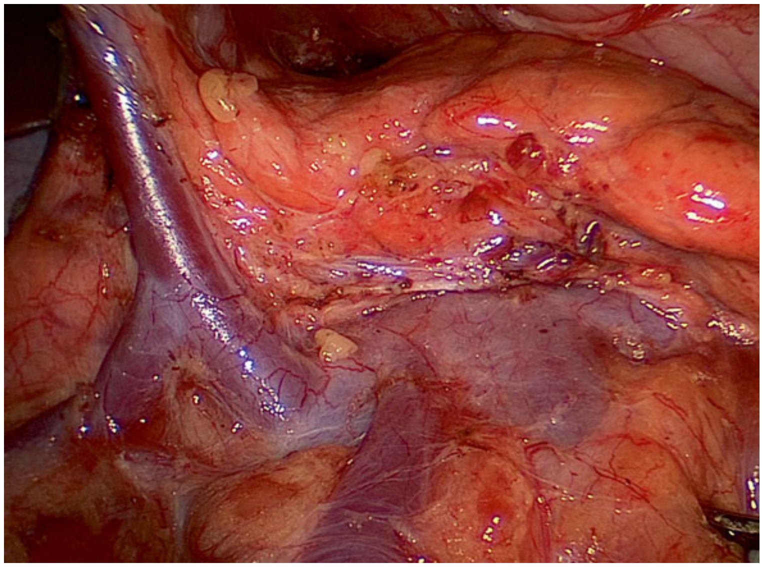


Fig. 4.83 Appearance after the dissection of the No. 14v LNs

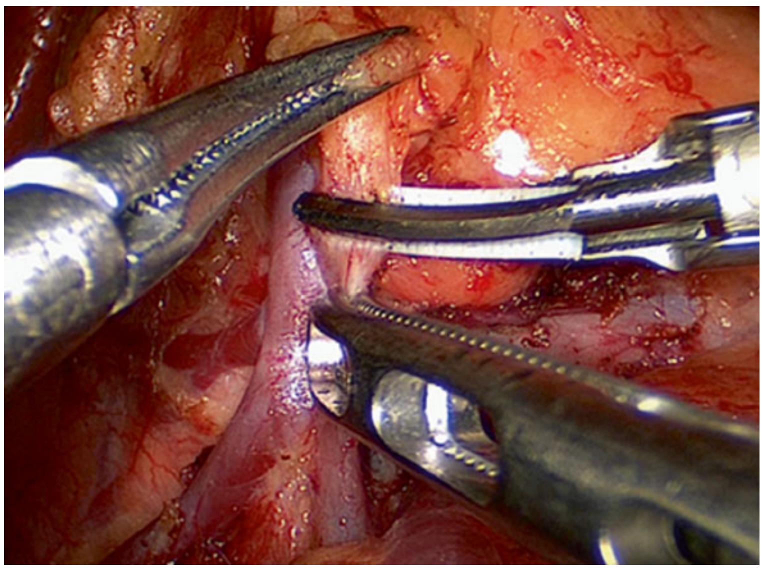


Fig. 4.84 The approach to the No. 6 lymph node dissection is from the GIS

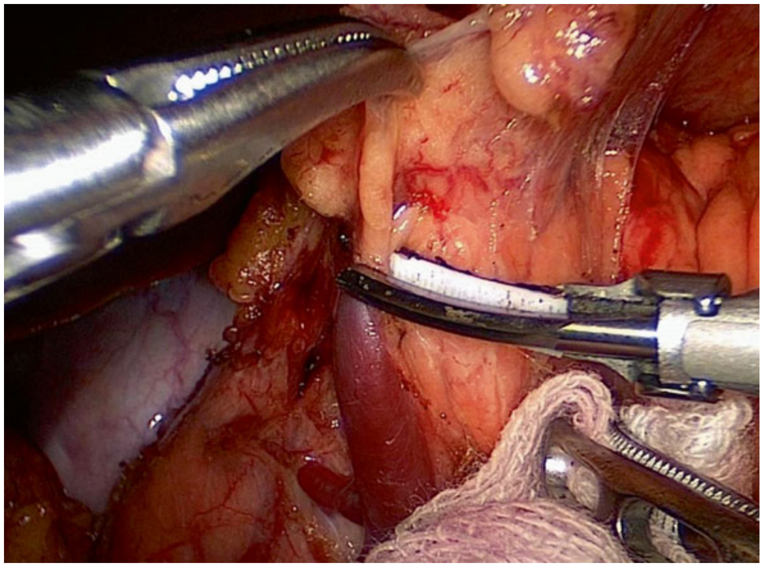


Fig. 4.85 The infrapyloric area is exposed to facilitate the dissection of the No. 6 LNs

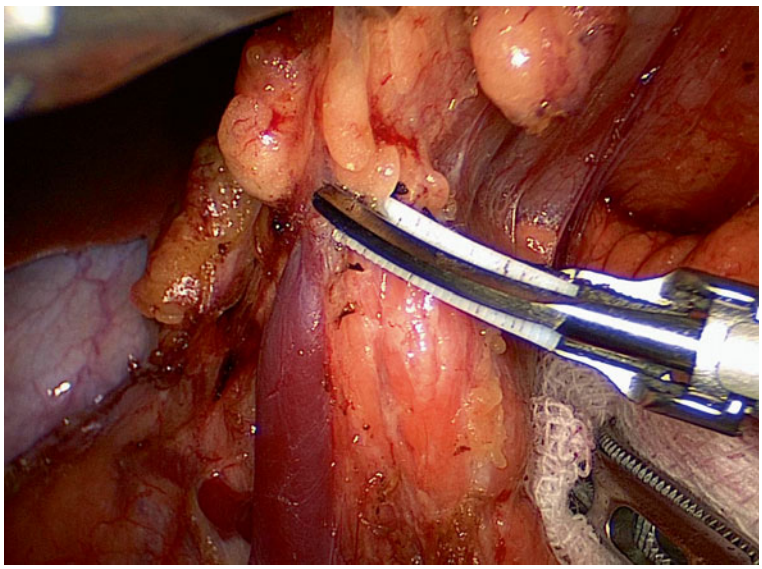


Fig. 4.86 The RGEV is dissected until the superior border of the pancreatic head

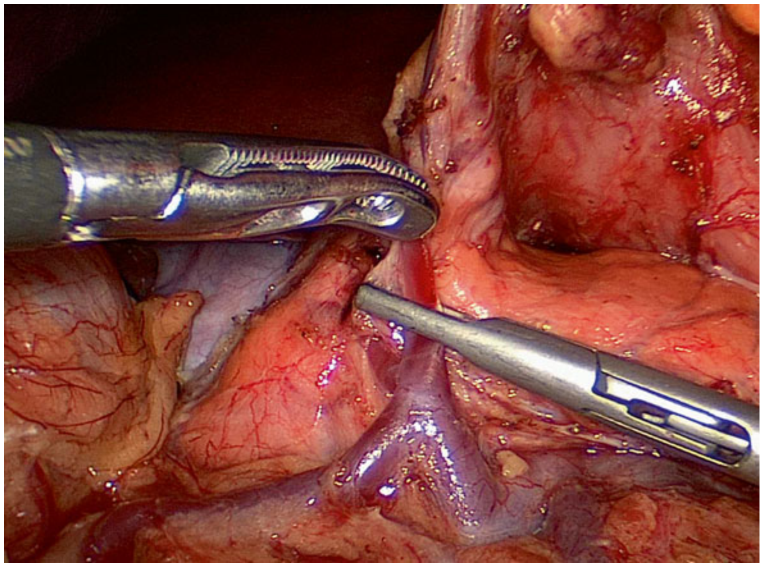


Fig. 4.87 The RGEV is divided above the confluence of the SPDV

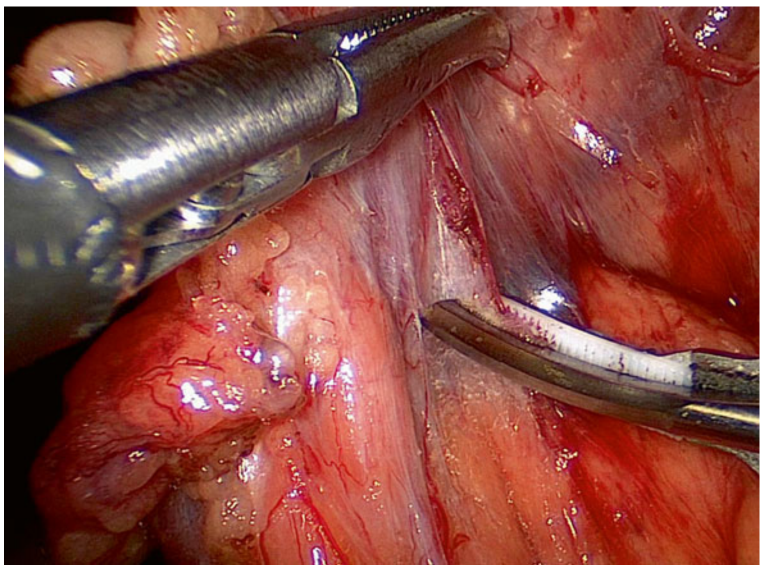


Fig. 4.88 The separation of the intrafascial space between the pancreatic head and the duodenum

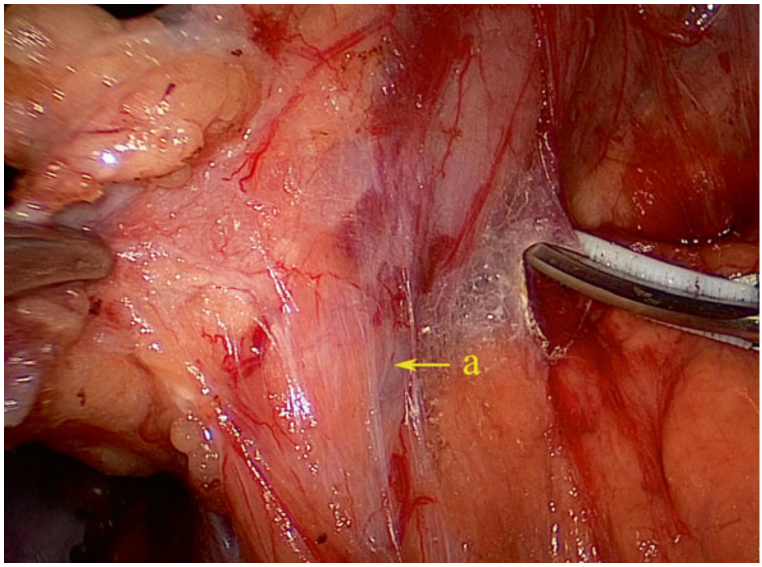


Fig. 4.89 The exposure of the end of the GDA (*a*)

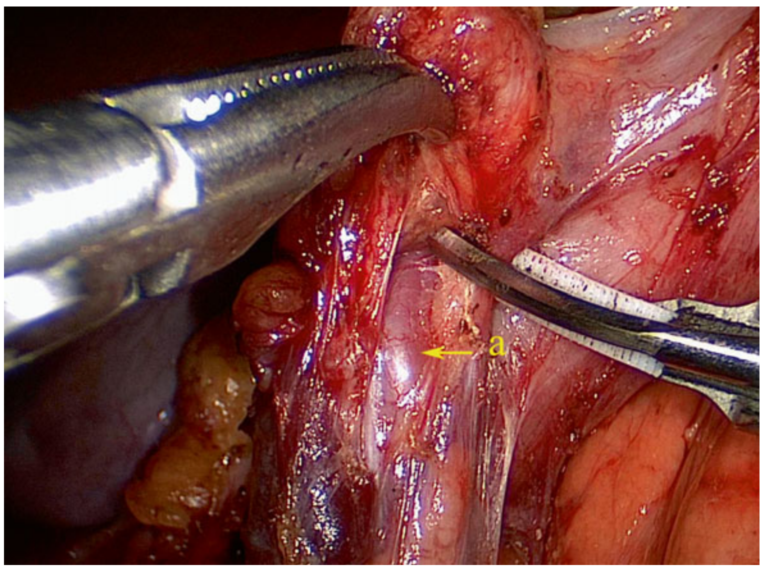


Fig. 4.90 The exposure of the root of the RGEA (*a*)

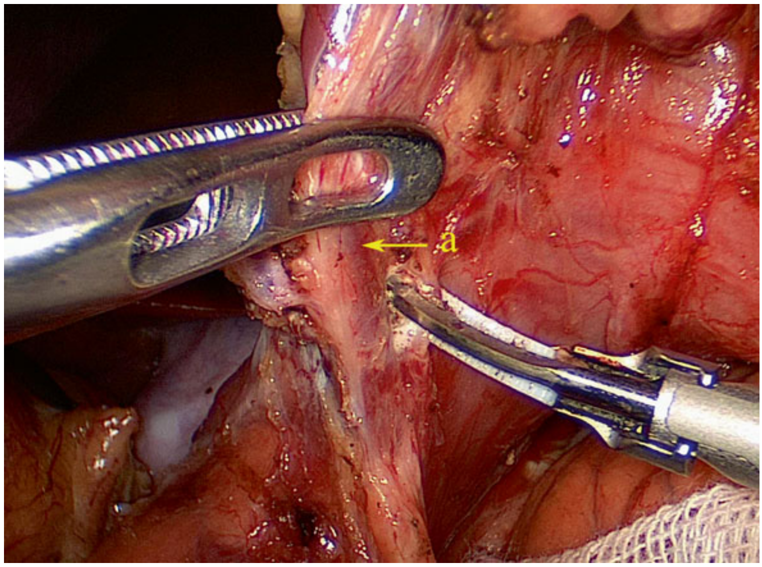


Fig. 4.91 The RGEA (*a*) is vascularized

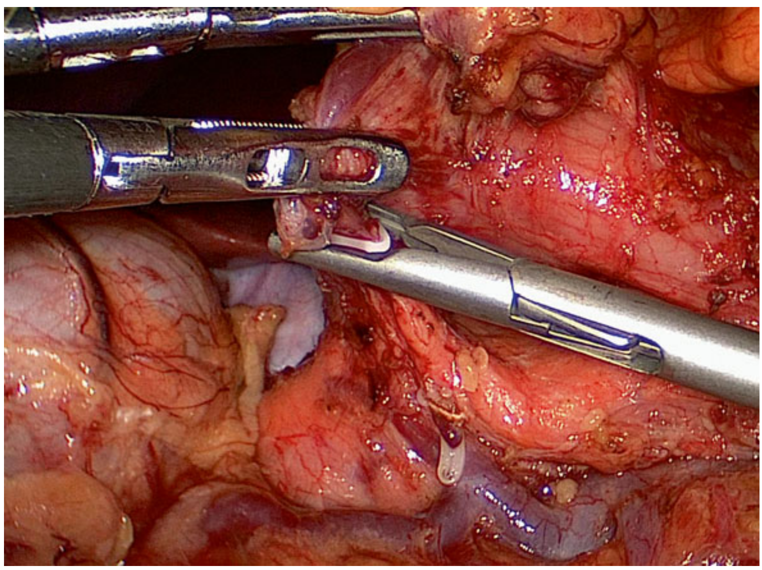


Fig. 4.92 The root of the RGEA is divided with clamps

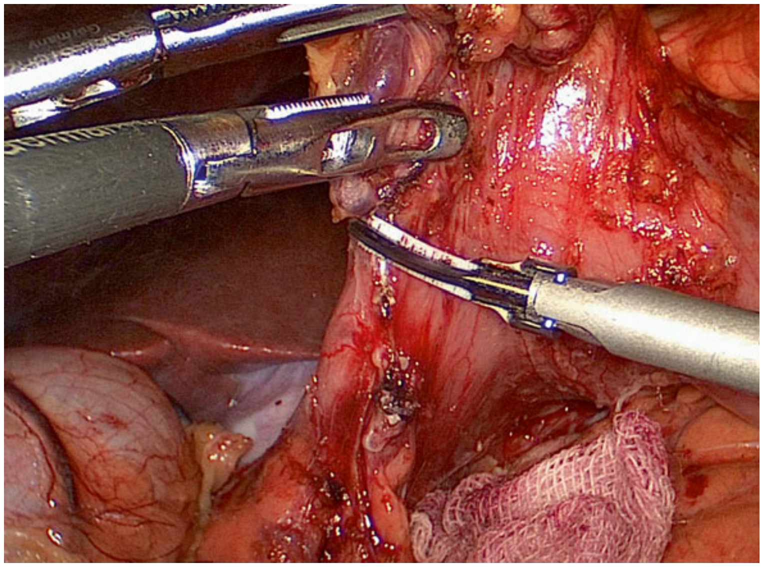


Fig. 4.93 Dissect along the duodenum toward the pylorus until the pylorus is reached

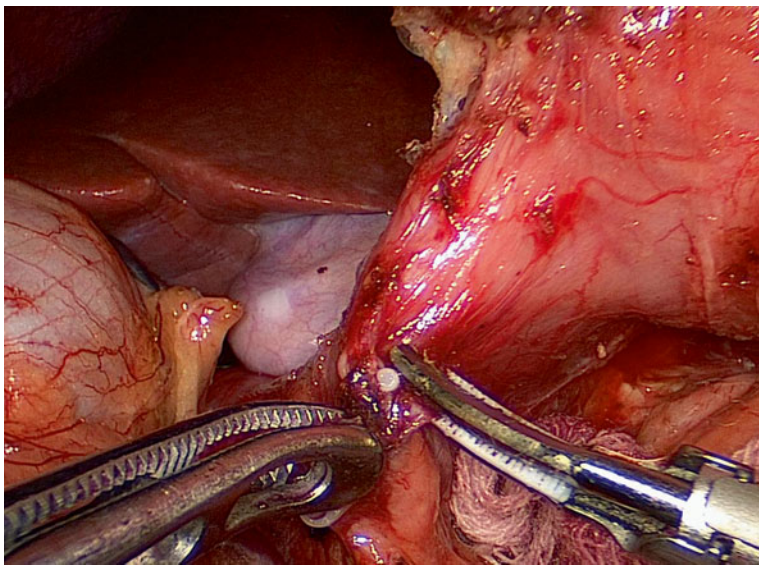


Fig. 4.94 Appearance after the dissection of the No. 6 LNs

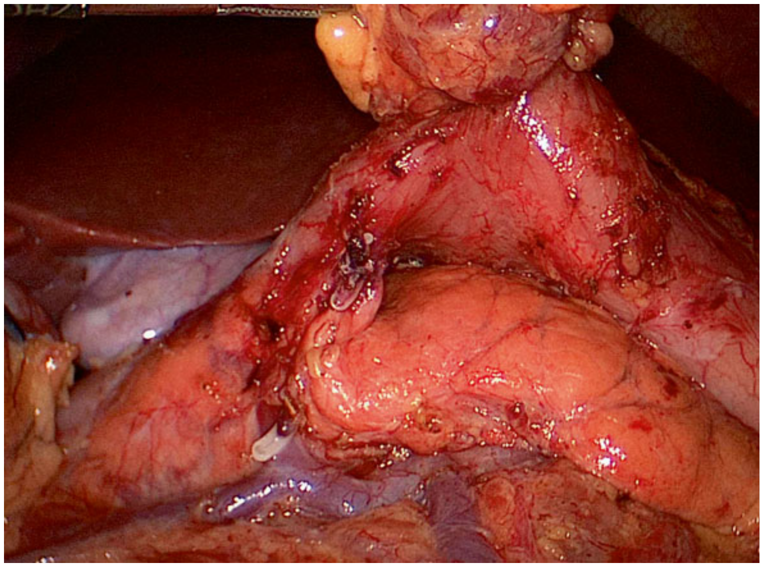


Fig. 4.95 Appearance after dissection of the No. 14v and the No. 6 LNs

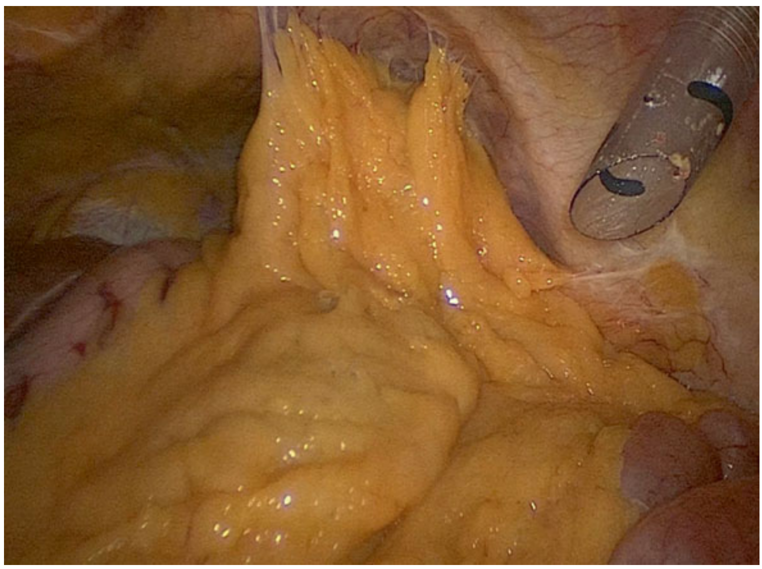


Fig. 4.96 Adhesions may be encountered even in some without previous surgical history

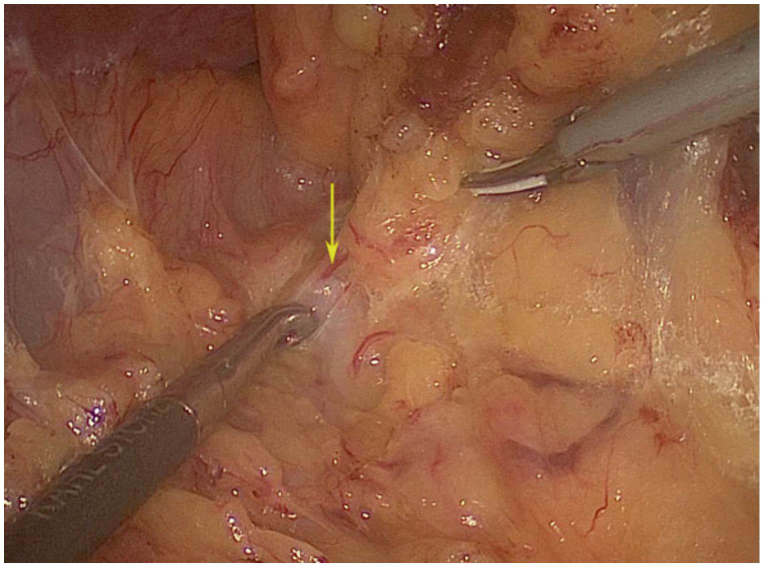


Fig. 4.97 Dissecting on the cases of fat patients should be meticulous. Because the transverse colon is always wrapped in the thick, rich great omentum (the *arrow* represents the transverse colon)

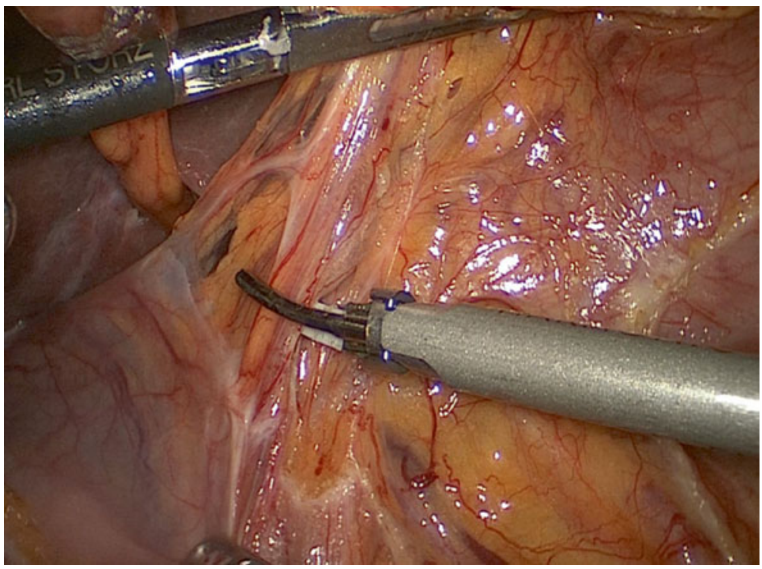


Fig. 4.98 The duodenum can be smoothly exposed inside after pulling the hepatic flexure outward

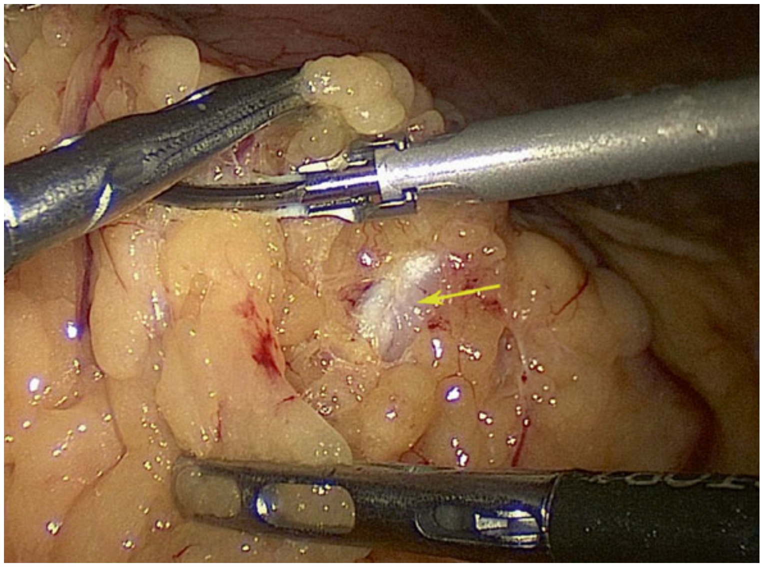


Fig. 4.99 The serosal surface of the colon is injured (the *arrow* represents the serosal surface of the colon)

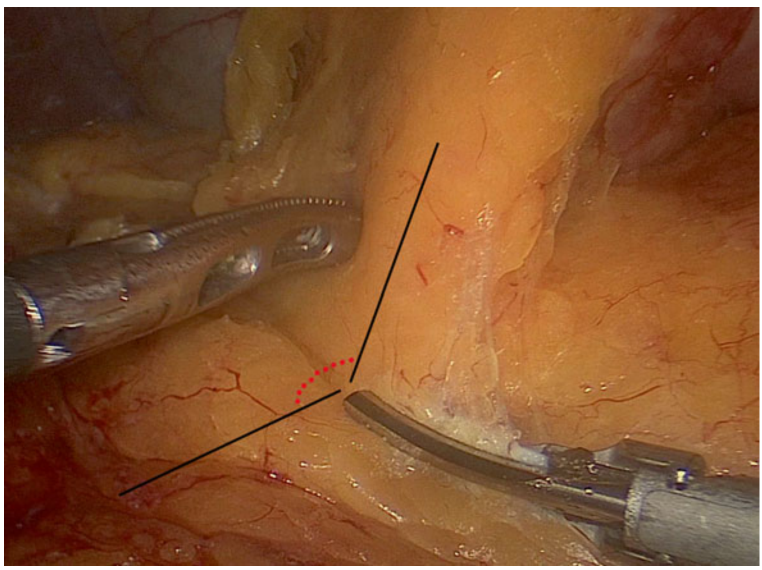


Fig. 4.100 The angle between the ATM and PTM

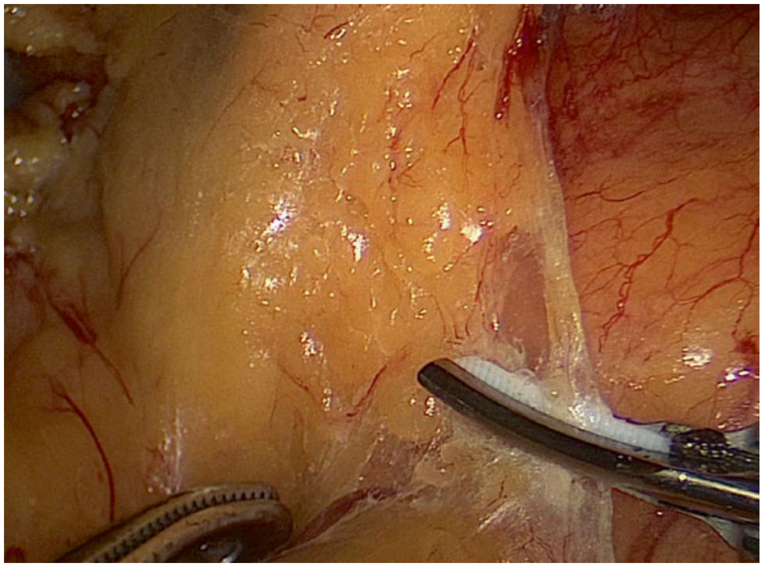


Fig. 4.101 The assistant could use the right grasping forceps to bluntly dissect the inferior of the pancreatic head to help expose the anatomic space

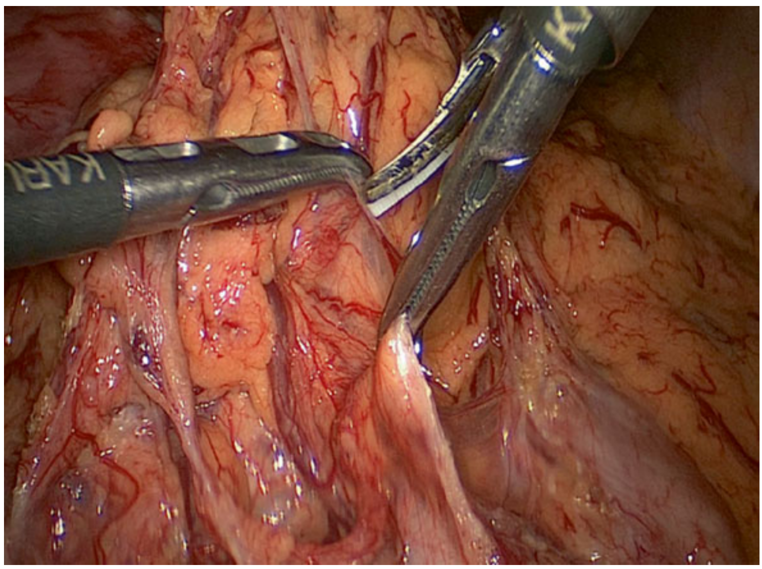


Fig. 4.102 If the dividing plane is too deep or shallow, it is appropriate to search the anatomic plane again

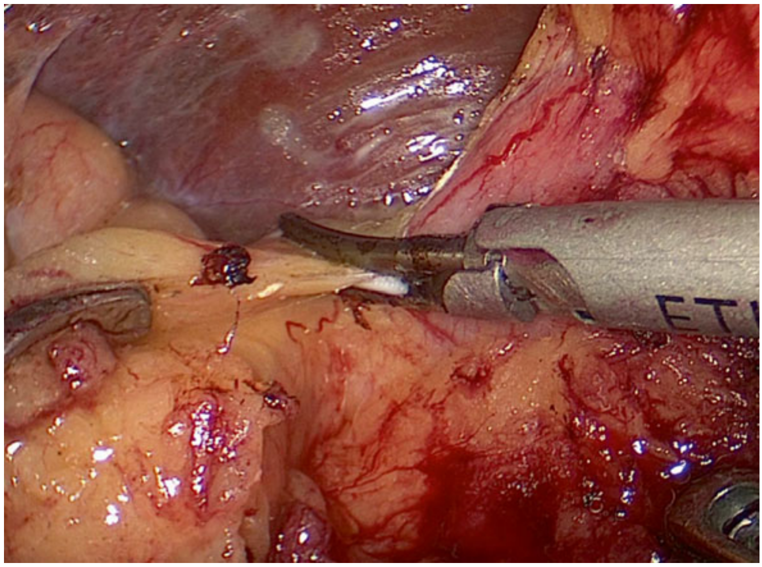


Fig. 4.103 The adhesions between the duodenal bulb, the descending portion, and the hepatic flexure of the colon should be divided sufficiently

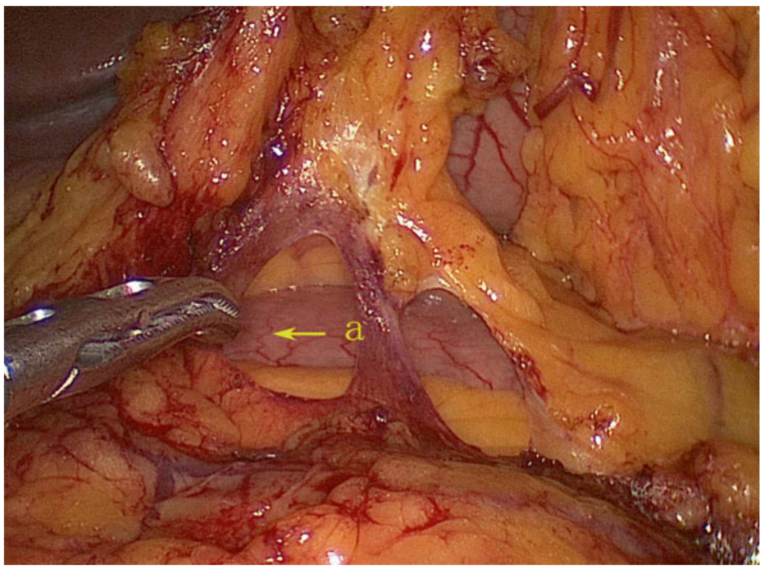


Fig. 4.104 The small intestine (*a*) behind can be seen through the broken TM

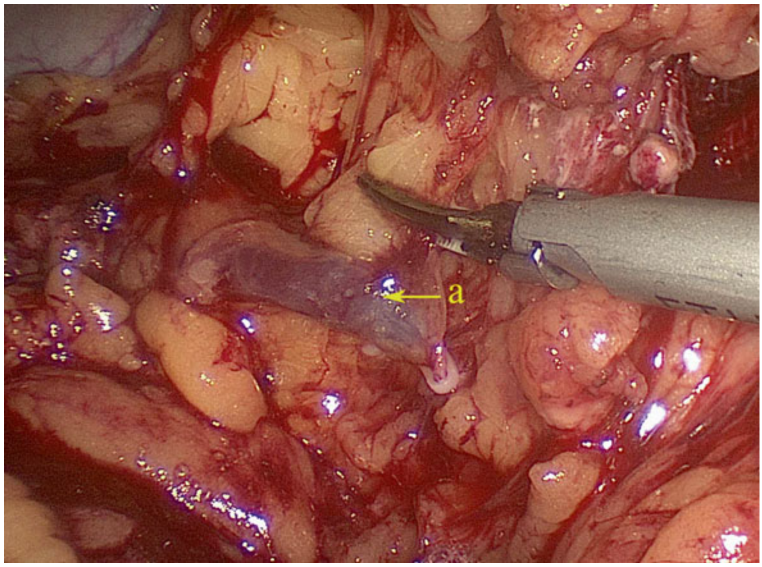


Fig. 4.105 The RCV (*a*) is incorrectly identified as the right gastroepiploic vessel and severed

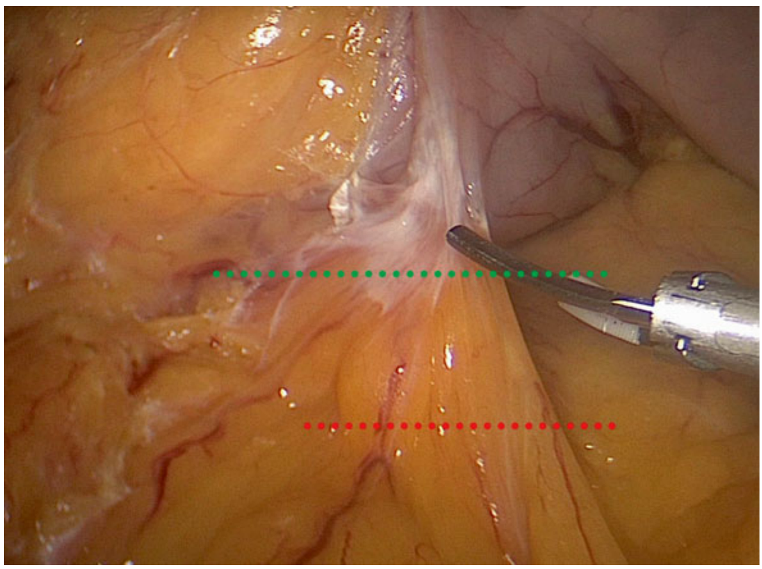


Fig. 4.106 The TM is lifted; thus, division should be operated on the side closest to the stomach (The *green dotted line* represents the correct operative plane. The *red dotted line* represents the wrong one)

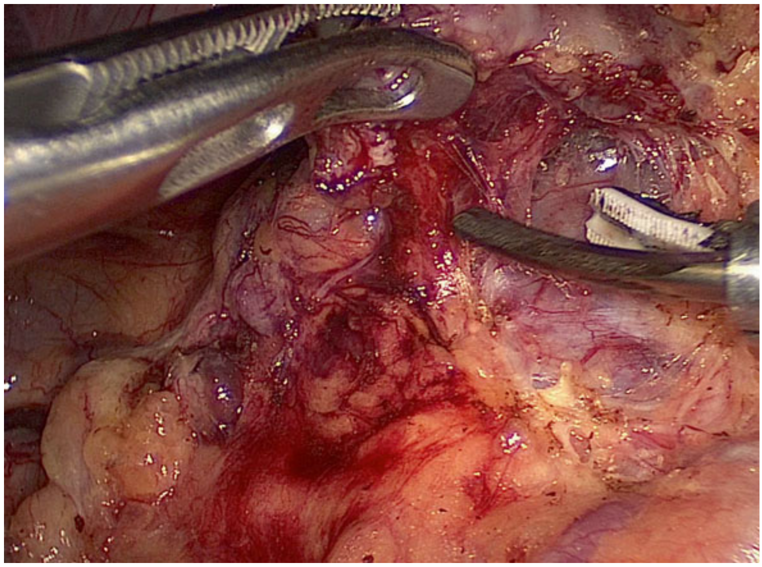


Fig. 4.107 Proficient cooperation of the assistant facilitates exposure of the anatomical space and the use of ultrasonic scalpel

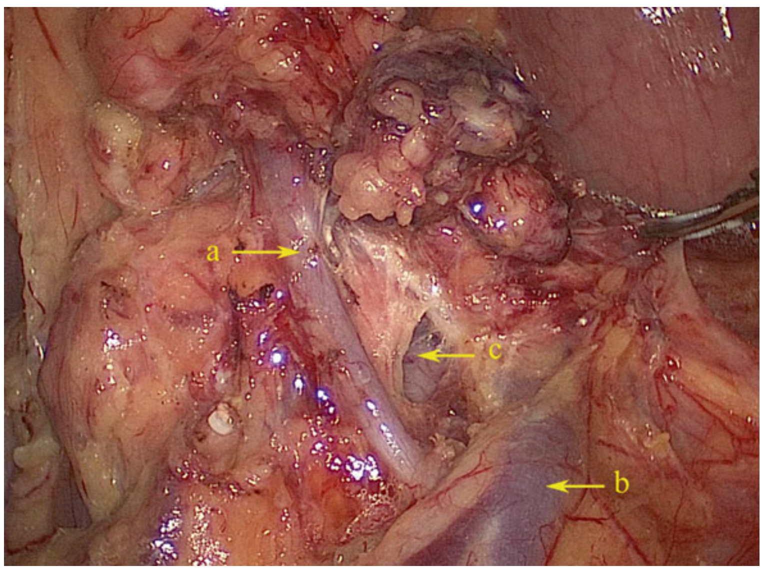


Fig. 4.108 The SMV (*c*) can be exposed if dissecting along the course of the RGEV (*a*) and the MCV (*b*)

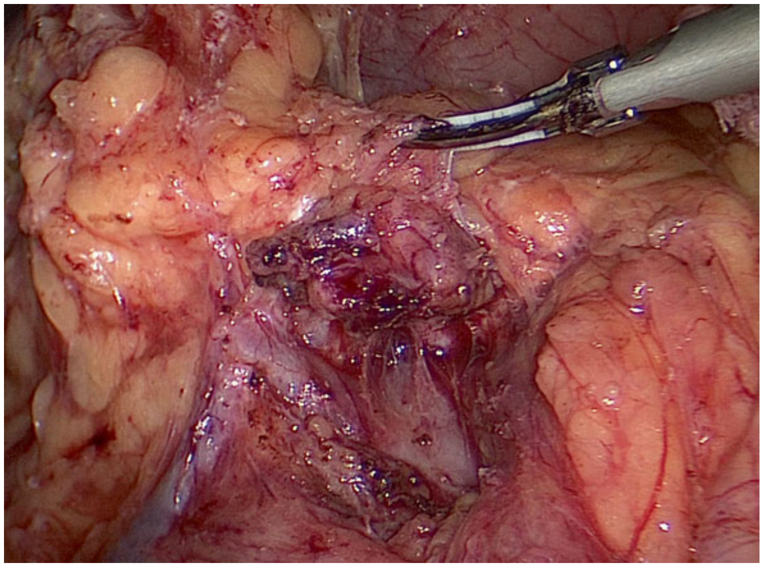


Fig. 4.109 When the No. 14v LNs are obviously swollen, it is important to expose the basilar aspect of LNs to avoid injury to them

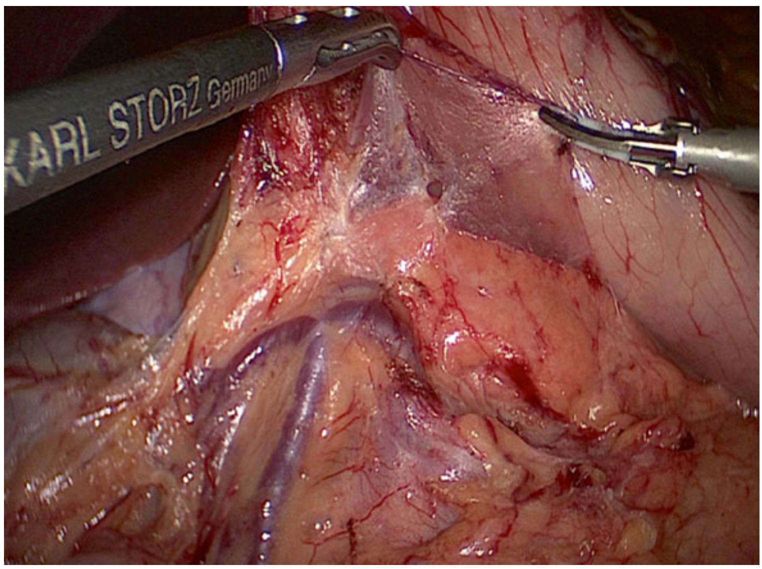


Fig. 4.110 The SMV will be exposed naturally during the process of separating the ATM

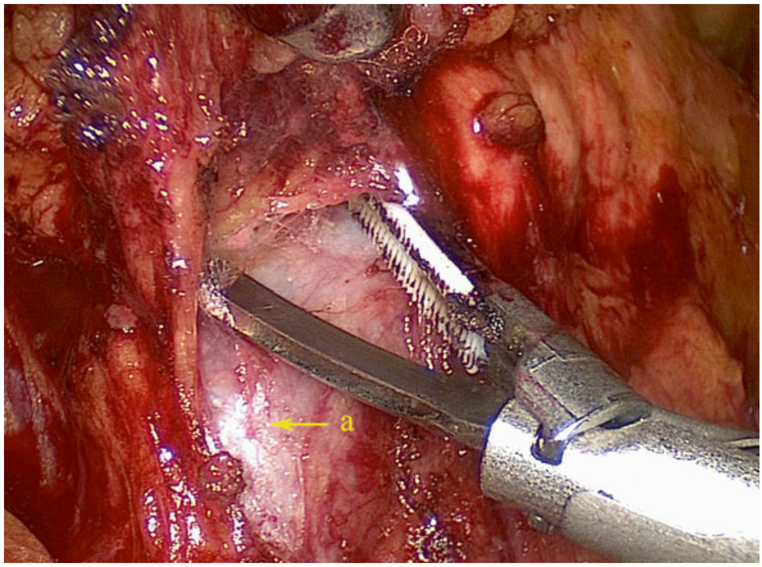


Fig. 4.111 The fascia in front of the SMV (*a*) is opened with ultrasonic scalpel

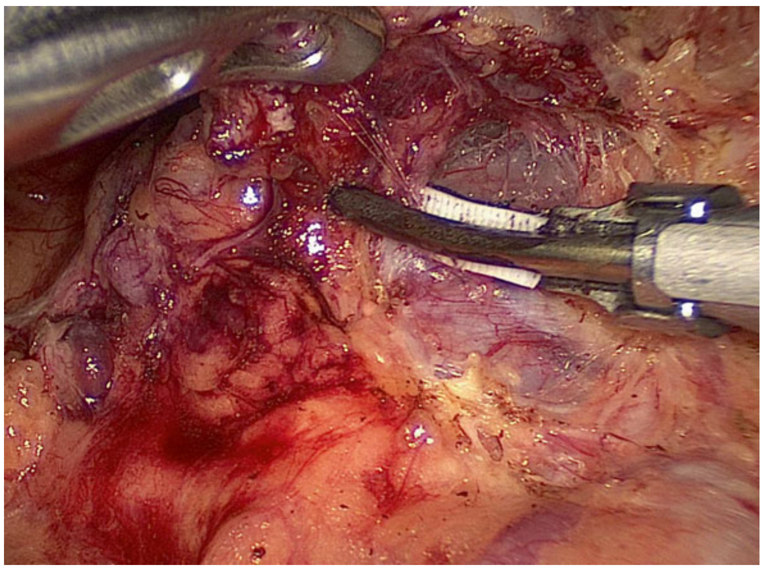


Fig. 4.112 The nonfunctional face of ultrasonic scalpels should be positioned close to the venous wall

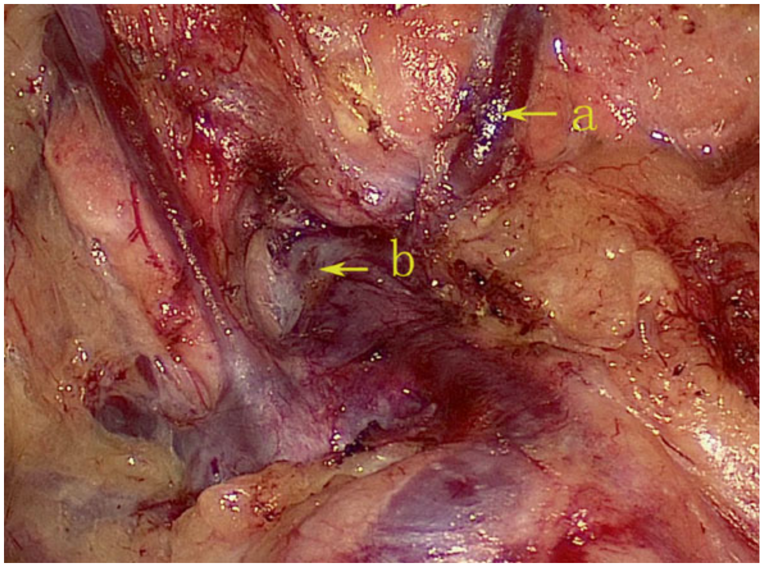


Fig. 4.113 Some venules (*a*) draining directly into the SMV (*b*) at the inferior margin of the pancreas

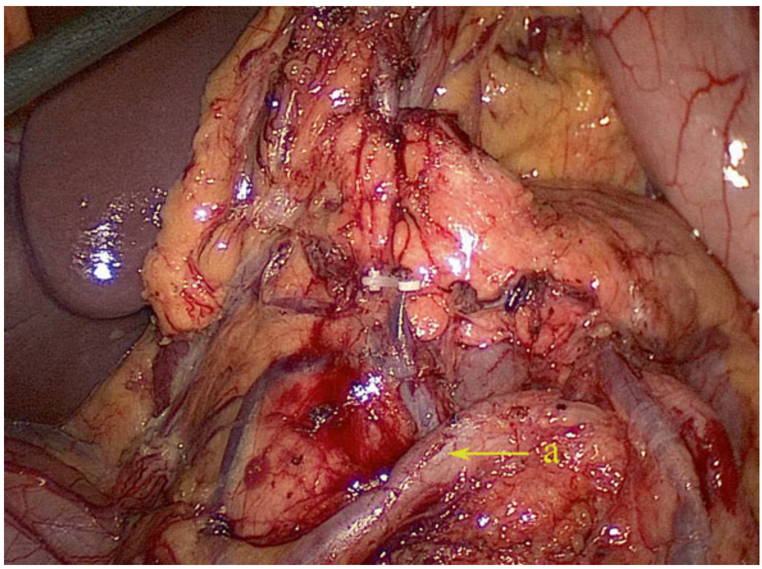


Fig. 4.114 The RCA (*a*) runs across the ventral side of the SMV

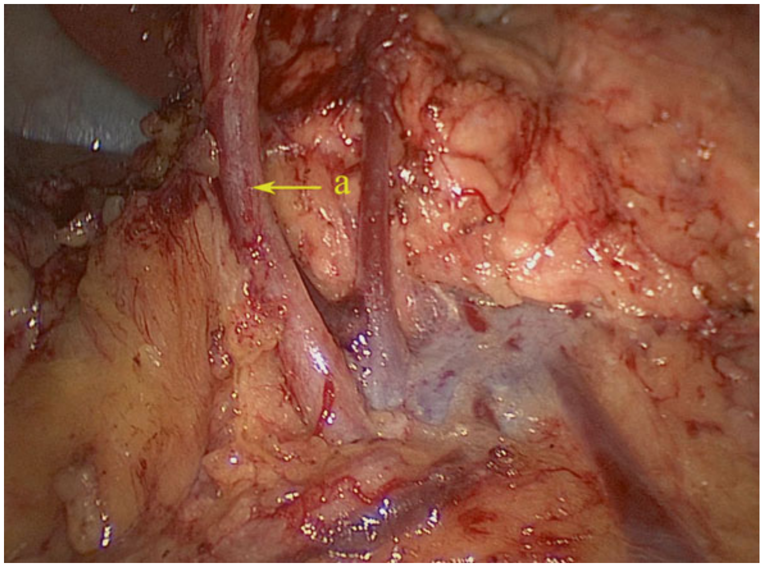


Fig. 4.115 The variant RCA (*a*) which arises from the SMA is lifted and presented as a vertical running course

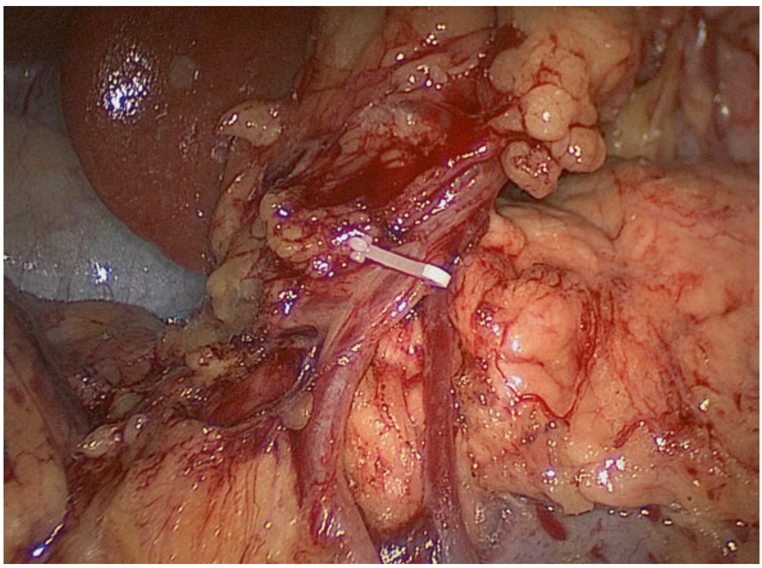


Fig. 4.116 The RCA is recognized as the gastroepiploic vessel and severed mistakenly

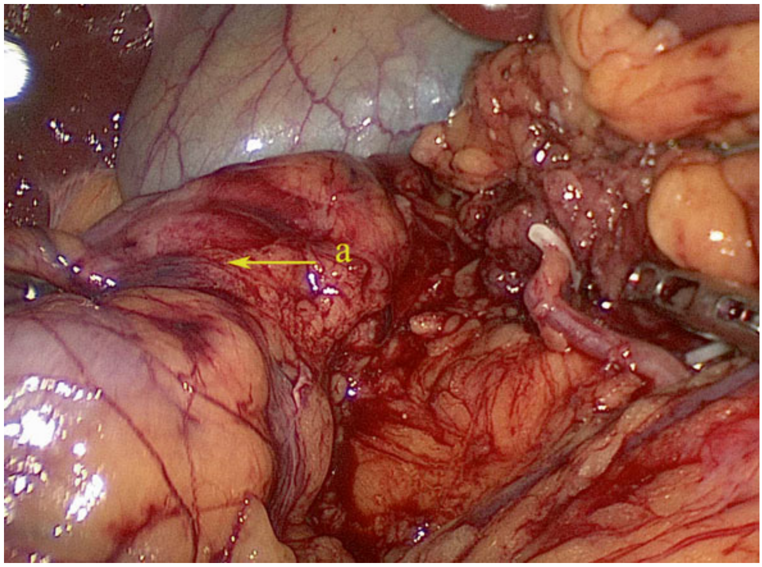


Fig. 4.117 Ischemia of the colon (*a*) occurs when severing the artery wrong

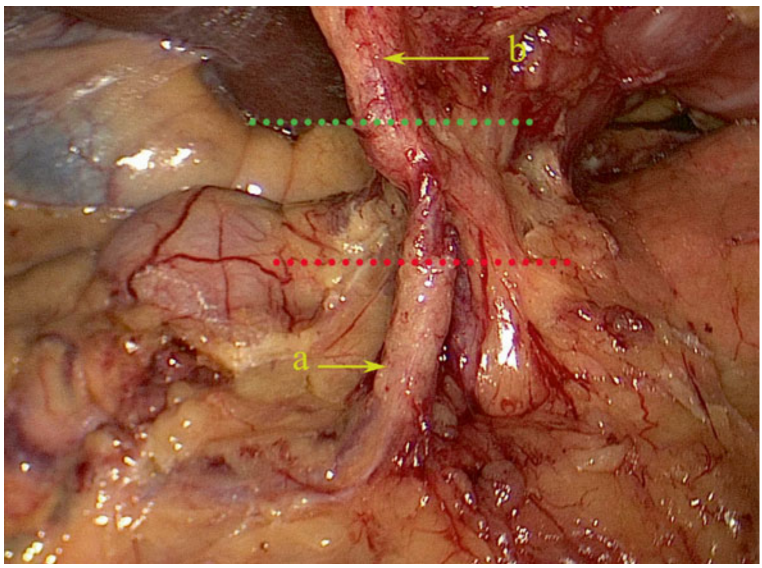


Fig. 4.118 The variant RCA (*a*) originates from the RGEA (*b*). The *green dotted line* shows the cutting position of the artery

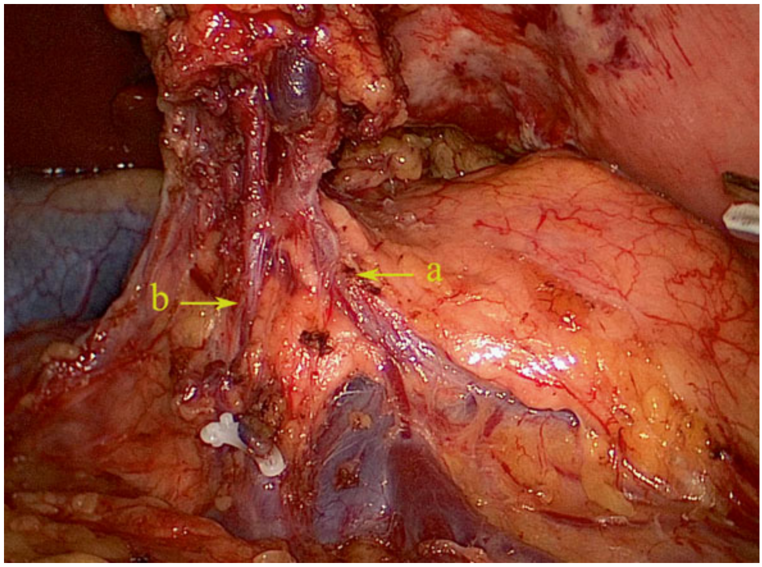


Fig. 4.119 The SPDA gives off two branches, the upper anterior branch (*a*) and upper posterior branch (*b*)

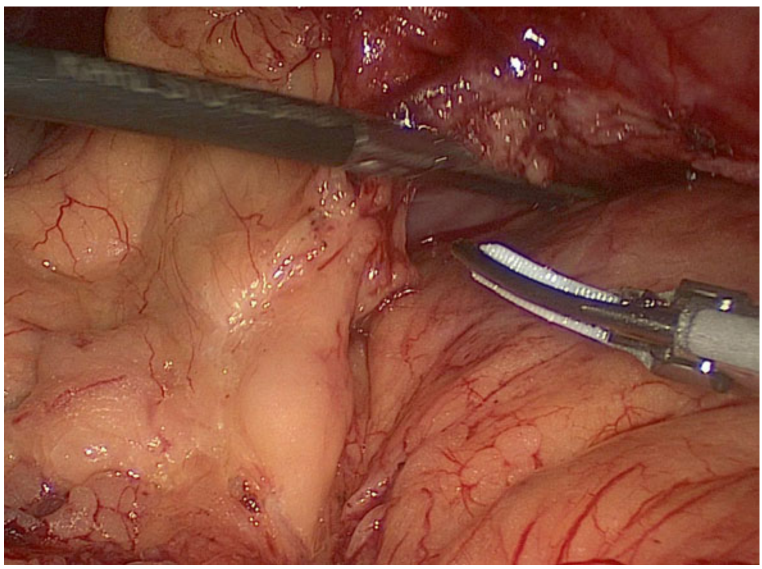


Fig. 4.120 The assistant uses the atraumatic grasping forceps to hold the stomach in patients with tumor on the posterior wall of the gastric antrum

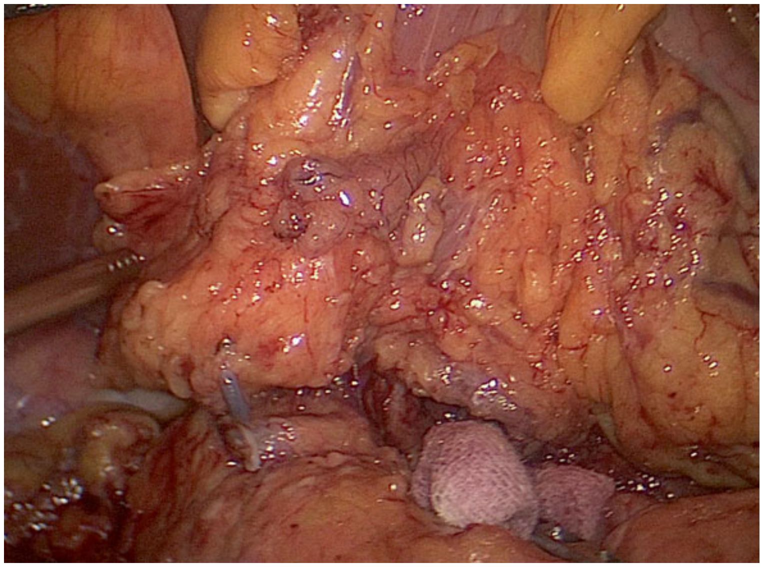


Fig. 4.121 The figure shows the situation of the infrapyloric region before rotating the body of the stomach. It is difficult to expose the operating field because of the adipose accumulation

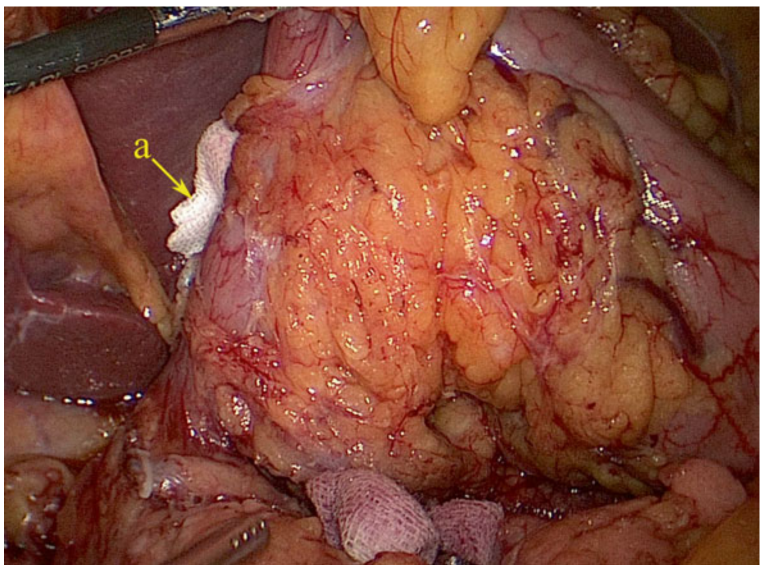


Fig. 4.122 A piece of gauze (*a*) can be used to fix the dropping adipose tissues between the liver and duodenum

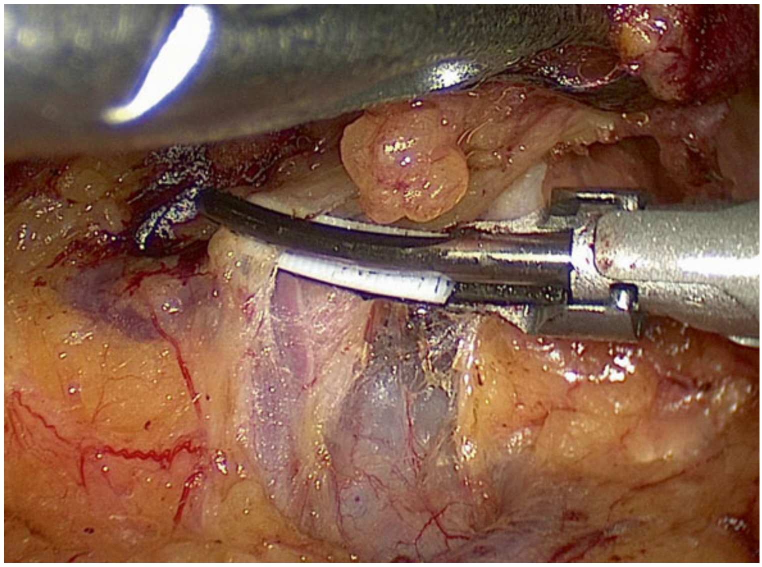


Fig. 4.123 The SMV is exposed first and the RGEV later

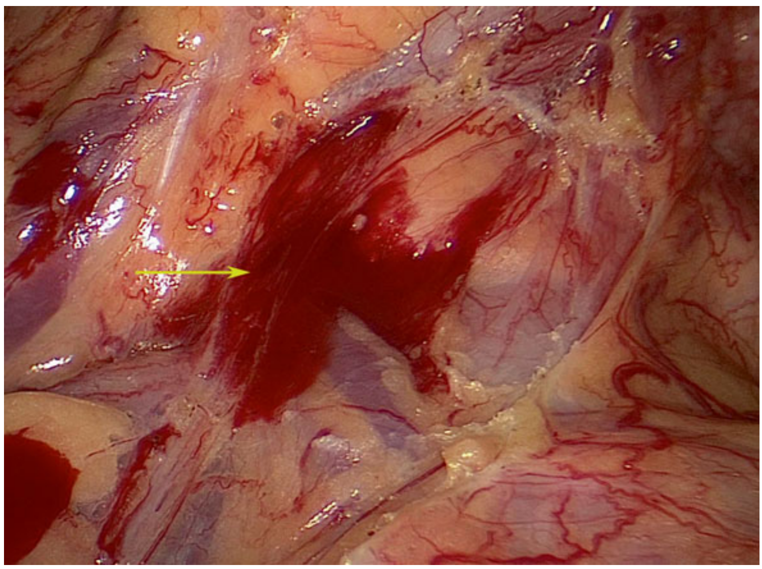


Fig. 4.124 Hemorrhage of the omental tissues resulting from retracting without proper tension

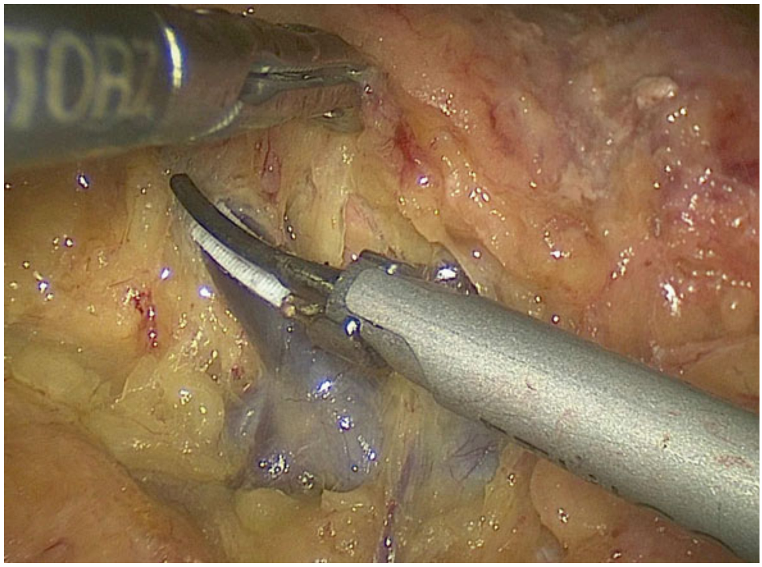


Fig. 4.125 Dissection should be along the horizontal axis of the vessel

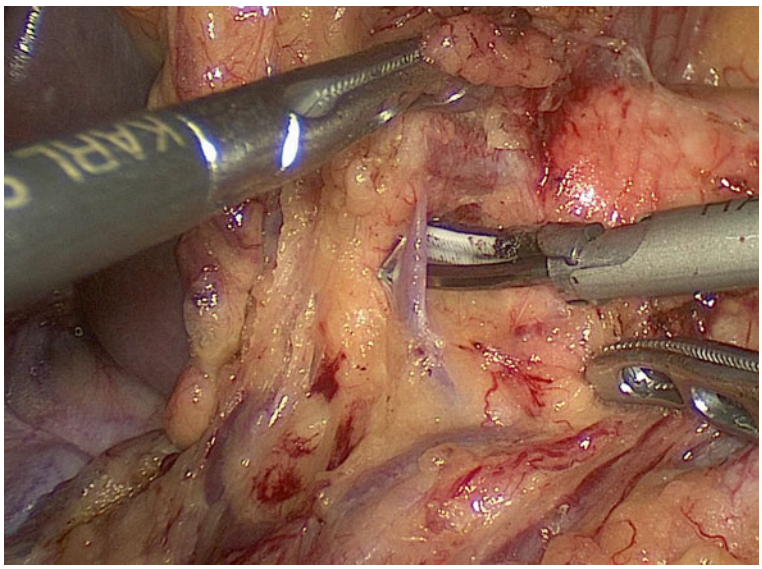


Fig. 4.126 It is proper to denude the vessel completely with ultrasonic scalpel

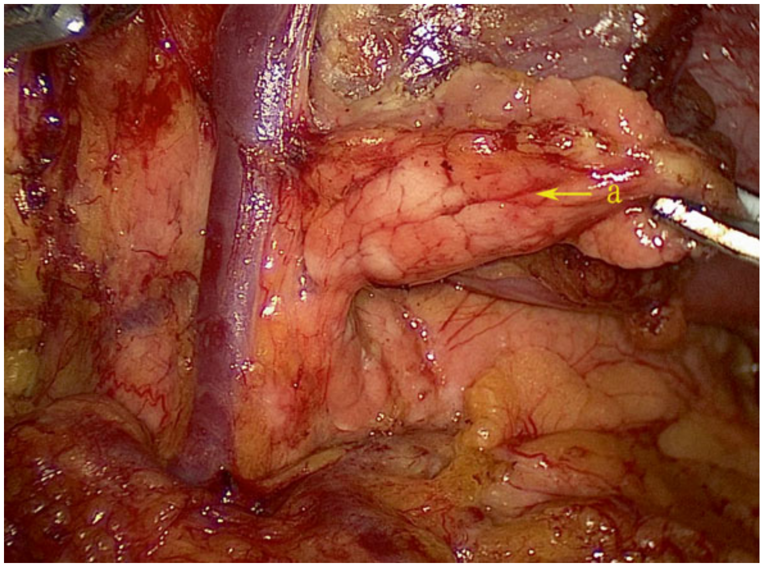


Fig. 4.127 The heterogenic lobe of the pancreas (*a*)

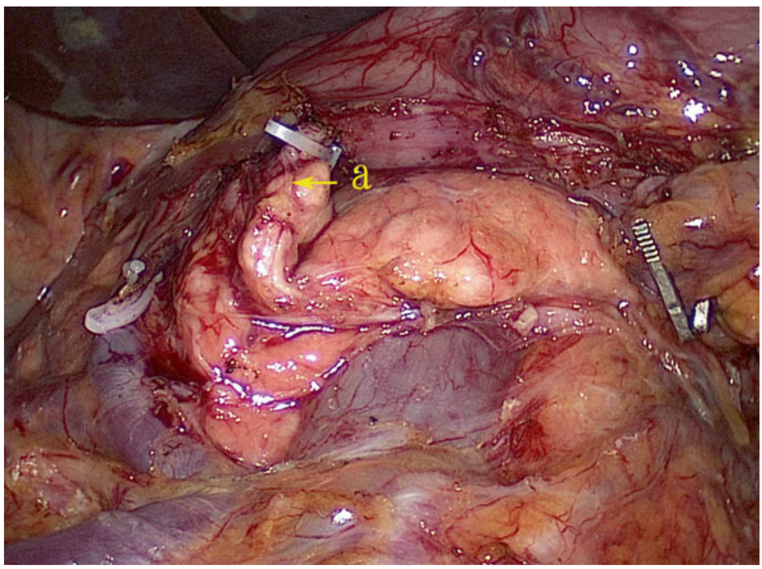


Fig. 4.128 The heterogenic lobe of the pancreas (*a*) preserved intraoperatively

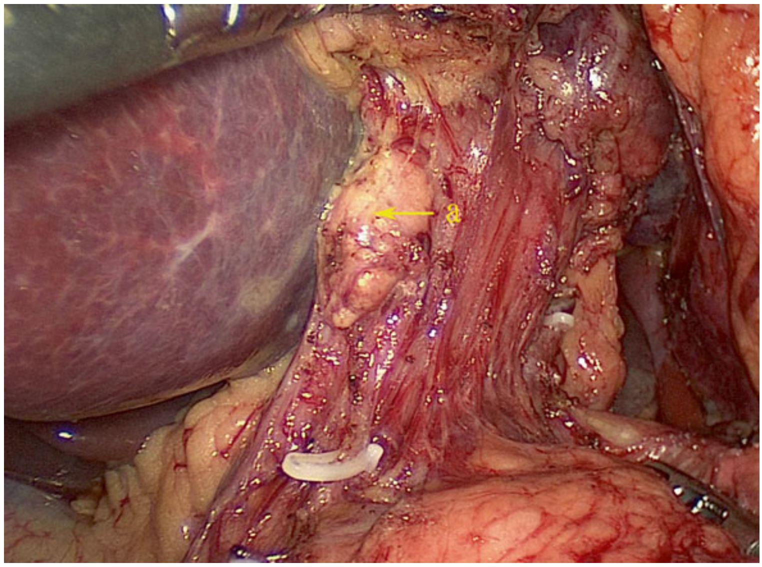


Fig. 4.129 The aberrant pancreas (*a*) on the wall of the gastric antrum

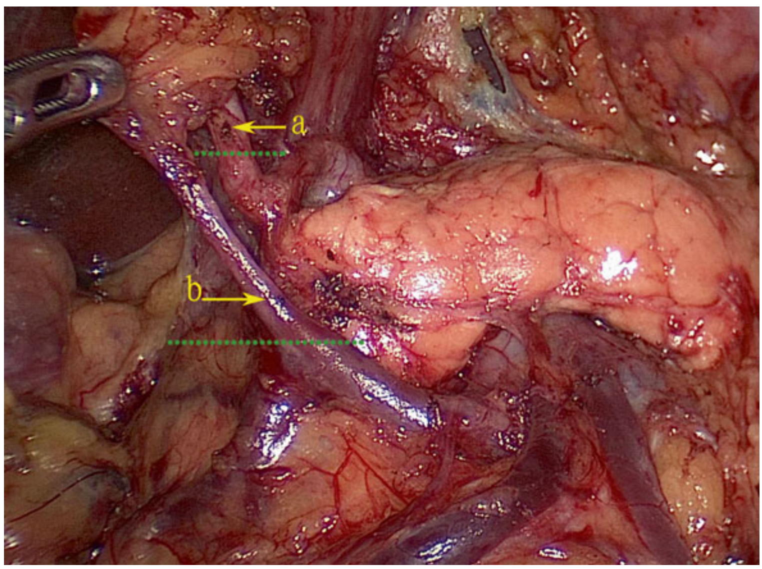


Fig. 4.130 The RGEA (*a*) and RGEV (*b*) are severed at different positions (The *green dotted lines* represent the two different operative planes of two vessels)

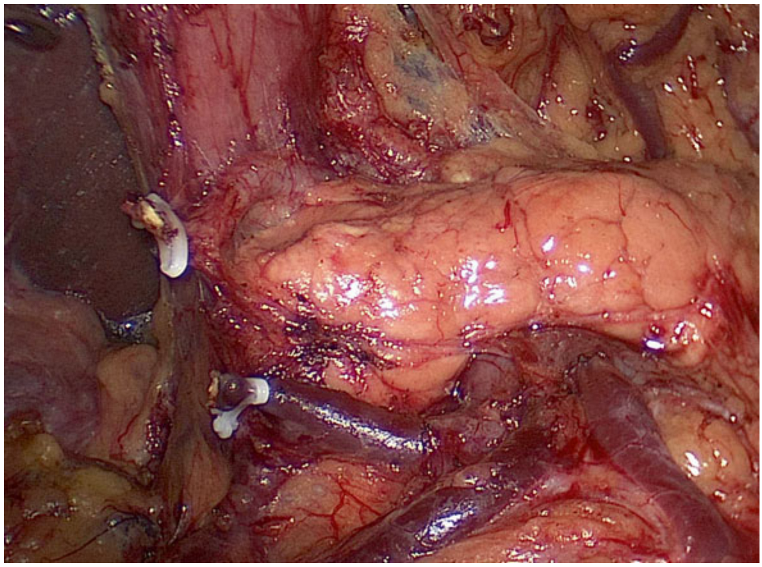


Fig. 4.131 The RGEA and RGEV after severing

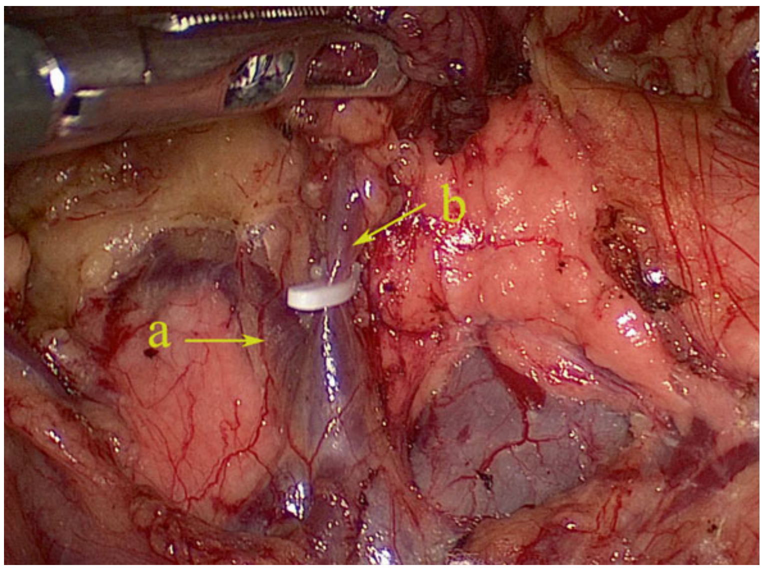


Fig. 4.132 The dissecting plane of the RGEV (*b*) should be above the confluence with the ASPDV (*a*)

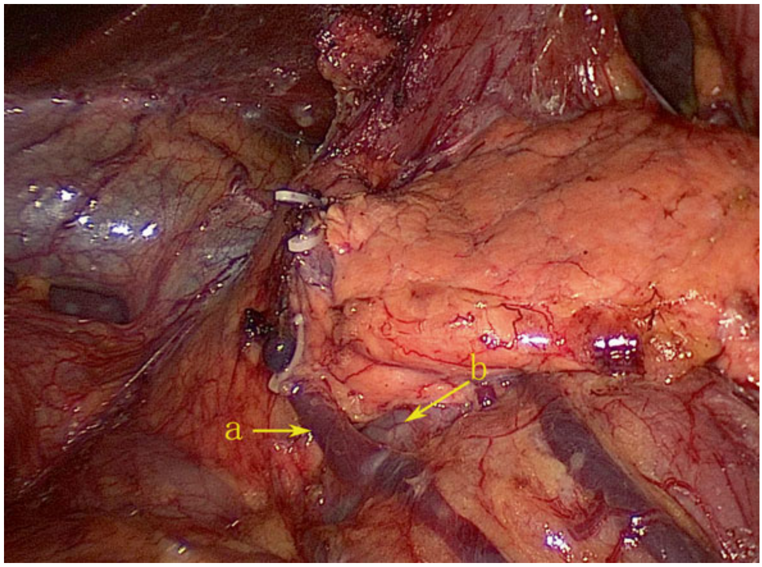


Fig. 4.133 The RGEV (*a*) converges directly into the SMV (*b*)

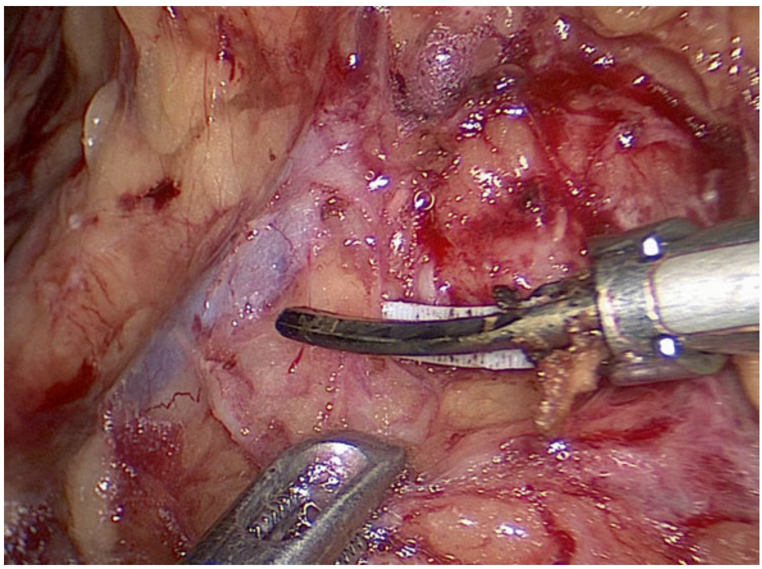


Fig. 4.134 Insufficient exposure of the RGEV

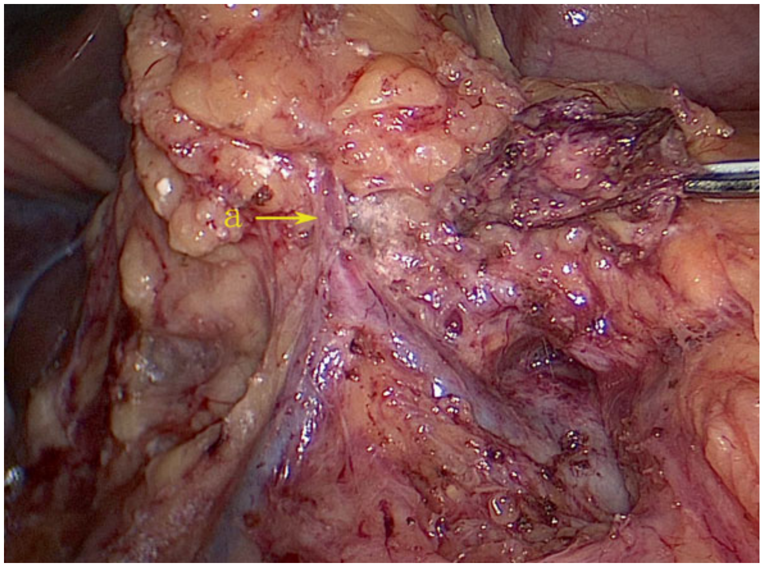


Fig. 4.135 The RGEV (*a*) is exposed

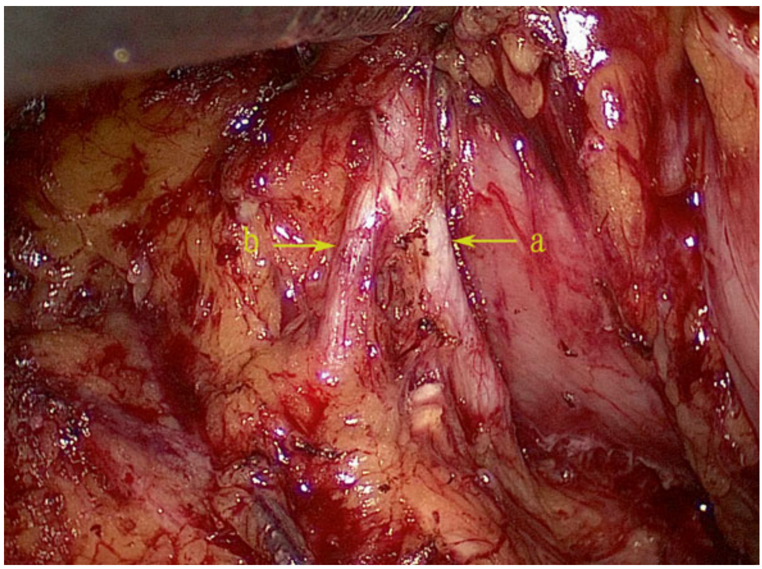


Fig. 4.136 The GDA (*a*) and the SPDA (*b*) are lifted together and form an angle

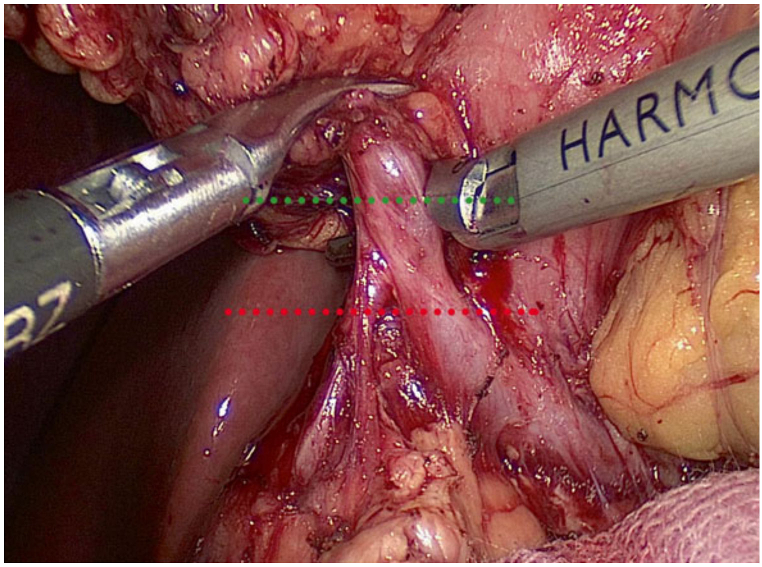


Fig. 4.137 The dissecting plane of the RGEA should be at the *green dotted line* (The *red dotted line* represents the wrong plane)

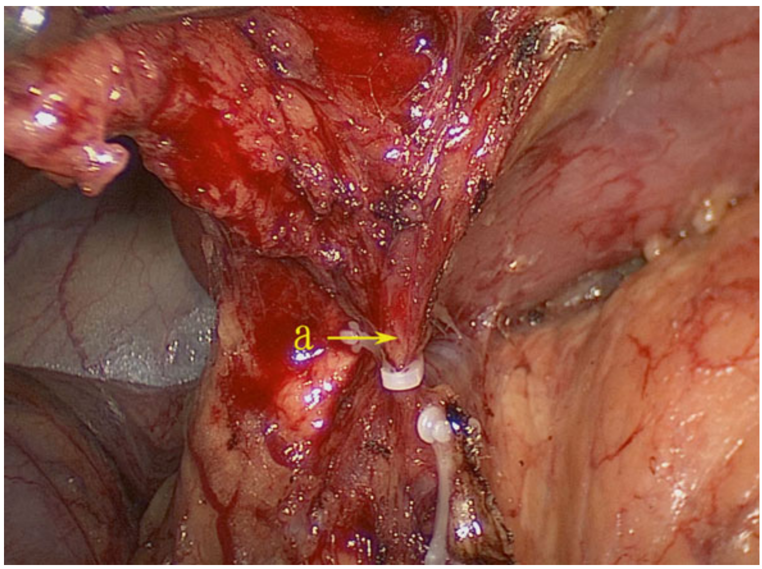


Fig. 4.138 The IPA (*a*) is ligated

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5 Laparoscopic Suprapancreatic Area Lymph Node Dissection for Gastric Cancer

Abstract

The lymph nodes (LNs) that lie along the celiac artery (CA) system in the suprapancreatic area include LNs around the root of the right gastric vessels (No. 5 and No. 12a) and those around the root of the left gastric vessels (No. 7, No. 8a, No. 9, and No. 11p). There is a high incidence of lymph node metastasis (LNM) in the suprapancreatic area for gastric cancer. Thus, complete clearance of LNs in this area is of great importance during radical gastrectomy for gastric cancer. It is also a critical procedure during laparoscopic D2 lymphadenectomy.

5.1 Review of Laparoscopic Suprapancreatic Area Lymph Node Dissection for Gastric Cancer

The lymph nodes (LNs) that lie along the celiac artery (CA) system in the suprapancreatic area include LNs around the root of the right gastric vessels (No. 5 and No. 12a) and those around the root of the left gastric vessels (No. 7, No. 8a, No. 9, and No. 11p) (Fig. 5.1). There is a high incidence of lymph node metastasis (LNM) in the suprapancreatic area for gastric cancer. Thus, complete clearance of LNs in this area is of great importance during radical gastrectomy for gastric cancer [1]. It is also a critical procedure during laparoscopic D2 lymphadenectomy [2].

The frequency of No. 7 LNM varied between 19.0 % and 35.0 % [1, 3–7], while the 5-year survival rate among patients with positive No. 7 LNs was only 19.0 % [3]. The rate of No. 7 LNM differed depending on the location of the primary tumor. The metastatic rates of No. 7 LNs in proximal gastric cancer were reported to be between 19.0 % and 33.0 % [3–5], while the frequency in middle gastric cancer varied between 7.4 % and 22.0 % and in lower gastric cancer between 3.1 % and 23.0 % [3, 8]. In addition, the incidences of No. 7 LNM in early middle and lower gastric cancer were determined at 2.5 % and 0.8 %, respectively [9]. Dissection of the No. 7 LNs is part of D1 lymphadenectomy, as defined by the 3rd edition of Japanese Gastric Cancer Treatment Guidelines [10]. Therefore, No. 7 LNs should be routinely removed.

There are no strict boundaries among the No. 8, No. 9, and No. 7 LNs. The incidence of No. 8a LNM was reported to be between 9.7 % and 36.0 % [5, 6, 11], while the metastatic rate varied between 4.9 % and 24.0 % in No. 9 LNs [4–7, 11]. The 5-year survival rate was shown to be

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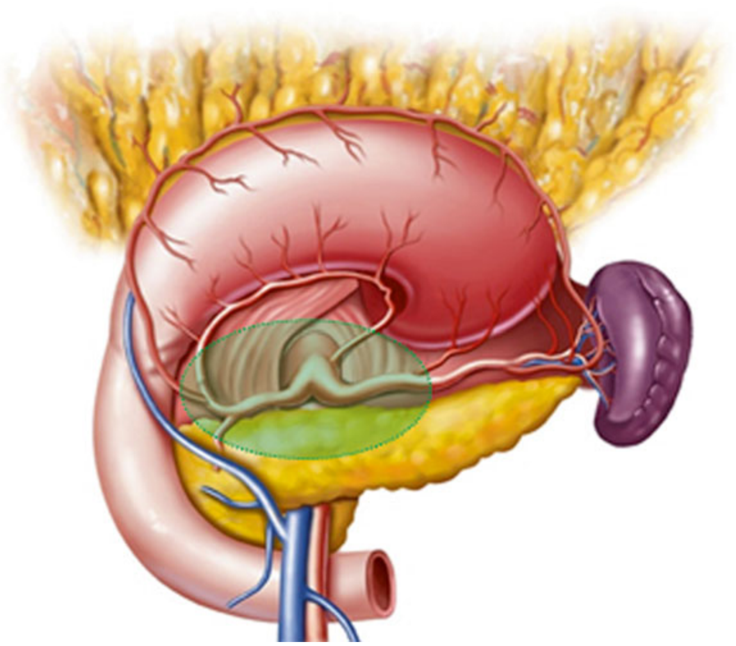


Fig. 5.1 Suprapancreatic area

16.0 % when No. 8a or No. 9 LNs are positive [3]. The incidences of No. 8a and No. 9 LNM were also associated with tumor location, T staging, and other factors. In proximal gastric cancer, the metastatic rates of No. 8 and No. 9 LNs were 7.0–16.7 % and 4.2–13.0 %, respectively [3, 8]. The incidence of No. 8 LNM was the highest in advanced proximal gastric cancer, at 68.0 % [12]. In middle gastric cancer, the metastatic rates of No. 8 and No. 9 LNs were 2.4–11.0 % and 2.2–8.0 %, respectively [3, 8]. Even in early middle gastric cancer, the incidences of No. 8 and No. 9 LNM were as high as 1.3 % [9]. Furthermore, in distal gastric cancer, the frequency of No. 8 LNM varied between 4.1 % and 13.4 % [8, 13], while the incidence of No. 9 LNM was 13.0 % [3]. And 1.6 % of patients with early distal gastric cancer exhibited metastasis to No. 8 LNs [9]. Dissection of the No. 8 LNs and No. 9 LNs is included in D1+ or D2 lymphadenectomy despite gastric resection according to the 3rd edition of Japanese Gastric Cancer Treatment Guidelines [10]. Therefore, excision of No. 8 LNs and No. 9 LNs should be given sufficient attention.

The incidence of No. 11 LNM was also high, varying between 12.0 % and 13.7 % [3, 4], and the 5-year survival rate among patients with positive No. 11 LNs was 6.0 % [3]. The incidence of No. 11 LNM can reach up to 15.5 % in advanced proximal gastric cancer [5]. No. 11 LNs are divided into No. 11p LNs (along the proximal splenic artery (SpA) near the CA) and No. 11d LNs (along the distal SpA near the splenic hilum). The former has a higher metastatic rate. In middle gastric cancer, the metastatic rate of No. 11p LNs was 20.0 % [1], and the frequencies of No. 11p LNM in early middle and lower gastric cancer were 2.0 % and 0.8 %, respectively [9]. Hence, No. 11p LNs should be also excised during D2 dissection based on the treatment guidelines.

The 5-year survival rate among patients with positive No. 5 LNs was 17.0 % [3], and the incidence of No. 5 LNM varied, 16.6–36.0 %, in patients with tumors located in middle and upper gastric cancer [4, 6, 11, 14]. Hence, there was no objection against complete clinical clearance of No. 5 LNs for middle and upper gastric cancer. There were rare reports of No. 5 LNM in early proximal gastric cancer [15, 16], while the incidence of No. 5 LNM varied between 6.8 % and 9.0 % in advanced proximal gastric cancer [5, 17]. Thus, No. 5 LNs should be routinely removed in all patients except those with early proximal gastric cancer. Dissection of No. 12a LNs is still considered part of D2 lymphadenectomy during distal or total gastrectomy based on the 3rd edition of Japanese Gastric Cancer Treatment Guidelines [10]. It has been reported that the incidence of No. 12a LNM is between 2.9 % and 22.0 % in patients with gastric cancer [3, 5–7, 11]. The 5-year survival rate among patients with positive No. 12a LNs was 9.0 % [3]. Therefore, No. 12a LNs should be resected attentively during distal or total gastrectomy.

In conclusion, LNs along the CA system in the suprapancreatic area should be critically excised during either D1+ or D2 lymph node dissection based on the 3rd edition of Japanese Gastric Cancer Treatment Guidelines [10]. These LNs have a strong relationship with gastric cancer metastasis and are the critical components during lymphadenectomy. Lymph node dissection in the suprapancreatic area is an important and technically demanding procedure during radical lymphadenectomy for gastric cancer.

5.2 Anatomy Associated with Lymph Node Dissection in the Suprapancreatic Area

Most of the gastric arteries originate from the celiac trunk, which generally has three branches: the splenic, common hepatic, and left gastric arteries. Each in turn has its own branches that supply the greater and lesser curvatures of the stomach. The efferent lymphatic vessels of the stomach follow the adjacent arteries and their branches in reverse to gather at their roots. There are many LNs that drain these efferent vessels lying along the arteries. Thus, the LNs along the celiac artery system in the suprapancreatic area are intimately associated with metastasis in gastric cancer.

5.2.1 Fascia and Intrafascial Space in the Suprapancreatic Area

5.2.1.1 Pancreatic Fascia and the Intrafascial Space

The pancreatic fascia encompasses the pancreas, forming the anterior and posterior pancreatic fascia (APF and PPF). The space between the APF and the PPF is called the pancreatic intrafascial space (PIS) (Figs. 5.2 and 5.3). The pancreatic parenchyma and related vessels along with their branches are situated in the PIS. The APF passes to the right of the pancreatic head and becomes continuous with the transverse and ascending mesocolon at the right colic flexure. It extends below the pancreas to come into contact with the PPF and joins the anterior lobe of the transverse mesocolon (ATM) to form the lower part of the

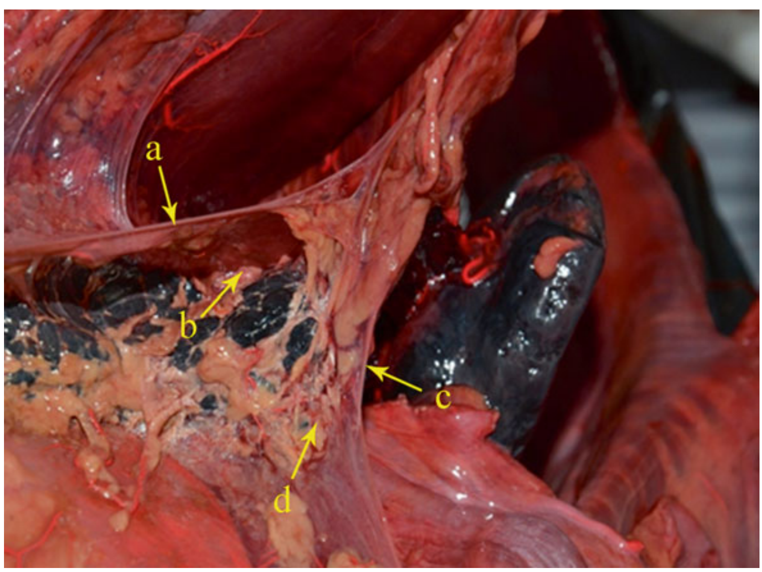


Fig. 5.2 APS (*a*), APF (*b*), PPF (*c*), and RPS (*d*) (in autopsy)

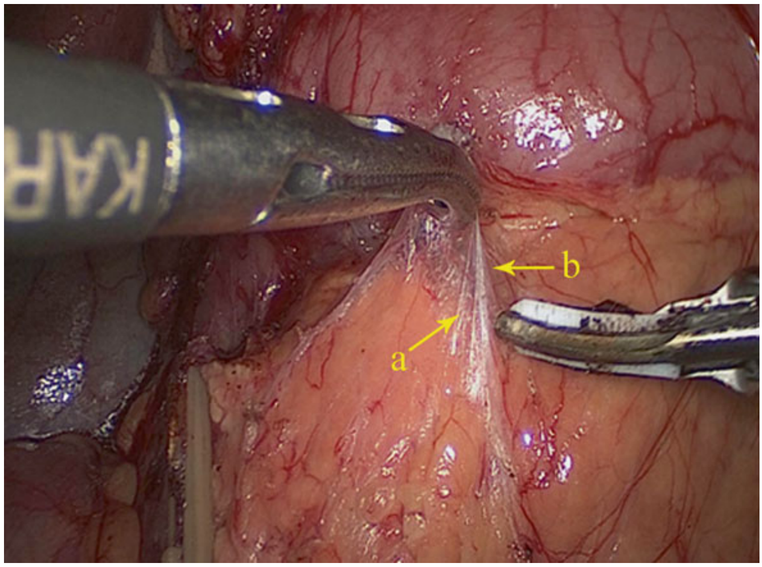


Fig. 5.3 APF (*a*) and APS (*b*)

posterior wall of the omental bursa. It passes left along the anterior pancreatic tail to become continuous with the gastrosplenic ligament (GSL) at the top as well as the lateral splenorenal ligament (SRL). The anterior pancreatic space (APS) is the space between the APF and the inherent pancreatic fascia. The pancreatic capsule can be completely peeled along the APS.

The PPF is formed by the posterior layer of the posterior leaf of the dorsal mesogastrium (DM), which attaches to the posterior abdominal wall. The PPF covers the posterior aspect of the pancreas and extends below it to fuse with the APF. The space between the PPF and the inherent pancreatic fascia is the retropancreatic space (RPS), which is in the suprapancreatic area and contains the three branches of the celiac trunk and their concomitant lymphatic vessels and LNs.

5.2.1.2 Gastropancreatic and Hepatopancreatic Folds

At the anterior upper side of the pancreas, the peritoneum behind the omental bursa covers the posterior abdominal wall, part of the pancreatic head, the pancreatic body and neck, the anterior part of the left kidney, most of the adrenal gland, the initial part of the abdominal aorta, the celiac trunk, and part of the diaphragm. The section extending from the middle upper border of the pancreatic body to the posterior wall of the gastric lesser curvature is called the gastropancreatic fold (GPF). It passes along the upper border of the pancreas and becomes continuous with the left edge of the posterior HDL to form the hepatopancreatic fold (HPF) (Figs. 5.4, 5.5, and 5.6). The GPF and HPF form the isthmus of the omental bursa, dividing it into two parts (the lesser sac on the right and the greater sac on the left). The GPF provides a pathway for the left gastric vessels, vagus nerve, and lymphatic vessels to penetrate the lesser sac (the posterior and front walls) and enter the mesogastrium attached at the lesser curvature of the stomach. The HPF provides a pathway for the common hepatic artery (CHA), gastric coronary vein, vagus nerve, and lymph vessels to penetrate the lesser sac. It extends to the furcation of the CHA and SpA from the celiac trunk.

5.2.1.3 HDL

The HDL consists of two layers of peritoneum, which cover the anterior and posterior walls of the lower part of the gastric lesser curvature, the porta hepatis and the upper edge of the duodenum. It is the portion of the lesser omentum that extends between the liver and the superior part of the duodenum. The right free border of the HDL

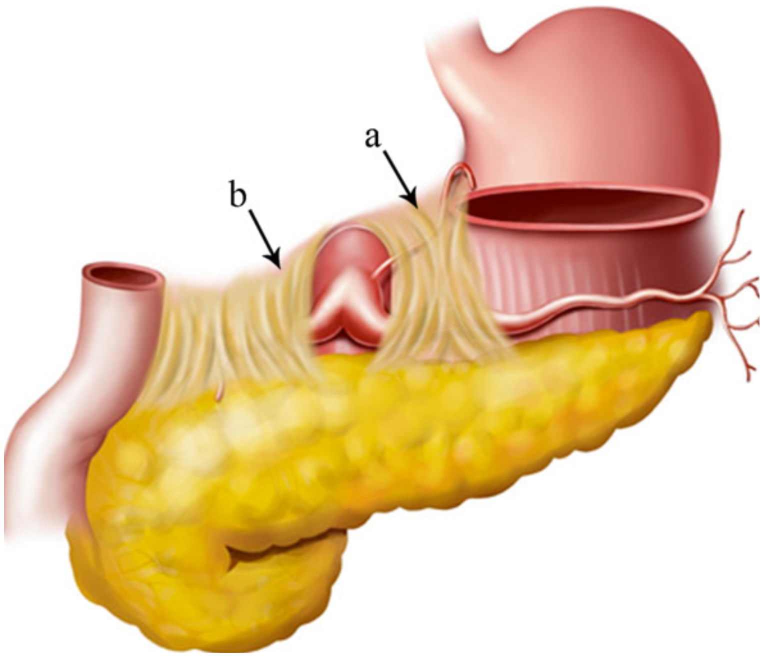


Fig. 5.4 GPF (*a*) and HPF (*b*)

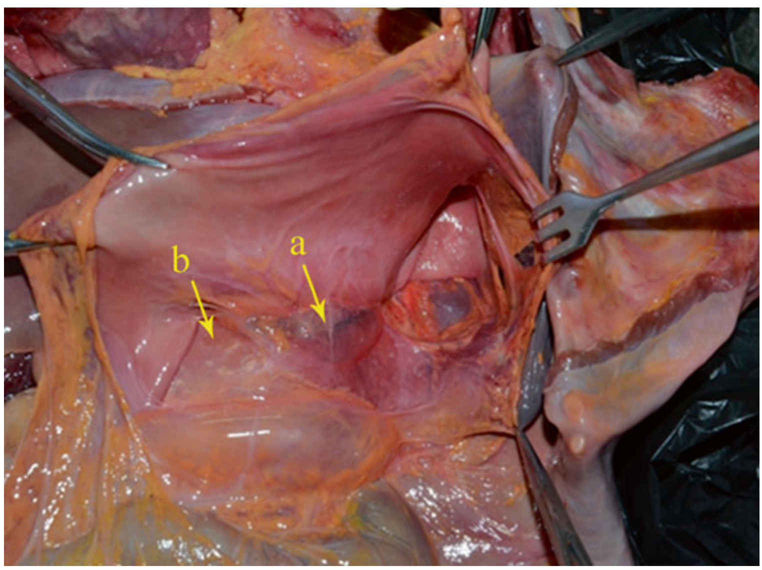


Fig. 5.5 GPF (*a*) and HPF (*b*) (in autopsy)

forms the anterior boundary of the epiploic foramen, and its left border is continuous with the hepatogastric ligament (HGL). The HDL contains the hepatic pedicle (the common bile duct, hepatic artery, and PV) and the No. 12 LNs. In addition, the HDL and the falciform ligament are mutually linked (Figs. 5.7 and 5.8).

5.2.1.4 Retrogastric Space (RGS)

The potential space at the superior border of the pancreas, between the parietal peritoneum and the posterior abdominal wall, is called the RGS. It is full of loose connective tissue and contains the No. 9 LNs and the celiac trunk (Fig. 5.9).

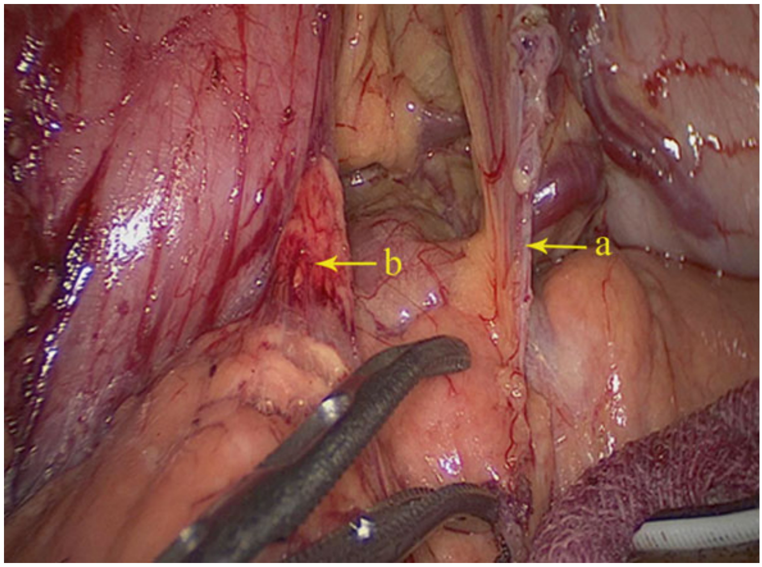


Fig. 5.6 GPF (*a*) and HPF (*b*)

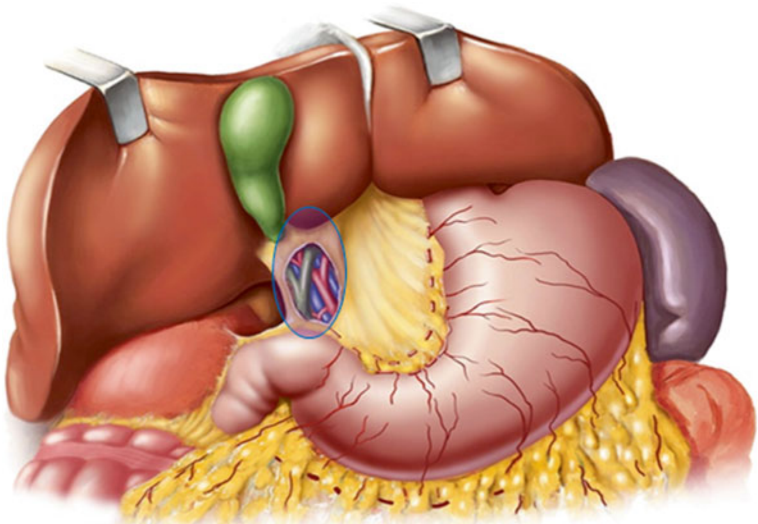


Fig. 5.7 HDL

5.2.2 Vascular Anatomy Associated with Lymph Node Dissection in the Suprapancreatic Area

5.2.2.1 Arteries Associated with Lymph Node Dissection in the Suprapancreatic Area

CA

The CA, also known as the celiac trunk, is the first unpaired branch of the abdominal aorta. It is only 1–2 cm in length and branches from the aorta anterior to the level of T12, slightly below the aortic hiatus of the diaphragm. The gastric arteries originate from the CA, which has three main divisions: the LGA, CHA, and SpA (Figs. 5.10, 5.11, and 5.12).

Adachi's classification of the CA describes six variant subtypes based on the analysis of 252 cases [18].

Type I: The celiac trunk is formed from the LGA, SpA, and CHA. This is known as the normal type and was present in 222 patients (88.1 %) (Figs. 5.13 and 5.14).

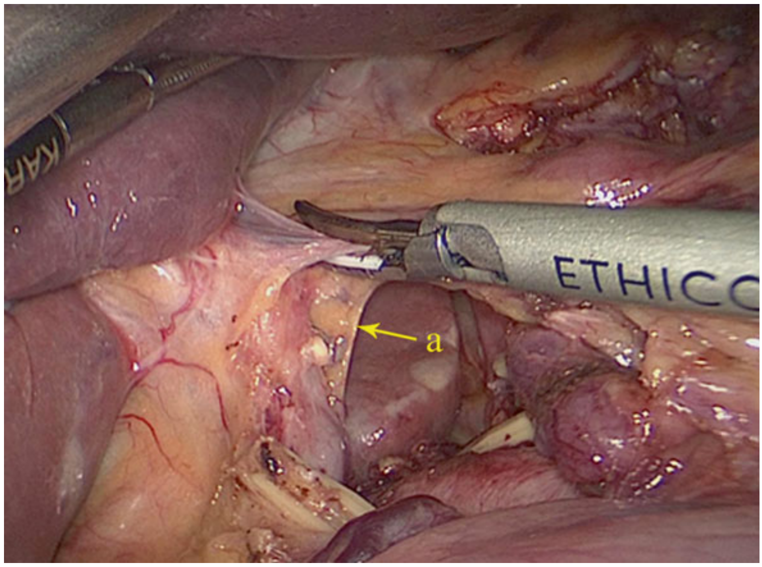


Fig. 5.8 HDL (*a*)

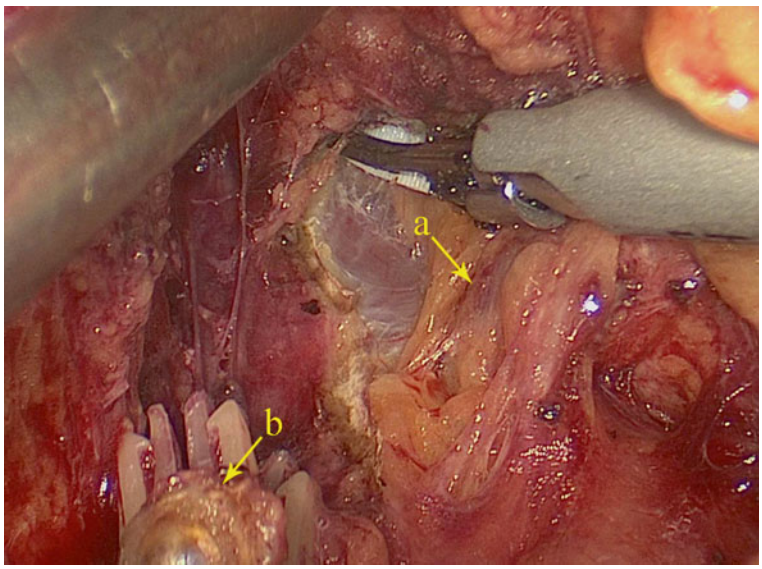


Fig. 5.9 RGS (*a*). The end of the left gastric artery (LGA) (*b*)

Type II: The LGA originates from the abdominal aorta, while the SpA and CHA issue from the celiac trunk. It is present in 16 patients (6.3 %) (Figs. 5.15, 5.16, and 5.17).

Type III: The LGA arises from the abdominal aorta, while the celiac trunk is formed from the CHA, SpA, and superior mesenteric artery (SMA). It is present in three patients (1.2 %) (Fig. 5.18).

Type IV: The celiac trunk is formed from the LGA, CHA, SpA, and SMA. It is present in six patients (2.4 %) (Fig. 5.19).

Type V: The LGA and SpA originate from a common trunk derived from the abdominal aorta, while the CHA and SMA originate from a separate common trunk derived from the CA. It is present in one patient (0.4 %) (Figs. 5.20 and 5.21).

Type VI: The LGA and the SpA originate from the CA, while the CHA is absent and is replaced by a branch of the SMA or abdominal aorta (AA) (for details, see the anatomy of CHA later in this chapter). It is present in five patients (2.0 %) (Figs. 5.22 and 5.23).

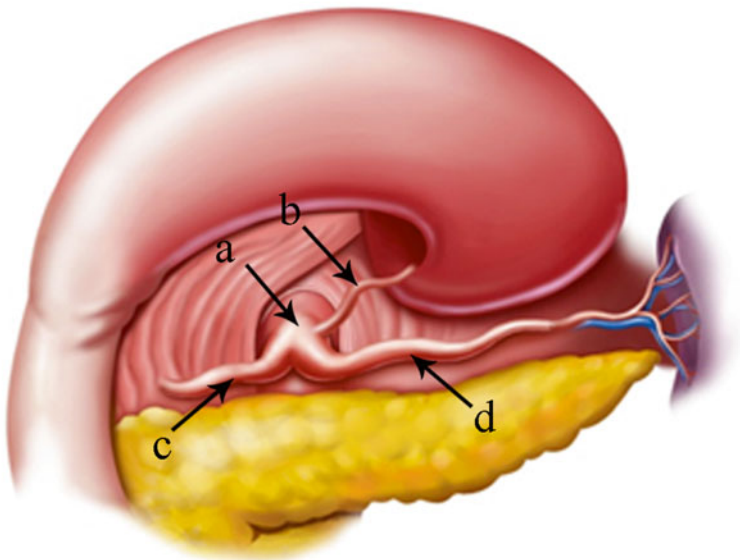


Fig. 5.10 The CA (*a*) divides into LGA (*b*), CHA (*c*), and SpA (*d*)

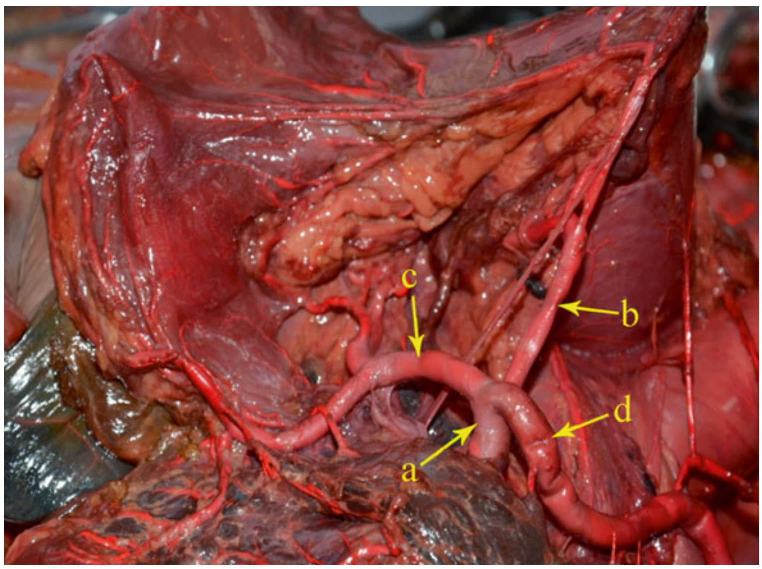


Fig. 5.11 The CA (*a*) divides into LGA (*b*), CHA (*c*), and SpA (*d*) (in autopsy)

LGA

In most cases, the LGA stems from the CA. In 2.5–7.5 % of cases, it instead arises directly from the right posterior aspect of the abdominal aorta above the origin of the CA. After issuing from the CA, the LGA clings to the posterior abdominal wall and runs toward the upper left side along the deep parietal peritoneum of the omental bursa to the dorsal side of the cardia. Then, it turns right and passes along the lesser curvature of the stomach between the layers of the lesser omentum to join with the right gastric artery (RGA) (Fig. 5.24). In approximately 1.0–23.0 % of cases, an accessory left gastric artery (ALGA) issues from the left or proper hepatic artery (LHA or PHA) (Figs. 5.25, 5.26, and 5.27) and runs along the same course to supply the lesser curvature of the stomach. In addition, in some patients, an accessory LHA (ALHA) originates from the LGA, branching off from this artery at its highest point or at the turning point before it runs down toward the lesser curvature of the stomach. The

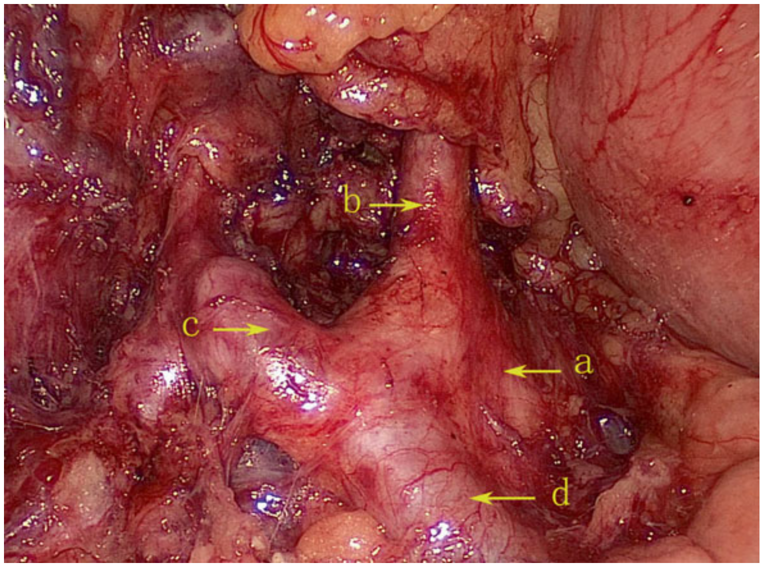


Fig. 5.12 The CA (*a*) divides into LGA (*b*), CHA (*c*), and SpA (*d*)

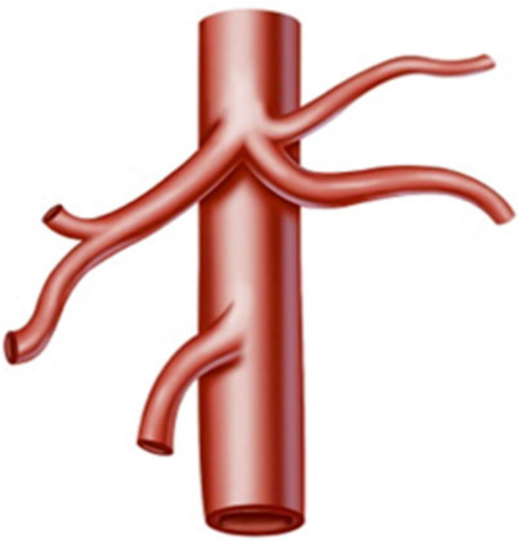


Fig. 5.13 Type I

extrahepatic part of the ALHA is short. Within the HGL, the ALHA extends toward the right or upper right in a straight or slightly tortuous course to enter the hepatic parenchyma through the left sagittal groove, anterior to the caudate lobe. It extends to the left, dividing into several segmental or subsegmental branches to supply the left lateral lobe of the liver. Its diameter is equivalent to the level 2 and 3 hepatic artery.

The incidence of an ALHA has been reported to be 5.0–11.5 %. Of our 1,173 patients who underwent radical gastrectomy for gastric cancer, 135 (11.5 %) had an ALHA [19] (Figs. 5.28 and 5.29).

CHA

The CHA, which arises from the celiac trunk, passes to the right side and runs forward along the upper border of the pancreatic head. It then enters the HDL and gives off the gastroduodenal artery (GDA) and PHA above the duodenum (Figs. 5.30 and 5.31).

Less variation is associated with the CHA, but occasionally it may be absent (range, 1.4–6.2 % of cases). When the CHA doesn't arise from the CA as usual, it can be regard as absence according to Gray's Anatomy [20]. The CHA was found to be absent in 38 cases (1.8 %) based on the analysis of 2,170 patients with gastric cancer by our center. The anatomy of absence of CHA was classified into six types according to the anatomy of the replaced CHA (RCHA) as follows:

Type I: The RCHA arose from SMA and ran across the posterior side of pancreas and was present in 28 cases (1.3 %, 28/2,170). The RCHA branched off GDA when it lay adjacent to posterior wall of duodenal and its distal end is continued with the replaced PHA (RPHA) (Figs. 5.32, 5.33, 5.34, and 5.35).

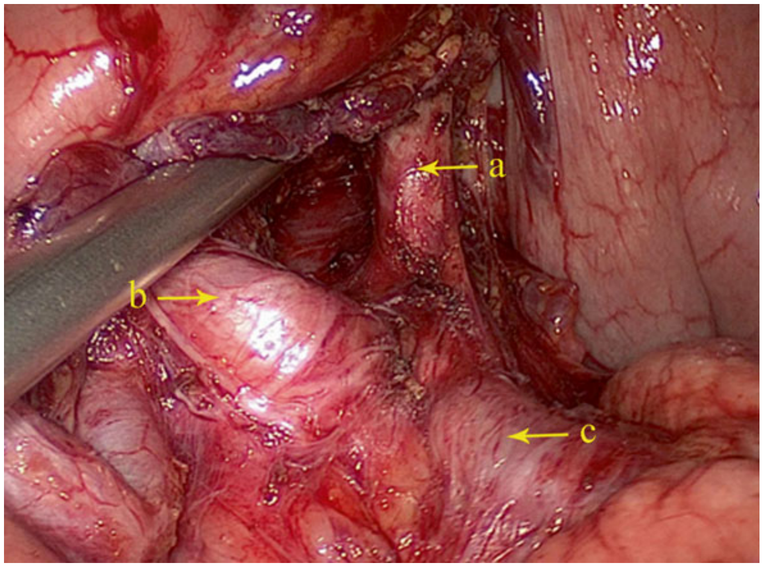


Fig. 5.14 Type I. LGA (*a*), CHA (*b*), and SpA (*c*)

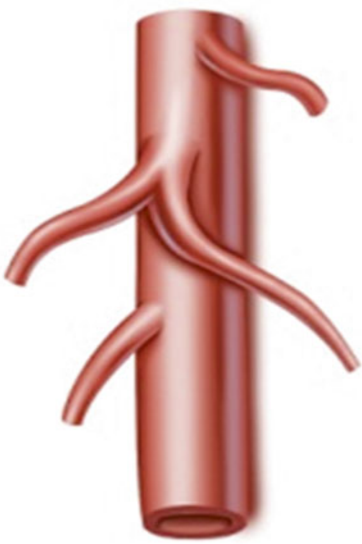


Fig. 5.15 Type II

Type II: The RCHA arose from SMA and ran across the anterior side of pancreatic head and was present in one case (0.05 %, 1/2,170). In this type, the RCHA surrounded the pancreatic head like "U" shape and ran toward the direction of upper right. When it reached the junction of superior border of pancreas and medial wall of duodenal, the RCHA branched off the RPHA, RGEA, and SPDA (Figs. 5.36, 5.37, 5.38, 5.39, and 5.40).

Type III: The RCHA arose from AA in one case (0.05 %, 1/2,170). The RCHA passed in front of the PV and bifurcated into GDA and RPHA near the posterior wall of duodenal (Figs. 5.41, 5.42, 5.43, and 5.44).

Type IV: The replaced LHA (RLHA) arose from the LGA, and the replaced RHA (RRHA) arose from SMA. It is present in five cases (0.2 %, 5/2,170). In this type, the RLHA lay in the lesser omentum, and the RRHA ran behind the PV and gave off the GDA on the suprapancreatic border (Figs. 5.45, 5.46, 5.47, and 5.48).

Type V: The RLHA arose from the LGA, and the RRHA arose from the CA in two cases (0.09 %, 2/2,170). The RLHA lay in the lesser omentum, and the RRHA passed behind the PV. The aberrant GDA arose from the CA (Figs. 5.49, 5.50, and 5.51).

Type VI: The RLHA arose from aberrant GDA and RRHA arose from SMA in one case (0.05 %, 1/2,170). The aberrant GDA arose

Fig. 5.16 Type II. LGA (*a*), CHA (*b*), and SpA (*c*) (in autopsy)

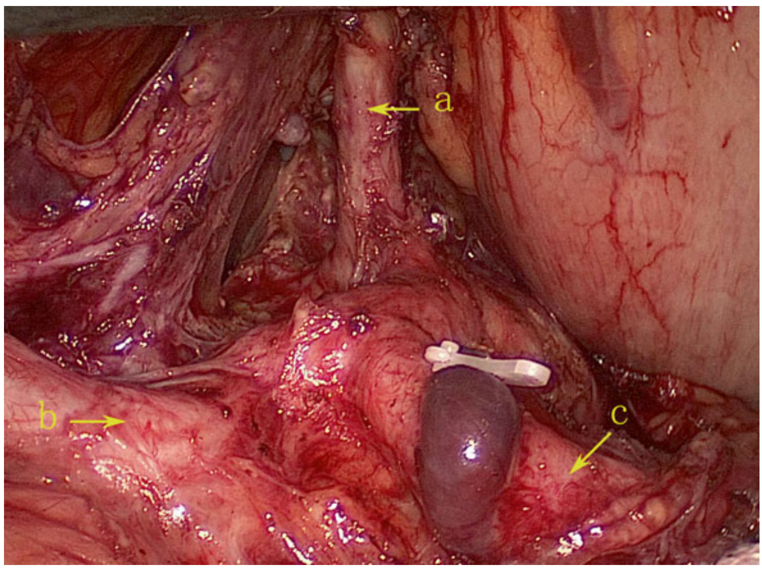


Fig. 5.17 Type II. LGA (*a*), CHA (*b*), and SpA (*c*)

from CA and branched off the RLHA to supply the left liver lobe. The RRHA arose from SMA and passed behind PV, supplying the right liver lobe (Figs. 5.52, 5.53, and 5.54).

GDA

The GDA stems from the CHA. It descends behind the first part of the duodenum. Upon reaching the lower border of the pylorus, it splits into right gastroepiploic and anterior superior pancreaticoduodenal arteries (Figs. 5.55 and 5.56).

PHA

The PHA arises directly from the CHA and runs to the upper right within the HDL. It runs to the

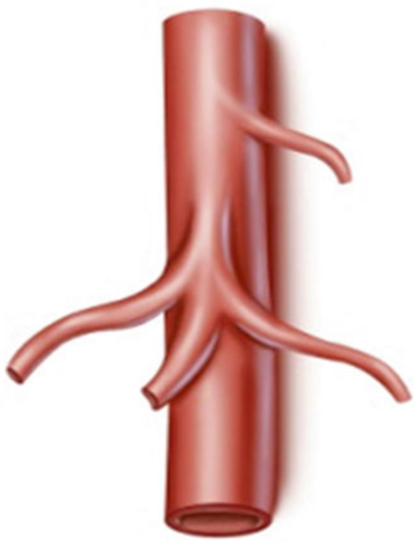


Fig. 5.18 Type III

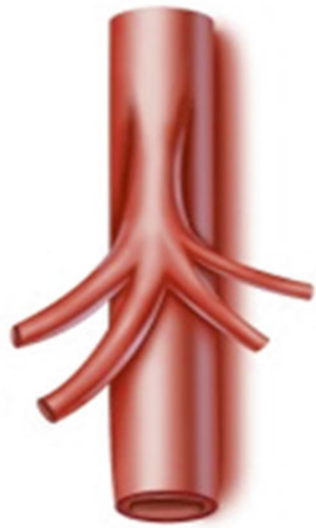


Fig. 5.19 Type IV

left and anterior of the PV and on the left side of the common bile duct in the HDL. Then, it terminates by bifurcating into the right and left hepatic arteries near the porta hepatis, sending small branches to the middle of the common bile duct along the way. The PHA is separated from the CHA by the bifurcation of the GDA, called the T-shaped intersection. The PHA is distal to the division, while the CHA is proximal to it (Figs. 5.57 and 5.58).

RGA

The RGA most frequently arises from the PHA above the first part of the duodenum. It runs upward between the two layers of the HDL to the pylorus. It then passes from right to left along the lesser curvature of the stomach, supplying both of its surfaces with branches, and joins with the LGA (Figs. 5.59 and 5.60).

According to Adachi's study of the RGA in 191 patients, the origin of this artery varies considerably [18]: The RGA originated from the PHA in 93 patients (48.7 %) (Figs. 5.61 and 5.62); LHA in 38 patients (19.9 %) (Figs. 5.63 and 5.64); GDA in 28 patients (14.7 %) (Figs. 5.65 and 5.66); near the T-shaped intersection of the CHA, PHA, and GDA in 17 patients (8.9 %) (Figs. 5.67 and 5.68); and CHA in 3 patients (1.6 %) (Figs. 5.69 and 5.70).

SpA

The SpA branches from the CA to supply blood to the spleen. It meanders toward the left along the upper border of the pancreas and gives off branches to the stomach and pancreas before reaching the spleen (see the Chap. 6.2 for details).

5.2.2.2 Veins Associated with Lymph Node Dissection in the Suprapancreatic Area

Left Gastric Vein (LGV)

The LGV (or gastric coronary vein) receives venous blood from the branches corresponding to the area of the LGA. It originates from small venous branches coming from the anterior and posterior walls of the stomach and accompanies the artery of the same name to run along the gastric lesser curvature between the two layers of the lesser omentum. It receives the venous blood of branches from the anterior and posterior sides of the gastric lesser curvature, the cardiac region, and the lower half of the esophagus as well as drains one to two small vessels in the posterior abdominal wall. It ascends to the cardia and receives the esophageal vein from the lower half of the esophagus and then turns right. The drainage of the LGV has three possible patterns: the LGV ends in the PV (approximately 60.0 % of cases), it drains into the splenic vein (SpV) (approximately 30.0 %), or it drains into the splenoportal confluence (approximately 10.0 %) (Figs. 5.71, 5.72, 5.73, 5.74, and 5.75). The course of the LGV can also vary. In an analysis of 1,325 patients who underwent laparoscopic radical gastrectomy for gastric cancer by our center [21], we found that the LGV passed to the ventral side of the SpA and the CHA in 56.1 % of cases and to the dorsal side of the CHA in 41.5 % of cases. In approximately 1.6 % of cases, the coronary vein independently passes through the GHL and drains into the PV at the porta hepatis without accompanying the similarly named artery. It is called the intrahepatic LGV in this situation (Figs. 5.76 and 5.77). In about 0.5 % of cases, the LGV is absent, and the right gastric vein (RGV) is enlarged in compensation (Figs. 5.78 and 5.79). Moreover, we have described a rare anatomical variant of the LGV (Fig. 5.80), in which it descends along the GPF, runs across the dorsal side of the SpA, and drains into the SpV [22]. This previously undescribed anatomical variant had an incidence of 0.3 % (six cases) in our study. The mean diameter and length of this variant LGV were 5.10 ± 0.40 mm and 37.40 ± 5.19 mm, respectively, and the mean distance from the end of the

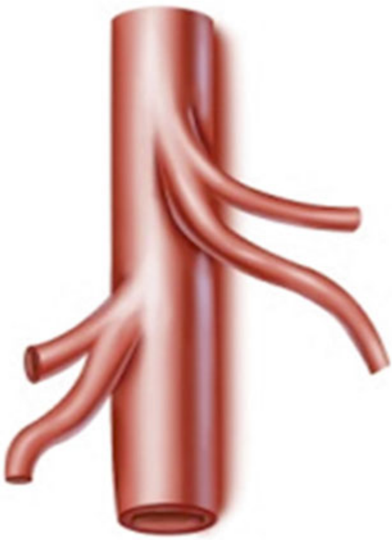


Fig. 5.20 Type V

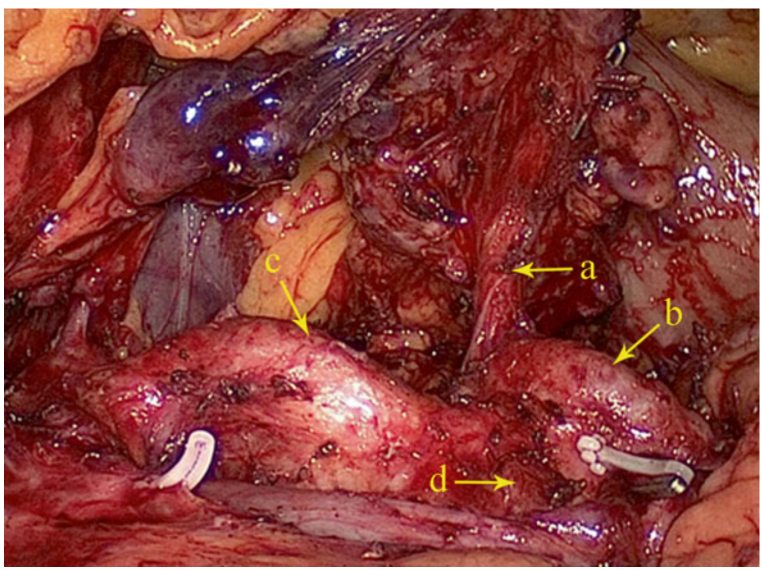


Fig. 5.21 Type V. LGA (*a*), SpA (*b*), CHA (*c*), and SMA (*d*)

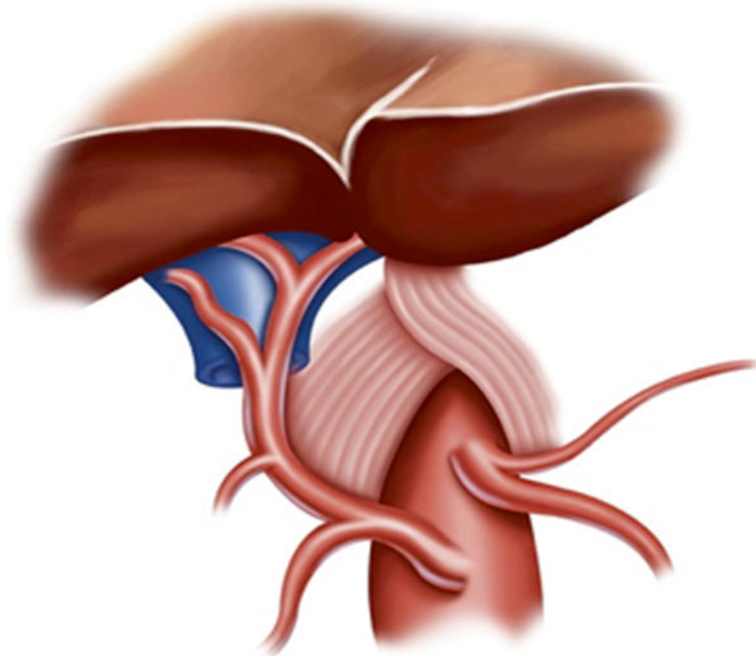


Fig. 5.22 Type VI

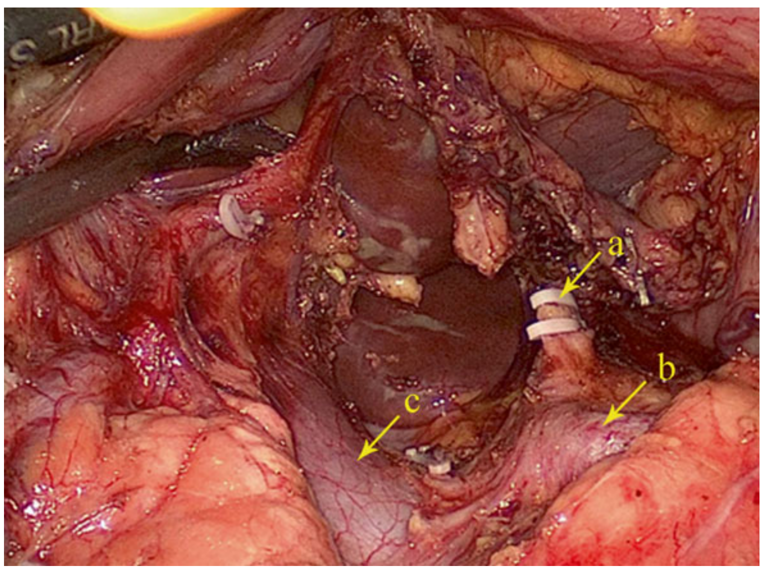


Fig. 5.23 Type VI, the end of LGA (*a*), SpA (*b*), and portal vein (PV) (*c*)

LGV to the splenoportal confluence was 13.05 ± 0.86 mm. The closer the LGV and LGA were to the root, the greater the distance between them, with a mean difference of 13.85 ± 1.02 mm between the end of the LGV and the root of the LGA. In addition, there may be double LGVs (Fig. 5.81).

SpV

The SpV is formed by the union of the splenic lobar veins that issue from the splenic hilum. It receives blood from the splenic pole veins, the pancreatic vein branches, the short gastric and left gastroepiploic vessels, and the inferior mesenteric vein on the way (see the Chap. 6.2 for details).

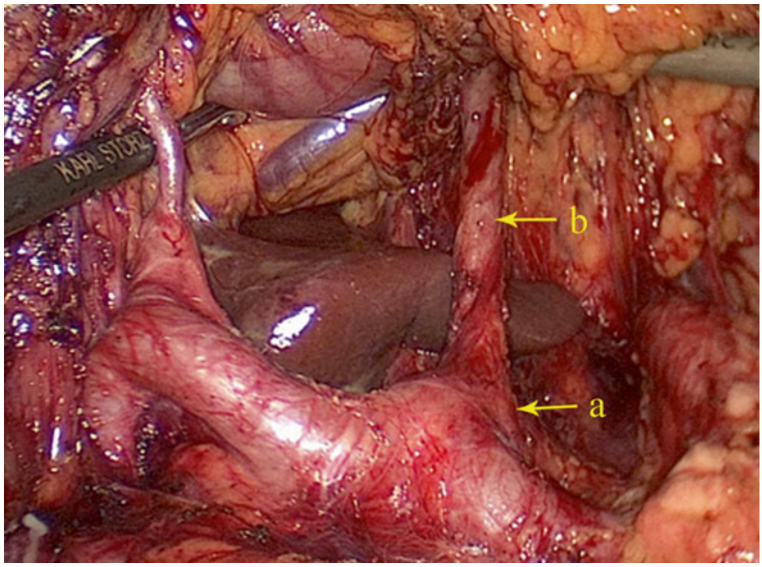
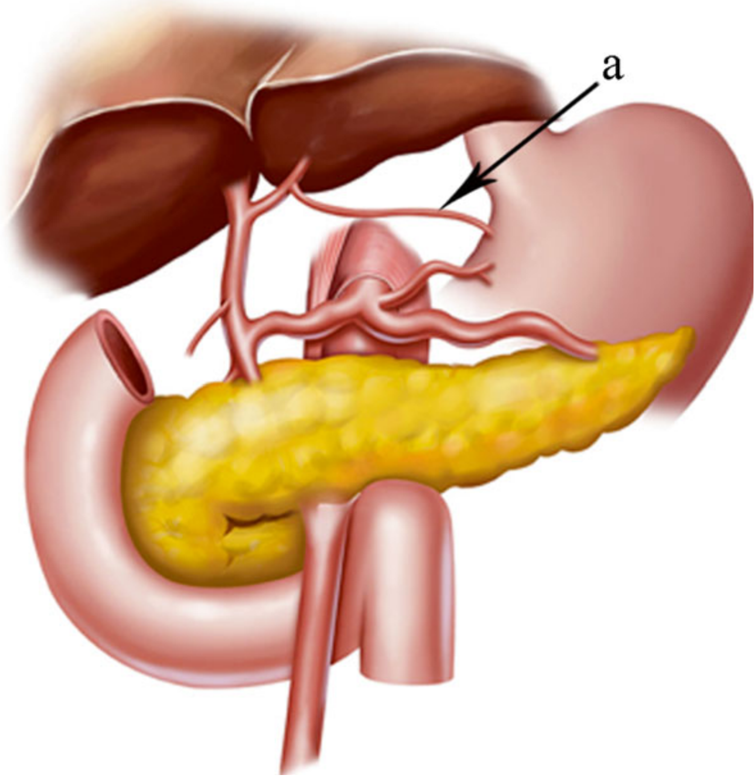


Fig. 5.24 The CA (*a*) gives off the LGA (*b*)

Fig. 5.25 ALGA (*a*)



PV

The PV, a large but short vein, is approximately 6–8 cm in length and 1.4–1.8 cm in diameter. It passes posterior to the CHA and the common bile duct in the HDL. In most individuals (approximately 76.0 %), the PV is formed by

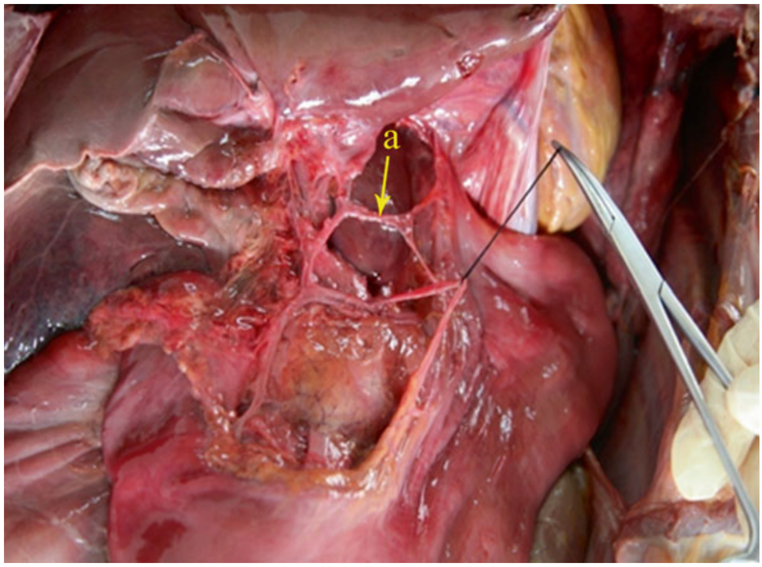


Fig. 5.26 The LHA gives off the ALGA (*a*) (in autopsy)

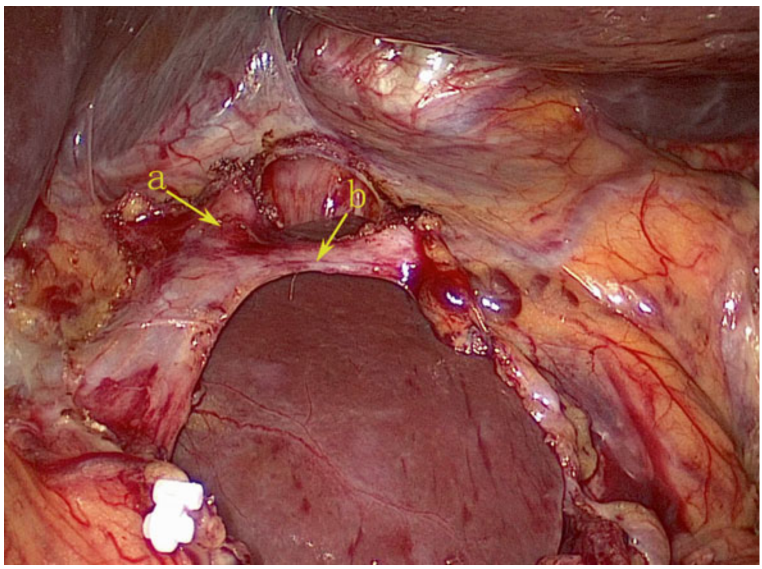


Fig. 5.27 The LHA (*a*) gives off the ALGA (*b*)

the junction of the SMV and SpV. Occasionally (in approximately 24.0 %), it also directly communicates with the inferior mesenteric vein (IMV). The union of these veins takes place between the pancreatic head and the inferior vena cava. Usually, the venous blood from the stomach flows to the liver through the PV, which is an important structure in the portal triad (Figs. 5.82 and 5.83).

RGV

The RGV is small. It is approximately 1.0–4.5 mm in diameter with an average diameter of 2.18 mm. Usually, there are two or three of these vessels (RGVs). The left one passes from left to right along the lesser curvature of the stomach within the lesser omentum, receiving small veins from the gastric walls. A tributary of the RGV called the prepyloric vein passes vertically

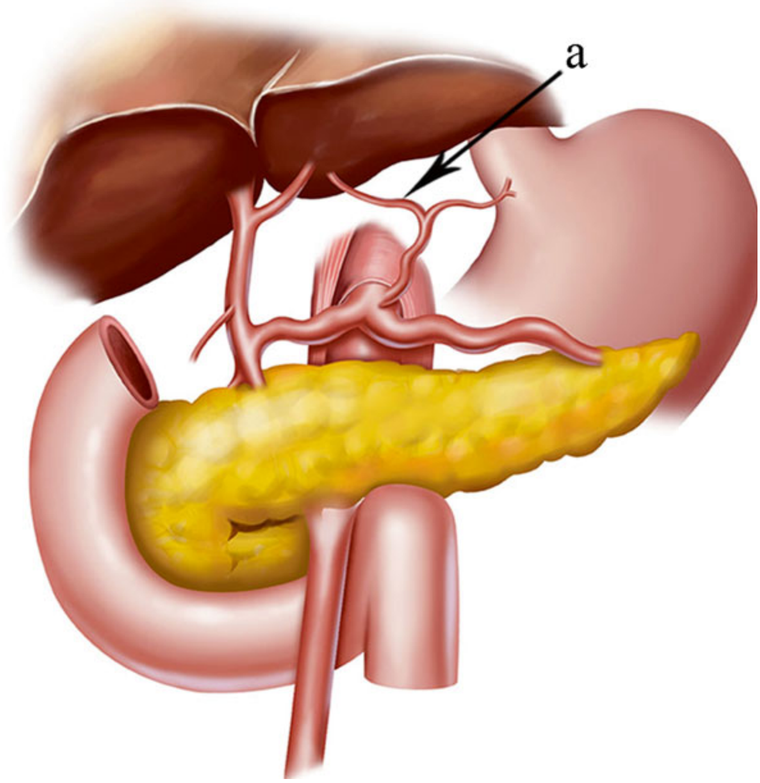


Fig. 5.28 ALHA (*a*)

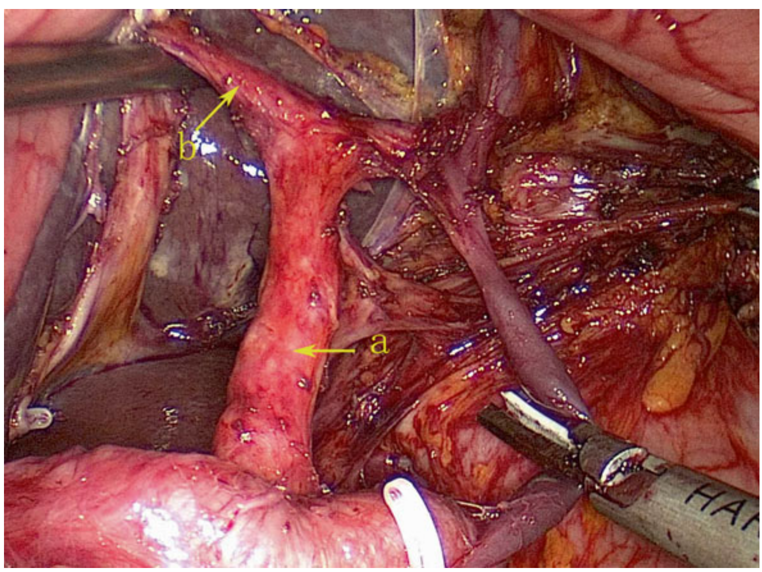


Fig. 5.29 The LGA (*a*) sends the ALHA (*b*)

anterior to the pylorus in the subserosa (Fig. 5.84). It is used to identify the pylorus during surgery. The RGV runs continually toward the right and ultimately empties into the PV. It generally drains into the PV behind the upper border of the duodenal bulb, or it may run upward to enter the HDL before draining into the PV (Fig. 5.85).

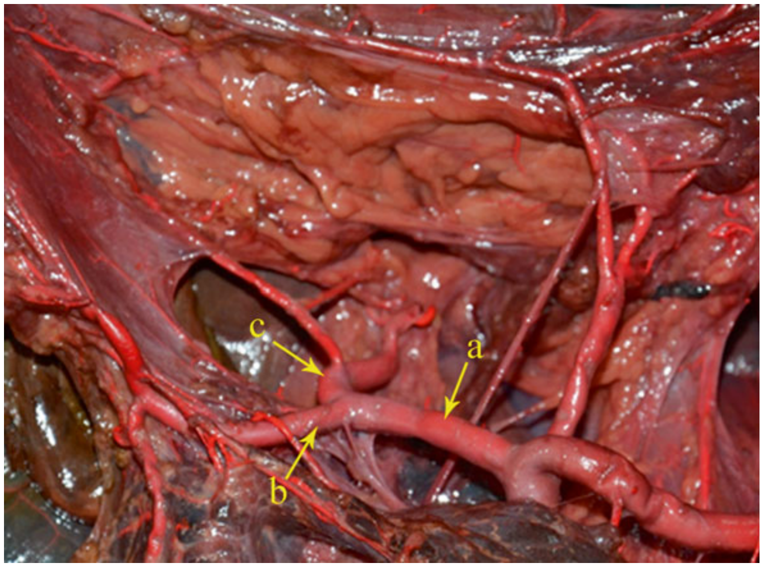


Fig. 5.30 The CHA (*a*) gives off the GDA (*b*) and PHA (*c*) (in autopsy)

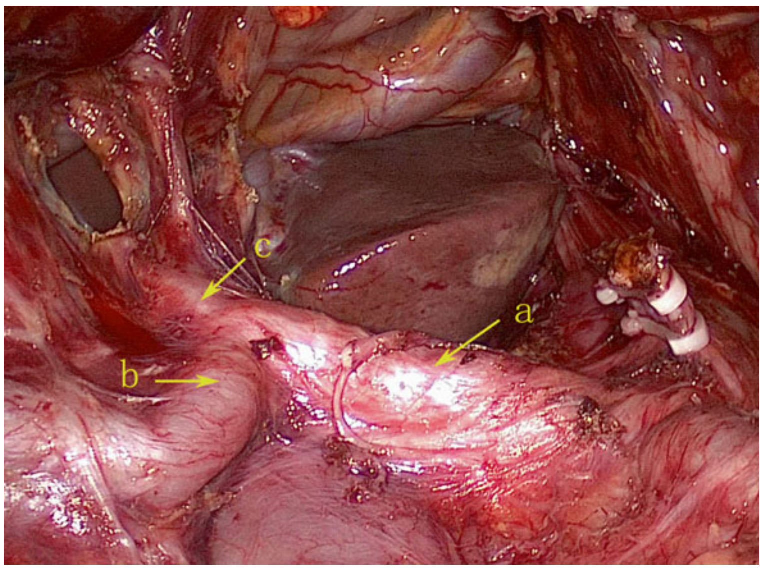


Fig. 5.31 The CHA (*a*) gives off the GDA (*b*) and PHA (*c*)

5.2.3 Lymph Node Anatomy of the Suprapancreatic Area

5.2.3.1 The No. 9 LNs (LNs Around the CA)

Definition of the No. 9 LNs

The No. 9 LNs are located at the roots of the LGA, CHA, and SpA around the CA (Figs. 5.86 and 5.87).

No. 9 LNM (Figs. 5.88, 5.89, and 5.90)

5.2.3.2 The No. 7 LNs (LNs Around the LGA)

Definition of the No. 7 LNs

The No. 7 LNs lie around the left gastric vessels in the GPF outside the lesser omentum. They are distributed from the root of the LGA to the bifurcation of the ascending branch (Figs. 5.91 and 5.92).

No. 7 LNM (Figs. 5.93, 5.94, and 5.95)

5.2.3.3 The No. 8 LNs (LNs Around the CHA)

Definition of the No. 8 LNs

The No. 8 LNs lie around the CHA at its anterosuperior and posterior sides from its origin to the root of the GDA. Those located anterosuperior to the CHA belong to the No. 8a LNs (anterosuperior group), while those located posterior to the artery belong to the No. 8p LNs (posterior group) (Figs. 5.96 and 5.97).

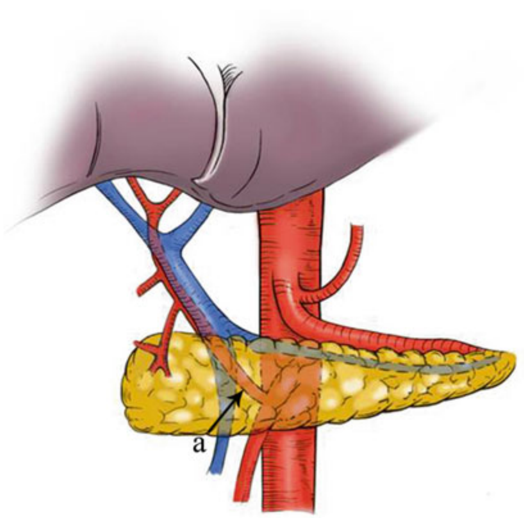


Fig. 5.32 Type I. RCHA (*a*)

No. 8 LNM (Figs. 5.98, 5.99, 5.100, 5.101, and 5.102)

5.2.3.4 No. 12 LNs (LNs in the HDL)

Definition of the No. 12 LNs

The No. 12 LNs are located in the HDL along the hepatic artery, bile duct, and PV. They are divided into the following five substations based on studies of bile duct cancer (Figs. 5.103 and 5.104):

No. 12a (beside the hepatic artery): LNs along the CHA

No. 12b (beside the bile duct): LNs along the bile duct

No. 12p (behind the PV): LNs along the PV

No. 12h (hepatic hilar LNs): LNs at the porta hepatis

No. 12c (beside the cystic duct): LNs along the cystic duct

No. 12 LNM (Figs. 5.105, 5.106, and 5.107)

5.2.3.5 The No. 5 LNs (Suprapyloric LNs)

Definition of the No. 5 LNs

The No. 5 LNs, the LNs in the suprapyloric area within the HDL, include the LNs located at the root of the RGA and lie along its first branch that feeds the stomach. They are separated from the

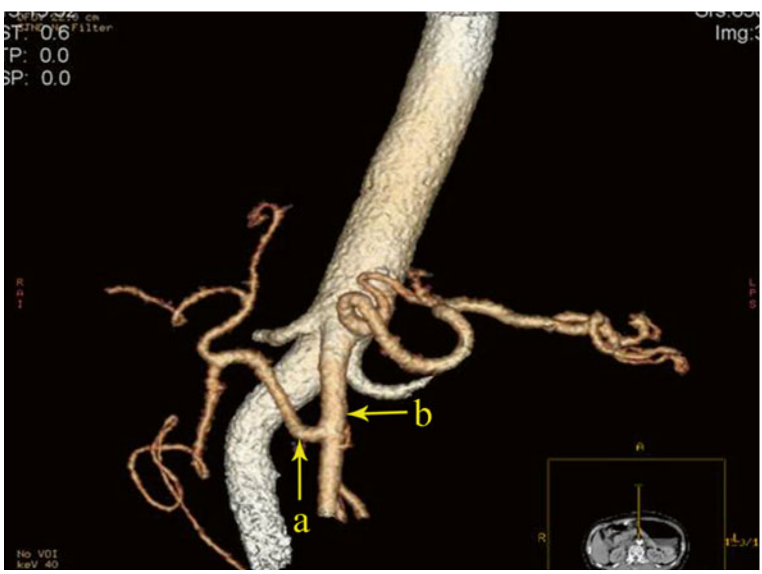


Fig. 5.33 Type I. RCHA (*a*) arose from SMA (*b*)

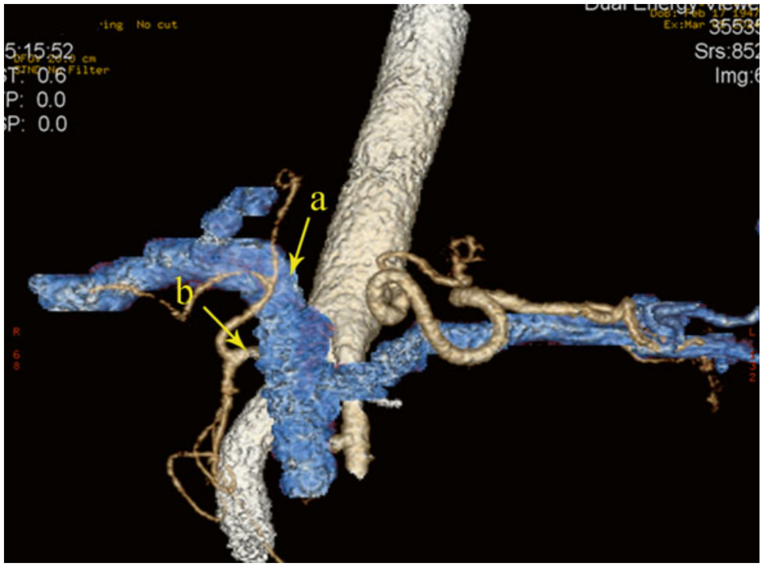


Fig. 5.34 Type I. The PV (*a*) ran in front of the RCHA (*b*)

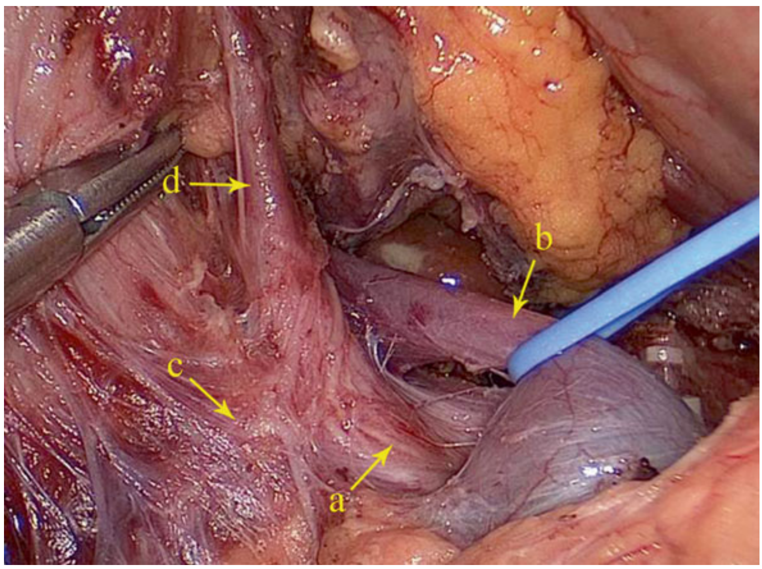


Fig. 5.35 Type I. The RCHA (*a*) ran behind the PV (*b*) and branched off the GDA (*c*) and RPHA (*d*)

No. 12 LNs by the root of the RGA. The No. 5 LNs are on the upper side, and the No. 12 LNs are on the lower side (Figs. 5.108 and 5.109).

No. 5 LNM (Figs. 5.110, 5.111, and 5.112)

5.2.3.6 View of LNs in the Suprapancreatic Area Before and After Neoadjuvant Chemotherapy

Case one: Figs. 5.113, 5.114, 5.115, and 5.116
Case two: Figs. 5.117, 5.118, 5.119, and 5.120

5.3 Procedures for Lymph Node Dissection in the Suprapancreatic Area

Lymph node dissection in the suprapancreatic area includes dissection of the No. 5, 7, 8a, 9, 11p, and 12a LNs. The duodenum isn't transected at first when we perform lymph node dissection in this area. We, via the HGL warding off the left lateral liver, denude the vessels and fatty lymphatic tissue from the behind of the stomach. So the LNs will be completely removed from the roots of the vessels (Fig. 5.121). At the same time, we dissect these LNs from the left to the right side. The No. 11p LNs are dissected first, followed by the No. 9, 7, and 8a LNs. Dissection of the No. 5 and 12a LNs is accomplished last. Dissection of the LNs in this order creates favorable conditions for dissection of each subsequent station.

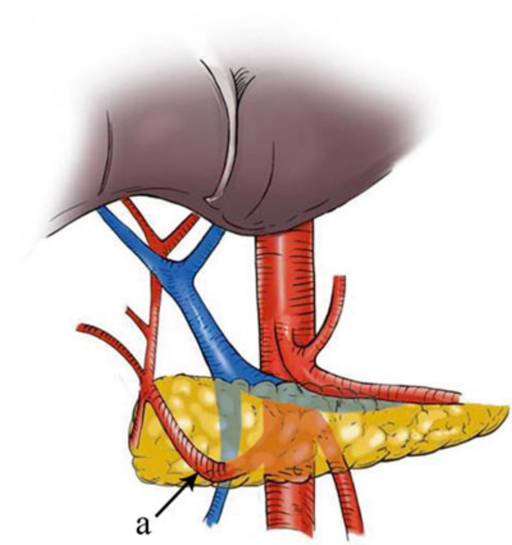


Fig. 5.36 Type II. RCHA (*a*)

5.3.1 Dissection of the No. 7, 8a, 9, and 11p LNs

5.3.1.1 Operative Approach

The approach to the dissection is from the initial segment of the SpA (Fig. 5.122). Because the initial segment of the SpA is the closest artery to the suprapancreatic border and its location is relatively constant with lesser anatomical variation (Fig. 5.123), the SpA is easy to expose after peeling the pancreatic capsule (Fig. 5.124). The initial segment of the SpA should serve as the landmark for further exposing the CA, the LGA, and the CHA on the right (Fig. 5.125). Moreover, this approach allows for a large operating field. This area is almost avascular, resulting in a low risk of bleeding (Fig. 5.126).

5.3.1.2 Exposure Methods

The assistant places the free omentum on the left upper side of the abdomen between the inferior border of the liver and the anterior gastric wall and then turns the greater curvature of the gastric body over to the cephalic side using a right-handed grasper. Next, the assistant's left hand continues to lift up the GPF by clamping the junction of its upper and middle segments (Fig. 5.127). The right hand pulls out the posterior wall of the duodenal bulb. The surgeon

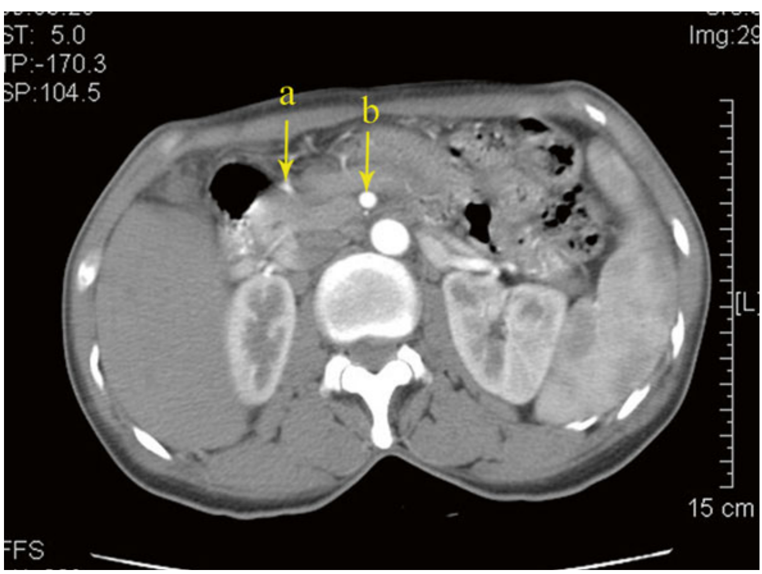


Fig. 5.37 Type II. RCHA (*a*) arose from SMA (*b*)

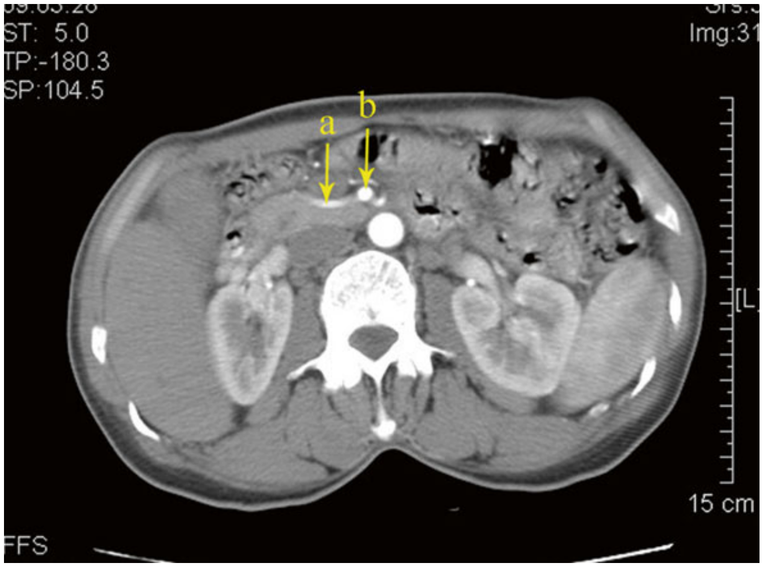


Fig. 5.38 Type II. RCHA (*a*) arose from SMA (*b*)

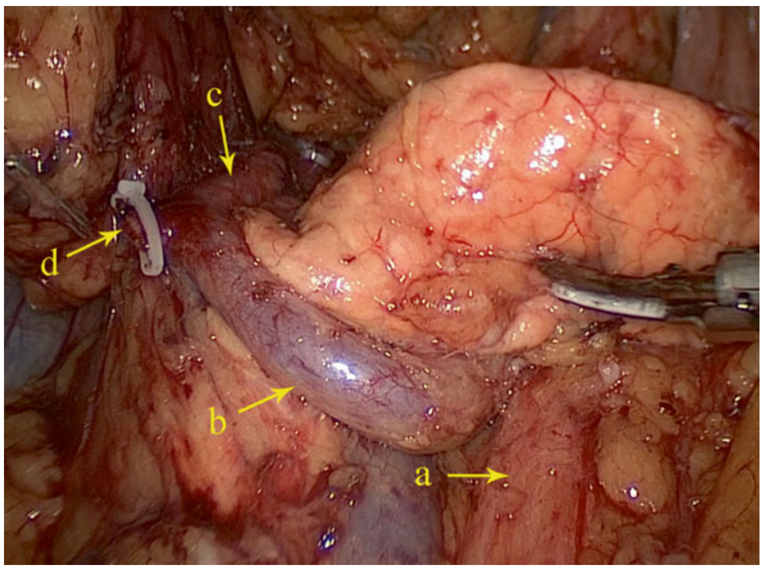


Fig. 5.39 Type II. SMA (*a*), RCHA (*b*), RPHA (*c*), and REGA (*d*)

gently presses down on the body of the pancreas with a gauze pad located at the uppermost point of its surface to tense the GPF. In this way, the suprapancreatic area can be extended to facilitate the lymph node dissection. During the process, the assistant's right hand should flexibly apply different techniques (such as lifting, pulling, holding, pushing, picking, and peeling) with a grasper or an aspirator to assist the surgeon in separating and exposing the tissue.

5.3.1.3 Operative Procedures

Using the ultrasonic scalpel, the pancreatic capsule is meticulously peeled along the pancreatic surface up to the superior border, and the GPF is opened to enter the RPS (Fig. 5.128). The HPF is then opened toward the right. Next, the assistant's right hand pulls up the free pancreatic capsule from the left side of the GPF, while the surgeon continues to peel it in order to separate and expose the initial segment of the SpA (Figs. 5.129 and 5.130). Subsequently, the assistant pulls up

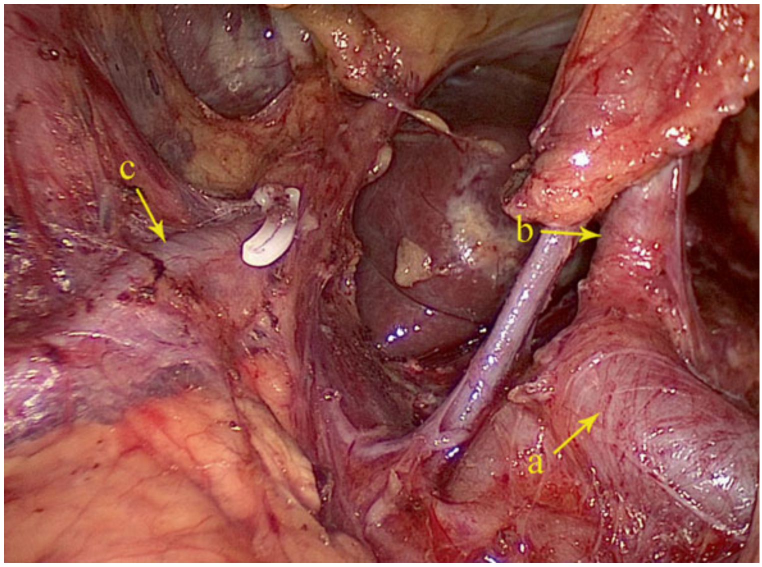


Fig. 5.40 Type II. SpA (*a*), LGA (*b*), and RPHA (*c*)

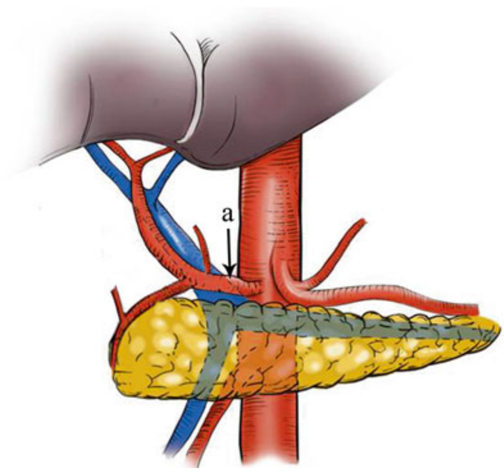


Fig. 5.41 Type III. RCHA (*a*)

the isolated fatty lymphatic tissue on the surface of the SpA, and the surgeon uses the nonfunctional face of the ultrasonic scalpel to dissect this lymphatic tissue along the latent anatomical space on the SpA's surface toward the right up to its root. The origin of the CHA can be encountered in this region (Fig. 5.131). After acquiring a general knowledge of the SpA's course on the superior border of the pancreatic body, the assistant's right hand continues to pull up the fatty lymphatic tissue on the surface of the SpA, and the surgeon uses the ultrasonic scalpel to meticulously dissect the lymphatic tissue along the SpA until the origin of the posterior gastric artery (PGA) is reached (Fig. 5.132). The soft tissue around the proximal portion of the SpA is dissected and removed en bloc. This completes the dissection of the No. 11p LNs (Fig. 5.133).

The dissection of the No. 9 LNs is started from the origin of the SpA. The assistant pulls up the isolated fatty lymphatic tissue at the left side of the GPF, and the surgeon uses the ultrasonic scalpel to dissect this tissue along the anatomical space on the surface of the left margin of the CA (Fig. 5.134) toward the crus of the diaphragm. The left margin of the root of the LGA can then be exposed (Fig. 5.135). The dissection continues until the gastrophrenic ligament (GPL) is opened (Fig. 5.136). Subsequently, the surgeon uses the ultrasonic scalpel to separate and expose the LGV (Fig. 5.137) by dissecting along the anatomical space on the surface of the right margin of the CA starting from the origin of the CHA. The soft tissues around the LGV are dissected on the superior margin of the CHA, and the LGV is vascularized and divided at its root between the clips (Fig. 5.138). Subsequently, the surgeon uses the ultrasonic scalpel to dissect the fatty lymphatic tissue along the right margin of the CA's surface (Fig. 5.139). The LGA is then denuded from its right margin (Fig. 5.140) and divided at its root between the clips (Fig. 5.141).

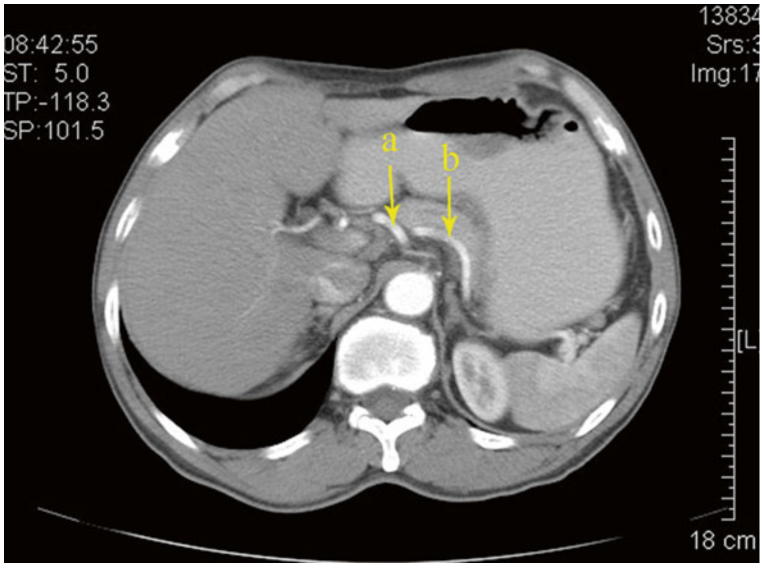


Fig. 5.42 Type III. RCHA (*a*) and SpA (*b*)

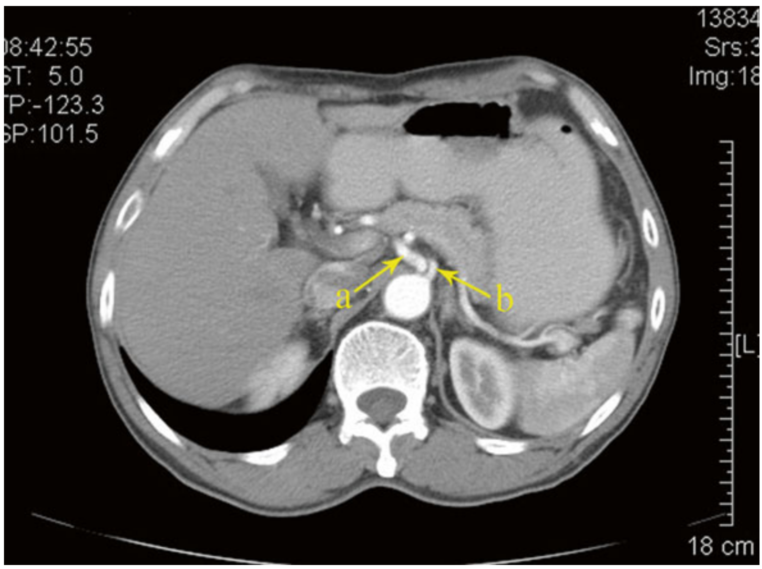


Fig. 5.43 Type III. RCHA (*a*) and SpA (*b*)

The excision of the No. 7 and No. 9 LNs is accomplished.

Next, the assistant's right hand pulls out the posterior wall of the duodenum, and the surgeon's left hand gently presses down on the pancreas with gauze to expose the general course of the CHA on the superior border of the pancreas (Fig. 5.142). Then, the assistant's right hand pulls up the isolated fatty lymphatic tissue on the surface of the CHA, and the surgeon uses the ultrasonic scalpel to carefully dissect along the anatomical space on the surface of the CHA in the direction of the duodenum (Fig. 5.143) until reaching the origin of the GDA and PHA from the CHA (Fig. 5.144). The fatty lymphatic tissue in front of the CHA is completely dissected, and the No. 8a LNs are completely removed. Next, the assistant's right hand gently lifts the lower edge of the left liver upward and outward to expose the crus of the diaphragm and the GPL (Fig. 5.145). The surgeon applies the ultrasonic scalpel along the avascular space on the surface

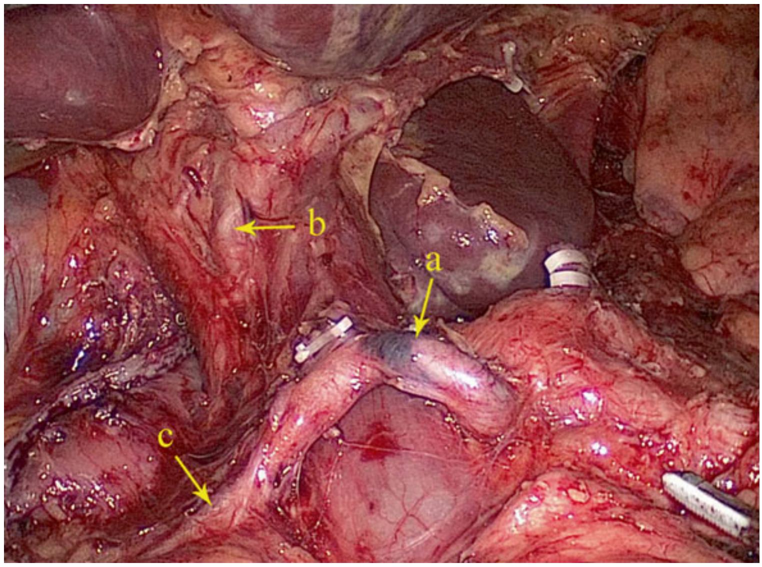


Fig. 5.44 Type III. The RCHA (*a*) bifurcated into the RPHA (*b*) and GDA (*c*)

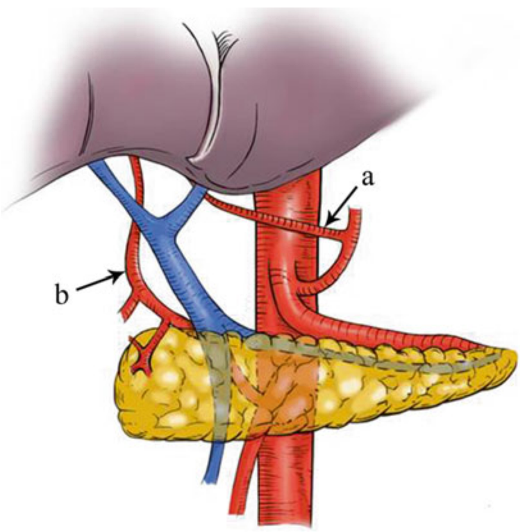


Fig. 5.45 Type IV. RLHA (*a*) and RRHA (*b*)

of the left and right crura of the diaphragm to divide the GPL until exposure of the esophageal hiatus (Fig. 5.146).

5.3.2 Dissection of the No. 5 and No. 12a LNs

5.3.2.1 Operative Approach

The approach to the dissection of the No. 5 and No. 12a LNs is from the origin of the PHA (Fig. 5.147), where the CHA divides into the GDA and the PHA. From here, it is easy to separate, expose, and identify the PHA. After the division of the GPF, HPF, GPL, and left gastric vessels, the assistant can successfully elevate the posterior wall of the gastric antrum to expose the HDL area. At this time, the operating field in the suprapyloric area provides the surgeon with good exposure for manipulation on the patient's left side. Furthermore, it allows the surgeon to rapidly and successfully stanch bleeding from the right gastric vessels during the operation.

5.3.2.2 Exposure Methods

The assistant's left hand loosens the GPF and lifts up the posterior wall of the gastric antrum, while the right hand pushes the duodenal bulb out using noninvasive grasper forceps. The surgeon gently presses down on the pancreas using a gauze pad near the fork of the CHA to keep tension on the HDL. In this way, the suprapyloric area is sufficiently exposed behind the stomach (Fig. 5.148). Afterward, the assistant should flexibly apply different exposure techniques to assist the surgeon in the dissections of the No. 5 and No. 12a LNs.

5.3.2.3 Operative Approach

The surgeon uses the ultrasonic scalpel along the course of the PHA, starting from the medial

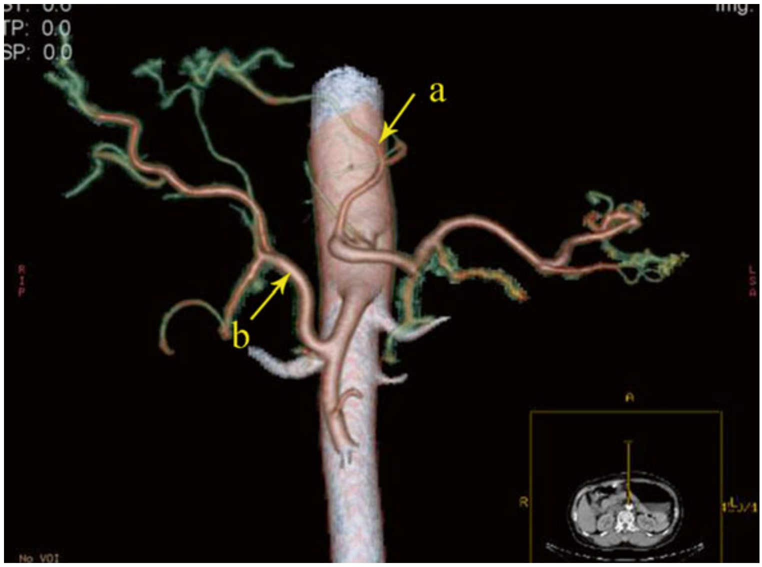


Fig. 5.46 Type IV. RLHA (*a*) and RRHA (*b*)

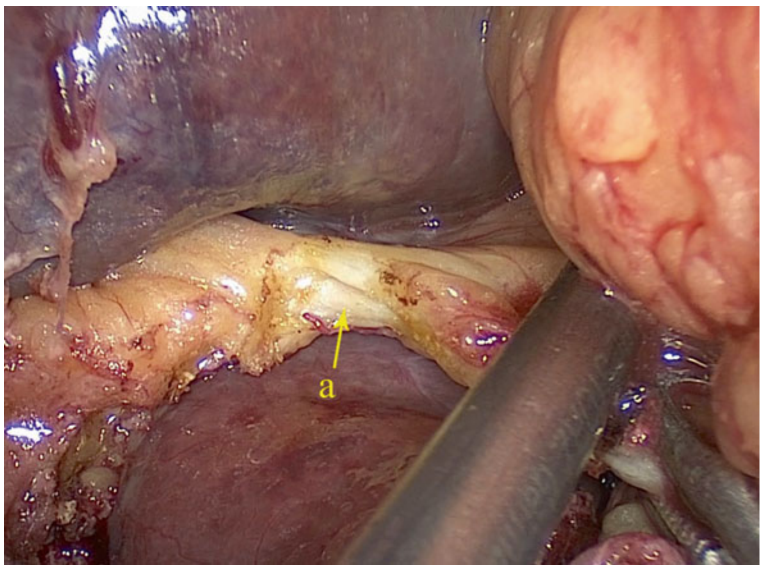


Fig. 5.47 Type IV. RLHA (*a*)

margin of its origin (Fig. 5.149), to open the medial margin of the HDL (Fig. 5.150). Next, the assistant's right hand pushes the duodenum up and down along its surface to help the surgeon expose the root of the RGA near the origin of the PHA (Fig. 5.151). The RGA is carefully and meticulously vascularized (Fig. 5.152) and then divided at its root between the clips (Fig. 5.153). The No. 5 LNs are excised.

Subsequently, the assistant's right hand gently pulls on the isolated fatty lymphatic tissue on the surface of the PHA, and the surgeon uses the ultrasonic scalpel to carefully dissect this tissue along the anatomical space on the vessel's surface toward the hepatic hilum until reaching the origin of the left and right hepatic arteries. The soft tissues in front of the PHA and root of the RGA are dissected and removed en bloc (Fig. 5.154). The excision of the No. 12 LNs is then completed. At this point, the assistant's right hand lifts the anterior lobe of the HDL upward and outward, while the surgeon uses the ultra-

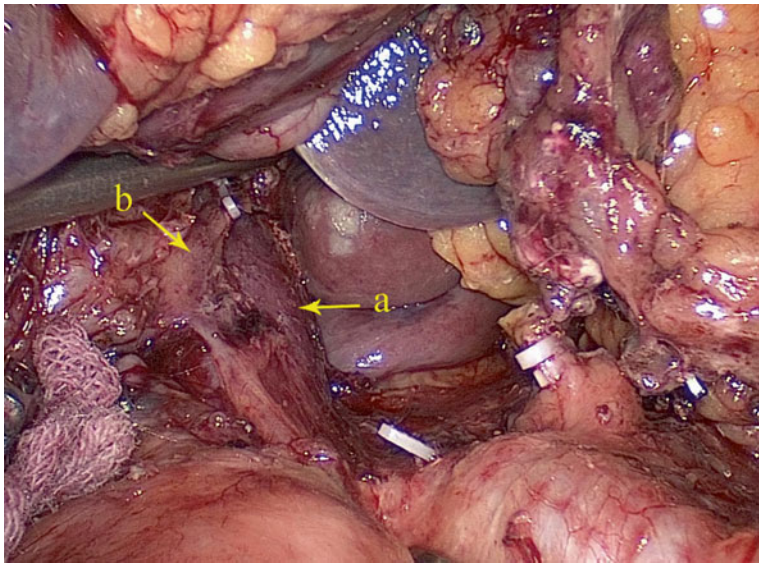


Fig. 5.48 Type IV. PV (*a*) and RRHA (*b*)

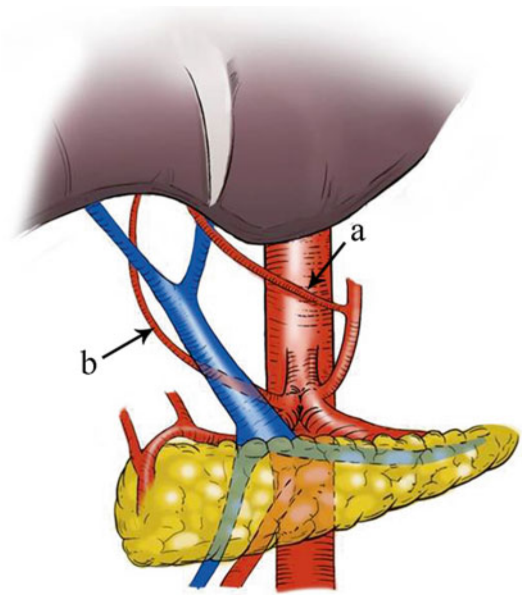


Fig. 5.49 Type V. RLHA (*a*) and RRHA (*b*)

sonic scalpel to dissect toward the right along this lobe (Fig. 5.155), opening a window in the free anterior lobe of the HDL (Fig. 5.156). This window provides a precise starting point for the subsequent division of the HGL.

The procedures described above complete the lymph node dissection within the suprapancreatic area (Figs. 5.157 and 5.158).

5.4 Common Situations Encountered and Surgical Techniques Utilized During the Dissection of the Suprapancreatic Region

5.4.1 Surgical Techniques Involved in Dissection of No. 7, 8a, 9, and 11p LNs

5.4.1.1 Surgical Techniques Involved in Dissection

Before lymph node dissection, the adhesion between the transverse mesocolon, pancreatic capsule, and posterior wall of the stomach should be divided sufficiently (Fig. 5.159), and the greater curvature and greater omentum should be rotated and placed under the liver. Then, the assistant clamps and lifts the GPF upward and forward. On the one hand, this manipulation puts the GPF under tension, and on the other hand, it moves the stomach and greater omentum backward, preventing the hanging tissues from affecting exposure of the operating field (Fig. 5.160). Hence, the grasping site on the fold is important. It is necessary for it to be between the middle and upper thirds of the fold. If the grasping site is too low, the stomach and greater omentum

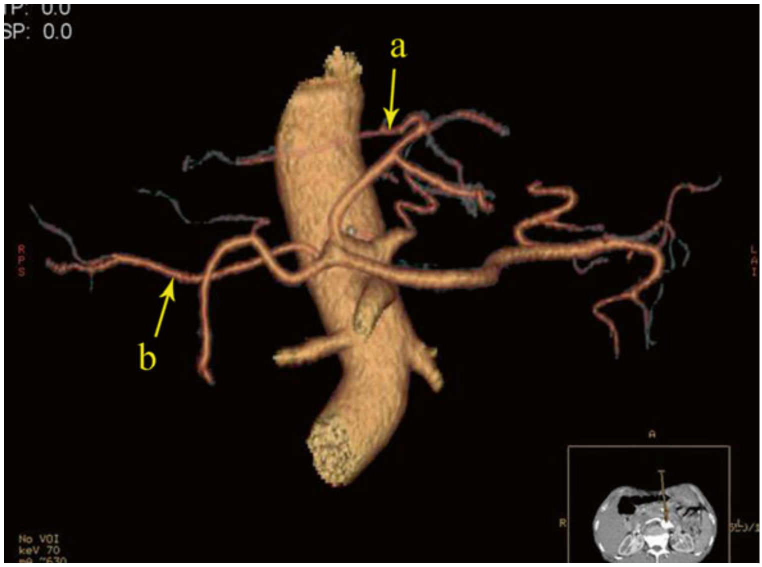


Fig. 5.50 Type V. RLHA (*a*) and RRHA (*b*)

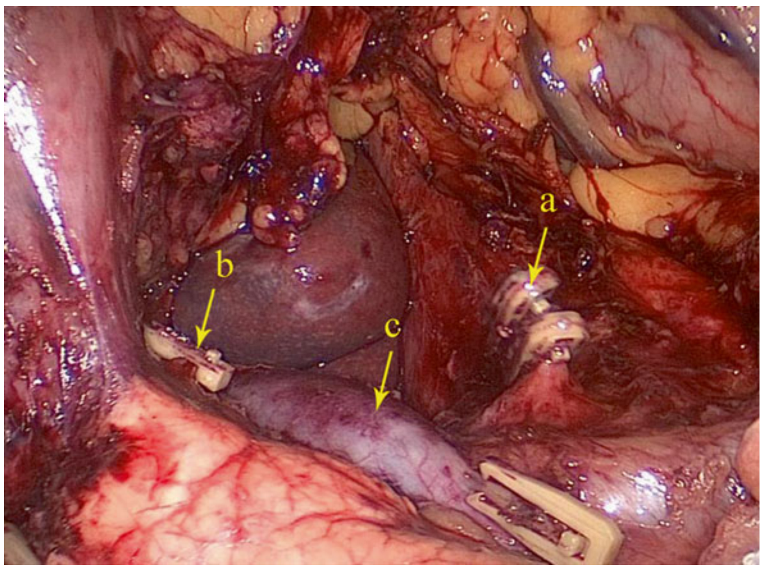


Fig. 5.51 Type V. LGA (*a*), RGA (*b*), and PV (*c*)

cannot be blocked well. On the contrary, if the grasping site is too high, insufficient tension in the fold can result, influencing the following lymph node dissection. Sometimes, the GPF is invaded by advanced gastric body cancer or with obviously swollen LNs in the suprapancreatic area, and therefore, it is difficult to grasp and pull the fold. In this situation, the assistant should hold and elevate the GPF, with the gastric forceps opening, to reveal the operating field (Fig. 5.161).

During the process of lymph node dissection in this region, our approach is generally from the origin of the SpA, which is at the left side of the GPF. However, if one approaches from the CHA, the dividing plane may be too deep to damage to the PV during the exploration procedure of this artery, because the CHA of some patients can be far from the superior margin of the pancreas (Fig. 5.162). Or incorrect identification of the CHA as the swollen LNs may result. In addition, the approach from the GDA has a benefit for the surgeon's standing position on the right side, but it also has some disadvantages: (1) There is difficult in exposure of the operating field, because before the suprapancreatic vessels are exposed, the space between the pancreatic head and the posterior wall of the duodenum is long and narrow; (2) the duodenum is limited by the left and right gastric vessels, and the assistant cannot lift the duodenum to create the proper tension (Fig. 5.163); (3) it is easy for many small vessels distributed around the posterior wall of the duodenum to be injured and bleed; and (4) it is difficult to achieve hemostasis once bleeding occurs (Fig. 5.164).

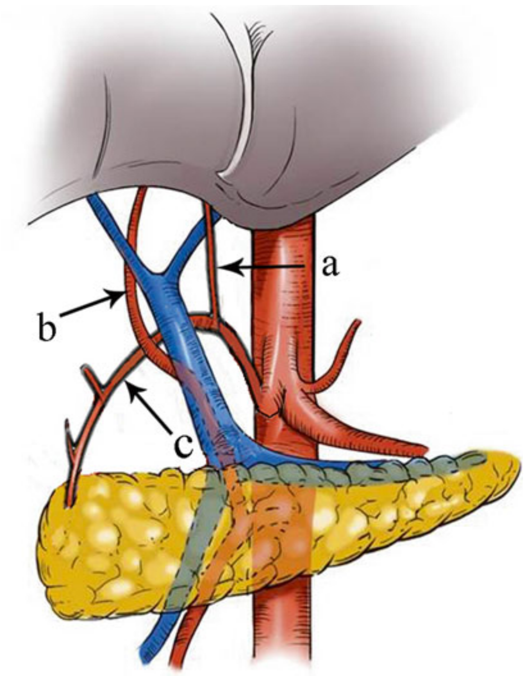


Fig. 5.52 Type VI. RLHA (*a*), RRHA (*b*), and aberrant GDA (*c*)

During the process of excising the No. 11p LNs, the existence and traction of the LGA results in insufficient tension on the lymphatic fatty tissues on the middle of the SpA. Under these conditions, it is appropriate to stop dividing at the root of the PGA (near the middle of the SpA), instead of continuing to dissect leftward, to avoid entering unclear anatomical layers and intraoperative hemorrhage.

However, it is insufficient to produce proper tension simply by clamping and elevating the GPF. Low-level tension on local tissues created by the assistant's right hand and the surgeon's left hand is also vital. In addition, a small piece of gauze with the radiopaque marker, grasped in the gastric forceps of the surgeon's left hand, can be used as a pad. The friction of the gauze enables firm compression to the pancreas without sliding and reduces the risk of injury to pancreatic tissues (Fig. 5.165). During the process,

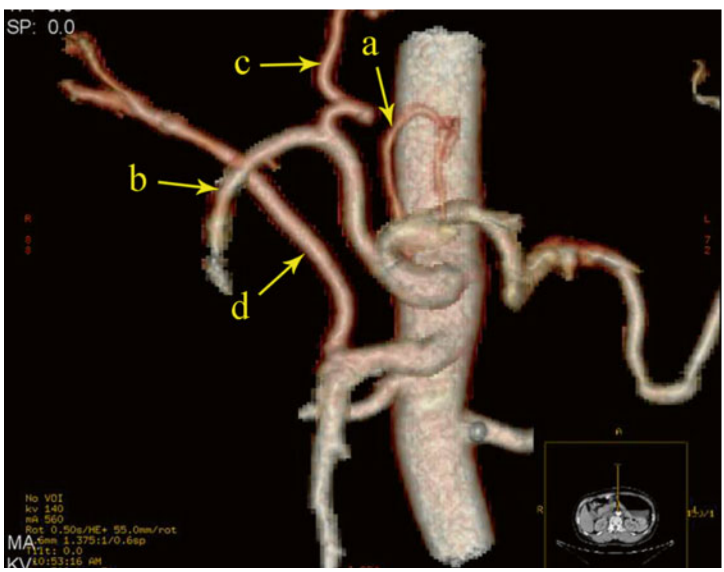


Fig. 5.53 Type VI. LGA (*a*), aberrant GDA (*b*), RLHA (*c*), and RRHA (*d*)

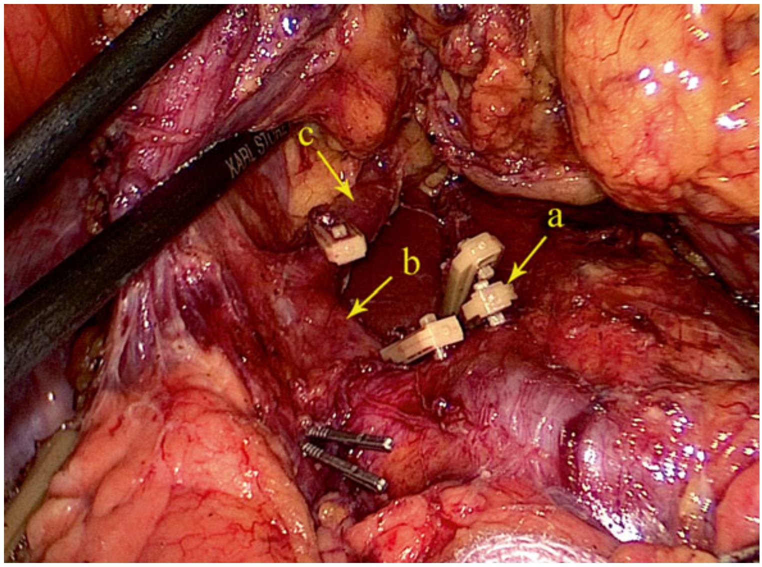


Fig. 5.54 Type VI. LGA (*a*), aberrant GDA (*b*), and RLHA (*c*)

Fig. 5.55 The CHA (*a*) gives off the GDA (*b*) (in autopsy)

the assistant's right hand should flexibly and gently apply different techniques (such as lifting, pulling, holding, pushing, picking, and peeling) to assist the surgeon in keeping appropriate tension (Figs. 5.166 and 5.167).

Besides the close cooperation between the surgeon and assistant, the importance of the camera assistant cannot be ignored. With the aim of presenting a clear operating view, the camera assistant should keep the lens clean and choose the proper landmark of observation, which should commonly be the horizontal pancreas in the suprapancreatic region. When the assistant lifts the GPF, the operating view from the bottom up has formed, corresponding to the maneuver of lymph node dissection, which is performed by following the intrafascial space. During surgery, the tiny structures can be identified clearly with the near focal distance, which is suitable for operation on the surface of vital vessels. Under these conditions, however, spattering of adipose particles or blood can pollute the lens.

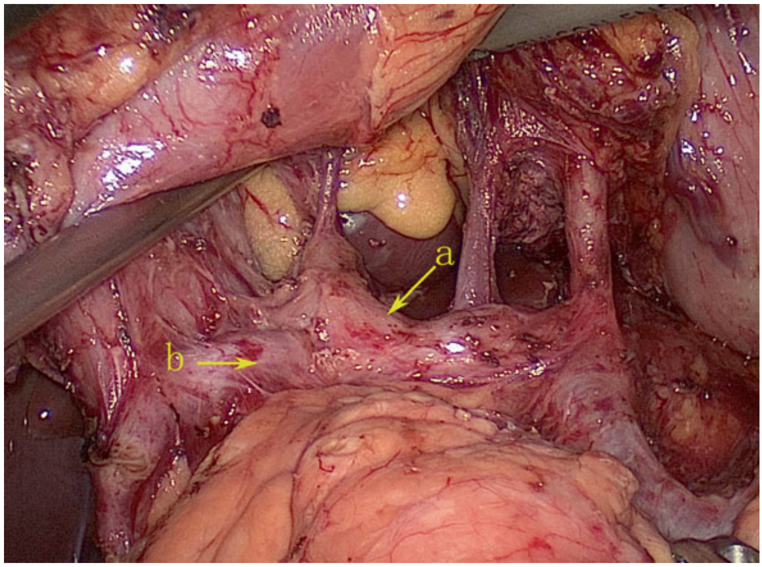


Fig. 5.56 The CHA (*a*) gives off the GDA (*b*)

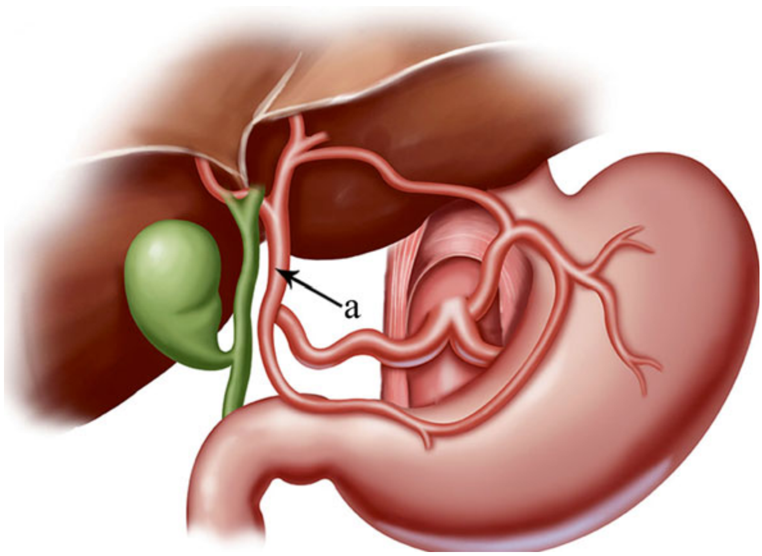


Fig. 5.57 The course of the PHA (*a*)

The camera assistant should be prepared for any pollutants in advance and wipe the lens at any time. The laparoscope can be pulled out slightly from its original position before ultrasonic shearing by the surgeon to avoid pollution of the lens. The adjusted distance is advised to be 1 cm, because sudden movement of the lens may lead to shaking of the operating field. To aid fluency of the operation, when only some parts of the lens are polluted, without affecting the operation, cleaning of the lens can be suspended until the surgeon or assistant changes the instruments. On the contrary, if the lens is sufficiently dirty to influence the operation, it should be removed quickly, wiped with povidone–iodine gauze, and cleaned with dry gauze (Fig. 5.168).

5.4.1.2 Prevention of Damage to Adjacent Tissues and Organs

Peeling of the pancreatic capsule under laparoscopy is the approach to enter the RPS from the superior border of the pancreas. However, during the process, the fragile pancreatic tissues are susceptible to injury and bleeding. In these cases,

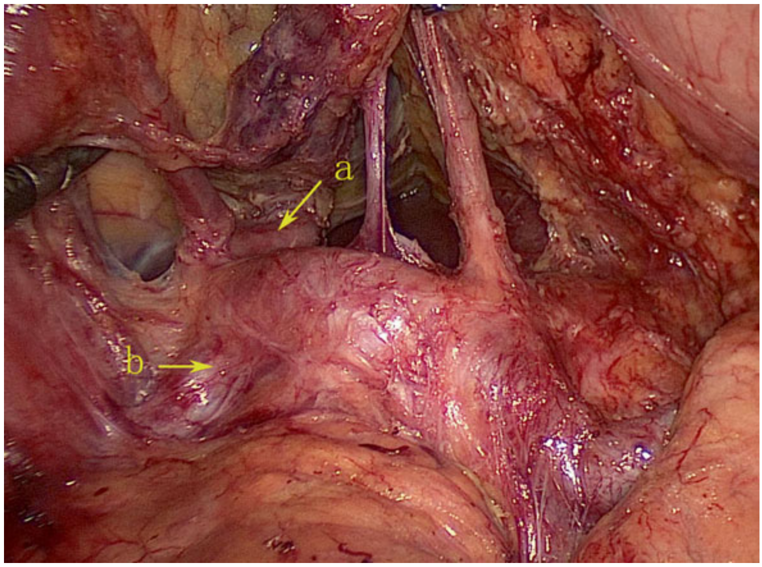


Fig. 5.58 The PHA (*a*) is distal to the bifurcation of the GDA (*b*)

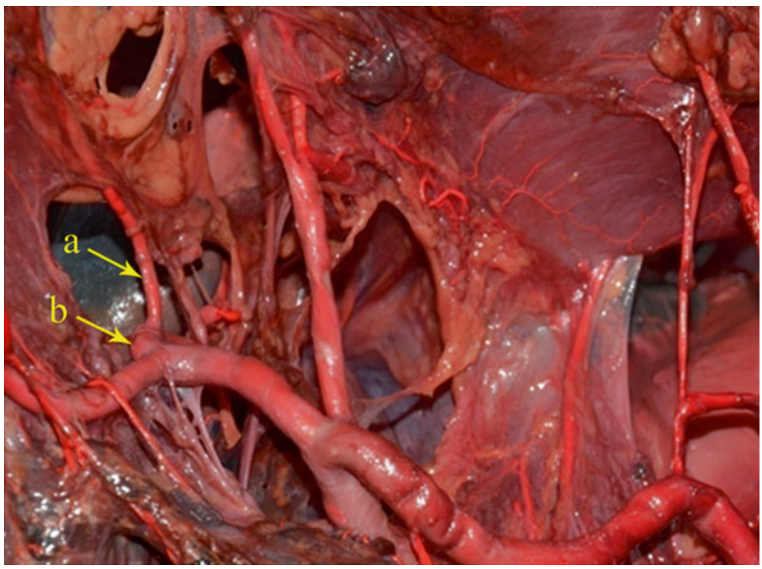


Fig. 5.59 The RGA (*a*) arises from the PHA (*b*) (in autopsy)

gauze compression or electrocoagulation can be useful. It is improper to use ultrasonic scalpels immediately, because it is difficult to clamp the bleeding point, which can result in further injury to the pancreas and cause more severe hemorrhage (Fig. 5.169). In addition, the nonfunctional face of the ultrasonic scalpels should be placed close to the pancreas throughout the dissection to avoid injury (Fig. 5.170).

If the LNs of the suprapancreatic area are swollen, looking for the correct anatomical plane is particularly important. An excessively high operating plane always leads to incorrect shearing into the LNs and hemorrhage. Therefore, small intervals on the surface of the vessel should be detected, followed by division of the basilar part of the LNs along the surface of the vessel to achieve en bloc excision. LNs are fragile. Thus, the assistant should lift the fascia on the surface of the swollen LNs to assist with exposure of the anatomical space, rather than clamping and lifting the LNs directly, avoiding bleeding and tumor

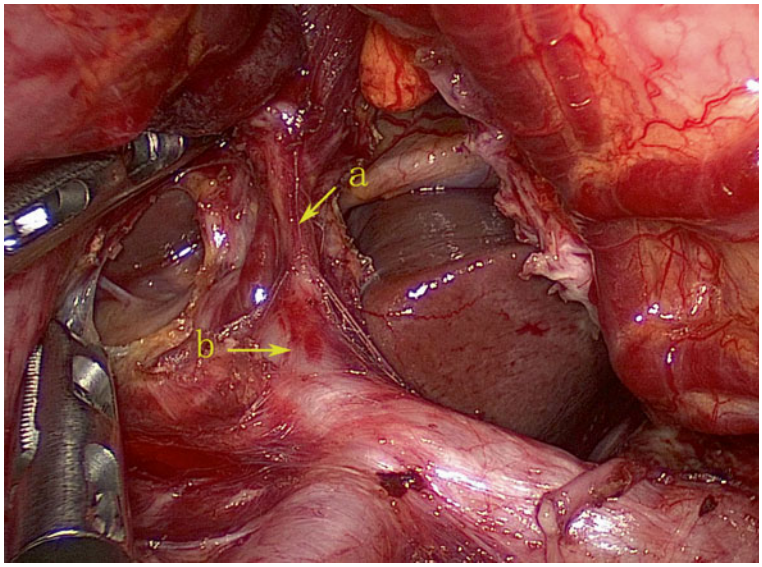


Fig. 5.60 The RGA (*a*) arises from the PHA (*b*)

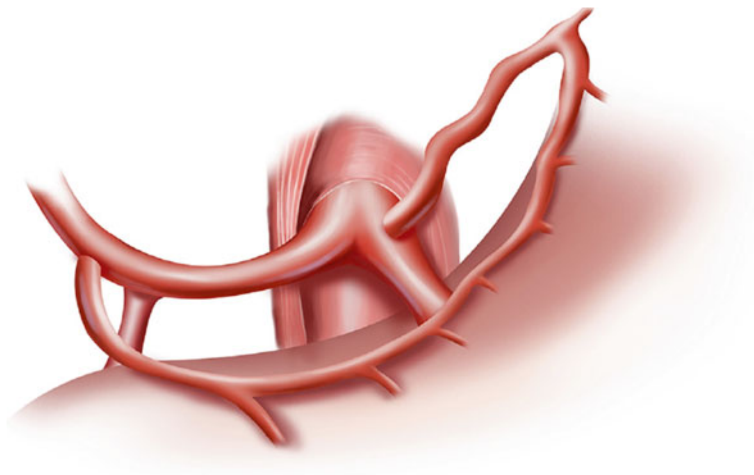


Fig. 5.61 The RGA originated from the PHA

cell dissemination. The ultrasonic scalpel is useless in controlling LNs bleeding. Because it is difficult to achieve coagulation, even more massive hemorrhage can result. Thus, minor volumes of blood, which have only a small influence on the operating field, can be suspended to deal with. After total dissection of the LNs from the root, bleeding stops naturally. If the operating field is obscured by blood, the surgeon should apply gauze compression to stop the bleeding. However, if the volume of blood is too large to affect surgical manipulation, it is appropriate to look for and ligate the LGA first to reduce blood volume. During the procedure of hemostasis, the surgeon should apply gauze compression with grasping forceps in the left hand to reduce bleeding. Simultaneously, the assistant should take the aspirator in the right hand and compress the hemorrhagic area directly to reduce blood volume, or intermittently suck up any fluid and blood, creating a clean operating field and exposing the bleeding spot. In addition, the aspirator should move horizontally or vertically during the suction process, rather than staying in situ, increasing the efficiency of suction.

The efferent lymphatic vessels along the LGA, SpA, CHA, and its branches are thick, which drain into the LNs around the CA. Thus, it

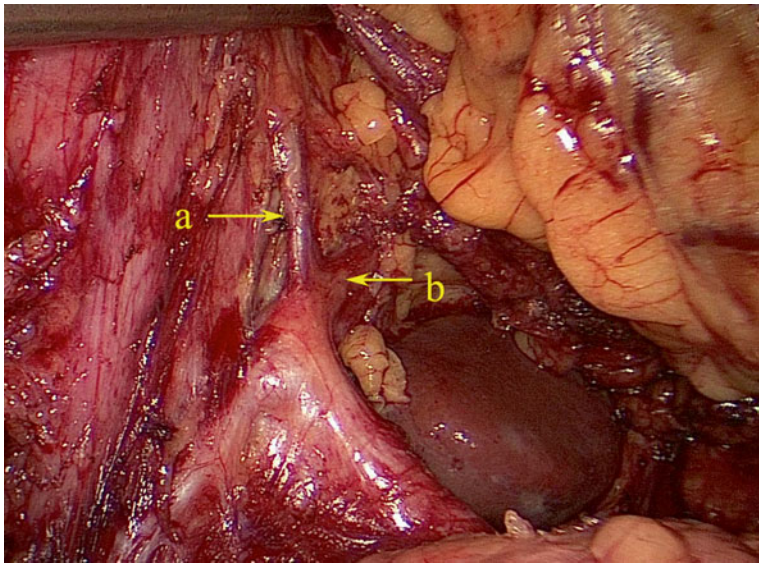


Fig. 5.62 The RGA (*a*) originated from the PHA (*b*)

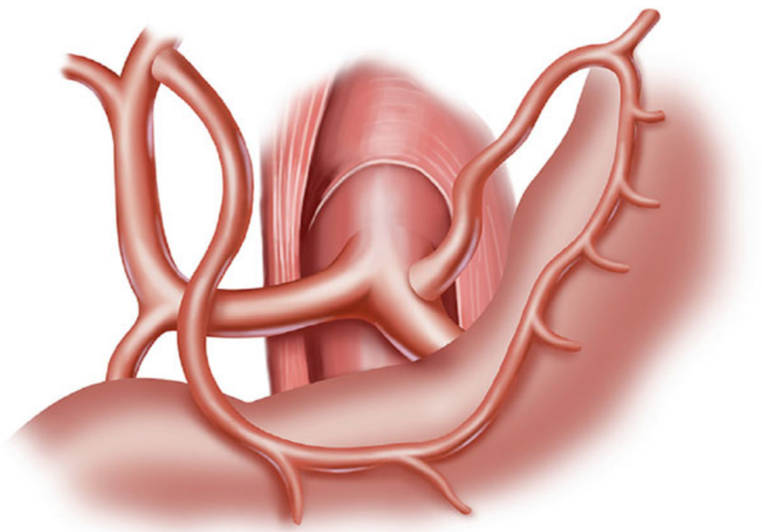


Fig. 5.63 The RGA derived from the LHA

is better to sever them with the minimum speed of the ultrasonic scalpels, or ligature them with clips if necessary (Fig. 5.171). In overweight patients or those with swollen LNs, there is always retention of lymphatic fluid and blood in the local operating field, which blocks the view and reduces the efficiency of ultrasonic shearing. In this situation, the assistant should change to the aspirator, which helps to expose the operating field. If the milky or limpid fluid, which suspected to be the lymphatic fluid, is detected during the operation, a titanium clip should be used to mark the position that requires to be sutured when the following operation from auxiliary incision is performed, to prevent postoperative lymphatic fistula.

5.4.1.3 Prevention of Vascular Injury

During the excision procedure, the LGV is the most susceptible vessel to injury. Therefore, it is important to be acquainted with the anatomical features of the LGV. The course of the LGV can be vaguely identified through the mesentery

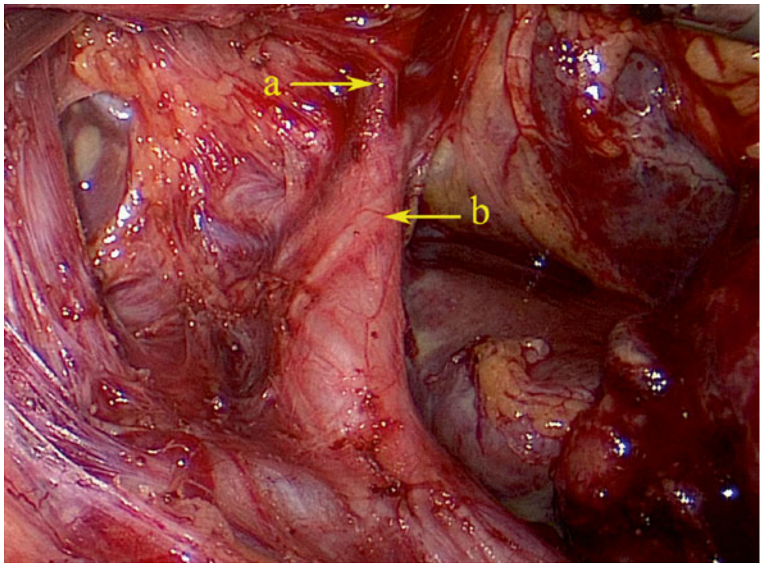


Fig. 5.64 The RGA (*a*) derived from the LHA (*b*)

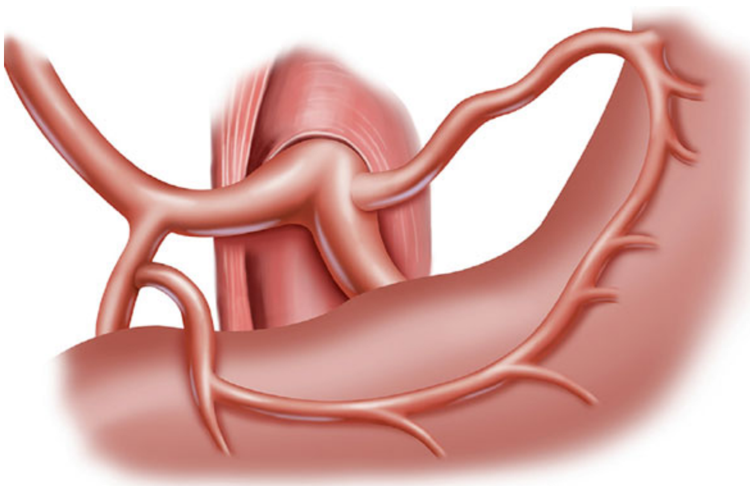


Fig. 5.65 The RGA arose from the GDA

before lymph node dissection. However, if it is hard to identify the course in some cases, it is necessary to expose the trunk of the SpA and then continue to explore and divide it in the direction of the CHA and along the trunk. After the LGV is exposed, the surgeon should sever it and dissect the LNs around the LGA later to avoid injury to the LGV during excision and to avoid bleeding (Fig. 5.172). Sometimes, there are venules draining into the LGV, which are easily injured during the process of vascularization. Thus, the LGV should be severed below the confluence of the venules after it has been revealed (Fig. 5.173). Normally, the LGV runs in association with the LGA, but they are separated in some cases. Therefore, this special variation should be considered if the LGV is not encountered in the vicinity of the LGA, to avoid injuring the vein (Fig. 5.174). The LGV is not present in the GPF in some cases. After excluding the possibility that the LGV has been severed in error, the intrahepatic LGV, which runs in the HGL, should be taken into consideration. In few cases, the vein runs alone on the left side of the LGA and descends along the GPF and then drains into the SpV by running across the dorsal side of the

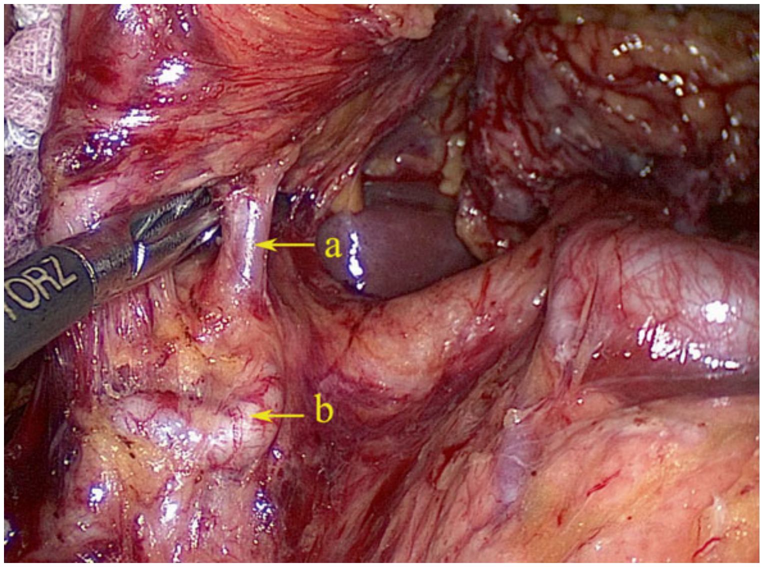


Fig. 5.66 The RGA (*a*) arose from the GDA (*b*)

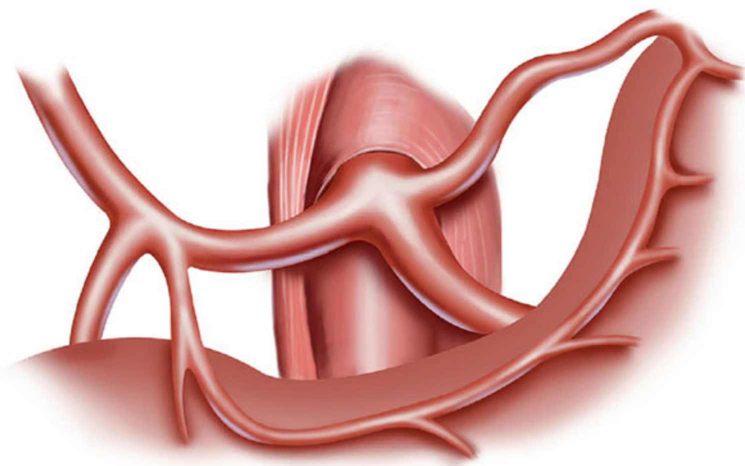


Fig. 5.67 The RGA originated near the bifurcation of the PHA and GDA

SpA. This anatomical variation is rare and difficult to detect. Thus, dividing the space at the dorsal side of the SpA should be meticulous. If the vein is injured, the blood has a large influence on the continuity of surgery and subsequent operation. In addition, in patients with enlarged LNs at the suprapancreatic region, or those with high BMI, the presence of adipose tissue around the LGV results in difficult exposure and higher risk of injury to the vein. If accidental injury to the LGV occurs, the surgeon should clamp the LGV in the GPF rapidly with the left hand and use a titanium clip to ligature the distal end of the vein to reduce venous blood reflux with the right hand. For the assistant, a low-volume aspirator can be used to compress the hemorrhagic area and suck up the blood intermittently. The proximal terminal of the LGV can be ligatured after cleaning the operating field, sufficiently exposing the hemorrhagic area after the above manipulation (Figs. 5.175 and 5.176).

Complete severing of the LGV enables further tensing of the LGA in the GPF by the assistant as well as better exposure and division of the LGA. When dissecting the No. 7 LNs around the LGA, the surgeon should patiently divide the tissues layer by layer, rather than clamping too much tissue at one time. The latter manipulation may

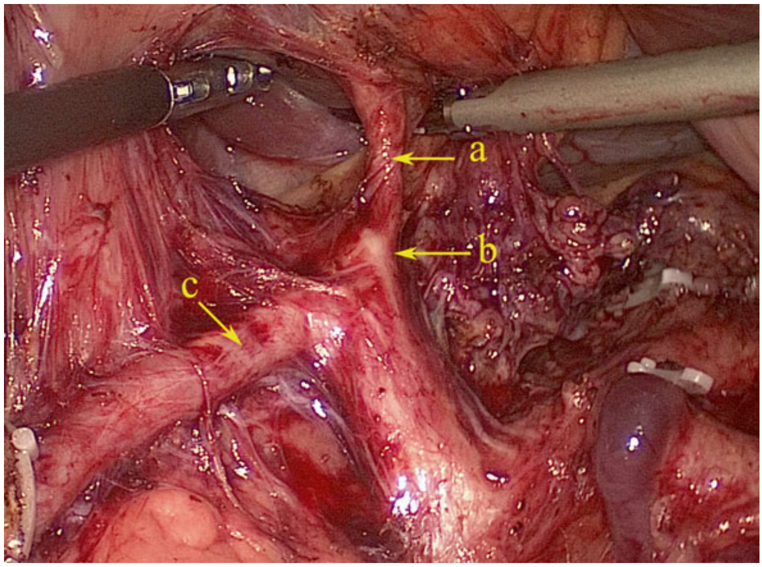


Fig. 5.68 The RGA (*a*) originates near the bifurcation of the PHA (*b*) and GDA (*c*)

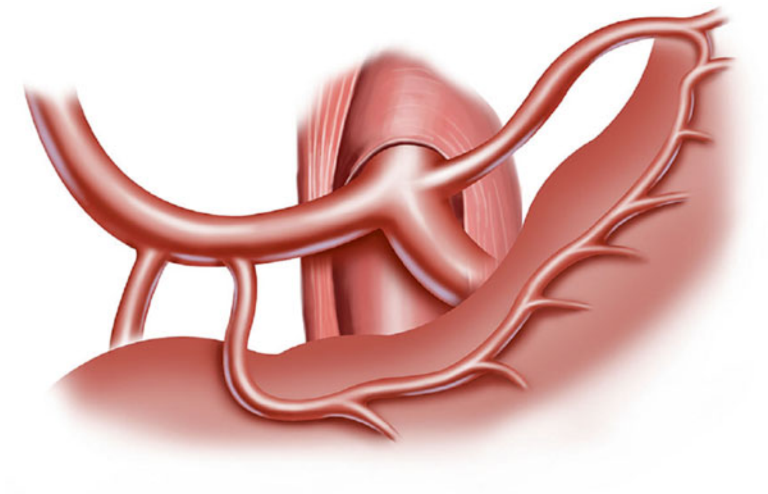


Fig. 5.69 The RGA originated from the CHA

lead to erroneous severing of the LGA when the LGA is thin and concealed in the lymphatic fatty tissues, resulting in a hidden risk of postoperative hemorrhage in enterocelia. Occasionally, the LGA of some patients derives from the abdominal aorta. In this case, the LGA cannot be found around the initial segment of the SpA, and it instead locates at the right posterior aspect of the CA. It is appropriate to dissect along this plane in a right posterior direction to expose the root of the LGA (Fig. 5.177). Subsequently, during the procedure of vascularizing the LGA, the functional face of the ultrasonic scalpels should not attach to the arterial wall, avoiding accidental damage to the LGA. If damage does occur, bleeding is vigorous. In these circumstances, the whole team should stay calm, and the assistant should maintain elevation of the stomach at the original position, using the left hand. And the right hand should use the aspirator and compress the hemorrhagic area and intermittently suck up the blood to control bleeding (Fig. 5.178). The surgeon should try to clamp the proximal end of the injured artery with the atraumatic grasping forcep to temporarily control the bleeding. After clearly exposing the bleeding area, the proximal end of the artery should be

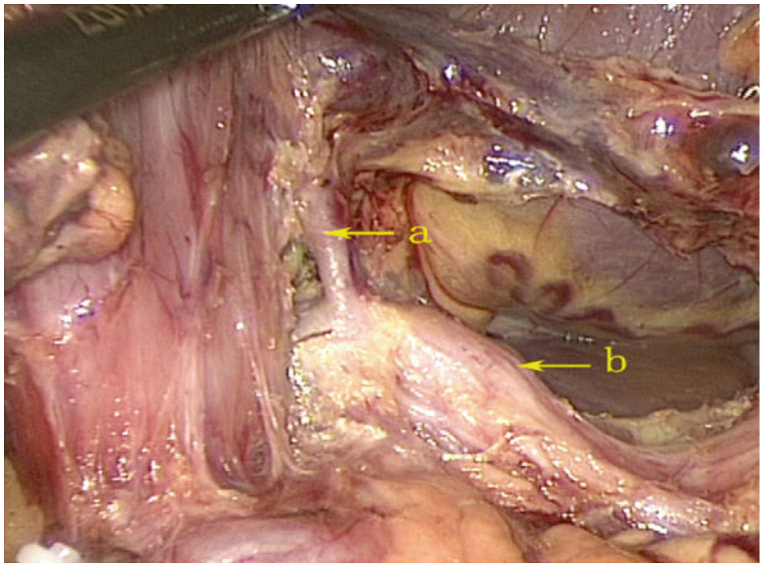


Fig. 5.70 The RGA (*a*) originated from the CHA (*b*)

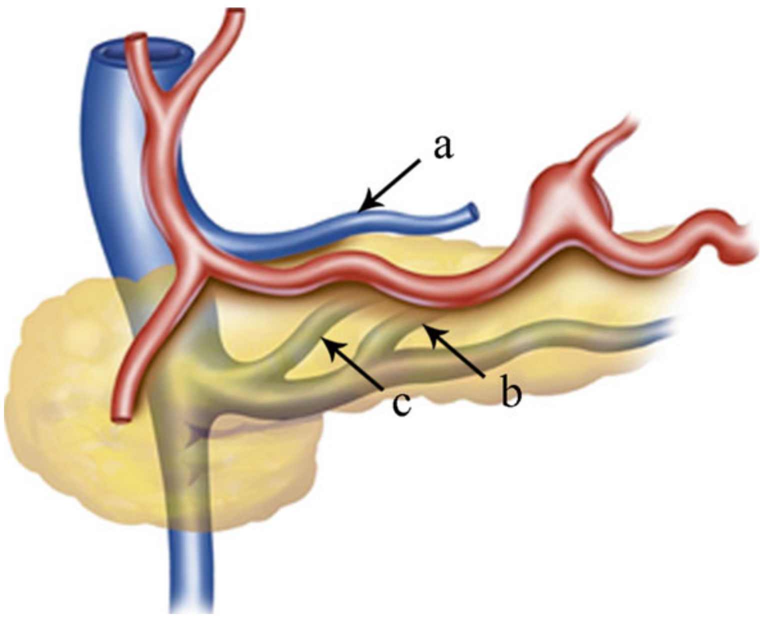


Fig. 5.71 The LGV (*a*) ends in the PV. The LGV (*b*) drains into the SpV. The LGV (*c*) drains into the splenoportal confluence

ligated to achieve hemostasis. Furthermore, the vascularized segment of the LGA should be longer than 1 cm to ensure enough space for severing after ligating with two clips. And it also prevents the clip on the stump of artery from dropping. When ligaturing the LGA, the clips should be clamped at a sufficient distance from the root of the LGA to prevent damage to the clips by the ultrasonic scalpels, which may result in unnecessary intraoperative hemorrhage (Fig. 5.179).

The CHA is the main anatomical landmark for dissection of the No. 8a LNs. Generally, we should detect the CHA along the surface of the SpA toward the right. For the patients whose CHA is absent, dissection is performed on the surface of the PV or the SpV directly. In these cases, the surgeon should shear with ultrasonic scalpels directly and gently rather than blunt dissection to avoid injuring the PV and causing bleeding (Figs. 5.180 and 5.181). If it really

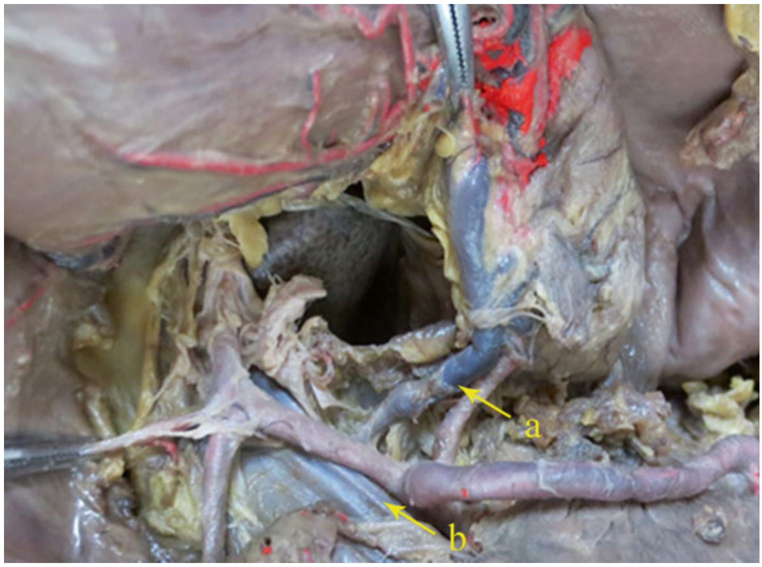


Fig. 5.72 The LGV (*a*) ends in the PV (*b*) (in autopsy)

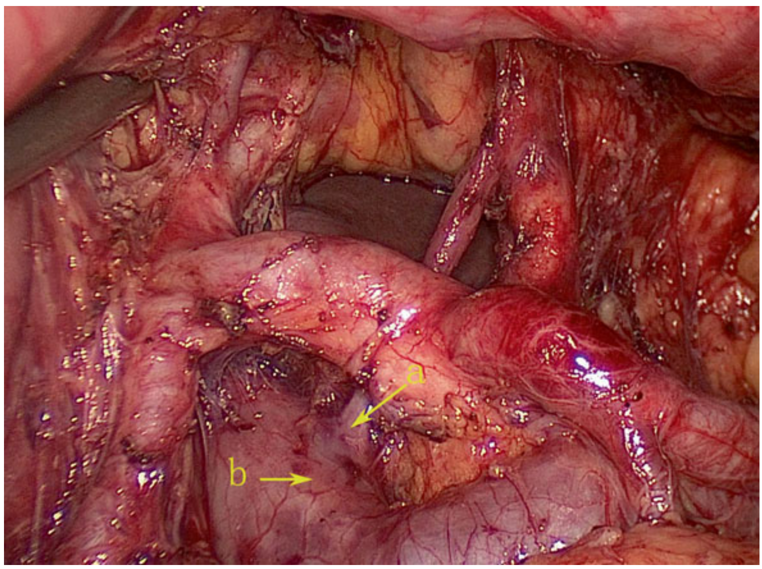


Fig. 5.73 The LGV (*a*) ends in the PV (*b*)

occurs, however, it does not allow the surgeon to grasp the hemorrhagic area directly, which may enlarge the hole and cause more severe hemorrhage. Minor bleeding can be handled through adequate gauze compression. If the bleeding is too serious to control, the operation should be changed to open surgery with compression of the hemorrhagic area in the meantime (Fig. 5.182). The surgeon should detect the anatomical space between the LNs and the CHA meticulously when the No. 8a LNs are obviously swollen. The assistant can lift the basilar part of the LNs to assist with exposure. The nonfunctional face of the ultrasonic scalpels should be placed close to the vessel by the surgeon to dissect the swollen LNs from the surface of the CHA (Fig. 5.183). The CHA of some patients is long and tortuous, which can easily be misidentified as swollen LNs. The difference can be identified by observing the arterial pulse (Figs. 5.184 and 5.185). During the procedure of dissection in this region, the focal distance of the lens should be set to the

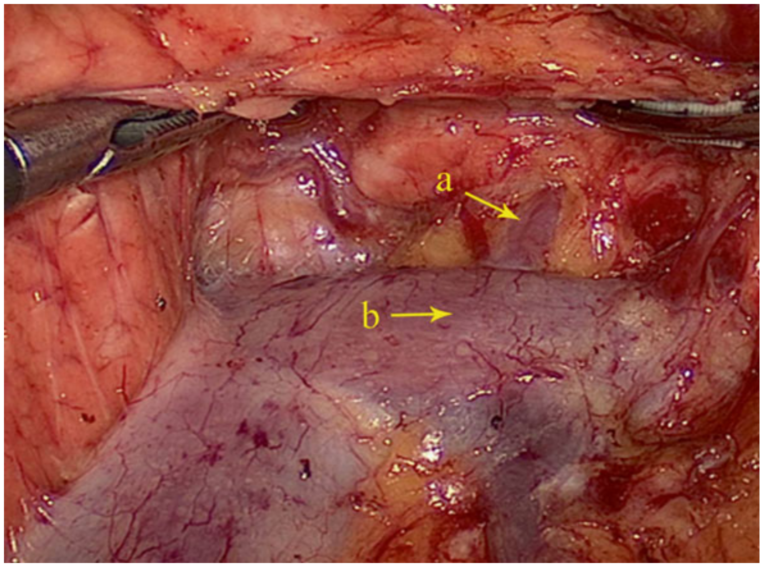


Fig. 5.74 The LGV (*a*) drains into the SpV (*b*)

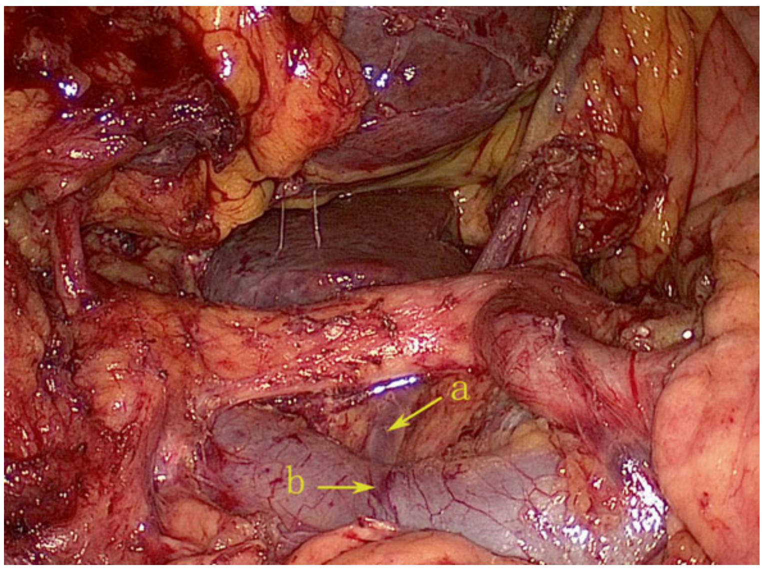


Fig. 5.75 The LGV (*a*) drains into the splenoportal confluence (*b*)

close view, which may be beneficial for the identification of vessels and LNs. Moreover, if the operation time is too long, visual fatigue can result, leading to unclear vision. In these cases, the camera assistant should adjust to the best focal distance by comparing with images from surrounding tissues. In other words, when the reflected light appears in the view, or the tissue capillaries or the texture of the nonfunctional face of the ultrasonic scalpels becomes distinct, the focal distance can be demonstrated to be optimal (Figs. 5.186, 5.187 and 5.188).

5.4.2 Surgical Techniques Involved in Dissection of the No. 12a and 5 LNs

5.4.2.1 Surgical Techniques Involved in Dissection

Continuing to the right side along the surface of the CHA, the No. 5 LNs can be dissected. The assistant lifts the posterior wall of the gastric antrum right upward with the forceps in the left hand and pushes the duodenum outward with the other hand to expose the CHA, the GDA, and the

Fig. 5.76 The frontal view of the intrahepatic LGV (*a*)

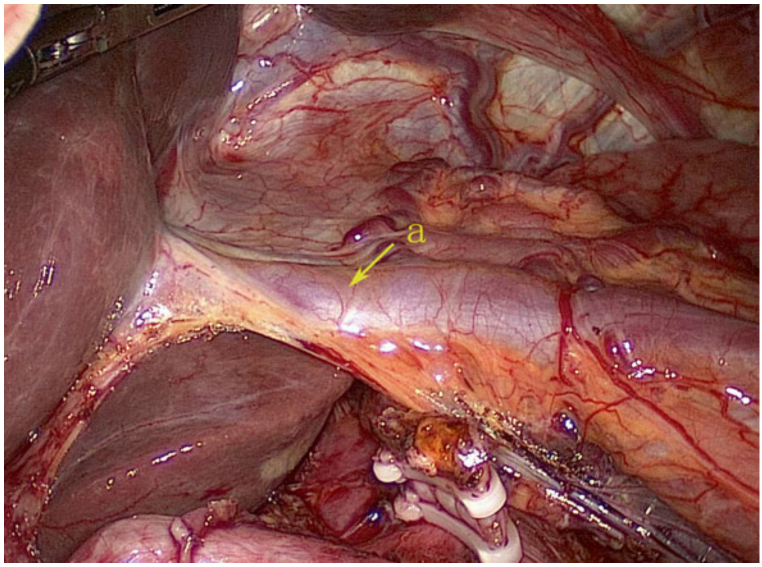
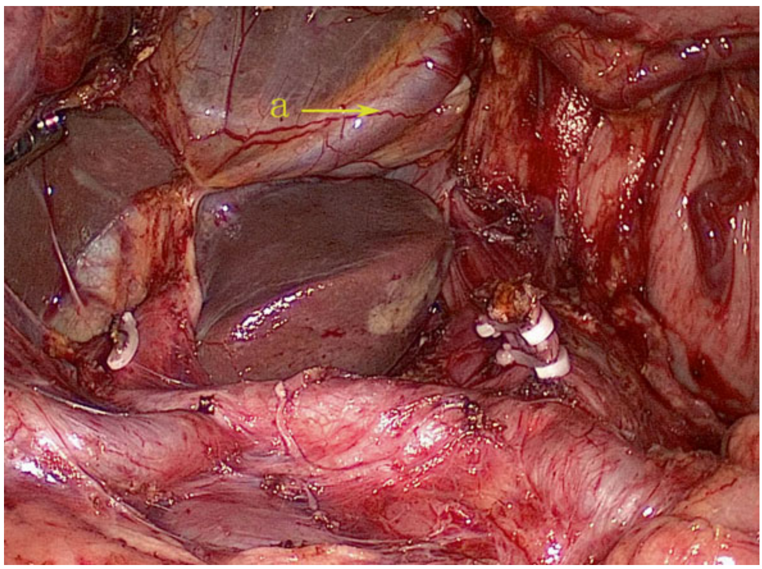


Fig. 5.77 The rear view of the intrahepatic LGV (*a*)



partially vascularized PHA (Fig. 5.189). Next, the assistant should use the aspirator or forceps to dissect bluntly the posterior wall of the duodenum up and down, assisting the surgeon in separation and exposure of the course of the RGA. Dissection of the No. 5 LNs is completed after vascularizing and severing the vessel at the root (Fig. 5.190). After severing the RGA, the surgeon should divide the anterior lobe of the HDL along the PHA until it has been dissociated completely. A window should be created on the right side of the ligament, which serves as a landmark for separation of the dissociated ligament from the ventral side later (Figs. 5.191 and 5.192). In some overweight patients or those with adhesions on the right side of the HDL, it is difficult to create such a window. Therefore, a piece of gauze should be settled on the surface of the PHA to act as a landmark for division as well as to avoid injury to the common bile duct caused by separating too deeply (Figs. 5.193 and 5.194). As a result of the narrow and deep operating field here, the camera assistant should adjust the orientation of the optical fiber properly to avoid

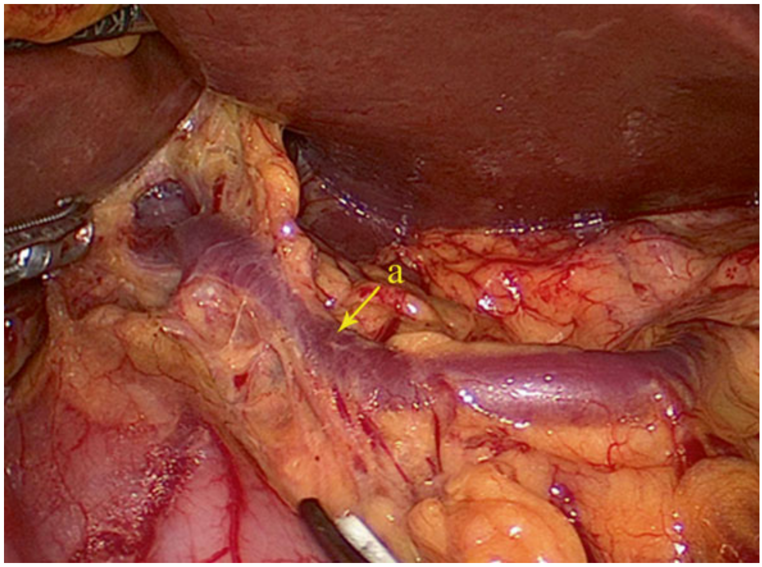


Fig. 5.78 The LGV is absent and the RGV (*a*) is enlarged in compensation (frontal view)

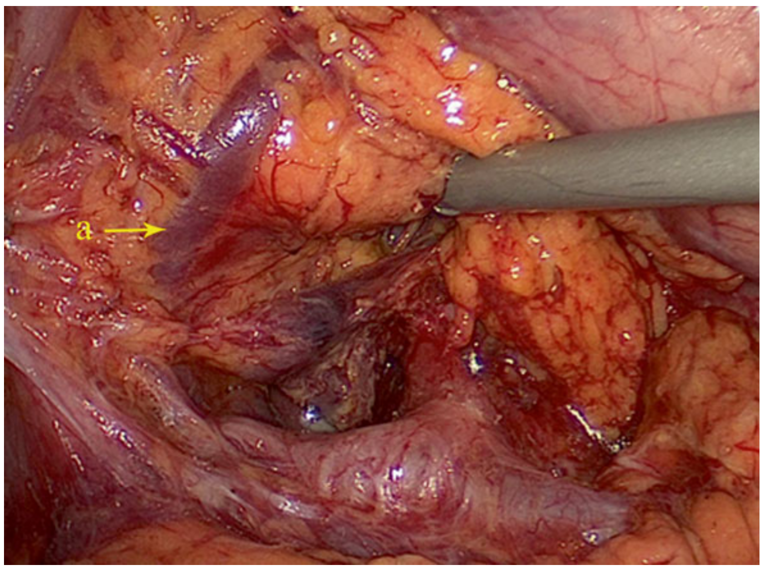


Fig. 5.79 The LGV is absent and the RGV (*a*) is enlarged in compensation (rear view)

visual obscuring by other instruments (Fig. 5.195).

5.4.2.2 Prevention of Damage to Adjacent Tissues and Organs

Adhesion between the caudate lobe of the liver and the HGL may be detected in some patients, which should be divided before transecting the ligament to avoid laceration and hemorrhage. The PHA is an important anatomical landmark for division of the No. 12a LNs. After vascularizing the CHA, the initial segment of the PHA can be exposed by continuing to the right side. No. 12a lymph node dissection is achieved after the PHA has been vascularized from the origin to the porta hepatis (Fig. 5.196). The GDA, which has few variations, runs in the groove between the duodenum and the head of the pancreas. When denuding the duodenum, the small vessels that branch off from the GDA and supply the posterior wall of the duodenum should be divided carefully. Moreover, during the process, these vessels should be confirmed to be occluded suf-

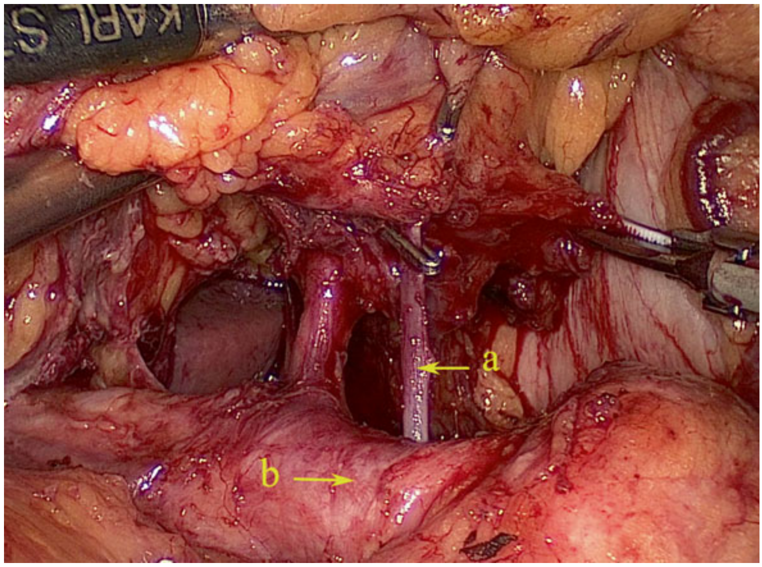


Fig. 5.80 The LGV (*a*) runs across the dorsal side of the SpA (*b*)

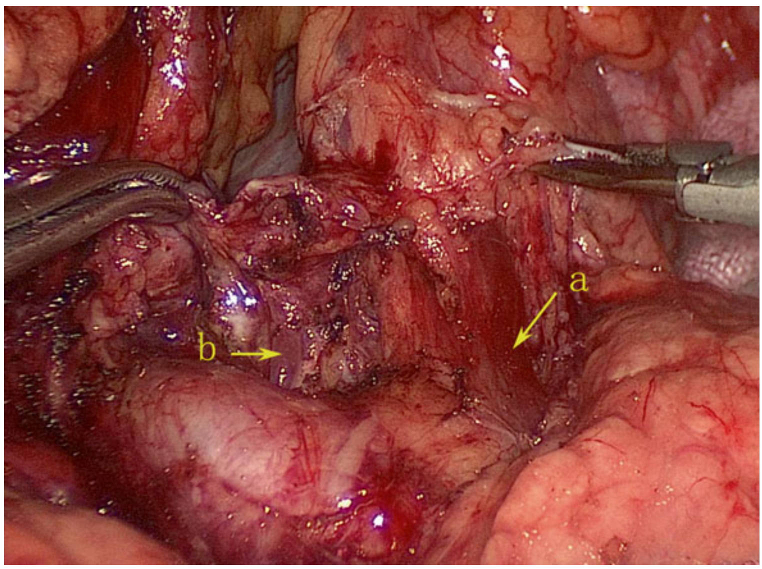


Fig. 5.81 Double LGVs (*a*, *b*)

ficiently with the ultrasonic scalpels and then severing with minimum speed (Fig. 5.197). If the vessels bleed here, it is appropriate to compress with gauze to stop it rather than using ultrasonic scalpels, because a blind operation may cause massive hemorrhage or even injure the posterior wall of the duodenum.

Vascular Injury Prevention

The origin of the RGA always varies considerably. During surgery, unknown vessels should not be severed blindly, because the thin and long PHA may be incorrectly identified as the RGA when the assistant elevates the gastric antrum (Fig. 5.198). For some patients, the hepatic branches of the vagus nerve, which run in front of the RGA, are enlarged, making it difficult to distinguish them from the RGA. The differences can be identified by observing the arterial pulse or further vascularizing the structure. Thus, the enlarged vagus nerve should be severed first to make it beneficial for following exposure of the RGA (Fig. 5.199). The RGA is most frequently associated with the RGV, and

Fig. 5.82 PV (*a*) (in autopsy)

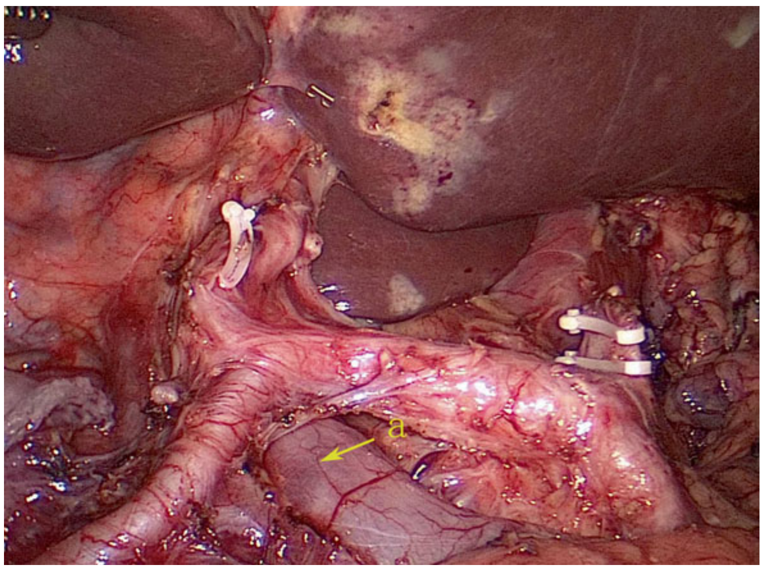


Fig. 5.83 The PV (*a*) is an important structure in the portal triad

under these circumstances, the two vessels can be ligatured together (Fig. 5.200). However, the RGV is far away from the RGA in some cases, which should be severed respectively (Fig. 5.201).

When dividing the HGL, the ALHA or ALGA should be identified. The latter can be severed at its origin. However, whether the ALHA can be severed during surgery has not reached a consensus. Complications have been reported, including abscess formation, cholangitis, liver failure, and even liver lobe necrosis after severing the ALHA. Some authors have even suggested performing prophylactic resection of the left liver lobe to avoid hepatic necrosis when the artery is severed during surgery. We retrospectively analyzed the clinical data of 1,173 cases of gastric cancer that underwent laparoscopy-assisted radical gastrectomy in our center [19]. Patients were divided into groups with or without ALHA, and the artery was routinely severed. We found that patients with or without an ALHA had similar intraoperative and postoperative recovery

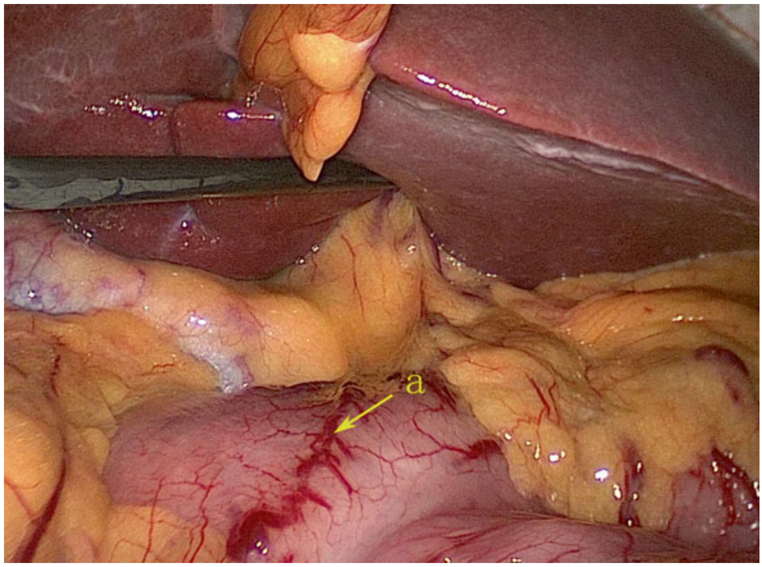


Fig. 5.84 Prepyloric vein (*a*)

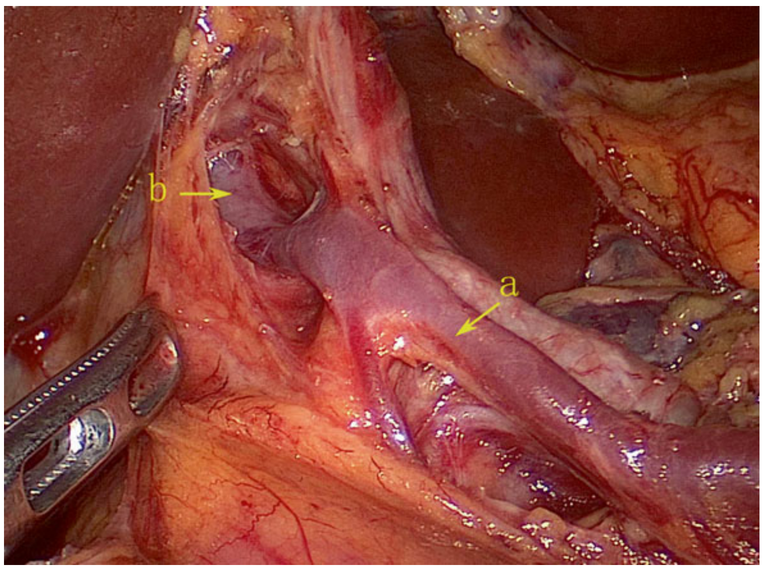


Fig. 5.85 The RGV (*a*) enters the HDL before draining into the PV (*b*)

characteristics and morbidity and mortality rates. Although our findings suggest that patients with an ALHA have poorer liver function at postoperative day 7 than those without an ALHA, stratified analysis showed no significant differences in liver function in patients without chronic liver disease (CLD) between patients with a severed ALHA and those without an ALHA. In patients with CLD, however, those with a severed ALHA had significantly higher liver function indices than those without an ALHA. Angiographic examination before and after therapeutic ligation of the hepatic artery, as well as corrosion cast studies [23–25], has shown collateralization between the intrahepatic and adjacent arteries. Although we detected ischemia in the left liver lobe intraoperatively, neither hepatic necrosis nor impaired liver function was observed following hepatic artery ligation. However, because infiltration of inflammatory cells, extensive hepatocyte necrosis, and proliferation of fibrous tissue reduce liver reserve function in patients with

CLD, including chronic hepatitis and cirrhosis [26–28], these patients are less tolerable of ischemia and hypoxia than patients without CLD. Thus, severing the ALHA can easily induce liver dysfunction in patients with CLD. As a result, we suggest that the ALHA should be left intact in patients with CLD to prevent liver dysfunction. That is to say, the LGA should be severed above the bifurcation of the ALHA from the LGA. If ALHA is severed intraoperatively, the patient should be monitored, and liver-protecting therapy may be necessary (Figs. 5.202, 5.203, 5.204, 5.205, and 5.206).

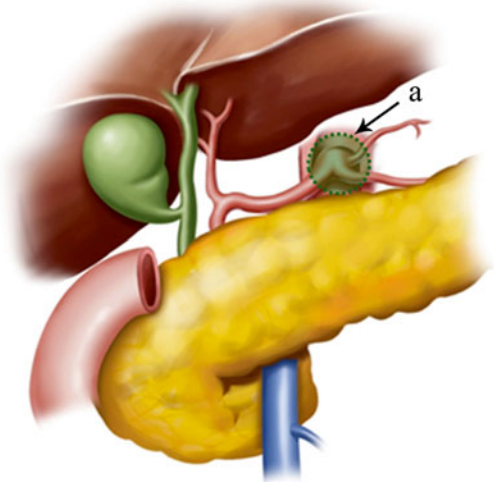


Fig. 5.86 No. 9 LNs (*a*)

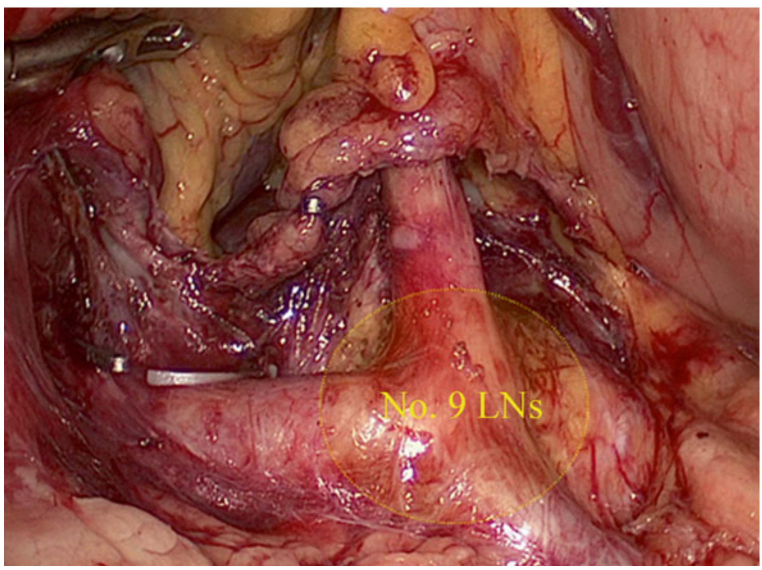


Fig. 5.87 The scope of the No. 9 LNs

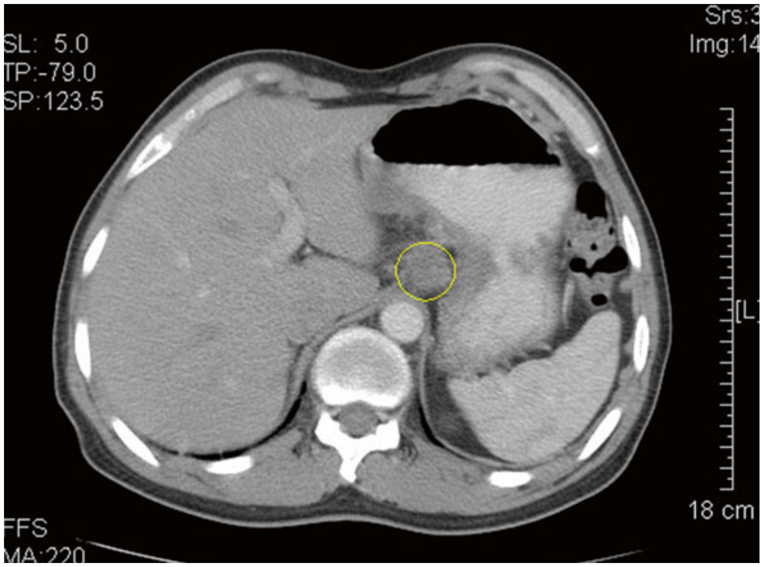


Fig. 5.88 The preoperative CT image showing No. 9 LNM (the *circle* represents the swollen No. 9 LNs)

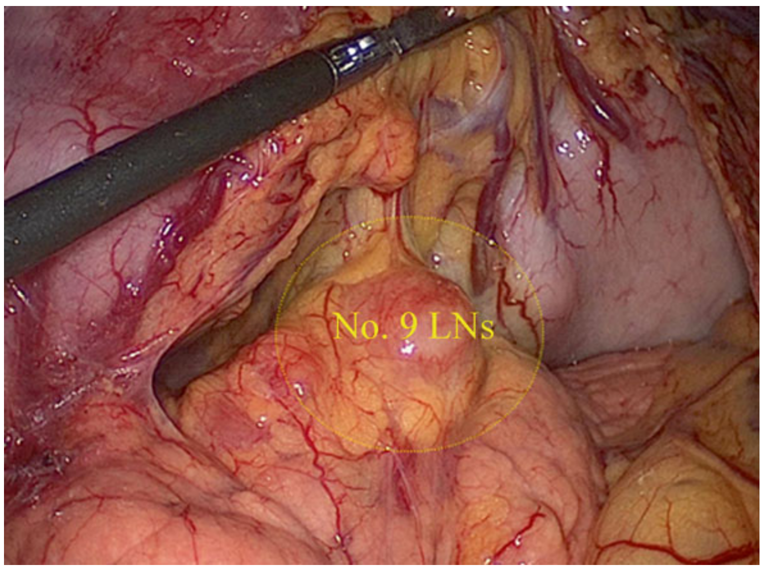


Fig. 5.89 The preoperative view of the No. 9 LNM

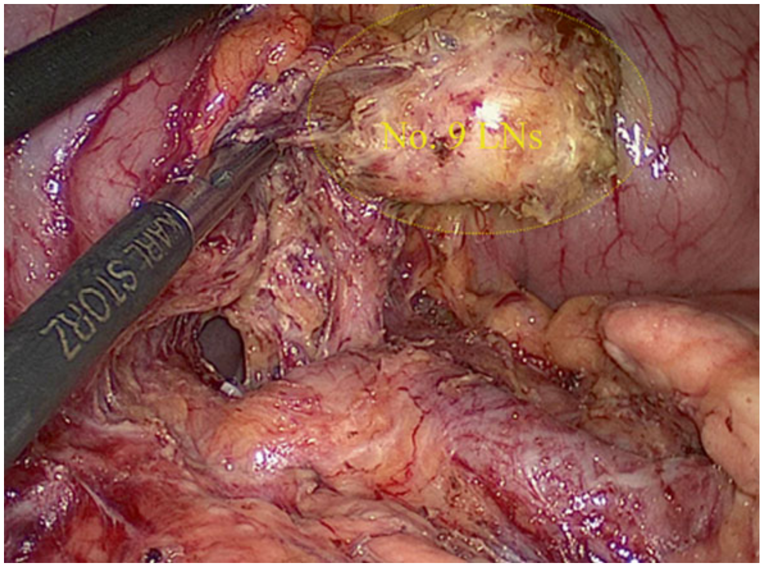


Fig. 5.90 No. 9 LNM (appearance after the dissection)

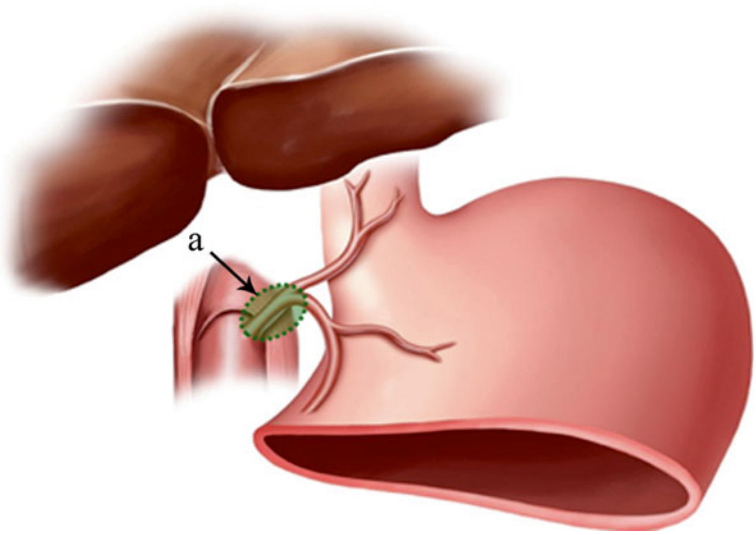


Fig. 5.91 No. 7 LNs (*a*)

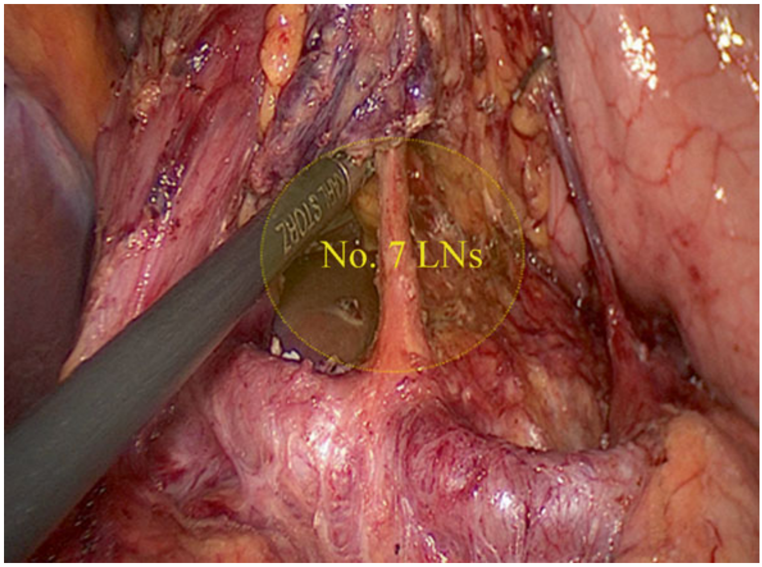


Fig. 5.92 The scope of the No. 7 LNs

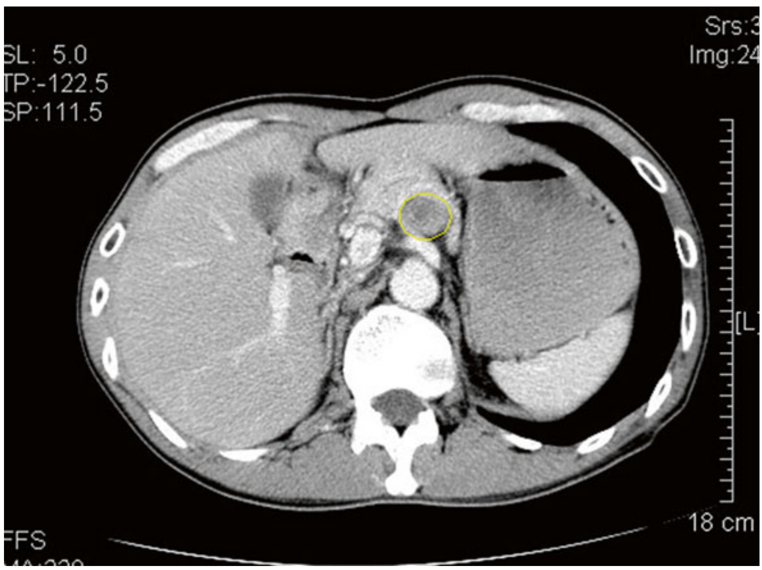


Fig. 5.93 The preoperative CT image of No. 7 LNM (the *circle* represents the swollen No. 7 LNs)

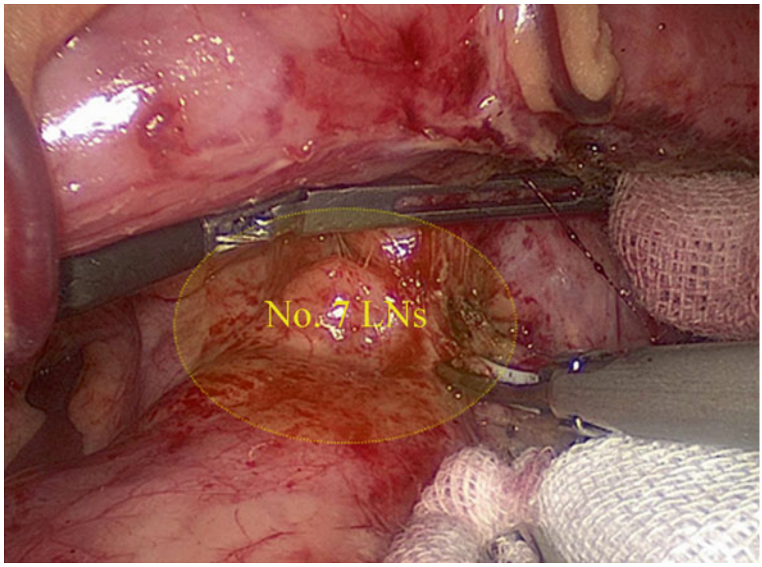


Fig. 5.94 The preoperative view of No. 7 LNM

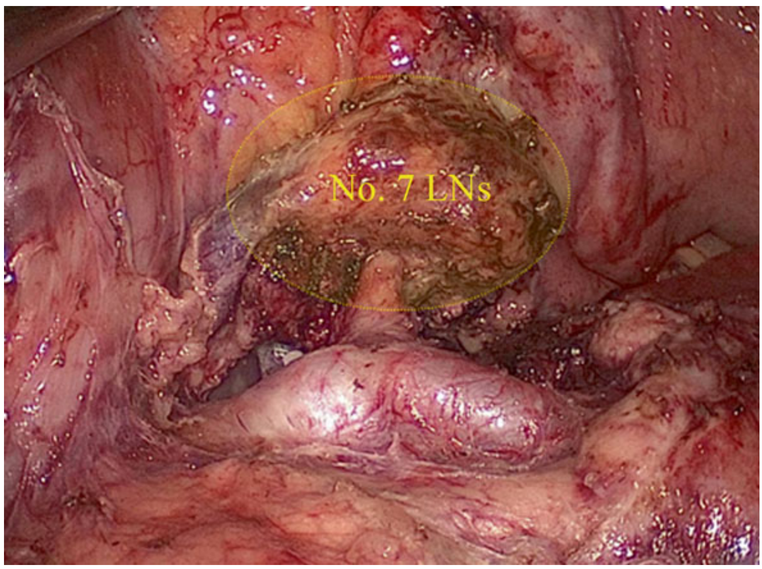


Fig. 5.95 No. 7 LNM (appearance after the dissection)

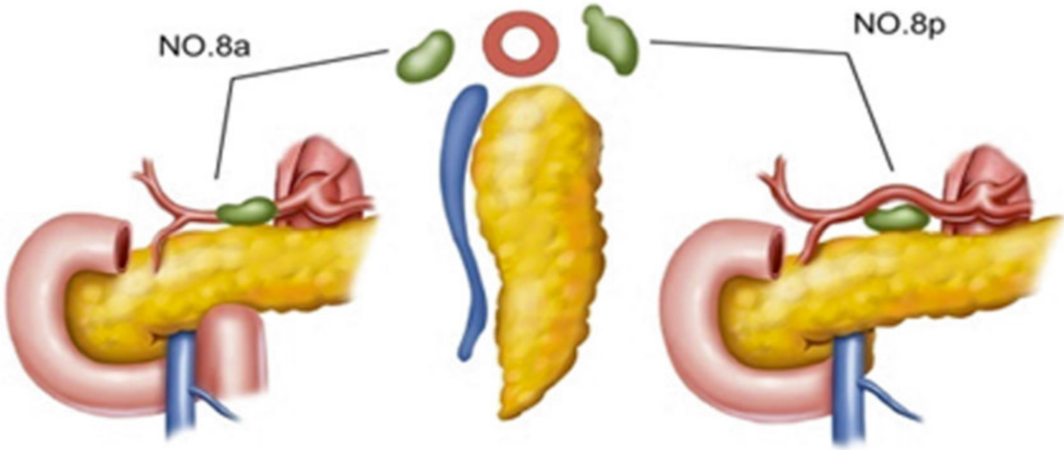


Fig. 5.96 The schematic figure of the No. 8 LNs

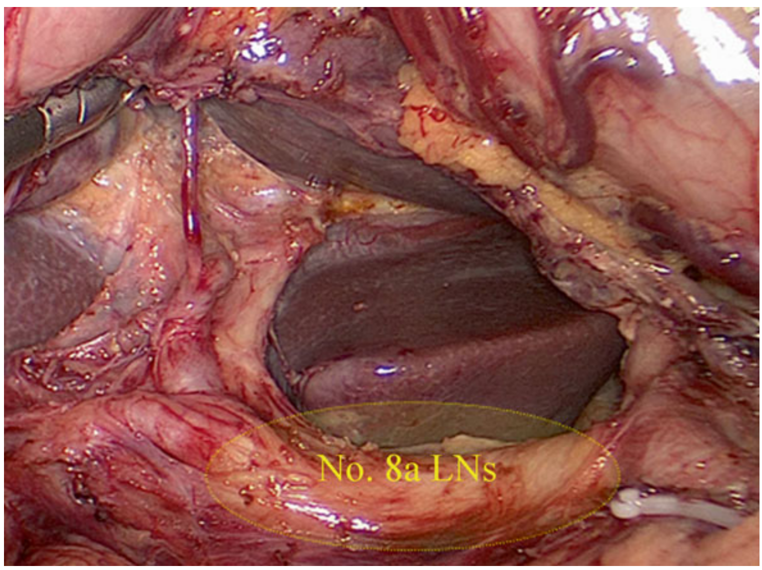


Fig. 5.97 The scope of the No. 8 LNs

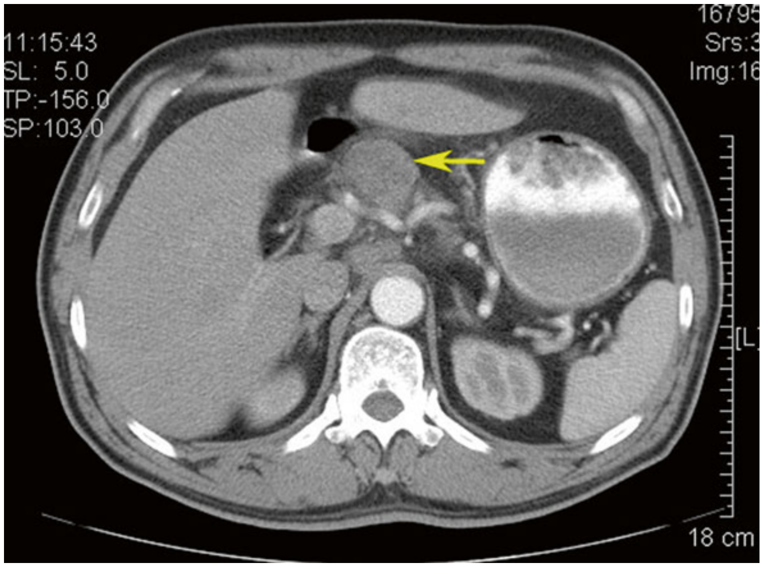


Fig. 5.98 The preoperative CT image of No. 8 LNM (the *arrow* represents the swollen No. 8 LNs)

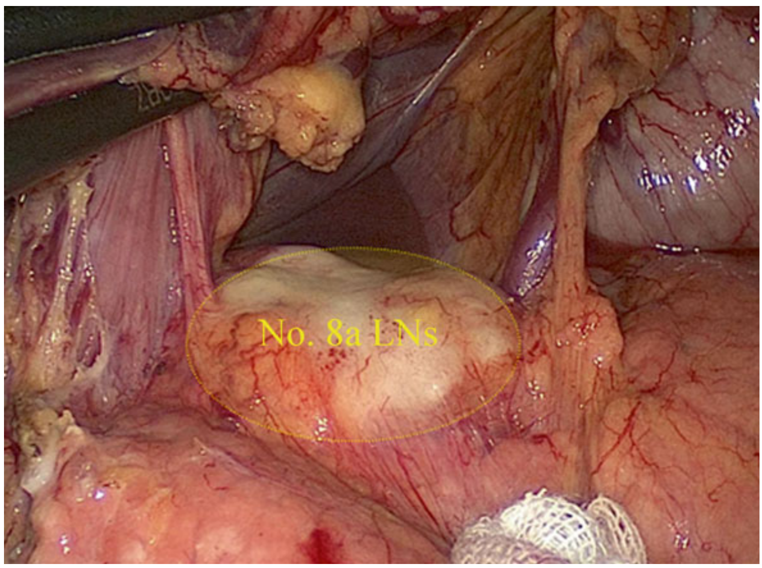


Fig. 5.99 The preoperative view of No. 8a LNM

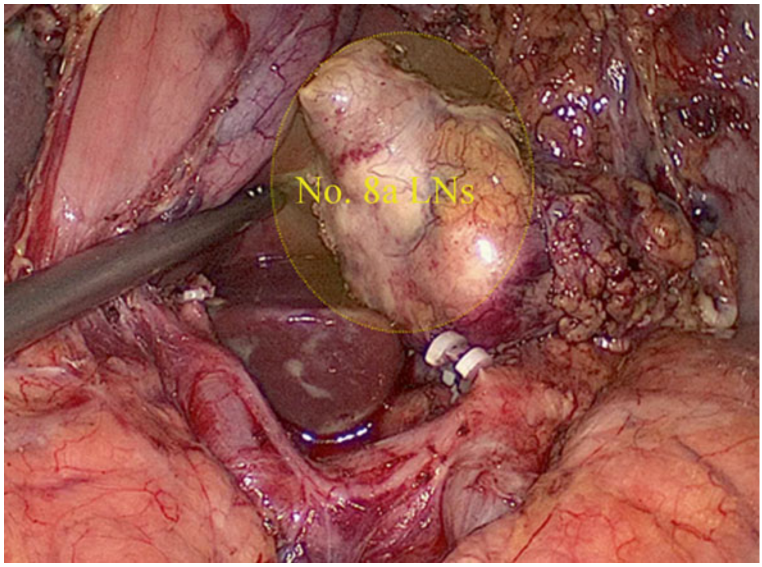


Fig. 5.100 No. 8a LNM (appearance after the dissection)

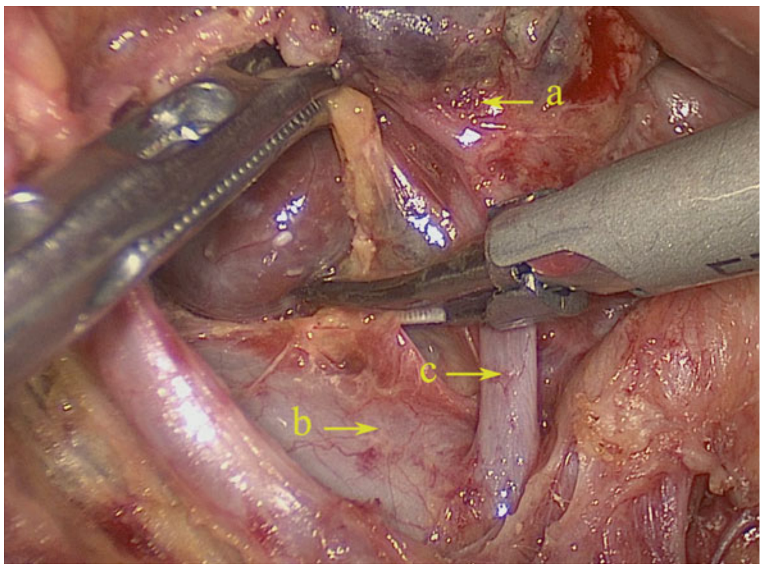


Fig. 5.101 No. 8p LNM (*a*). PV (*b*) and LGV (*c*)

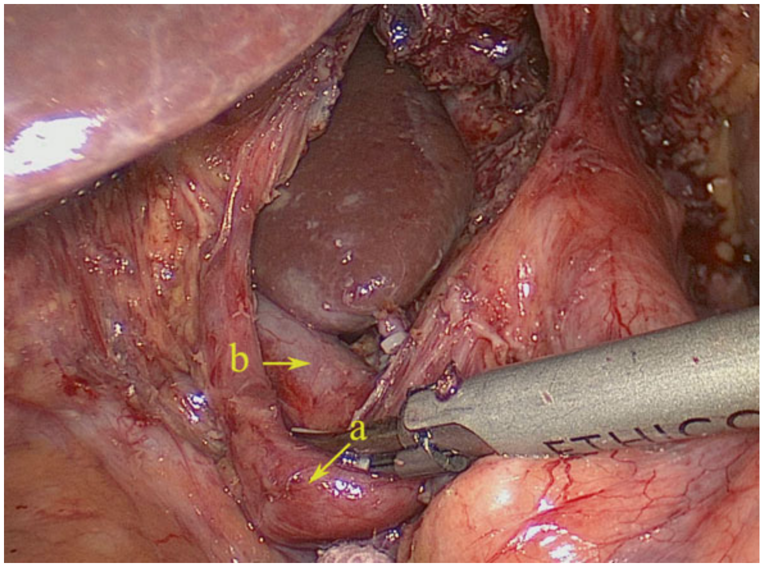


Fig. 5.102 View after the No. 8p LNM. CHA (*a*) and PV (*b*)

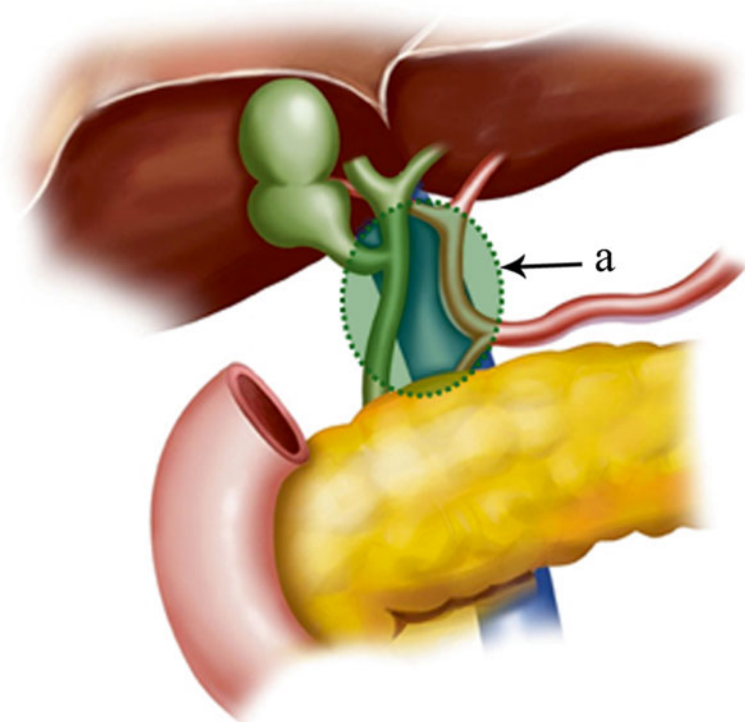


Fig. 5.103 No. 12 LNs (*a*)

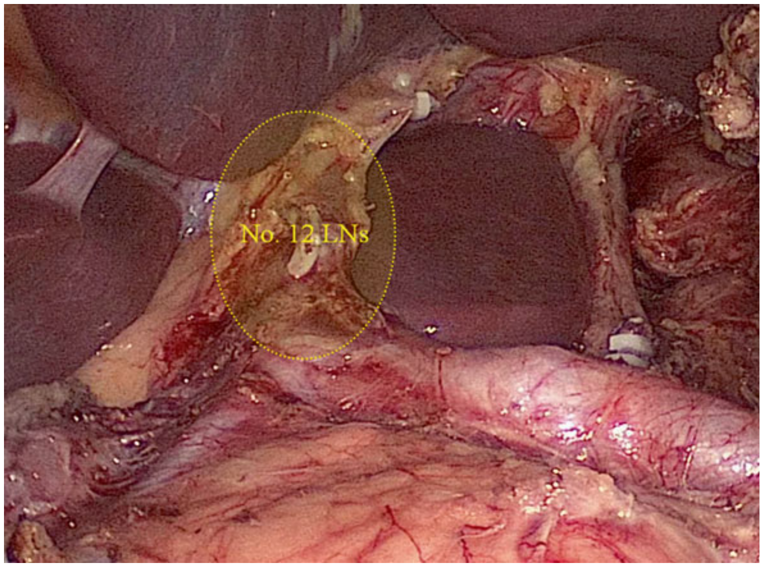


Fig. 5.104 The scope of the No. 12 LNs

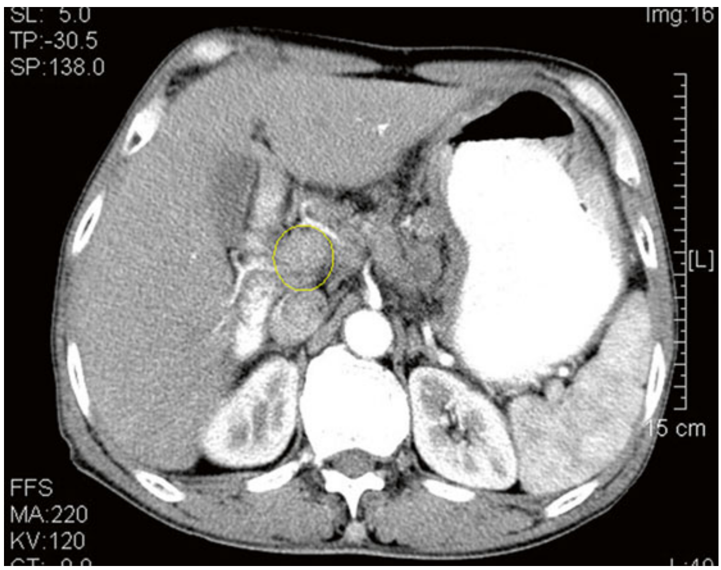


Fig. 5.105 The preoperative CT image of No. 12 LNM (the *circle* represents the swollen No. 12 LNs)

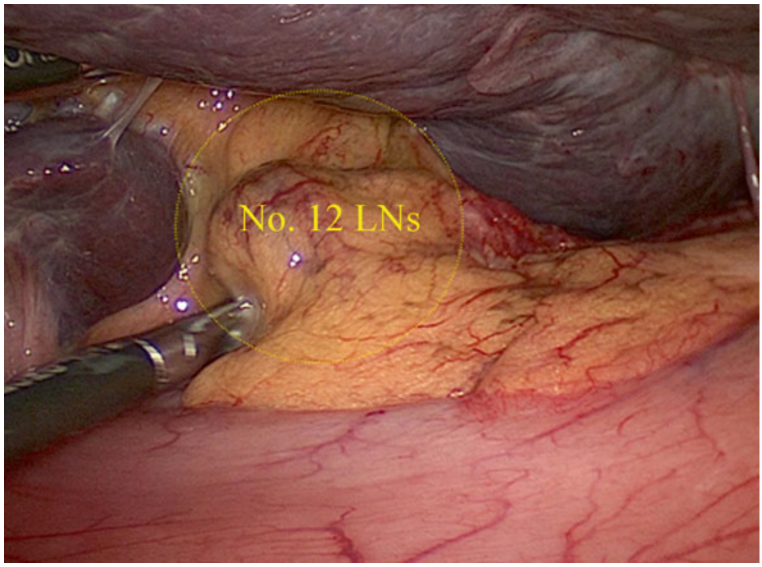


Fig. 5.106 The preoperative view of No. 12 LNM

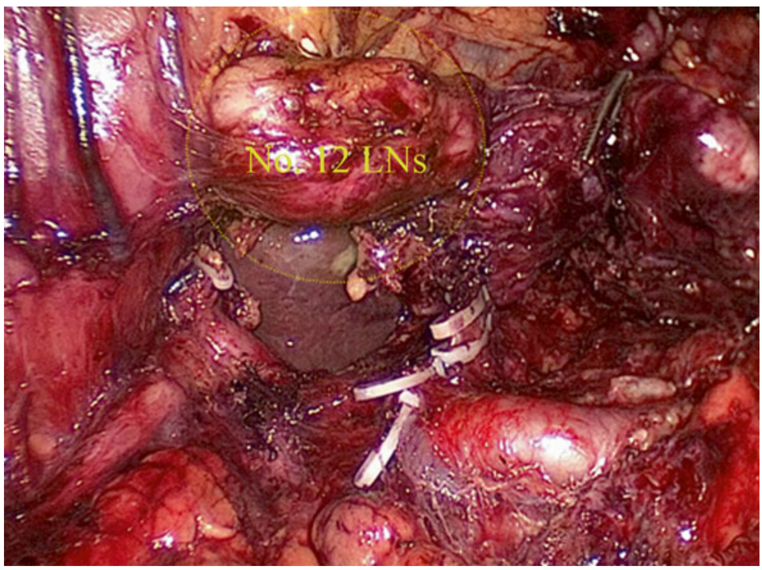
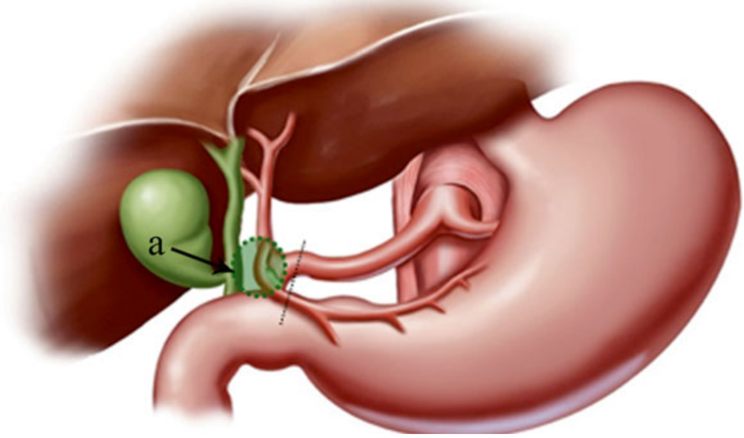


Fig. 5.107 No. 12 LNM (appearance after the dissection)

Fig. 5.108 No. 5 LNs (*a*)



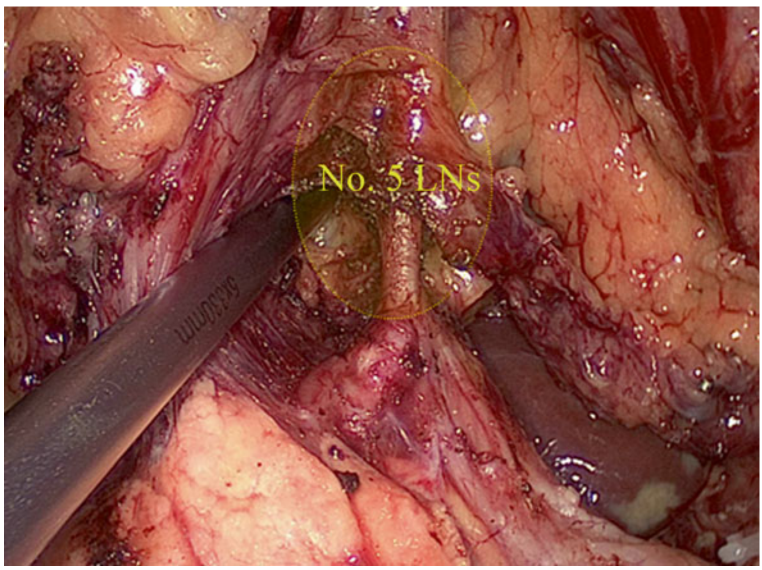


Fig. 5.109 The scope of the No. 5 LNs

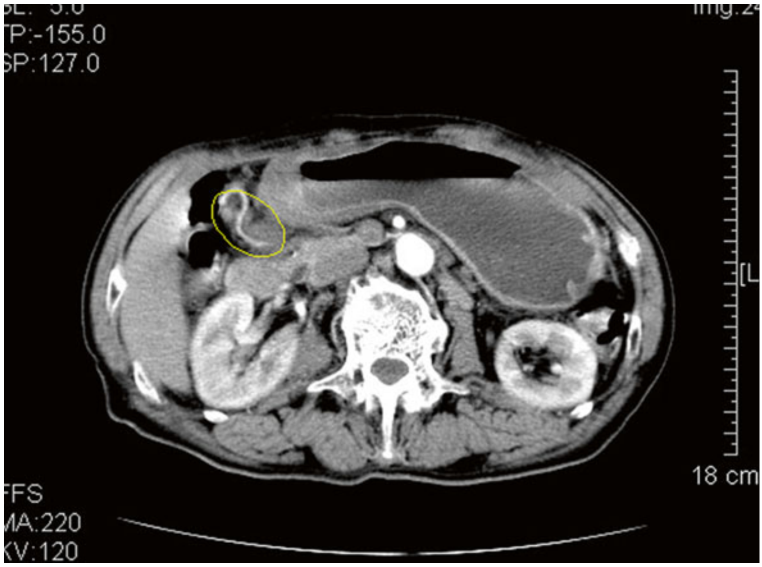


Fig. 5.110 The preoperative CT image of No. 5 LNM (the *circle* represents the swollen No. 5 LNs)

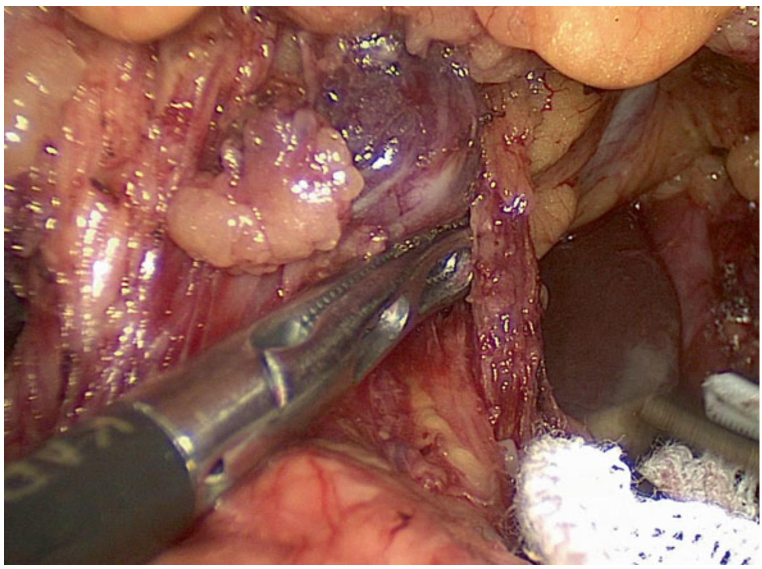


Fig. 5.111 The preoperative view of No. 5 LNM

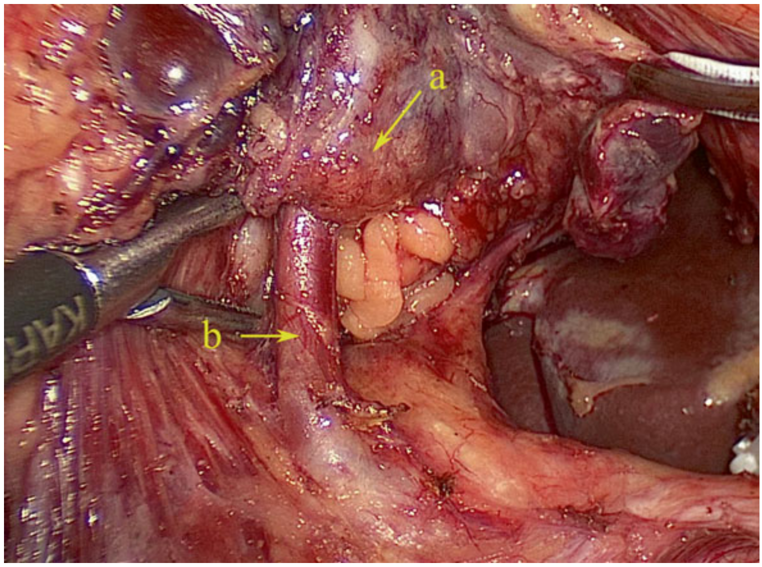


Fig. 5.112 No. 5 LNM (*a*) (appearance after the dissection). RGA (*b*)

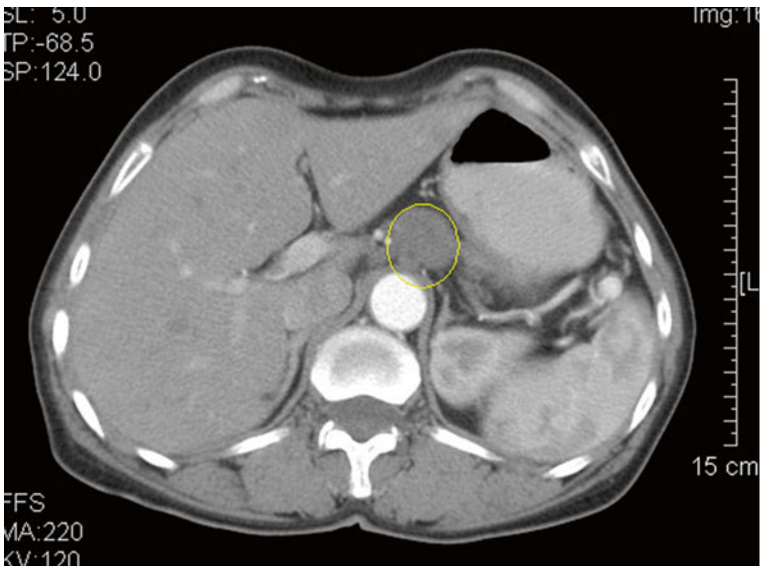


Fig. 5.113 The CT image of LNs in the suprapancreatic area before the neoadjuvant chemotherapy (the *circle* represents the swollen LNs in the suprapancreatic area)

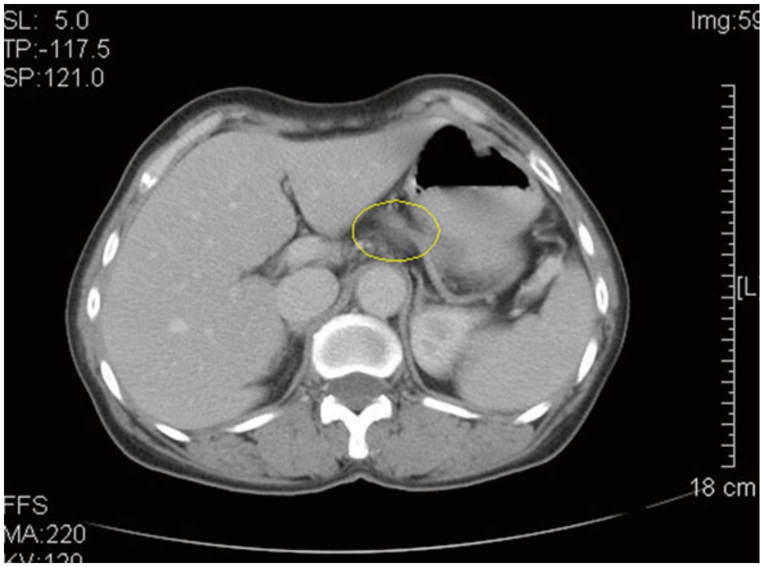


Fig. 5.114 The CT image of LNs in the suprapancreatic area after the neoadjuvant chemotherapy (the *circle* represents the swollen LNs in the suprapancreatic area)

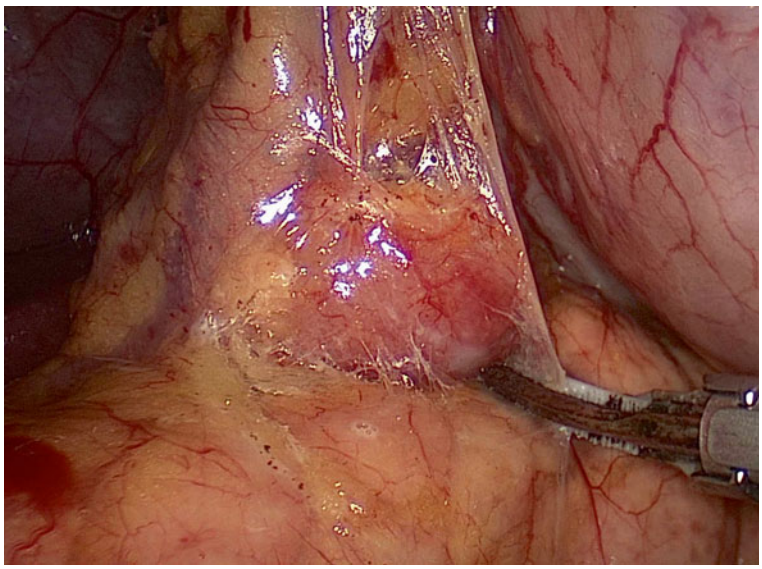


Fig. 5.115 Intraoperative view of LNs in the suprapancreatic area

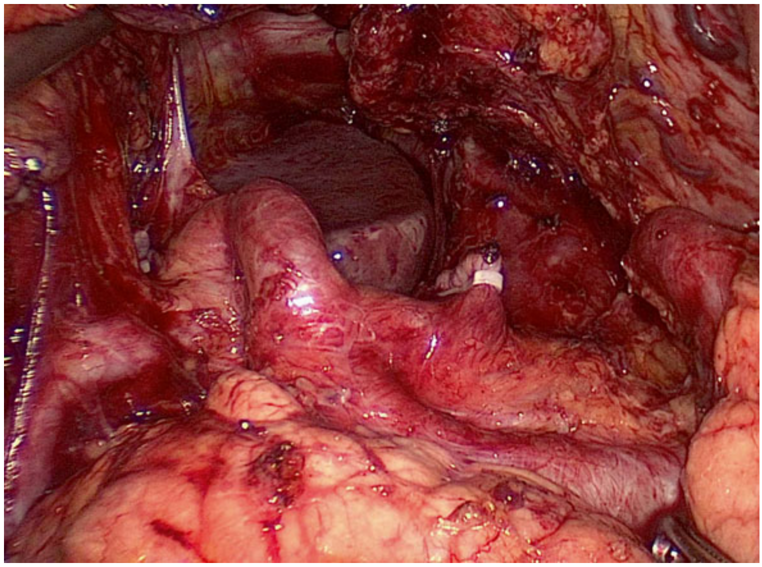


Fig. 5.116 View after lymph node dissection in the suprapancreatic area

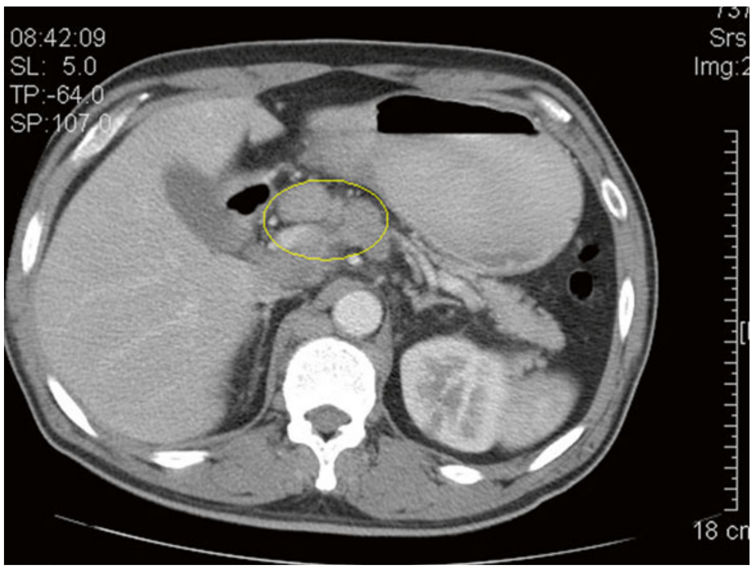


Fig. 5.117 The CT image showing LNs in the suprapancreatic area before the neoadjuvant chemotherapy (the *circle* represents the LNs in the suprapancreatic area)

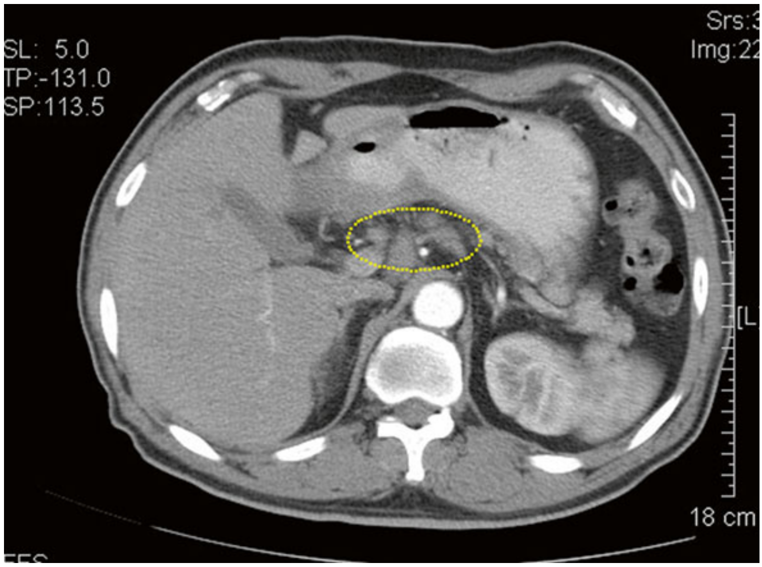


Fig. 5.118 The CT image showing LNs in the suprapancreatic area after the neoadjuvant chemotherapy (the *circle* represents the LNs in the suprapancreatic area)

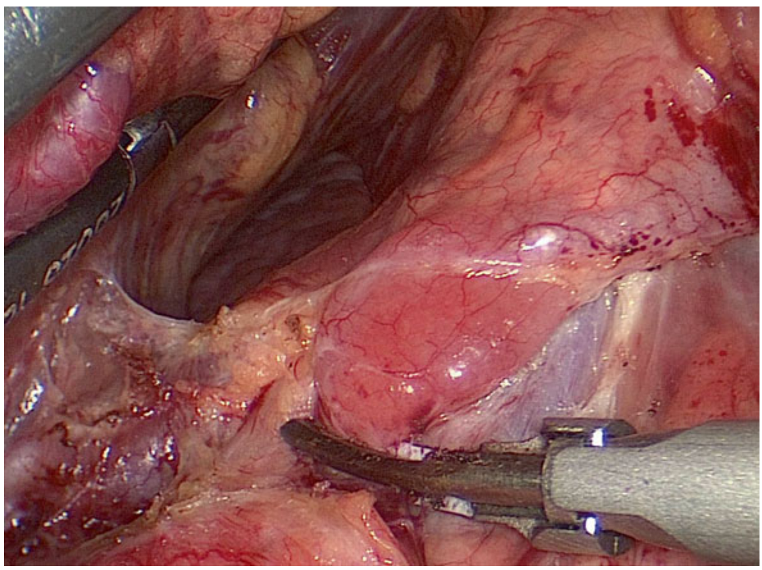


Fig. 5.119 Intraoperative view of LNs in the suprapancreatic area

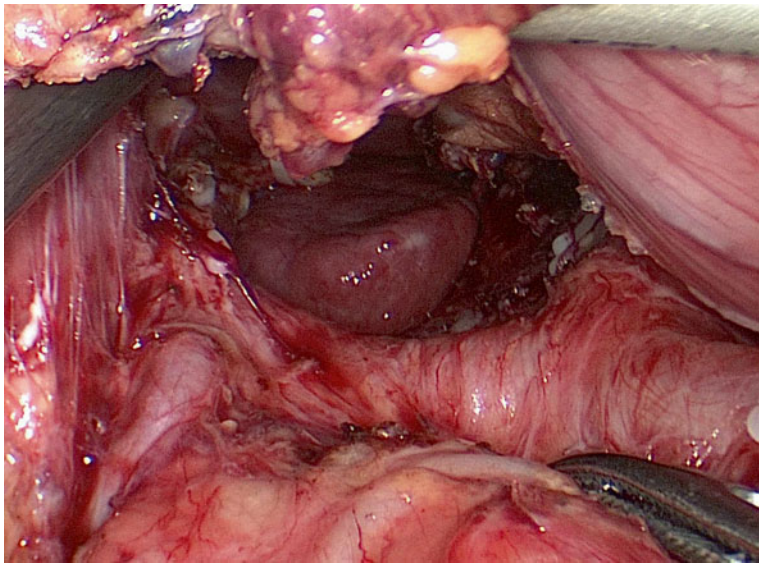


Fig. 5.120 View after lymph node dissection in the suprapancreatic area

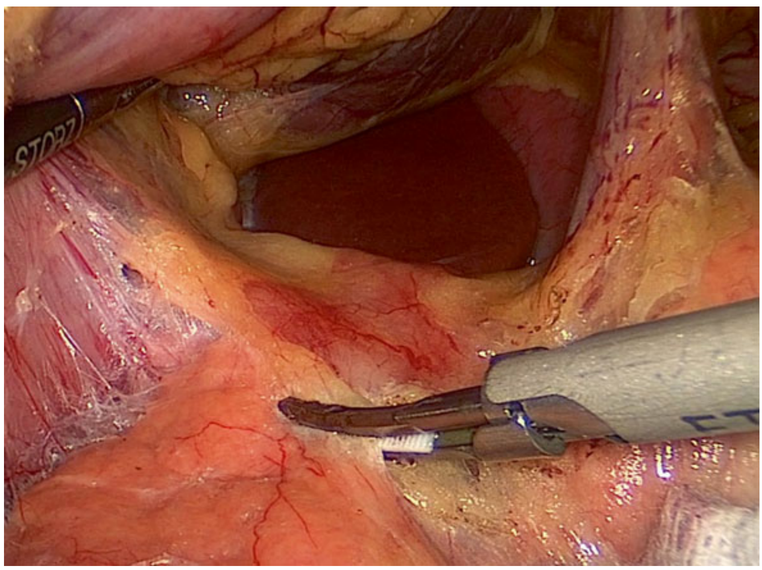


Fig. 5.121 The LNs are dissected from the behind of the stomach

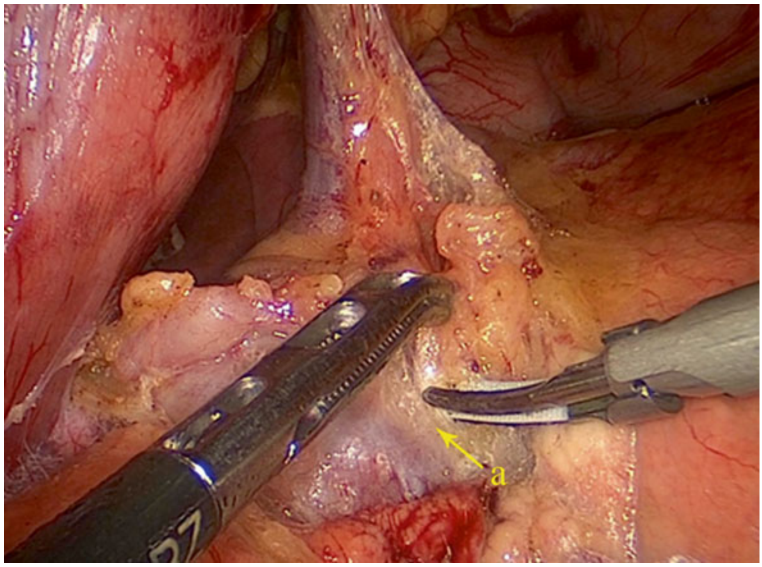


Fig. 5.122 The approach to the dissection is from the initial segment of the SpA (*a*)

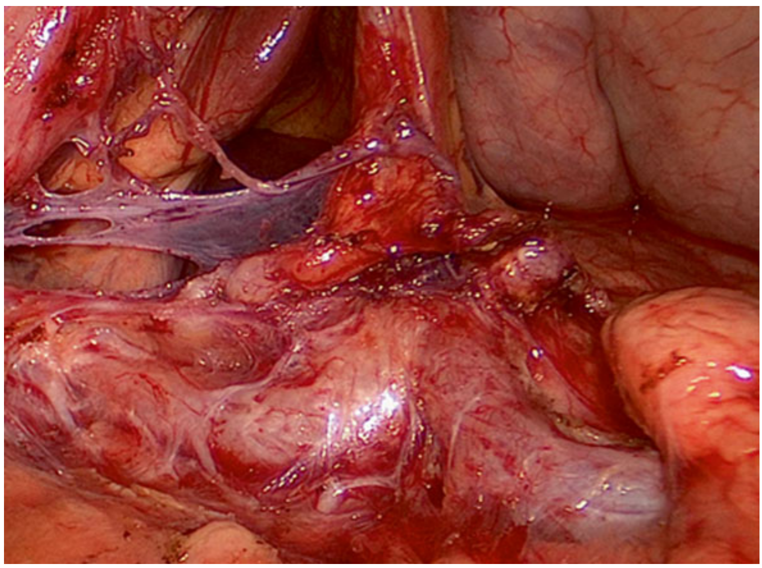


Fig. 5.123 Location of the initial segment of the SpA is relatively constant with lesser anatomical variation

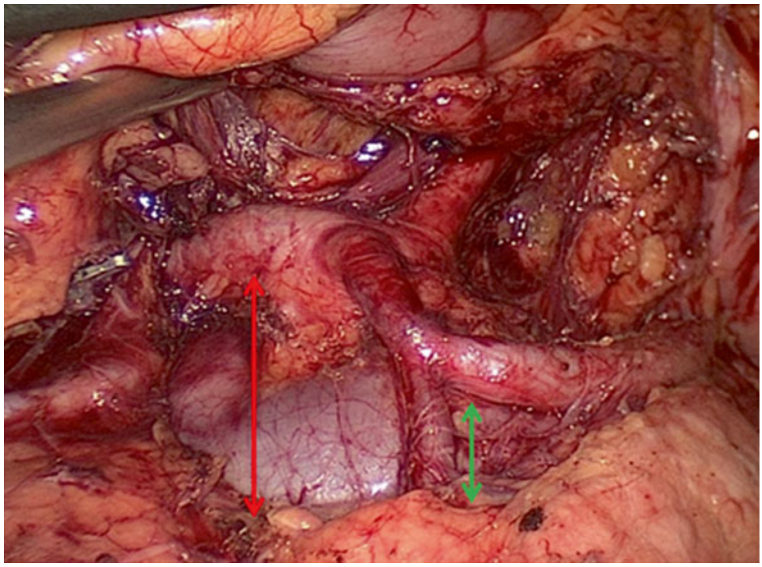


Fig. 5.124 The initial segment of the SpA is relatively constant with the proximity to the superior margin of the pancreas, and it is easy to be exposed (The *red* and *green* *double-headed arrows* represent the distance)

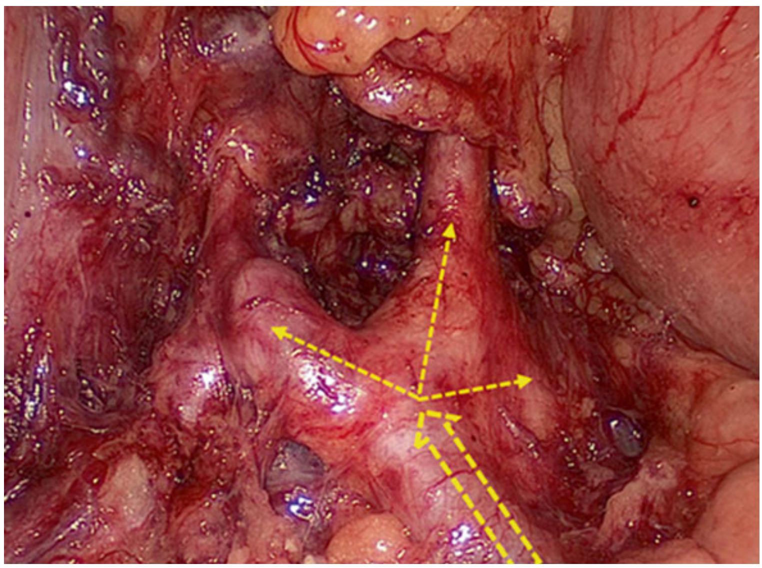


Fig. 5.125 Searching the CA, the LGA, and the CHA from the root of the SpA toward right side

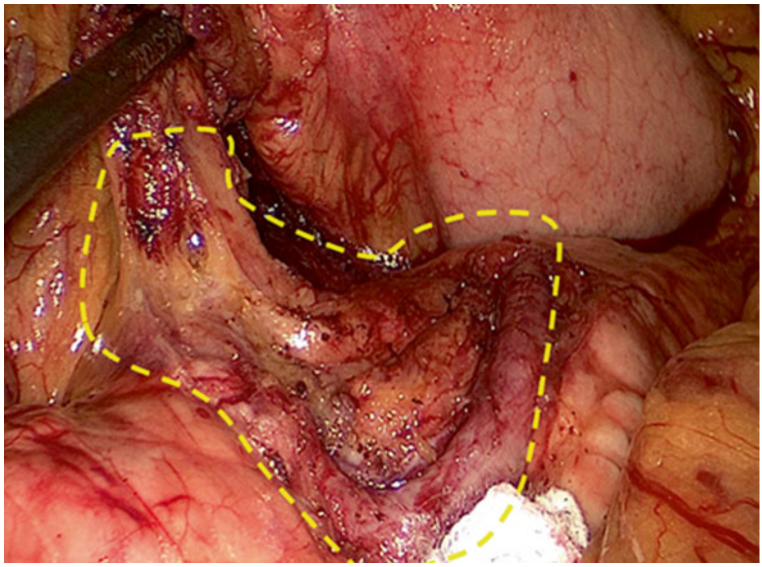


Fig. 5.126 This area is almost avascular, resulting in a low risk of bleeding

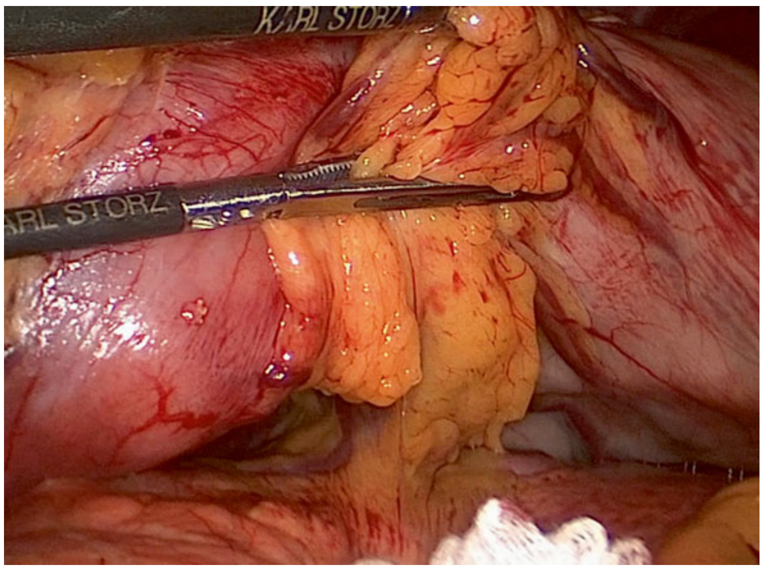


Fig. 5.127 The assistant's left hand lifts up the GPF by clamping the junction of its upper and middle segments

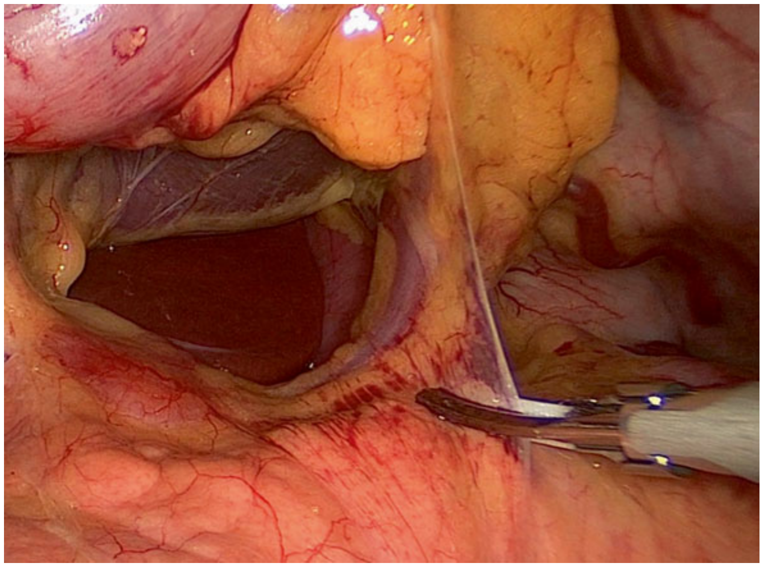


Fig. 5.128 The RPS is entered by dissecting along the left side of the GPF

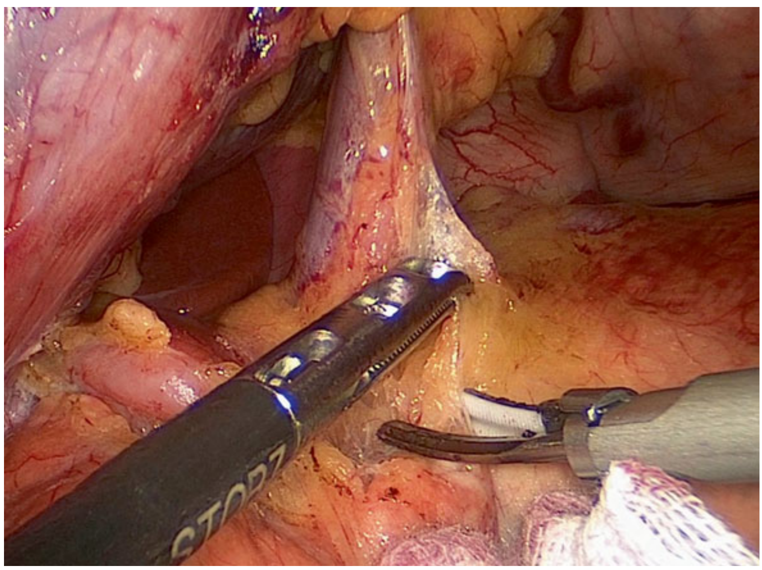


Fig. 5.129 The initial segment of the SpA can be found at the left side of the GPF in the RPS

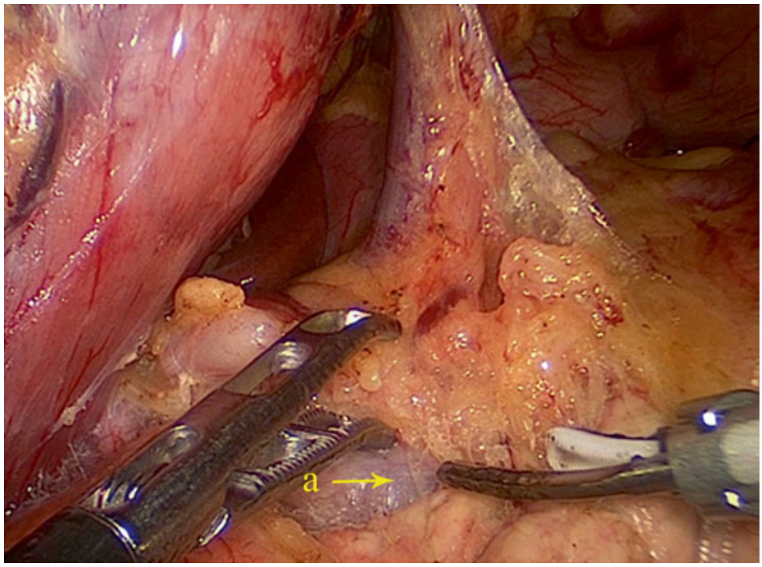


Fig. 5.130 The exposure of the initial segment of the SpA (*a*)

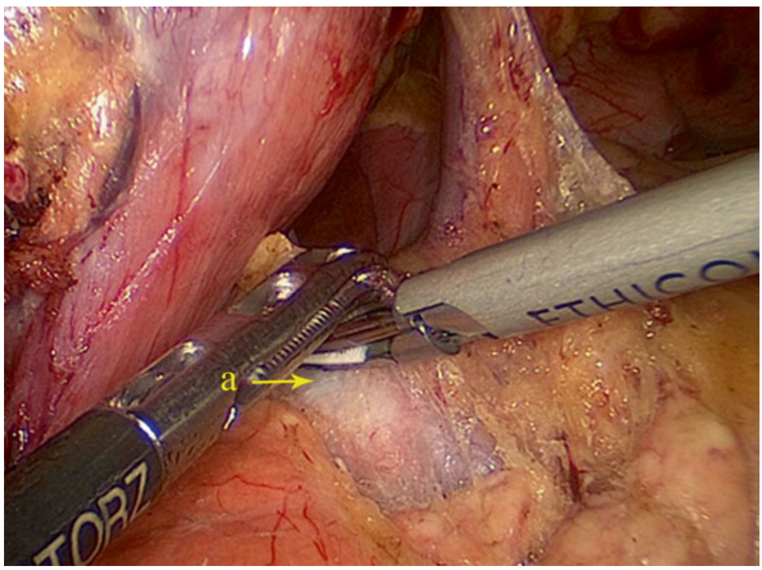


Fig. 5.131 The origin of the CHA (*a*) can be exposed by dissecting toward the root of the SpA

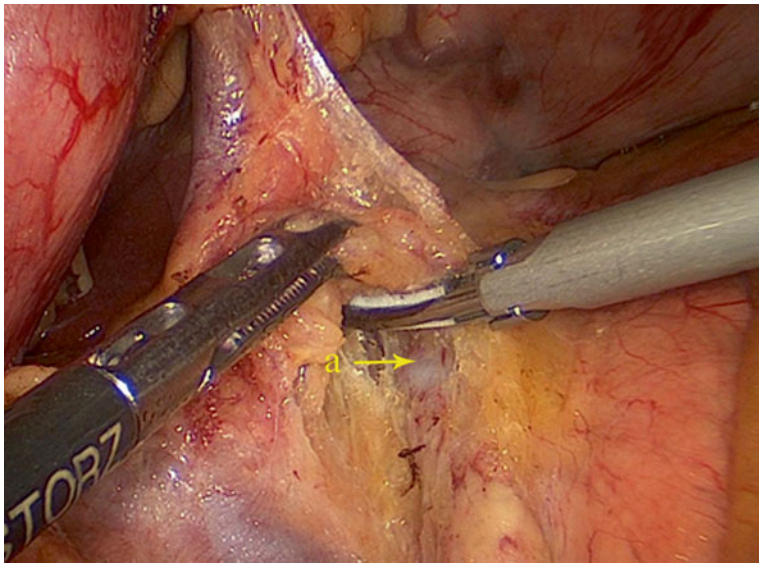


Fig. 5.132 Lymph node dissection of the No. 11p is along the superior border of the pancreas on the surface of the SpA (*a*)

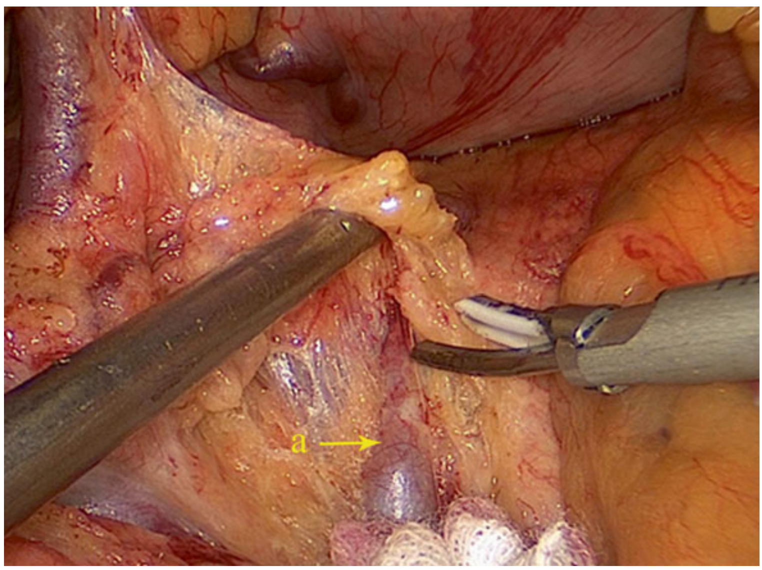


Fig. 5.133 The dissection of the No. 11p LNs is accomplished. Proximal end of the SpA (*a*)

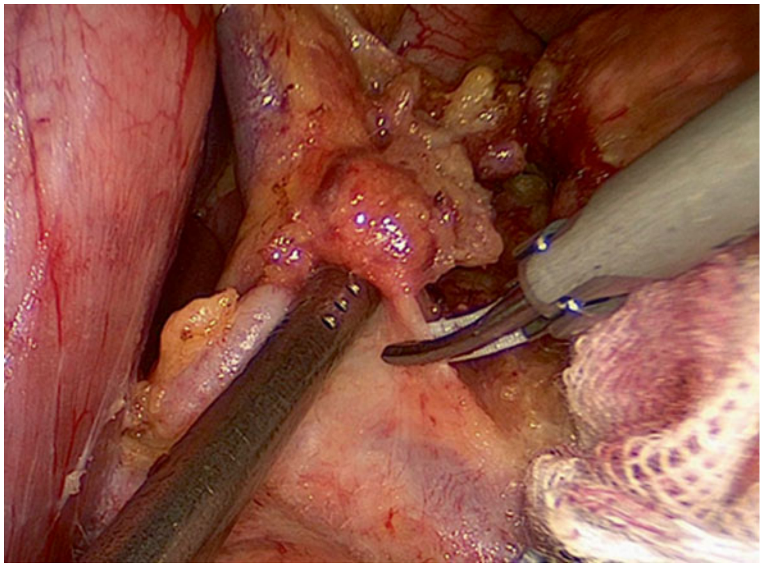


Fig. 5.134 Dissection of the No. 9 LNs is along the left margin of the CA

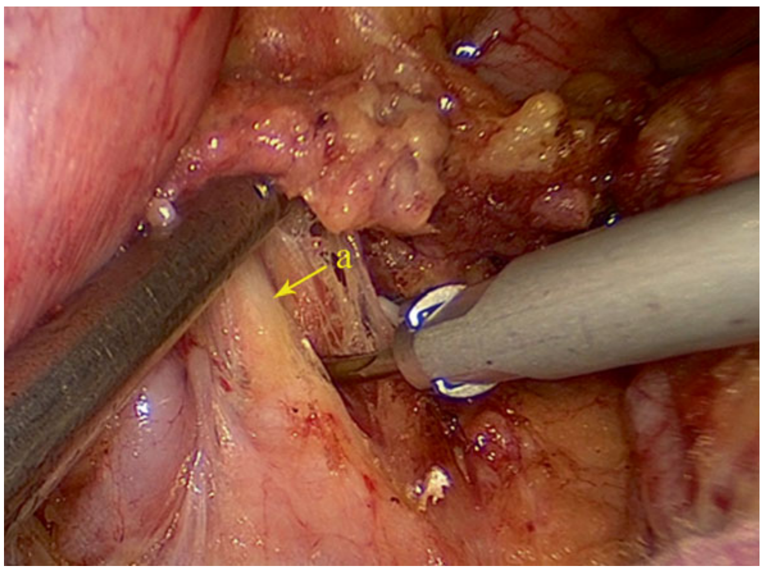


Fig. 5.135 The left margin of the root of the LGA (*a*) is exposed

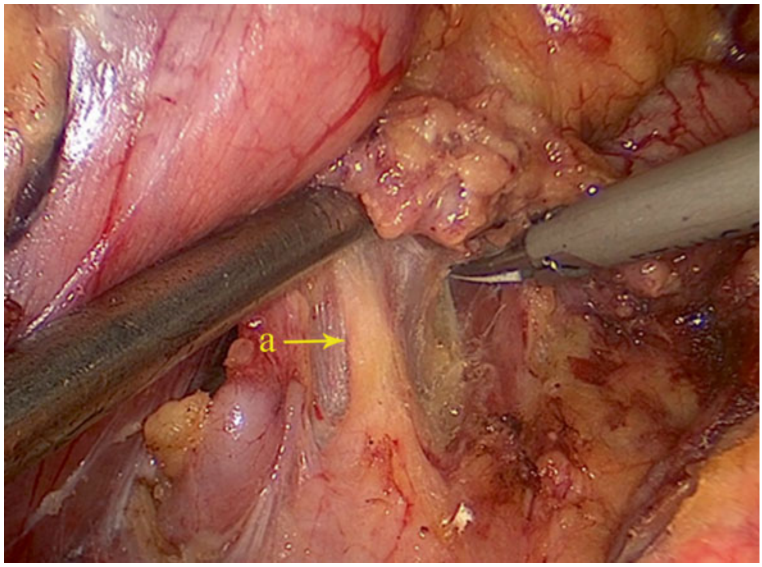


Fig. 5.136 The GPL is opened at the left margin of the LGA (*a*)

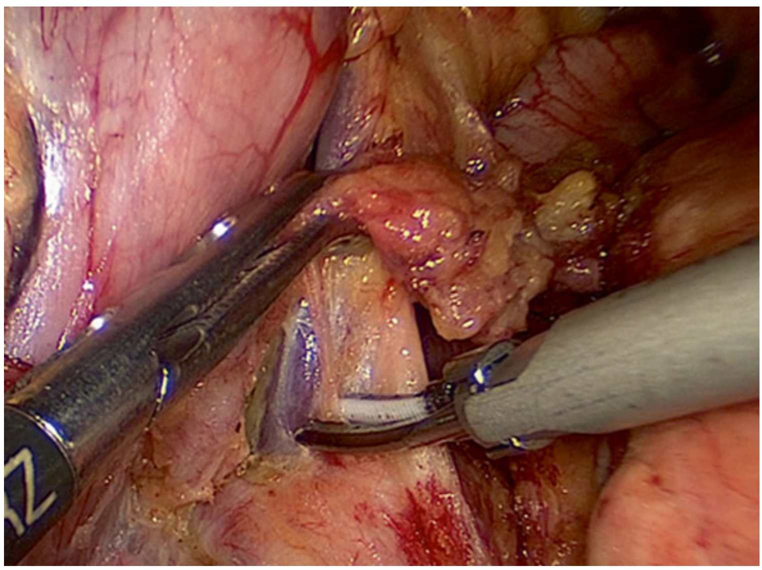


Fig. 5.137 The separation and exposure of the LGV

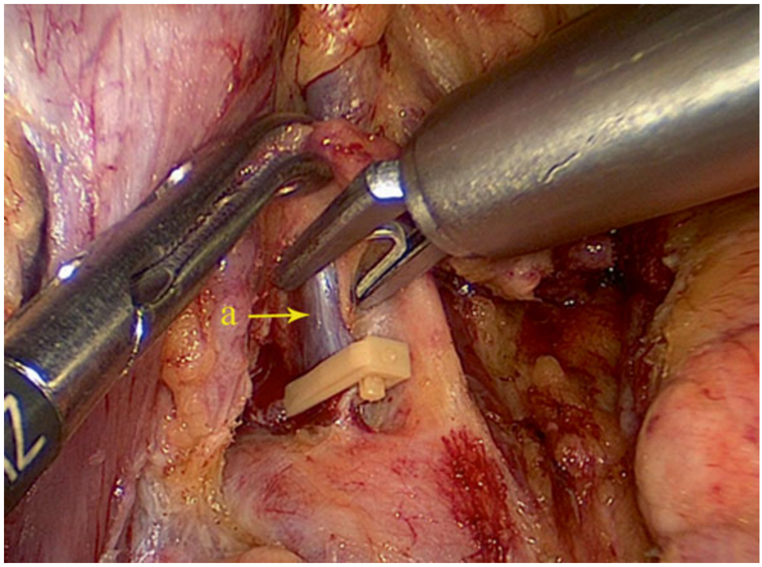


Fig. 5.138 The division of the LGV (*a*) on the superior margin of the CHA

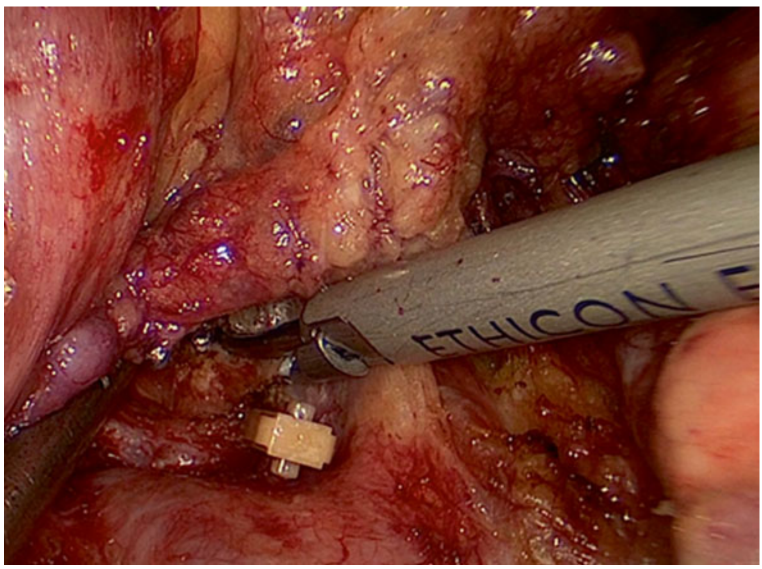


Fig. 5.139 Dissect the lymphatic fatty tissue along the right margin of the CA on its surface

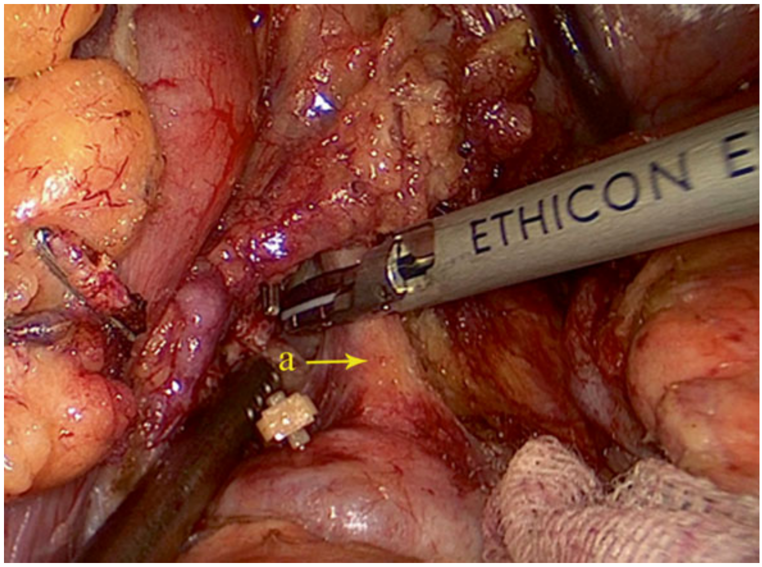


Fig. 5.140 The right margin of the LGA (*a*) is denuded

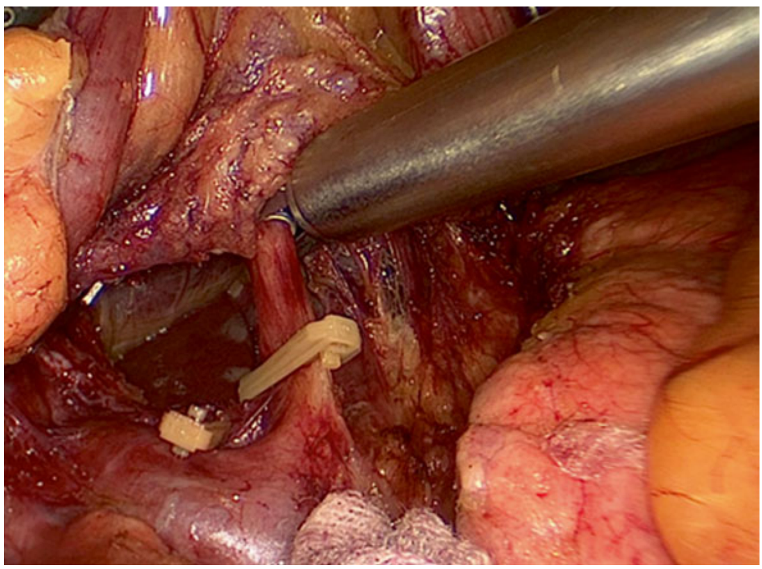


Fig. 5.141 The division of the LGA at its root

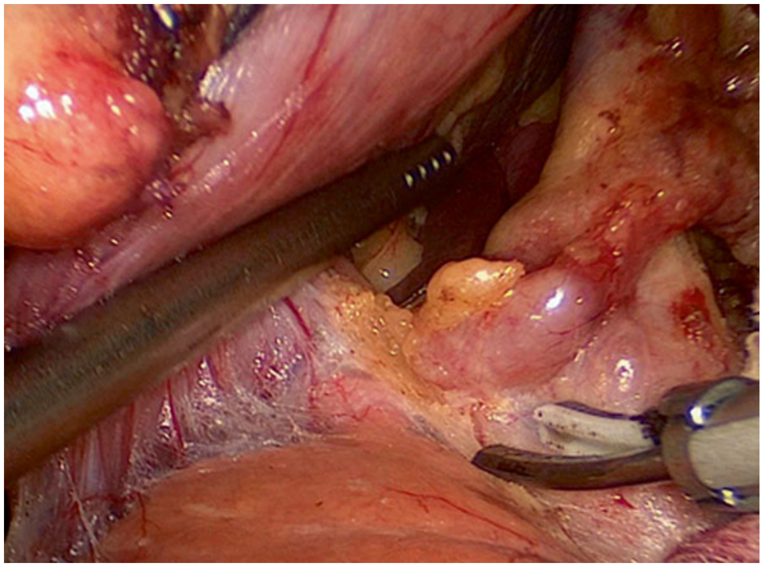


Fig. 5.142 The general course of the CHA on the superior border of the pancreas

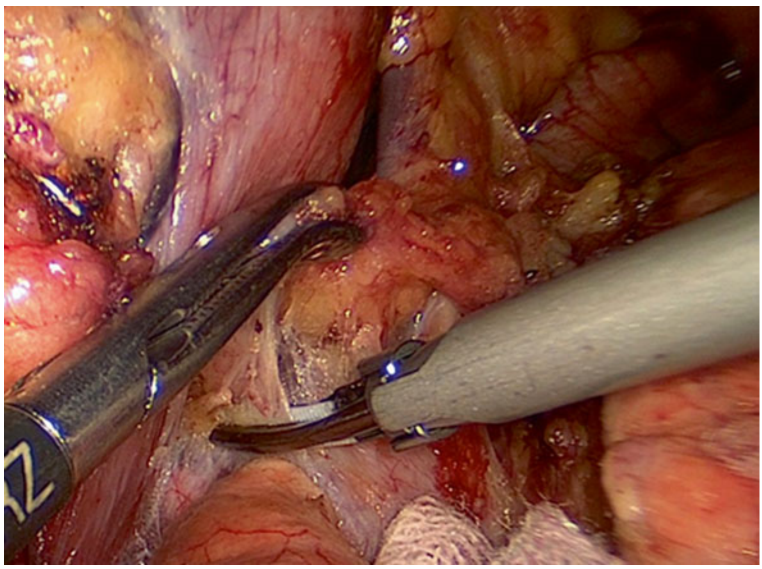


Fig. 5.143 Dissection of the No. 8a LNs

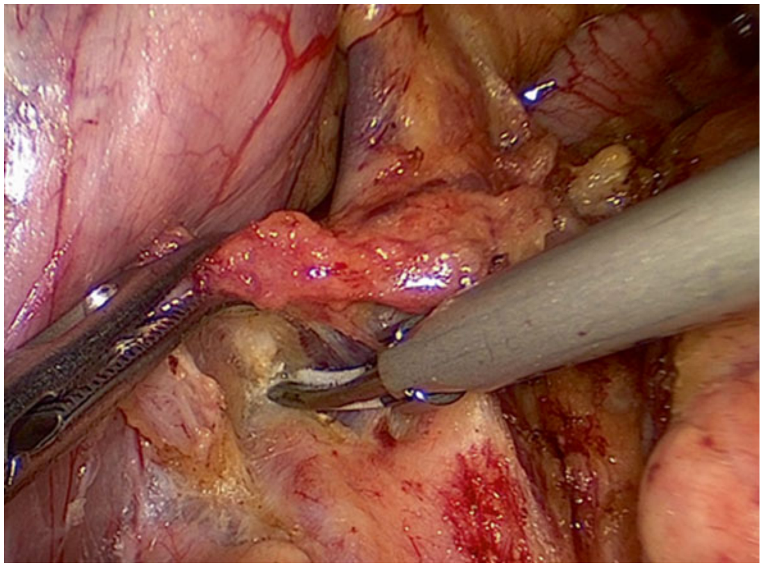


Fig. 5.144 Dissection of the No. 8a LNs until reaching furcation of the CHA

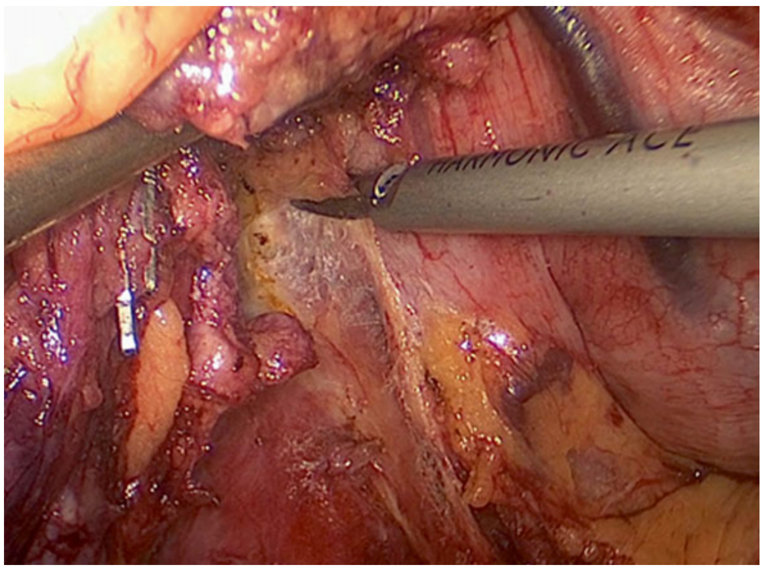


Fig. 5.145 The exposure of the crus of the diaphragm and the GPL

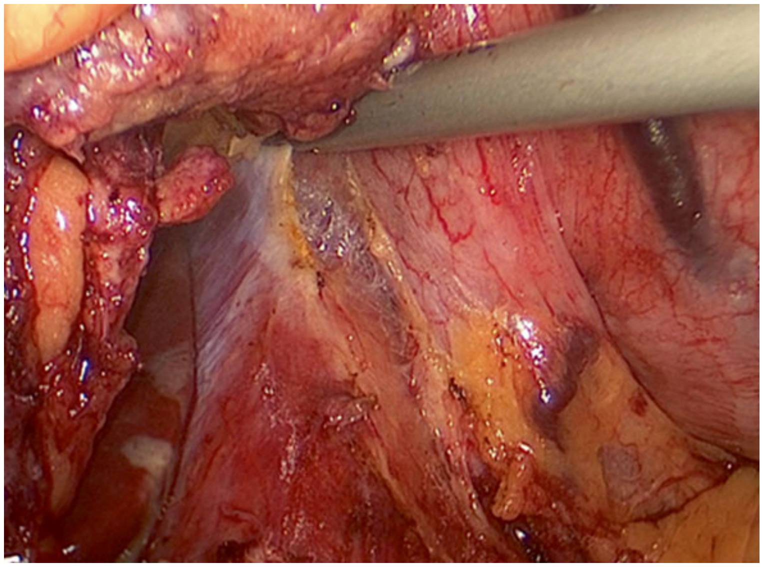


Fig. 5.146 The separation and exposure of the esophageal hiatus

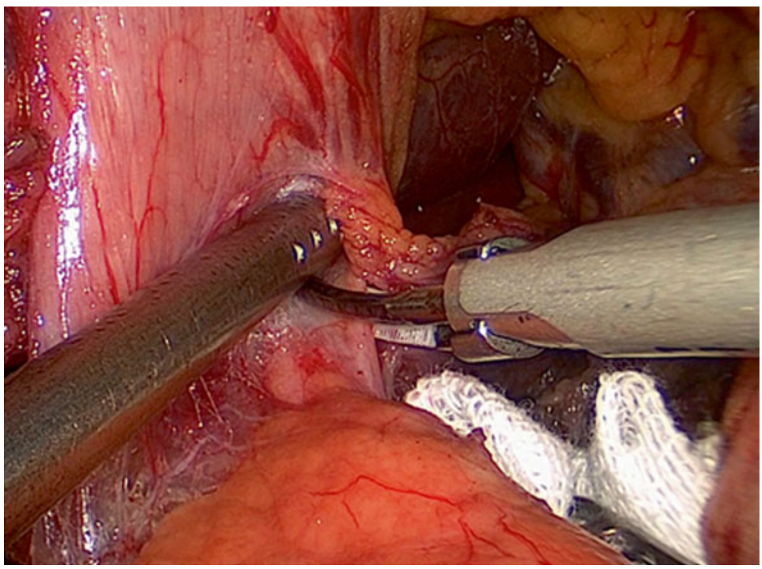


Fig. 5.147 The dissection is started from the origin of the PHA

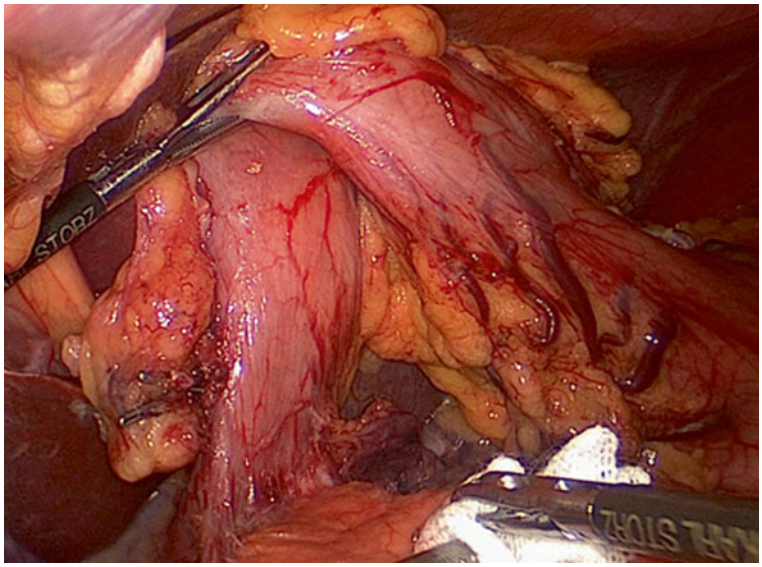


Fig. 5.148 The assistant lifts up the posterior wall of the gastric antrum, while the surgeon presses down on the pancreas to expose the suprapyloric area

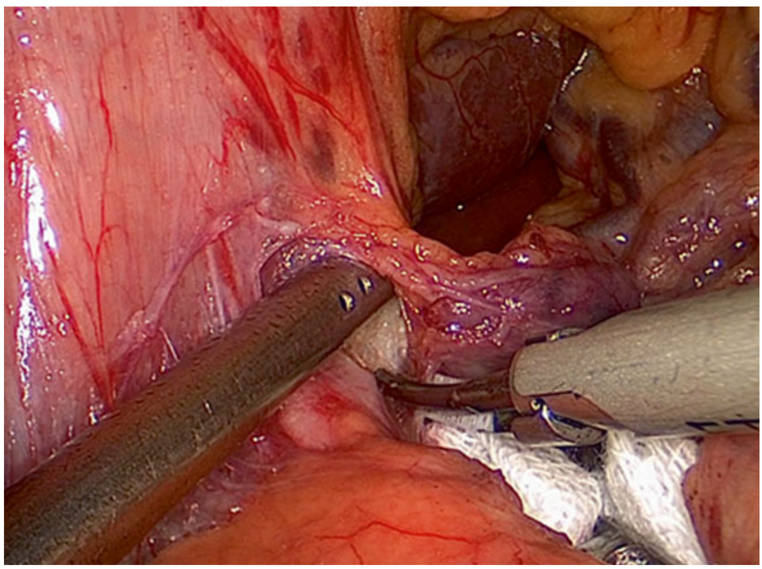


Fig. 5.149 Dissections of the No. 12a LNs is started from the medial margin of the origin of the PHA

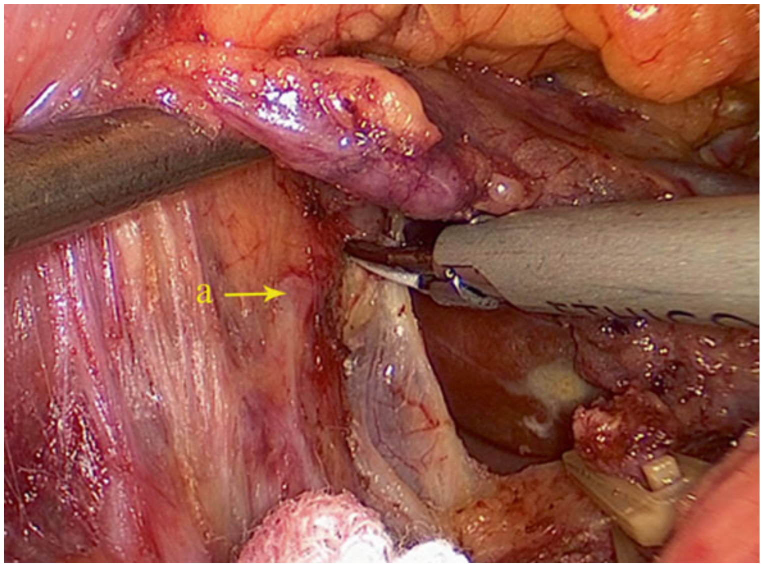


Fig. 5.150 The medial margin of the HDL is opened along the CHA (*a*)

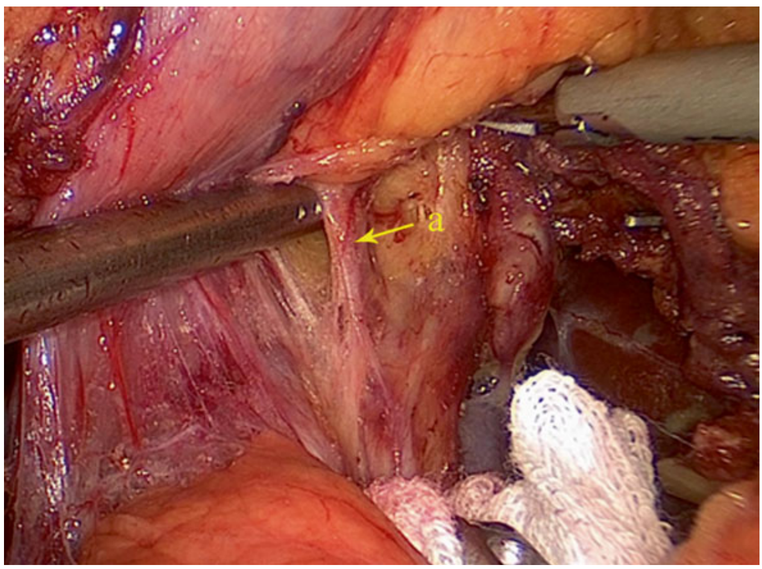


Fig. 5.151 The root of the RGA (*a*) is exposed

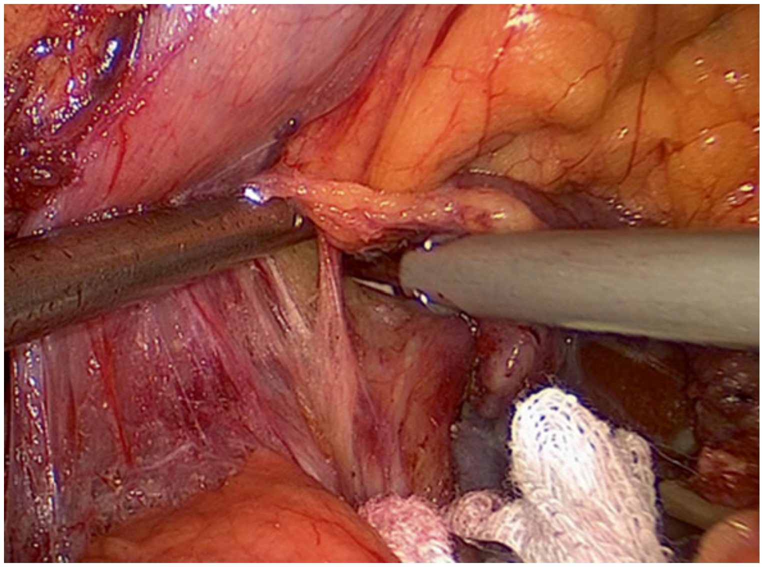


Fig. 5.152 The root of the RGA is vascularized

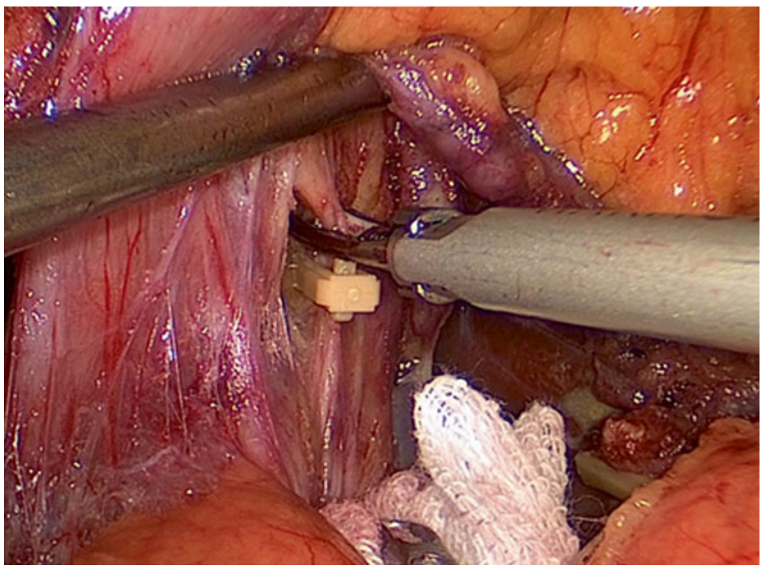


Fig. 5.153 The RGA is divided at its root

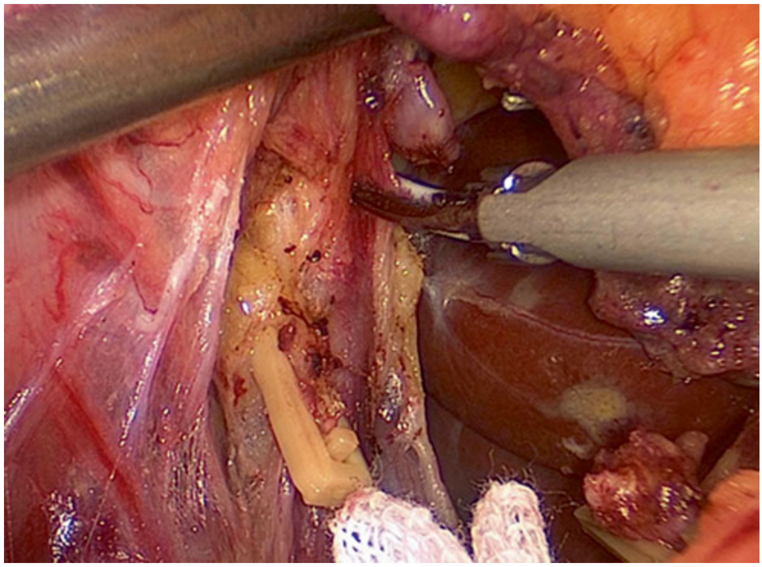


Fig. 5.154 No. 12a LNs are dissected along the front of the PHA

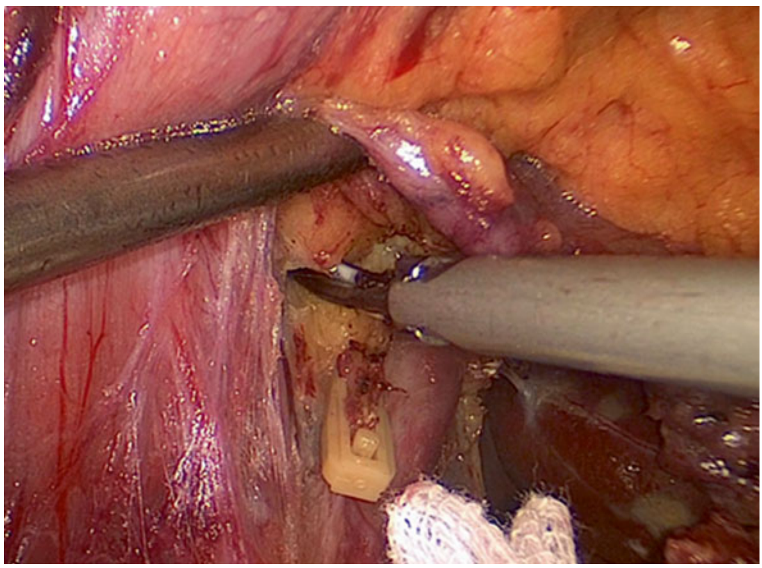


Fig. 5.155 Dissection of the anterior lobe of the HDL

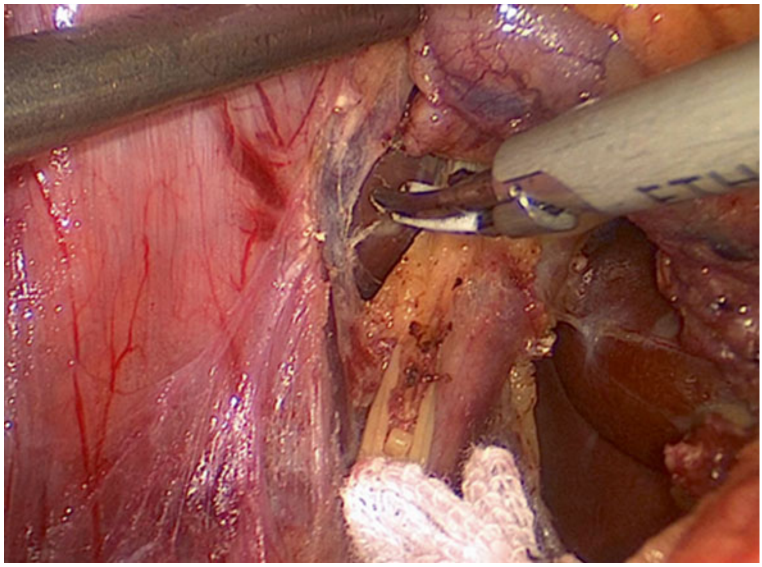


Fig. 5.156 A window is opened in the free anterior lobe of the HDL

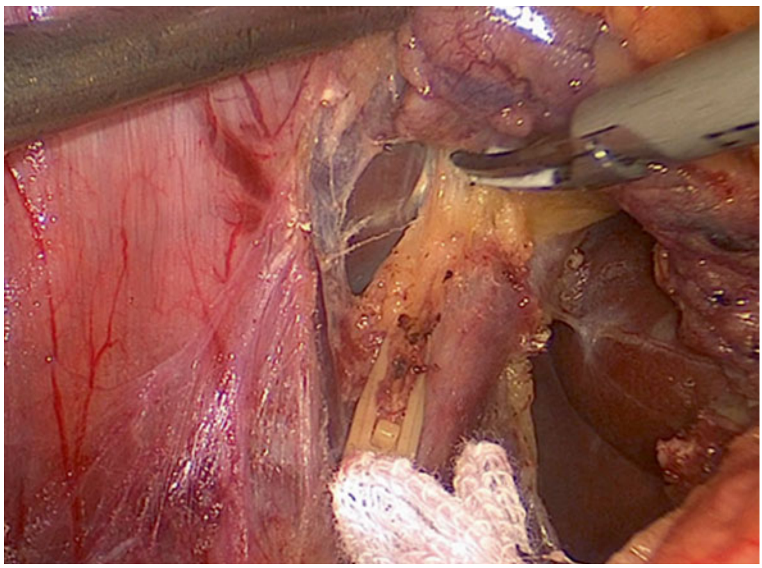


Fig. 5.157 Dissection of the No. 5 and the No. 12a LNs is accomplished

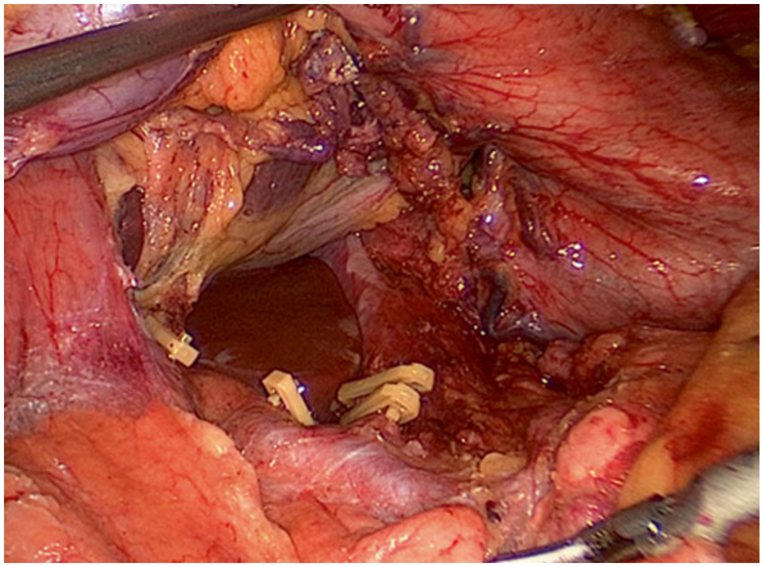


Fig. 5.158 Lymph node dissection within the suprapancreatic area is accomplished

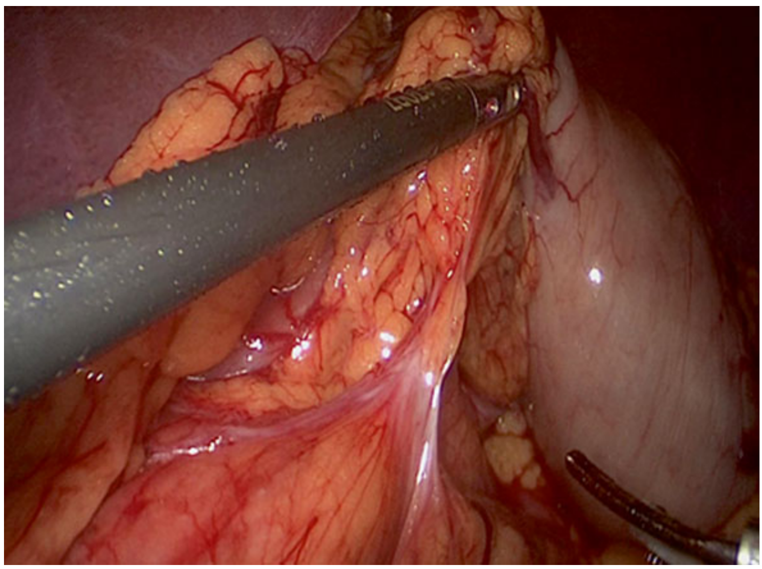


Fig. 5.159 The adhesion between the transverse mesocolon, pancreatic capsule, and posterior wall of the stomach should be divided first

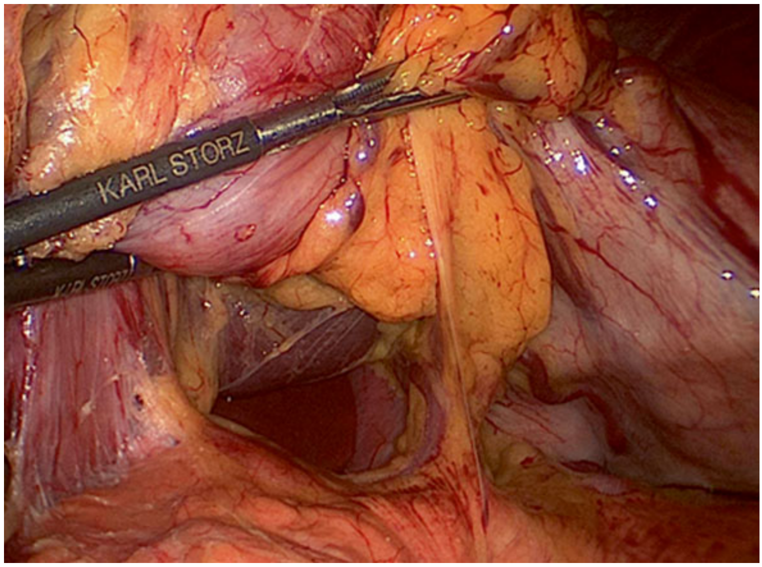


Fig. 5.160 The assistant clamps and lifts the GPF upward and forward to keep it under tension, preventing the hanging tissues from affecting exposure of the operating field

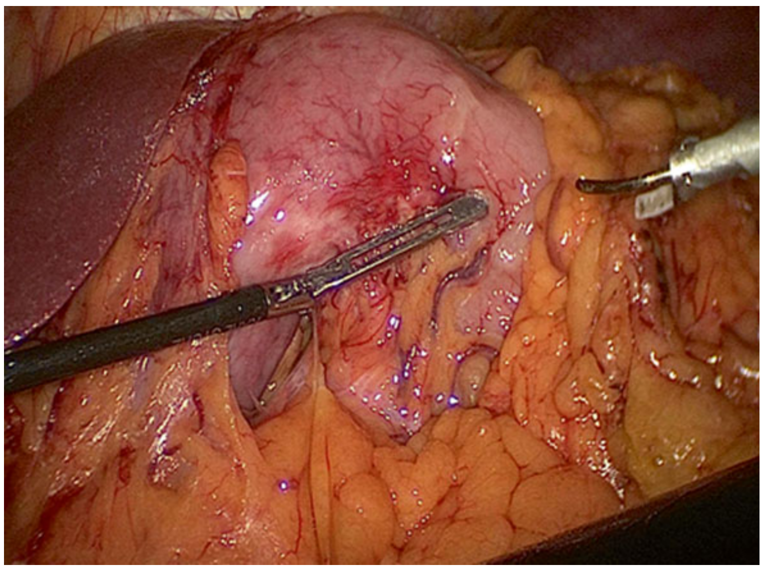


Fig. 5.161 The assistant should hold and elevate the GPF, with the gastric forceps opening, to reveal the operating field

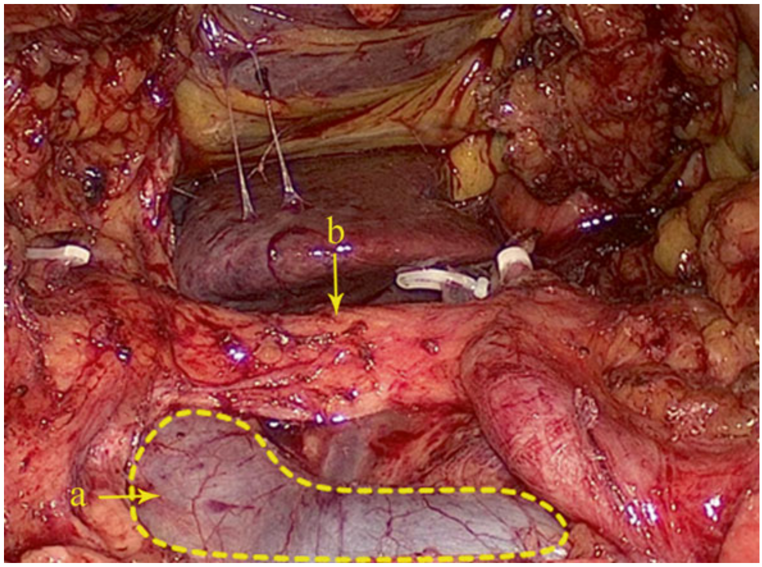


Fig. 5.162 The PV (*a*) may be injured during the exploration procedure of this artery, because the CHA (*b*) of some patients can be far from the superior margin of the pancreas

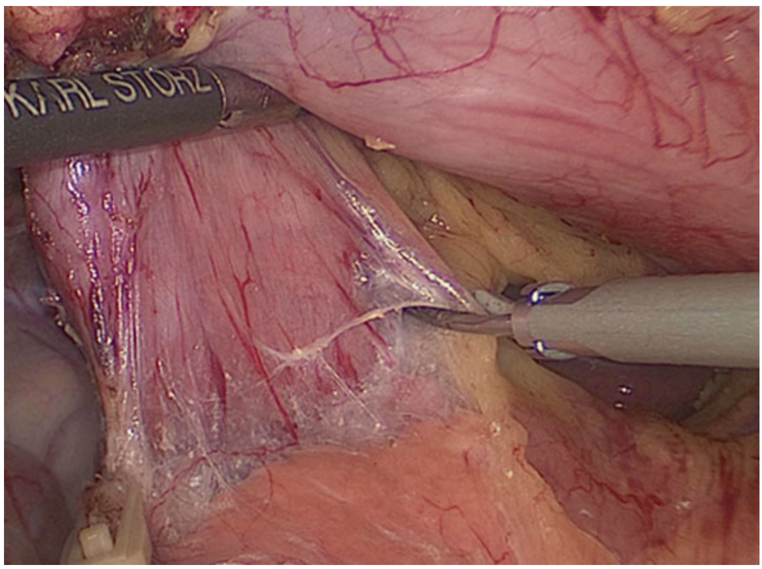


Fig. 5.163 If taking the duodenum as the approach, the operative space will be narrow, and it is difficult to expose the operating filed

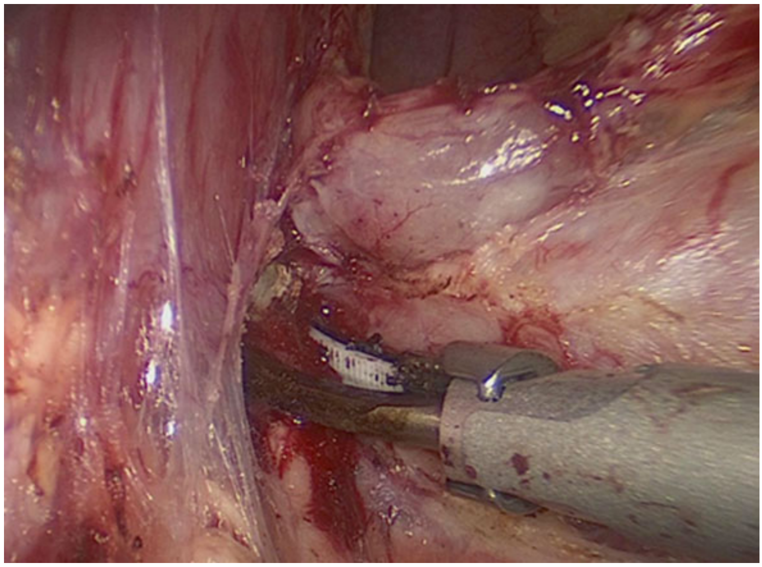


Fig. 5.164 There are many small vessels distributed around the posterior wall of the duodenum, which are easy to be injured and bleed but difficult to achieve hemostasis

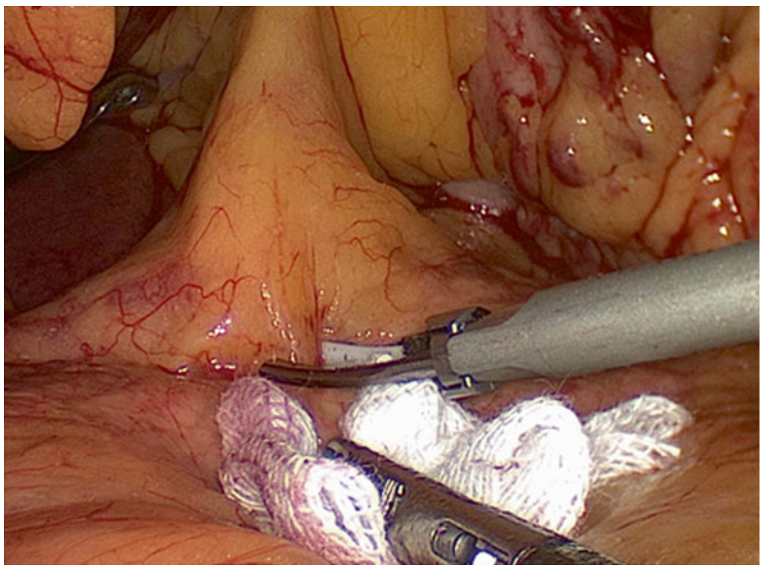
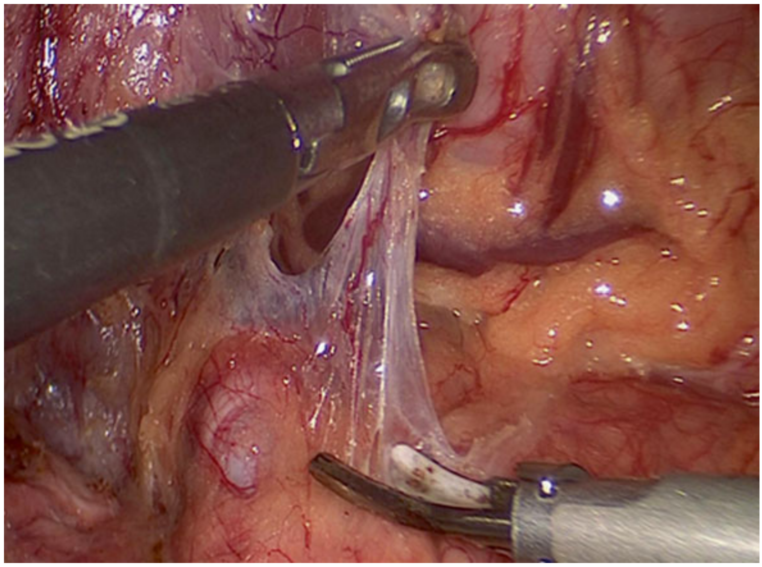


Fig. 5.165 A piece of small gauze with the radiopaque marker should be used as a pad, under the atraumatic grasping forcep, when pressing the pancreas

Fig. 5.166 Lifting



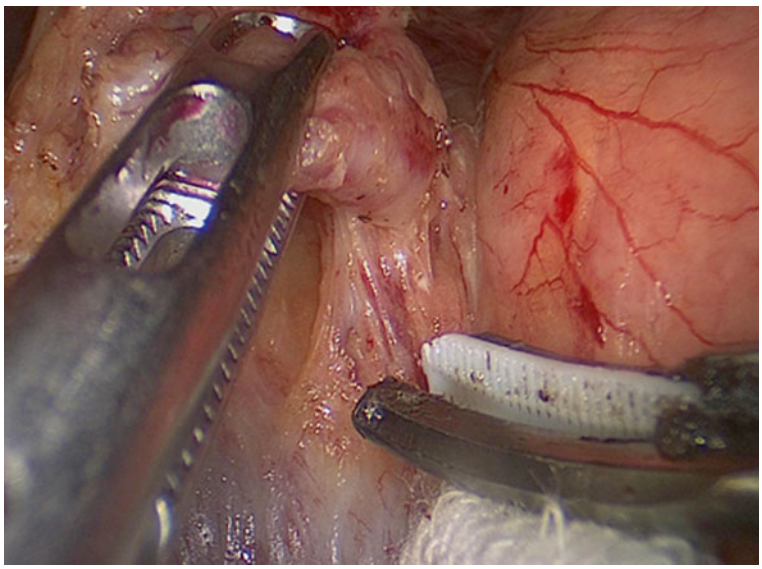


Fig. 5.167 Holding

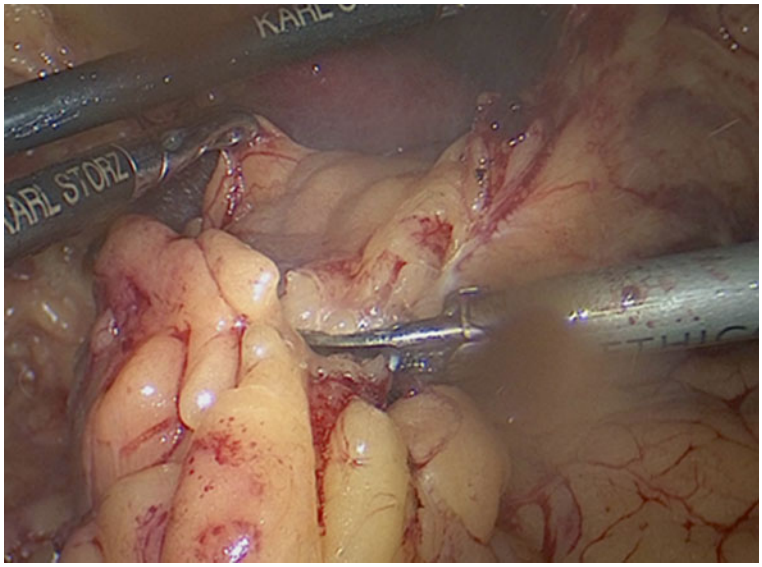


Fig. 5.168 An unclear view caused by pollution of lens

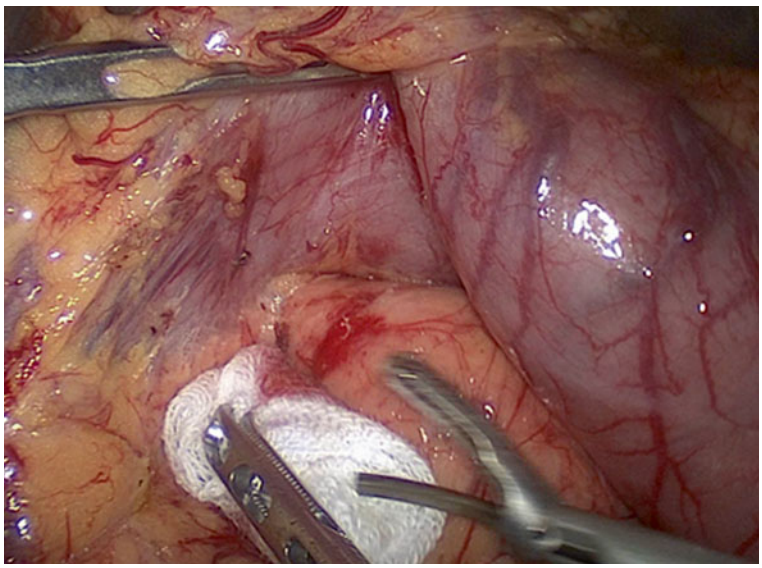


Fig. 5.169 Gauze compression is applied to control the minor bleeding of pancreas

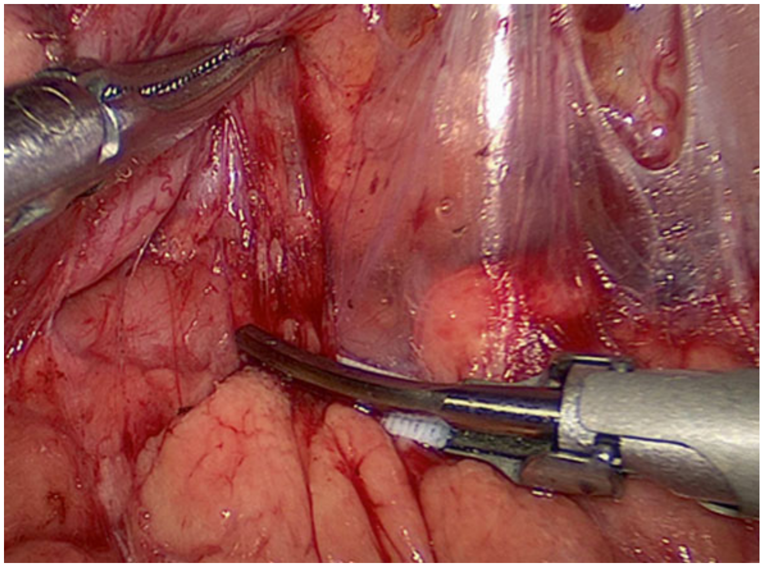


Fig. 5.170 The nonfunctional face of ultrasonic scalpels should be put close to the surface of the pancreas to avoid injury

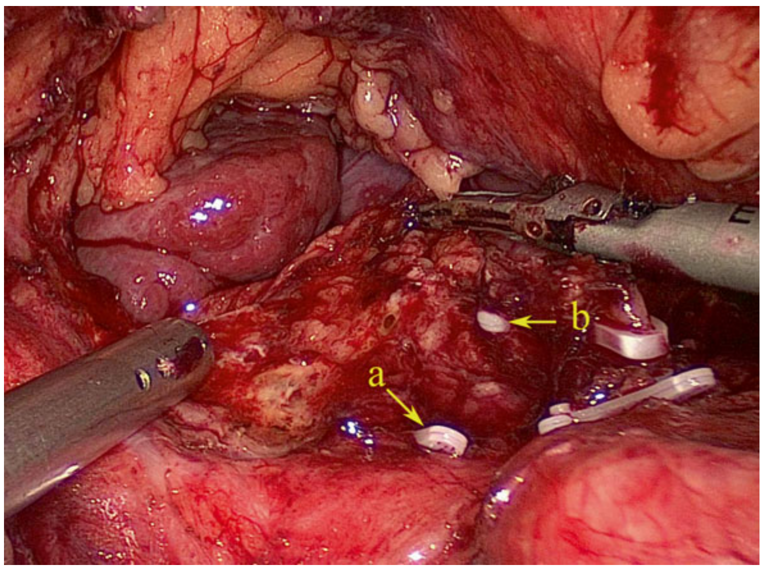


Fig. 5.171 A clip (*a*) is used to ligate the lymphatic vessel at the root of the CHA. The stump of the lymphatic vessel (*b*)

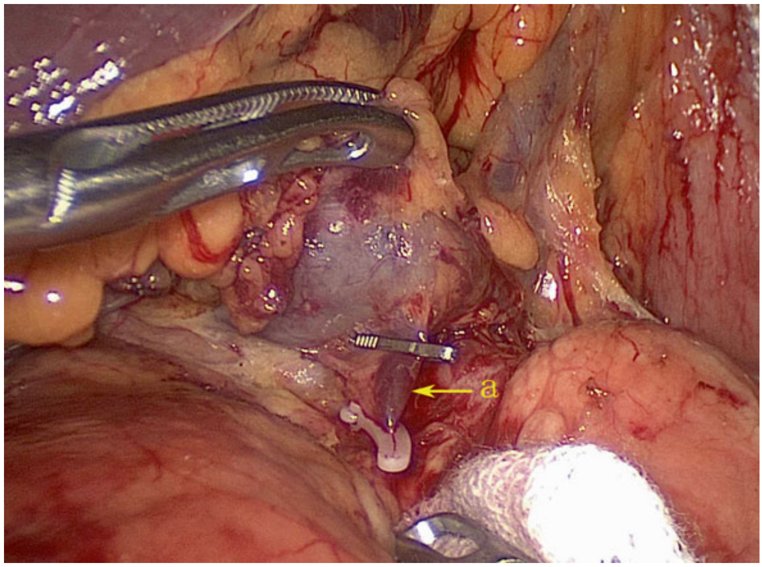


Fig. 5.172 In patients with obviously swollen No. 7 LNs, the surgeon should sever the LGV (*a*) first after exposing it

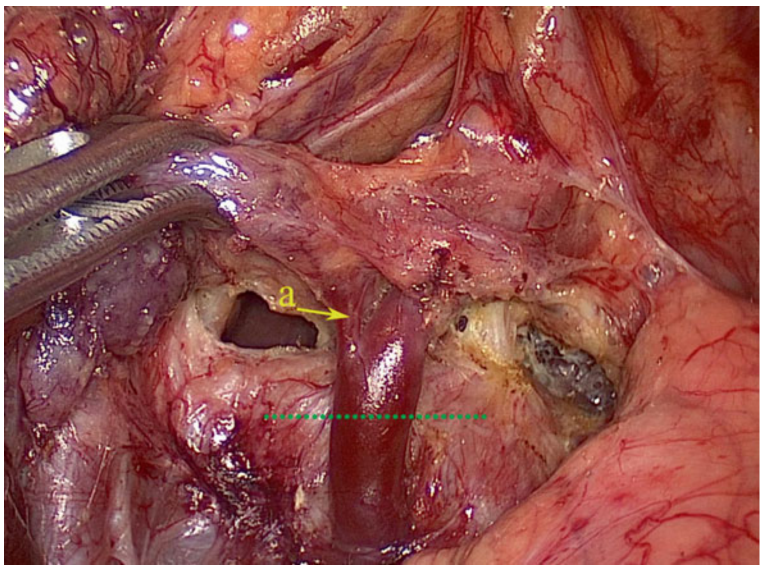


Fig. 5.173 Small branch of the LGV (*a*). The LGV should be severed at the plane of *green dotted line*

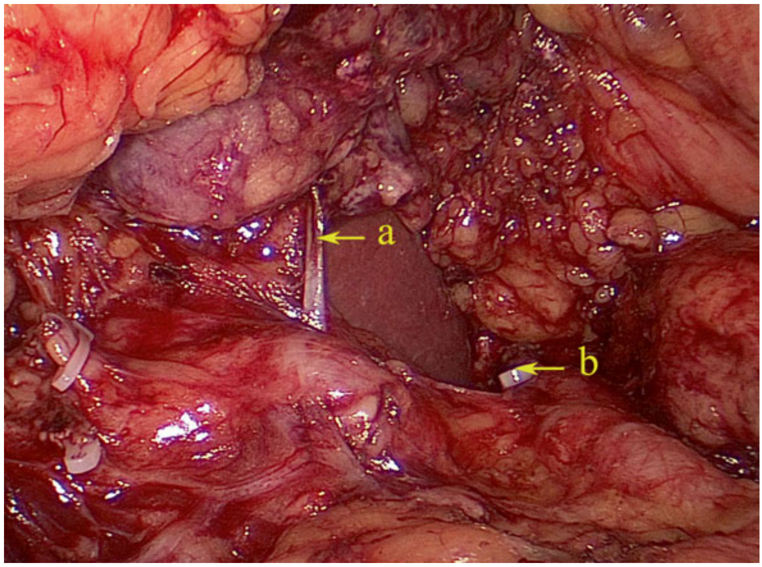


Fig. 5.174 In some cases, the LGV (*a*) and LGA (*b*) are far apart from each other

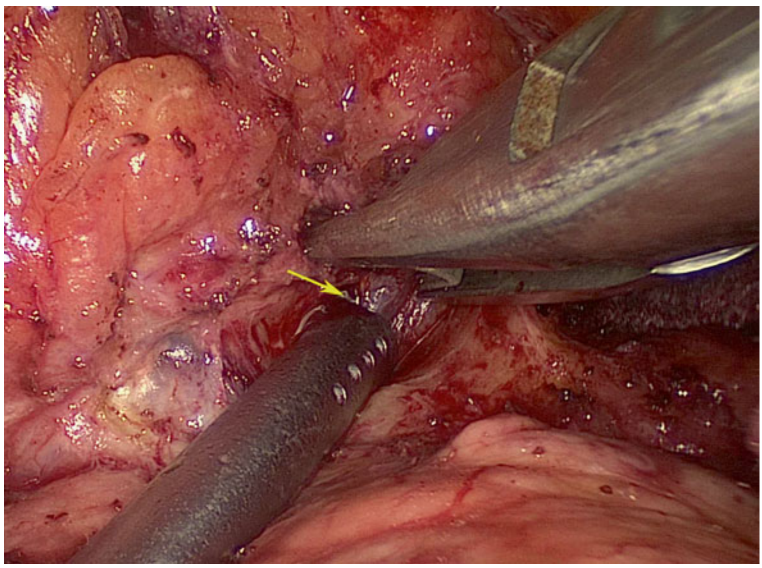


Fig. 5.175 A low-volume aspirator is used to intermittently suck up the blood and expose the hemorrhagic area

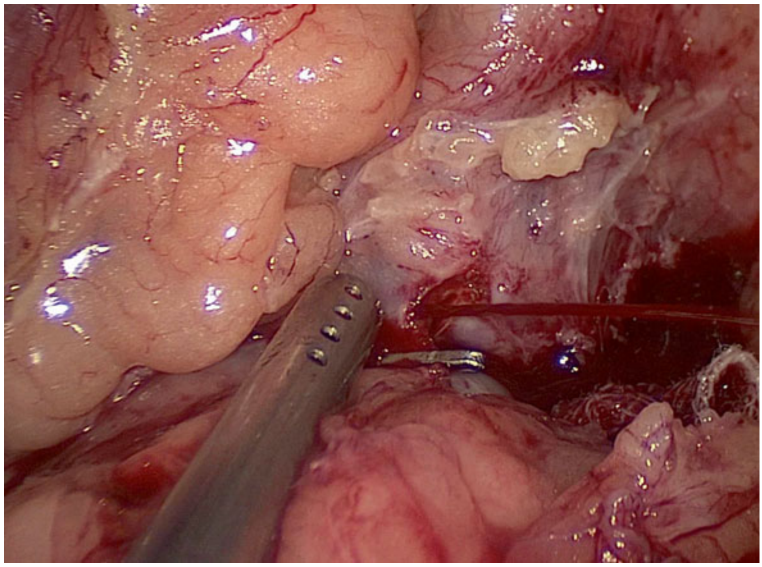


Fig. 5.176 If ligating the proximal end of the LGV first, more severe hemorrhage can result

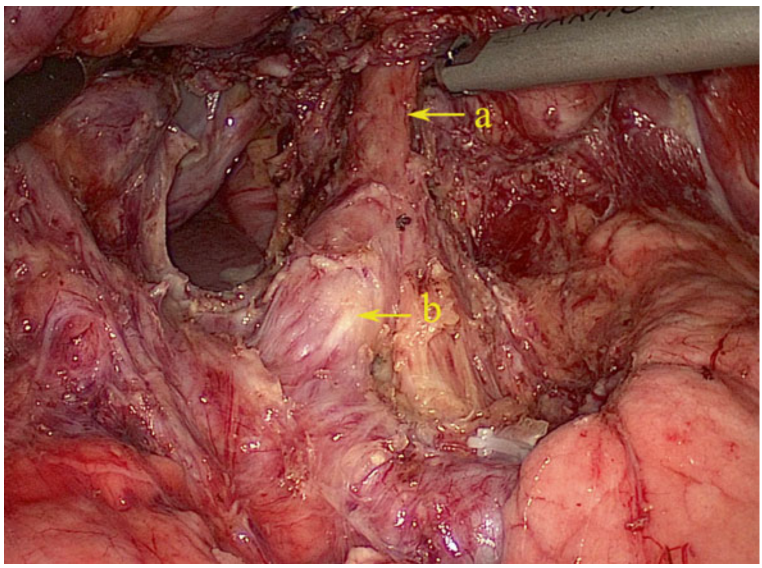


Fig. 5.177 The LGA (*a*) originates from the abdominal aorta and locates above the CA (*b*) and at the right posterior aspect

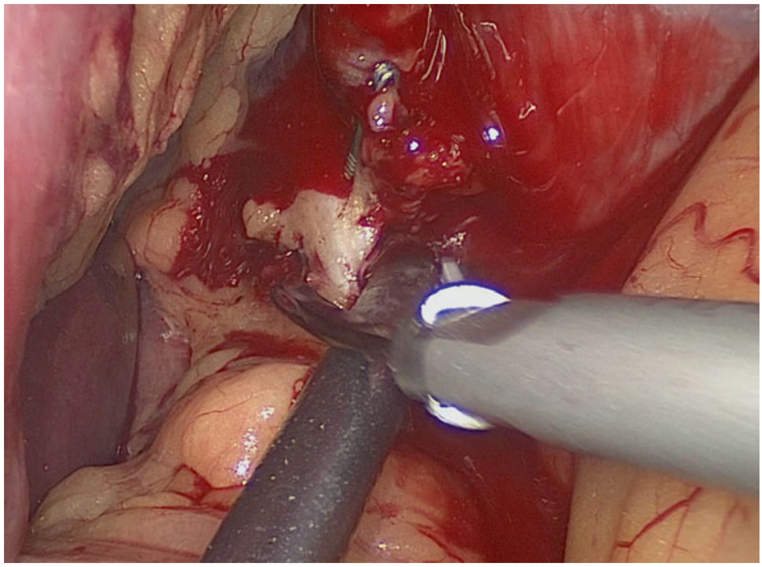


Fig. 5.178 If the LGA bleeds, the assistant should use the aspirator and press it on the hemorrhagic spot

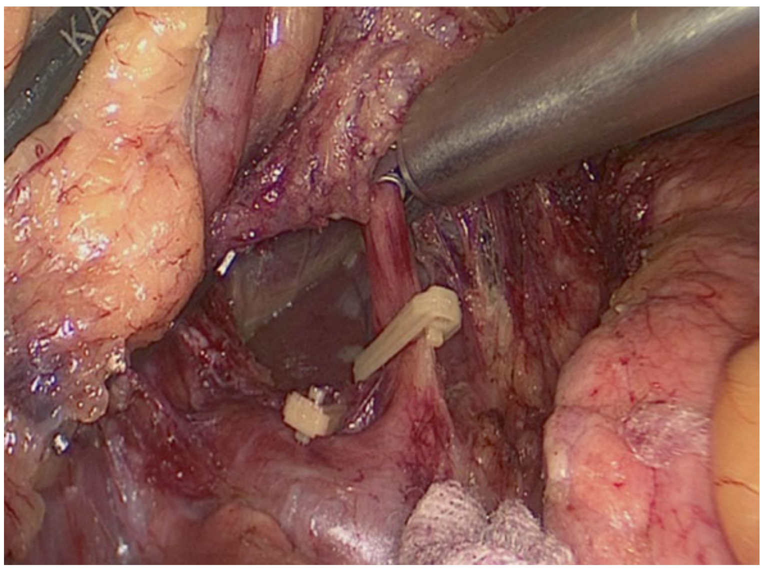


Fig. 5.179 When ligating the LGA, the clips should be clamped at a sufficient distance from the root of the LGA

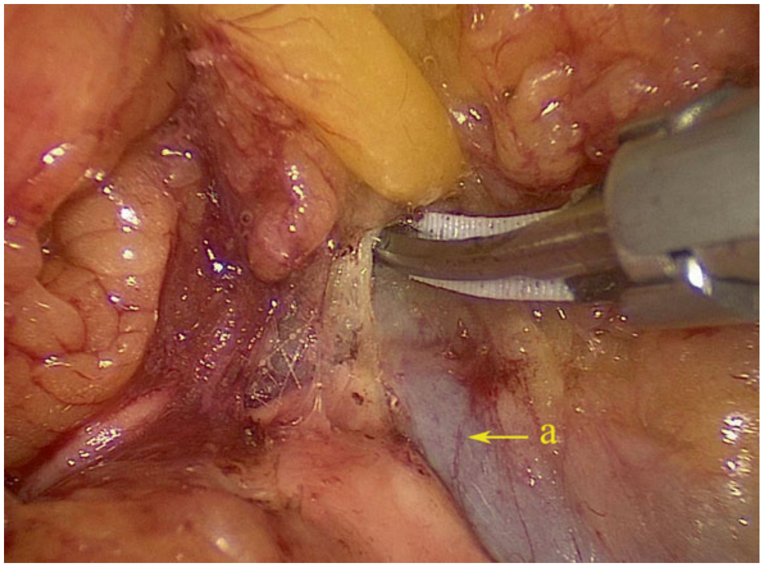


Fig. 5.180 The fascia on the ventral side of the vein should be divided carefully to expose the PV (*a*)

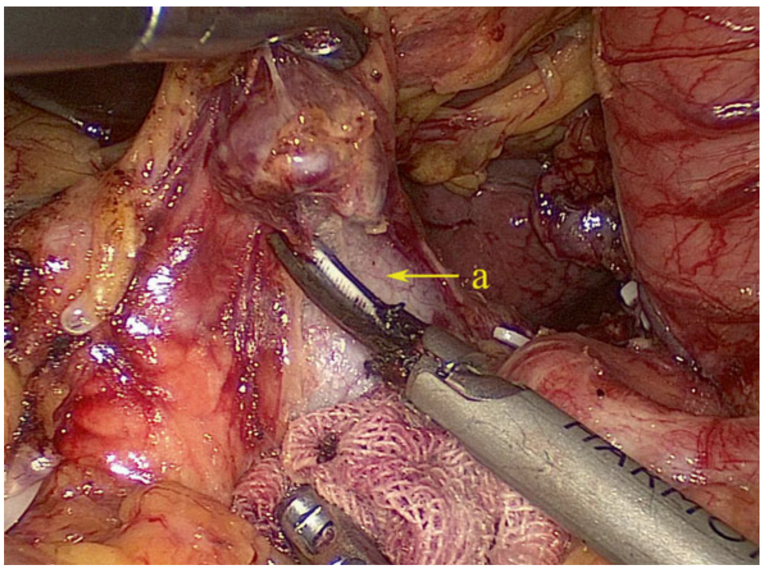


Fig. 5.181 For the patients with absent CHA, division is directly performed on the surface of the PV (*a*)

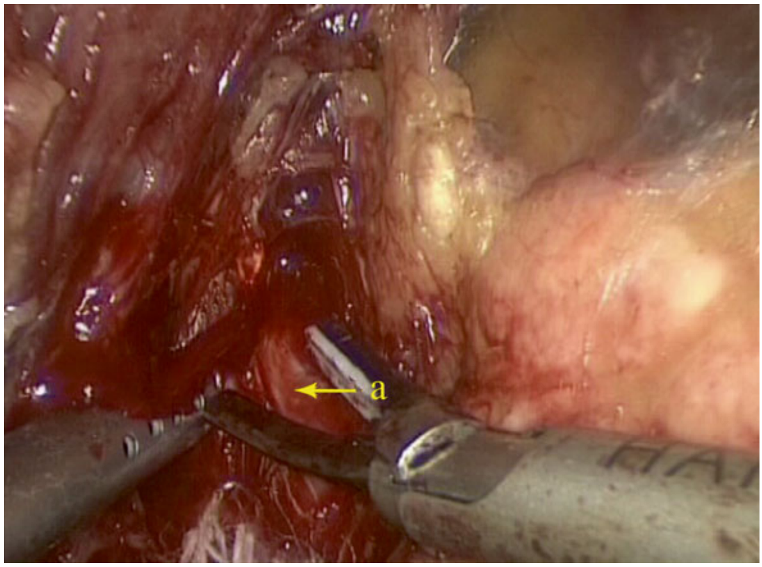


Fig. 5.182 Injury and bleeding of the PV (*a*) results in open conversion

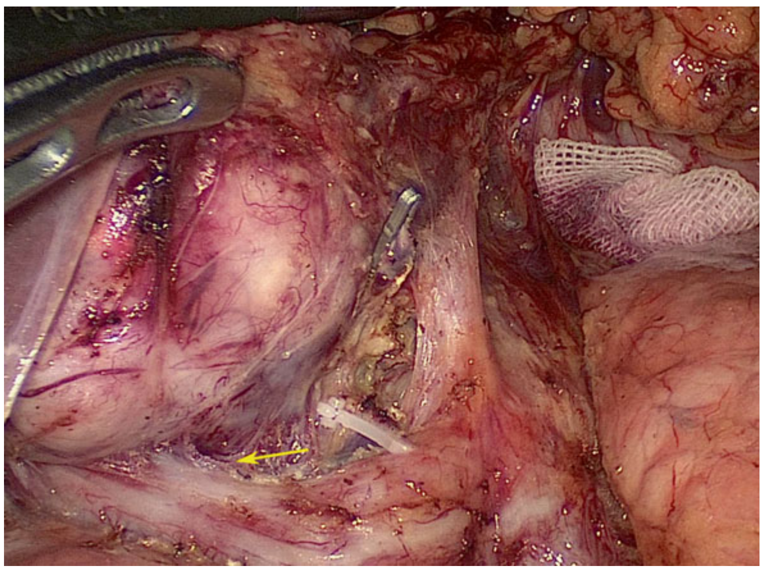


Fig. 5.183 The anatomical space between the basilar part of LNs and surface of the vessel should be meticulously detected when the No. 8a LNs are swollen (the *arrow* represents the anatomical space)

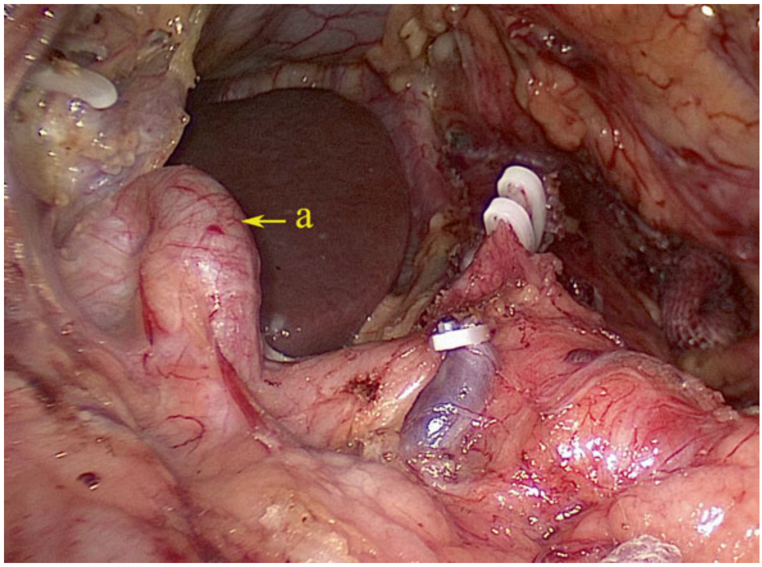


Fig. 5.184 The CHA (*a*) is long and tortuous, which can easily be misidentified as swollen LNs

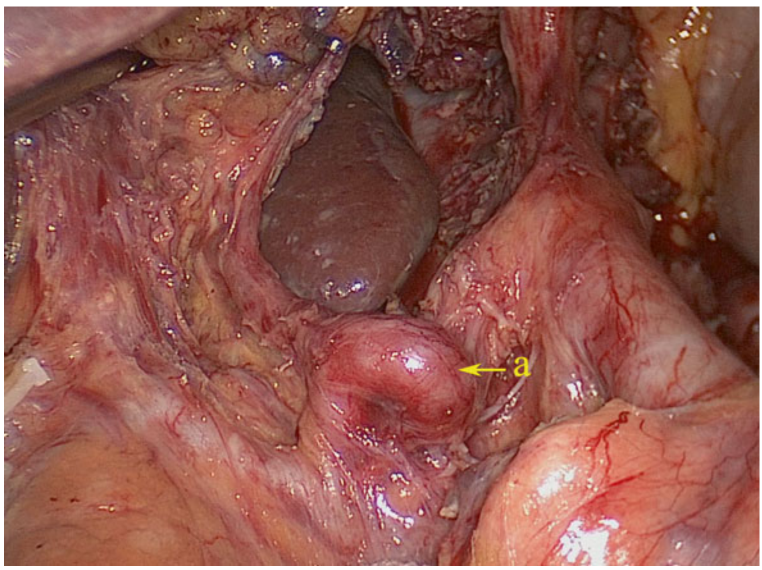


Fig. 5.185 The CHA (*a*) is long and tortuous, which may easily be recognized as the swollen LNs

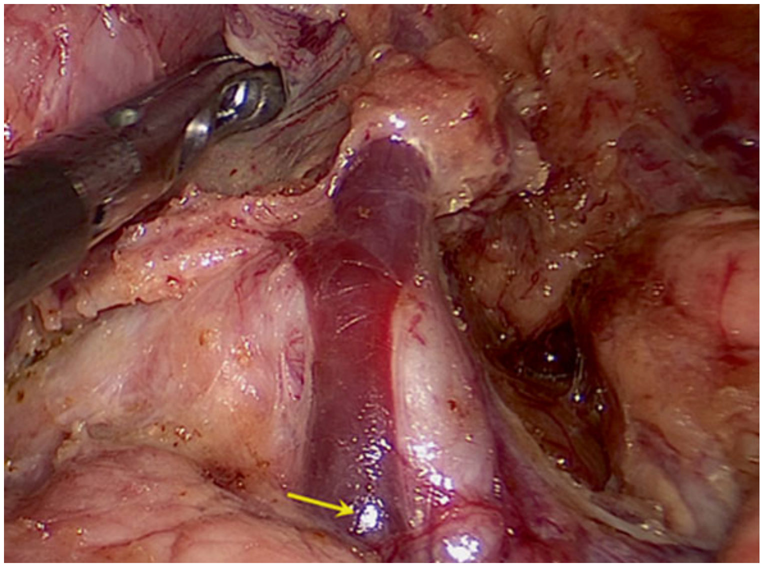


Fig. 5.186 The reflction of light appears in the view (the *arrow* represents the reflction of light)

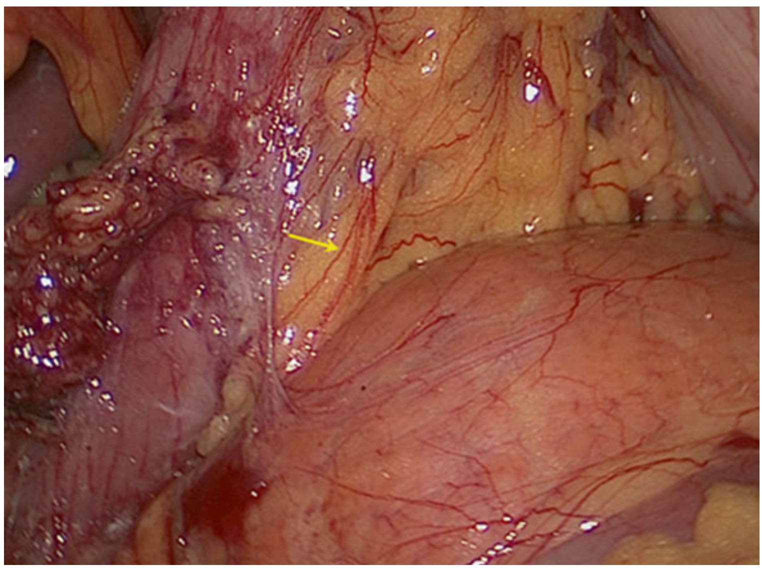


Fig. 5.187 Capillaries are distinct (the *arrow* represents the capillary)

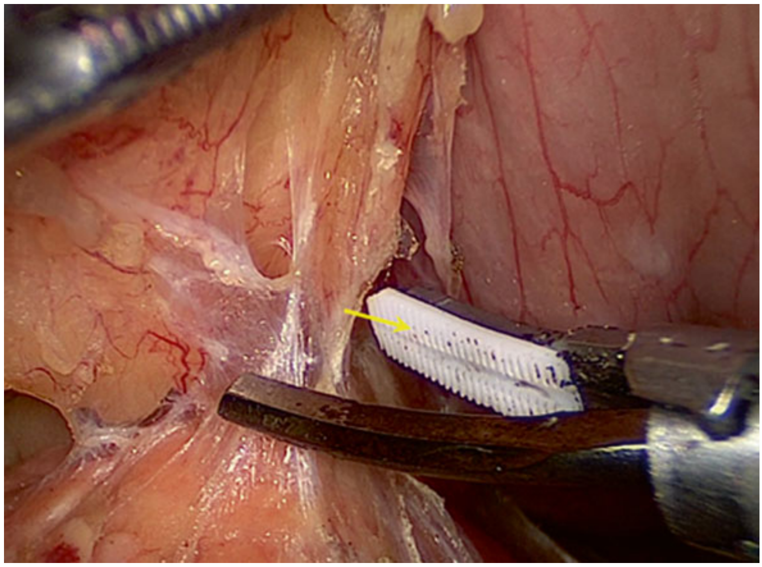


Fig. 5.188 The nonfunctional face of ultrasonic scalpels is distinct (the *arrow* represents the nonfunctional face of ultrasonic scalpels)

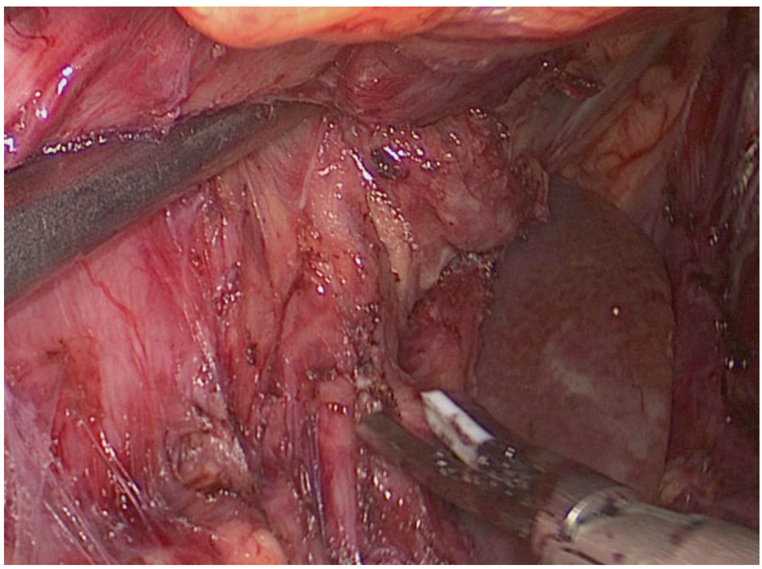


Fig. 5.189 The assistant lifts the posterior wall of the gastric antrum right upward with the forcep in the left hand and pushes the duodenum outward with the other hand to expose the CHA, the GDA, and the partially vascularized PHA

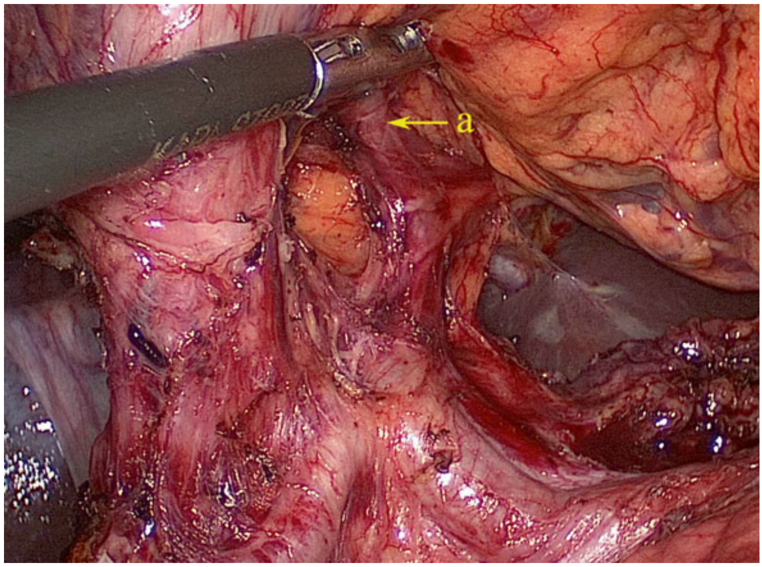


Fig. 5.190 The RGA (*a*) is in the vertical position with elevation of the gastric antrum

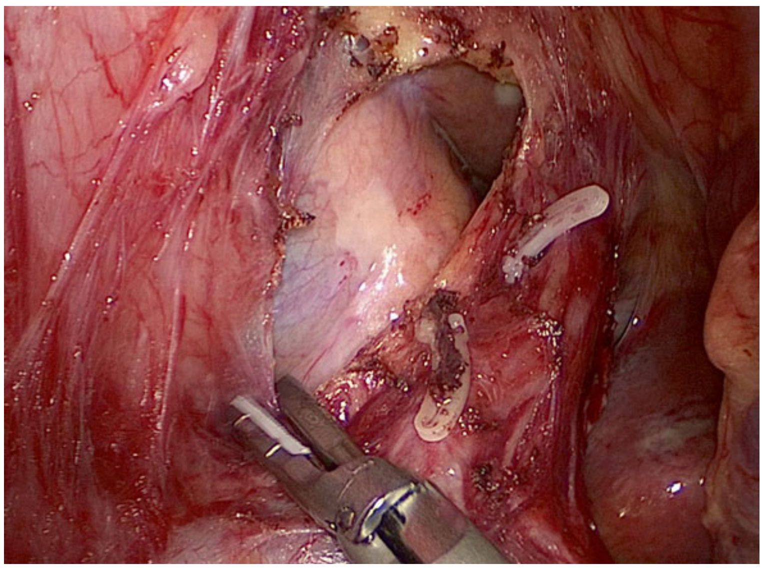


Fig. 5.191 A window can be created on the right side of the dissociated anterior lobe of the HDL

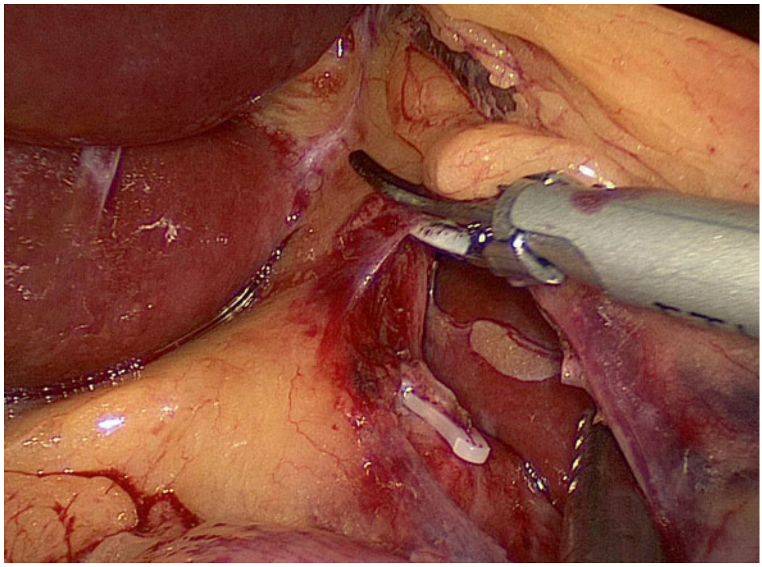


Fig. 5.192 The anterior lobe of the HDL is divided through the window

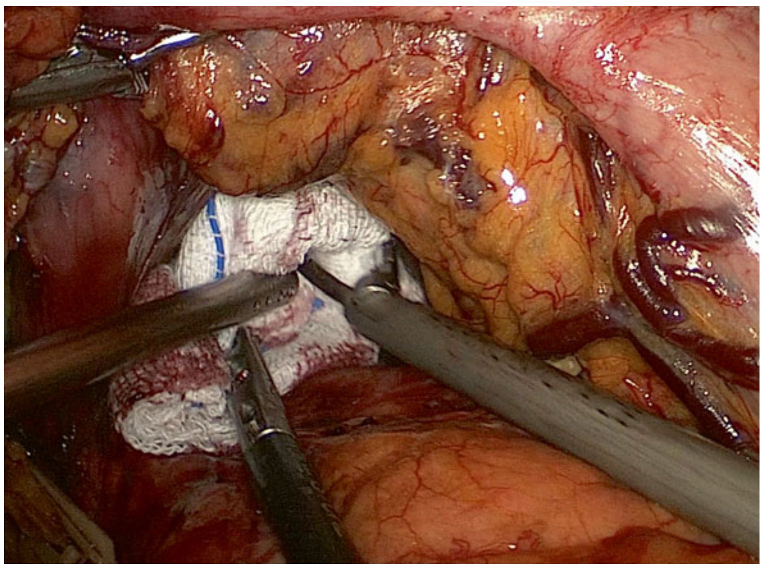


Fig. 5.193 A piece of gauze should be settled on the surface of the PHA to act as a landmark for division of the HDL

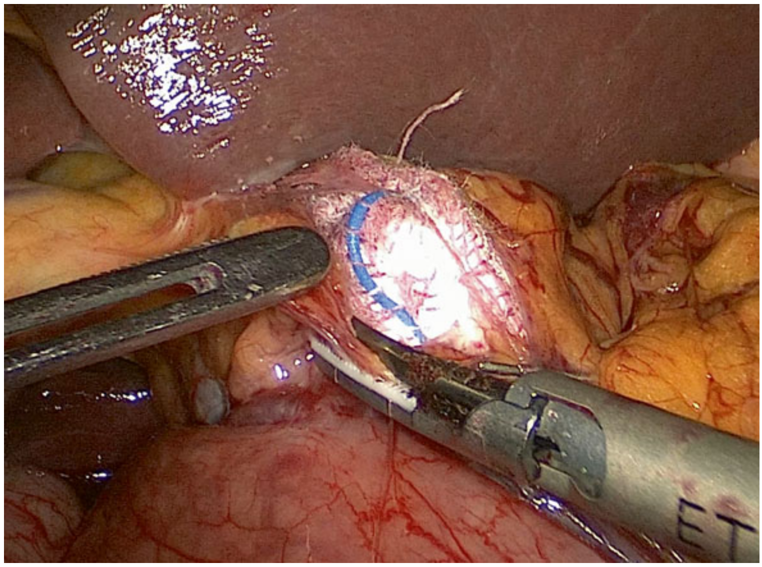


Fig. 5.194 A piece of gauze settled on the surface of the PHA can avoid separating too deeply

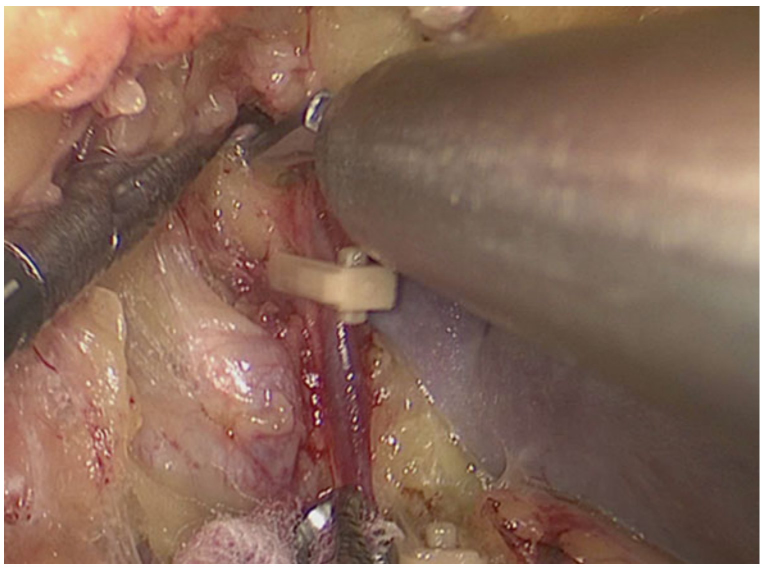


Fig. 5.195 The camera assistant should adjust the orientation of the optical fiber properly to avoid visual obscuring by titanium clip applier

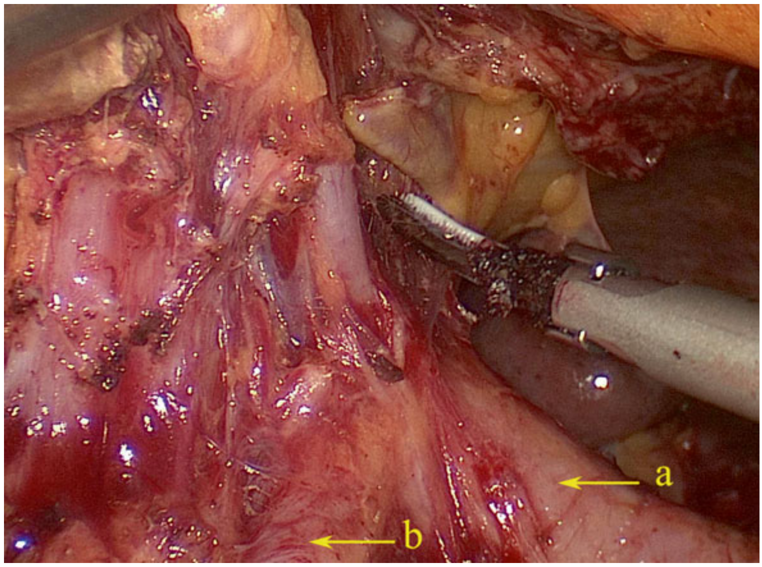


Fig. 5.196 After exposing the origin segment of the GDA (*b*) which gives off from the CHA (*a*), the PHA can be detected

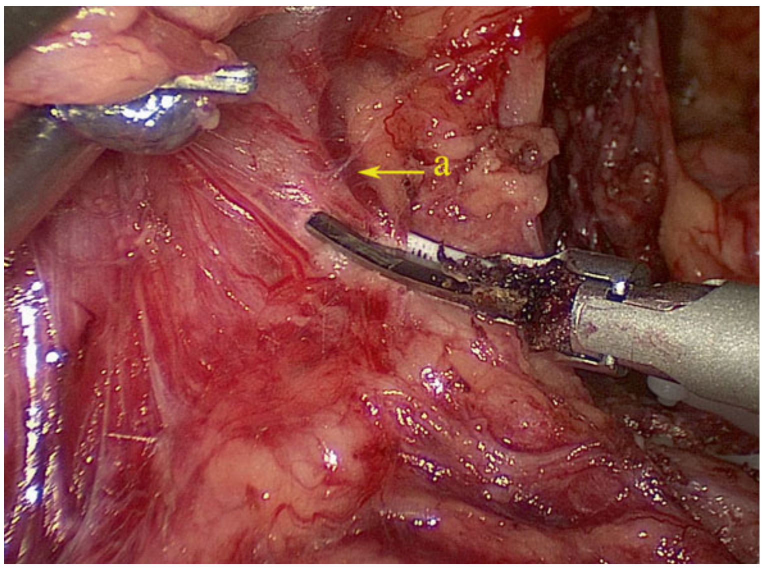


Fig. 5.197 When denuding the posterior wall of duodenum, the vessels (*a*) should be occluded completely with the ultrasonic scalpels

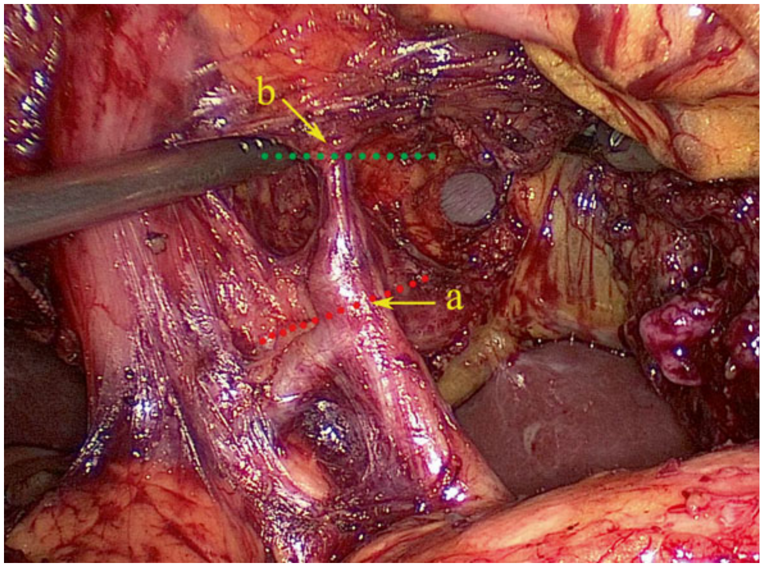


Fig. 5.198 The PHA (*a*) will form an angle with the elevation of the RGA (*b*), and the RGA should be severed at the plane of the green dotted line (The *red dotted line* represents the wrong plane)

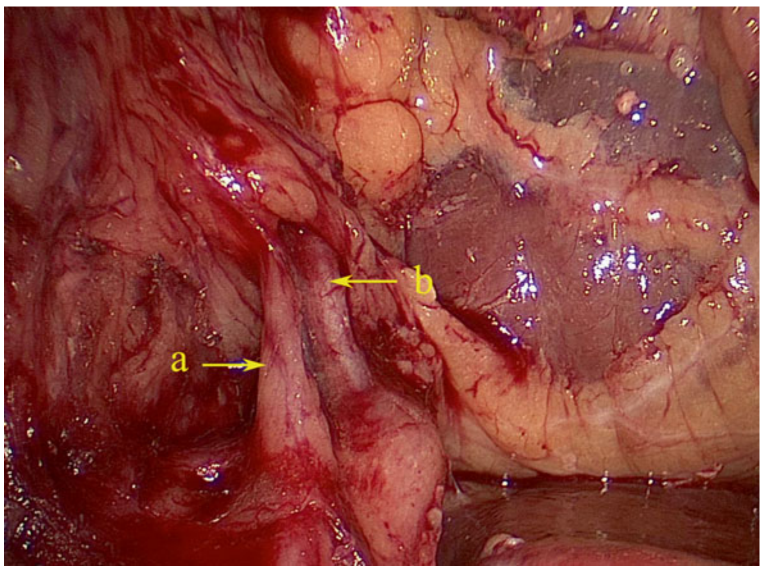


Fig. 5.199 The enlarged hepatic branches of vagus nerve (*a*) are difficult to distinguish from the RGA (*b*)

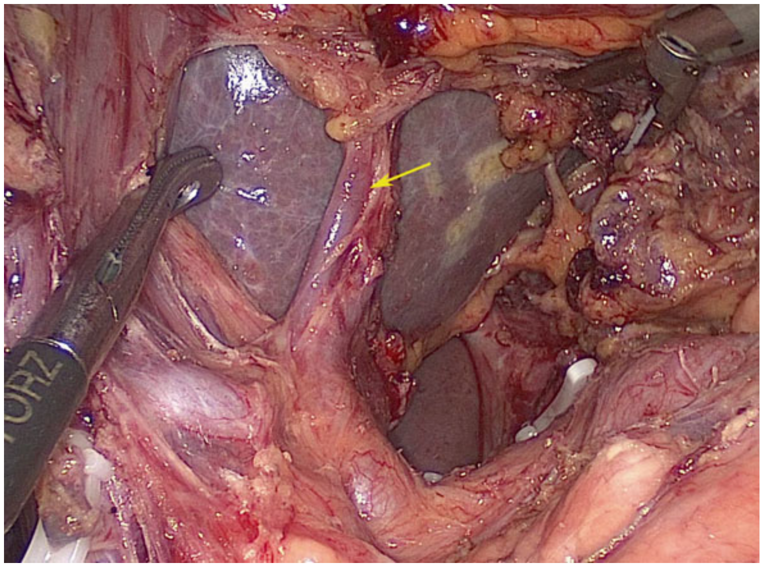


Fig. 5.200 The RGV accompanies the RGA (the *arrow* represents the right gastric vessels)

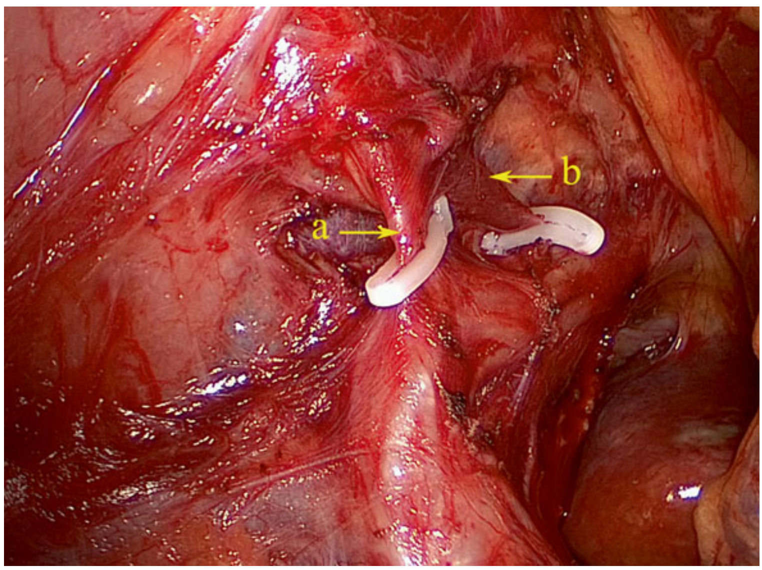


Fig. 5.201 The RGA (*a*) and RGV (*b*) are far from each other, which should be respectively ligated

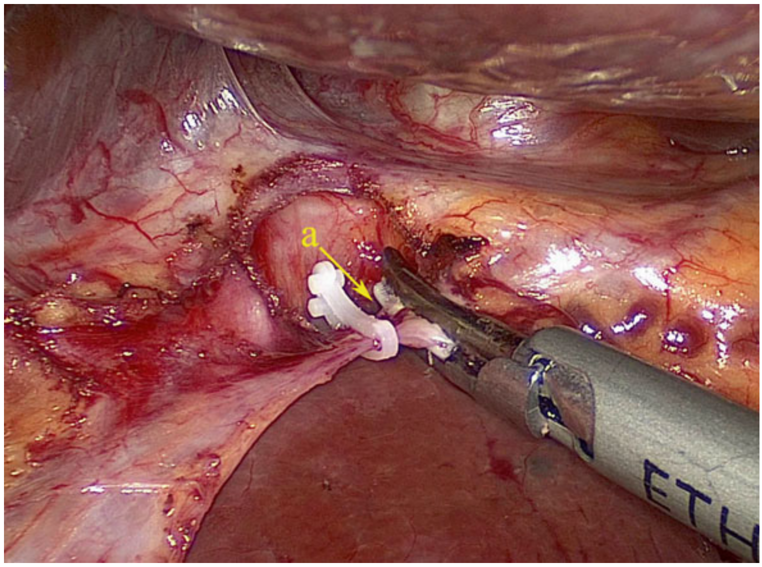


Fig. 5.202 The ALGA (*a*) should be severed at its origin segment

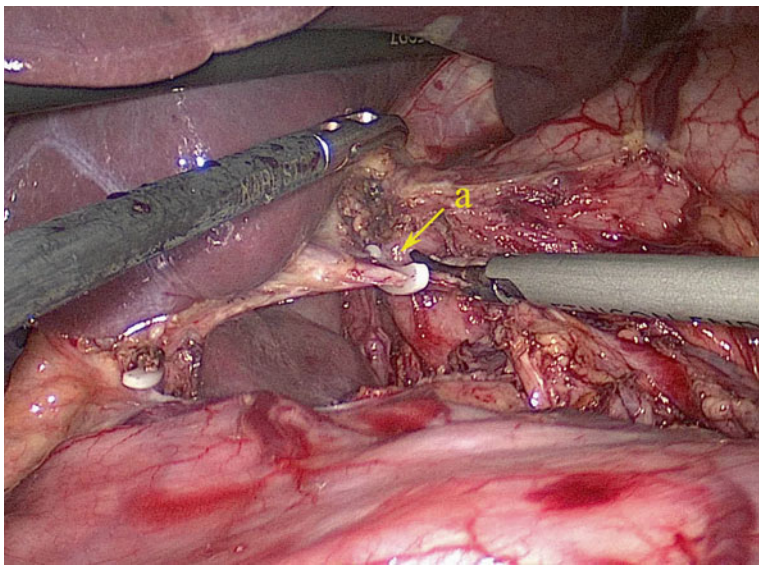


Fig. 5.203 A *thin* ALHA (*a*) can be severed at the inferior margin of the liver

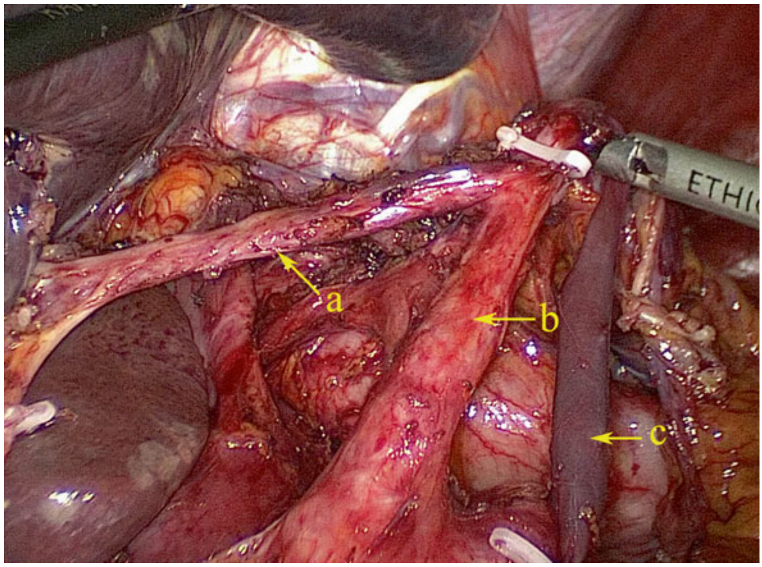


Fig. 5.204 The enlarged ALHA (*a*) should be preserved. The LGA (*b*) should be severed above the bifurcation of the ALHA from the LGA. LGV (*c*)

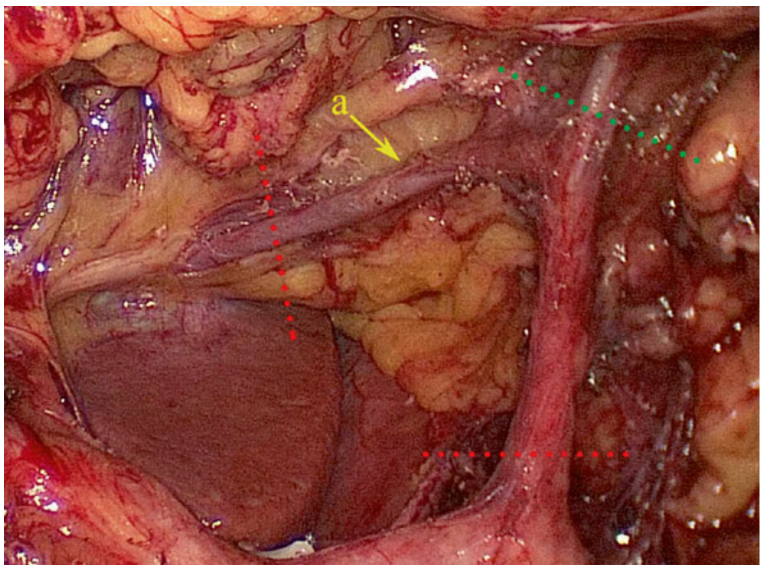


Fig. 5.205 The enlarged ALHA (*a*) should be severed at the plane of *green dotted line* (The *red dotted line* represents the wrong plane)

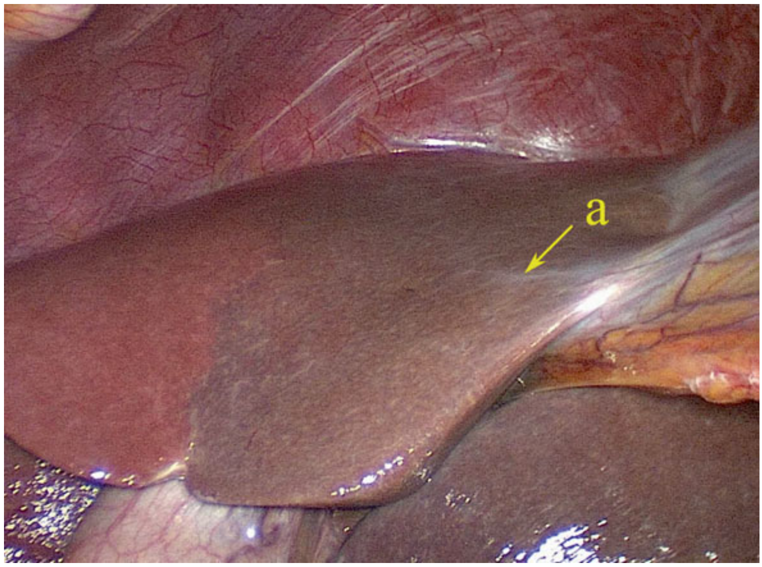


Fig. 5.206 Severing of the enlarged ALHA (*a*) results in left hepatic ischemia

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6 Laparoscopic Splenic Hilar Area Lymph Node Dissection for Gastric Cancer

6.1 Review of Laparoscopic Splenic Hilar Area Lymph Node Dissection for Gastric Cancer

Generally, the lymph nodes (LNs) in the splenic hilar region include the No. 4sa, No. 4sb, No. 10, and No. 11d LNs. This is an important segment in gastrectomy regarding D2 lymph node dissection in gastric cancer, particularly cancer located in the middle and upper third of the stomach (Fig. 6.1).

With respect to the relationship between the metastasis of the No. 4sa and No. 4sb LNs and the location of the tumor, it has been reported [1] that the rate of No. 4sa LNs metastasis (LNM) is 4.0–12.0 % for gastric body cancer and 19.0–36.0 % for the gastric fundus and cardial cancer. However, the incidence is relatively low for distal gastric cancer and is commonly <5.0 %. The metastatic rate of No. 4sb LNs is 18.0 %, 19.0 %, and 26.0 % in cardial, gastric body, and antrum cancer, respectively. Therefore, routine resection of the No. 4sa and No. 4sb LNs for advanced upper or middle gastric cancer and routine resection of the No. 4sb LNs for advanced lower gastric cancer are no longer controversial during D2 lymphadenectomy.

The ratio of No. 10 and No. 11 LNM has been reported to be 9.8–27.9 % [2–4] and 13.7–20.0 % [5, 6], respectively. A 346 case analysis for laparoscopic spleen-preserving No. 10 lymph node dissection for proximal gastric cancer by our center indicated that the incidence of No. 10 LNM is 10.1 % in advanced proximal gastric cancer [7]. No. 10 LNM is mainly associated with tumor location, depth of invasion, and Borrmann type [8]. The rate of gastric cancer in the upper and middle third of the stomach is significantly higher, particularly for advanced cancer located on the side with the greater curvature. No metastatic No. 10 and No. 11 LNs have been observed in early gastric cancer [9]. Our results [7] revealed that tumor location, depth of invasion, and metastases to No. 7 and No. 11 LNs were independent risk factors for No. 10 LNM. The status of No. 10 and

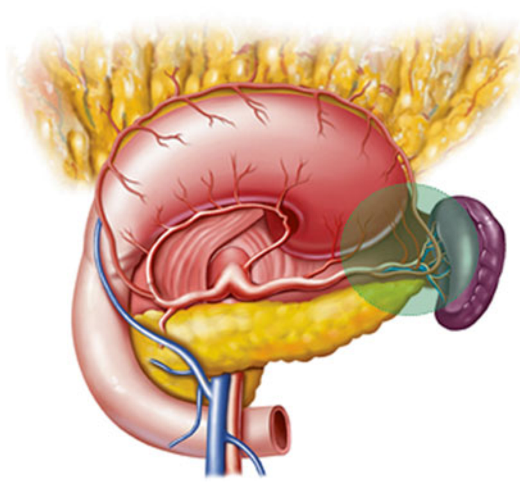


Fig. 6.1 Splenic hilar area

C.-M. Huang, C.-H. Zheng (eds.), *Laparoscopic Gastrectomy for Gastric Cancer: Surgical Technique and Lymphadenectomy*, DOI 10.1007/978-94-017-9873-0_6,

No. 11 LNs is a significant prognostic factor for gastric cancer. It has been demonstrated that the 5-year survival rate of patients without metastases is 51.6 %, while that of patients with LNM is 11.0 % [10]. Therefore, dissection of the No. 10 and No. 11 LNs is necessary in advanced upper and middle gastric cancer. This approach is also suggested in the 3rd edition of Japanese Gastric Cancer Treatment Guidelines [11]. However, for advanced proximal gastric cancer located in the lesser curvature, without serosal invasion or No.7 and No. 11 LNM, whether there is a need to undergo No. 10 lymph node dissection demands further research [7]. In the 1990s, pancreaticosplenectomy was performed to entirely excise the No. 10 and No. 11 LNs. Prophylactic dissection of splenic hilar LNs by conducting such surgery increases the risk of complications associated with distal pancreatectomy such as pancreatitis, pancreatic fistula, intra-abdominal infection or abscess, and postoperative diabetes. It also does not significantly improve the 5-year survival rate (35.6 % vs. 42.2 %; $P=0.622$) [12, 13]. Hence, some investigators have suggested that pancreaticosplenectomy cannot be used as a routine surgical method. In addition, the spleen and pancreas tail are only resected when obvious tumor invasion has been observed [14]. To achieve radical excision and avoid the complications caused by distal pancreatectomy as mentioned above, some investigators have advocated that it should be appropriate to exclusively perform pancreas-preserving splenic hilar lymph node dissection using splenectomy to cure upper and middle third gastric cancer. In recent years, researchers have gradually concentrated on the immunological aspects of the spleen, such as antitumor and anti-infection functions, which are also important in maintaining the health of patients. It is reported by Schwarz et al. [14] that, with the development of surgical techniques, spleen-preserving splenic hilar lymph node dissection has been demonstrated to be technically feasible, with a curative effect similar to splenectomy. And no survival benefits have been observed after splenectomy (48.3 % vs. 54.8 %; $P=0.503$), while patient morbidity and mortality were significantly increased. In contrast, pancreas- and spleen-preserving lymph node dissection (D2) has achieved improved prognosis. Therefore, whether splenectomy should be performed requires careful consideration. The concept of spleen-preserving splenic hilar lymph node dissection is being accepted by an increasing number of clinicians.

In the clinic, the areas adjacent to the splenic hilar are complex and located in a narrow, but very deep, operating space. The spleen often adheres to the omentum or peritoneum, making it susceptible to injury. The vessels in the splenic hilar are particularly intricate and variable; thus, in open surgery, the spleen and distal pancreas must be pulled out of the abdomen, and the No. 10 LNs can then be dissected thoroughly. However, this manipulation is traumatic and time-consuming; moreover, spleen floating or twisting might occur after the operation. If the spleen and distal pancreas are not mobilized before splenic hilar region dissection, it can be difficult to radically remove the LNs because of the lack of adequate exposure. Laparoscopic amplification and the superior effects of ultrasonic scalpel for cutting and hemostasis allow the surgeon to clearly visualize the perigastric fascia, intrafascial space, vasculature, nerves, and other structures. The splenic vessels and their branches can thereby be comfortably exposed, and the meticulous procedure involved in No. 10 and No. 11 lymphadenectomy can be smoothly and efficiently completed. Therefore, the application of laparoscopy may have advantages in spleen-preserving splenic hilar lymph node dissection.

The first report of laparoscopic spleen-preserving splenic hilar lymph node dissection, regarding the treatment of gastric cancer in the upper and middle third of the stomach, was published by Hyung et al. [15] in 2008. A mean number of 2.7 (1–5) LNs per patient was found in the splenic hilar, and the effect of dissection was the same as that in open surgery. In addition, laparoscopic surgery provides obvious advantages including smaller incision, minimal invasiveness, and shorter operating time because of maintenance of the spleen in situ. In addition, it has been found that laparoscopic spleen-preserving splenic hilar lymphadenectomy is safe and feasible. In our study, the average number of retrieved LNs under laparoscopic surgery was 3.6 per patient, and no patients required open conversion resulting from injury to the spleen or its vessels; no complications associated with dissection of the splenic hilar region, such as hemorrhage, splenic ischemia, and splenic necrosis, have been observed post-operatively indicating favorable short-term outcomes [16]. It can be predicted that, with the improvement of standardized training and the development of laparoscopic techniques, laparoscopic spleen-preserving splenic hilar lymphadenectomy will become one of the standard treatments for advanced upper and middle gastric cancer.

6.2 Anatomy Associated with Lymph Node Dissection in the Splenic Hilar Area

6.2.1 Fascia and Intrafascial Space in the Splenic Hilar Area

6.2.1.1 Gastrosplenic and Splenorenal Ligaments

The gastrosplenic ligament (GSL) connects the greater curvature of the stomach with the splenic hilar above the pancreas (Figs. 6.2, 6.3, and 6.4), while the splenorenal ligament (SRL) extends from the spleen to the left kidney at the lateral abdominal wall (Figs. 6.5 and 6.6). The GSL consists of two layers of peritoneum, and the short gastric and left gastroepiploic vessels lie between them. The posterior layer is continuous with the peritoneum, which covers the splenic hilar and the posterior wall of the stomach. The anterior layer is formed by peritoneal reflection which leaves the spleen in the gastric notch of its

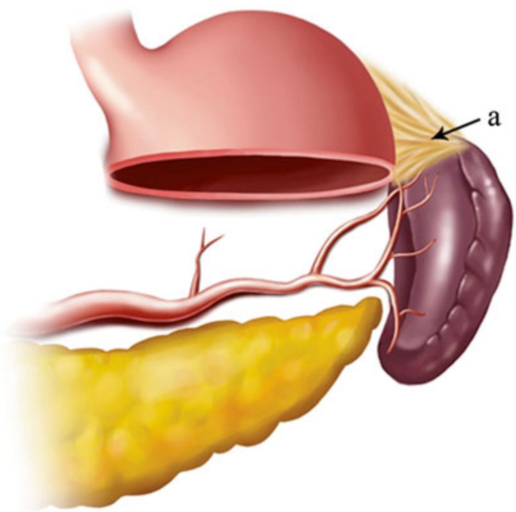


Fig. 6.2 GSL (*a*)

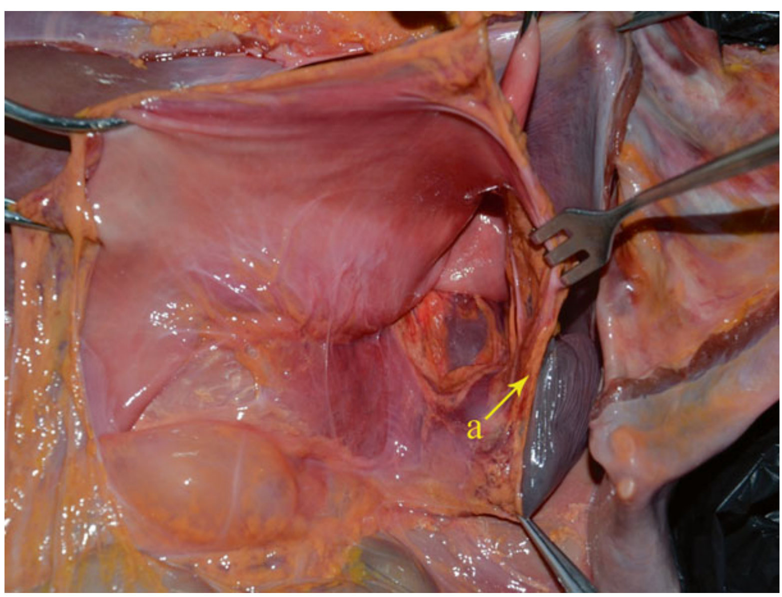


Fig. 6.3 GSL (*a*) (in autopsy)

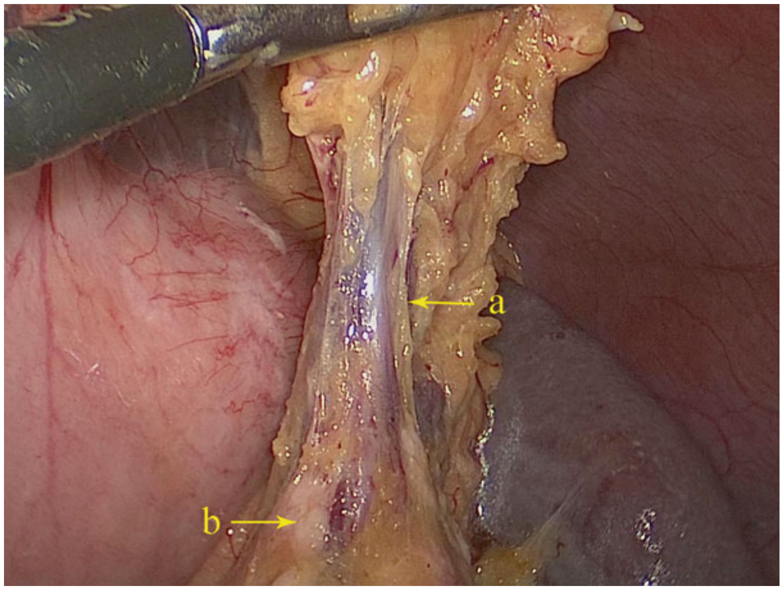


Fig. 6.4 GSL (*a*). Pancreas tail (*b*)

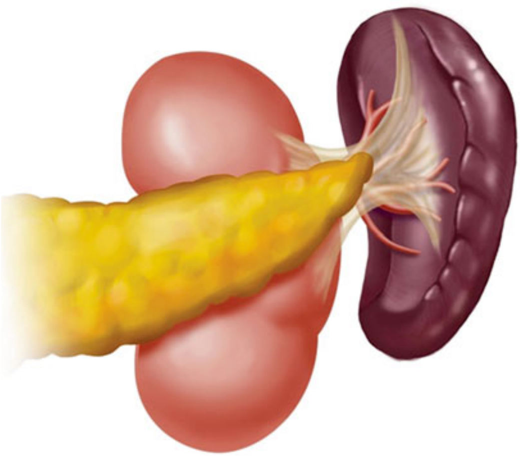


Fig. 6.5 The schematic figure of the SRL

upper pole. It then becomes continuous with the peritoneum covering the anterior wall of the stomach.

The SRL also consists of two layers of peritoneum, with the following structures located between them: the splenic artery (SpA) and all of its branches, nerves, and lymph vessels; the tail of the pancreas is located at the lower part of the SRL. The anterior layer of the SRL inwardly joins the peritoneum of the posterior wall of the omental bursa above the left kidney, and it extends upward to the splenic hilar, where it connects with the posterior layer of the GSL. The posterior layer of the SRL passes outward to join the peritoneum below the diaphragm and then runs to the surface of the spleen above the splenic incisura. There is a mutually linked potential space within the GSL and the SRL. This space, which is linked with the space at the upper pancreatic border, provides a pathway for the splenic vessels and their branches. The front of the GSL is continuous with the anterior pancreatic fascia (APF) at the pancreatic tail. Thus, the space within the GSL can be entered by opening the APF from the pancreatic tail along the space at the upper border of the pancreas. The ligaments around the splenic hilar can be dissected to expose the terminal branches of the SpA and the origin of the left gastroepiploic artery (LGEA) (Fig. 6.7).

6.2.1.2 Toldt's Space (TS) and Gerota's Fascia

TS is a widely distributed avascular plane that forms a complete boundary between the retropancreatic fascia and Gerota's fascia. Gerota's fascia, which encloses the renal vessels, the left kidney, and the adrenal gland, constitutes the rear of TS. The front

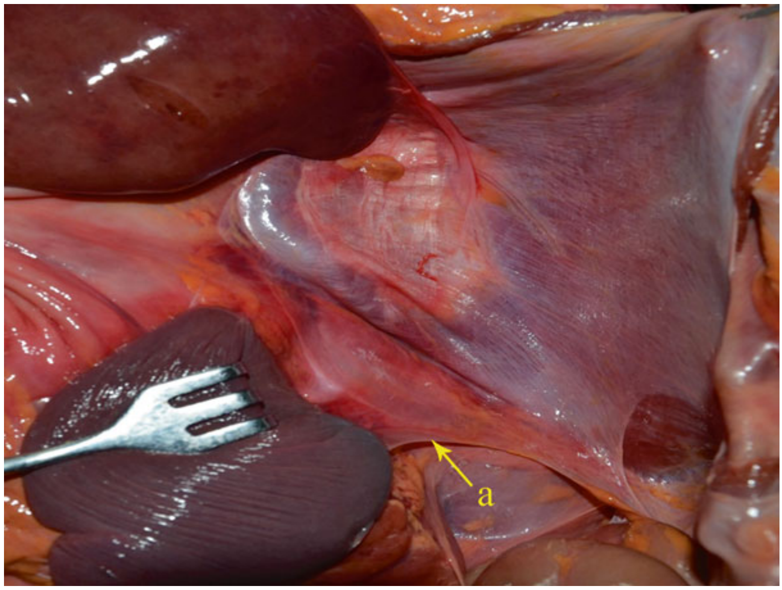


Fig. 6.6 SRL (*a*) (in autopsy)

consists of the back of the pancreatic body and tail. The transverse colonic intrafascial space is linked with the anteroinferior side of TS (Fig. 6.8).

6.2.2 Vascular Anatomy Associated with Lymph Node Dissection in the Splenic Hilar Area

6.2.2.1 Arterial Anatomy Associated with Lymph Node Dissection in the Splenic Hilar Area

SpA

The SpA branches from the celiac artery (CA). It meanders toward the left along the upper border of the pancreas, and it gives off the great pancreatic artery, caudal pancreatic artery, and some small arteries to the pancreas along the way. It also gives rise to the posterior gastric, short gastric, and left gastroepiploic arteries, which supply the posterior wall and the greater curvature of the stomach (Figs. 6.9, 6.10, and 6.11).

Relation Between the Course of the SpA and the Pancreas

The course of the SpA is intimately associated with the pancreas. The anatomical data of 319 patients with advanced proximal gastric cancer who underwent laparoscopic spleen-preserving hilar lymph node dissection in our center were retrospectively analyzed. The course of the SpA was divided into four variations based on the results.

Type I: In the majority of cases, the SpA follows the suprapancreatic course to the splenic hilar after arising from the CA. Present in 87 cases (27.2 %) (Figs. 6.12, 6.13, and 6.14).

Type II: The middle one-half of the SPA has either a retro- or intrapancreatic course in 213 cases (66.8 %) (Figs. 6.15 and 6.16).

Type III: The distal one-half of the SPA follows either a retro- or intrapancreatic course in 13 cases (4.1 %) (Figs. 6.17 and 6.18).

Type IV: The distal three-fourths of the SpA is entirely embedded in the substance of the pancreas or follows a retropancreatic course in six cases (1.9 %) (Figs. 6.19 and 6.20).

Branches of the SpA

Splenic Lobar Artery (SLA)

The SLA refers to the terminal branch of the SpA at the splenic hilar, and there are four types of anatomical variation according to the anatomical data of 319 cases in our center:

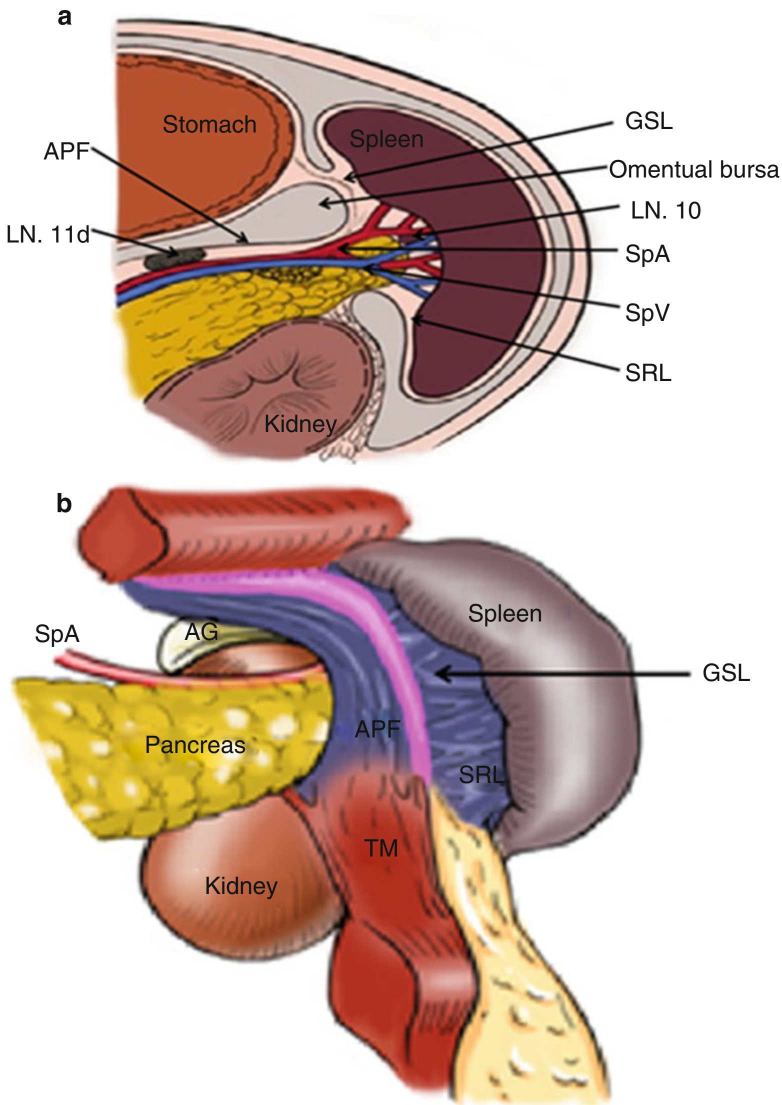


Fig. 6.7 (**a**) The *GSL* and the *SRL* are mutually linked. (**b**) The GSL and the SRL are mutually linked

One-branched type: The SpA passes tortuously through the splenic hilar without dividing into terminal branches. This type is relatively rare, observed in 22 cases (6.9 %) (Figs. 6.21 and 6.22).

Two-branched type: The SpA gives off the superior and inferior lobar arteries of the spleen. This type is common, observed in 252 cases (79.0 %) (Figs. 6.23, 6.24, and 6.25).

Three-branched type: The SpA divides into the superior, middle, and inferior lobar arteries of the spleen. Present in 43 cases (13.5 %) (Figs. 6.26 and 6.27).

Multiple-branched type: Rarely, the SpA branches out into four to seven branches that enter the splenic hilar. Present only in two cases (0.6 %) (Figs. 6.28 and 6.29).

Splenic Pole Artery (SPoA)

The SPoA refers to an artery that directly enters the upper and/or lower pole of the spleen without passing through the splenic hilar. The splenic

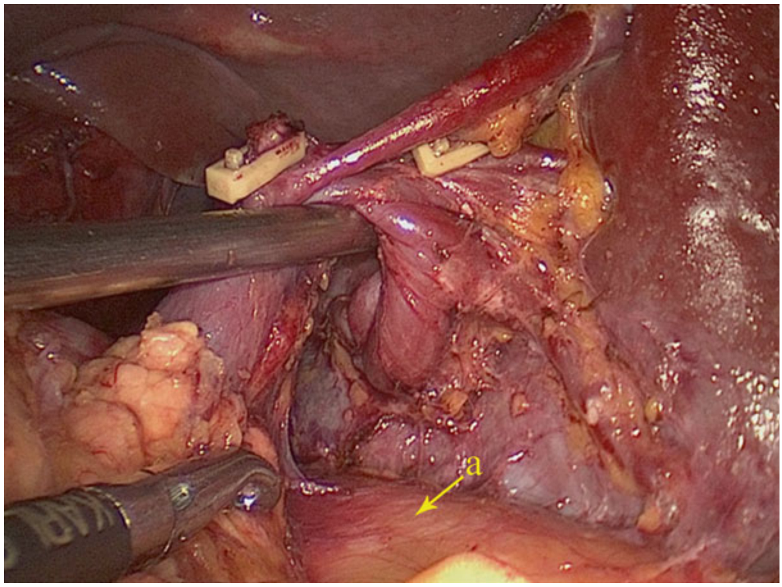


Fig. 6.8 Gerota's fascia (*a*)

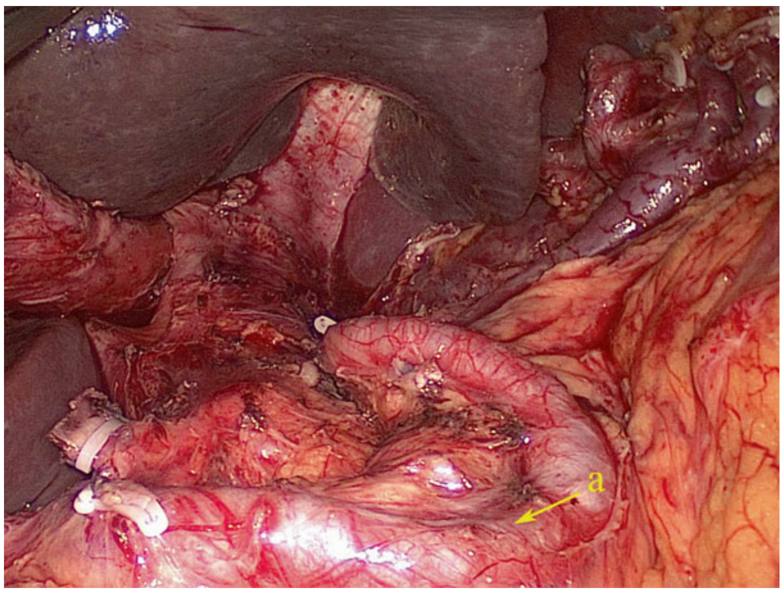


Fig. 6.9 SpA (*a*)

upper-pole artery (SUPA) mostly arises from the SpA trunk (SpAT), but in rare cases it arises from the SLA. The splenic lower pole artery (SLPA) generally issues from the LGEA or inferior lobar artery of the spleen (ISLA) and infrequently originates from the SpAT. Our results show that the incidence of the SUPA is 16.6 % (53/319), and the incidence of the SLPA is 5.0 % (16/319) (Figs. 6.30, 6.31, 6.32, and 6.33).

LGEA

The LGEA arises as a branch of the SpA, ISLA, or SLPA. It then runs from left to right along the greater curvature of the stomach

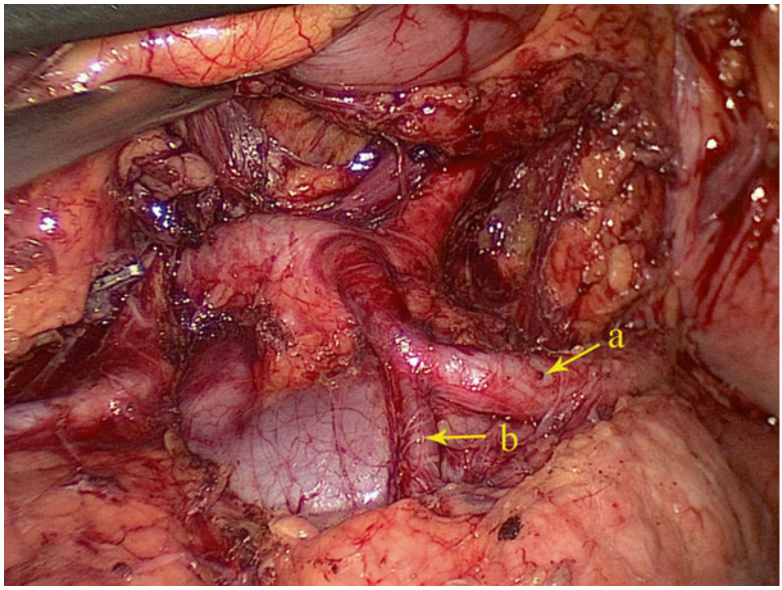


Fig. 6.10 The SpA (*a*) gives off the caudal pancreatic artery (*b*)

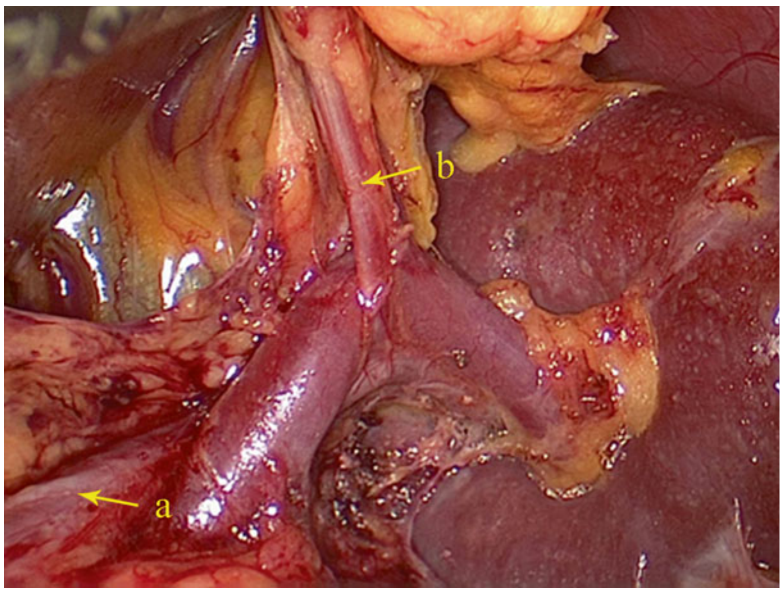


Fig. 6.11 The SpA (*a*) gives rise to the LGEA (*b*) before reaching the spleen

between the two anterior layers of the greater omentum in the GSL. The LGEA gives off several branches to both surfaces of the stomach and to the greater omentum before it joins the right gastroepiploic artery (RGEA) to form the gastroepiploic arterial arch (Figs. 6.34, 6.35, 6.36, and 6.37).

Short Gastric Artery (SGA)

The SGA, which has four to six small branches, arises from the SpAT or its terminal divisions. Individual SGAs occasionally issue from the LGEA (Figs. 6.38, 6.39, 6.40, and 6.41). They all pass between the layers of the GSL and are distributed outside of the gastric fundus. During

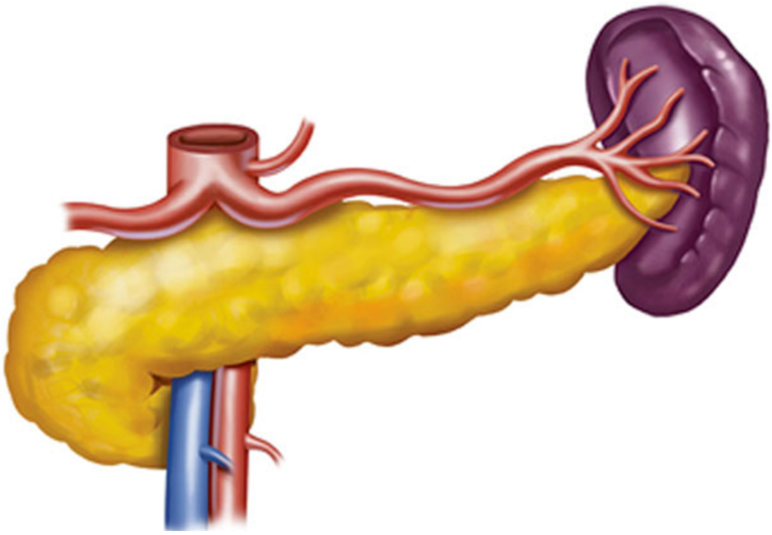


Fig. 6.12 Type I. SpA

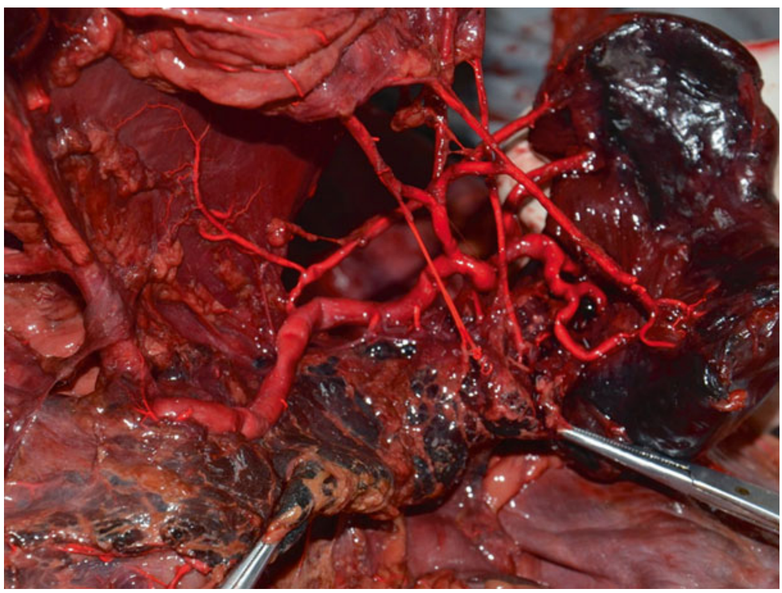


Fig. 6.13 Type I. SPA (in autopsy)

total gastrectomy, it should be noted that the lengths of the short gastric vessels (SGVs) are shorter, the closer they are to the superior pole region of the spleen (Fig. 6.42).

Posterior Gastric Artery (PGA)
The PGA arises from the SpAT and its branches on the posterior wall of the stomach. It most frequently arises from the trunk of the SpA (Figs. 6.43 and 6.44), while it may arise from the SUPA in a few cases (Figs. 6.45, 6.46, and 6.47). The PGA is present in 60.0–80.0 % of cases and ascends in the rear of the omental bursa accompanying the vein of the same name.

Classification of the Terminal Branches of the SpA

We usually define the different terminal branches by the distance between the artery's furcation to the splenic hilar region, including

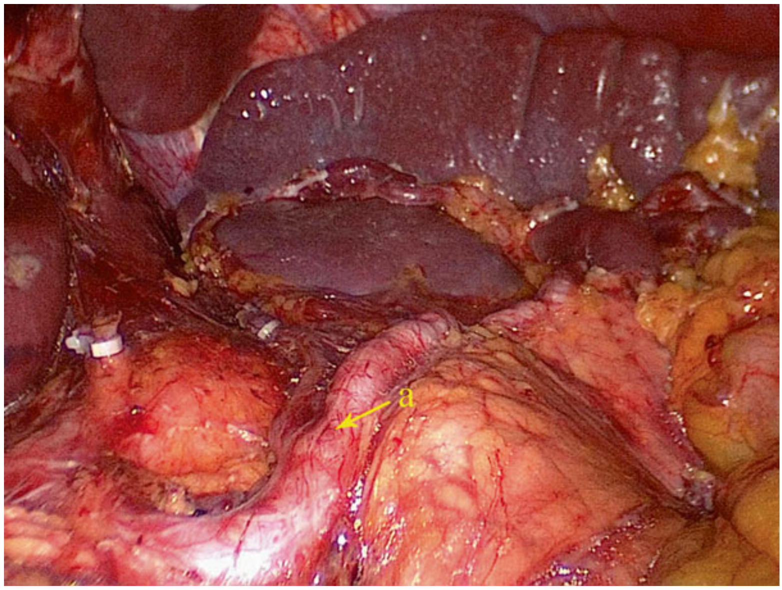


Fig. 6.14 Type I. SpA (*a*)

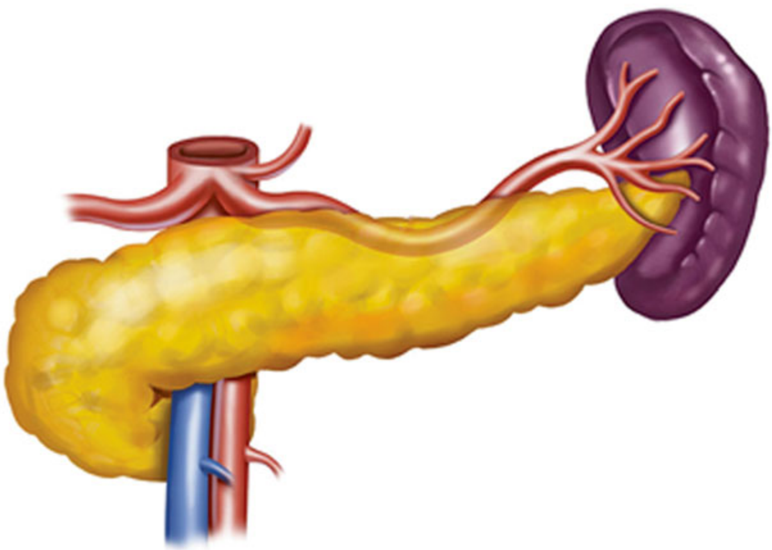


Fig. 6.15 Type II. SpA

the distributed type and concentrated type of SpA. The concentrated-type SpA always divides into its terminal branches within 2 cm from the splenic hilum. And the SpAT is long while the SLAs are short and centralized (Figs. 6.48 and 6.49). On the contrary, the distributed-type SpA generally divides into its terminal branches more than 2 cm from the splenic hilum. And the branches are long and of smaller caliber, always accompanying the SPoA (Figs. 6.50 and 6.51). The anatomical data of 319 patients in our center showed 64.3 % of the patients were the

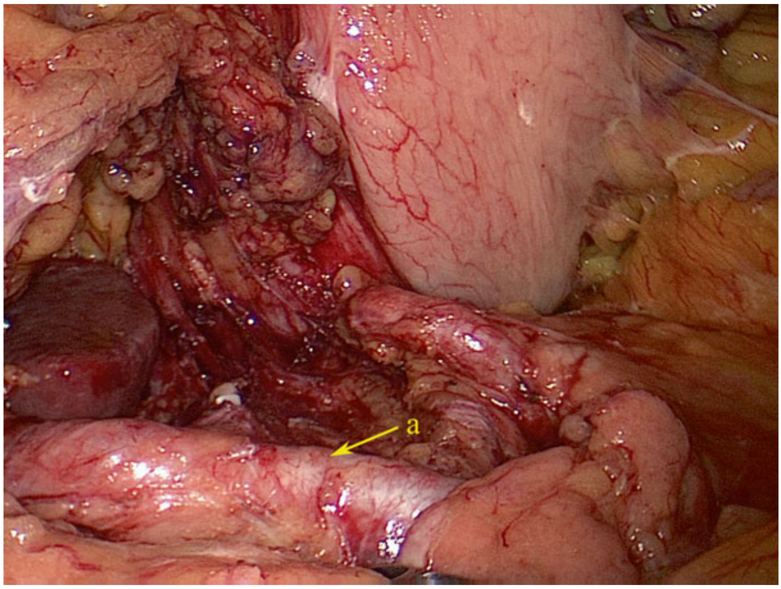


Fig. 6.16 Type II. SpA (*a*)

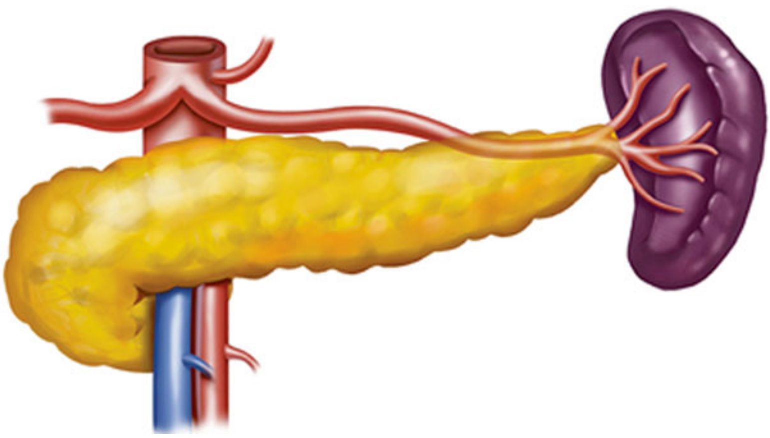


Fig. 6.17 Type III. SpA

concentrated type (205 cases) and 35.7 % were the distributed type (114 cases).

6.2.2.2 Veins Associated with Lymph Node Dissection in the Splenic Hilar Area

Left Gastroepiploic Vein (LGEV)

The LGEV runs parallel with the artery of the same name and ends in the splenic vein (SpV) (Fig. 6.52).

SpV

The SpV is formed by the union of splenic lobar veins that issue from the splenic hilar. It also receives the blood of the splenic pole vein (SPoV), branches of the pancreatic vein, the short gastric vein, the LGEV, and the inferior mesenteric vein (IMV). The SpV generally accompanies the SpA, but it is less tortuous than the artery (Figs. 6.53 and 6.54).

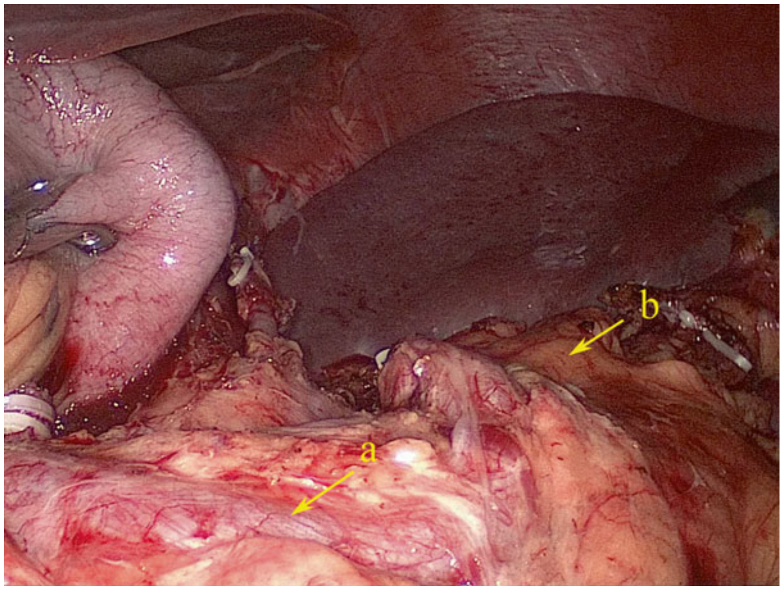


Fig. 6.18 Type III. SpA (*a*) and pancreatic tail (*b*)

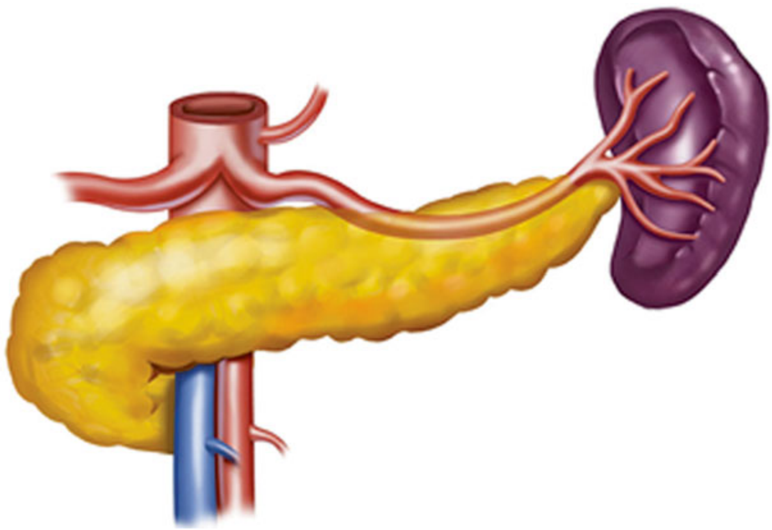


Fig. 6.19 Type IV. SpA

6.2.3 Lymph Node Anatomy Associated with Lymph Node Dissection in the Splenic Hilar Area

6.2.3.1 No. 4 LNs (LNs Around the Greater Curvature of the Stomach)

The No. 4 LNs are divided into the following three substations according to the arteries they accompany.

No. 4d LNs

Definition of the No. 4d LNs

The No. 4d LNs are included in the two layers of the mesogastrium attached to the greater curvature of the stomach along the RGEA. They are separated from the No. 6 LNs by the first branch of the RGEA feeding the gastric wall. The No. 6 LNs are on the right side of the branch, and the No. 4d LNs are on the left side (Figs. 6.55 and 6.56).

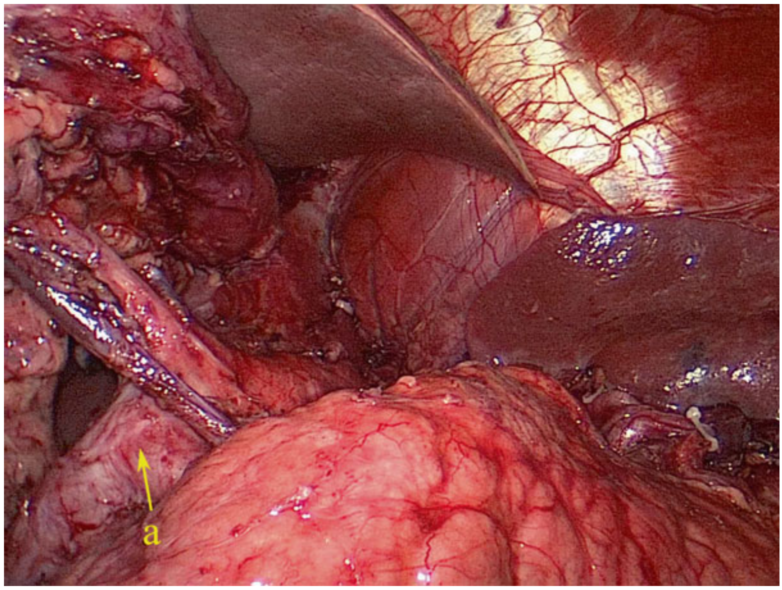


Fig. 6.20 Type IV. SpA (*a*)

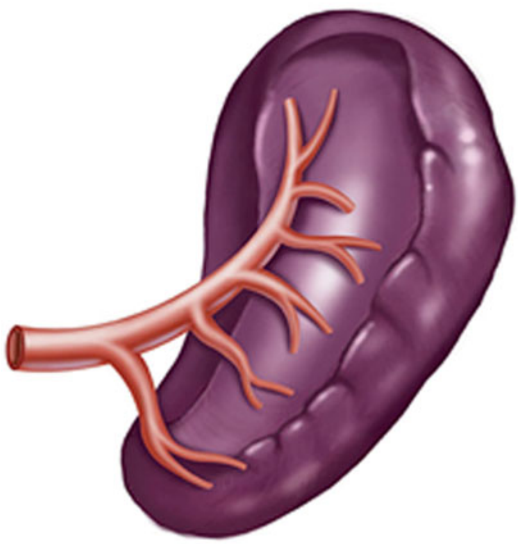


Fig. 6.21 One-branched type

No. 4d LNM (Figs. 6.57 and 6.58)

No. 4sb LNs

Definition of the No. 4sb LNs

The No. 4sb LNs lie between the two layers of the mesogastrium attached to the greater curvature of the stomach in the GSL along the LGEA. They are separated from the No. 10 LNs by the first branch of the LGEA feeding the gastric wall. The No. 10 LNs are on the proximal side of the branch at the splenic hilar, and the No. 4sb LNs are on the distal side (Fig. 6.59).

No. 4sb LNM (Figs. 6.60, 6.61, and 6.62)

No. 4sa LNs

Definition of the No. 4sa LNs

The No. 4sa LNs are located at the gastric wall between the two layers of the mesogastrium attached to the greater curvature of the stomach along the SGAs (Fig. 6.63).

No. 4sa LNM (Fig. 6.64)

6.2.3.2 No. 10 LNs (LNs Located at the Splenic Hilar)

Definition of the No. 10 LNs

The No. 10 LNs are located at the splenic hilar along the vessels leaving the pancreatic tail and passing into the spleen. They are separated from the No. 11 LNs by the end of the pancreatic tail (Figs. 6.65 and 6.66).

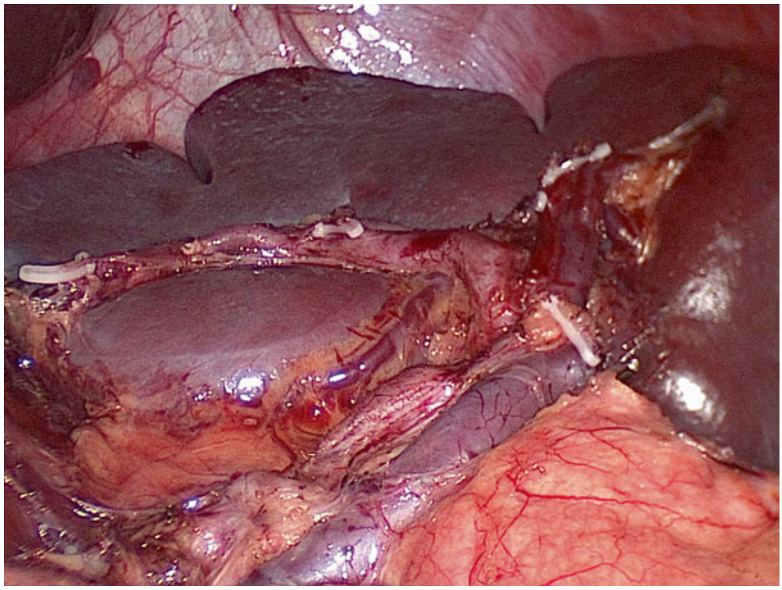


Fig. 6.22 One-branched type

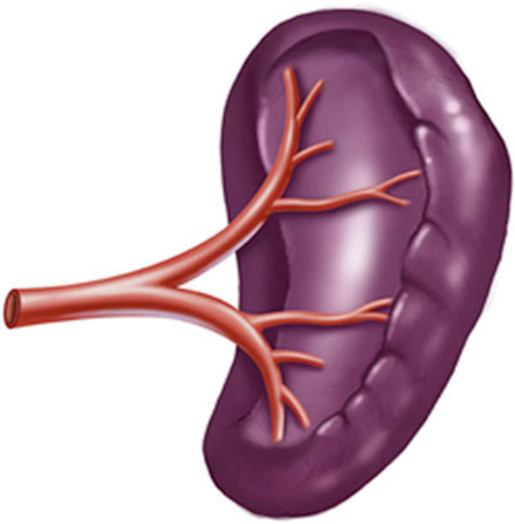


Fig. 6.23 Two-branched type

No. 10 LNM (Figs. 6.67, 6.68, and 6.69)

6.2.3.3 No. 11 LNs (LNs Along the Trunk of SpA)

Definition of the No. 11 LNs

The No. 11 LNs lie along the SpAT and include the LNs in this region that are located behind the pancreas. Based on the direction of lymphatic flow and on clinical needs, the No. 11 LNs are divided into two substations by the middle point of the SpA. Those along the proximal SpA near the CA are classified as No. 11p LNs, while those along the distal SpA near the splenic hilar are classified as No. 11d LNs (Figs. 6.70 and 6.71).

No. 11 LNM (Figs. 6.72 and 6.73)

6.3 Procedures for Lymph Node Dissection in the Splenic Hilar Area

Lymph node dissection in the splenic hilar area includes the dissection of the No. 4sb, 10, and 11d LNs. We have summarized an effective procedure called Huang's three-step maneuver [17] for the performance of laparoscopic spleen-preserving splenic hilar lymphadenectomy in clinical practice. The first step is the dissection of the LNs in the inferior pole region of the spleen. The second step is the dissection of the LNs in the trunk of SpA region, and the third step is the dissection of the LNs in the superior pole region of the spleen.

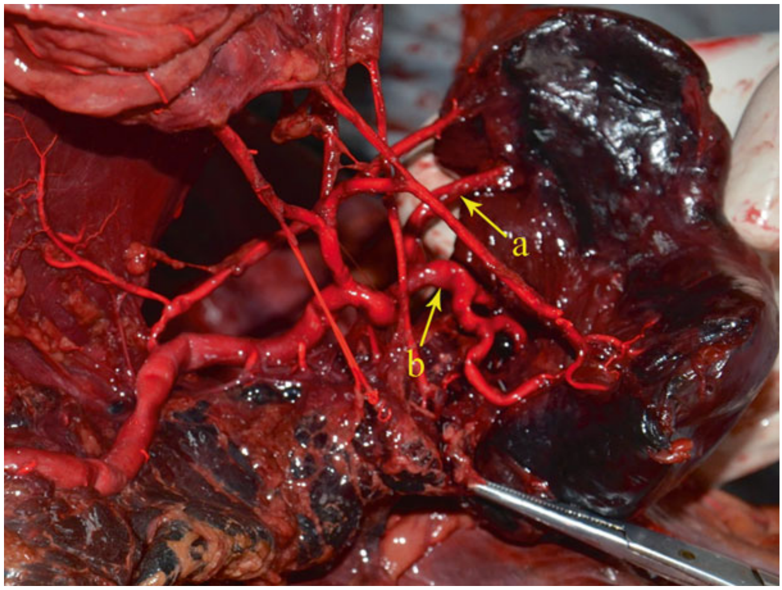


Fig. 6.24 Two-branched type. The superior lobar artery (*a*) and inferior lobar artery of the spleen (*b*) (in autopsy)

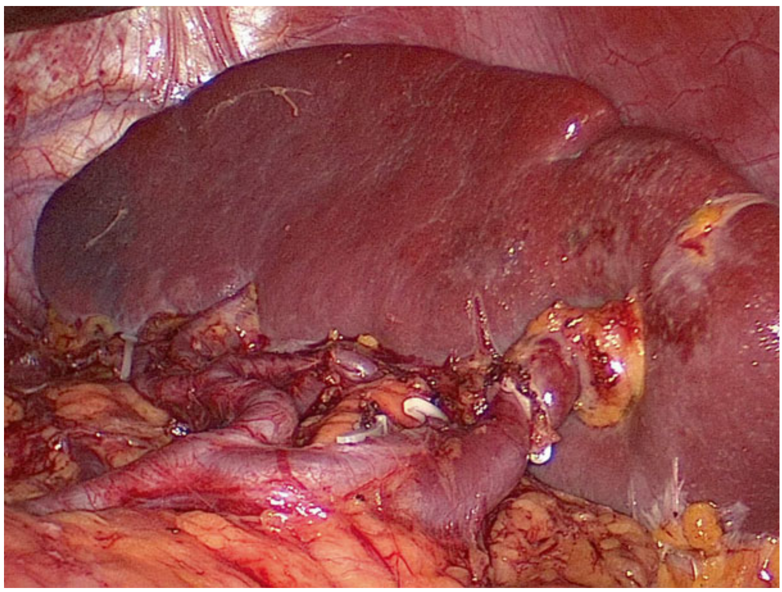


Fig. 6.25 Two-branched type

6.3.1 Operative Approach

We use a favorable left-sided approach to dissect the LNs of the splenic hilar area [17, 18]. This means that the membrane of the pancreas is separated at the superior border of the pancreatic tail in order to reach the posterior pancreatic space, revealing the end of the splenic vessels' trunk (Fig. 6.74) [19, 20]. The splenic hilar area can be sufficiently exposed because of the relative immobility of the spleen and the patient's position (tilted left side up with the head elevated), as well as the gravity exerted by the stomach and omentum themselves. The surgeon stands between the patient's legs to enable an easy and smooth operation with his or her right hand during the splenic hilar lymphadenectomy. During the dissection, the GSL is not initially transected, with the advantage of easy exposure of the splenic hilar as the assistant applies sufficient traction to the GSL [21]. Thus, good tension can be obtained, assisting the surgeon in dissection and separation of the vessels in the splenic hilar area. Furthermore, if the spleen or the splenic vessels are damaged, the surgeon is able to conveniently and rapidly stanch the bleeding. At the same time, the LGEVs and the SGVs are divided at their roots, and the No. 10 and 11d LNs are successively excised from the end of the SLA toward its root, allowing for the complete removal of the splenic hilar area LNs as well as the stomach in accordance with an oncological en bloc resection.

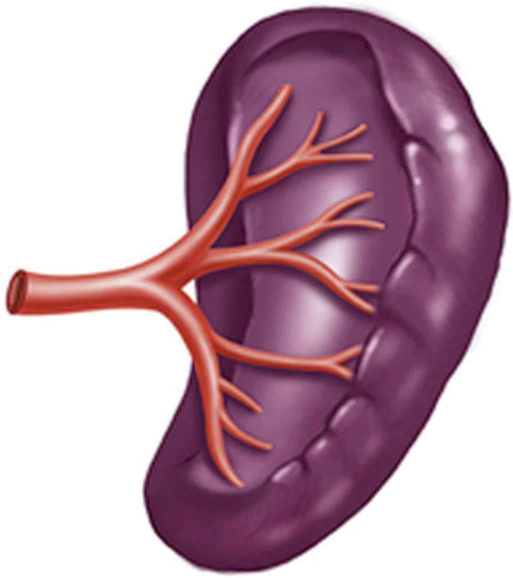


Fig. 6.26 Three-branched type

6.3.2 Exposure Methods

The assistant's exposure methods are divided into three main steps according to the three-step maneuver performed by the surgeon.

First step: dissection of the LNs in the inferior pole region of the spleen

The assistant places the free omentum of the anterior gastric wall at the right upper side of the abdomen and uses his or her left hand to

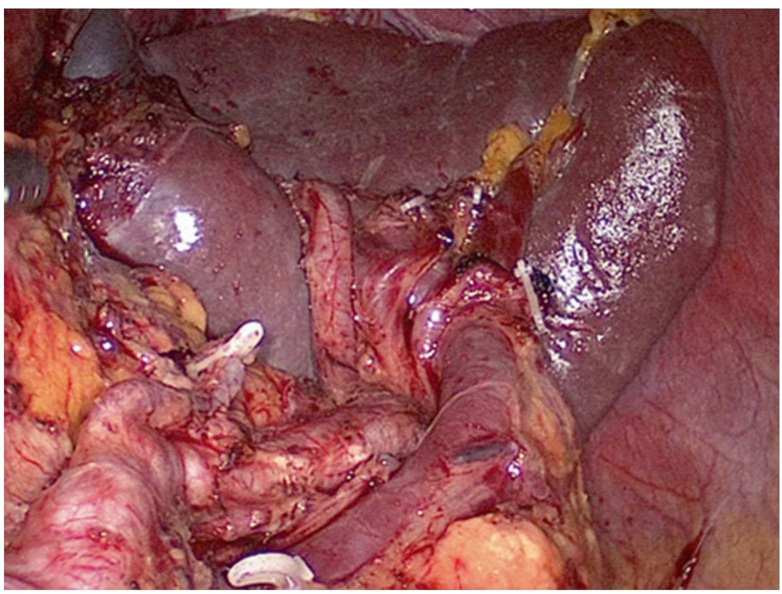


Fig. 6.27 Three-branched type

pull up the initial segment of the GSL, while the surgeon gently presses the lower edge of the pancreatic body and tail toward the lower left with gauze to reveal the inferior pole region of the spleen (Fig. 6.75).

Second step: dissection of the LNs in the region of the SpAT

The assistant places the free omentum and part of the GSL between the anterior gastric wall and the inferior border of the liver, and then uses his or her left hand to pull the greater curvature of the fundus to the upper right, tensing the rest of the GSL. The surgeon's left hand presses on the body of the pancreas to expose the SpA area in the retropancreatic space (RPS) (Fig. 6.76).

Third step: dissection of the LNs in the superior pole region of the spleen

The assistant uses his or her left hand to pull the greater curvature of the fundus toward the lower right side, while the surgeon's left hand presses on the vessels of the splenic hilar to fully reveal the superior pole region of the spleen (Fig. 6.77). During the procedures, the assistant's right hand can apply different techniques, such as picking, lifting, holding, pushing, and peeling, to assist the surgeon in the splenic hilar lymphadenectomy.

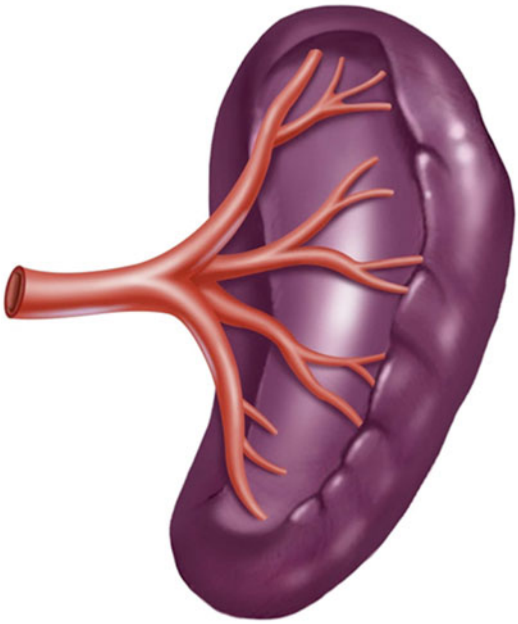


Fig. 6.28 Multiple branched

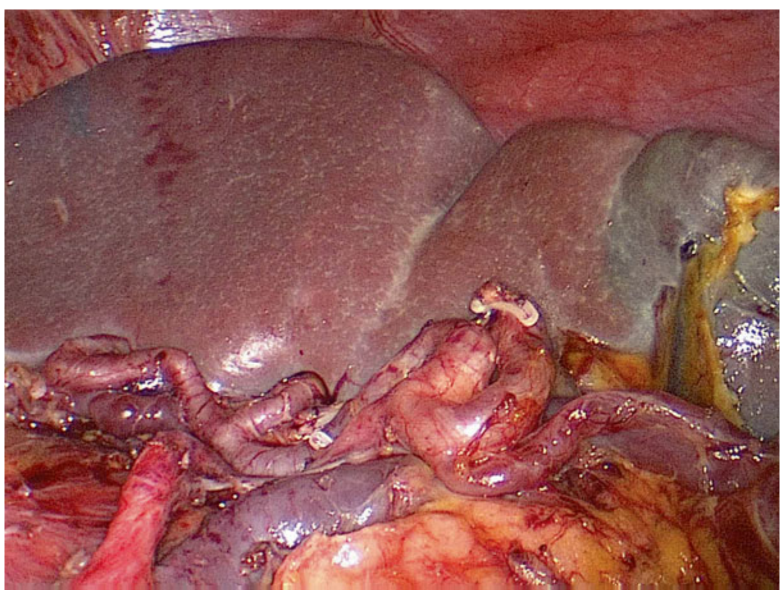


Fig. 6.29 Multiple branched

6.3.3 Operative Procedures

6.3.3.1 First Step: Dissection of the LNs in the Inferior Pole Region of the Spleen

The surgeon uses the ultrasonic scalpel to separate the greater omentum toward the left up to the splenic flexure of the colon along the superior border of the transverse colon (Fig. 6.78). Next, the APF is peeled against the anterior inherent pancreatic fascia along the direction of the pancreas to the superior border of the pancreatic tail (Fig. 6.79). Then, the surgeon uses the ultrasonic scalpel to open the APF along the fascia's continuation, and the RPS is entered at the superior border of the pancreas. Next, the mutually linked potential space in the GSL and the SRL can be entered by following the RPS, and the end of the splenic vessels' trunk can be exposed at the initial segment of the GSL (Fig. 6.80).

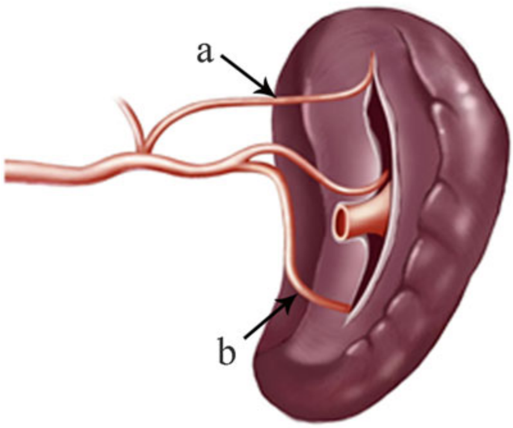


Fig. 6.30 SUPA (*a*) and SLPA (*b*)

The dissection is continued along the end of the splenic vessels to expose the lower lobar vessels of the spleen (LLVSs) or the lower pole vessels of the spleen (LPVSs) (Fig. 6.81). The assistant's right hand pulls up the fatty lymphatic tissue on the surface of the vessels, and the surgeon uses the nonfunctional face of the ultrasonic scalpel to dissect the lymphatic tissue along the vessels distally up to the splenic hilar (Fig. 6.82). During the dissection, the roots of the LGEVs can be revealed at the SLA or SLPA near the lower pole of the spleen (Fig. 6.83). The assistant pulls up the fatty lymphatic tissue at the LGEVs' roots, and the surgeon uses the ultrasonic scalpel to vascularize the vessels by dissecting the tissue along the anatomical space at the surface of the

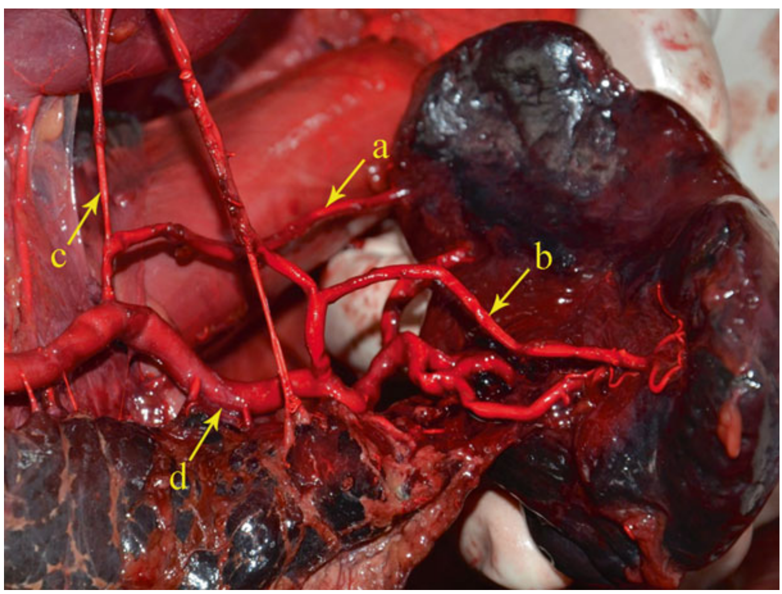


Fig. 6.31 SUPA (*a*), SLPA (*b*), PGA (*c*), and SpA (*d*) (in autopsy)

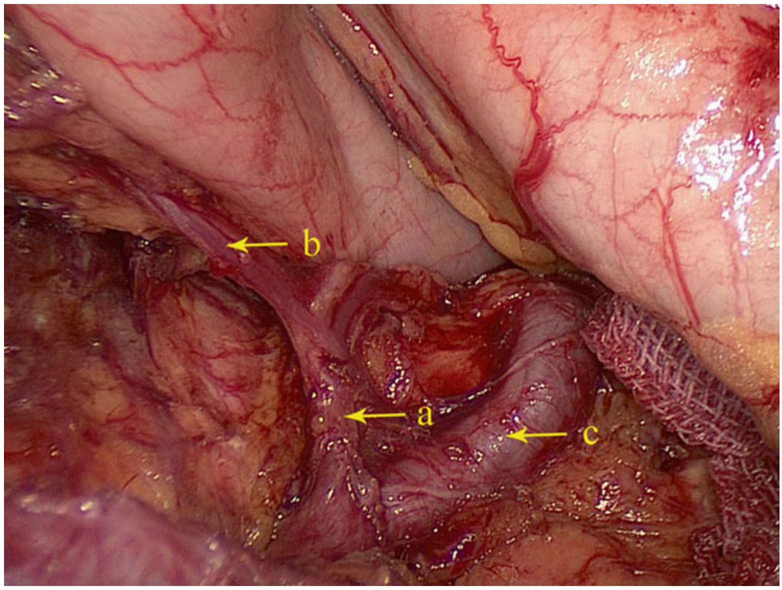


Fig. 6.32 SUPA (*a*), PGA (*b*), and SpA (*c*)

Fig. 6.33 The SLPA (*a*) arises from the SpA (*b*)

vessels (Figs. 6.84 and 6.85). Next, the LGEVs are transected at their roots with vascular clamps (Fig. 6.86). The resection of the No. 4sb LNs is then accomplished.

At this time, the assistant pulls up the fatty lymphatic tissue on the surface of the LLVSs, while the surgeon uses the ultrasonic scalpel to meticulously dissect this tissue along the anatomical space on the surface of the LLVSs toward the splenic hilar, alternatively using blunt and sharp methods of separation. As the LLVSs are gradually revealed, one to two branches of the SGVs issuing from the ISLA may be encountered (Fig. 6.87). If so, the assistant gently pulls up the

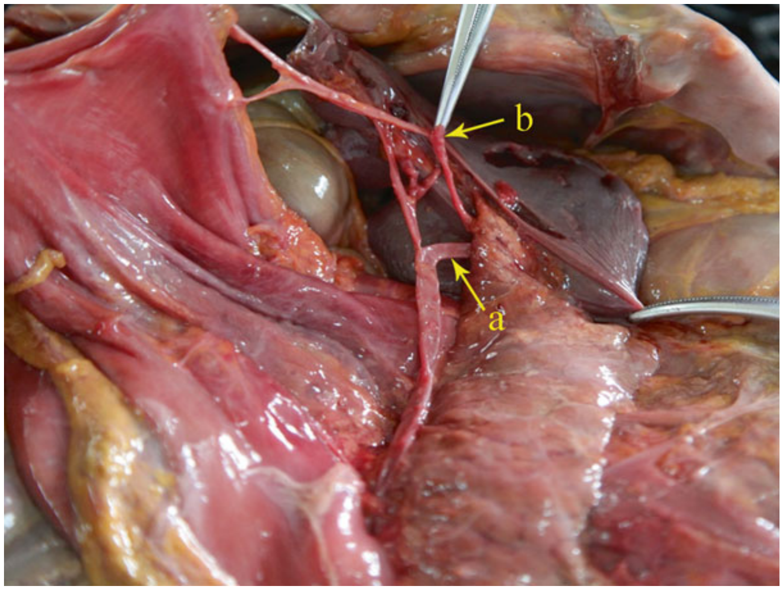


Fig. 6.34 The SLPA (*a*) gives off the LGEA (*b*) (in autopsy)

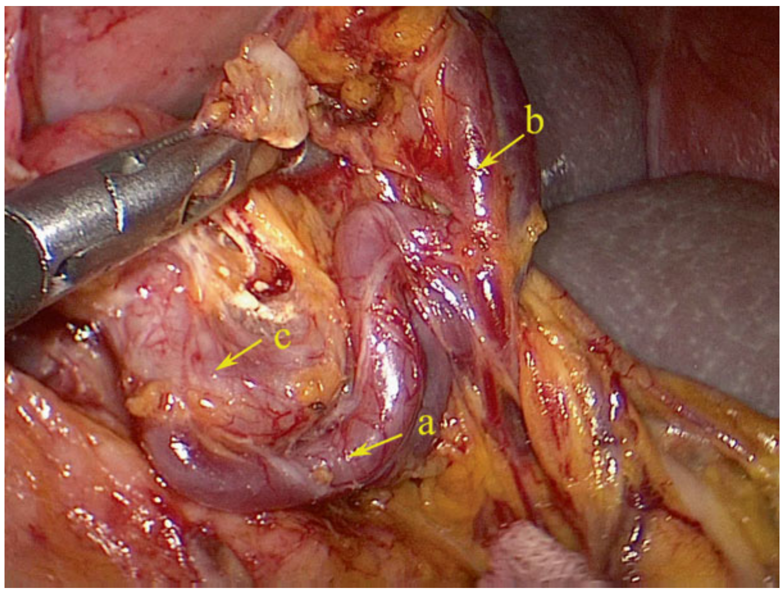


Fig. 6.35 The SLPA (*a*) gives off the LGEA (*b*) and the SpA (*c*)

SGVs, and the surgeon uses the ultrasonic scalpel to meticulously dissect the fatty lymphatic tissue around the vessels to vascularize the vessels (Fig. 6.88), which are divided at their roots with vascular clamps (Fig. 6.89).

For patients who have undergone distal subtotal gastrectomy, only one to two branches of the SGVs should be transected after the division of the LGEVs. Then the stomach is replaced in the natural position. The assistant pulls up the greater omentum at the middle part of the greater curvature of the gastric body. Meanwhile, the surgeon presses down on the posterior wall of the stomach to tense this part of the greater omentum, and

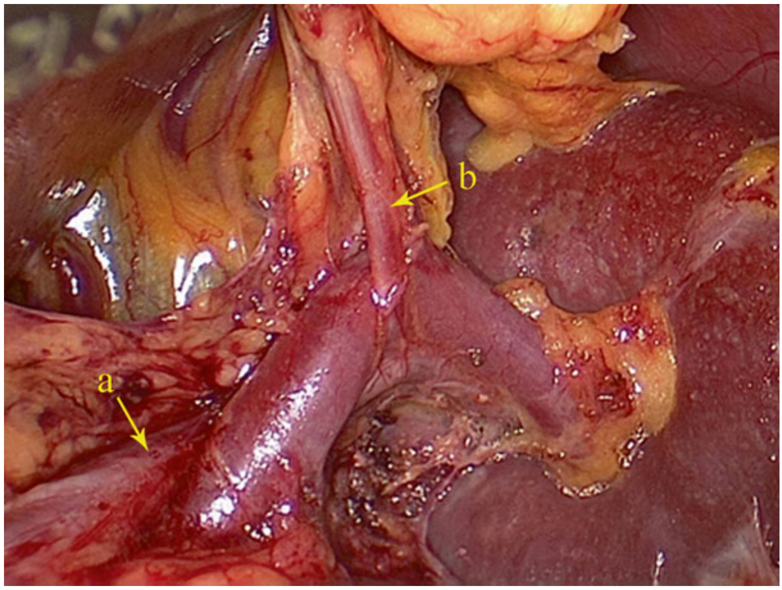


Fig. 6.36 The SpA (*a*) gives off the LGEA (*b*)

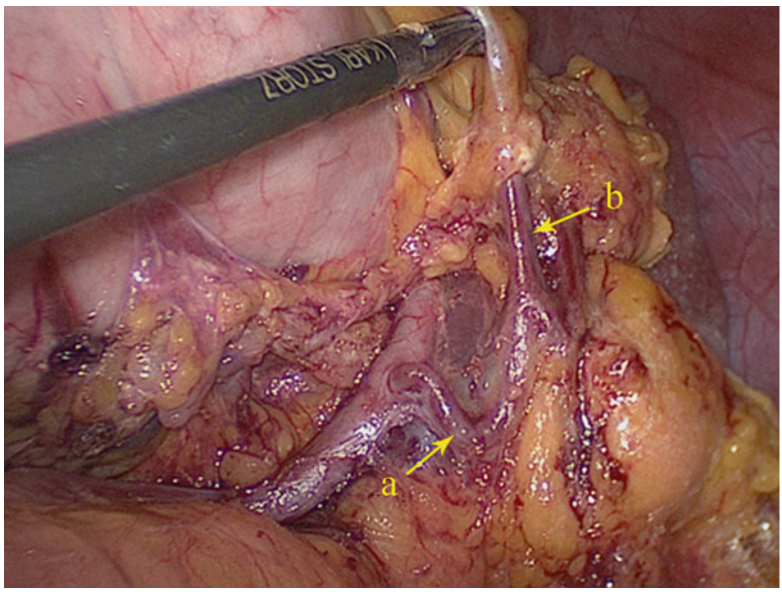


Fig. 6.37 The ISLA (*a*) branches out the LGEA (*b*)

the greater omentum is opened using the ultrasonic scalpel in the avascular area (Fig. 6.90). Subsequently, the greater omentum, the vessels, and the vessels' branches are separated against the gastric wall along the greater curvature of the stomach (Fig. 6.91). Thus, the greater curvature of the stomach is bared (Fig. 6.92).

6.3.3.2 Second Step: Dissection of the LNs in the Region of the Trunk of SpAT

The assistant's right hand pulls up the isolated fatty lymphatic tissue on the surface of the trunk of SpA. The surgeon uses the ultrasonic scalpel to denude the trunk of SpA along the latent anatomical space on its surface toward the splenic hilar until reaching the fork of the splenic lobar arteries. The fatty lymphatic tissue around the end of the SpA is then excised (Fig. 6.93). One or two branches of the PGAs, which are derived from the SpA, will always be encountered in this region. At this time, the assistant should clamp the vessels and pull them upward, while the surgeon uses the ultrasonic scalpel to dissect the fatty lymphatic tissue around the PGAs and close to the trunk of SpA (Fig. 6.94). The PGAs are divided at their roots using vascular clamps (Fig. 6.95). The excision of the No. 11d LNs is then accomplished.

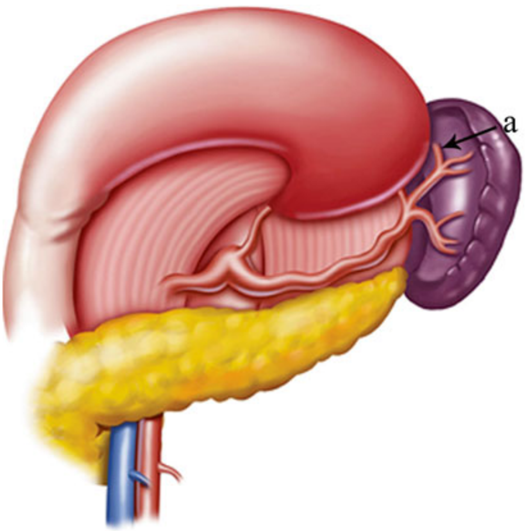


Fig. 6.38 SGA (*a*)

6.3.3.3 Third Step: Dissection of the LNs in the Superior Pole Region of the Spleen

The assistant gently pulls up the fatty lymphatic tissue on the surface of the splenic vessels' branches in the GSL, while the surgeon applies the nonfunctional face of the ultrasonic scalpel along the anatomical space on the surface of the splenic lobar artery and vein to completely vascularize the vessels in the splenic superior lobar area, using meticulous sharp or blunt pushing, peeling, and dissection (Figs. 6.96 and 6.97). At this time, one to three branches of the SGVs arising from the SLA (Fig. 6.98) and passing in the GSL are usually encountered. The assistant should clamp and pull the SGVs upward, while the surgeon meticulously resects the surrounding fatty lymphatic tissue, proceeding toward

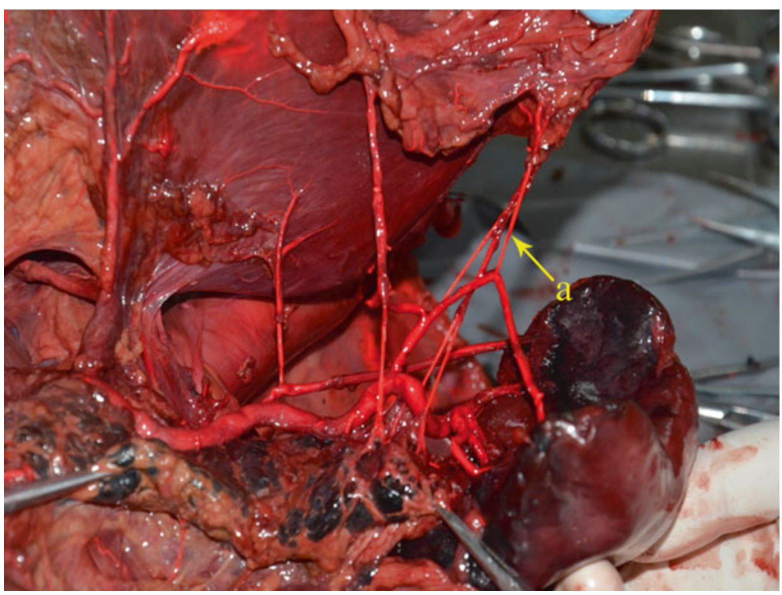


Fig. 6.39 SGA (*a*) (in autopsy)

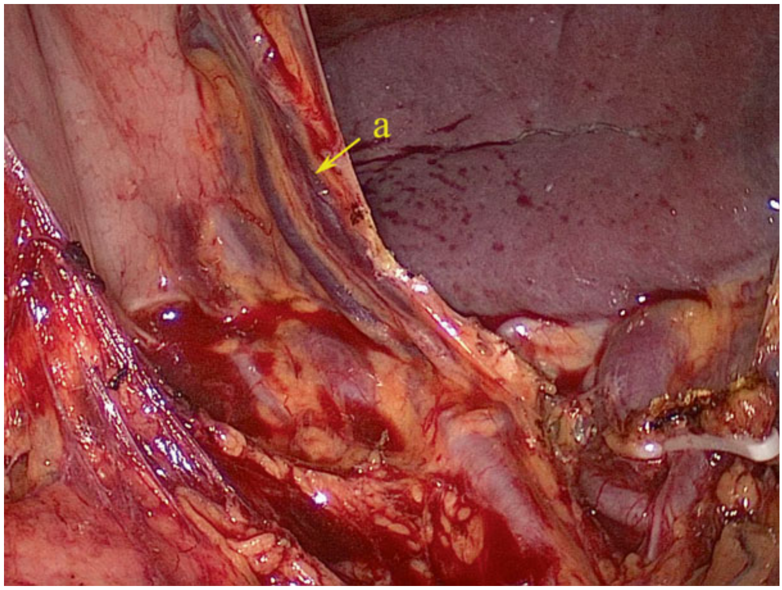


Fig. 6.40 The SGAs (*a*) issue from the SpA or its branches

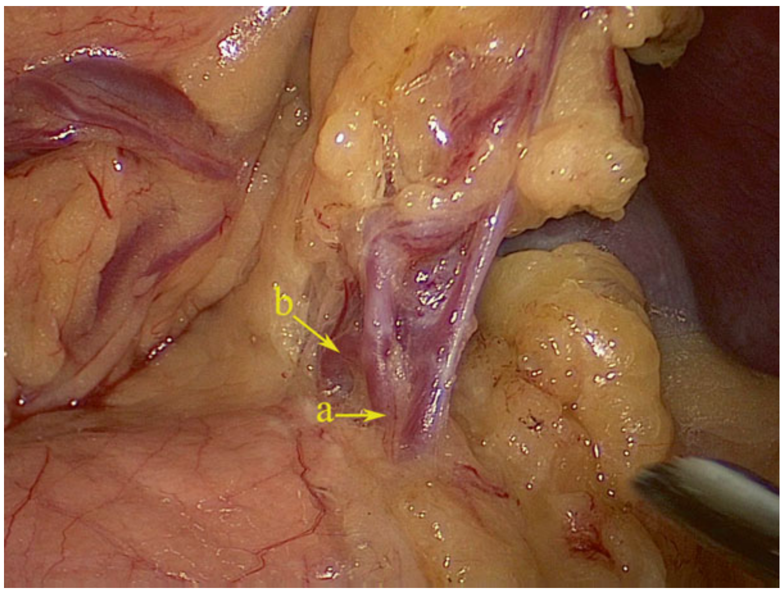


Fig. 6.41 The left gastroepiploic vessels (*a*) give off the SGVs (*b*)

the roots of the vessels. Next, the SGVs are divided at their roots with clamps (Fig. 6.99). The last branch of SGVs in the superior pole region of the spleen is often very short (Fig. 6.100), which causes the fundus to lie close against the splenic hilar. The last branch will be easily damaged, causing bleeding, if there is lack of proper traction. At this time, the assistant should pull the fundus toward the lower right side enough to completely expose the vessel, while the surgeon transects the vessel at its root with vascular clamps after carefully separating the surrounding fatty lymphatic tissue (Fig. 6.101).

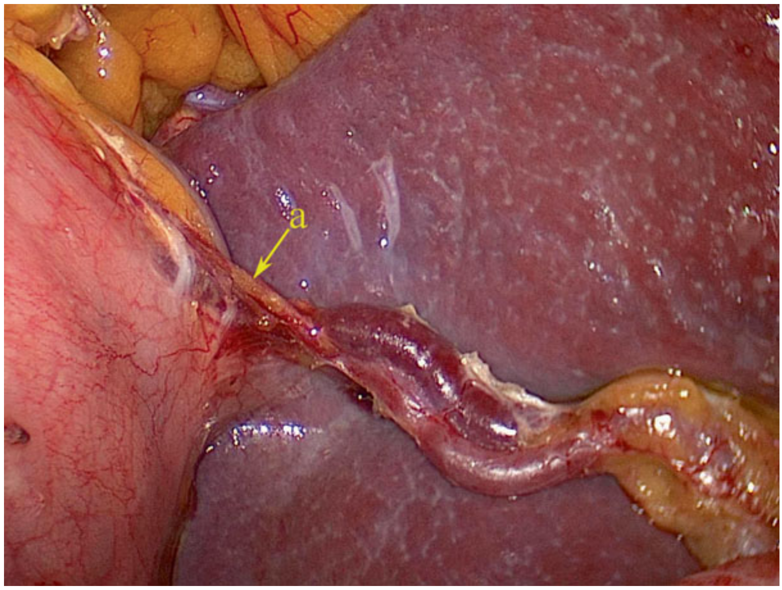


Fig. 6.42 The lengths of the SGVs (*a*) are shorter, the closer they are to the superior pole region of the spleen, which is closely against the fundus

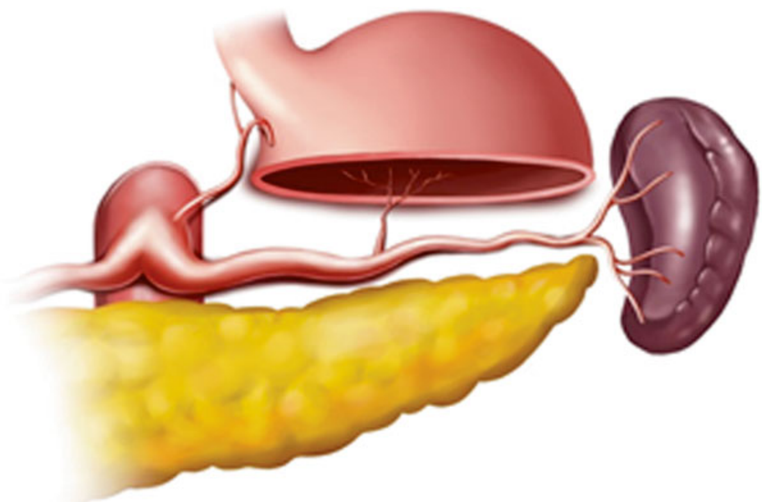


Fig. 6.43 The PGA arises from the trunk of SpA

Dissection of the LNs behind the splenic hilar can be performed when the tail of the pancreas is located at the inferior border of the spleen and lies a certain distance from the splenic hilar. The assistant lifts the terminal branches of the splenic vessels ventrally with the left hand using atraumatic grasping forceps and pulls up the fatty lymphatic tissue behind the splenic hilar with the right hand. Meanwhile, the surgeon presses on Gerota's fascia with the left hand and uses the ultrasonic scalpel to dissect the fatty lymphatic tissue

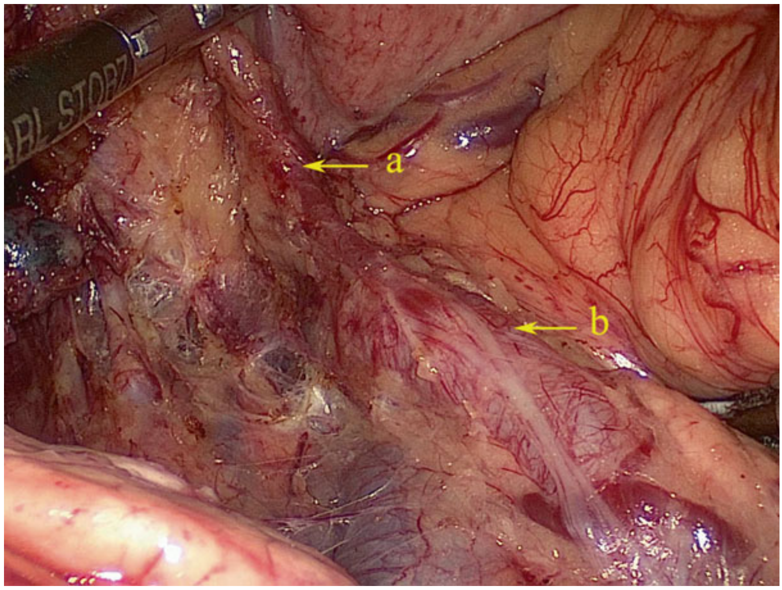


Fig. 6.44 The PGA (*a*) arises from the trunk of SpA (*b*)

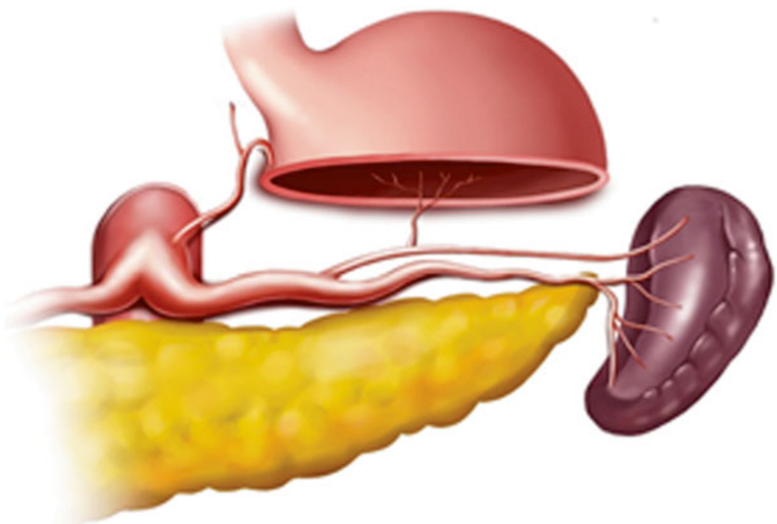


Fig. 6.45 The PGA issues from the SUPA

behind the splenic hilar along the front of Gerota's fascia, completing the dissection of the LNs below the splenic vessels (Figs. 6.102 and 6.103). It should be noted that the separation plane cannot extend beyond Gerota's fascia during this step in order to avoid bleeding. During the dissection of the No. 10 LNs, careful attention must be paid to the variant branches of the splenic lobar vessels to avoid damaging them and causing bleeding. At this point, the splenic hilar lymphadenectomy is completed (Fig. 6.104).

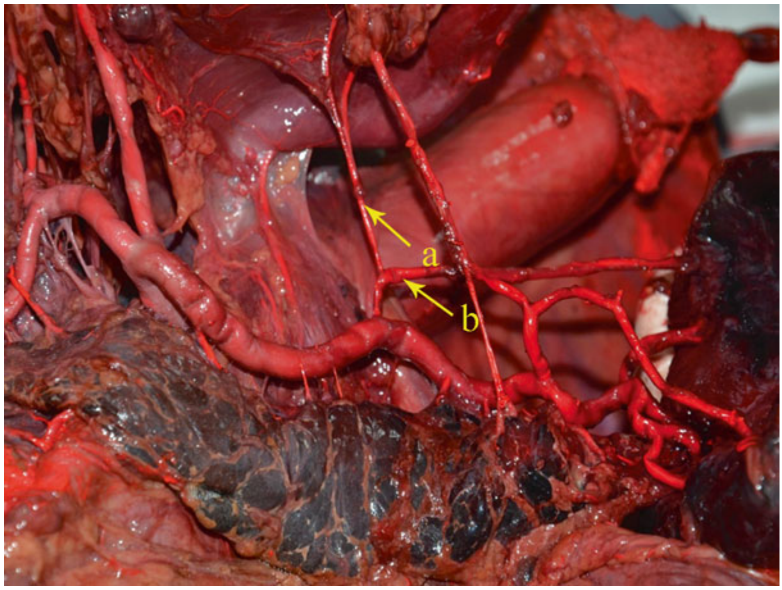


Fig. 6.46 The PGA (*a*) issues from the SUPA (*b*) (in autopsy)

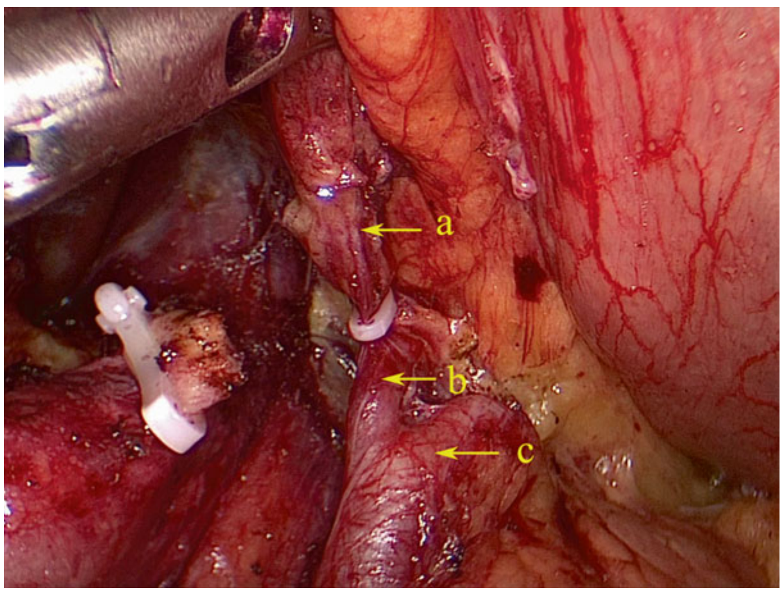


Fig. 6.47 The PGA (*a*) issues from the SUPA (*b*). SpA (*c*)

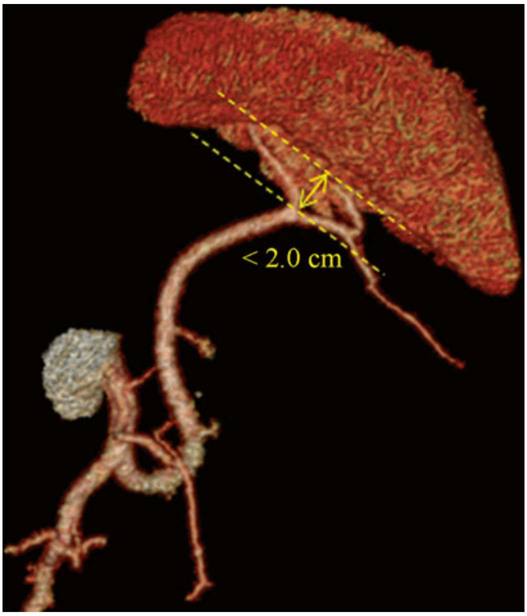


Fig. 6.48 Concentrated type (3D CT)

6.4 Common Situations Encountered and Surgical Techniques Utilized During the Dissection of the Splenic Hilar Region

6.4.1 Surgical Techniques Involved in Division

Generally, the surgical manipulations involved in laparoscopic spleen-preserving splenic hilar lymphadenectomy are fairly difficult. The main reasons for this difficulty are as follows: First, the deep location of the operative site within the abdominal cavity and the numerous organs surrounding the organs of interest result in a narrow, fixed operation field. Second, the splenic vessels exhibit a tortuous course, and their branches are complex; this may lead to a high risk of vessel or splenic parenchymal injury and resultant

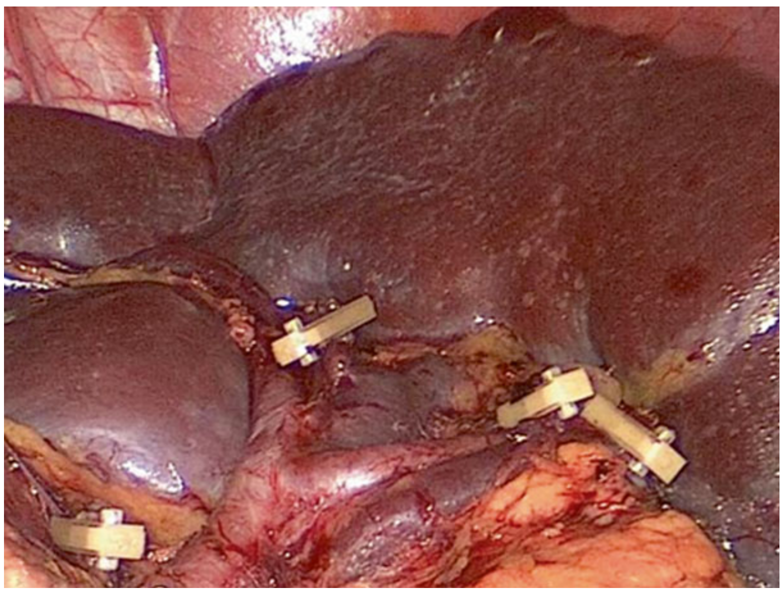


Fig. 6.49 Concentrated type

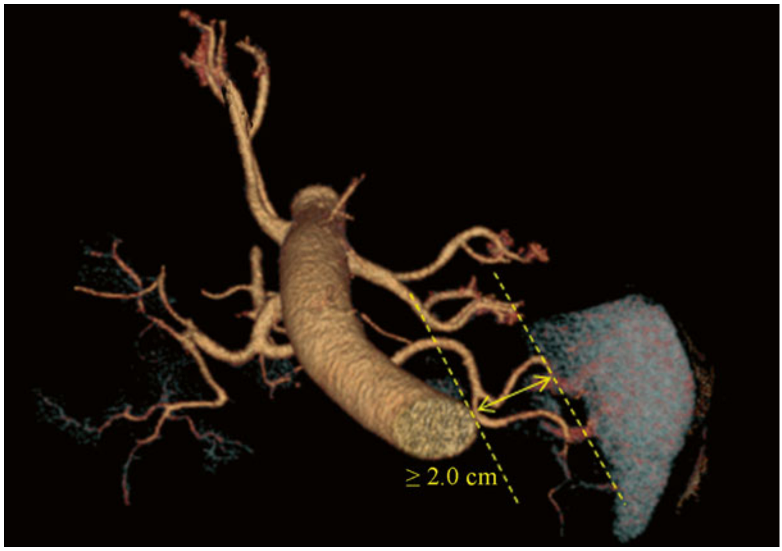


Fig. 6.50 Distributed type (3D CT)

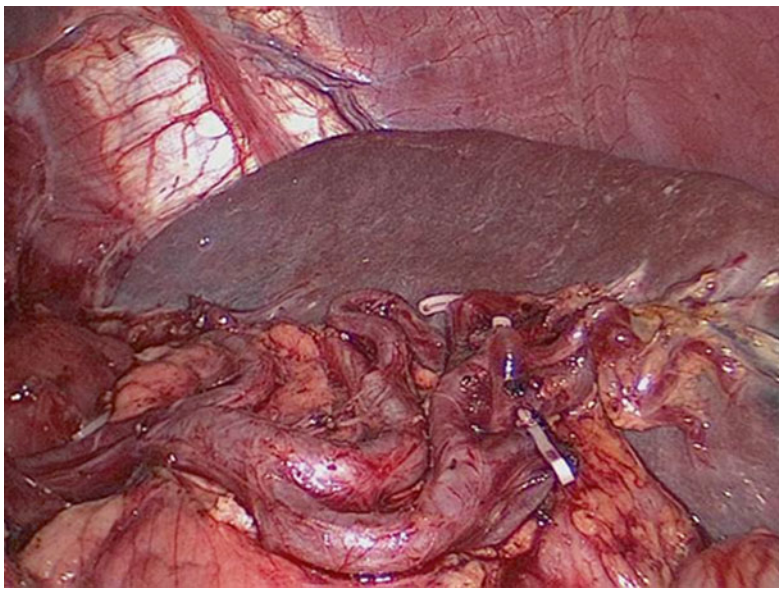


Fig. 6.51 Distributed type

uncontrollable hemorrhage during laparoscopic dissection in this region.; in patients with a high BMI, adequate exposure of the splenic hilar area is difficult in the presence of a large amount of adipose and lymphoid tissue, and the difficulty of lymph node dissection thus increases. Third, the omentum is always adhered to the spleen, and the splenic parenchyma is very fragile and readily tears at the point of attachment; as a result, splenic injury always leads to massive hemorrhage, and hemostasis is difficult to achieve. For these reasons, laparoscopic spleen-preserving splenic hilar lymphadenectomy in situ requires excellent surgical skills. This procedure can be

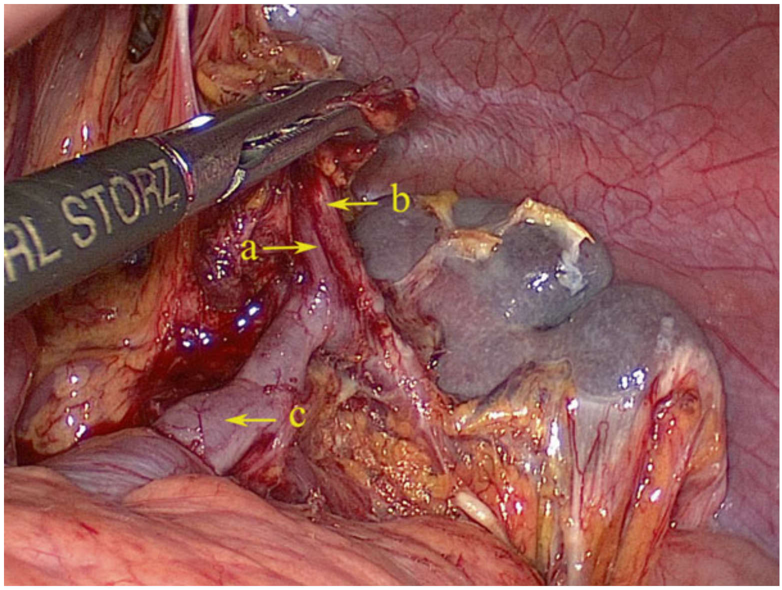


Fig. 6.52 The LGEV (*a*) runs parallel with the artery of the same name (*b*) and ends in the SpV (*c*)

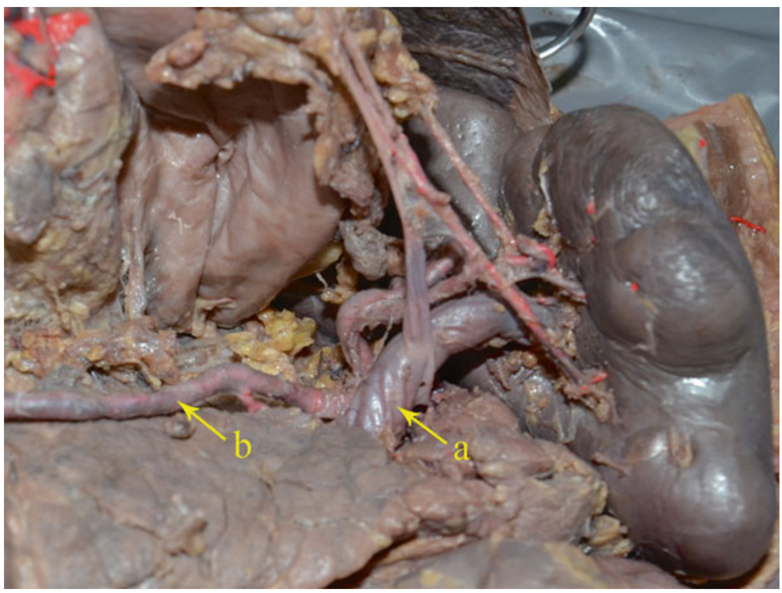


Fig. 6.53 The SpV (*a*) accompanies with the SpA (*b*) (in autopsy)

performed only by surgeons with extensive experience in open operations and proficient laparoscopic surgical techniques.

The performance of laparoscopic spleen-preserving splenic hilar lymph node dissection, like other laparoscopic surgeries, requires an initial learning phase to allow the surgeon to achieve adequate, stable skills for this procedure. This learning phase, namely, the learning curve of laparoscopic surgery, is usually measured by the number of surgical operations required for the beginner surgeon's skills to reach relative

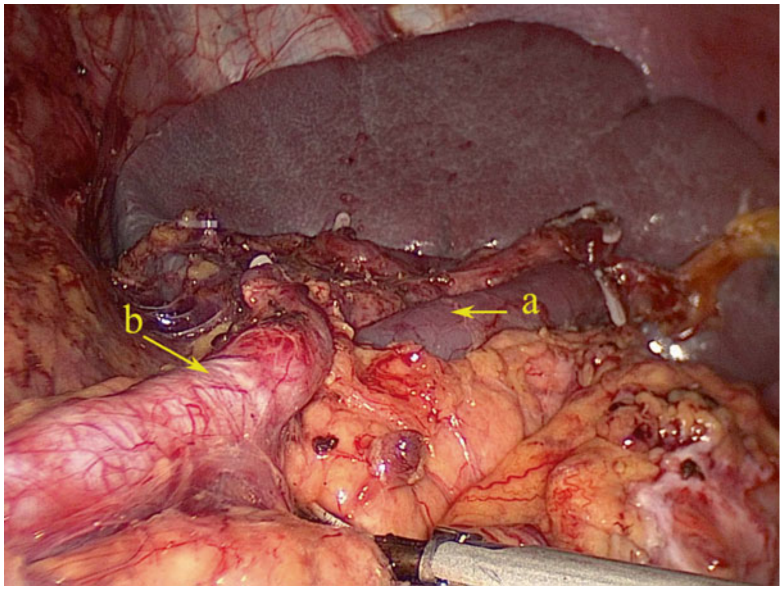


Fig. 6.54 The SpV (*a*) accompanies with the SpA (*b*)

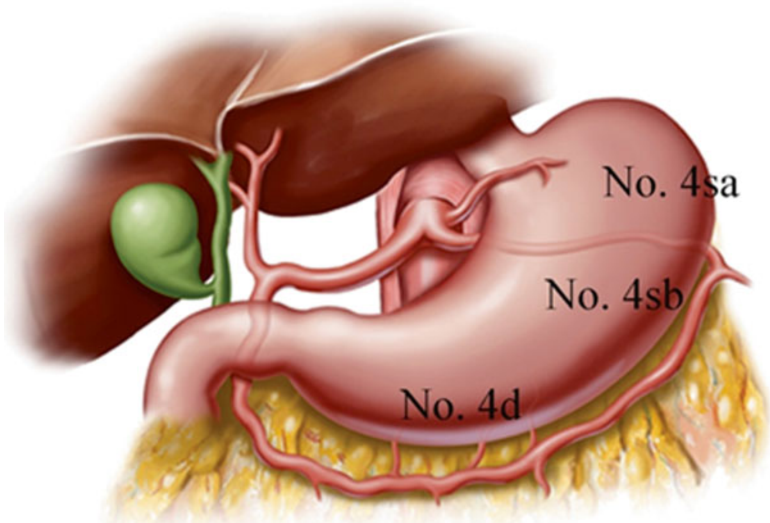


Fig. 6.55 Distribution of the LNs around the greater curvature of stomach

stability. Thus, when a certain number of surgeries are reached, the operative techniques have significantly improved and usually reach a plateau. The surgeon can then smoothly step over the learning curve. Evaluation indicators of the learning curve include the operative time, blood loss, laparotomy rate, complication rate, time until first liquid diet, and length of postoperative hospitalization. We have found that with respect to achieving proficient laparoscopic gastric cancer surgery techniques, a surgeon can be considered to have stable skills after having performed 40 surgical training procedures [22]. The following tips are useful to shorten the learning curve: (1) A stable and tacit teamwork plays an important role in this procedure. (2) The surgeon is

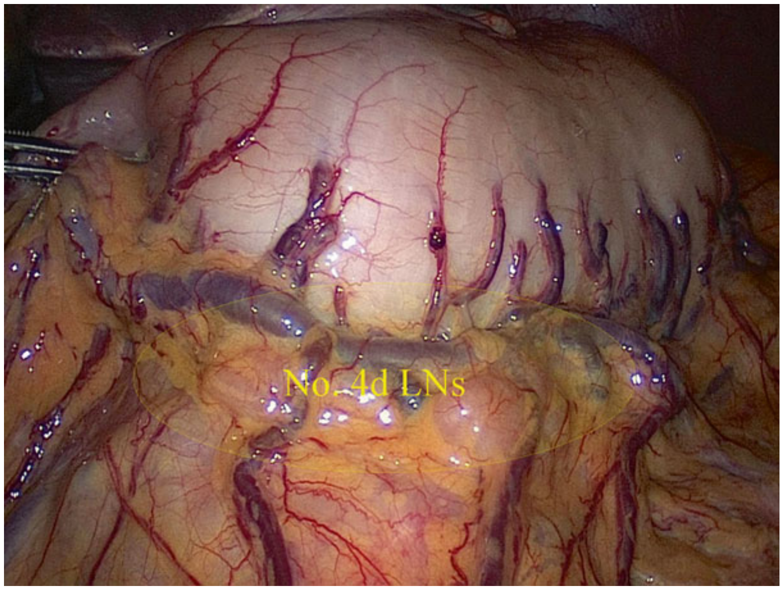


Fig. 6.56 The scope of the No. 4d LNs

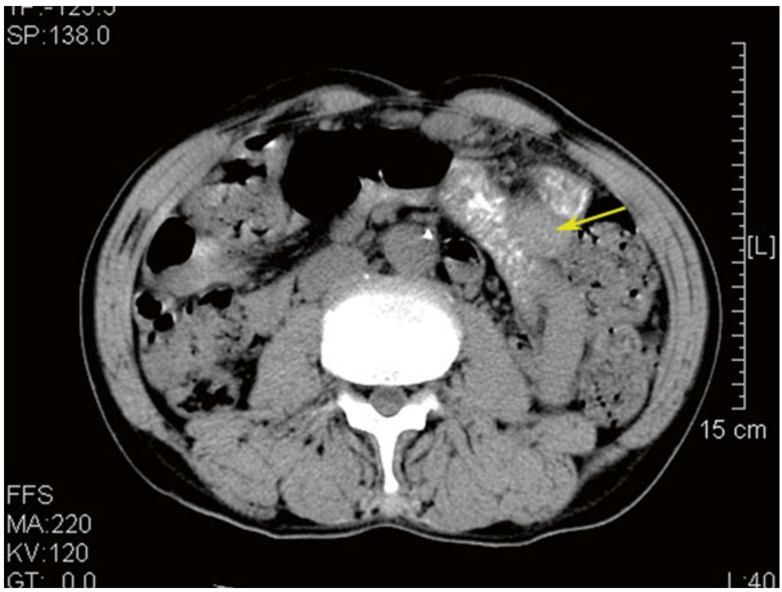


Fig. 6.57 CT image showing No. 4d LNM (the *arrow* represents the swollen No. 4d LNs)

equipped with a certain level of experience in laparoscopic gastrectomy. (3) Patients with good conditions, who are younger and have fewer complications, smaller tumors, or a leaner body figure, can be chosen for training during the initial phase of the learning curve; this facilitates a reduction in surgical risk while increasing the surgeon's confidence, helping to eventually step over the learning curve. (4) An adequate ability to summarize experiences and lessons and to explore the operating position and anatomical approach that is suitable for oneself will help the surgeon to gradually establish relatively stable surgical procedures.

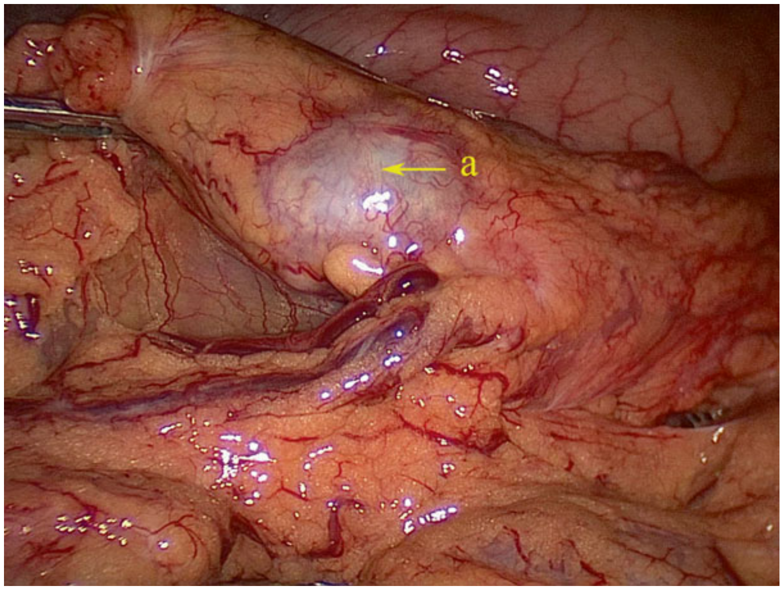


Fig. 6.58 The intraoperative view of No. 4d LNM (*a*)

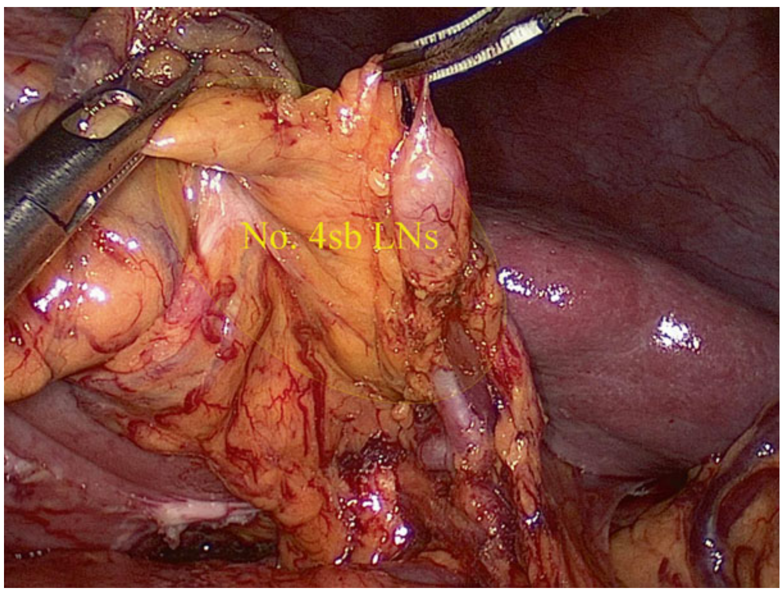


Fig. 6.59 The scope of the No. 4sb LNs

When the four instruments used by the surgeon and assistant point together into the narrow area in the left upper abdomen with a small angle between them, it's easy to block the observing view. This phenomenon is known as the "chopsticks effect." Thus, the camera assistant should adjust the orientation of the optical fiber and lens to avoid this situation.

Before conducting lymph node dissection, the assistant should push the gastric body toward the right lower abdomen as much as possible, and then rotate and move the greater omentum above the anterior wall of the stomach. This provides the advantage of easy exposure in the subsequent operation. Adhesions may exist between the spleen and the omentum

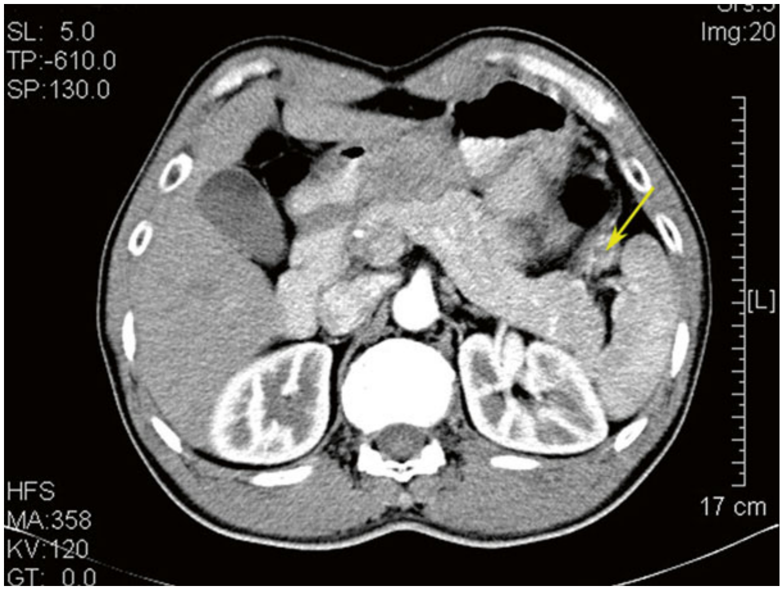


Fig. 6.60 CT image showing No. 4sb LNM (the *arrow* represents the swollen No. 4sb LNs)

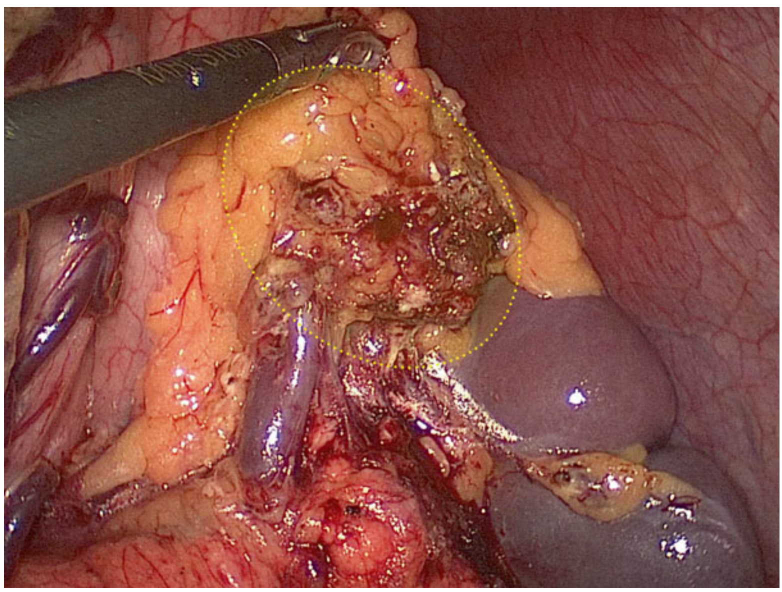


Fig. 6.61 The intraoperative view of No. 4sb LNM

in some patients (Fig. 6.105); thus, the assistant should apply the proper tension and angle of traction during the operation to avoid tearing the spleen and causing hemorrhage (Fig. 6.106). Adhesiolysis in the GSL should be performed first before lymph node dissection (Fig. 6.107).

With respect to the choice of surgical approaches, some experts use a medial approach in which the surgeon stands on the patient's right side and places an additional trocar below the xiphoid. Dissection of the No. 11p, 11d, and 10 LNs is then conducted from the root of the SpA toward its distal end with ultrasonic shears. This

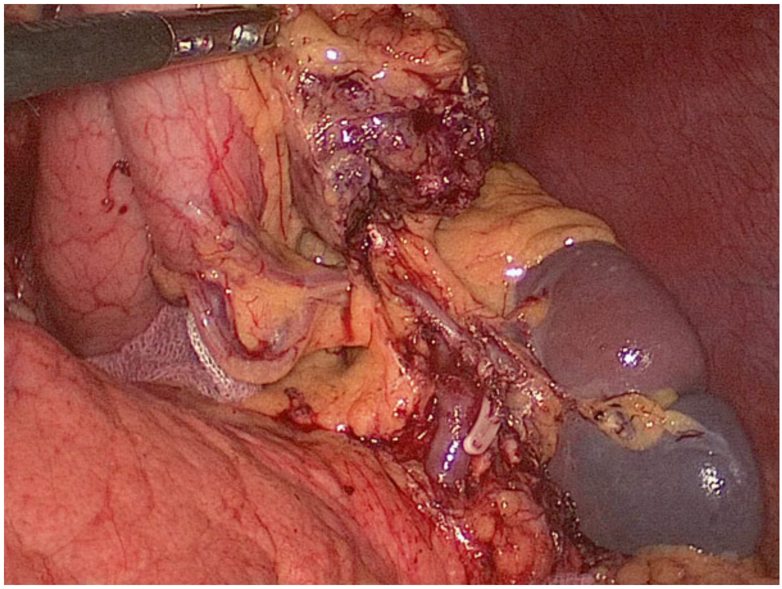


Fig. 6.62 No. 4sb LNM (appearance after the dissection)

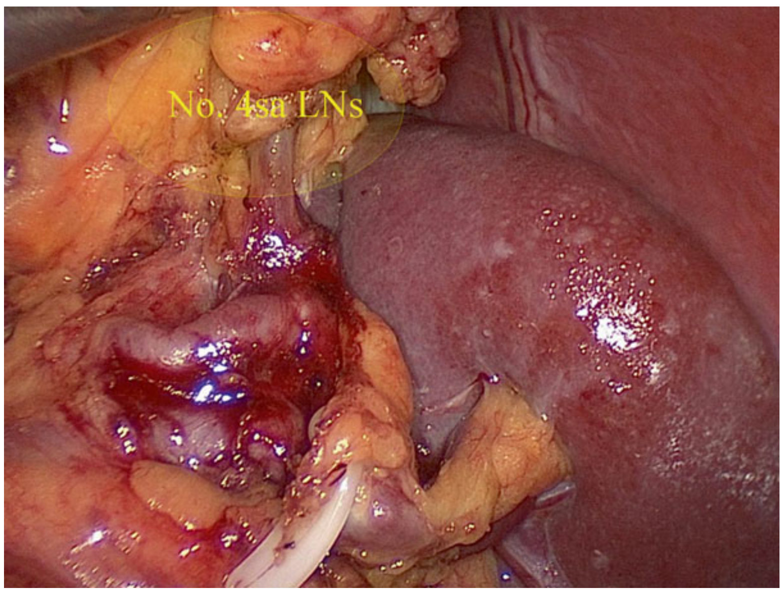
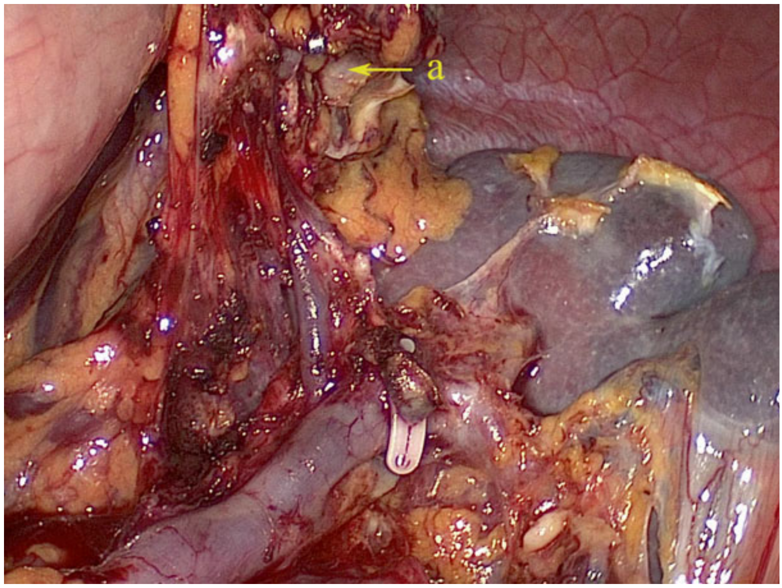


Fig. 6.63 The scope of the No. 4sa LNs

procedure requires prior severing of the SGVs before lymph node dissection, which is facilitated by the positioning of the surgeon on the patient's right side [18]. Other experts use a retropancreatic approach in which the surgeon stands on the patient's left side and the assistant stands on the right. This maneuver starts with division of the GSL and severing of the left gastroepiploic and short gastric vessels. The inferior border of the pancreas is then divided to enter the RPS, enabling subsequent division of the SpA and SpV and lymph node dissection within the space [21]. However, we consider that this approach requires removal of the whole stomach after severing the

Fig. 6.64 No. 4sa LNs (*a*)



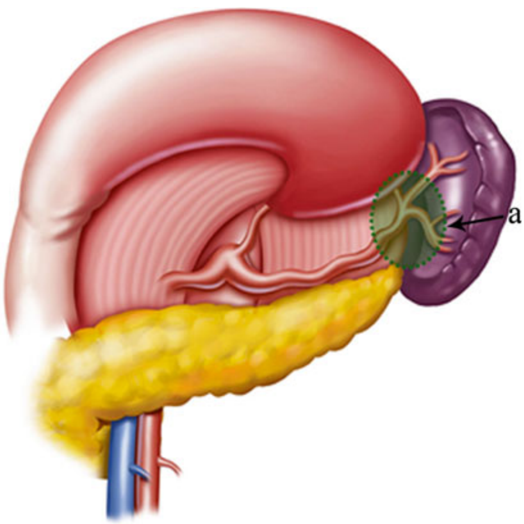


Fig. 6.65 The scope of the No. 10 LNs (*a*)

SGVs to provide better exposure, which departs from the oncological en bloc resection. Moreover, when metastatic splenic hilar LNs are present, both exposure of the anatomical plane and excision of the LNs may be inconvenient because of the lack of adequate traction on the GSL and posterior wall of the gastric fundus. Thus, we utilize the left-sided approach, in which we enter the RPS along the superior border of the pancreatic tail [16]. The LNs are excised from the SLA toward the root of the SpA, and the SGVs are severed at their roots. This enables complete removal of the splenic hilar LNs and stomach and is consistent with the concept of oncological radical resection. Meanwhile, the assistant is able to provide better exposure by drawing the GSL, which facilitates maintenance of proper tension in the operative field.

We summarize the operative procedure of laparoscopic spleen-preserving splenic hilar lymph node dissection, namely, Huang's three-step maneuver. Successful performance of this maneuver requires close cooperation among the surgeon, assistant, and camera operator. It reduces the difficulty of spleen-preserving surgery, enabling routine performance of splenic hilar lymphadenectomy in patients with advanced upper-third gastric cancer and further application of laparoscopic techniques [23].

A surgeon should only perform laparoscopic splenic hilar lymphadenectomy when he or she is familiar with the anatomy in this region. During the surgery, surgeons (particularly

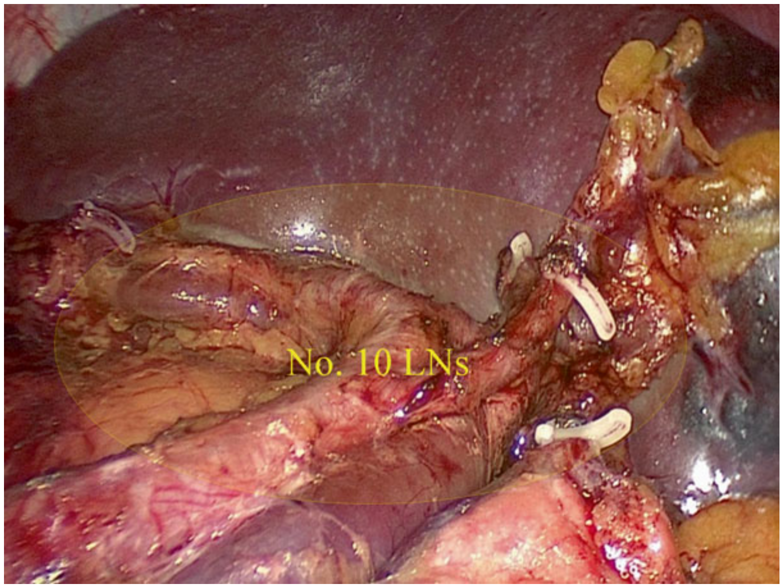


Fig. 6.66 The scope of the No. 10 LNs

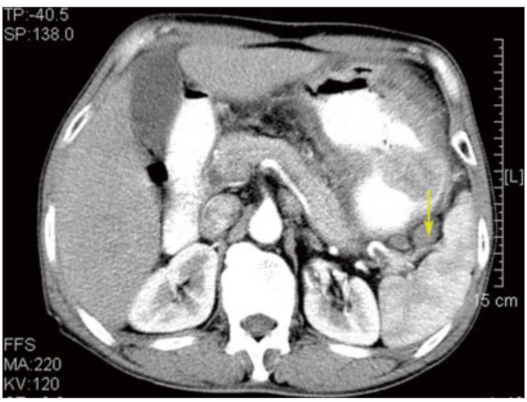


Fig. 6.67 No. 10 LNM (CT imaging) (the *arrow* represents the swollen No. 10 LNs)

beginners) may easily lose their sense of position and direction and enter the wrong anatomical layers, causing iatrogenic injury. Previous anatomical studies of the splenic hilar region in cadavers and biopsy specimens indicate that the APF, PPF, ATM, GSL, and SRL, despite their obviously different anatomical morphologies, are all derived from the embryonic DM [20]. They are continuous with one another, as are the potential spaces and connective tissues within each. This allows for systematic dissemination of malignant or inflammatory lesions. Additionally, the lymphatic system (including LNs and lymph vessels) accompanies the vessels and runs within the mesogastrium. Because of this mutual anatomical origin, the space between the two layers of the DM can be used as a surgical plane to guide the separation and standardize the operating range. The radical resection required for the treatment of gastric cancer is not merely performed by dissecting the related LNs. The corresponding fascial tissue should also be removed to achieve an oncological en bloc resection. Only in this manner can we effectively prevent residual cancer caused by micrometastases and truly achieve a radical cure. After opening the APF in front of the pancreatic tail and following the orientation of the fascia, the surgeon can enter the space in the SRL through the rear RPS. Then, as the space is gradually enlarged, the LPVSs or the LLVSs can be exposed during division (Fig. 6.108). Therefore, we should first enter the RPS after peeling the ATM and APF to expose the LPVSs and a portion of the splenic vessels' trunks. The separation then continues to the SRL and GSL,

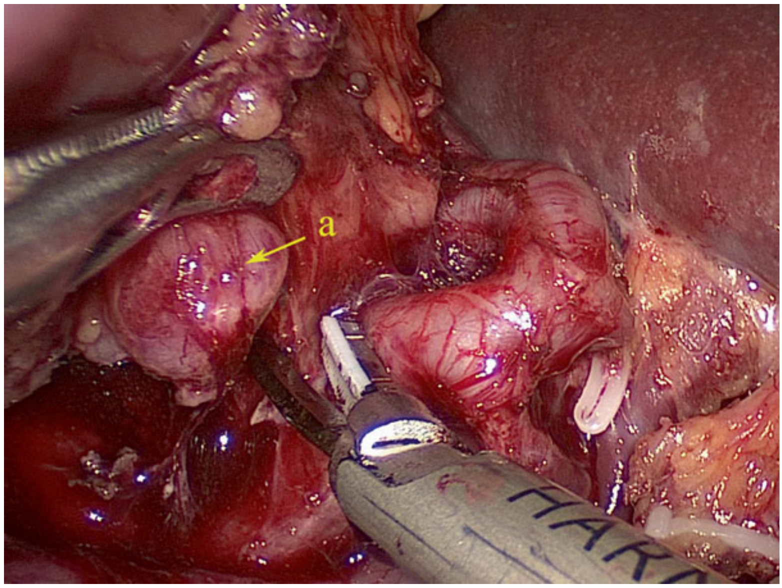


Fig. 6.68 No. 10 LNM (*a*)

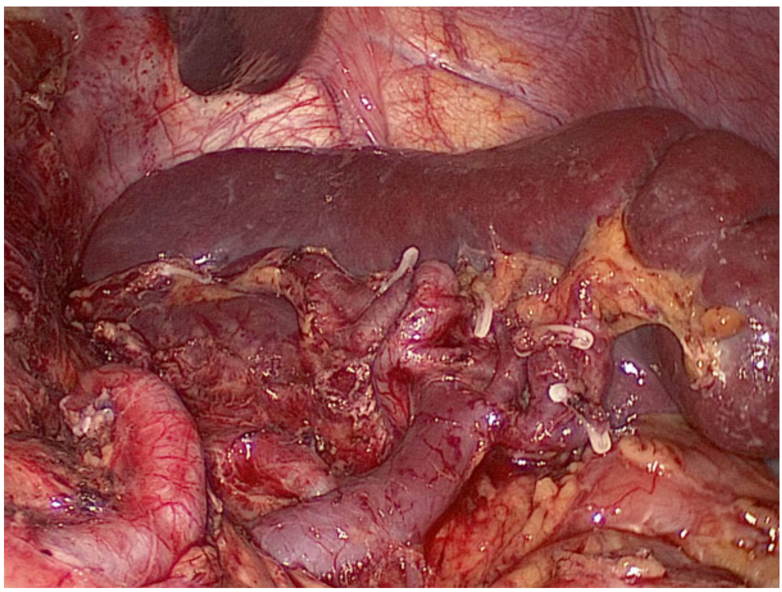


Fig. 6.69 No. 10 LNM (appearance after the dissection)

following the orientation of the fascia, to completely reveal the SpA and its branches. The surgeon is thus easily able to dissect the LNs along the distal splenic vessels and splenic hilar region along the latent anatomical spaces. Also, the supporting vascular and lymphatic systems must travel through these intrafascial spaces regardless of variability or individual differences among patients' anatomy. Moreover, dissection under the laparoscopy-specific view allows the surgeon to clearly visualize the perigastric fascia, intrafascial space, vasculature, nerves, and other structures. The splenic vessels and their branches can thereby be comfortably exposed at different levels, and the meticulous procedure of splenic hilar lymphadenectomy can be smoothly and efficiently completed without unexpected hemorrhage or injury to the spleen or pancreas. We compared the data of patients who underwent the surgery following the perigastric fascia and intrafascial spaces and patients who underwent the classic surgery; the results show that the operation time, mean splenic hilar lymph node dissection time, mean total blood loss, and mean blood loss due to splenic hilar lymph node dissection were significantly lower in the fascia group than in the classic group; moreover, the morbidity rate was slightly lower in the fascia group, and no abdominal organ injuries such as pancreatic fistula or chylous fistula occurred; no patients required conversion to laparotomy, and none required splenectomy for treatment of intraoperative injuries to the splenic vessels or spleen itself [20]. Therefore, techniques of dissection following the fascia and intrafascial spaces can provide a safe and sequential anatomical plane for surgeons; it can also guide the operating direction throughout the entire process, including during vessel vascularization and lymph node dissection. In conclusion, on the basis of the Huang's three-step maneuver mentioned above, splenic hilar lymphadenectomy performed by following the perigastric fascia and intrafascial spaces is a safe, feasible, and optimal technique. It reduces the difficulties associated with the surgery and allows for easy mastery of the technique. Moreover, it facilitates the application and promotion of the maneuver in D2 radical gastrectomy for advanced upper gastric cancer.

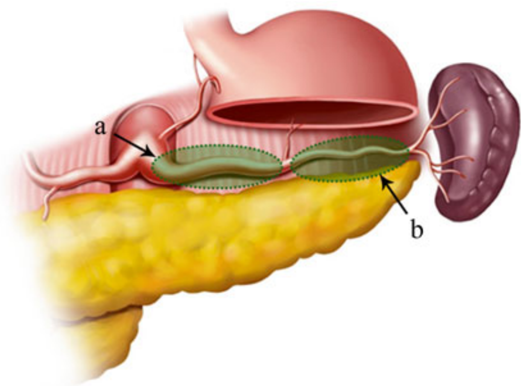


Fig. 6.70 The scope of the No. 11 LNs. No. 11p LNs (*a*) and No. 11d LNs (*b*)

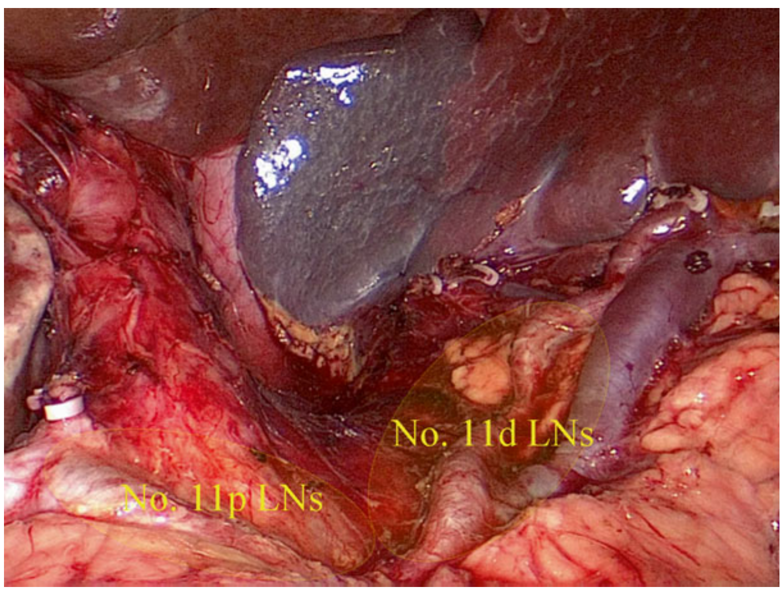


Fig. 6.71 The scope of the No. 11 LNs

6.4.2 Prevention of Damage to Adjacent Tissues and Organs

Splenic ischemia is always associated with mistakenly severing the branches of the vessels supplying the spleen. In particular, the splenic upper-pole vessel branching from the SpAT is usually lifted during dissection of the distal terminal of the SpA and may be incorrectly recognized as the posterior gastric vessel (Fig. 6.109).

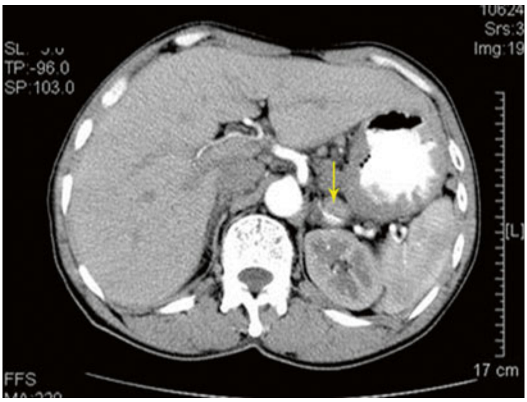


Fig. 6.72 CT image showing No. 11 LNM (the *arrow* represents the swollen No. 11 LNs)"

Thus, clear identification of an artery is important before severing it. If an uncertain vessel is encountered, it should be further denuded toward its distal end to confirm its course rather than cutting it off blindly. However, partial splenic ischemia cannot always be avoided. Splenectomy is unnecessary if the ischemic portion constitutes <50.0 % of the spleen. However, if a large area of ischemia is detected, the SpA or SpV should be checked for accidental severing. If a defect of the splenic blood supply is confirmed, splenectomy should be decisively performed. Occasionally, prolonged compression of the trunks of the splenic vessels during lymph node dissection also leads to entire splenic ischemia, which manifests as a color change of the spleen. Normal color can gradually resume after the compression is released. However, if ischemia is maintained for a long period of time, the intraoperative ultrasound examination of the spleen can be performed to evaluate the blood supply of the spleen.

Normally, the spleen and pancreatic tail have a fairly close relationship. The distance between them is about 1 cm in 50.0 % of patients, while 30.0 % of patients exhibit direct attachment between the pancreatic tail and splenic hilar region. Among these latter patients, the pancreatic

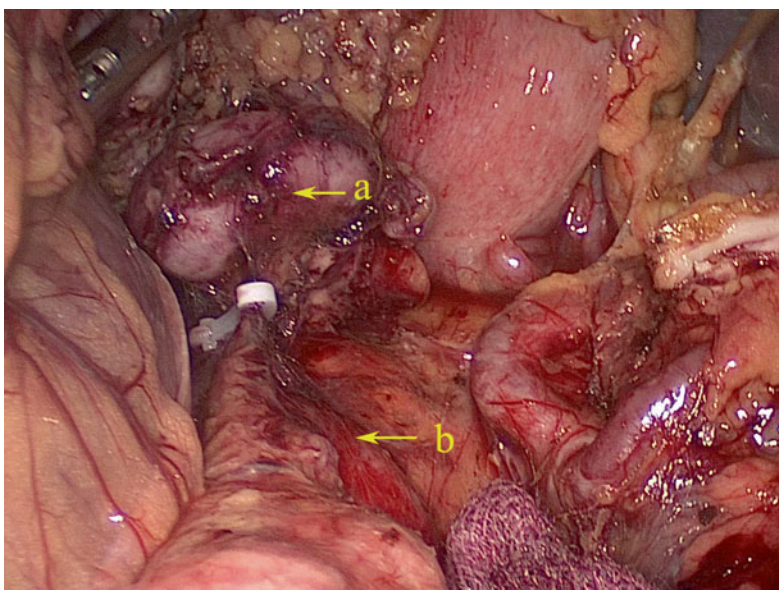


Fig. 6.73 No. 11 LNM (*a*). SpA (*b*)

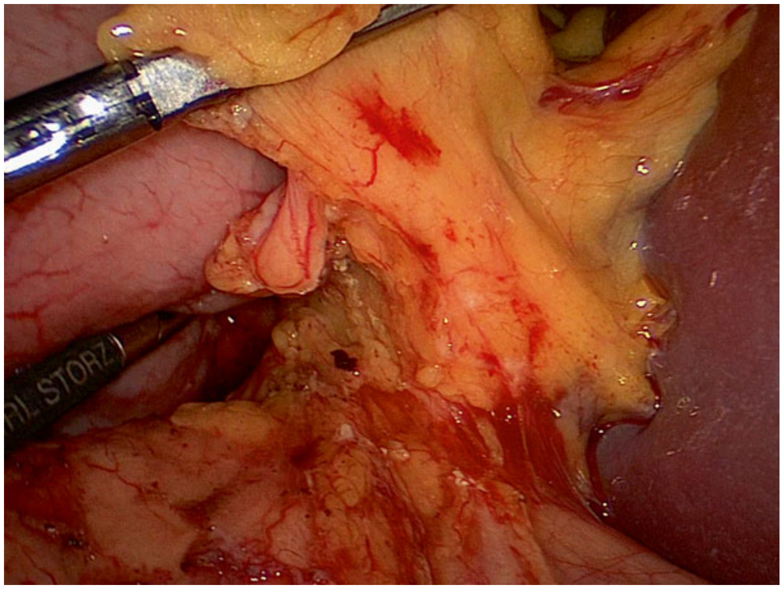


Fig. 6.74 Using a left-sided approach, the end of the splenic vessels' trunk is revealed at the superior border of the pancreatic tail

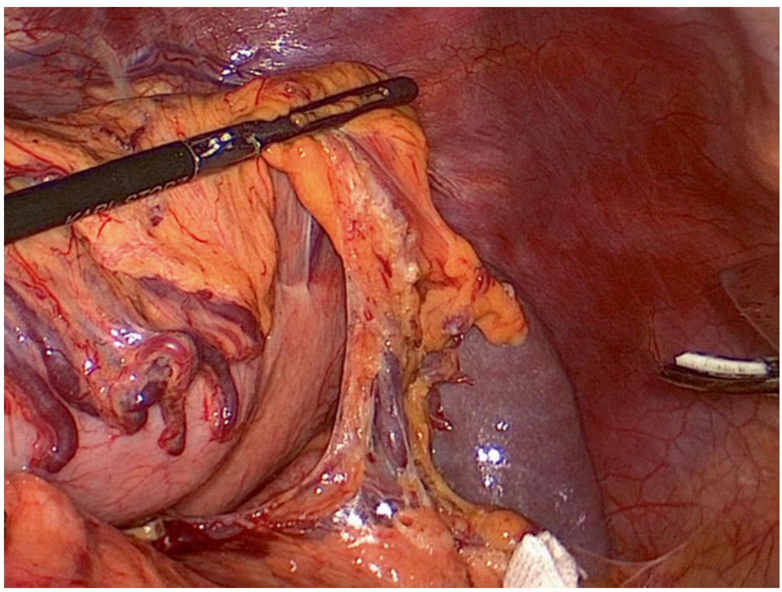


Fig. 6.75 First step: exposure of the inferior pole region of the spleen

tail is located close to the middle of the splenic hilar region in 49.5 % of patients, to the lower pole in 42.5 %, and to the upper pole in 8.0 % (Figs. 6.110, 6.111, and 6.112). Thus, dissection on the dorsal side of the splenic vessels should be carefully performed to avoid injuring the pancreatic tail. We believe that only when the pancreatic tail is located at the lower pole and at an appropriate distance from the splenic hilar region is it safe to excise that group of LNs. Additionally, during the entire dissection process, the operating plane should be maintained on the surface of Toldt's

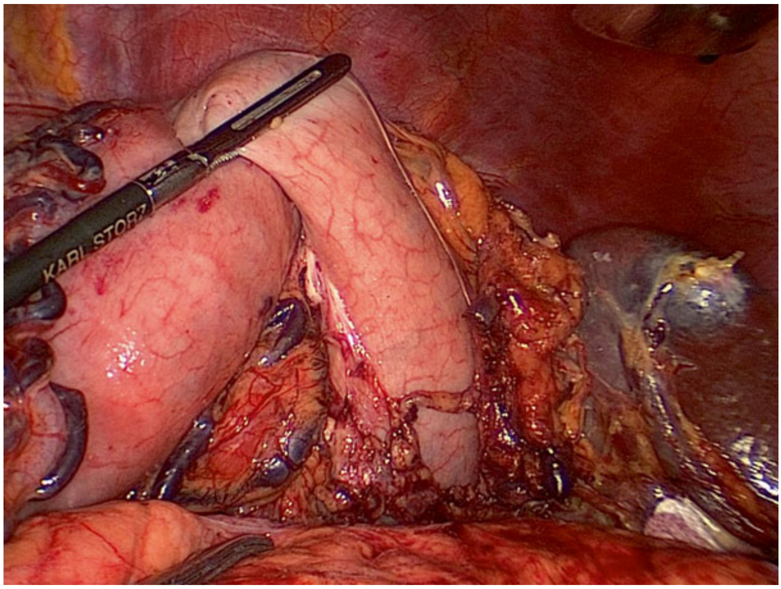


Fig. 6.76 Second step: exposure of the region of the SpAT

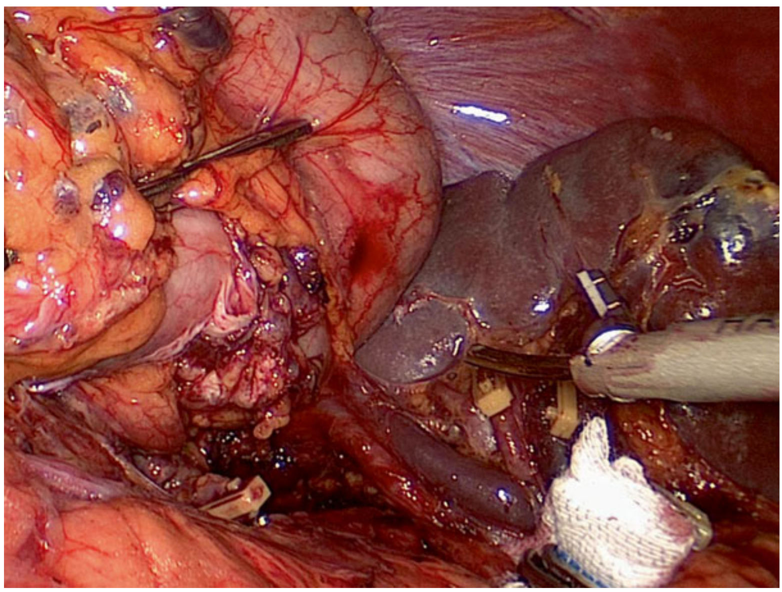


Fig. 6.77 Third step: exposure of the superior pole region of the spleen

fascia to avoid accidental injury of the Gerota's fascia and bleeding resulting from entering the deeper layer (Figs. 6.113 and 6.114).

Adhesions between the spleen and omentum or surrounding parietal peritoneum are also frequently encountered during this surgery. Injury to the spleen is always associated with splenic envelope laceration or incorrect use of ultrasonic scalpels. Therefore, the assistant should slowly draw the body of the stomach and greater omentum with equal tension. If resistance is encountered, the adhesive site should be

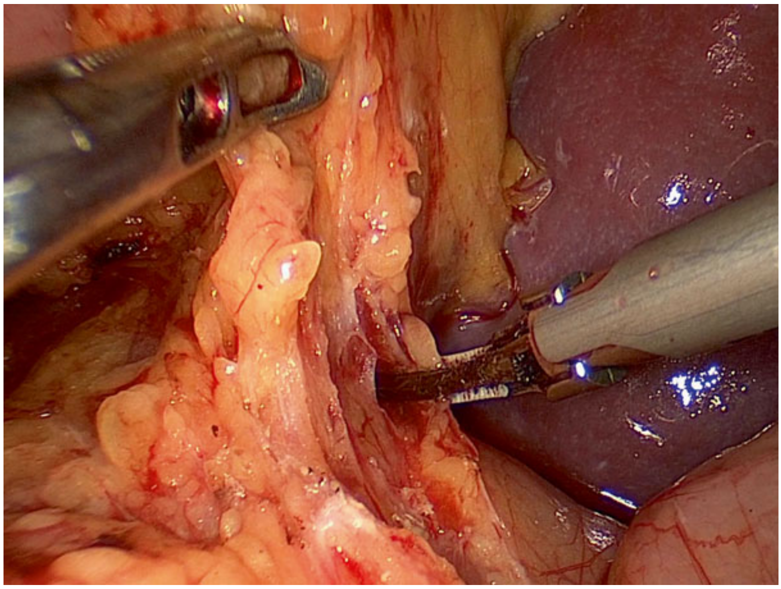


Fig. 6.78 The greater omentum is separated toward the left up to the splenic flexure of the colon

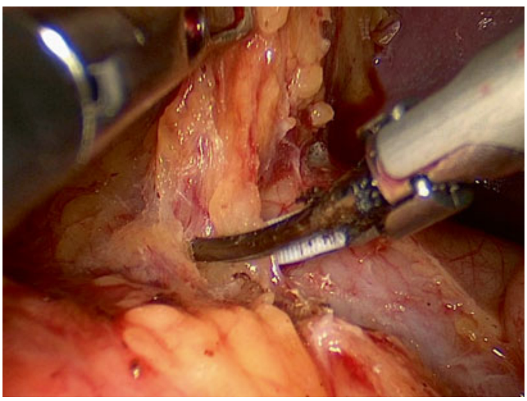


Fig. 6.79 The APF is peeled until the superior border of the pancreatic tail is reached

identified and its root divided rather than pulling violently. If separation is blindly performed under poor exposure, accidental injury and hemorrhage caused by ultrasonic shearing could result. Moreover, the nonfunctional face of the ultrasonic scalpel should be placed close to the splenic parenchyma throughout the dissection. This is also important to prevent damage to the spleen. Bleeding in this region is often intractable because even shallow injury to the surface of the spleen may cause rapid, large-volume bleeding. The blood soon fills the narrow operative region and blocks the field of view. Under these circumstances, the whole operative team should remain calm, and the assistant should take the aspirator in the right hand, ensuring interrupted, low-volume suctioning of blood, to expose the bleeding point. Meanwhile, the surgeon should grasp a small piece of gauze with the ultrasonic scalpel in the right hand to vertically compress the bleeding point. This is usually effective when the damage is minimal. However, if the hemorrhage is too massive to control, the surgeon should use a bipolar coagulation hook (power of 90–100 W) with a spray-coagulating model and with the hook parallel to the surface of the bleeding site to make the spleen parenchyma scabbing to control the hemorrhage (Fig. 6.115).

6.4.3 Prevention of Vascular Injury

Dissection and exposure of the root of the LGEV is considered to be the initial and key step of splenic hilar lymphadenectomy, and it is also a difficult step. The LGEV arise as a branch

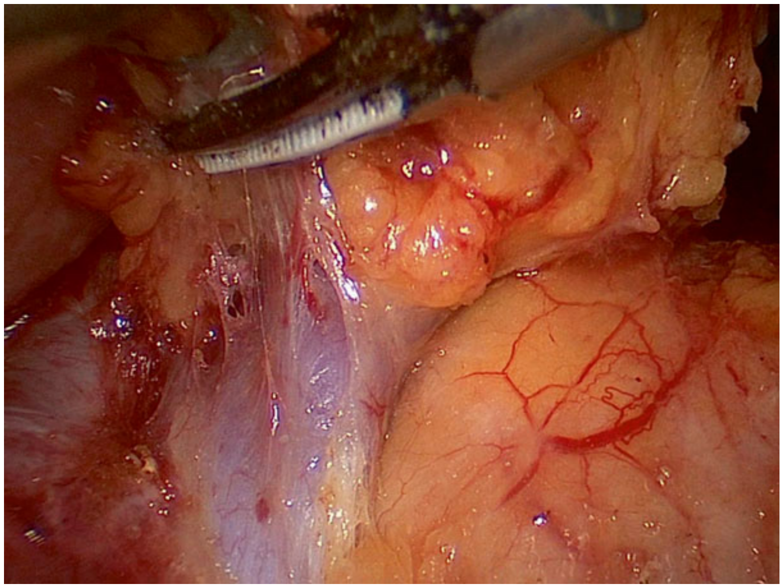


Fig. 6.80 The end of the splenic vessels' trunk is exposed in the RPS

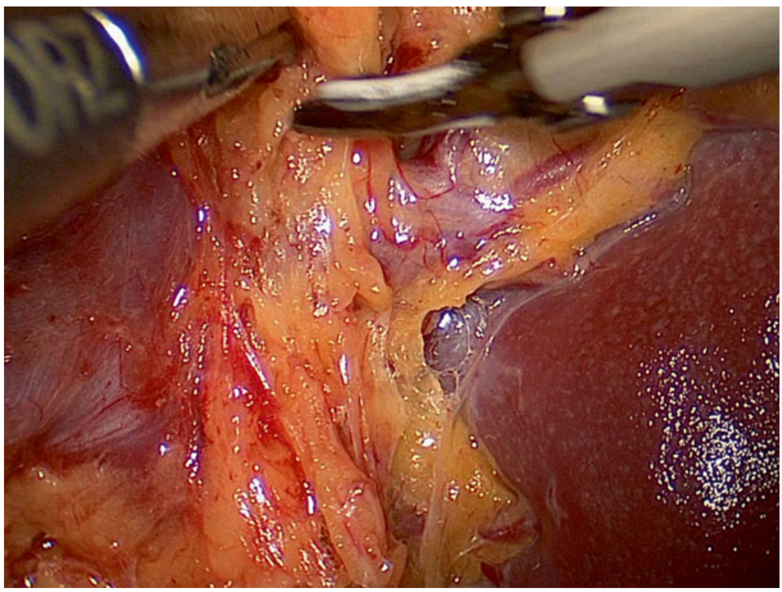


Fig. 6.81 The exposure of the LPVSs

of the LPVS or LLVS. The latter are usually lifted by the assistant following traction and elevation of the SGL, resulting in incorrect identification as the LGEV. Uncertain vessels should not be blindly severed. The surgeon should completely expose the RPS on the superior margin of the pancreatic tail and further denude the vessel toward the distal terminal to confirm its course. It is generally appropriate to reveal the splenic vessels first before cutting off the LGEV, thus avoiding injury to the splenic lobar vessel and resultant splenic ischemia (Figs. 6.116 and 6.117). During the process of distal gastrectomy, the surgeon should continue

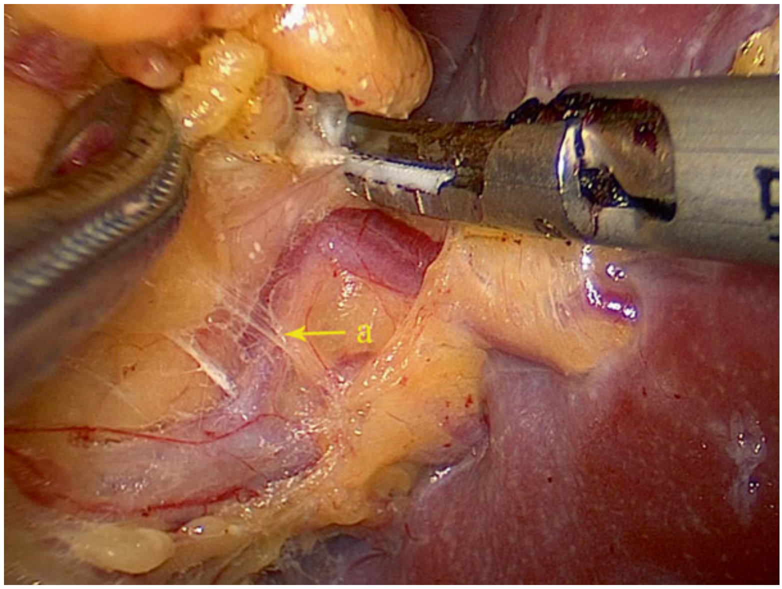


Fig. 6.82 The LLVSs (*a*) are separated up to the splenic hilar

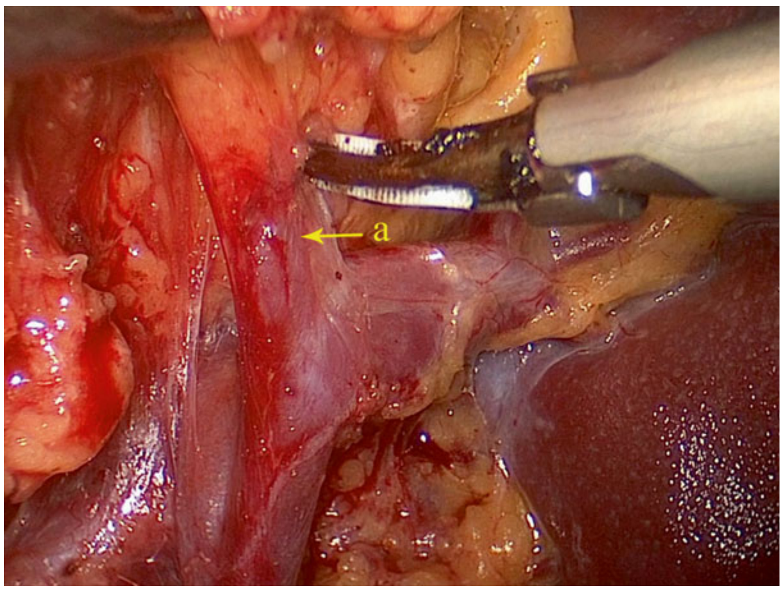


Fig. 6.83 The exposure of the roots of the LGEVs (*a*)

to sever one or two SGVs after severing the LGEV and then denude the greater curvature (Fig. 6.118). This latter manipulation should take place from the middle of the greater curvature. An operating hole should then be created in the avascular area, which allows for sufficient clamping of the vessels by ultrasonic scalpels (Figs. 6.119 and 6.120).

Although the origin of the SpA is relatively fixed (arising from the CA in 98.0 % of cases), its course exhibits several variations in terms of its relationship with the pancreatic parenchyma in some cases. Type I is the most common classification. This type can be sufficiently exposed and vascularized. Thus, it is easy to dissect the lymphatic fatty tissues around the entire artery.

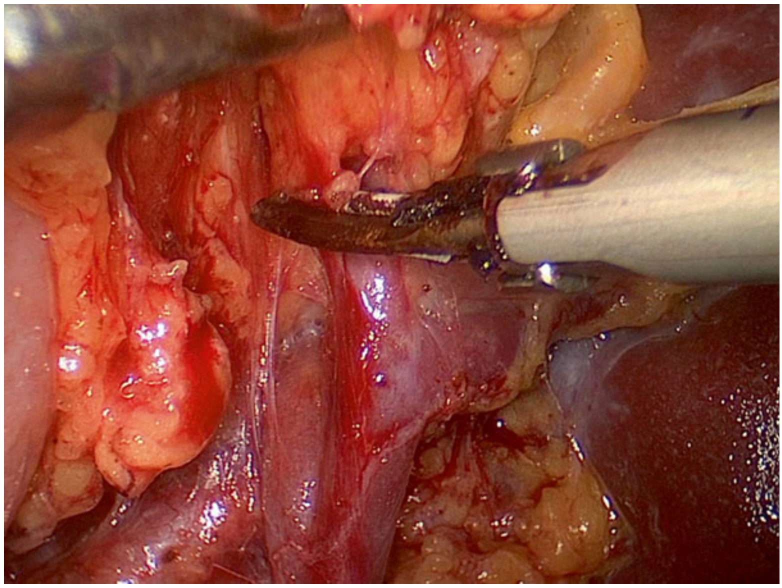


Fig. 6.84 The LGEVs are denuded along the anatomical space at the surface of the vessels

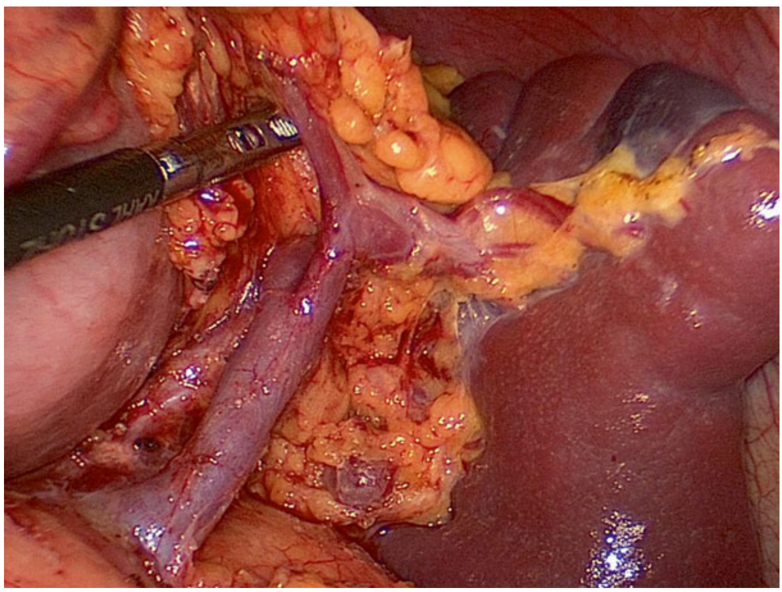


Fig. 6.85 The assistant pulls up the isolated LGEVs

However, in other types (types II, III, and IV), a portion of the SpA runs within the parenchyma of the pancreas. Resection of the lymphatic tissues should be performed more carefully because the pancreatic tissues may be incorrectly regarded as LNs, leading to postoperative complications such as hemorrhage and pancreatic fistula (Fig. 6.121). Moreover, the morphology of the SpA varies with age. It runs in a straight line during childhood and becomes tortuous to some extent in adulthood. In severe cases, the artery can take the shape of a loop. We experienced one case in which there were five curves in the course of the SpA. Greater numbers of bends result in greater difficulty during the procedure of denuding. Thus, the space between the artery and the LNs

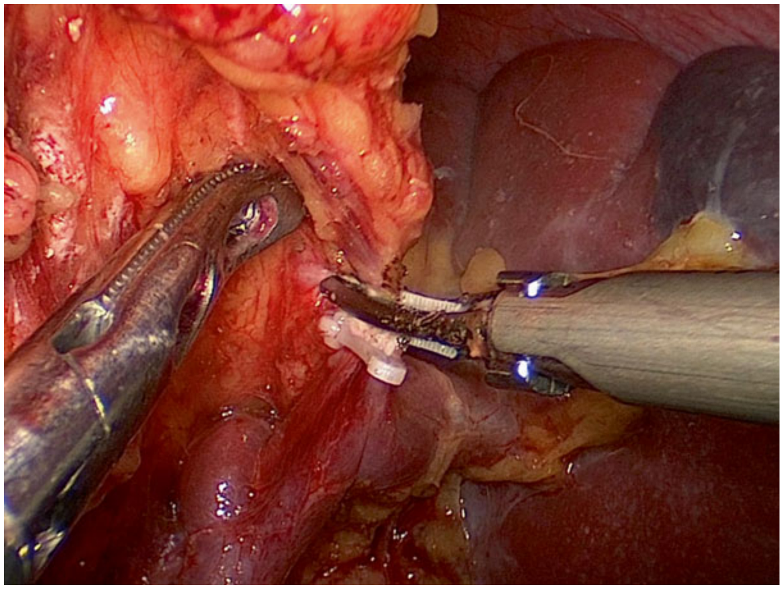


Fig. 6.86 The LGEVs are transected at their roots

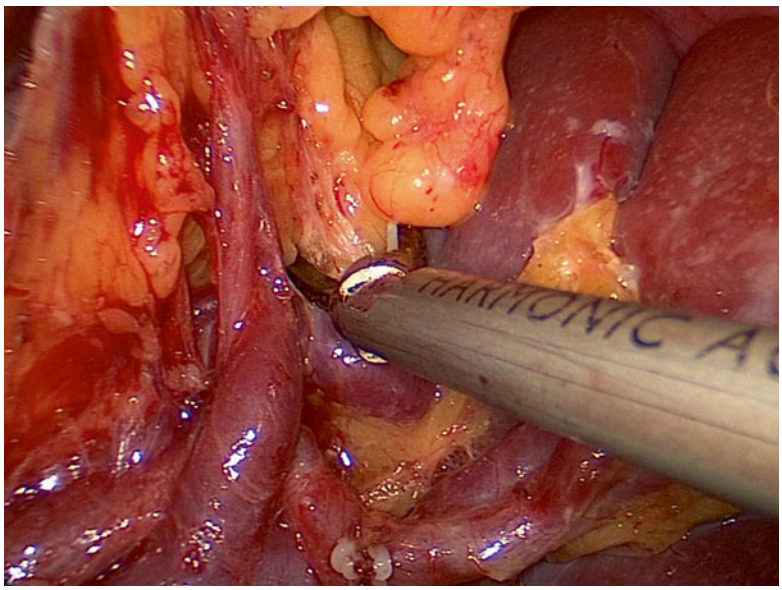


Fig. 6.87 The first branch of SGVs is revealed

should be differentiated to avoid incorrect identification of the SpA as swollen LNs because blind excision may cause bleeding and splenic ischemia (Fig. 6.122).

The SpV is commonly located on the dorsal and inner sides of the SpA. Dissection on the surface of the SpV should be performed gently using ultrasonic scalpel shearing rather than blunt dissection to prevent tearing of the vessel. Meanwhile, the continuity of the dissected lymphatic fatty tissues should be maintained; this is beneficial as the assistant lifts the tissues and exposes the anatomical space (Figs. 6.123 and 6.124). When dissecting the tissues on the dorsal

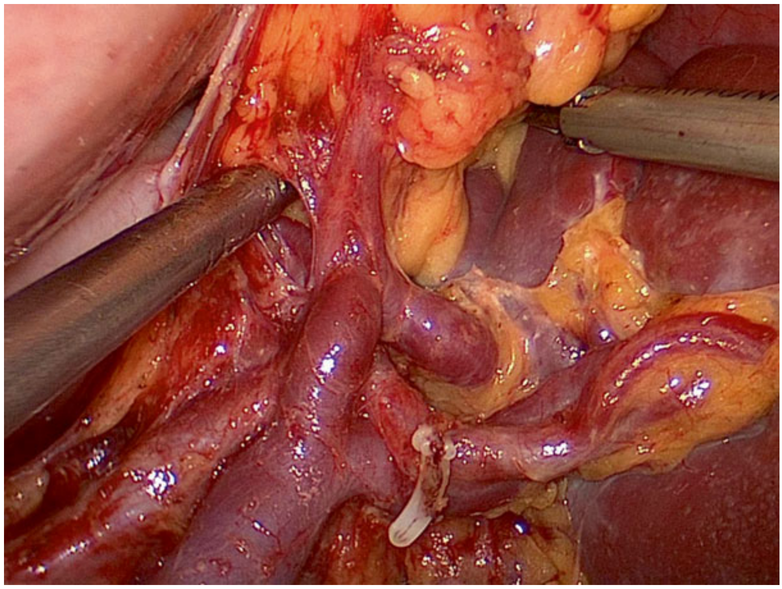


Fig. 6.88 The first branch of SGVs is vascularized

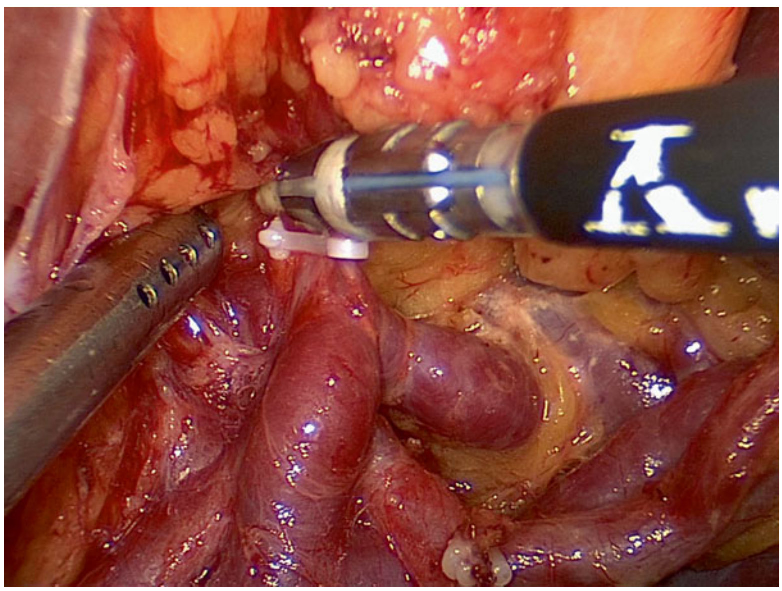


Fig. 6.89 The division of the first branch of SGVs

side of the splenic vessels, the assistant should grasp or push the splenic lobar vessel gently with the grasping forceps in the left hand and use the right hand to pull the tissues, assisting the surgeon in exposure of the operating field. The surgeon should simultaneously pull the tissues toward the lower left to create the appropriate amount of tension in the operating region and expose the anatomical space. This facilitates division of the lymphatic fatty tissues in this area (Figs. 6.125 and 6.126).

The type of the SLA also affects the splenic hilar lymph node dissection. The risk of vascular injury increases as the number of SLA branches

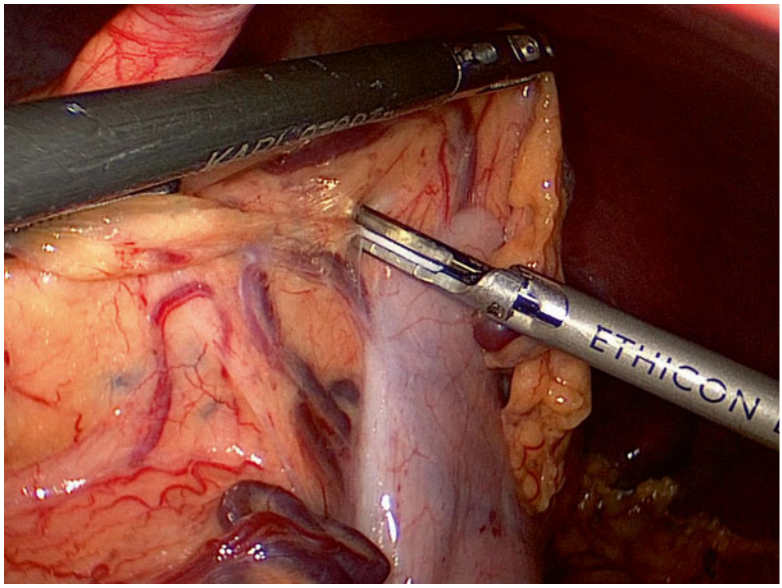


Fig. 6.90 The greater omentum is tensed and opened using the ultrasonic scalpel in the avascular area

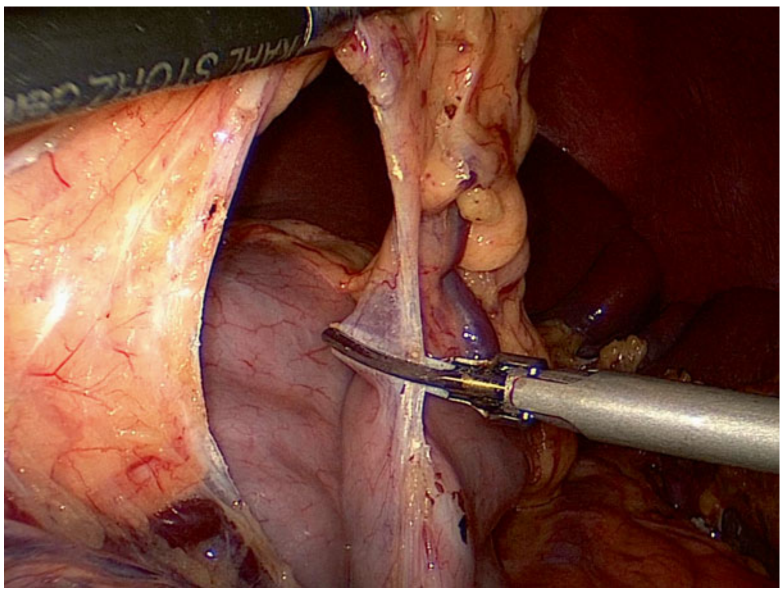


Fig. 6.91 Baring of the greater curvature of the stomach is against the gastric wall

increases. During vascularization in patients with many SLA branches, the tortuous SLV, which is usually identified as an SGV or posterior gastric vessel, may be incorrectly severed and lead to splenic ischemia. In patients with an SLA exhibiting one branch, the SLV clings to the splenic hilar. In such cases, the surgeon should simply divide along the trunk of the splenic vessels, and the LNs can then be successfully excised. However, injury may lead to splenic ischemia and splenic necrosis because of the single branch supplying the spleen, which will have a greater effect on the spleen. Therefore, vessels with an unclear course should be separated toward their

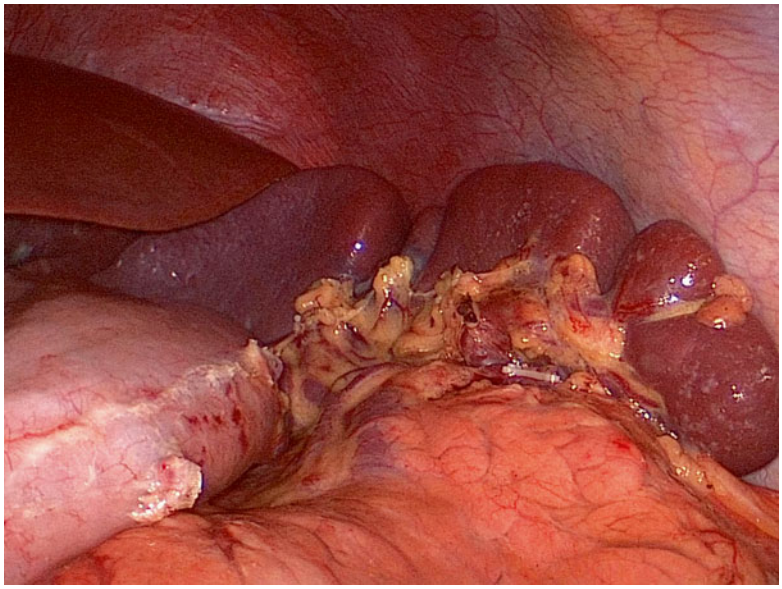


Fig. 6.92 The greater curvature of the stomach is bared

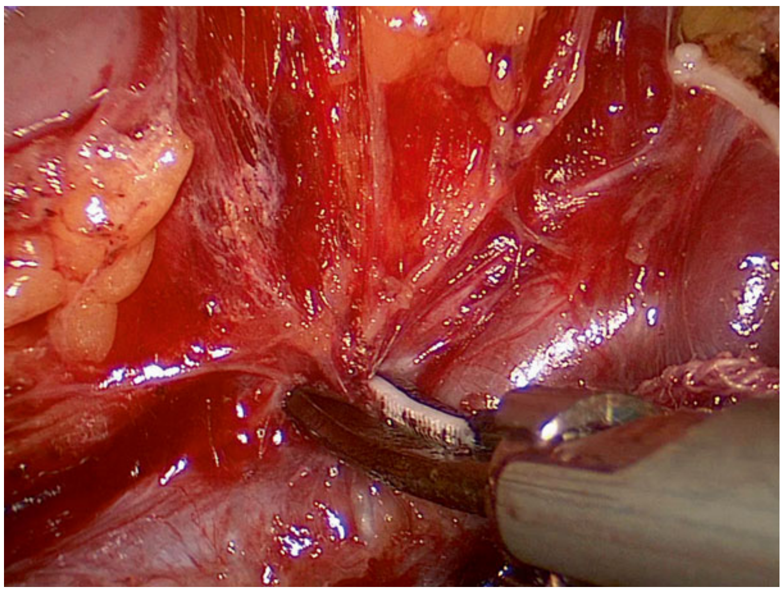


Fig. 6.93 Excision of the LNs at the end of the SpA

distal terminal while their orientation is distinctly noted. Such manipulation enables safe division and prevention of unnecessary injury caused by a blind operation. During the process of spleen-preserving hilar lymph node dissection, as the concentrated-type SpA is long, the SLA is relatively short and concentrated, which allows for easier skeletonization of the trunk of the artery and is associated with a lower risk of accidental injury to the SLA. However, the interval between the splenic lobar vessels is very narrow, and the surgeon should thus be very attentive when excising the LNs in this area to avoid injury to the vessel. On the other hand, the distributed-type SpA

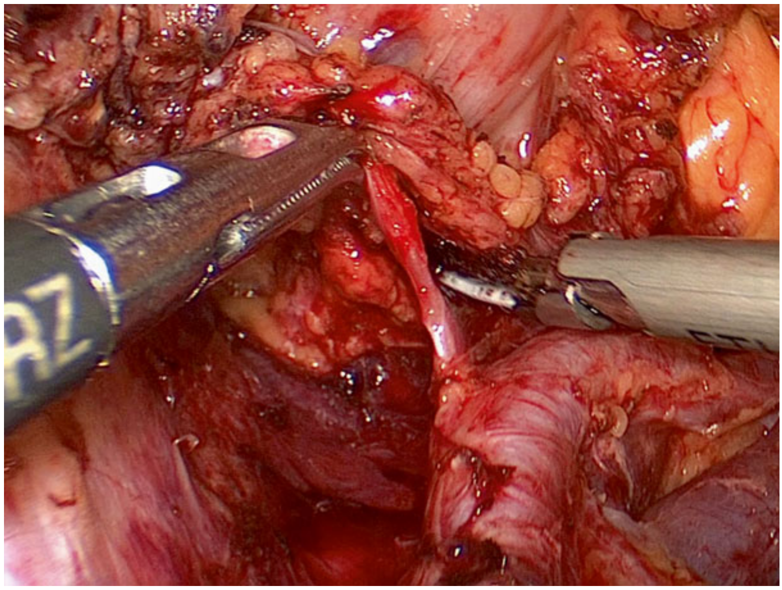


Fig. 6.94 The PGA is exposed and denuded

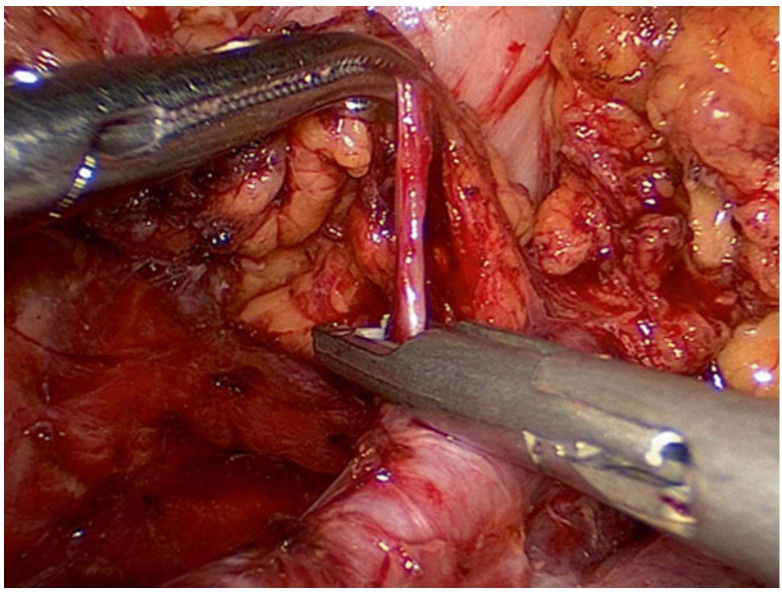


Fig. 6.95 The PGA is divided at its root

is relatively short, and the branches of the SLA are long and thin, causing difficulties in dissection and the risk of vascular injury. Moreover, it is preferable to clamp the smallest possible amount of tissue at a time, shearing and dividing the tissue step by step to reduce wound effusion. Excessive tension should be avoided to prevent tearing of the vessel and uncontrollable hemorrhage before coagulation and shearing has been completed with the ultrasonic scalpels.

The SGVs, which commonly comprise four to seven branches, are some of the most important structures that require severing during splenic hilar dissection. Before exposing these vessels, the GSL should first be divided layer by layer. The fascia of the splenic side should be resected

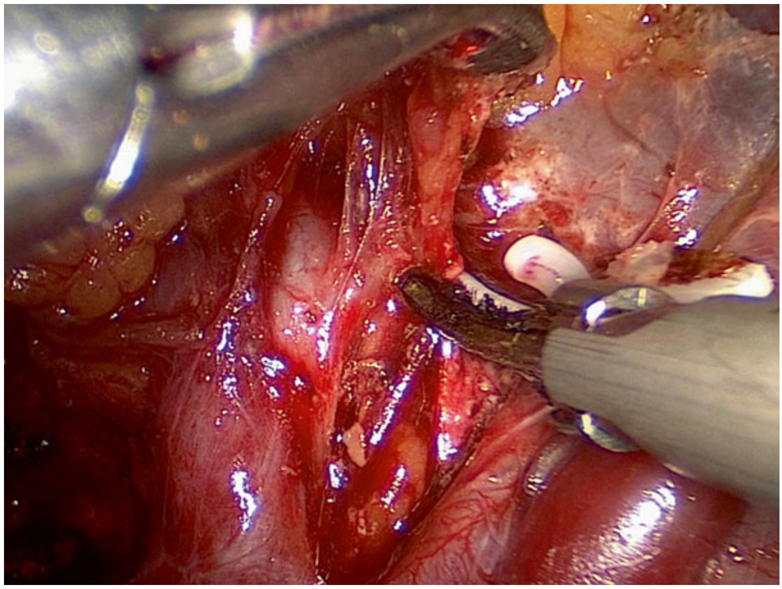


Fig. 6.96 Sharp peeling of the lobar vessels in the superior lobar area of the spleen

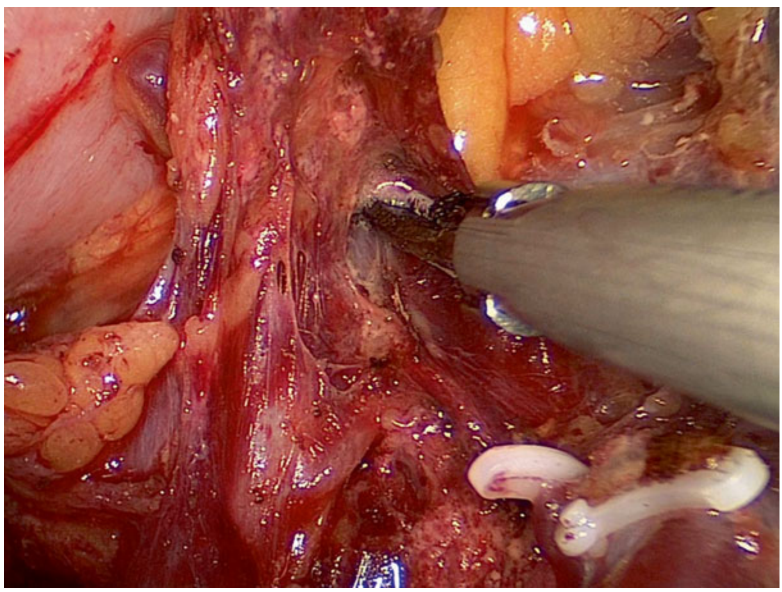


Fig. 6.97 Blunt peeling of the lobar vessels in the superior lobar area of the spleen

first, and an inboard fascial incision should then be performed (Figs. 6.127 and 6.128). The ultrasonic scalpel should not be used to clamp or dissect too many tissues at one time because the vessel may be incompletely clipped, leading to hemorrhage. The SGA originates from the SLA; thus, the SGA can be naturally revealed during the process of denuding the SLA, and then the vessel is severed at its root. No branches from the SGVs are encountered in this plane, and none of the branches have been twisted. Therefore, a minimal number of vessels require severing. More branches are encountered farther from the root, and these branches are more susceptible to injury (Figs. 6.129 and 6.130). When vascularizing the first branch of the SGVs, the vessel may

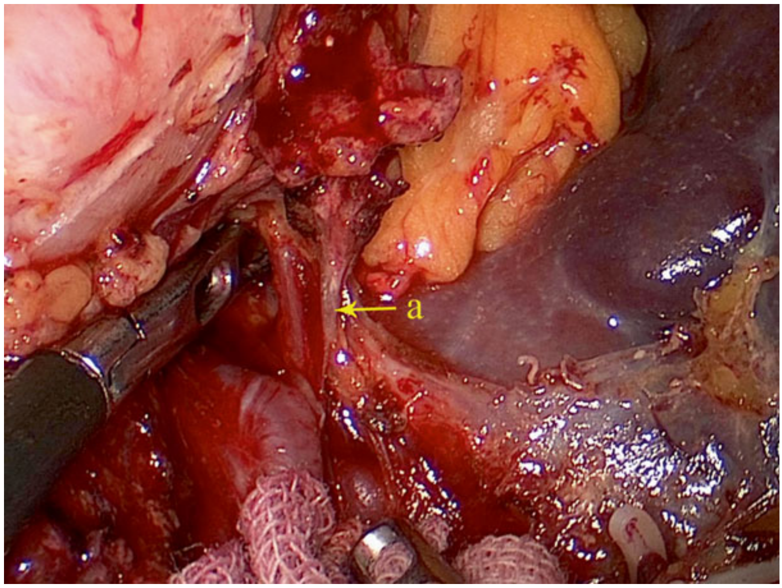


Fig. 6.98 The third branch of the SGVs (*a*) is vascularized

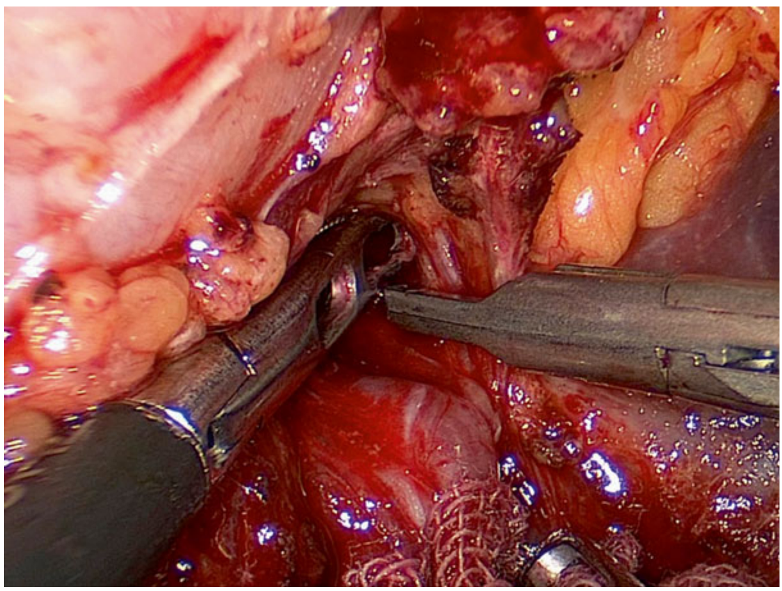


Fig. 6.99 The third branch of the SGVs is divided at its root

be easily injured by ligating the left gastroepiploic vessels because of their close proximity. In this situation, the assistant should push the tissues on the dorsal side of the vessel outward to assist the surgeon in ligating the vessel, avoiding accidental damage to the SGVs by the tail end of the clip. The branches of the SGVs generally become shorter as the surgeon approaches the upper pole of the spleen. The last branch is commonly the shortest, and the stomach thus lies closest to the spleen. Therefore, when dissecting in the region, the presence and characteristics of this vessel should be noted. First, the fundus of the stomach should be very gently manipulated.

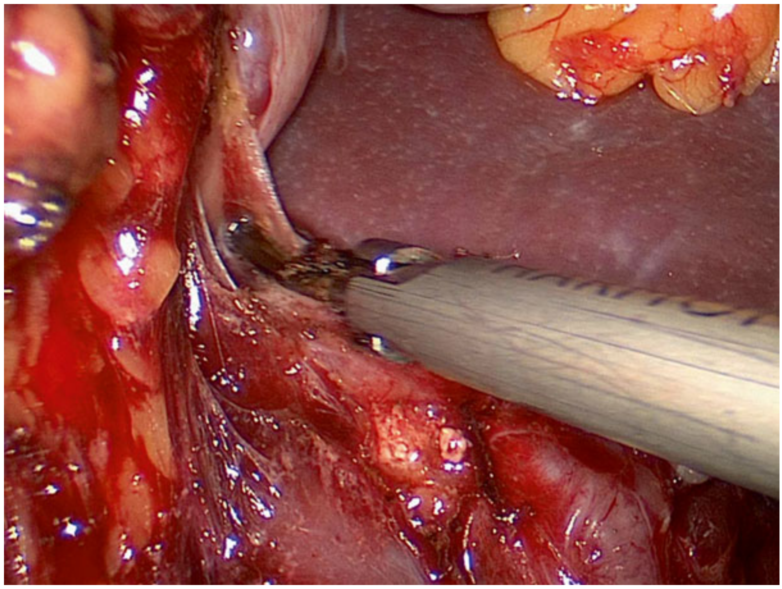


Fig. 6.100 The separation and exposure of the last SGV in the superior pole region of the spleen

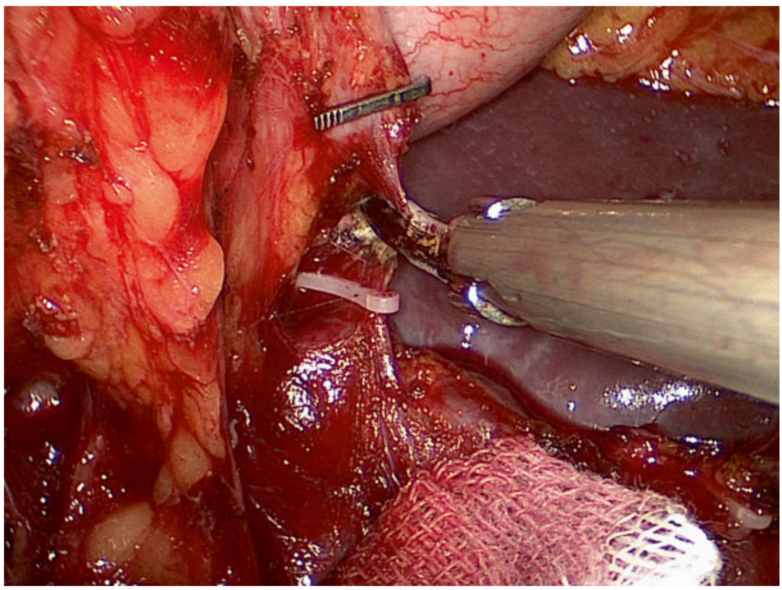


Fig. 6.101 The last SGV is transected at its root in the superior pole region of the spleen

On the other hand, the branch should be completely denuded before severing it because insufficient clamping of the vessel will cause unnecessary hemorrhage (Figs. 6.131 and 6.132). In some cases, the SGVs supply the upper pole of the spleen, and partial splenic ischemia could develop after cutting off these vessels (Fig. 6.133).

The course of the PGA should be taken into consideration during dissection of the SpAT. It must be distinguished from the upper lobar vessels of the spleen (ULVSs). In general, the PGA and PGV run together to supply the fundus, but the ULVSs only have arteries and run directly to the upper lobe of the spleen without running

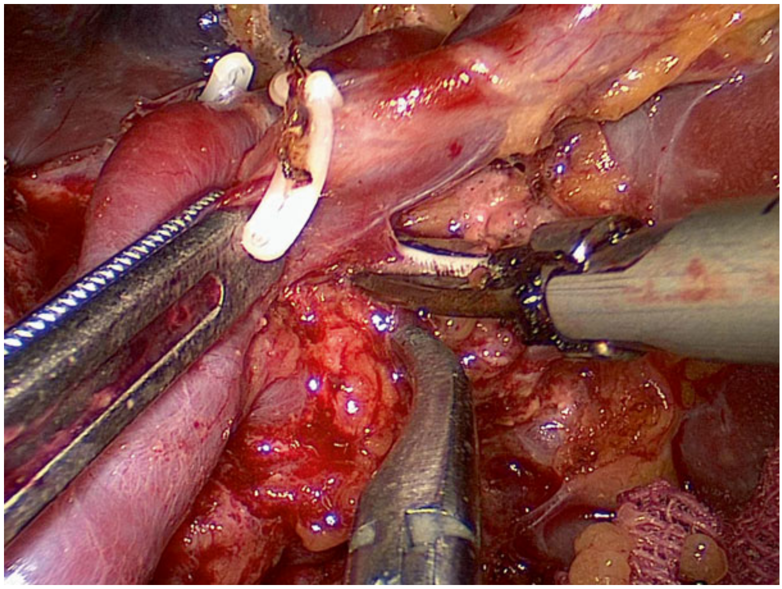


Fig. 6.102 Dissection of the LNs behind the splenic vessels along the front of Gerota's fascia

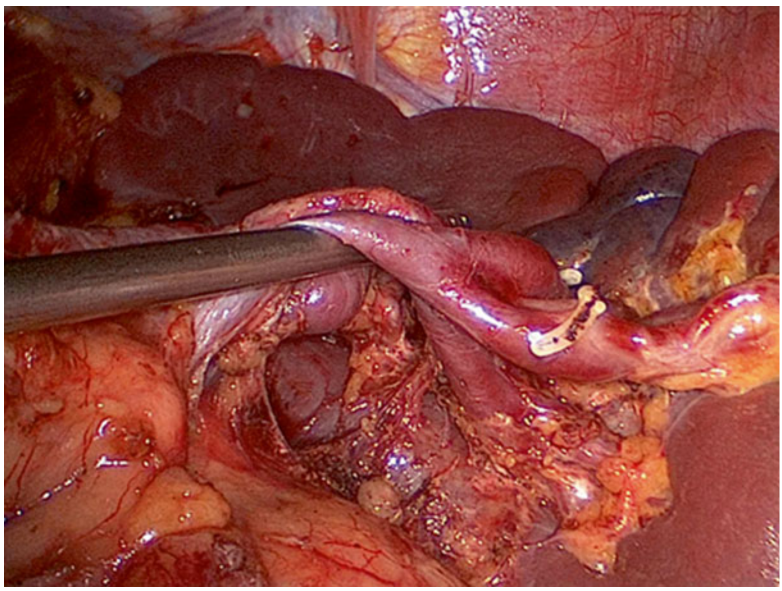


Fig. 6.103 The LNs behind the splenic vessels are excised

through the splenic hilar. At this point in the procedure, the assistant should lift the body of the stomach while the surgeon compresses the pancreas to maintain appropriate tension of the vessel and facilitate its easy identification and division. The vessel should be severed at its root after it has been vascularized; this will be beneficial for exposure of the splenic hilar region (Fig. 6.134).

Hemorrhage management is one of the most difficult points of splenic hilar lymph node dissection, particularly in obese patients, in whom abundant fat tissue accumulation leads to difficult exposure of the operating field. Under such circumstances, an aspirator, small gauze, titanic clip, and vascular clip are helpful. The assistant should lift the gastric wall to apply tension on the GSL with the grasping forceps in the left hand,

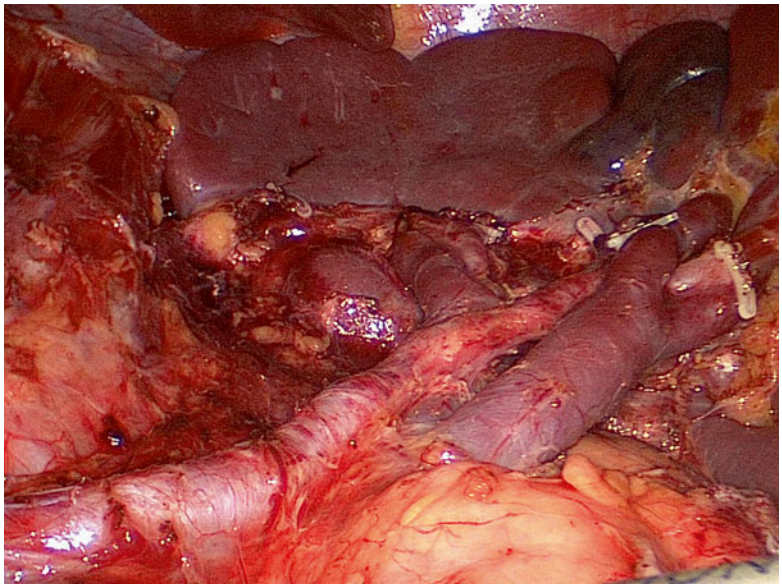


Fig. 6.104 Dissection of the No. 10 and No. 11d LNs is completed

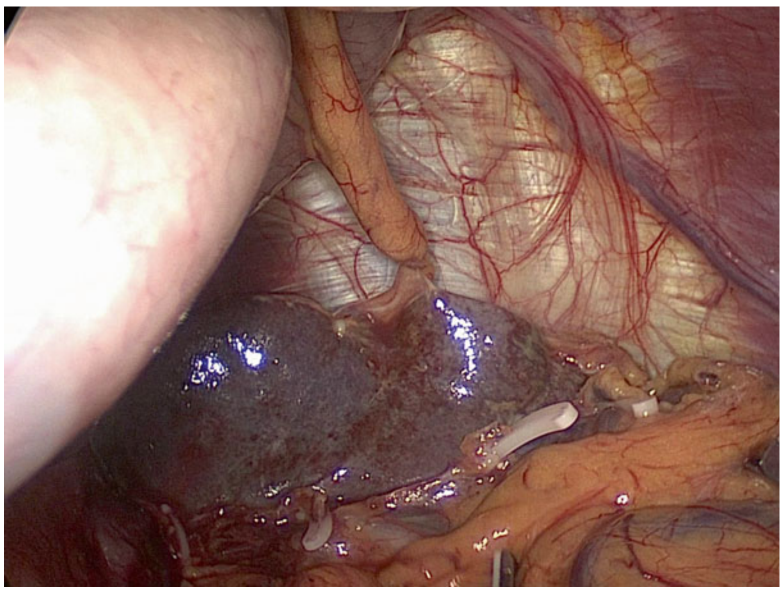


Fig. 6.105 Adhesions between the spleen and the omentum

assisting the surgeon in exposure. Meanwhile, the aspirator in the other hand should be used, ensuring interrupted, low-volume suctioning of blood, to expose the site of bleeding. Massive hemorrhage sometimes makes exposure of the bleeding site difficult. The surgeon should rapidly apply compression with a large piece of gauze to temporarily stop the bleeding. The assistant should then continue to suction the blood, readjusting the suction position to expose the bleeding site. The surgeon subsequently ligates the areas both superior and inferior to the site of bleeding using titanium clips to achieve hemostasis (Figs. 6.135 and 6.136).

In addition, we suppose that 3D CT reconstruction can be used preoperatively to detect the distribution of the splenic vessels. This will reduce the difficult and time-consuming nature of

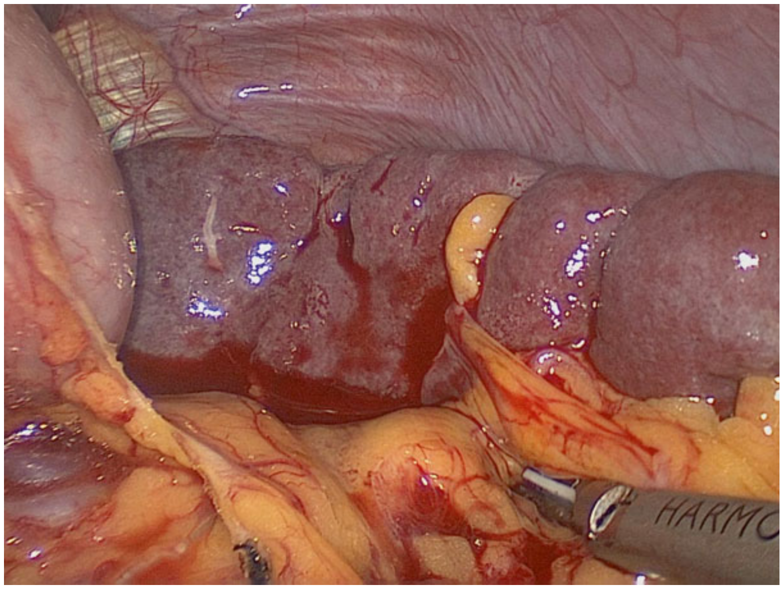


Fig. 6.106 The splenic capsule is torn and bleeding secondary to the application of excessive tension

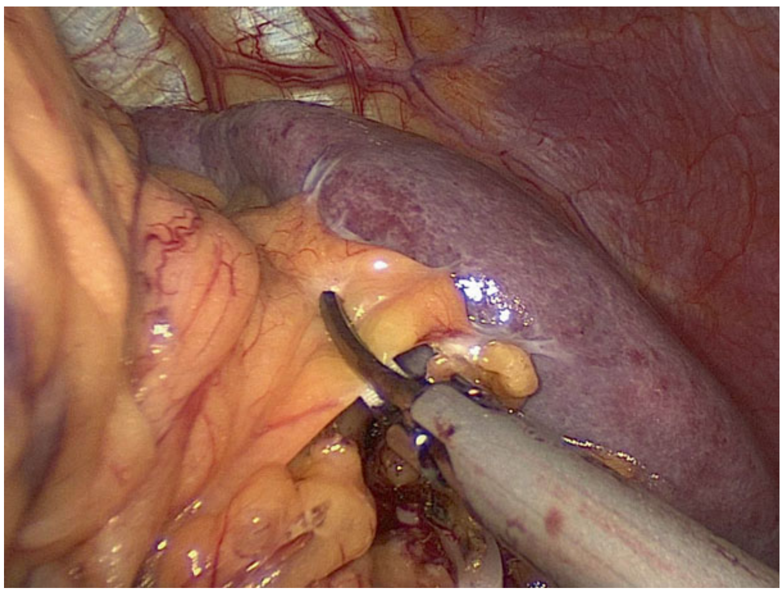


Fig. 6.107 Adhesiolysis should be performed first

the surgery as well as the risk of injury to the splenic hilar vessels. It will also increase the surgeon's confidence in laparoscopic surgery. In our study of the factors influencing the difficulty of splenic hilar lymph node dissection in different phases of the learning curve, we have found that in the early phase (within the first 40 operations), the operative technique affects the operation time and blood loss, but not the 3D vessel reconstruction. This can be attributed to the surgeon's

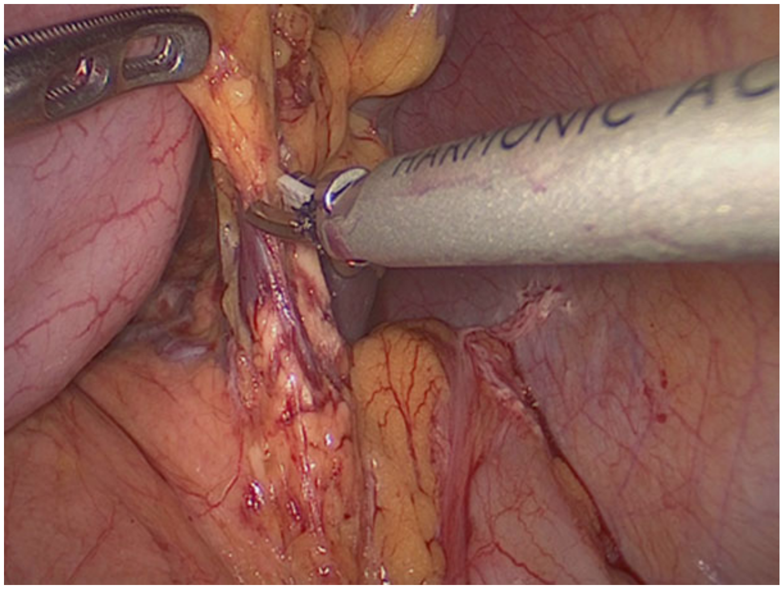


Fig. 6.108 Separation along the space in the SRL to expose the LPVSs

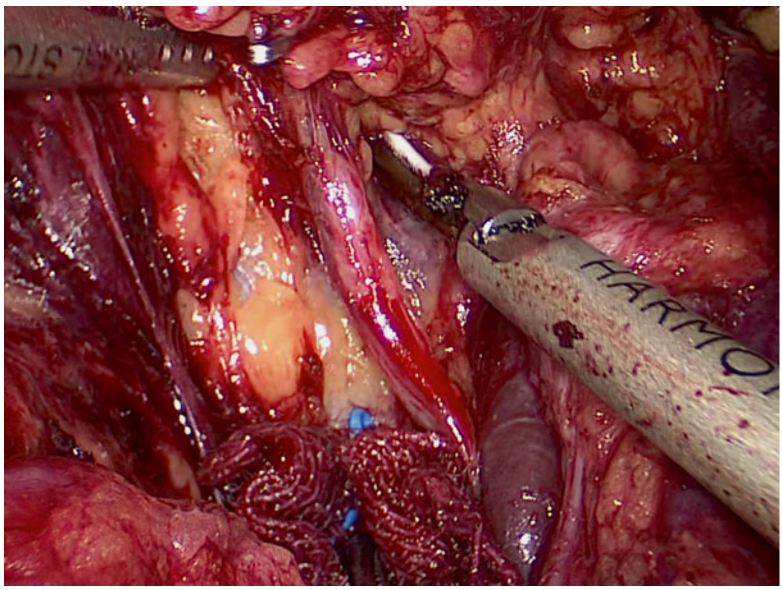


Fig. 6.109 The splenic upper-pole vessel branching from the SpAT is usually lifted and may be incorrectly recognized as the posterior gastric vessel

technical inexperience. However, as the surgeon's technical skill improves (after 40 operations), the anatomical variation in the splenic vasculature has become the most essential factor affecting the operation time and amount of blood loss. Thus, preoperative 3D CT analysis of the splenic vessels is informative for the surgeon, helping to prevent unnecessary injury and hemorrhage, reducing the operation time, and enhancing the effect of lymph node excision [24].

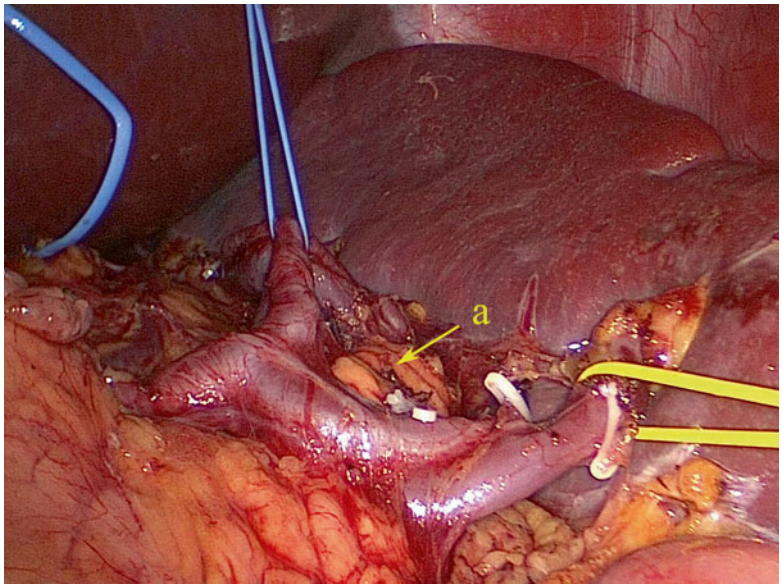


Fig. 6.110 The pancreatic tail (*a*) is close in proximity to the middle of the splenic hilar region

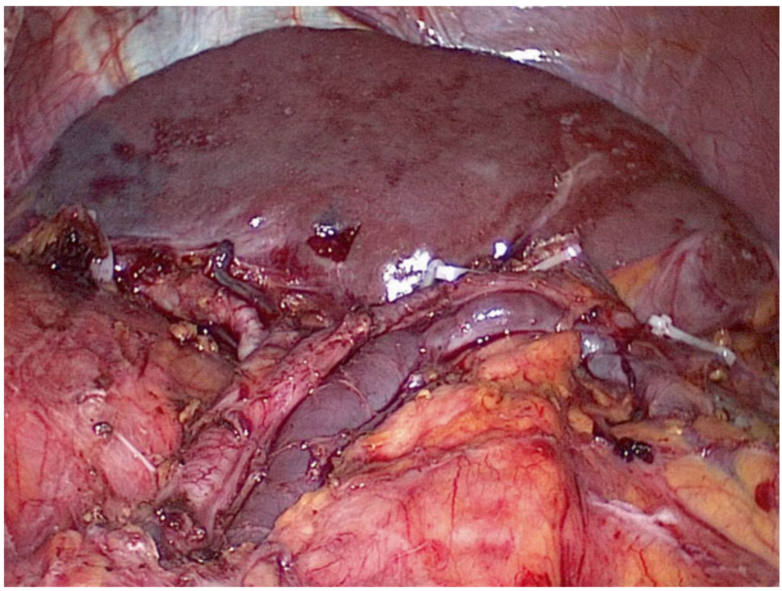


Fig. 6.111 The pancreatic tail is close to the lower pole of the spleen

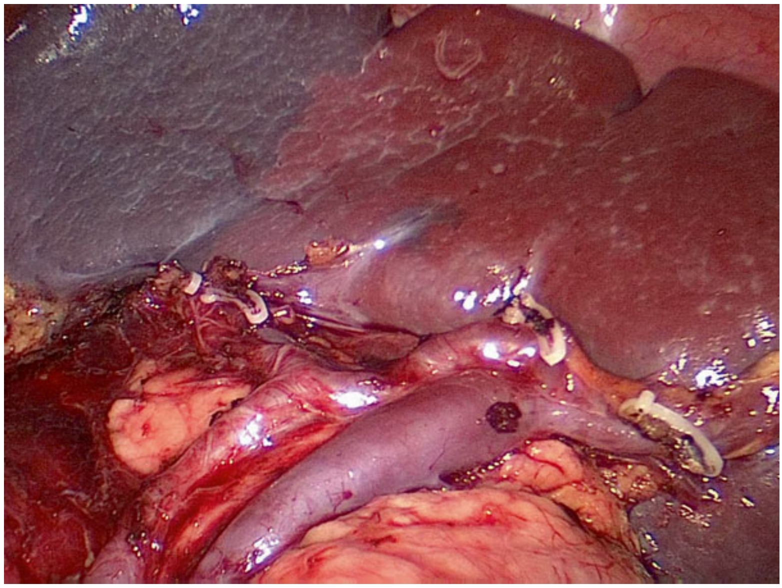


Fig. 6.112 The pancreatic tail is close to the upper pole of the spleen

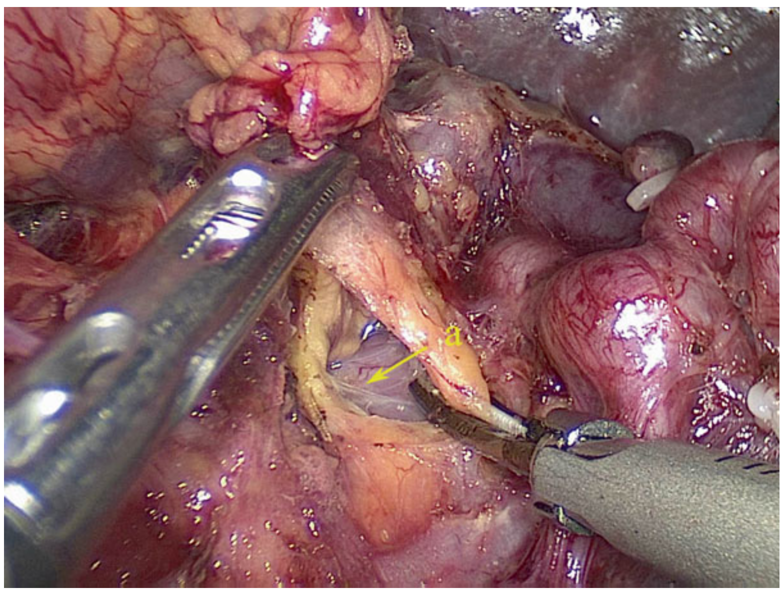


Fig. 6.113 If the operating plane is entered too deeply (under Gerota's fascia), the left kidney (*a*) is susceptible to injury

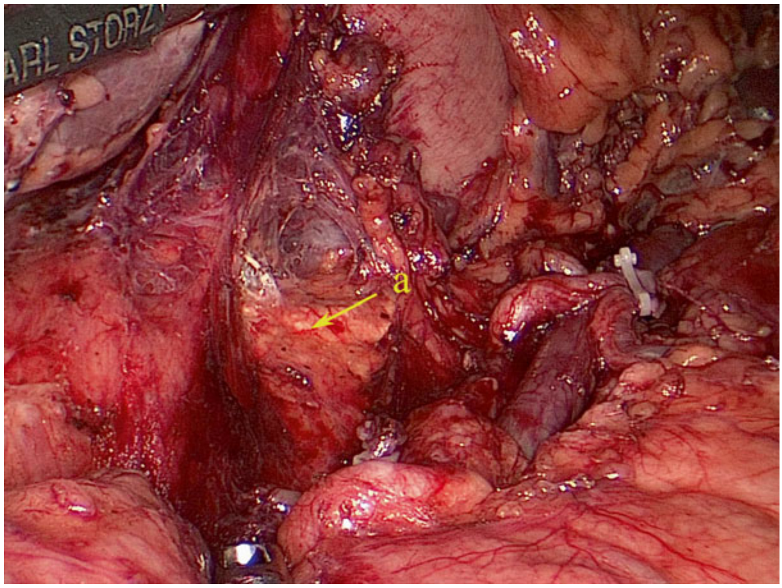


Fig. 6.114 The surgeon should clearly identify the space between the lymphatic fatty tissues and the adrenal gland (*a*) to avoid accidental injury

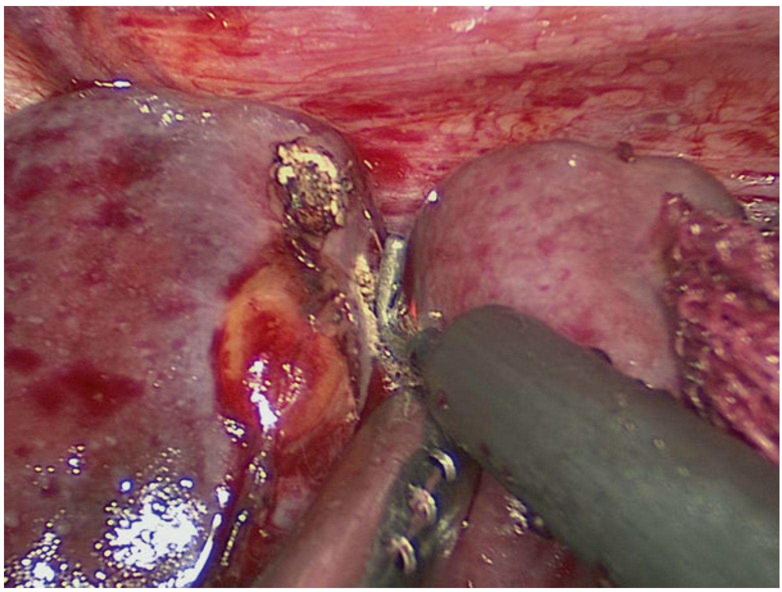


Fig. 6.115 The surgeon should use the hook parallel to the surface of the bleeding site

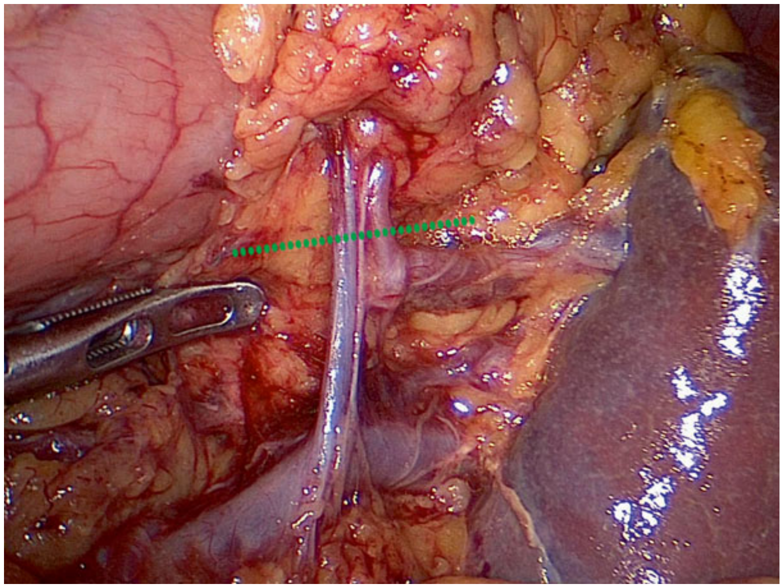


Fig. 6.116 LGEV should be severed above the *green dotted line* after exposing the roots

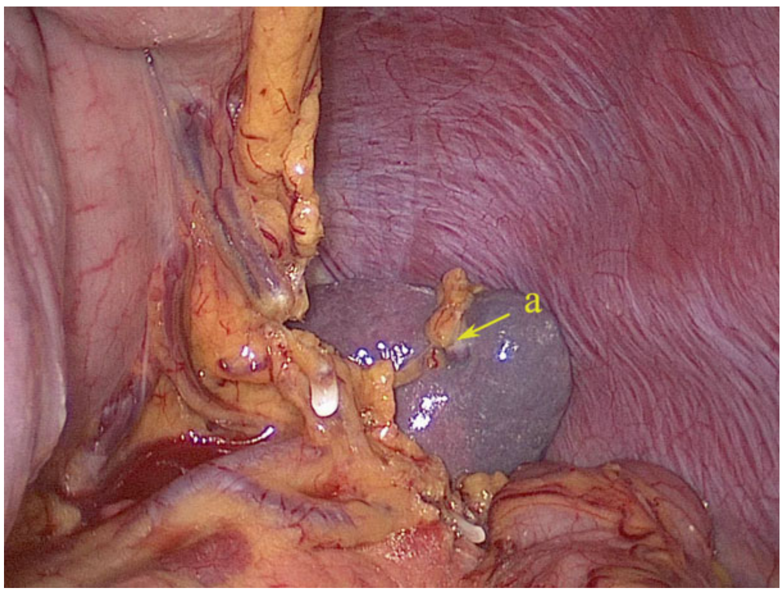


Fig. 6.117 LPVS (*a*) are severed, causing splenic ischemia

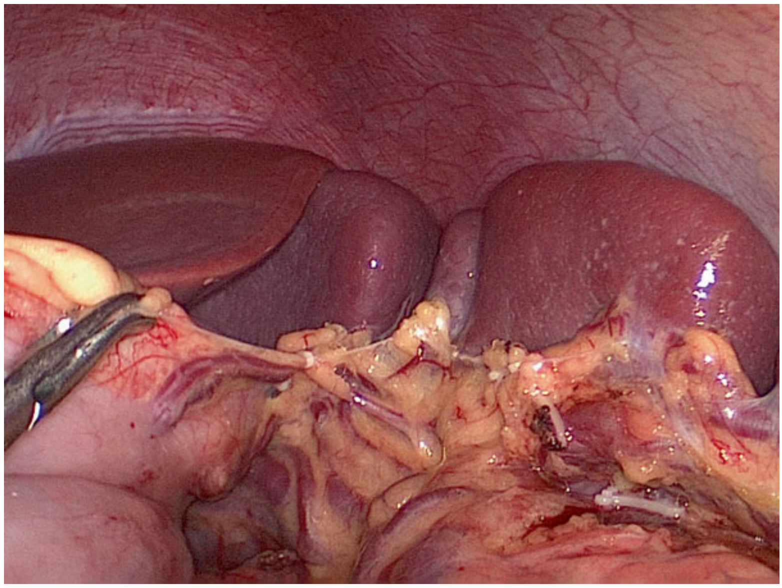


Fig. 6.118 The surgeon should continue to sever one or two SGVs toward the greater curvature of the fundus after severing the LGEV

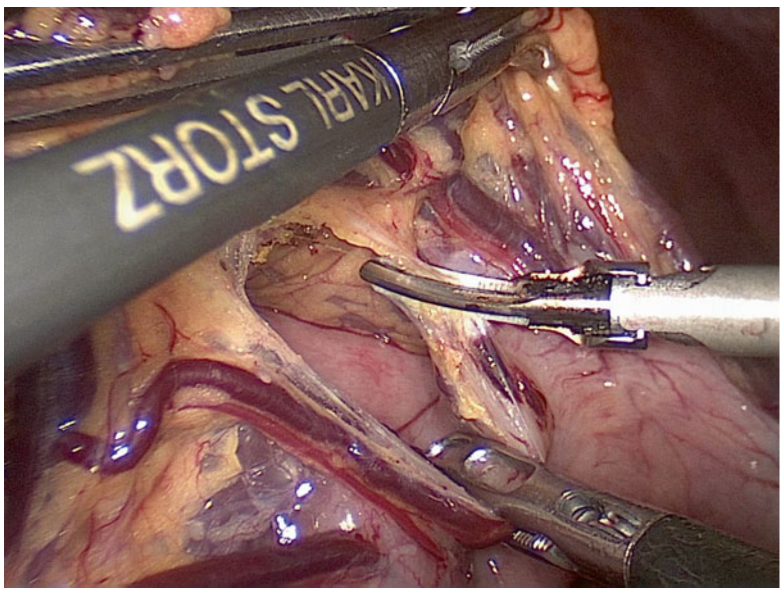


Fig. 6.119 The surgeon should create an operating hole within the avascular area of the greater curvature

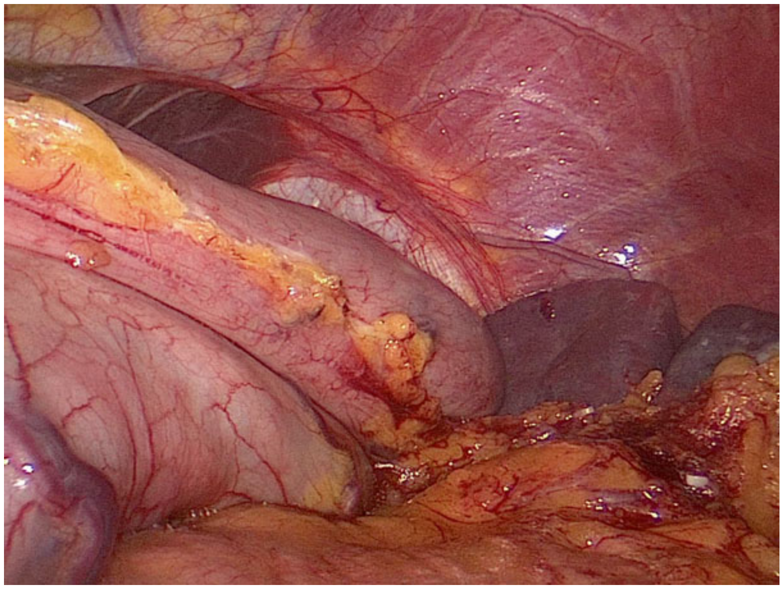


Fig. 6.120 The greater curvature after denuding

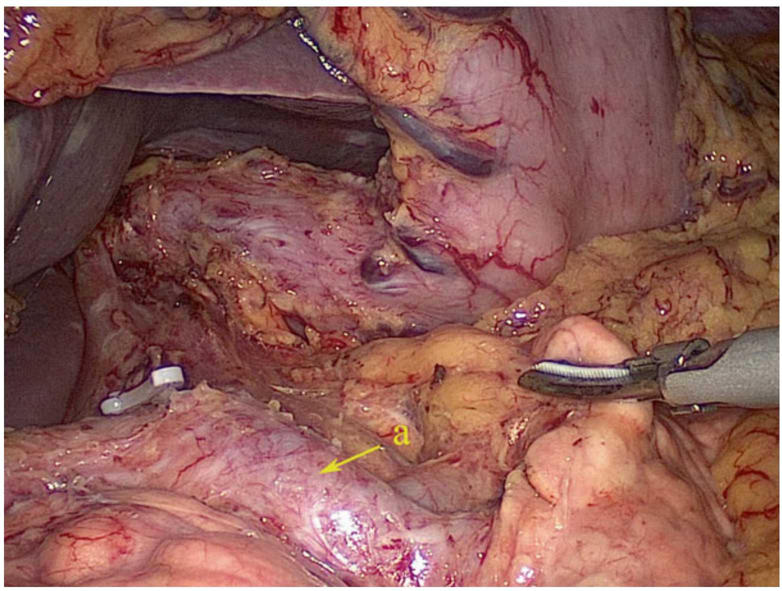


Fig. 6.121 The pancreas should be protected during dissection because a portion of the SpA (*a*) runs within the pancreatic parenchyma

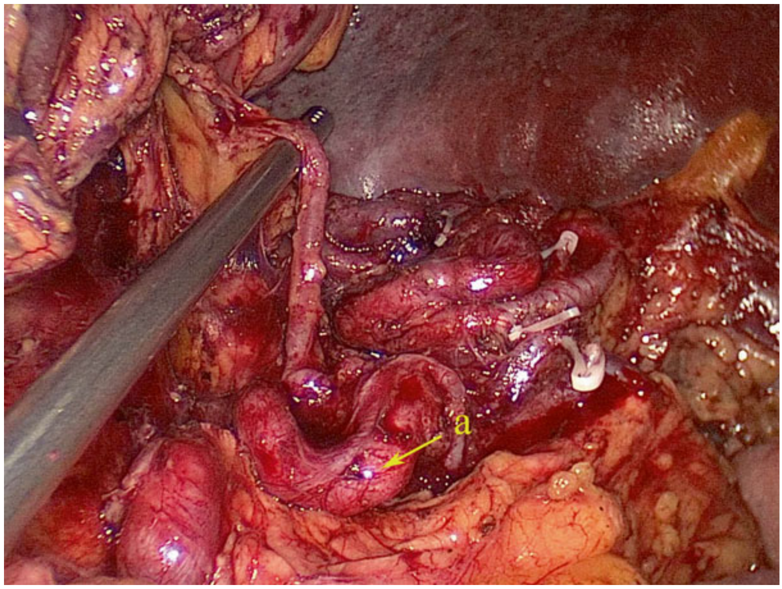


Fig. 6.122 SpA (*a*) runs tortuously in the shape of a loop

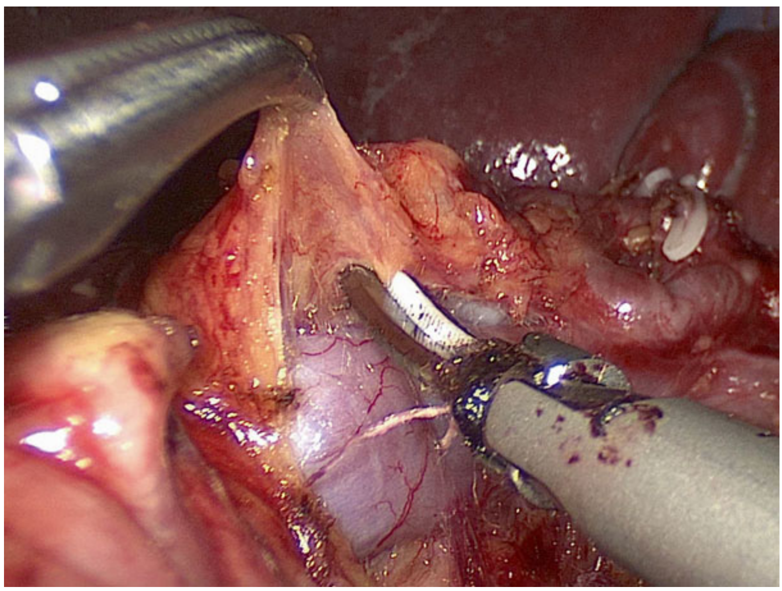


Fig. 6.123 The surgeon should operate gently on the surface of the vein using ultrasonic scalpel shearing

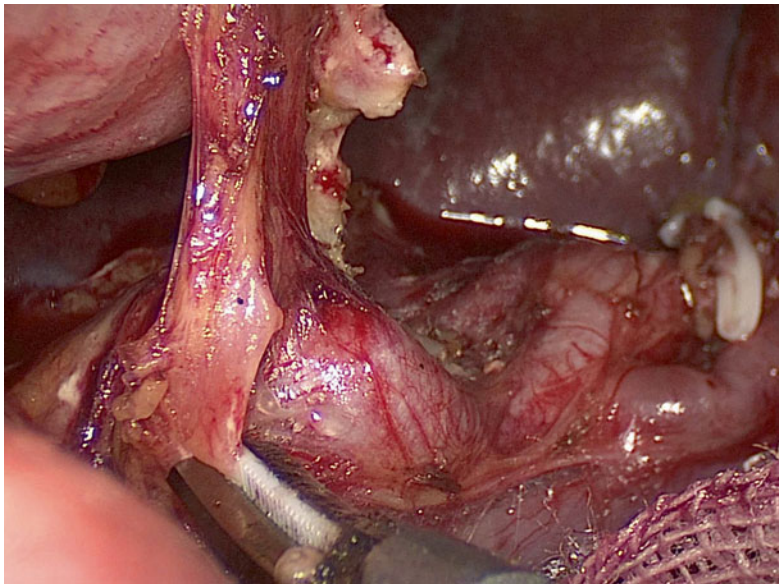


Fig. 6.124 Continuity of the dissected lymphatic fatty tissues should be maintained, which is beneficial as the assistant lifts the tissues and exposes the anatomical space

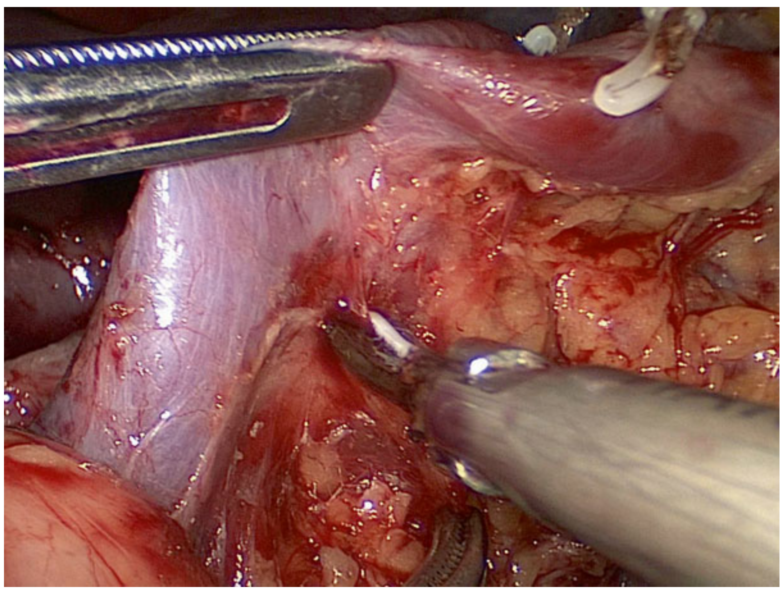


Fig. 6.125 The assistant should gently elevate the vessel, and the surgeon should pull the lymphatic fatty tissues downward to expose the anatomical space

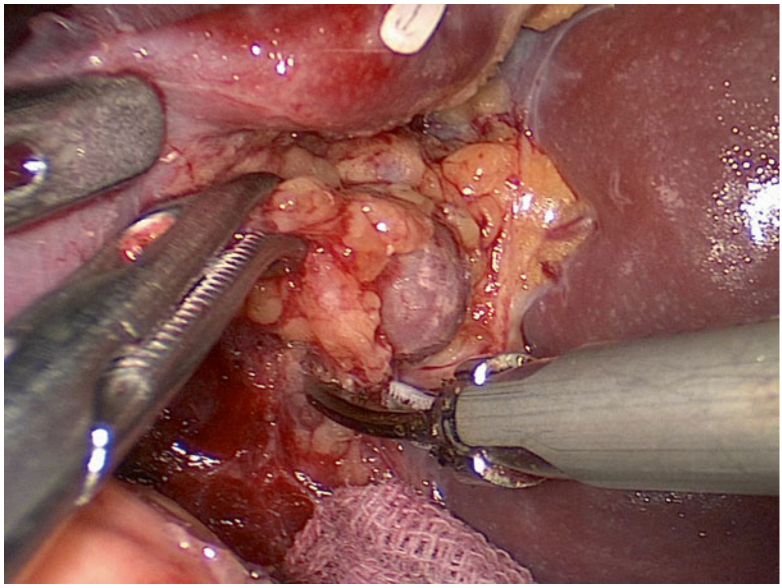


Fig. 6.126 Tissues should be pulled outward while the nonfunctional face of the ultrasonic scalpels is placed close to the spleen

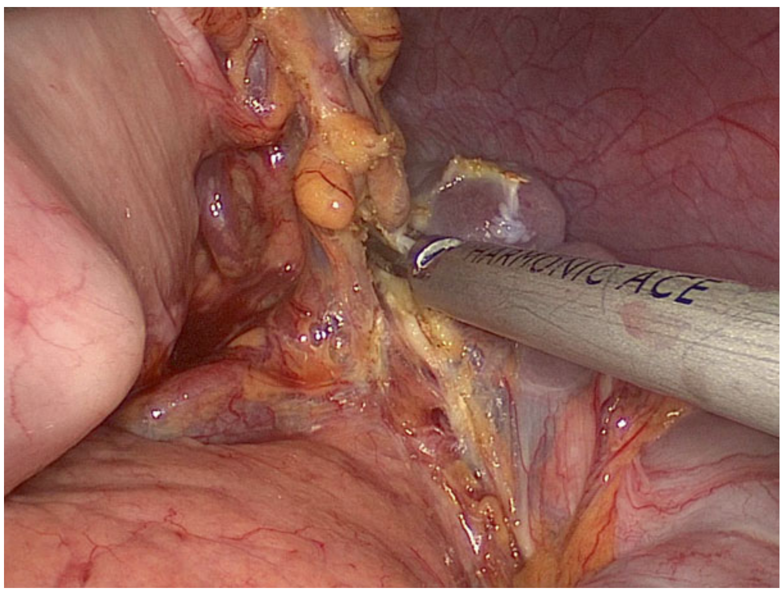


Fig. 6.127 Separation of the GSL by dividing the fascia of the splenic side

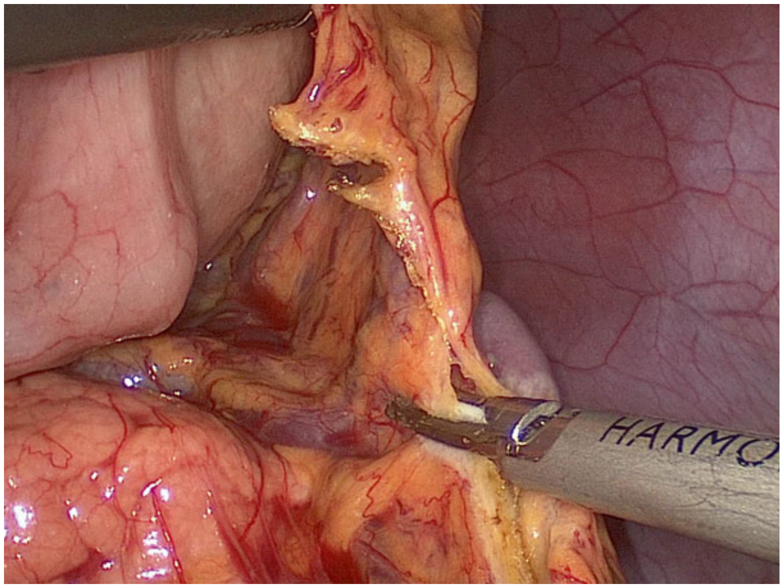


Fig. 6.128 Separation of the GSL by dividing the inboard fascia

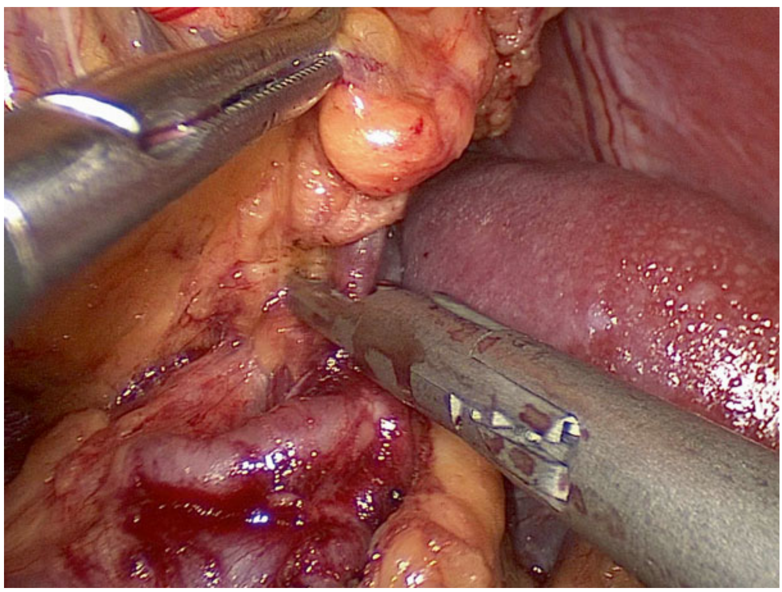


Fig. 6.129 Excision should be performed close to the surface of the splenic hilar vessels. The SGVs should be severed at their roots

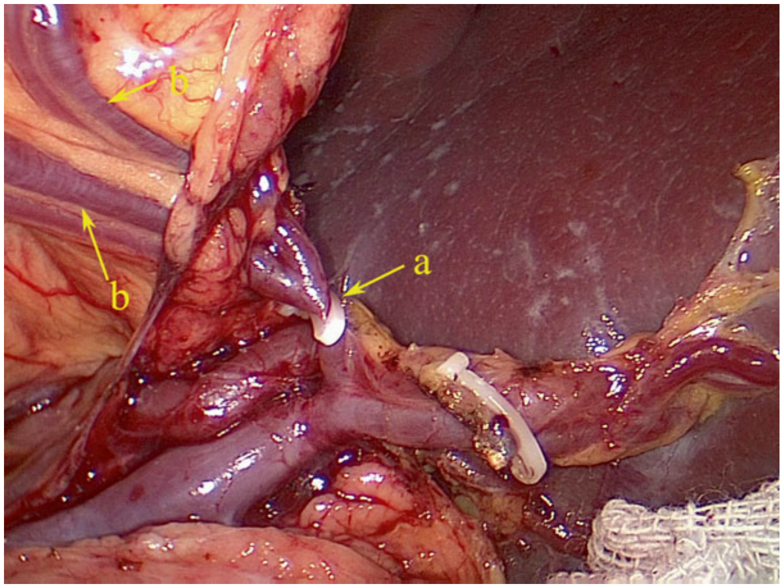


Fig. 6.130 SGVs (*a*) give off branches (*b*) throughout the courses. More vessels require to be conducted if the vessel is severed far from its root

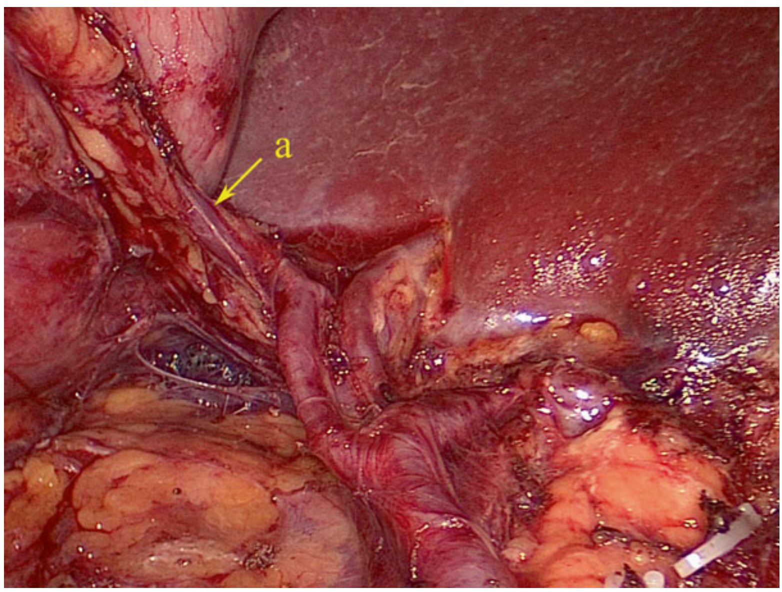


Fig. 6.131 Last branch of the SGVs (*a*) is commonly short, and the stomach thus lies close to the spleen

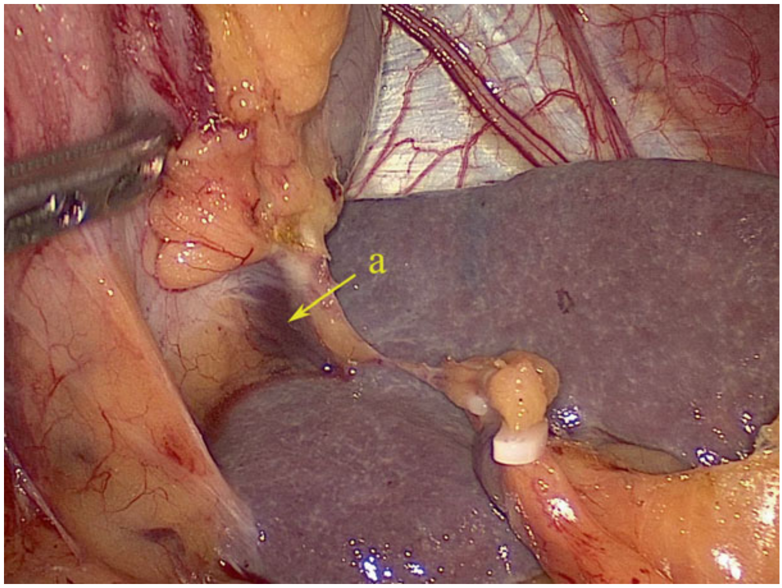


Fig. 6.132 The short gastric vein (*a*) drains directly into the upper pole of the spleen

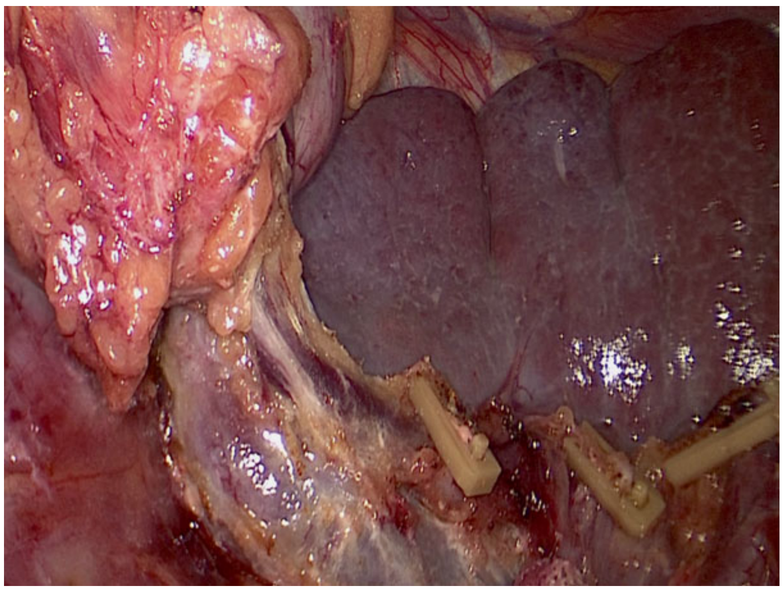


Fig. 6.133 The SGVs supply the upper pole of the spleen

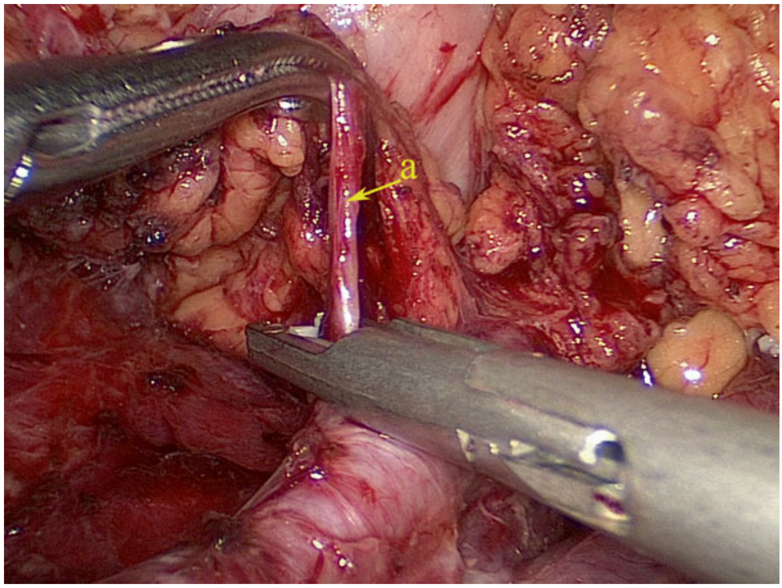


Fig. 6.134 Vascularization and severing of the PGA (*a*) at its root

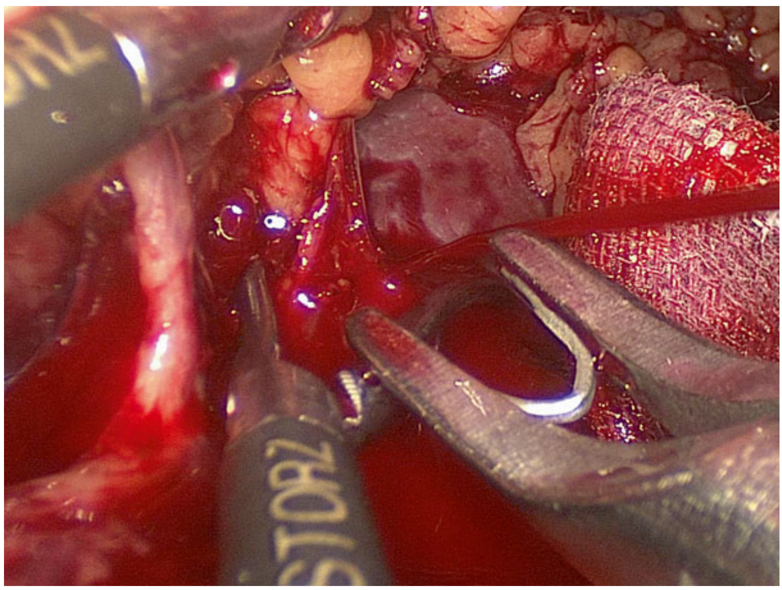


Fig. 6.135 The surgeon gently clamps the site with atraumatic forceps and ligates it with titanium clips

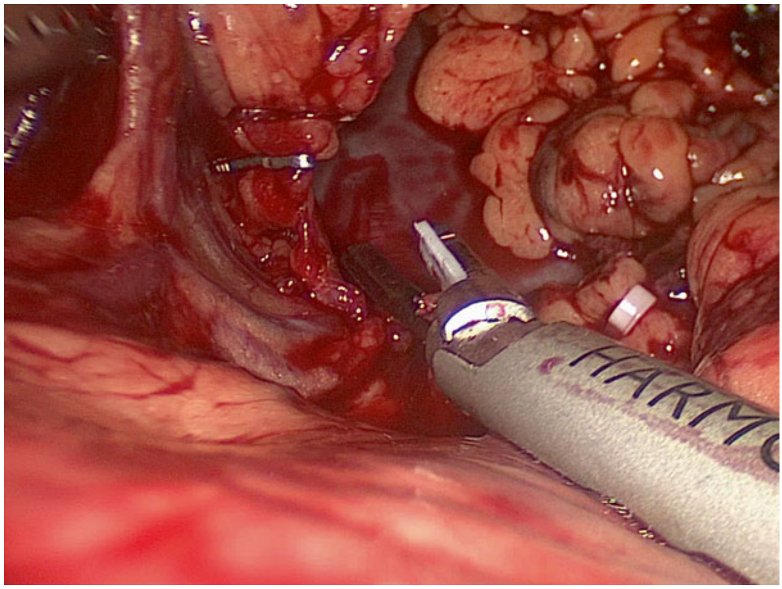


Fig. 6.136 Hemostasis has been achieved

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7 Laparoscopic Cardial Area Lymph Node Dissection for Gastric Cancer

7.1 Review of Laparoscopic Cardial Area Lymph Node Dissection for Gastric Cancer

The lymph nodes (LNs) in the cardial area are located on both sides of the cardia and along the gastric lesser curvature. They include the No. 1, No. 2, and No. 3 LNs (Fig. 7.1). Complete dissection of the LNs in this area is also an important procedure during radical gastrectomy for gastric cancer.

There is a higher frequency of No. 1 or No. 3 lymph node metastasis (LNM). The common metastatic pathway is from No. 3, No. 1, No. 7, to No. 9, wherever the tumor is located in the upper, middle, or lower third stomach. No. 1 and No. 3 LNM are correlated to tumor location, depth of invasion, and other factors. Advanced gastric cancer has a higher incidence of No. 1 LNM. Because upper gastric cancer always occurs in the lesser curvature, and the distance between the No. 1 LNs and the tumor is close, No. 1 LNM is the most frequent in advanced upper gastric cancer, demonstrating an incidence of between 50.0 % and 76.0 % [1–5]. The metastatic rate varies between 14.0 % and 24.0 % in gastric body cancer and between 6.0 % and 18.6 % in distal gastric cancer [6, 7]. Even for early proximal gastric cancer, the incidence of No. 1 LNM can be as high as 4.4 % [8]. However, the incidence of No. 1 LNM is low in early distal gastric cancer. Liu et al. [7] analyzed the status of LNM in 129 patients with early lower gastric cancer and showed No. 1 LNM; they suggested that No. 1 LNs should not be routinely removed for those patients. Thus, No. 1 LNs should be routinely removed for patients with gastric cancer except those with early lower gastric cancer. In addition, lymphatic vessels around the stomach mainly lie along the left gastric artery (LGA), splenic artery, and hepatic artery and finally drain into the celiac artery (CA). The gastric lesser curvature around the CA is a predilection site of LNM, especially the No. 3 LNs, which have a higher metastatic rate. The frequency of No. 3 LNM varied between 50.5 and 65.8 %, as reported [1, 3, 9]. In addition, the incidence of No. 3 LNM in early lower gastric cancer was up to 9.5 % [10]. No. 3 lymph node dissection is also part of D1 lymphadenectomy according to the 3rd edition of Japanese Gastric Cancer Treatment Guidelines [11]. Therefore, No. 3 LNs should be routinely excised during subtotal or total gastrectomy for early or advanced gastric cancer.

The rate of No. 2 LNM was 24.0–40.0 % in middle or upper gastric cancer, which was lower than No. 1 LNM. Moreover, the incidence of No. 2 LNM was even more reduced for lower third gastric cancer, at less than 1.0 % [3, 12]. Dissection of No. 2 LNs is included in D1 lymphadenectomy during subtotal or total gastrectomy for proximal gastric cancer, as based on the 3rd edition of Japanese Gastric Cancer Treatment Guidelines [11]. Thus, No. 2 LNs should be

C.-M. Huang, C.-H. Zheng (eds.), *Laparoscopic Gastrectomy for Gastric Cancer: Surgical Technique and Lymphadenectomy*, DOI 10.1007/978-94-017-9873-0_7,

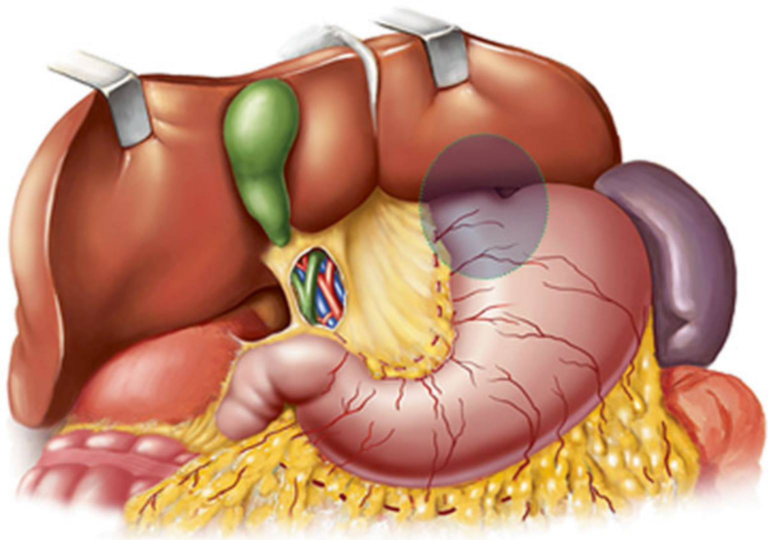

Fig. 7.1 Cardial area

routinely resected during proximal or total gastrectomy, while this dissection can be omitted when undergoing distal gastrectomy.

In conclusion, gastric cancer, especially middle or upper gastric cancer has a higher incidence of LNM in the cardial area. No. 1 LNs should be routinely removed for patients with gastric cancer except those with early lower gastric cancer. No. 3 LNs should be routinely excised during radical gastrectomy for gastric cancer. No. 2 LNs should be routinely resected during proximal or total gastrectomy, while this dissection can be omitted when undergoing distal gastrectomy.

7.2 Anatomy Associated with Lymph Node Dissection in the Cardial Area

7.2.1 Fascia and Intrafascial Space in the Cardial Area

7.2.1.1 Gastrophrenic Ligament (GPL)

The GPL is formed by the cranial part of the dorsal mesogastrium (DM) that extends upward to the diaphragm, and it is continuous with the upper portion of the gastrosplenic ligament (GSL) and the splenorenal ligament (SRL). It is a peritoneal fold between the gastric fundus (close to the cardia) and the left crus of the diaphragm. The fundic branch of the left inferior phrenic artery (LIPA) and the posterior gastric arteries (PGAs) run into the gastric fundus through the GPL (Figs. 7.2, 7.3 and 7.4).

7.2.1.2 Hepatogastric Ligament

The hepatogastric ligament (HGL) is derived from the primitive ventral mesogastrium, and it extends from the diaphragm and the fossa for the ductus venosus toward the lower left side up to the abdominal esophagus and the gastric lesser curvature (Figs. 7.5, 7.6, and 7.7). The HGL is continuous with the hepatoduodenal ligament (HDL). The HGL carries the right and left gastric vessels running along the gastric lesser curvature as well as the gastric, hepatic, and duodenal branches of the vagus nerve. Variant vessels, such as the left accessory hepatic and gastric arteries, are also included within the HGL.

7.2.2 Vascular Anatomy Associated with Lymph Node Dissection in the Cardial Area

7.2.2.1 Arteries Associated with Lymph Node Dissection in the Cardial Area

Terminal Branch of the LGA

After issuing from the CA, the LGA runs toward the upper left side until slightly below the lesser curvature of the cardia, where it enters the HGL. It

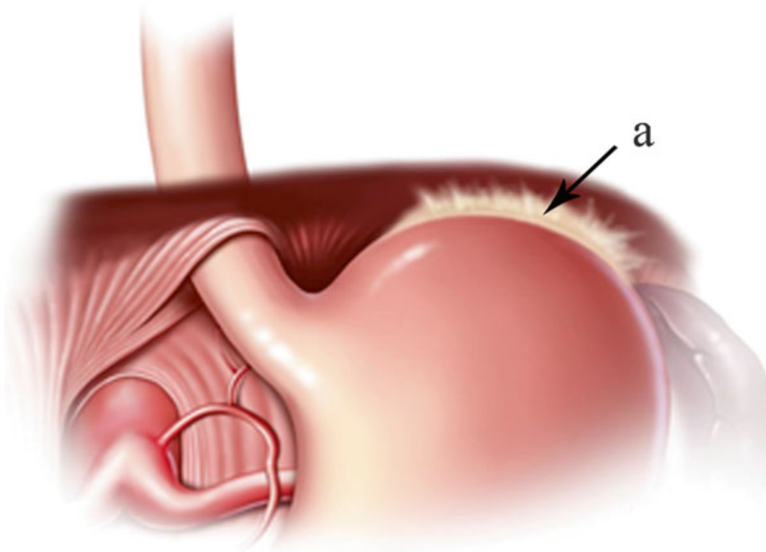

Fig. 7.2 The anterior aspect of the GSL (*a*)

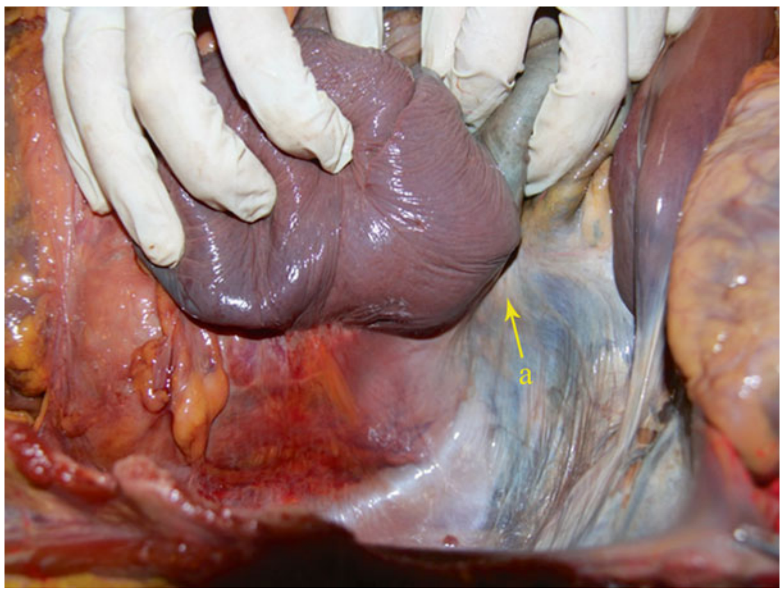

Fig. 7.3 GSL (*a*) (In autopsy)

gives off ascending branches near the gastric wall that join with the esophageal artery. It also branches into two descending gastric branches (anterior and posterior), which run downward and toward the right along the anterior and posterior sides of the gastric lesser curvature. It gives off four to six branches supplying both surfaces of the stomach along the way, and it joins with the right gastric artery (RGA) to form the arterial arch of the lesser curvature (Figs. 7.8, 7.9, 7.10, and 7.11).

Fundic Branch of the LIPA

The fundic branch of the LIPA is one of the terminal branches of the inferior phrenic artery (IPA), which arises from the abdominal aorta and passes upward to divide into the left and right inferior phrenic arteries. The left passes behind the cardial area and gives off a fundic branch near the gastric fundus, which runs through the GPL to supply the fundus (Figs. 7.12 and 7.13).

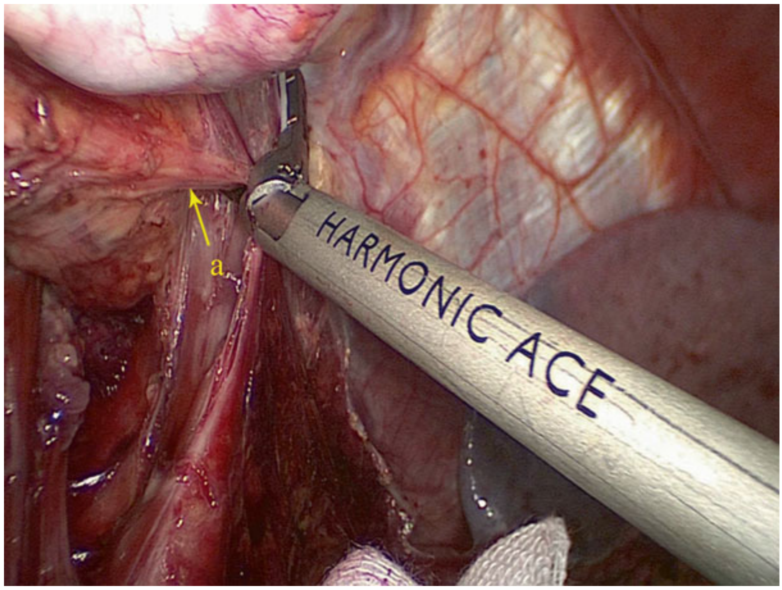

Fig. 7.4 GSL (*a*)

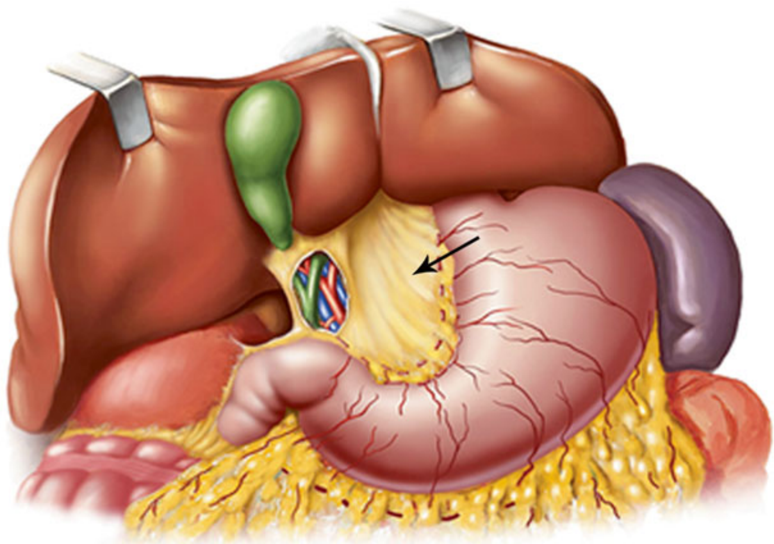

Fig. 7.5 The schematic figure of the HGL (the *arrow* represents the HGL)

7.2.2.2 Veins Associated with Lymph Node Dissection in the Cardial Area

The venous branches from the anterior and posterior walls of the gastric lesser curvature flow in the direction of the cardia within the lesser omentum and join together to form the coronary vein, which then drains into the splenic vein (SV) or the portal vein (PV). The venous branches from the greater curvature of the gastric fundus and cardia form the short gastric veins or the posterior gastric vein (PGV) to end in the SV. Some of the esophageal veins and part of the gastric submucosal venous plexus may join with the esophageal venous plexus to empty into the azygos vein, which communicates with the superior vena cava. This forms the portal-caval venous collateral circulation (Figs. 7.14 and 7.15).

Fig. 7.6 HGL (*a*) (In autopsy)

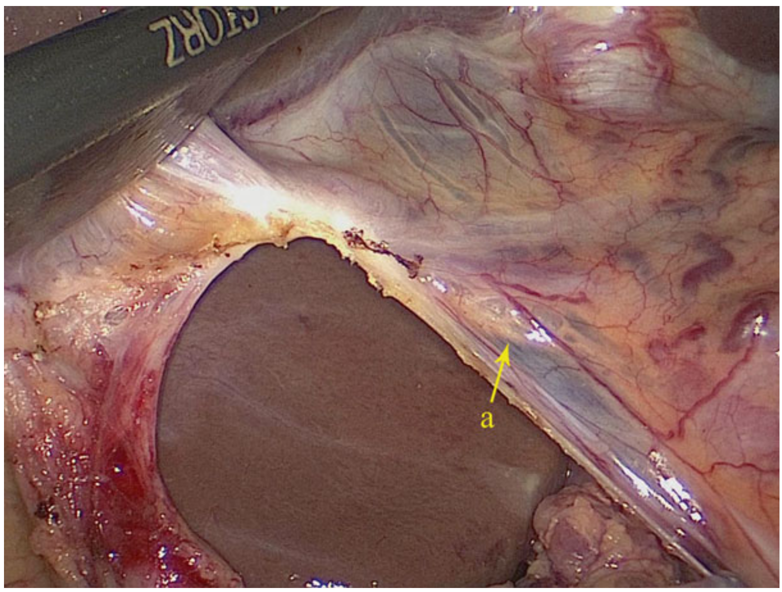

Fig. 7.7 HGL (*a*)

7.2.3 Lymph Node Anatomy of the Cardial Area

7.2.3.1 The No. 1 LNs (Right Paracardial LNs)

Definition of the No. 1 LNs

The No. 1 LNs are located at the right side of the cardia. They include the LNs lying above the first branch of the ascending LGA (cardial branch) that feeds the gastric walls and those located right at this vessel. This vessel separates the No. 1 LNs from the No. 3 LNs, which lie below it (Figs. 7.16 and 7.17).

Case of No. 1 LNM (Figs. 7.18 and 7.19)

7.2.3.2 The No. 2 LNs (Left Paracardial LNs)

Definition of the No. 2 LNs

The No. 2 LNs are located along the fundic branch of the LIPA and are located at the anterior

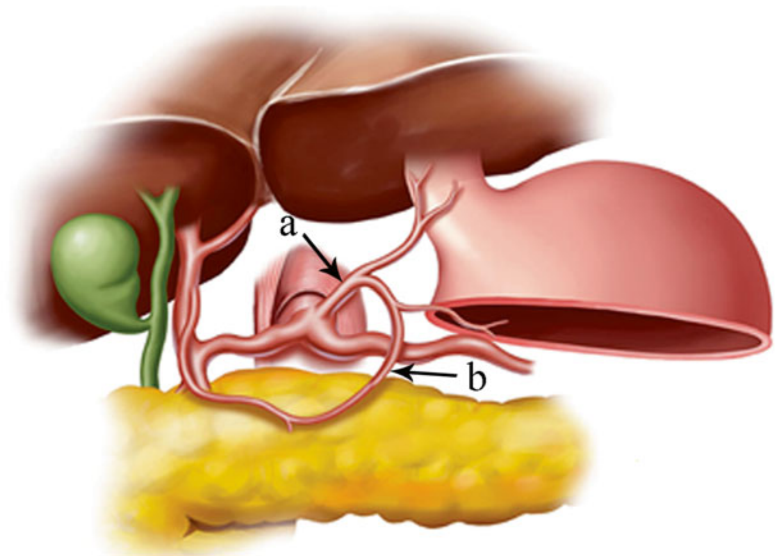

Fig. 7.8 Distribution of the terminal branch of the LGA. The LGA (*a*). Arterial arch of the lesser curvature (*b*)

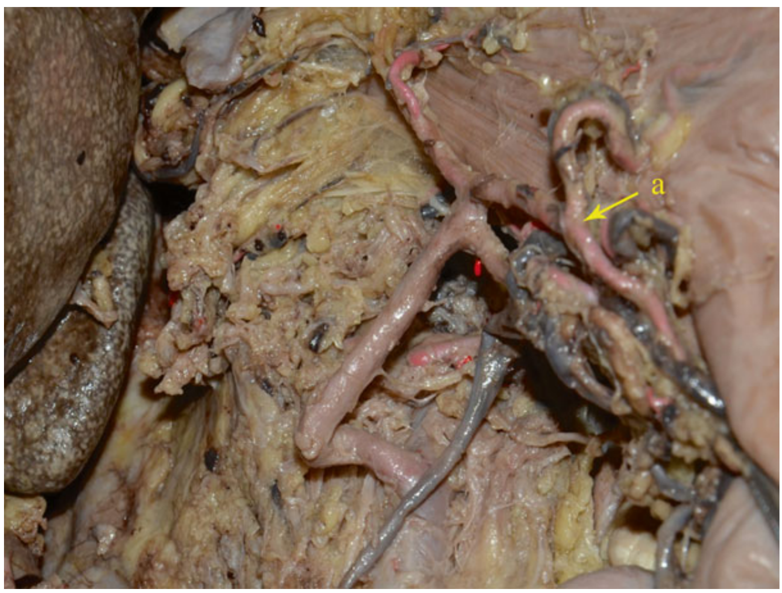

Fig. 7.9 Distribution of the terminal branch of the LGA (*a*) (In autopsy)

and posterior sides of the gastric fundus to the left of the cardia. The No. 1 LNs are separated from the No. 2 LNs by the esophageal axis (Figs. 7.20 and 7.21).

Case of No. 2 LNM (Figs. 7.22, 7.23, and 7.24)

7.2.3.3 The No. 3 LNs (LNs along the Gastric Lesser Curvature)

Definition of the No. 3 LNs

The No. 3 LNs are included in the two layers of the lesser omentum along the gastric lesser curvature, and they are distributed along the courses of the left and right gastric arteries.

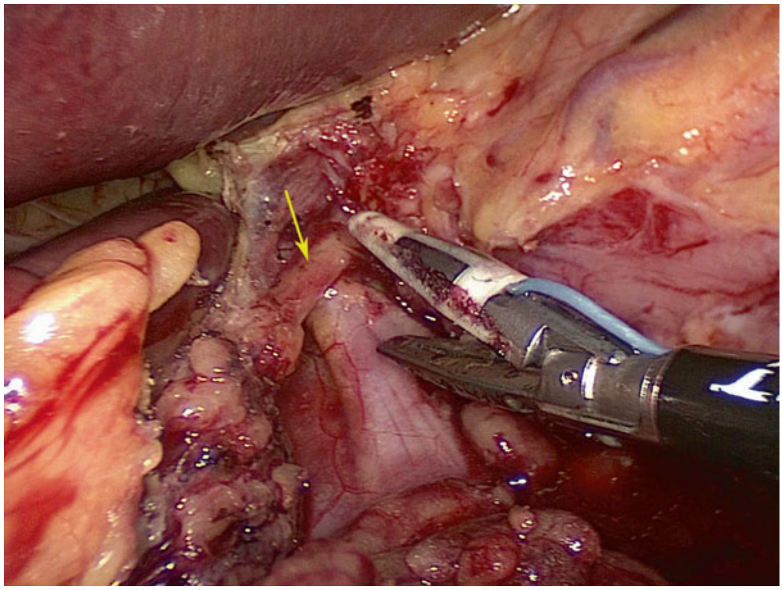

Fig. 7.10 The LGA gives off the ascending branches (the *arrow* represents the ascending branches)

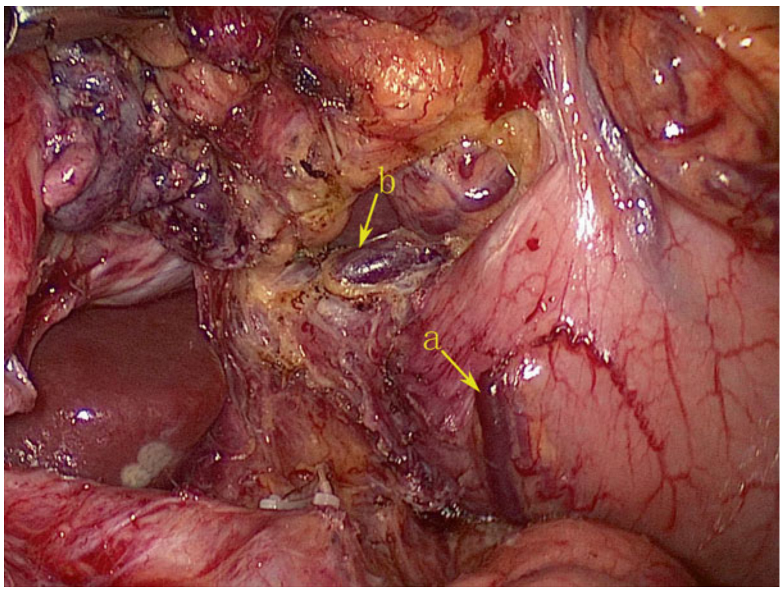

Fig. 7.11 The LGA sends the anterior (*a*) and posterior (*b*) gastric branches

The first branch of the ascending LGA that feeds the gastric walls forms the upper border (the LNs located right at the vessel are not included), and the lower border is the left side of the first branch of the RGA feeding the gastric lesser curvature (LNs located at the root of the vessel are classified as No. 5 LNs) (Figs. 7.25 and 7.26).

Case of No. 3 LNM (Figs. 7.27 and 7.28)

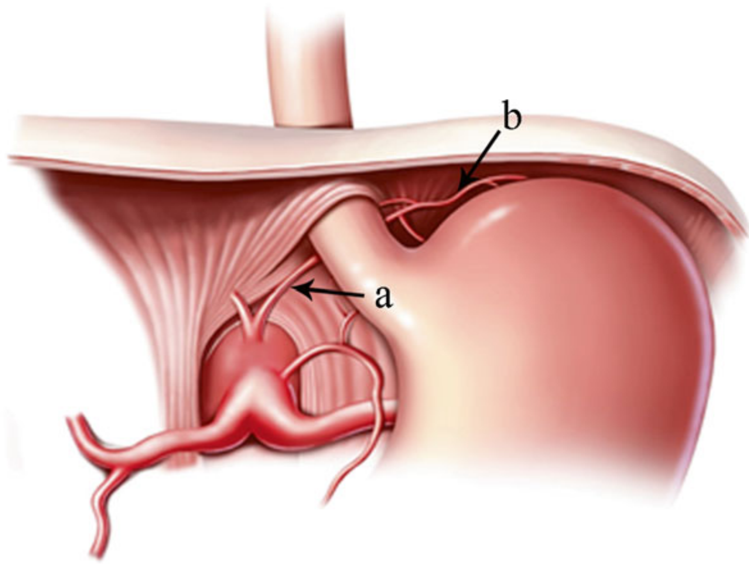

Fig. 7.12 The LIPA (*a*) gives off the fundic branch (*b*) to supply the fundus

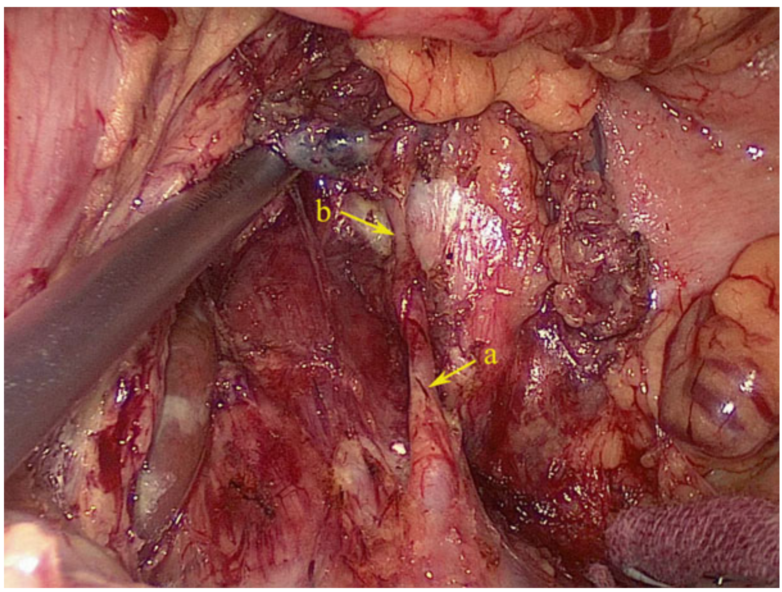

Fig. 7.13 The LIPA (*a*) gives off the fundic branch (*b*) to supply the fundus

7.3 Procedures for Lymph Node Dissection in the Cardial Area

7.3.1 Baring of the Gastric Lesser Curvature and Dissection of the No. 1 and No. 3 LNs

7.3.1.1 Operative Approach

We use a retro-gastric approach to excise the No. 1 and No. 3 LNs, taking the avascular area at the posterior wall of the gastric lesser curvature as the starting point (Fig. 7.29). The gastric anterior wall and the HGL can be used to ward off the liver to facilitate the exposure of the posterior wall of the gastric lesser curvature. Additionally, because the cutting direction of the ultrasonic scalpel is parallel with the gastric lesser curvature, division of the HGL along the gastric lesser curvature is facilitated. Furthermore, the approach makes it convenient for the surgeon to completely clip and divide the vessels of the gastric lesser curvature with the ultrasonic scalpel to avoid causing vascular bleeding.

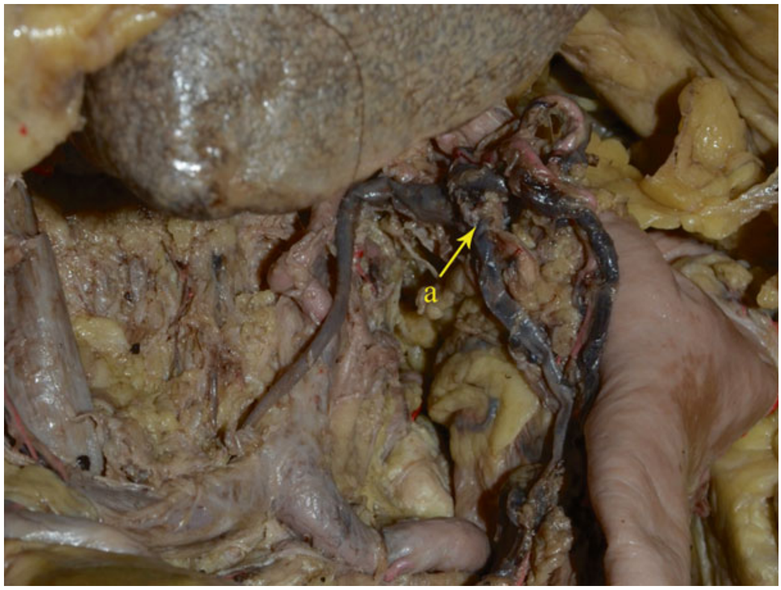

Fig. 7.14 The venous branches from the anterior and posterior walls of the gastric lesser curvature and join together to form the coronary vein (*a*) (In autopsy)

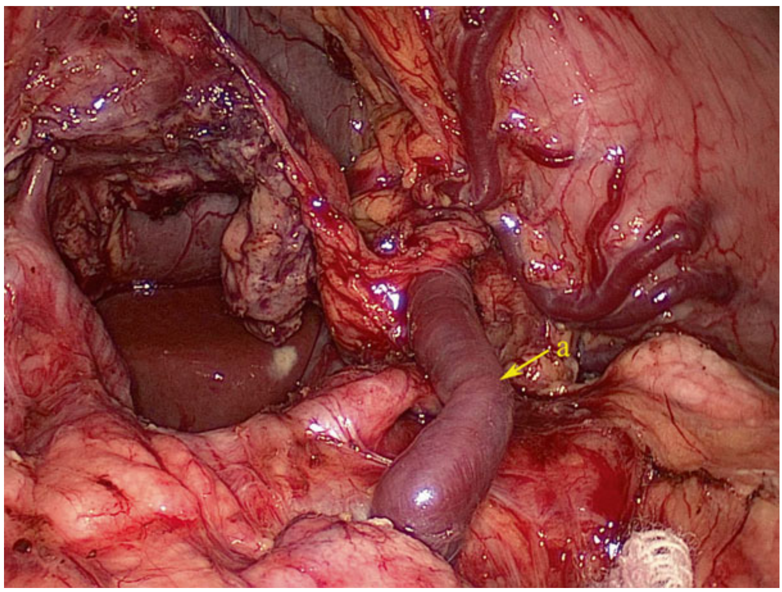

Fig. 7.15 The venous branches from the anterior and posterior walls of the gastric lesser curvature and join together to form the coronary vein (*a*)

7.3.1.2 Exposure Methods

The assistant turns the greater curvature of the gastric body over to the cephalic side. He or she then clamps the gastropancreatic fold (GPF) at the lesser curvature using a left-hand grasper and uses a right-hand grasper to clamp the lesser omentum at the posterior wall of the upper gastric lesser curvature to unfold it on both sides. The surgeon clamps the posterior wall of the gastric body to pull it down and create triangle traction, which keeps tension on the HGL at the upper gastric lesser curvature and the posterior wall of the gastric body (Fig. 7.30). This provides a better operating field and tension.

7.3.1.3 Operative Procedures

The posterior lobe of the HGL is opened by using the ultrasonic scalpel in the avascular area at the posterior wall of the gastric lesser curvature (Fig. 7.31). Then, the posterior lobe of the HGL and the vessels of the posterior gastric wall are separated and divided against the gastric wall (Fig. 7.32). The dissection is continued along the gastric wall in the direction of the anterior lobe of

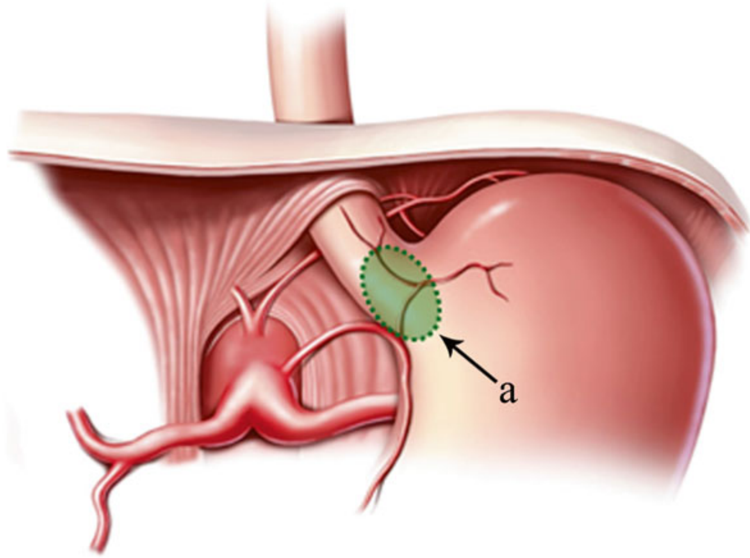

Fig. 7.16 The scope of the No. 1 LNs (*a*)

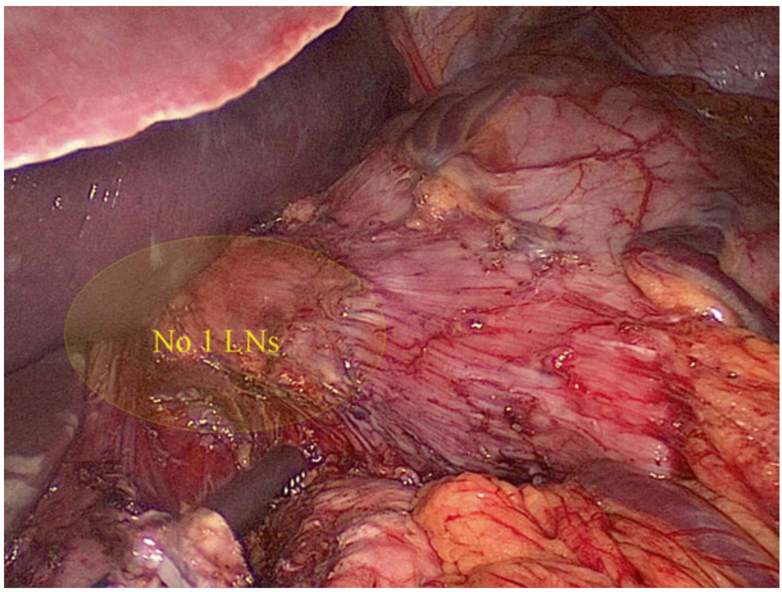

Fig. 7.17 The scope of the No. 1 LNs

the HGL (Fig. 7.33). The anterior lobe of the HGL and the vessels of the anterior gastric wall are then transected (Fig. 7.34). The dissection proceeds upward until the cardia is reached (Fig. 7.35) and downward until the gastric angle is reached (Fig. 7.36). Thus, the gastric lesser curvature is fully bared and dissection of the No. 3 LNs is accomplished (Fig. 7.37).

Next, the assistant turns the stomach back to the normal position and inserts a left-handed grasper along the inferior edge of the liver until reaching the right diaphragm, lifting up the left lateral external lobe of the liver. The surgeon's left hand presses down on the angle of the stomach to tense the HGL and expose the anterior lobe of the HDL from the front (Fig. 7.38). The

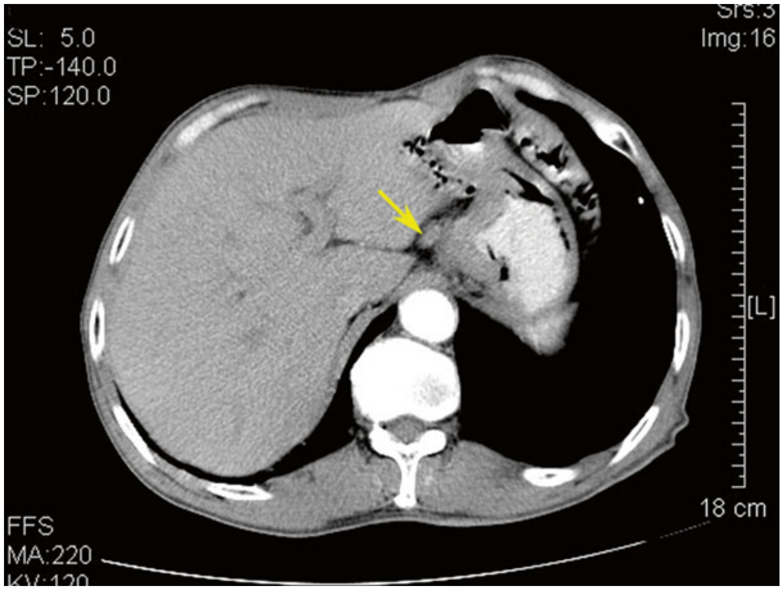

Fig. 7.18 CT scan showing No. 1 LNM (the *arrow* represents the swollen No. 1 LNs)

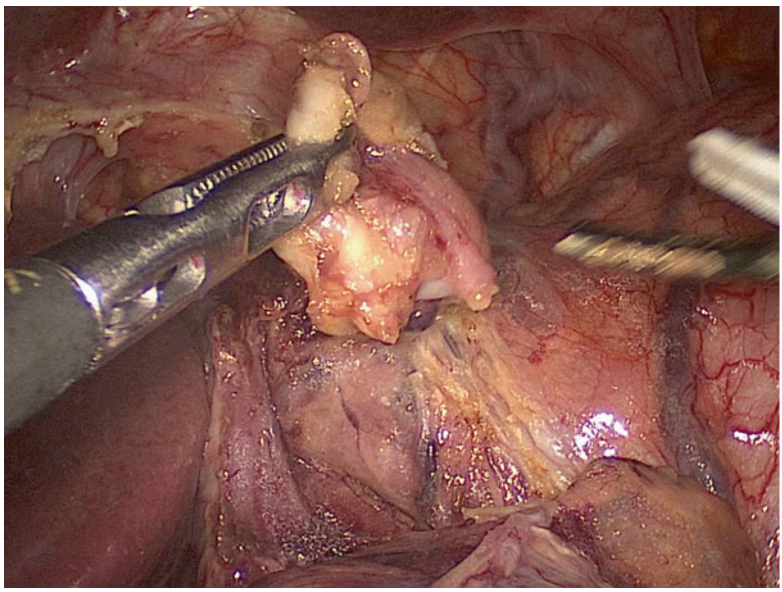

Fig. 7.19 The intraoperative view of No. 1 LNM

ultrasonic scalpel is then used to dissect upward via the window created in the anterior lobe of the right side of the HDL until the hepatic hilum is reached. Subsequently, the HGL is transected along the inferior edge of the liver in the direction of the cardia until the cardia is reached (Figs. 7.39 and 7.40). The No. 1 and No. 3 LNs are then removed (Fig. 7.41).

7.3.2 Baring of the Left Side of the Esophagus and Dissection of the No. 2 LNs

After the No. 4sa and No. 10 LNs are excised, the assistant places the free omentum and the GSL in the right lower quadrant of the abdo-

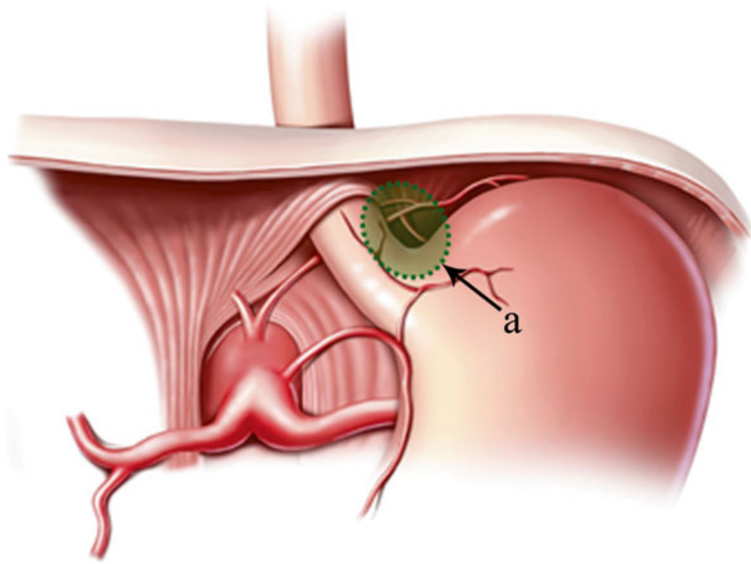

Fig. 7.20 The scope of No. 2 LNs (*a*)

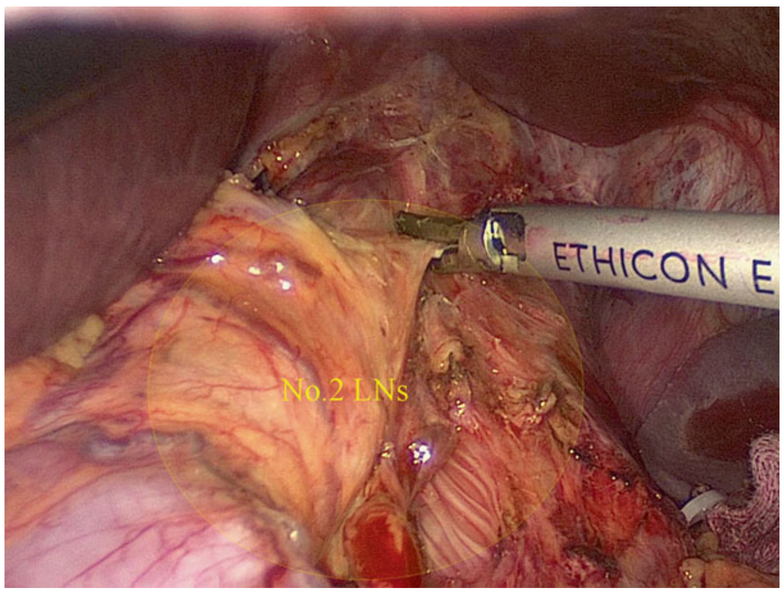

Fig. 7.21 The scope of No. 2 LNs

men and pulls the wall of the gastric fundus and body toward the lower right side to expose the left aspect of the cardia (Fig. 7.42). Using the ultrasonic scalpel, the GPL is dissected along the diaphragm from the superior pole of the spleen in the direction of the esophageal hiatus. Upon nearing the left diaphragmatic crus, the assistant should pull the wall of the gastric fundus and cardia toward the upper right side to facilitate the exposure of the crus. Meanwhile, the surgeon uses the ultrasonic scalpel against the left diaphragmatic crus to isolate the fatty lymphoid tissue on the left side of the esophagus and cardia (Fig. 7.43), further baring the lower part of the left side of the esophagus (Fig. 7.44). At this point, careful attention should be paid to the fundic branch of the LIPA, which supplies the gastric fundus. It should be isolated and divided at its origin (Figs. 7.45 and 7.46). Thus, dissection of the No. 2 LNs is fully accomplished (Fig. 7.47).

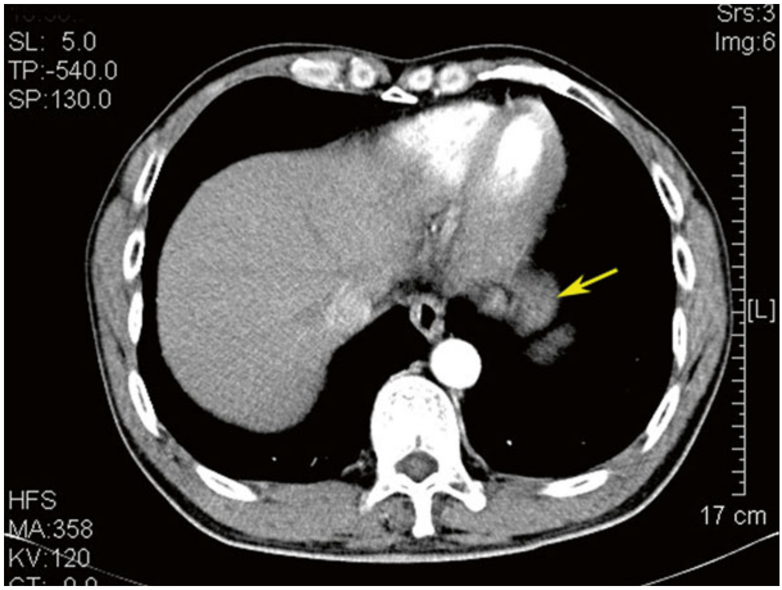

Fig. 7.22 CT scan image of No. 2 LNM (the *arrow* represents the swollen No. 2 LNs)

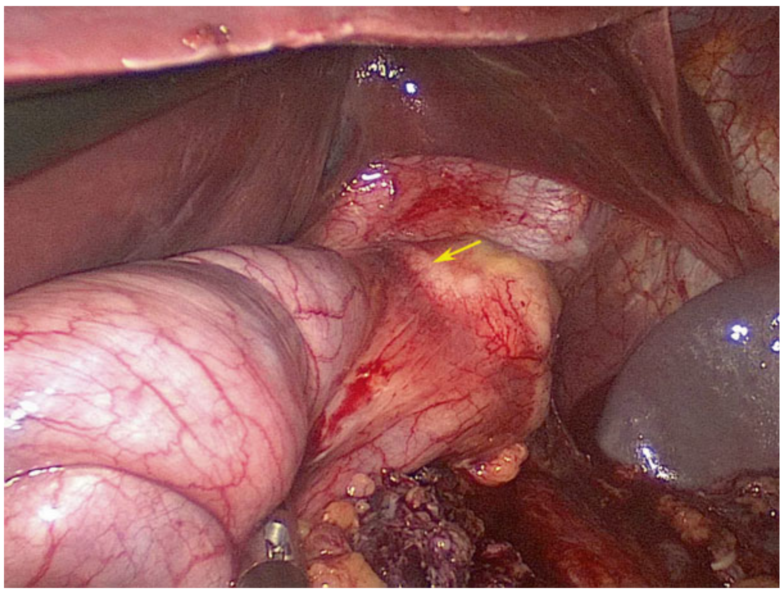

Fig. 7.23 The intraoperative view of No. 2 LNM (the *arrow* represents the swollen No. 2 LNs)

7.4 Common Situations Encountered and Surgical Techniques Utilized During the Dissection of the Cardial Region

7.4.1 Surgical Techniques Involved in Division

During the process of laparoscopy-assisted distal gastrectomy with D2 lymph node dissection, we utilize an approach in which the No. 1 and No. 3 LNs are excised from the lesser curvature and posterior wall of stomach. Dissection of this region should be performed right after retrieval of the No. 7, 8, and 9 LNs in the suprapancreatic region, because it can better keep the surgery perform fluently without having to change the grasping site by the assistant. Moreover, the assistant should grasp the lesser omentum with the right hand, while the surgeon simultaneously pulls the posterior wall of the gastric body toward the lower left with the grasping forceps in the left hand, creating a triangle

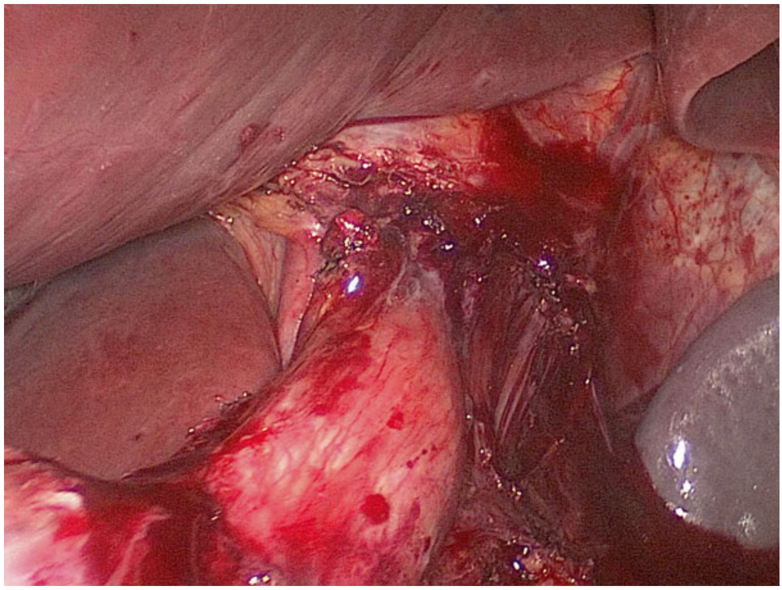

Fig. 7.24 No. 2 LNM (appearance after the dissection)

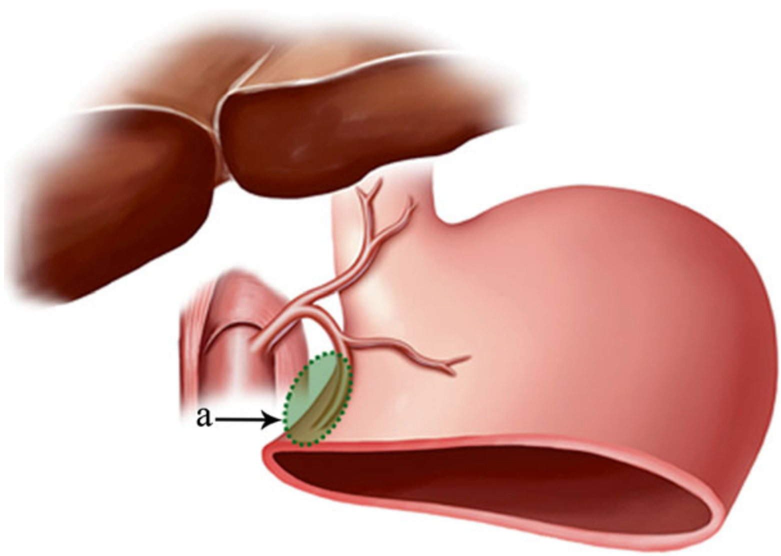

Fig. 7.25 The scope of No. 3 LNs (*a*)

traction together with the assistant. Dissection should be carried out from the posterior wall to the anterior wall and from the lesser curvature side to the cardial side with ultrasonic scalpel in the surgeon's right hand. The orientation of dissection should be consistent with that of the ultrasonic scalpel, which is not only beneficial to dissect LNs along the lesser curvature and enter the right anatomical plane for surgeon but also enables complete occlusion and severing of the vessels around the lesser curvature. When division continues to the cardia, the surgeon should clearly identify the esophageal tissues and avoid excessive dissection that may injure the esophagus. Meanwhile, the camera operator should adjust the orientation of the lens from the lower right toward the upper left and keep the pancreas in the horizontal position as a baseline. The stomach should be rotated to the

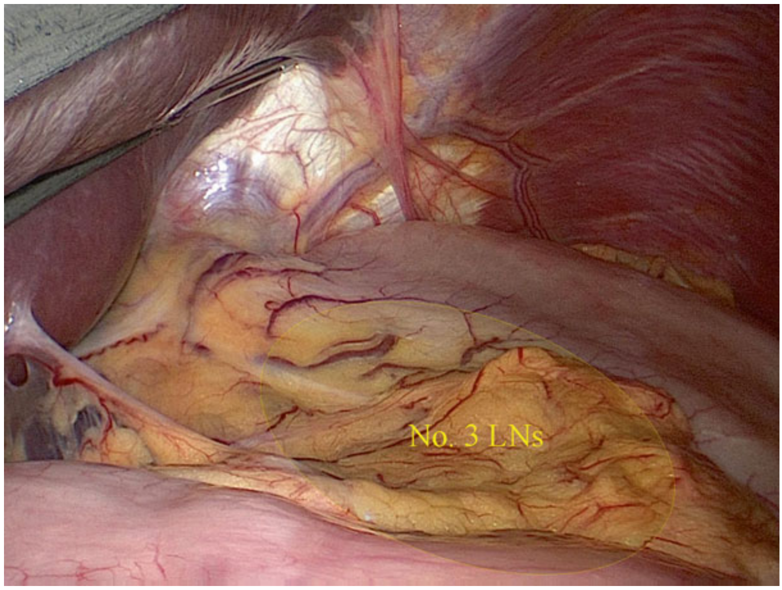

Fig. 7.26 The scope of No. 3 LNs

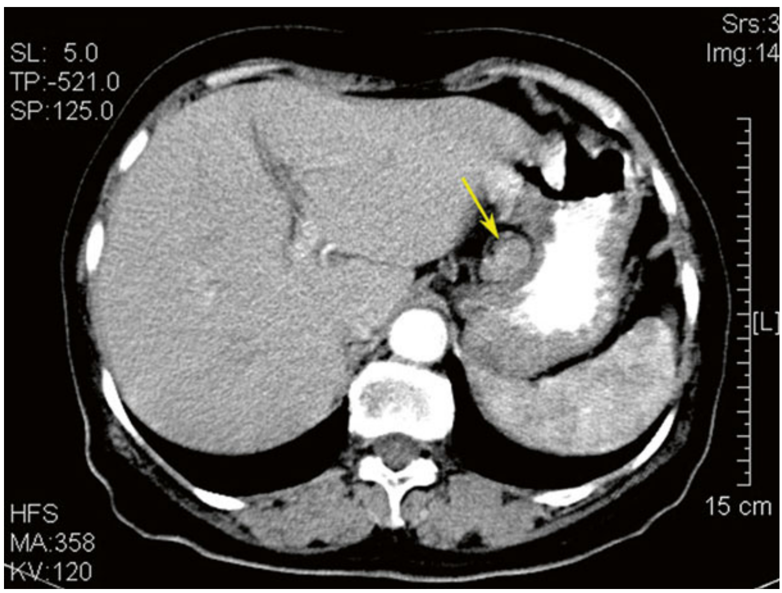

Fig. 7.27 CT scan showing No. 3 LNM (the *arrow* represents the swollen No. 3 LNs)

normal position after the lesser curvature of the stomach is sufficiently denuded. After accomplishing dissection of the suprapancreatic LNs, the HGL should be eventually divided along the inferior margin of the liver and the right side of the cardia from the anterior wall of the lesser omentum.

The No. 2 LNs are resected after retrieval of the splenic hilar LNs during the total gastrectomy. The patient is still tilted with the left side up and subjected to a head-up tilt, resulting in the dissociated gastric body being pulled toward the right lower abdomen. The left side of the cardial area can thus be sufficiently exposed. Next, the surgeon separates the GPL along the left crus of the diaphragm until completely mobilizing the left side of the esophagus and cardia.

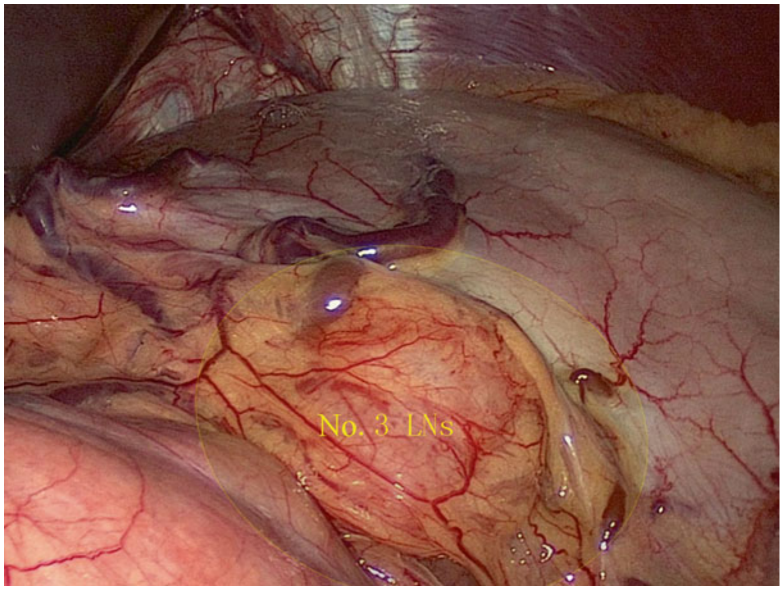

Fig. 7.28 The intraoperative view of No. 3 LNM

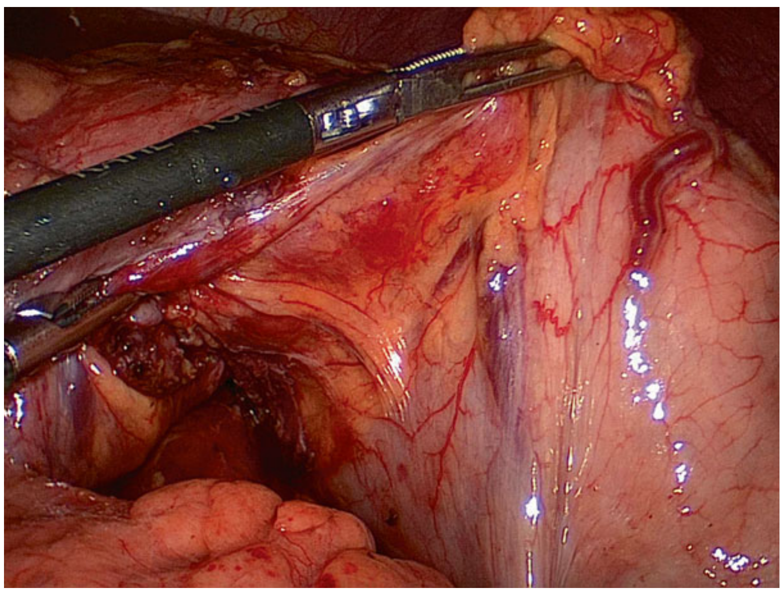

Fig. 7.29 A retro-gastric approach to excise the No. 1 and the No. 3 LNs

7.4.2 Prevention of Damage to Adjacent Tissues and Organs

Dissection of the cardial region is performed in a narrow space below the xiphoid; thus, sufficient exposure by the assistant will be beneficial for reduction of injury to this area. When dividing the anterior wall of the lesser omentum, the assistant can expose the operating view by using the grasping forceps in the left hand to push the left lateral lobe of liver upward (Fig. 7.48). Then the assistant should take an aspirator or gastric forceps in the right hand, assisting the surgeon in separating the tissues and denuding the esophagus. During the procedure of denuding, the trunk of the vagus

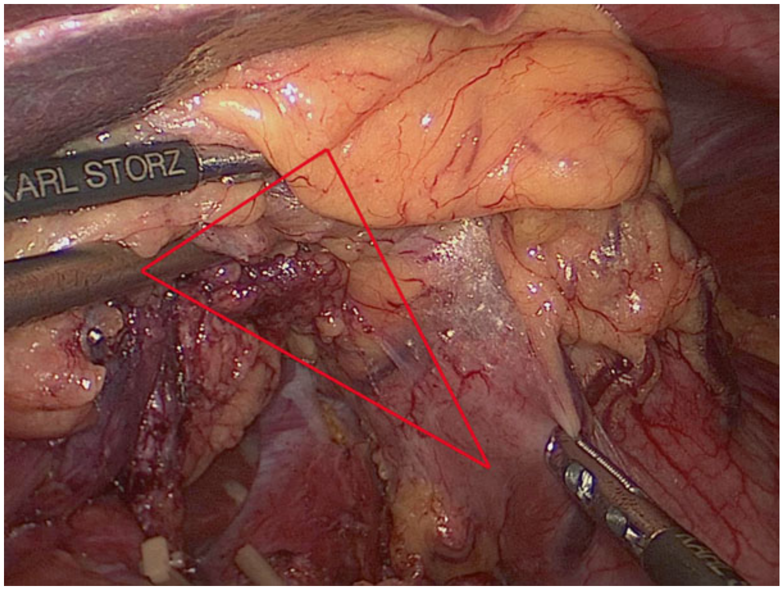

Fig. 7.30 *Triangle* traction keeps tension on the posterior wall of the gastric body

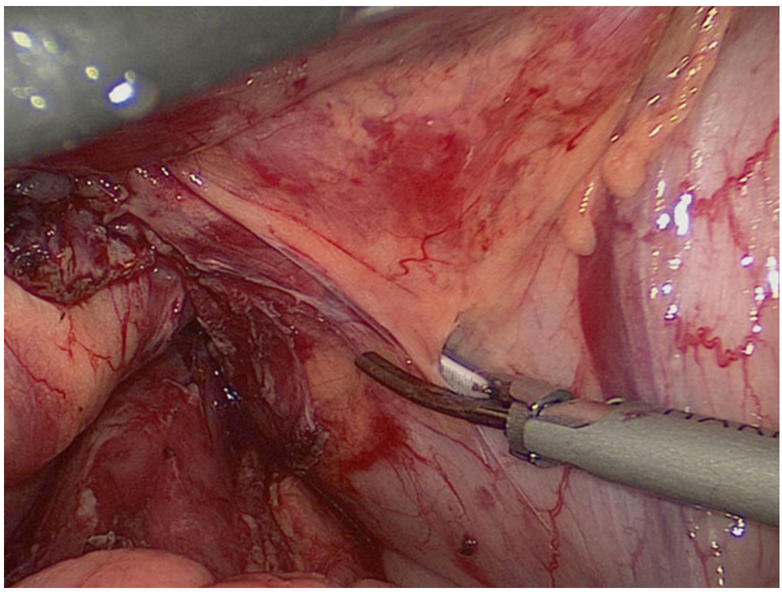

Fig. 7.31 The posterior lobe of the HGL is opened in the avascular area at the posterior wall of the gastric lesser curvature

nerve should be severed first (the left trunk is normally located along the anterior wall, the right one at the posterior), and the fascia between the esophagus and esophageal hiatus can then be divided. Such manipulation results in lengthening of the mobilized esophagus in the abdomen up to 6 cm (Figs. 7.49 and 7.50). The vagus nerve commonly manifests as a white bright line, strong in texture but with poor elasticity. The assistant should separate the vagus nerve along the vertical axis of the abdominal portion of esophagus with an aspirator or gastric forcep and pick apart the free vagus nerves from the esophagus, this manipulation enable easier severing of the vagus nerves (Fig. 7.51). The nonfunctional face of the ultrasonic scalpel should be placed closest to the

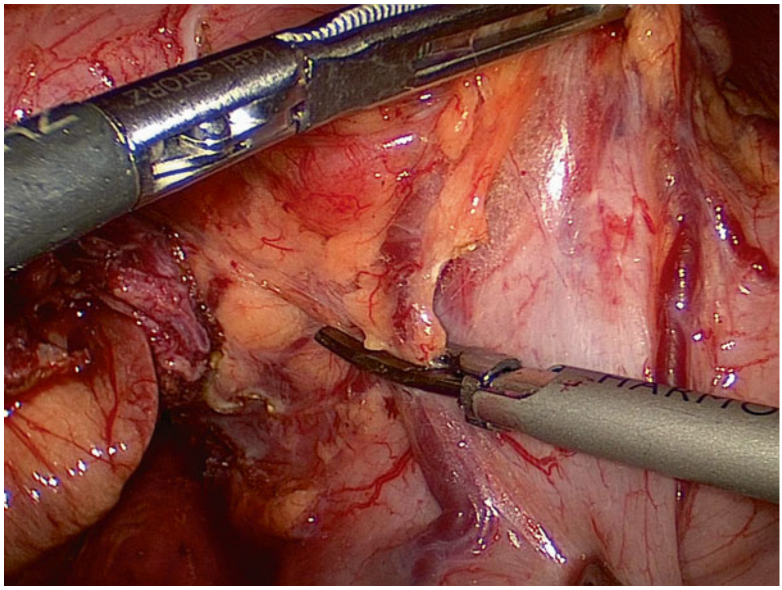

Fig. 7.32 The posterior lobe of the HGL and the vessels of the gastric posterior wall are divided to denude the posterior wall of the gastric lesser curvature

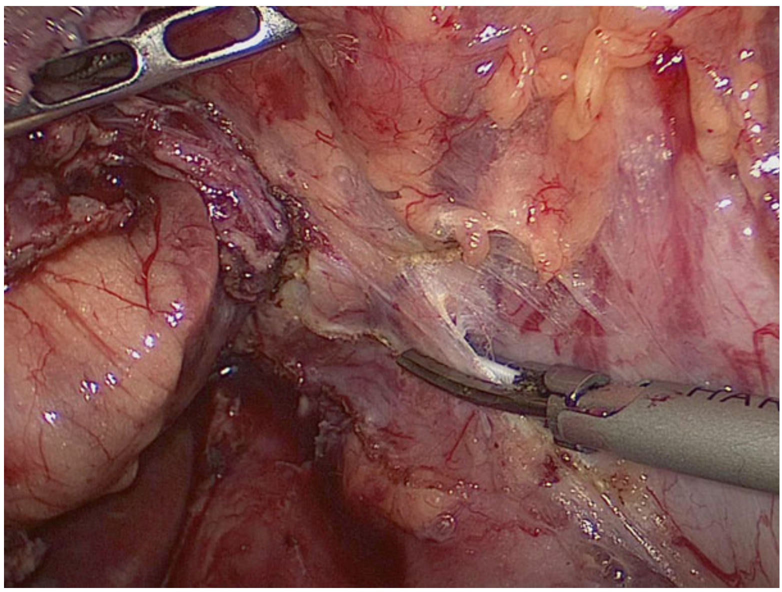

Fig. 7.33 The anterior lobe of the HGL is opened in the avascular area at the posterior wall of the gastric lesser curvature

esophagus when denuding at the esophageal hiatus to avoid accidental injury to the esophagus and mediastinal pleura (Fig. 7.52).

7.4.3 Prevention of Vascular Injury

Because of the sufficient blood supply in the lesser curvature of the stomach, resection of No. 1 and 3 LNs should be carefully performed to avoid hemorrhage. The omentum along the lesser curvature can be regarded as three layers, including the anterior layer, middle layer, and posterior layer, according to the distribution of the terminal LGA in the gastric wall. Thus, the surgeon should first open the posterior layer at the avascular region and continue to separate this layer and its vessels when performing the dissection. Then the

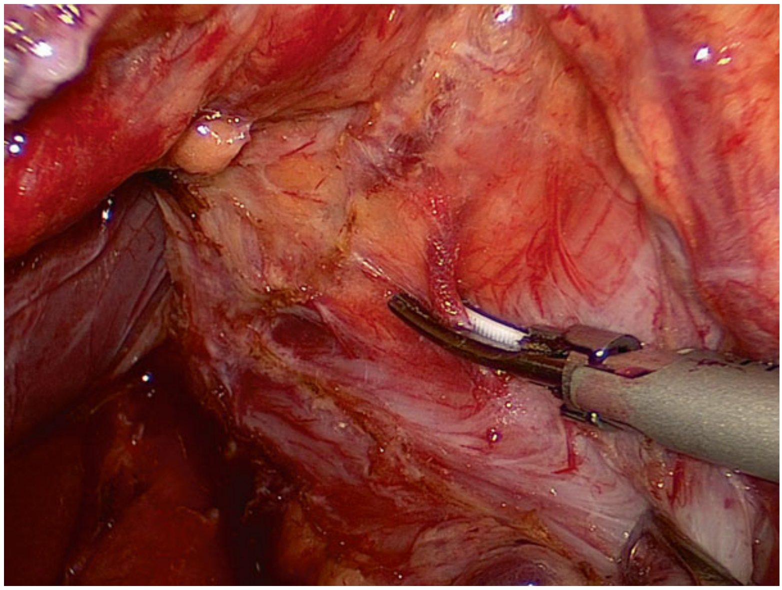

Fig. 7.34 The anterior lobe of the HGL and the vessels of the gastric anterior wall are divided to denude the anterior wall of the gastric lesser curvature

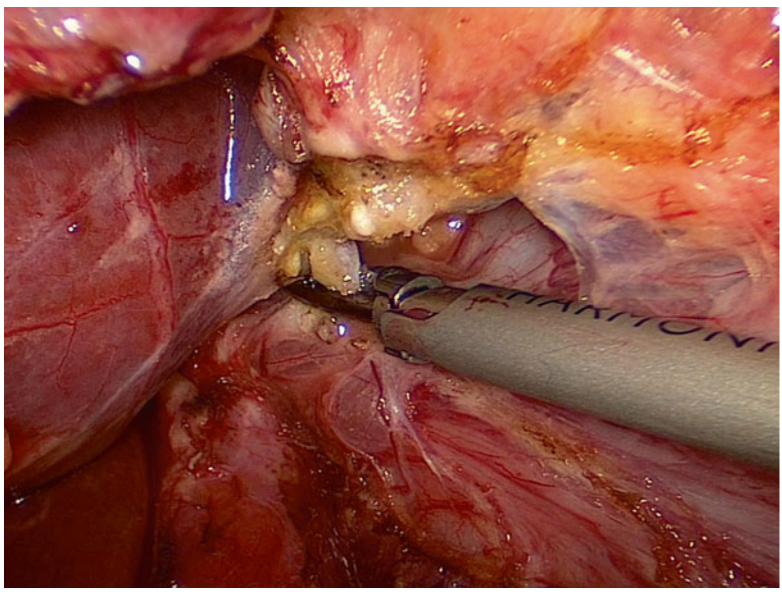

Fig. 7.35 The dissection proceeds upward along the gastric lesser curvature until the cardia is reached

middle and anterior layers are dissected sequentially (Figs. 7.53 and 7.54). The vessels that are distributed along the lesser curvature should be occluded completely with the head of the ultrasonic scalpel. Additionally, the vessel can be severed with minimum speed as necessary.

During the process of dissecting the HGL, the presence and running course of the ALHA or the ALGA should be taken into consideration (the relevant techniques and anatomical course are explained in Chap. 5). Occasionally, the LGA gives off branches to supply the diaphragm. These should be cut off to avoid causing hemorrhage when the lesser curvature is denuded (Fig. 7.55).

When dividing in this region, the presence of the LIPA and its branch, which supplies the gastric fundus, should be taken into consideration, especially for the artery originated from the

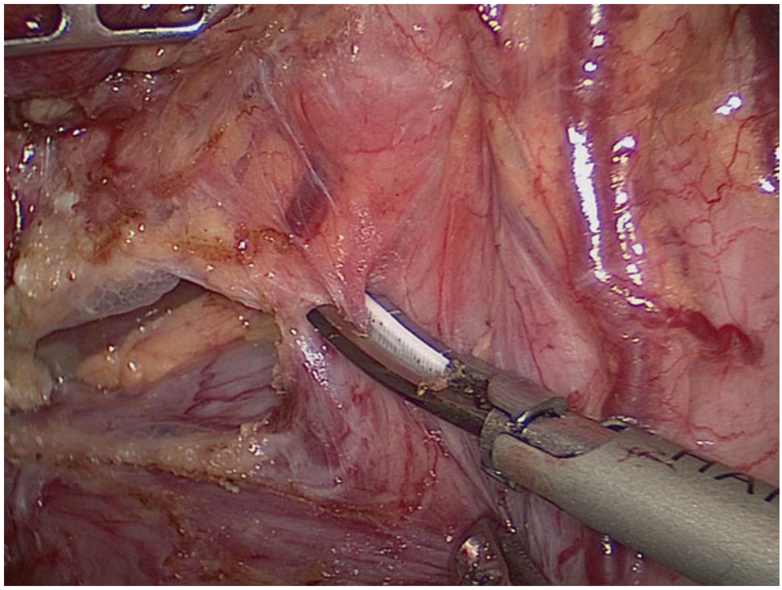

Fig. 7.36 The dissection proceeds downward along the gastric lesser curvature until the gastric angle is reached

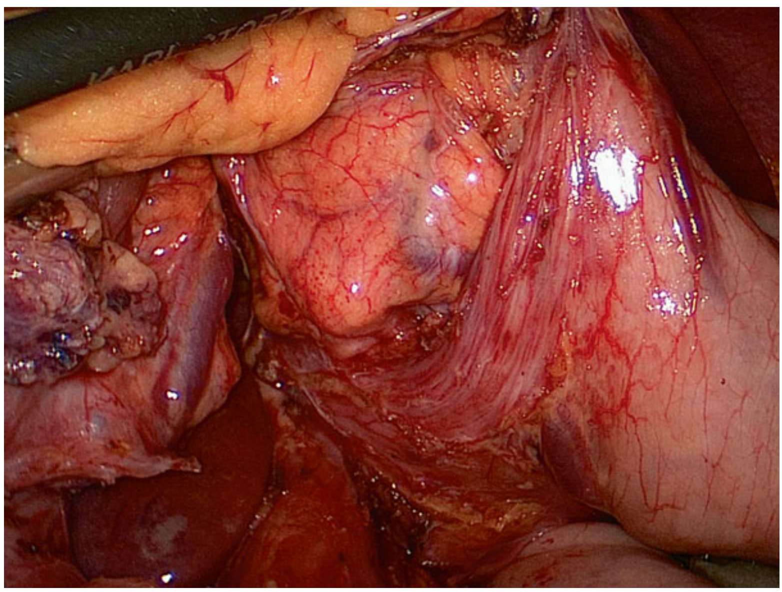

Fig. 7.37 The gastric lesser curvature is fully bared, and dissection of the No. 3 LNs is accomplished

celiac trunk because it may be susceptible to injury due to its superficial location (Fig. 7.56). Moreover, the fundic branch should be severed at its root after arising from the LIPA, while the LIPA should be protected to avoid accidental injury (Fig. 7.57).

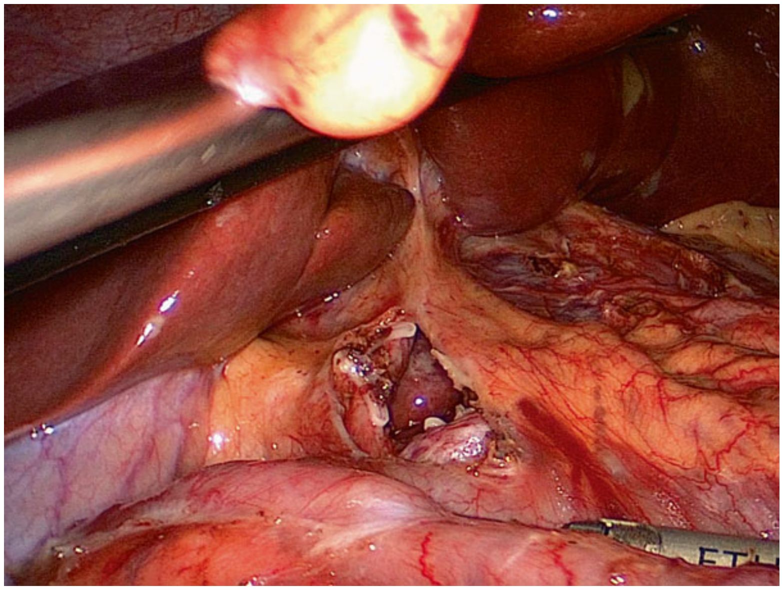

Fig. 7.38 The assistant lifts up the left lobe of liver to expose the HDL from the front

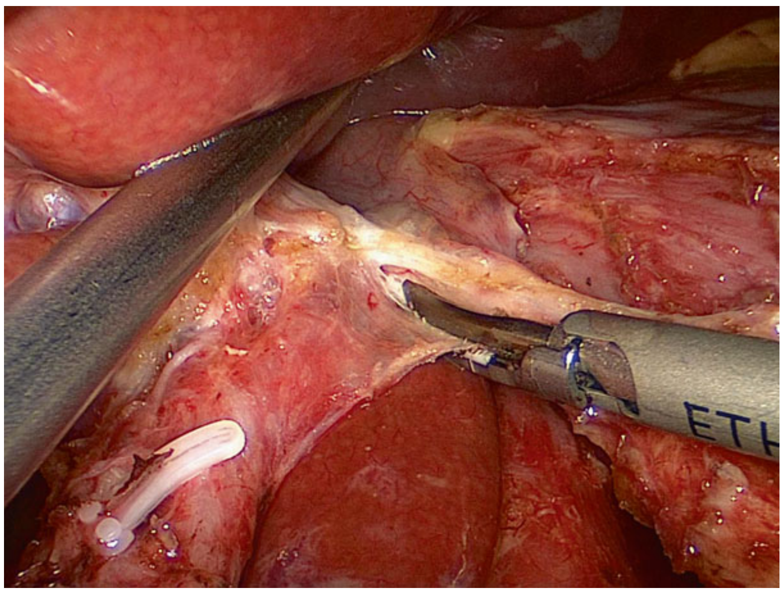

Fig. 7.39 The HGL is transected along the inferior edge of the liver

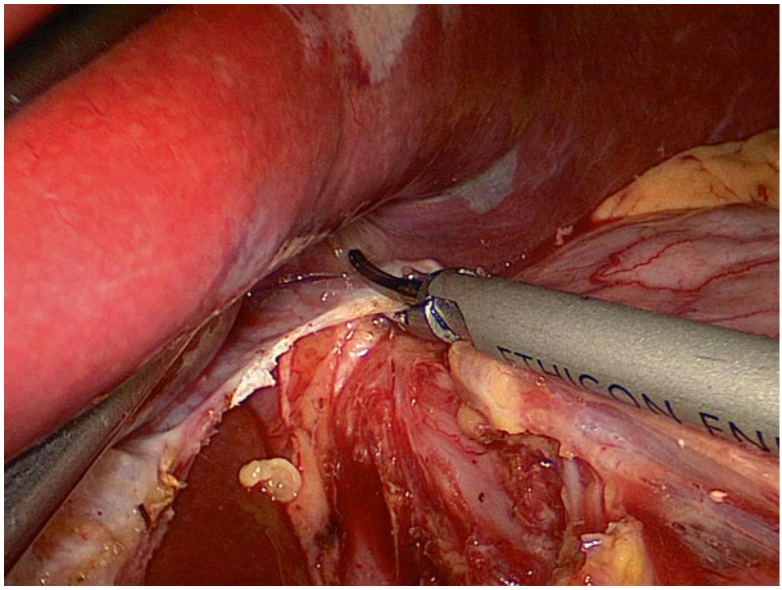

Fig. 7.40 The HGL is transected along the inferior edge of the liver until the cardia is reached

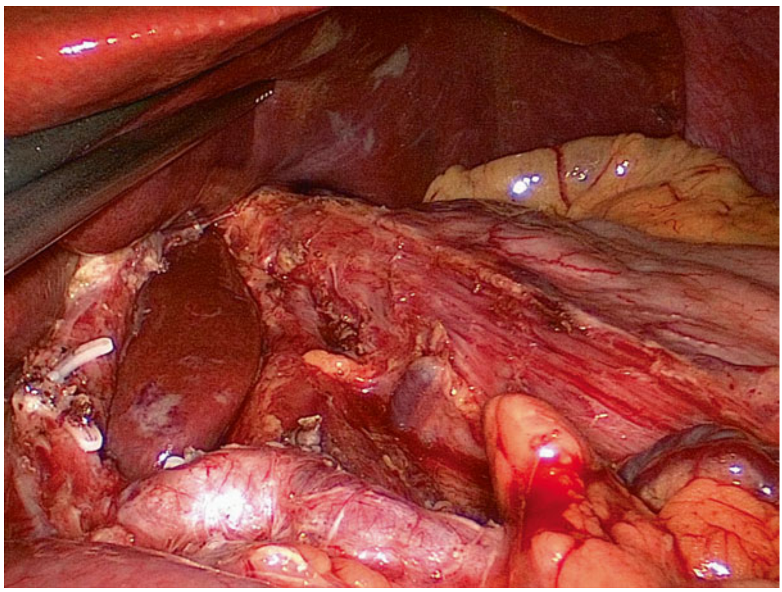

Fig. 7.41 The No. 1 and No. 3 LNs are removed

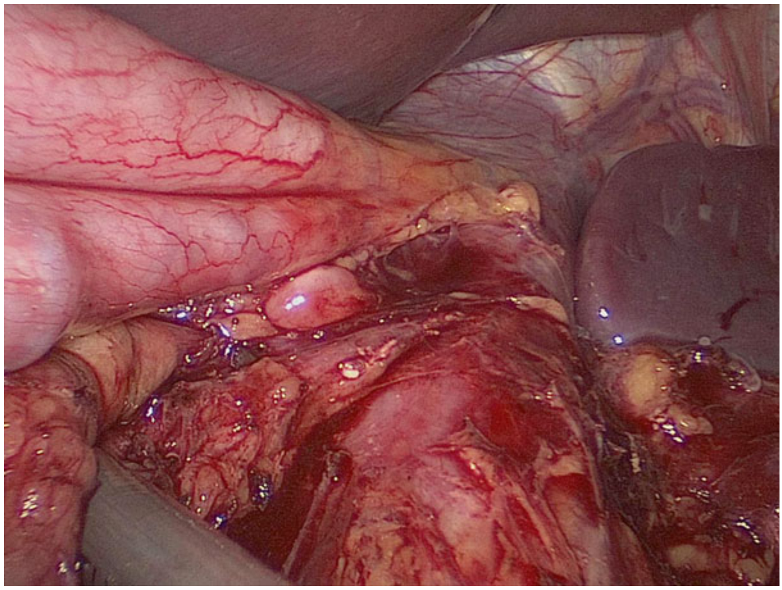

Fig. 7.42 The left aspect of the cardia is exposed

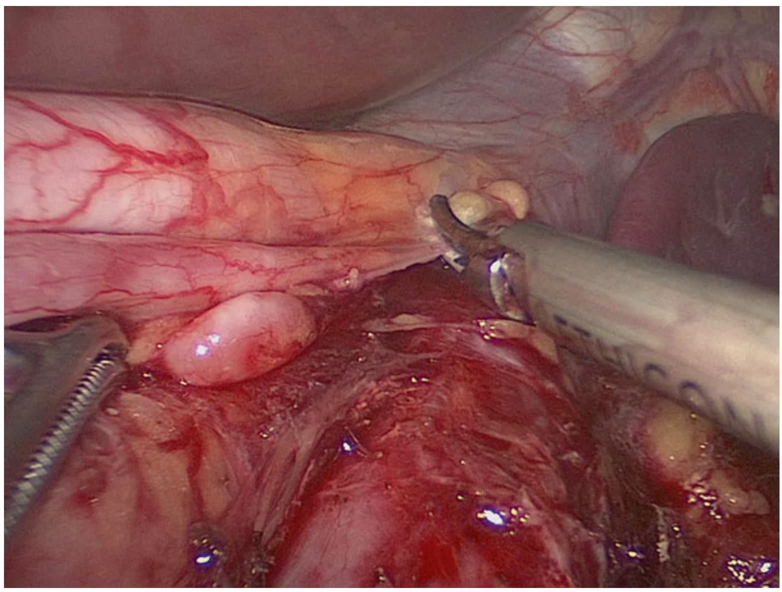

Fig. 7.43 The left side of the GPL is transected along the left diaphragmatic crus to dissect the No. 2 LNs

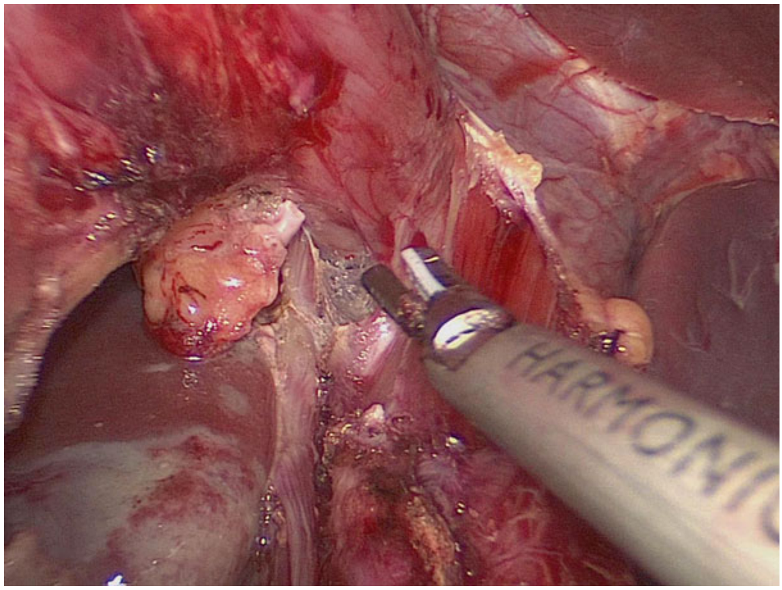

Fig. 7.44 Baring of the lower part of the esophagus' left side

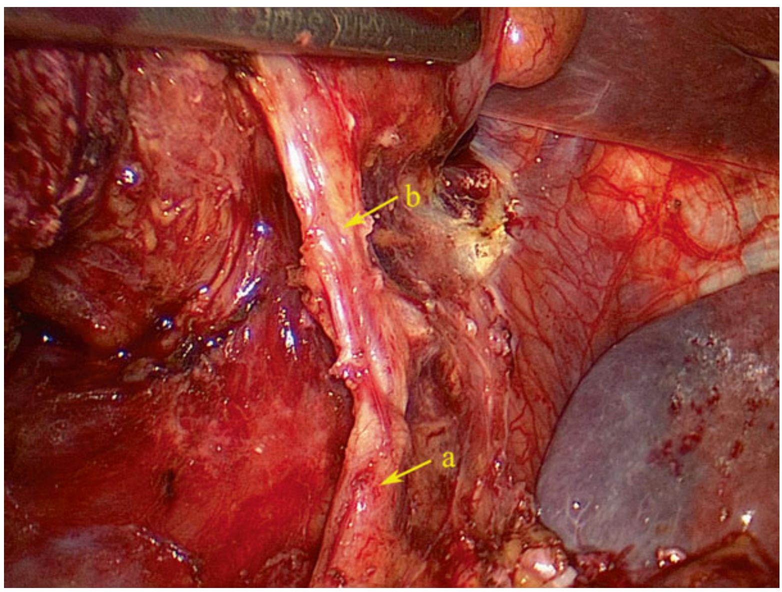

Fig. 7.45 The LIPA (*a*) and its fundic branch (*b*) are isolated

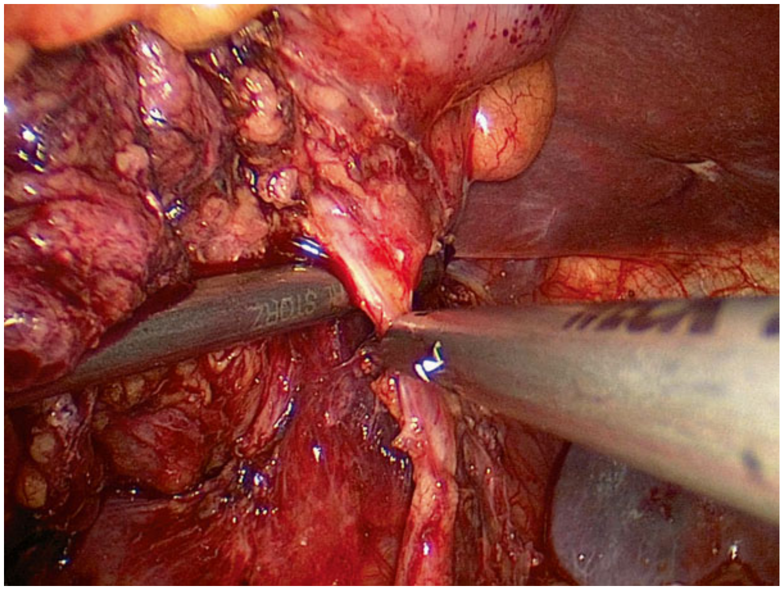

Fig. 7.46 The division of the fundic branch of the LIPA

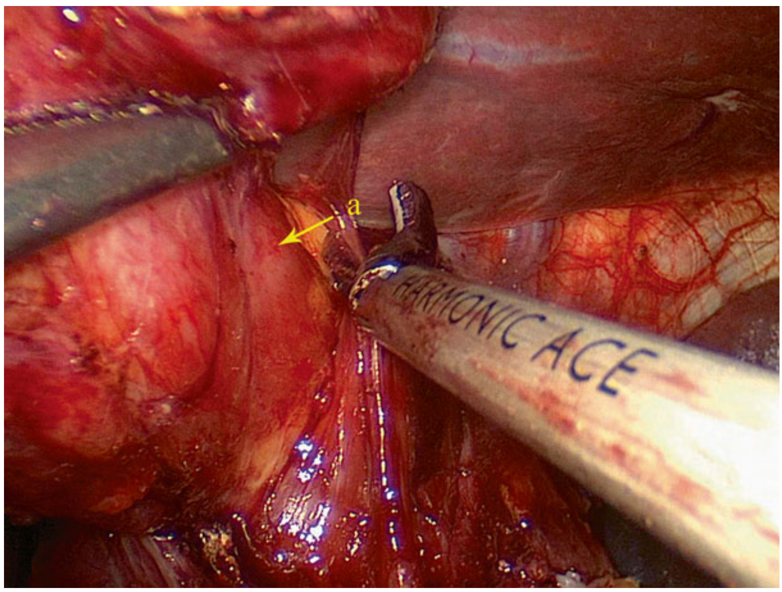

Fig. 7.47 Dissection of the No. 2 LNs is accomplished. The esophagus' left side (*a*)

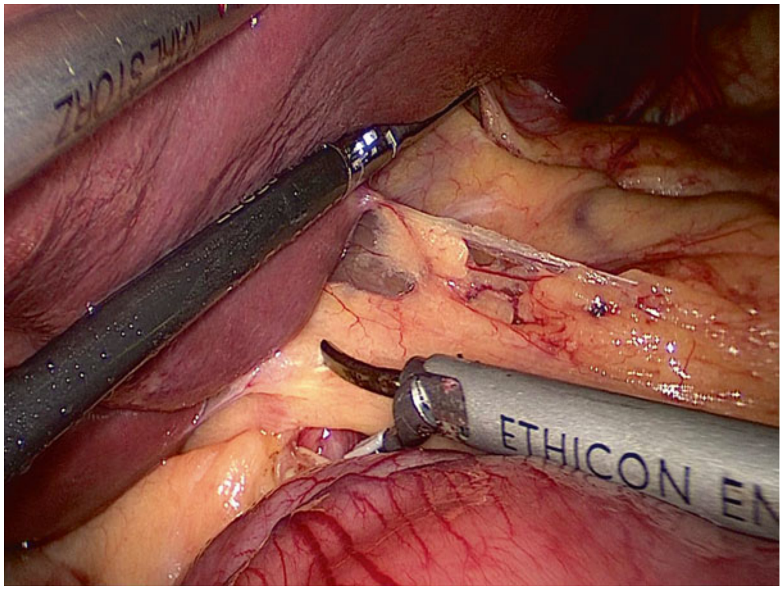

Fig. 7.48 The assistant can expose the operating view by using the grasping forceps in the left hand to push the left lateral lobe of liver upward

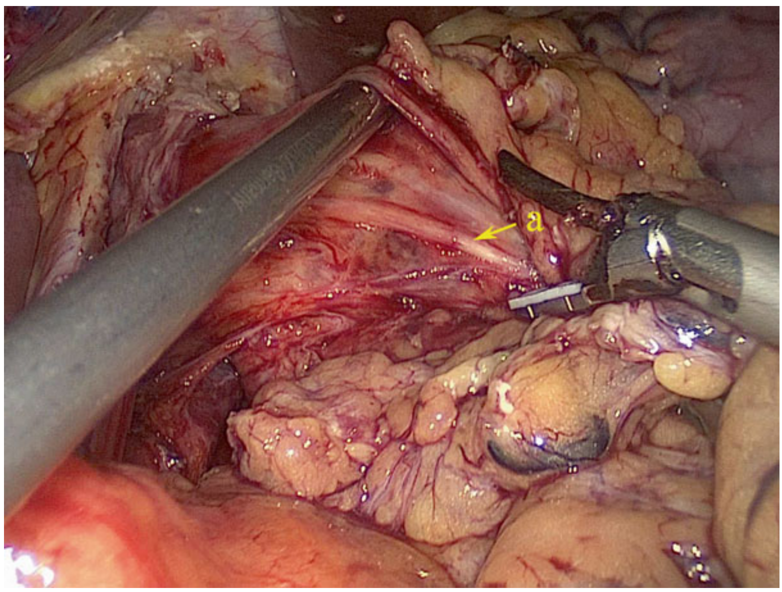

Fig. 7.49 The right trunk of the vagus nerve (*a*) is severed

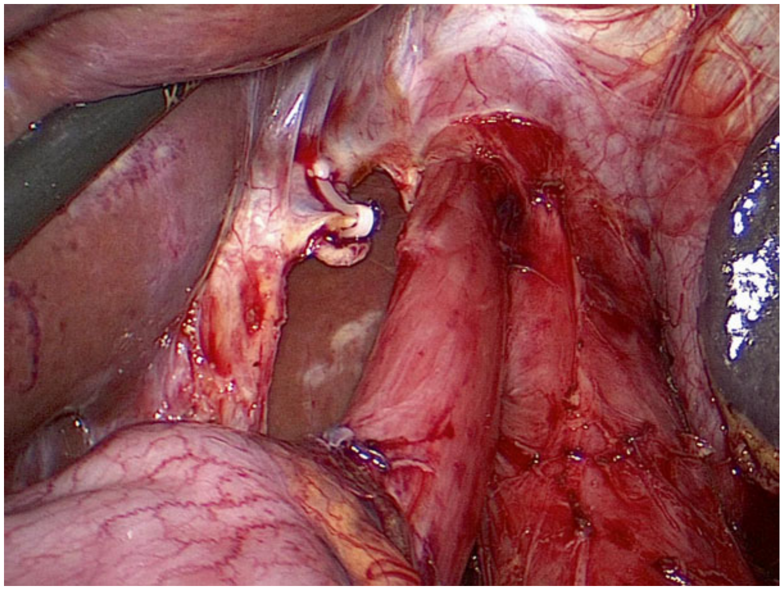

Fig. 7.50 Entirely mobilized esophagus

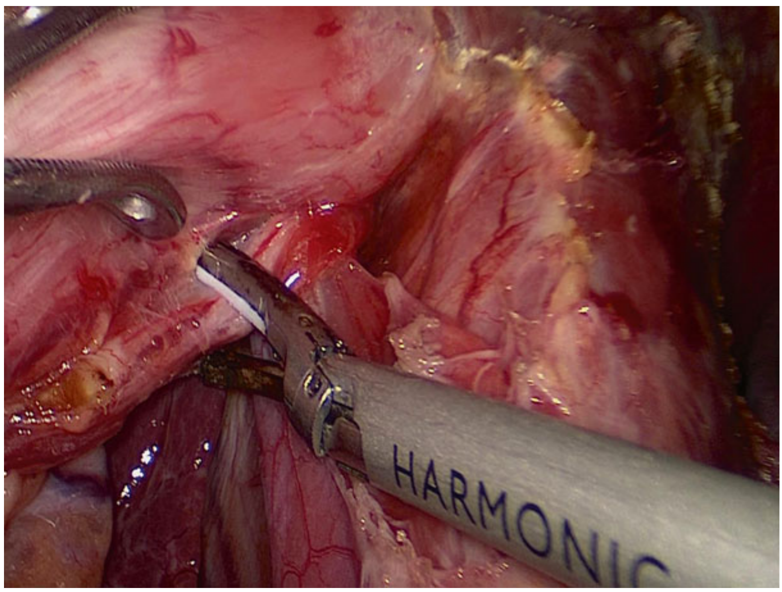

Fig. 7.51 The assistant separates the left vagus nerve with an aspirator or gastric forcep and picks apart the free vagus nerves from the esophagus

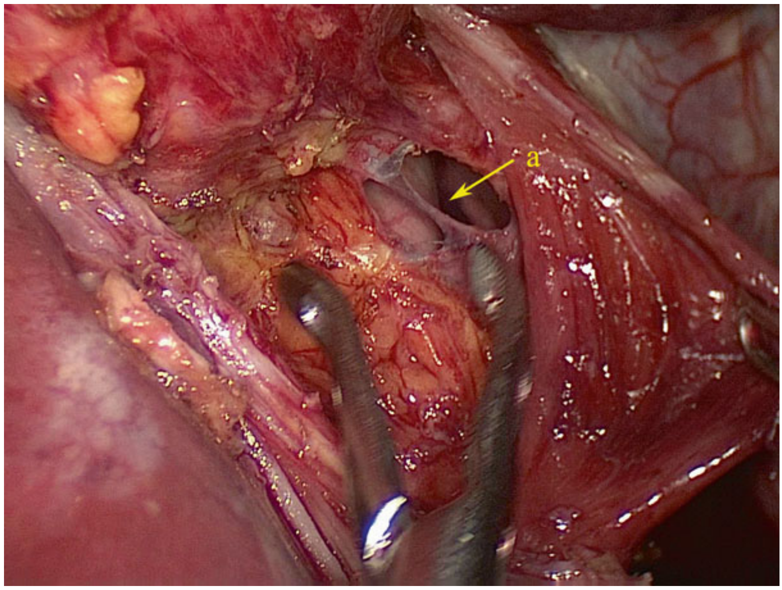

Fig. 7.52 The ultrasonic scalpel should be placed closest to the esophagus, or injury to the mediastinal pleura (*a*) can result

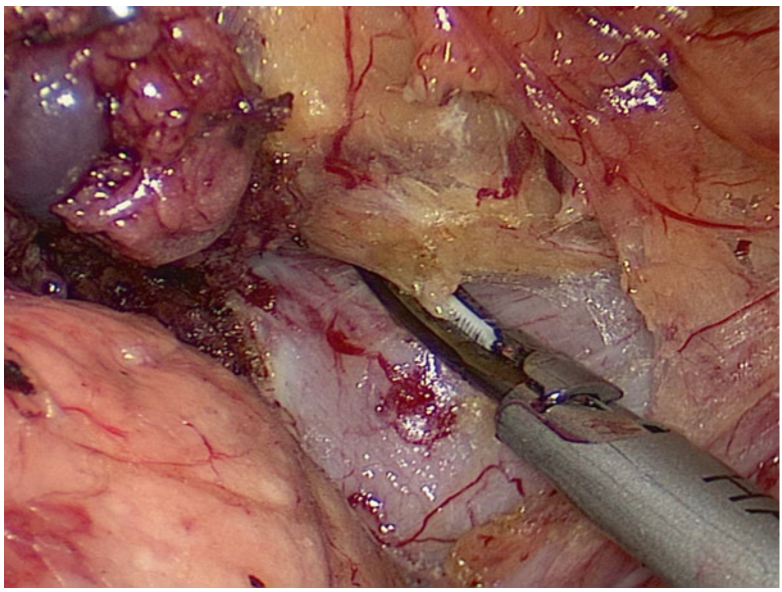

Fig. 7.53 Division of the middle layer of the lesser omentum

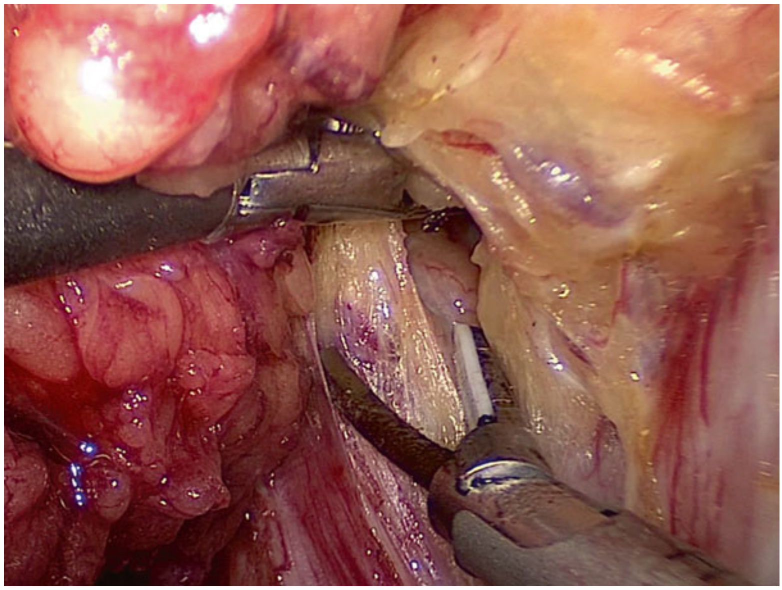

Fig. 7.54 Division of the anterior layer of the lesser omentum

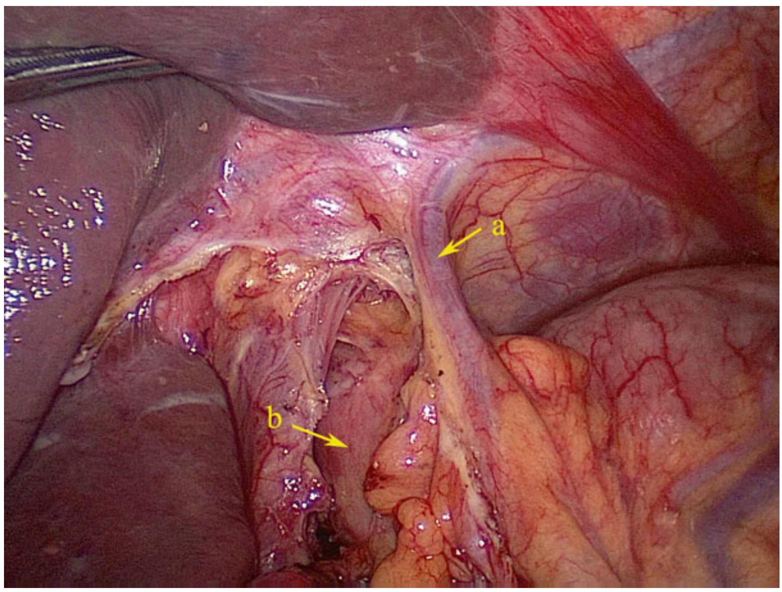

Fig. 7.55 LGA gives off branches (*a*) to supply to the diaphragm. The esophagus (*b*)

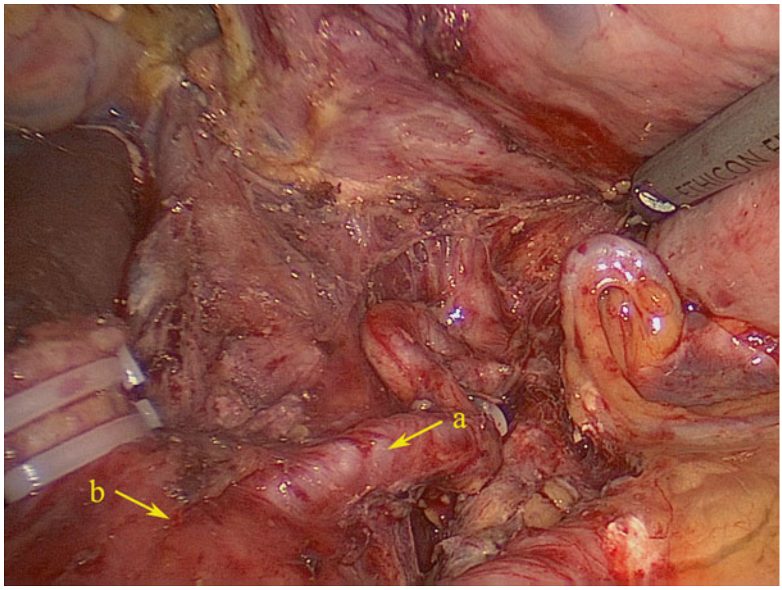

Fig. 7.56 LIPA (*a*) originates from the celiac trunk (*b*), the former artery may be susceptible to injury due to its superficial location

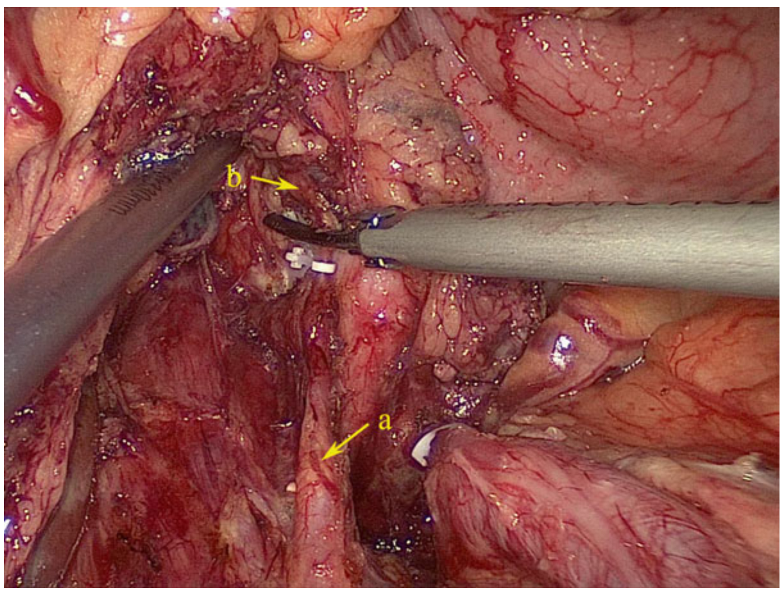

Fig. 7.57 The fundic branch (*b*) should be severed at its root after arising from the LIPA (*a*)

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Reconstruction of the Digestive Tract After Laparoscopic Gastrectomy for Gastric Cancer

8

Reconstruction of the digestive tract after laparoscopic gastrectomy for gastric cancer is an important aspect of clinical efficacy, which concerns postoperative recovery and quality of life. With prolonged survival of patients with gastric cancer, the postoperative quality of life deserves more attention. Researchers have paid increasing attention to reconstruction methods. As a result of the widespread application of laparoscopic techniques, reconstruction of the digestive tract after laparoscopic gastrectomy has become a research focus in surgery.

8.1 Outline of Reconstruction After Laparoscopic Radical Gastrectomy

8.1.1 Reconstruction Approach After Laparoscopic Gastrectomy

Laparoscopic gastrectomy is superior to conventional open gastrectomy because it is less invasive, which may lead to smaller wounds, faster recovery, fewer complications, and better cosmetic results. In addition, better clinical efficacy is achieved [1–4]. Currently, reconstruction of the digestive tract following laparoscopic gastrectomy is mostly divided into two categories: laparoscopy-assisted reconstruction and totally laparoscopic reconstruction. With laparoscopy-assisted gastrectomy (LAG), mobilization of the digestive tract, vascular ligation, and lymph node dissection are performed laparoscopically, while resection of the specimen and reconstruction of the digestive tract are performed under direct view through a minilaparotomy made on the epigastrium. The resected specimen mostly has to be removed via the minilaparotomy made on the epigastrium. Furthermore, the anastomosis can be performed with less difficulty, shorter operating time, and lower cost when surgery is performed through minilaparotomy, and this is a safe and feasible method. Thus, LAG has become a common approach in laparoscopic surgery.

Laparoscopic techniques were developed to achieve a radical cure with minimal invasion and to improve postoperative quality of life. Compared with LAG, totally laparoscopic gastrectomy (TLG) is considered to be more minimally invasive and has several superiorities in vision and tension, particularly for obese patients. Therefore, researches on the application of TLG have never stopped.

In 1996, Ballesta-Lopez et al. first reported Billroth-II anastomosis in totally laparoscopic distal gastrectomy (TLDG) for gastric cancer [5]. Uyama et al. first described totally laparoscopic side-to-side esophagojejunostomy after total gastrectomy in 1999 [6]. A method for intracorporeal Billroth-I anastomosis, called delta-shaped gastroduodenostomy (DSG) and using only endoscopic linear staplers, was first reported in 2002 by Kanaya et al. [7]. In 2005, Takaofi et al. proposed

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a secure technique of intracorporeal Roux-Y reconstruction after laparoscopic distal gastrectomy using linear staplers [8]. Intracorporeal circular stapling esophagojejunostomy using the transorally inserted anvil (OrVil™; Covidien) after laparoscopic total gastrectomy was reported in 2009 by Jeong et al. [9]. With improvements of surgical skills and dedicated intracorporeal devices, such as linear staplers and ultrasonic scalpels, Billroth-I, Billroth-II, and Roux-en-Y reconstruction, which are usually performed by open surgery, can all be performed laparoscopically.

8.1.2 Technical Tips of Reconstruction After Laparoscopic Radical Gastrectomy

8.1.2.1 Pay Attention to Operational Details and Avoid Unnecessary Injury

The details should be noted during the operation to avoid rework or contamination of the operating field, thus avoiding unnecessary trauma. For example, the gastric tube set up before surgery should be positioned at the appropriate location before anastomosis to prevent it being severed by the linear stapler. The specimen should be placed in a plastic specimen bag to ensure aseptic and tumor-free conditions. The principle of aseptic technique should be followed during making incisions in the digestive tract, and the digestive juice can be aspirated clearly using an aspirator inserted into the incisions before anastomosis.

8.1.2.2 Ensure Quality of the Anastomosis and Reduce the Postoperative Complications

At present, anastomosis-related complications mainly include anastomotic leakage, hemorrhage, and stenosis. Adequate blood supply to the tension-free anastomosis is the key to prevention of anastomotic leakage. However, the formation of scar tissues after healing of the intestinal wall or too much stitching is a common cause of anastomotic stenosis. With respect to the prevention of anastomotic hemorrhage, a common stab incision is created during anastomosis using a linear stapler; the anastomosis should be checked for bleeding or mucosal damage via the common stab incision. After anastomosis, the integrity of the stapler nails should be checked, including whether the anastomotic stoma and resected tissue are a complete circle in the circular stapler. If the anastomosis is not satisfactory or there is oozing of the blood, manual sutures can be added for reinforcement. The surgeon must carefully operate step-by-step to ensure that each stage in the anastomosis is practical and reliable. Thus, better postoperative quality of life can be achieved.

8.1.2.3 Familiarity with Instruments' Use to Reduce Trauma

A variety of instruments are needed to assist in the completion of totally laparoscopic reconstruction of the digestive tract, so it is necessary to be familiar with the performance of all kinds of laparoscopic instruments and techniques to avoid trauma from the instruments themselves. In the process of using the instruments, the following points should be noted: (1) cartilage-type staplers should be adapted to the thickness of the tissue; (2) the diameter of the stapler should be adapted to the diameter of the intestinal canal; (3) the gastric tube should be pulled out before firing the stapler, and overall inspection should be conducted to make the anastomosis site appropriate and prevent the stapler from clamping other structures; (4) after firing the stapler, the handle should be firmly squeezed for >15 s to expel the interstitial fluid, thus achieving a better stapling result; (5) the stapler should be fired completely, therefore, and the firing shaft will touch the closing shaft to stop the stapler from mistakenly firing or locking; and (6) during transection of specific positions such as the duodenum, the flexible stapler can be used to facilitate operation, and at this moment, the jaws should be opened because the stapler cannot bend at the tip if the jaws are closed.

8.2 Reconstruction of the Digestive Tract After LAG

Laparoscopy-assisted distal gastrectomy (LADG) is the earliest laparoscopic procedure in the field of gastric surgery. Currently, this procedure has been the most commonly performed for gastric cancer. With the increasing incidence of proximal gastric cancer and application of laparoscopic techniques for treatment of advanced gastric cancer, laparoscopy-assisted total gastrectomy (LATG) has gradually become popular. Here, we introduce Billroth-I anastomosis in LADG and Roux-en-Y anastomosis in LATG.

8.2.1 Technical Tips of Billroth-I Anastomosis in LADG

Mobilization of the stomach and lymph node dissection should be carried out completely by laparoscopy to prepare for successful reconstruction of the digestive tract through minilaparotomy. One should try to avoid other redundant operations through the minilaparotomy.

After the distal stomach is freed and the lymph nodes (LNs) are dissected, the intra-abdominal gas is expelled from the trocar, and the laparoscopic instruments are removed. A 5–7-cm midline incision below the xiphoid is made in the epigastrium as an accessory incision. The abdominal cavity is entered layer-by-layer, and the wound protector is placed in position. After complete retrieval of the duodenum from the abdominal cavity, a purse-string clamp is applied to the duodenum 3 cm distal to the pylorus. A Kocher clamp is applied just proximal to the purse-string clamp, and the duodenum is transected between the two clamps. The anvil of a disposable 28- or 29-mm circle stapler is inserted into the disinfected duodenal stump (Fig. 8.1), and a purse-string suture is tied over the anvil. Gastrotomy is performed on the anterior wall 5 cm away from the tumor edge and the shaft of the circular stapler is introduced into the stomach through the gastrotomy. The center rod of the stapler is advanced to penetrate the posterior wall at the greater curvature side of the stomach (Fig. 8.2) and then connected to the anvil placed in the duodenal stump, completing the end-to-side gastroduodenostomy between the duodenal stump and the gastric posterior wall (Fig. 8.3). After checking and

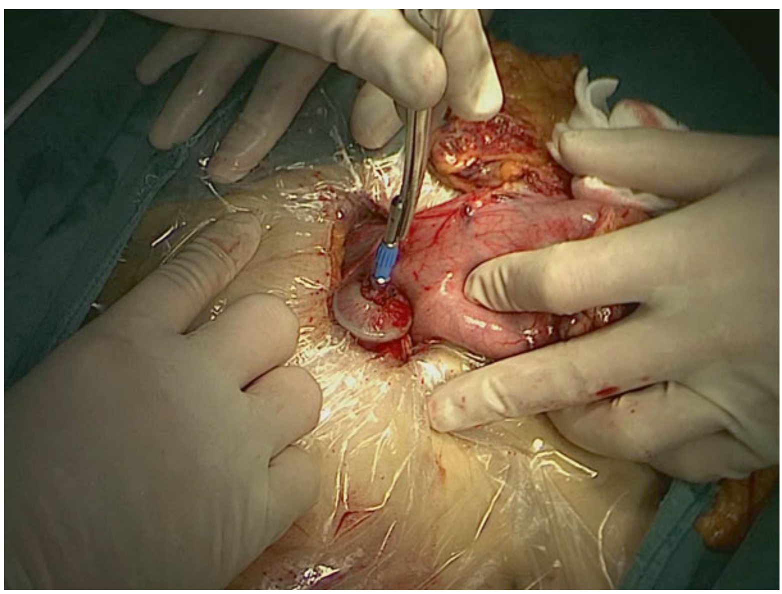

Fig. 8.1 The anvil of a disposable circle stapler is inserted into the duodenal stump

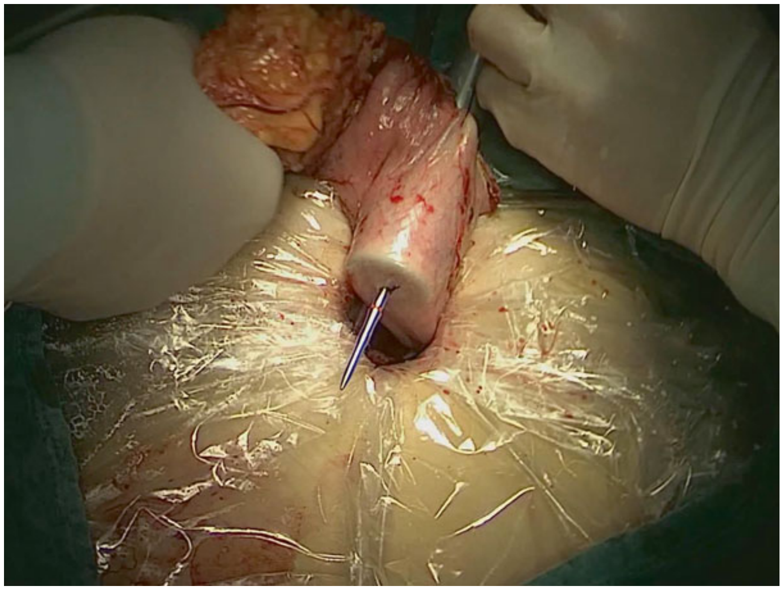

Fig. 8.2 The center rod of the stapler is advanced to penetrate the posterior wall at the greater curvature side of the stomach

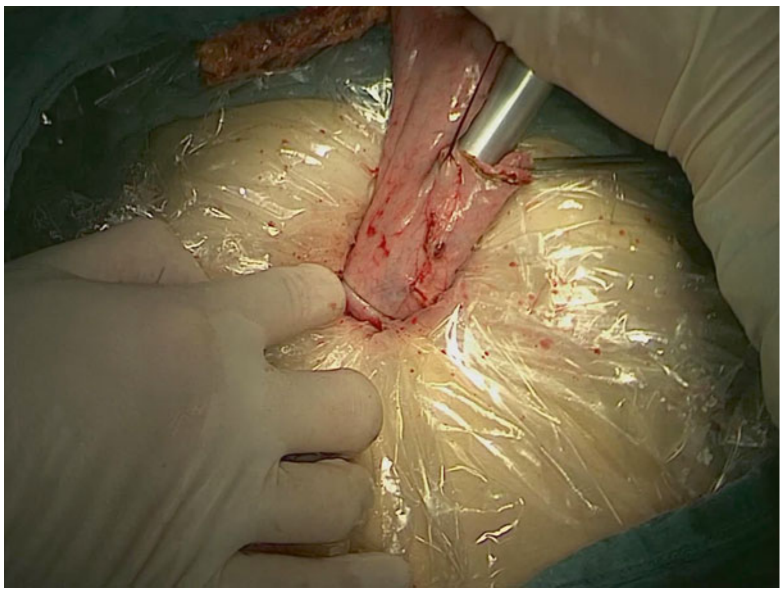

Fig. 8.3 The end-to-side gastroduodenostomy is performed

confirming the quality of the anastomosis through the gastrotomy under direct view, the stomach is closed 5 cm away from the tumor edge using the extracorporeal linear stapler (Fig. 8.4). The resected distal gastric specimen is sent for histopathological examination. Thus, Billroth-I reconstruction is accomplished (Fig. 8.5). Although the visual field and working space are narrow during laparoscopy-assisted reconstruction, every step of the procedure should be completed under direct view, which avoids iatrogenic injury or uncertain anastomosis caused by blind operation.

8.2.2 Technical Tips of Roux-en-Y Anastomosis in LATG

After completing lymph node dissection and mobilization of the stomach laparoscopically, the duodenal bulb is transected 3 cm distal to the

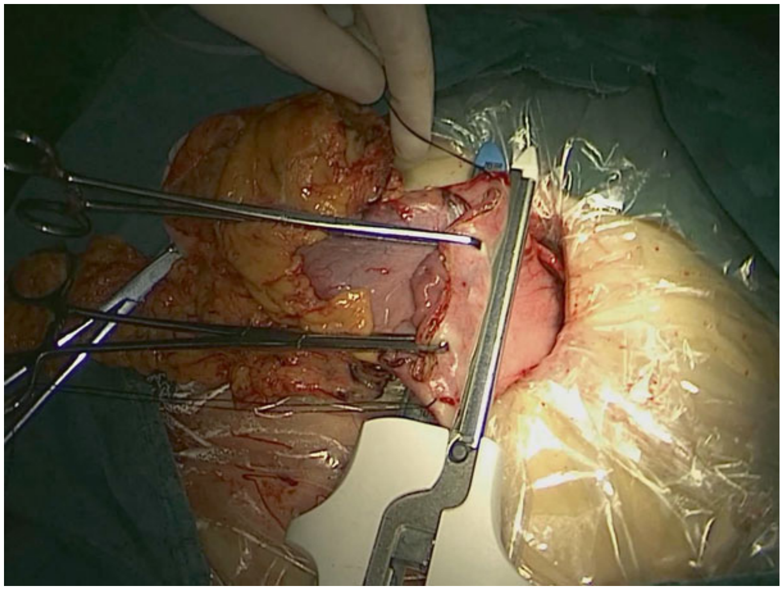

Fig. 8.4 The anterior and posterior walls of the stomach are closed 5 cm away from the tumor edge using the extracorporeal linear stapler

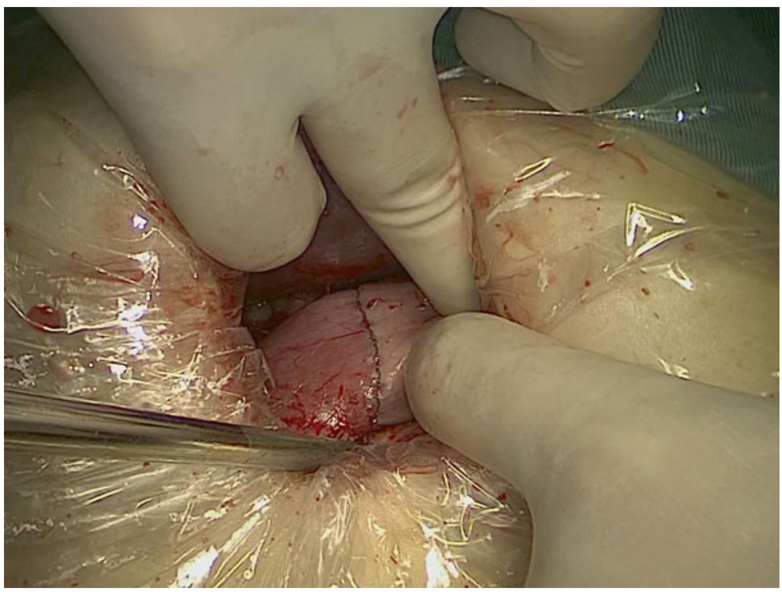

Fig. 8.5 Billroth-I reconstruction is accomplished

pylorus using the intracorporeal linear stapler, and the duodenal stump is closed. The laparoscopic instruments are removed, and a 5–7-cm upper midline abdominal incision below the xiphoid is made as an accessory incision. The abdominal cavity is entered layer-by-layer, and the wound protector is placed in position. A purse-string clamp is applied to the distal esophagus 5 cm away from the cardia and the esophagus is transected. Thereafter, a purse-string suture is placed in the disinfected esophageal stump. Once the frozen section confirms negative margins, the anvil of a disposable 25-mm circular stapler is inserted into the esophageal stump (Fig. 8.6), and the purse-string suture is tied over the anvil. The entire gastric specimen is delivered out through the minilaparotomy. The jejunum and the mesentery are cut off 15–20 cm distal to the ligament of Treitz. The body of the circular stapler is inserted into the distal limb of the jejunum, and this section

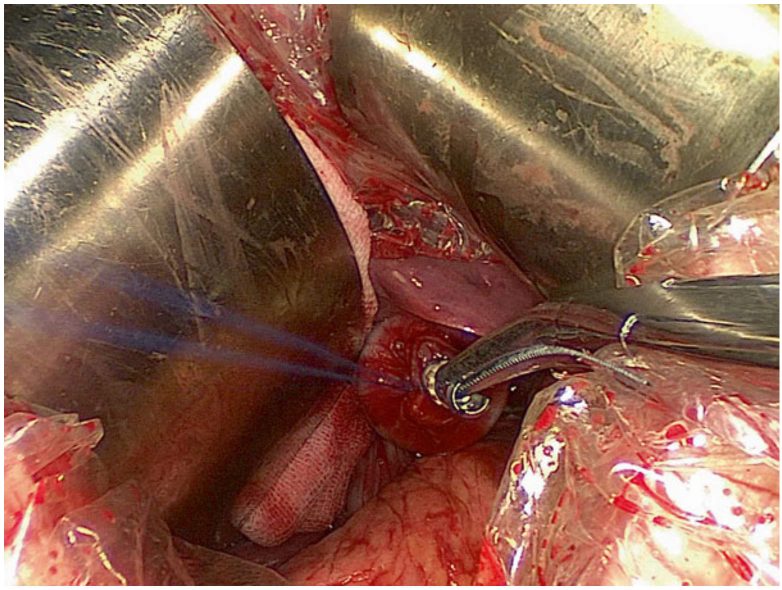

Fig. 8.6 The anvil of a disposable 25-mm circular stapler is inserted into the esophageal stump

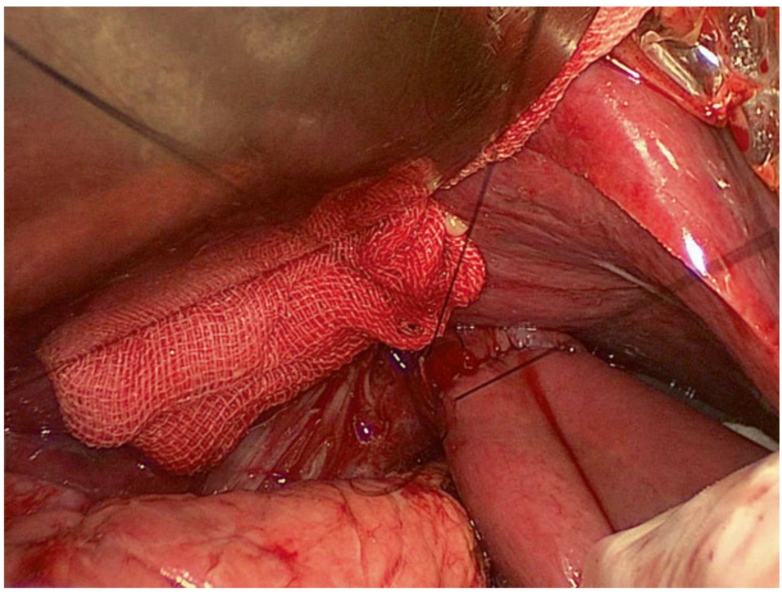

Fig. 8.7 The end-to-side esophagojejunostomy is performed

of jejunum is brought up in antecolic fashion to meet the lower end of the esophagus, creating the end-to-side esophagojejunostomy with the jejunum configured in a "J" fashion (Fig. 8.7). The stumps of distal and proximal jejunum are closed respectively using the linear stapler. A side-to-side jejunojejunostomy is performed 40 cm distal to the J-shaped anastomosis under direct view using a linear stapler or hand-sewn suture (Fig. 8.8). The proximal and distal end of the mesojejunum should not be reversed and the mesentery should be maintained without tension, to prevent improperly clamping the surrounding tissues and foreign object. The cutting edge of mesojejunum can then be closed to accomplish the entire procedure of reconstruction.

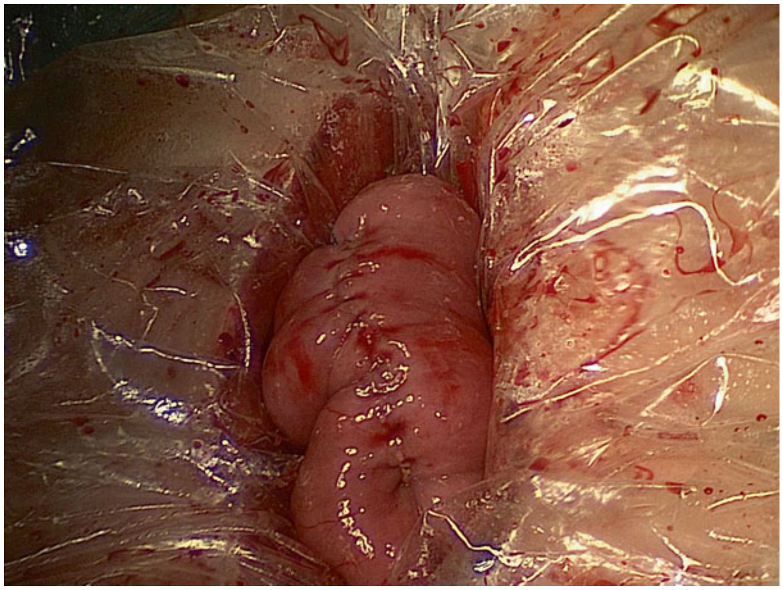

Fig. 8.8 The side-to-side jejunojejunostomy is accomplished

8.3 Reconstruction of the Digestive Tract After TLG for Gastric Cancer

8.3.1 Characteristics of Reconstruction After TLG

8.3.1.1 Superiorities of TLG for Gastric Cancer

Surgical treatment of gastric cancer has improved as a result of the emergence of reconstruction after TLG. The superiority of laparoscopic reconstruction is related to its smaller incisions and less touch and surgical trauma. Related reports indicate that TLG has several advantages over LAG in terms of short-term outcomes, such as less intraoperative blood loss, smaller wounds, earlier recovery of gastrointestinal function with time to first flatus shortened, and shorter hospital stay [1, 10–13]. The operating time is shorter because of accumulated surgical experience [14, 15]. There are no significant differences between TLG and other procedures [10, 11]. In terms of perioperative and long-term complications, TLG does not increase the incidence of major complications (e.g., hemorrhage, anastomotic leakage, and stump leakage) and minor complications (e.g., incision infection and lymphatic leakage) [10, 16–20]. The superiority of TLG for obese patients is also supported by results from multicenter studies. The advantages of TLG mainly include more convenient anastomosis, better visualization, and better quality of life [16, 21, 22]. Additionally, TLG ensures adherence to the principals of tumor resection, such as the no-touch technique and no extrusion. Stomach resection and anastomosis are performed in situ, which reduces anastomotic trauma and additional pulling on the remnant stomach. Therefore, laparoscopic surgeons are increasingly focusing on reconstruction of digestive tract in total laparoscopy.

8.3.1.2 Influence of the Staplers for Anastomosis on Laparoscopic Reconstruction of the Digestive Tract

The widespread application of laparoscopic appliances has become an indispensable factor in the advancement of laparoscopic surgery for gastric cancer. Continuous improvement of the staplers for anastomosis has simplified reconstruction of the digestive tract, and the time for anastomosis has been shortened. Anastomosis using staplers, which is technically safe and feasible, has similar results and complication rates to anastomosis using hand-sewn sutures. Furthermore, in TLG, the application of the staplers has shortened the time for anastomosis. The complex operative manipulations due to the difficult exposure and limited work space are also made easier. Laparoscopic anastomosis is simplified, and the contamination of the abdominal cavity and the surgical trauma are reduced, which improves the efficacy of surgical treatment. Novel stapler production offers new techniques for laparoscopic reconstruction, for example, the transorally inserted anvil (OrVil™) is used in esophagojejunostomy for Roux-en-Y anastomosis after laparoscopic total gastrectomy. Anastomosis using staplers has the following advantages: (1) small vessels can pass through the intervals between the staplers, so as not to affect the blood supply of the anastomotic site and its distal end; (2) the stapler is made of titanium or tantalum; therefore, tissue reactions are reduced compared with hand-sewn anastomosis; and (3) the staplers are neatly arranged at equal intervals, which ensures good tissue healing.

8.3.2 Indications for Totally Laparoscopic Reconstruction of the Digestive Tract

Reconstruction of the digestive tract should be performed within a certain distance of the normal tissues. The normal tissues at a certain distance from the proximal or distal border of the tumor must be resected according to tumor location and TNM staging. Preoperative laparoscopic exploration is performed first to confirm the tumor site. Patients with T4b tumor, peritoneal implantation, or liver metastasis should be excluded. If it is difficult to identify the tumor site in early tumors during total laparoscopy, intraoperative gastroscopy can be used for accurate positioning to ensure R0 resection of the tumor. Transection of the duodenum, stomach, or esophagus should ensure not only R0 tumor resection but also appropriate anastomotic tension. The resected margins should be confirmed as tumor free, and the margin of the removed specimen must be sent for frozen section analysis prior to proceeding with anastomosis.

8.3.2.1 Reconstruction of the Digestive Tract After Distal Gastrectomy

The delta-shaped Billroth-I anastomosis may be more suitable for patients diagnosed with early primary distal gastric cancer, whereas it may be used for clinical investigation in patients with locally advanced gastric cancer [23, 24]. When a tumor has invaded the pyloric canal or duodenum, Billroth-II anastomosis can be performed to achieve R0 resection [25]. In distal gastrectomy, two-thirds to three-quarters of the distal stomach should be resected, including the distal gastric body, antrum, pylorus, and proximal duodenal bulb. The line between the right side of the first descending branch of the left gastric artery (LGA) and the left side of the lowest vertical branch of the left gastroepiploic artery (LGEA) can be used to mark the extent of gastric resection. The greater curvature of the stomach should be denuded, preserving two to three branches of short gastric arteries and the posterior gastric artery (SGAs and PGA) to ensure the blood supply for the remnant stomach, reduce the anastomotic tension, and facilitate anvil of the linear stapler insertion.

8.3.2.2 Reconstruction of Digestive Tract After Total Gastrectomy

Laparoscopic total gastrectomy with functional end-to-end esophagojejunostomy is more suitable for patients with non-cardia upper or middle gastric cancer. Laparoscopic total gastrectomy can also be performed for patients with early cardial cancer or localized cardial cancer invading the abdominal esophagus <1–2 cm, with the secure cutting line of the esophagus under the esophageal hiatus [26]. Anastomosis using OrVil™ is appropriate for patients with laparoscopically resectable early proximal gastric carcinoma, which invades the distal esophagus within 3 cm above the gastroesophageal junction (visualized by preoperative X-ray barium meal) and has no obvious external invasion in the preoperative evaluation of the tumor [27]. For patients with a tumor of the non-cardia proximal stomach or gastric body, only the abdominal esophagus should be freed. When the tumor is located at the cardia or invades the distal esophagus, it must be removed. The esophageal hiatus can be adequately extended by incising the diaphragm at the vault of the esophageal hiatus 4–5 cm in the ventral direction. The left triangular ligament can be severed to facilitate the exposure. The middle to lower part of the crus of the diaphragm is transected on both sides, and the pleura is pushed toward both sides to extend fully the space of the posterior mediastinum; thus, the jejunum can be sent into the posterior mediastinum for anastomosis with the esophagus.

8.3.3 Procedures of Reconstruction After TLG

Currently, there are a variety of reconstruction methods after TLG for gastric cancer, including Billroth-I anastomosis, Billroth-II anastomosis, and Roux-en-Y reconstruction after TLDG, and functional side-to-side esophagojejunostomy, OrVil™-assisted anastomosis, and overlap anastomosis after totally laparoscopic total gastrectomy (TLTG). Here, the more mature techniques of delta-shaped Billroth-I anastomosis and Billroth-II anastomosis after TLDG, functional side-to-side esophagojejunostomy, and OrVil™-assisted anastomosis after TLTG are described. The patient's position, surgeons' locations, and location of trocars are identical to those during the process of lymph node dissection (described in Chap. 3).

8.3.4 Delta-Shaped Billroth-I Anastomosis After TLDG

8.3.4.1 Anastomosis Method

The DSG is a functional end-to-end anastomosis between the posterior wall of the stomach and that of the duodenal bulb, using endoscopic linear staplers. The anastomosis is finished with an internal delta-shaped stapling line, hence the name. DSG after LDG has been widely performed and yielded good therapeutic efficacy since it was first reported by Kanaya et al. in 2002.

8.3.4.2 Technical Tips

After completing laparoscopic lymph node dissection, a linear stapler is inserted through the left upper major trocar, positioned across the duodenum vertical to the long axis in the predetermined position, and fired to transect the duodenum by rotating 90° from back to front (Fig. 8.9). The stomach is resected from the greater to the lesser curvature with two staplers

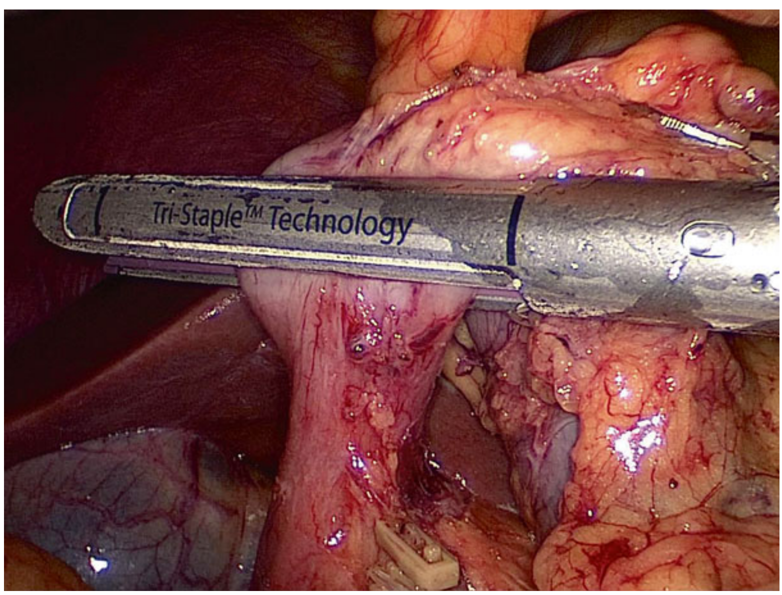

Fig. 8.9 The duodenum is transected using a linear stapler

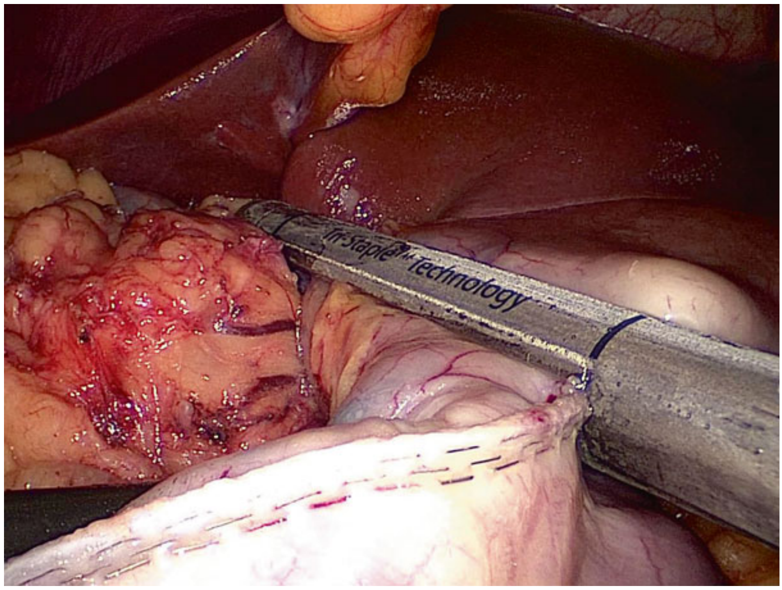

Fig. 8.10 The stomach is resected using the linear stapler

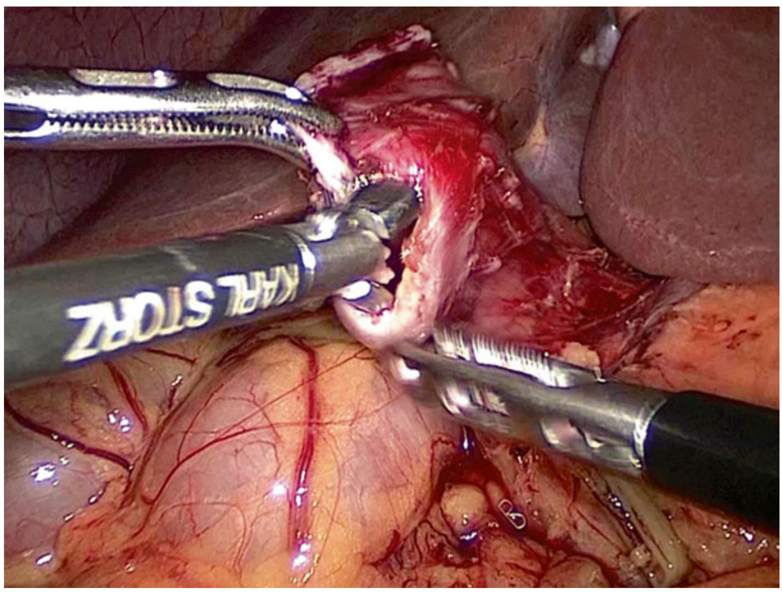

Fig. 8.11 A small incision is created on the posterior side of the duodenum

(Fig. 8.10). The specimen is placed in a plastic bag, and small incisions are created on the greater curvature side of the remnant stomach and the posterior side of the duodenum (Figs. 8.11 and 8.12). Due to the greater mobility of the stomach, one limb of the stapler is first inserted into the incision on the greater curvature side of the remnant stomach, and the predetermined anastomotic site on the posterior wall should be 2 cm away from the cutting edge. Another limb of the stapler is positioned on the posterior side of the duodenum, and the cutting edge of the duodenum is rotated 90° in the anticlockwise direction. The posterior side of the duodenum is anastomosed to the remnant stomach (Fig. 8.13). After confirming the quality of the anastomosis via the common stab incision (Fig. 8.14), three sutures are added to each end of the common stab incision

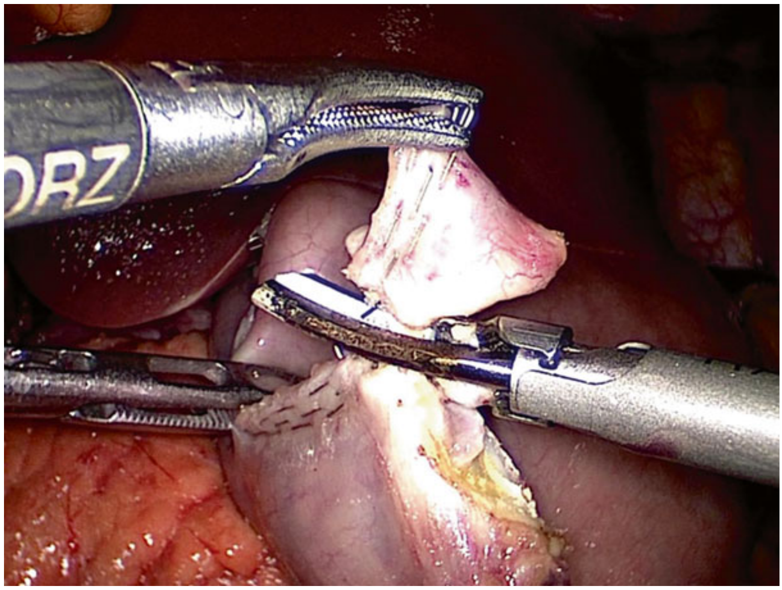

Fig. 8.12 A small incision is created on the greater curvature side of the remnant stomach

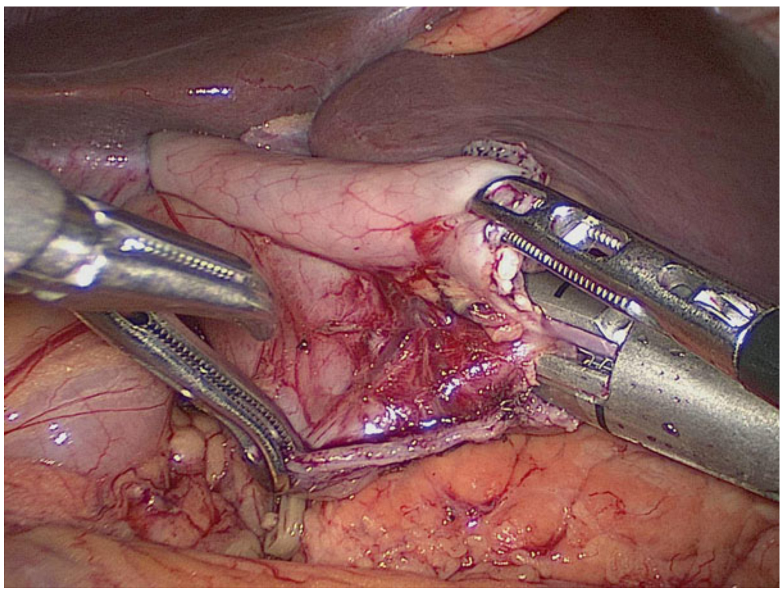

Fig. 8.13 The posterior side of the duodenum is anastomosed to the remnant stomach using the linear stapler

and to the cutting edges of the stomach and duodenum to obtain a better involution and pull (Fig. 8.15). Finally, the common stab incision is closed with the stapler (Fig. 8.16), resulting in the conventional DSG (Fig. 8.17). The trocar incision below the umbilicus is enlarged to 3 cm to remove the specimen.

However, this conventional method contains a duodenal blind side and two intersections of the cutting edge of the remnant stomach with the duodenum and common closed edge. In theory, there will be three weak points (Fig. 8.18), which may increase the risk of anastomosis-related complications. Therefore, we have modified the conventional DSG procedure to improve its safety [28, 29]. The duodenal cutting edge is completely resected, and the intersection of the duodenal cutting edge and the common closed edge is resected

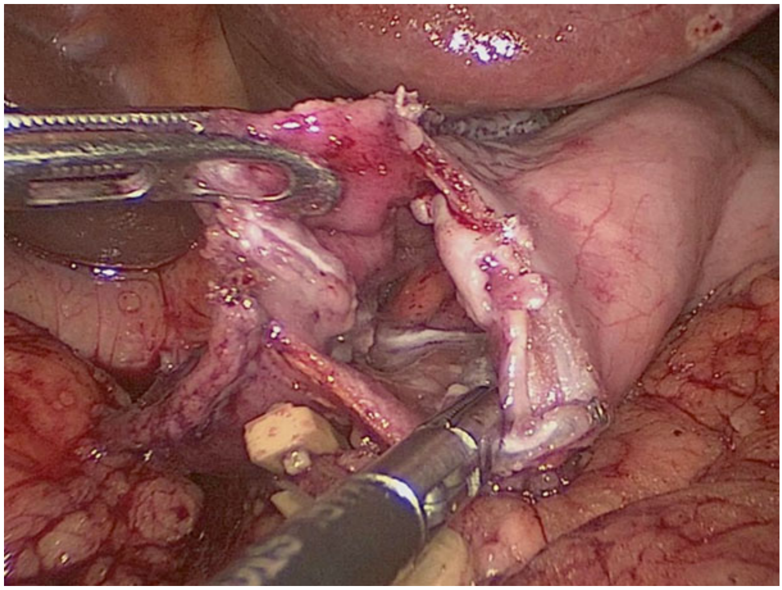

Fig. 8.14 Check the common stab incision

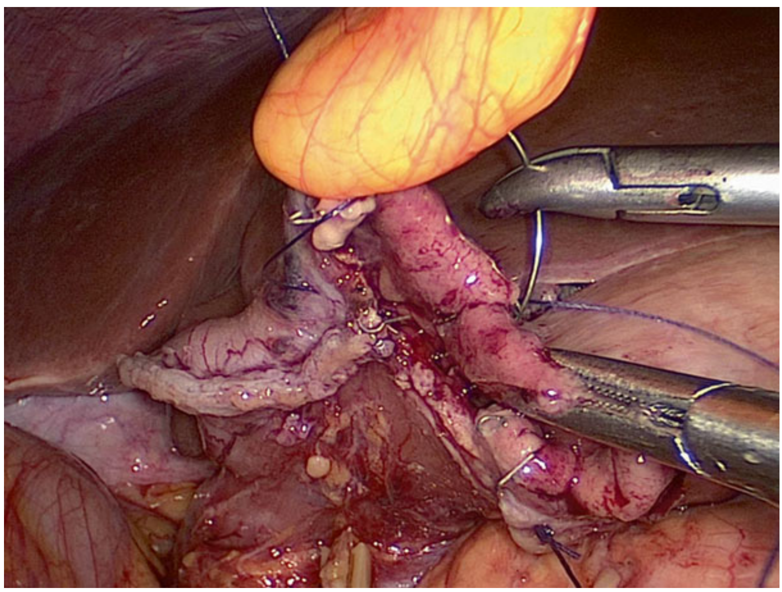

Fig. 8.15 Three sutures are added to each end and middle of the common stab incision to obtain a better involution and pull

at the same time. As a result, there is only one intersection of the gastric cutting edge and the common closed edge, leaving only one weak point instead of three in the conventional DSG. The anastomosis appears as an inverted T-shape (Fig. 8.19). Operationally, after the involution of the common stab incision, the end of the duodenal cutting edge is pulled up into the linear stapler by the assistant's right forceps (Fig. 8.20). The surgeon fires the stapler to close the common stab incision vertically to the gastric cutting edge, with the duodenal cutting edge completely resected at the same time. It can only require the instruments of the surgeon and assistant to grasp directly the tissue to accomplish involution of the common stab incision instead of the laparoscopic suturing in conventional DSG. Thus, it simplifies the operation procedures (Fig. 8.21).

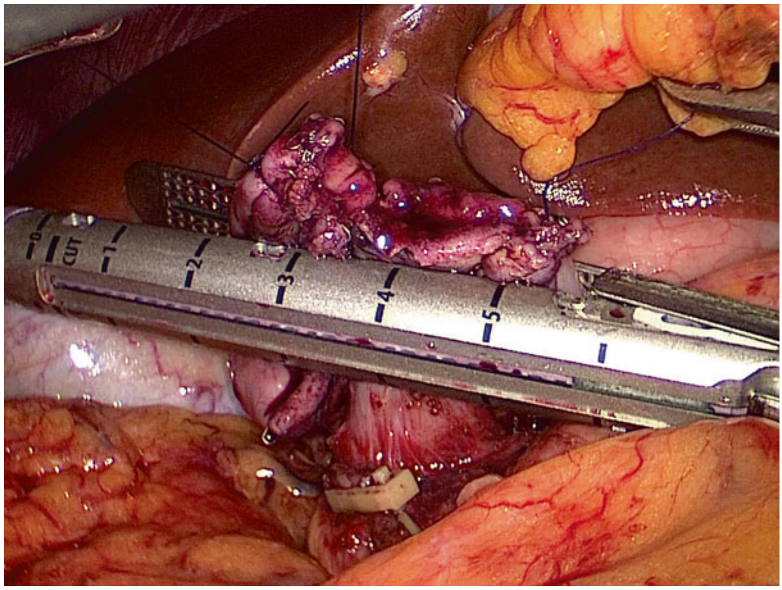

Fig. 8.16 The common stab incision is closed with the stapler

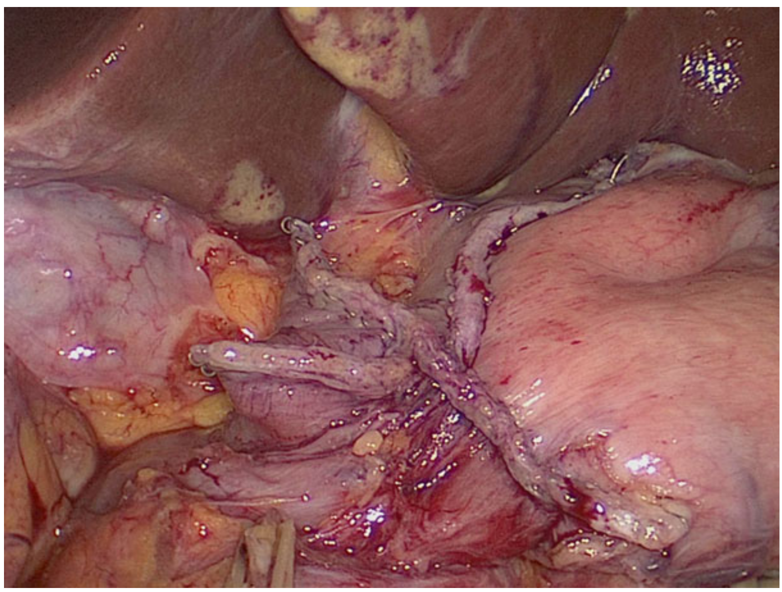

Fig. 8.17 The appearance of the anastomosis in the conventional DSG

Out center found that the modified DSG is a simpler process with significantly shorter anastomosis time by comparing the clinical data of the 22 patients undergoing a conventional DSG and 41 patients undergoing a modified DSG [23]. In addition, we summarized the clinical data of 122 patients undergoing modified DSG along with TLDG. Our results show that no patient of the 46 cases of early gastric cancer experienced any anastomosis-related complications such as anastomotic leakage and anastomotic hemorrhage. Of all the patients, only two elderly patients with late-stage gastric cancer experienced a minor anastomotic leakage after surgery and were managed conservatively. The average time of anastomosis was 12.2 ± 4.2 min. And the mean blood

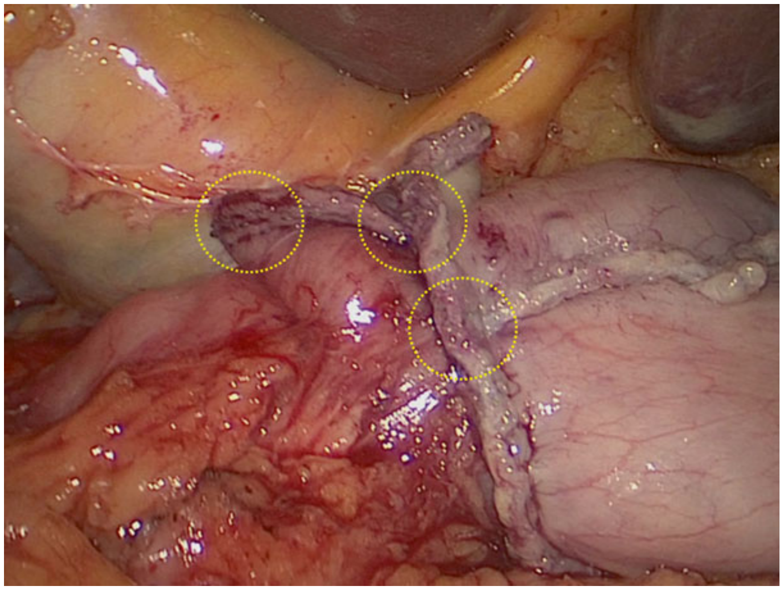

Fig. 8.18 The conventional DSG contains three weak points

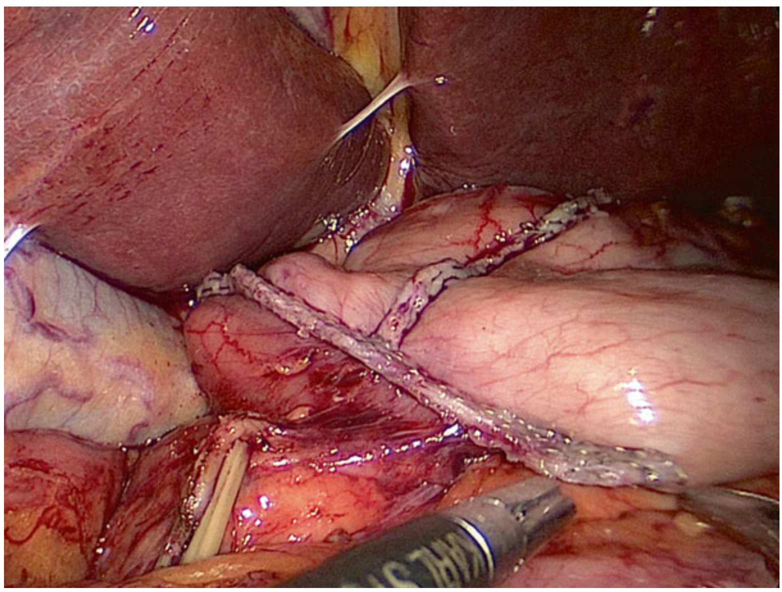

Fig. 8.19 The modified DSG appears as an inverted T-shape

loss and postoperative morbidity were comparable with other reports. Therefore, our results indicated that the modified DSG was technically safe and feasible in patients with gastric cancer undergoing TLDG. The procedure decreased the anastomotic weak points and avoided the poor blood supply to the duodenal stump. It may be promising and easier to perform with acceptable surgical outcomes [29].

8.3.5 Billroth-II Anastomosis After TLDG

8.3.5.1 Anastomosis Method

It is the functional side-to-side gastrojejunostomy using the linear stapler under totally laparoscopy. If the tumor invades the pylorus or duodenum, Billroth-II anastomosis can be safely performed to achieve R0 resection. Since

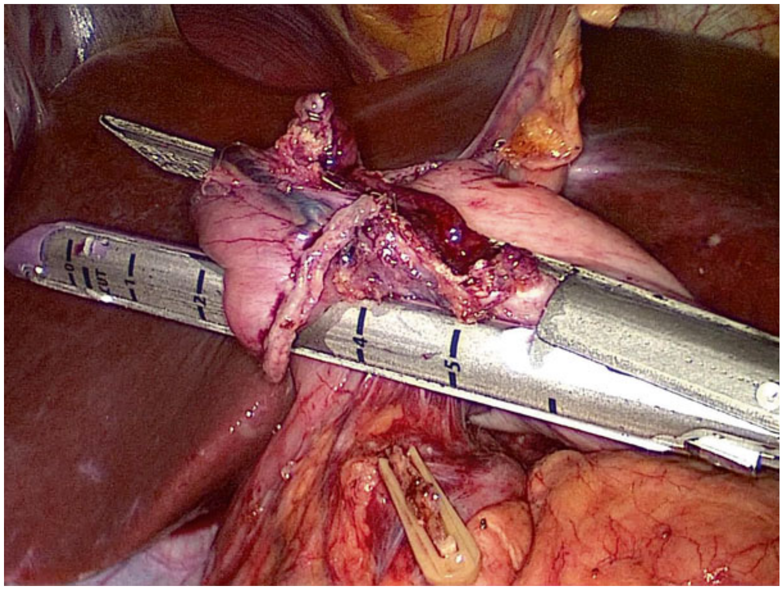

Fig. 8.20 The duodenal blind side is pulled up into the linear stapler, and the common stab incision is closed

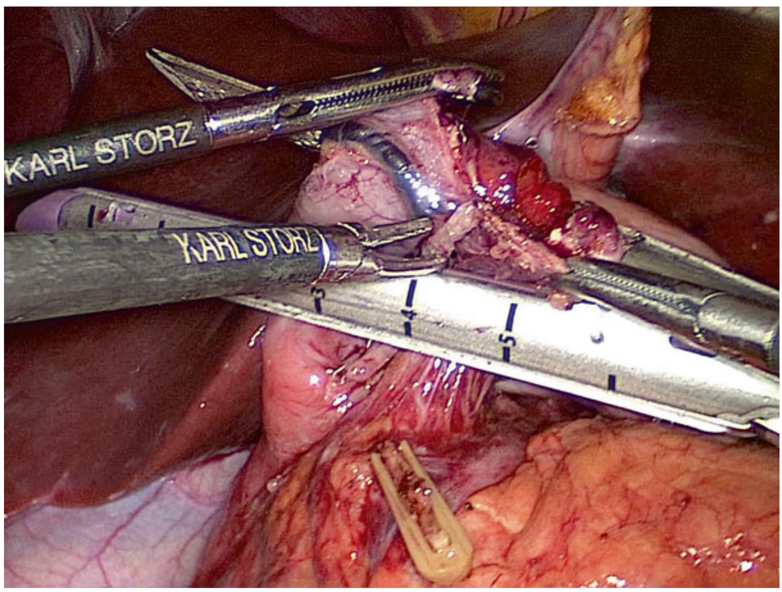

Fig. 8.21 The instruments of the surgeon and assistant directly grasp the tissue and accomplish the involution of the common stab incision

Ballesta-Lopez from Spain first reported Billroth-II anastomosis in TLDG in 1996, various methods of Billroth-II anastomosis have been created. Among all, the one using the linear stapler is proved to be the simplest in technical.

8.3.5.2 Technical Tips

Reconstruction of the digestive tract is performed using the linear stapler after completion of laparoscopic lymph node dissection. The duodenum is transected in the predetermined positions using an endoscopic linear stapler after it is fully dissociated, and the stomach is resected from the greater curvature side to the lesser curvature side with two staplers. The specimen is then placed into a plastic specimen bag. Small incisions are made both on the greater curvature of the remnant stomach and the anti-mesenteric

Fig. 8.22 A small incision is made on the antimesenteric side of the jejunum located 12–15 cm distal to the ligament of Treitz

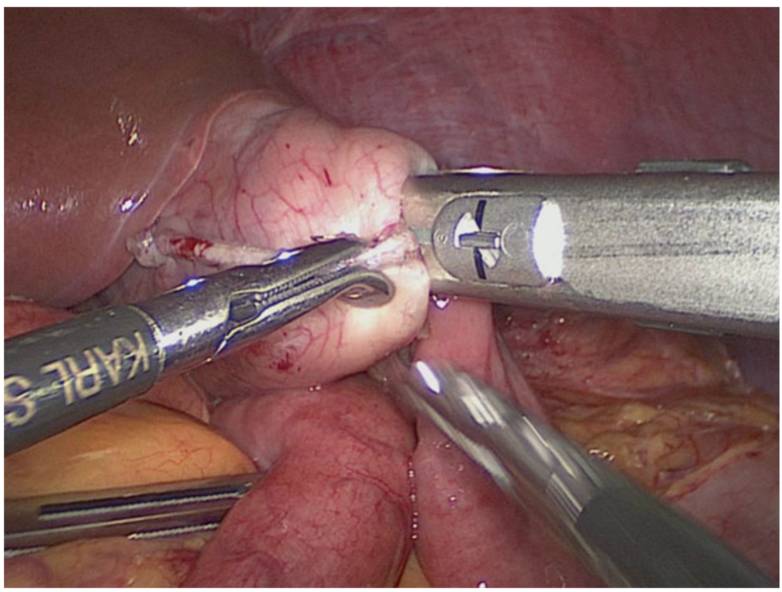

Fig. 8.23 The stapler is fired to perform a side-to-side gastrojejunostomy

side of the jejunum located 12–15 cm distal to the ligament of Treitz (Fig. 8.22). After opening the 60-mm endoscopic linear stapler, one limb is first inserted into the small incision in the jejunum toward the direction of the jejunal proximal end, and the stapler is temporarily closed. The jejunum is pulled up antecolically, and the stapler is opened again to insert the other limb into the small incision on the greater curvature of the remnant stomach. The stapler is then fired to perform a side-to-side gastrojejunostomy with a common stab incision created (Fig. 8.23). The afferent loop of the proximal jejunum should not be too long during the antecolic anastomosis. Otherwise, it may cause internal herniation or bowel ischemic necrosis due to bowel tortuosity or torsion. After confirming the quality of the anastomosis via the common stab incision

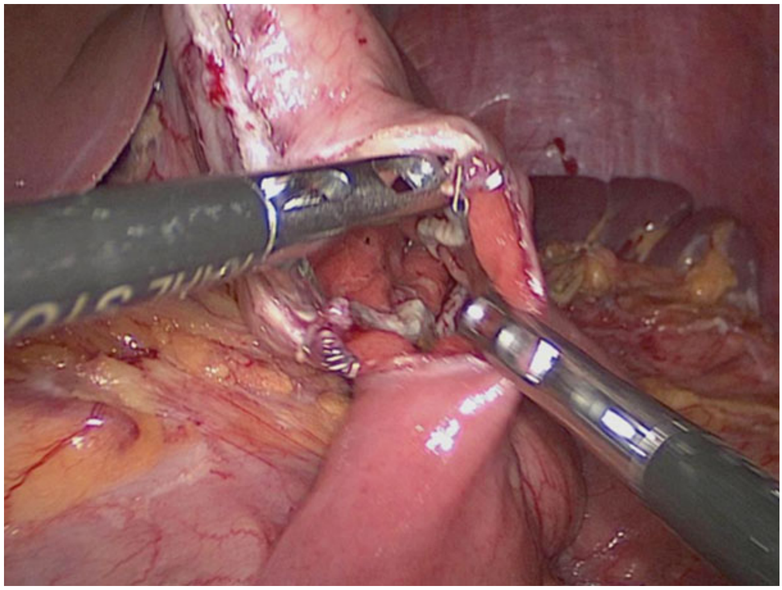

Fig. 8.24 Check the anastomosis via the common stab incision

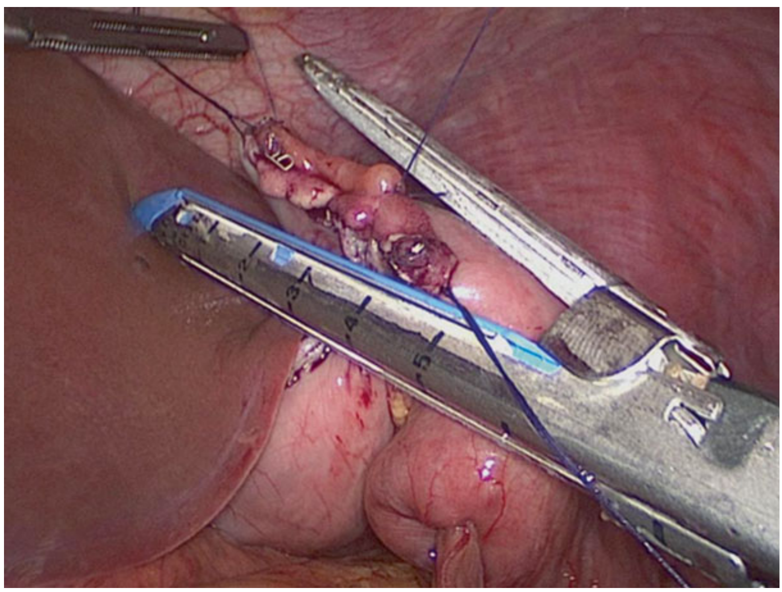

Fig. 8.25 The common stab incision is closed with the linear stapler

(Fig. 8.24), both ends of the common stab incision are pulled to be aligned, using atraumatic graspers. Three sutures are made at each end of the common stab incision to obtain better involution and pull. The common stab incision is then closed with the 60-mm linear stapler (Fig. 8.25), completing the reconstruction (Fig. 8.26). The trocar incision below the umbilicus is enlarged to 3 cm to remove the specimen.

8.3.6 Functional Side-to-Side Esophagojejunostomy After TLTG

8.3.6.1 Anastomosis Method

Functional side-to-side esophagojejunostomy is an anastomosis method that is carried out under totally laparoscopic view using the linear stapler. The abdominal esophagus and duodenum are

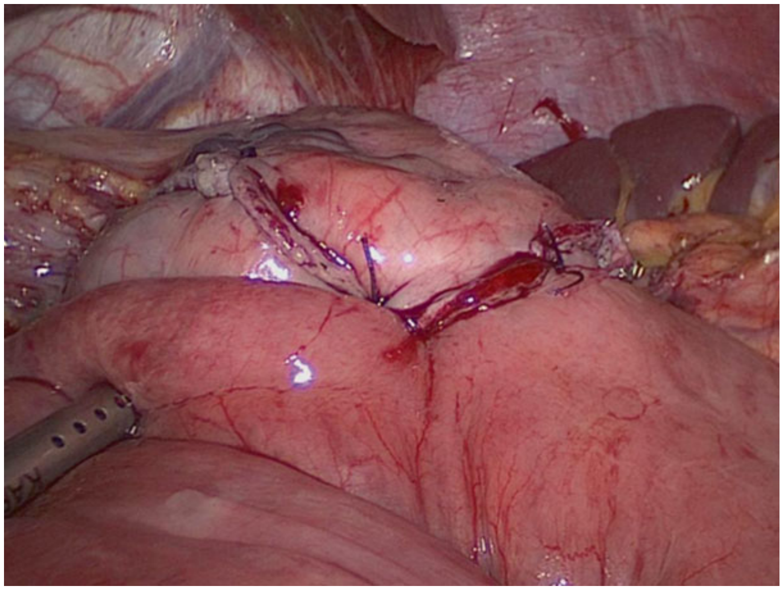

Fig. 8.26 The appearance of the anastomosis after the reconstruction

transected to complete functional side-to-side esophagojejunostomy and side-to-side jejunojejunostomy. This anastomosis method was first reported by Uyama et al. in Japan [6]. Anvil placement and purse-string suture are two difficult steps during the anastomosis using a circular stapler, especially when the diameter of the esophagus or the jejunum is small. Hence, they are omitted during functional side-to-side esophagojejunostomy in TLTG, and the anastomosis size is not restricted to the diameter of the esophagus, reducing the incidence of postoperative anastomotic stricture. Therefore, functional side-to-side esophagojejunostomy in TLTG is an ideal Roux-en-Y anastomosis procedure.

8.3.6.2 Technical Tips

After completing laparoscopic lymph node dissection, the stomach is pulled down to expose the vagus nerve and then severed. The esophagus is mobilized and bared to >5 cm distal to the upper border of the tumor to ensure a negative cutting edge. The duodenum is transected in the predetermined positions using an endoscopic linear stapler after it is fully mobilized, and the esophagus is transected above the cardia (Fig. 8.27). The mesenteric border of the jejunum located 20 cm distal to Treitz's ligament is denuded up to about 1 cm, and this segment of the jejunum is then transected using a linear stapler (Fig. 8.28). Small holes are made using the ultrasonic scalpel on the left side of the esophageal cutting edge and the antimesenteric border of the distal jejunum about 7 cm distal to its cutting edge (Figs. 8.29 and 8.30). Care should be taken to avoid injuring the esophageal or bowel wall on the opposite side. Subsequently, two limbs of the 60-mm linear stapler are respectively inserted into the small holes. The jejunum is more mobile; therefore, one limb of the stapler is first inserted into the hole in the jejunum (Fig. 8.31) and the other into the esophageal lumen. At this moment, the limb should not be inserted into the false lumen between the esophageal submucosa and muscular layer. The stapler is fired to create a common stab incision (Fig. 8.32). After confirming the quality of the anastomosis via the common stab incision (Fig. 8.33), the incision is closed with a laparoscopic suture, completing the esophagojejunostomy (Figs. 8.34 and 8.35). Using the ultrasonic scalpel, small holes are made in the proximal jejunum and the antimesenteric border of the distal jejunum about 40 cm distal to the esophagojejunostomy. Each limb of the 45-mm stapler is placed into the lumens, and the stapler is fired to create a side-to-side jejunojejunostomy (Fig. 8.36). After checking for no bleeding points and intestinal mucosa injury, the common stab incision is closed using a laparoscopic suture (Fig. 8.37), completing the anastomosis (Fig. 8.38).

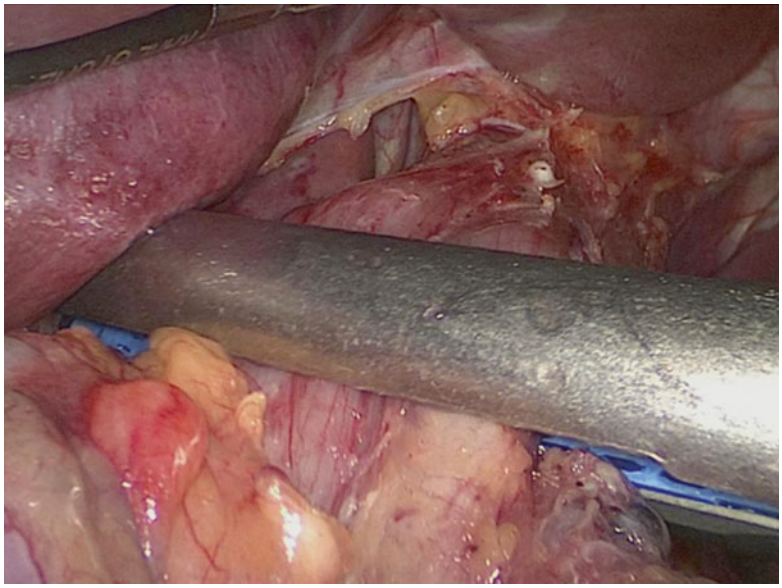

Fig. 8.27 The esophagus is transected above the cardia using a linear stapler

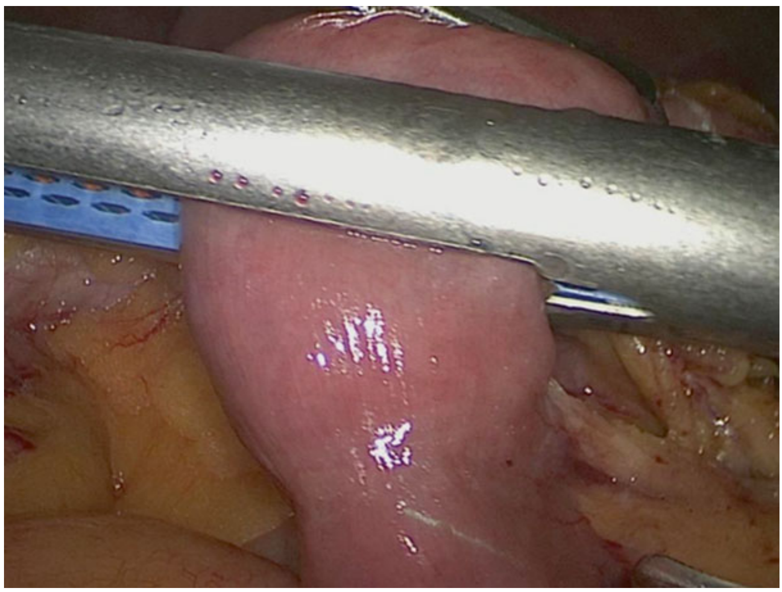

Fig. 8.28 The jejunum is transected using a linear stapler

8.3.7 Orvil™: Assisted Anastomosis After TLTG

8.3.7.1 Anastomosis Method

OrVil™ is an integrative transorally inserted device. The orogastric tube is connected to the center rod of the anvil head by the connecting thread. The anvil head is transorally inserted to work directly without purse-string sutures for the esophageal stump. The leaning anvil head at the top of the OrVil™ device is designed to facilitate its passing through the oral cavity and proximal esophagus. When the anvil head is connected to the stapler body, it automatically restores it to a horizontal position. Application of the OrVil™ device offers a clearer visual field, more convenient anastomosis, and a higher cutting edge. It successfully simplifies the difficulties of anvil

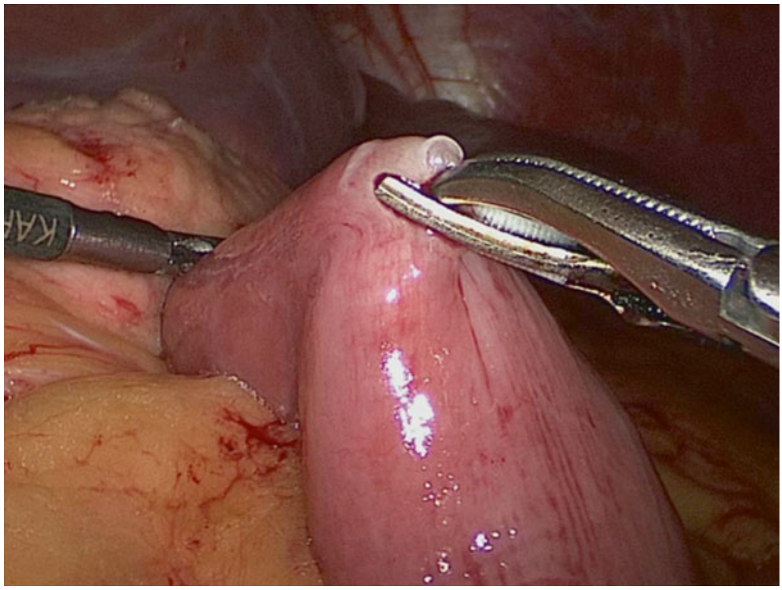

Fig. 8.29 A small hole is made on the distal jejunum

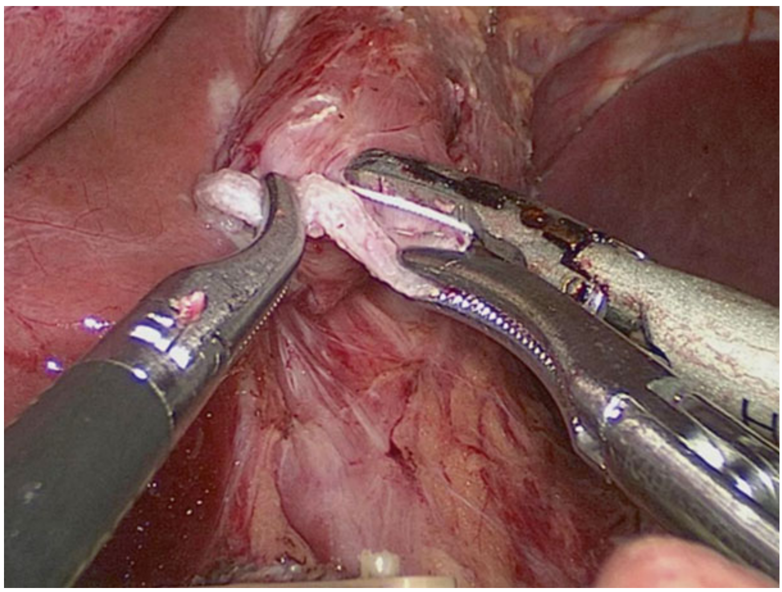

Fig. 8.30 A small hole is made on the left side of the esophageal cutting edge

placement, making the anastomosis faster and easier. An anastomosis at a higher site can also be performed. Therefore, the OrVil™ device provides ideal anvil placement during intracorporeal reconstruction of the digestive tract.

8.3.7.2 Technical Tips

After completing laparoscopic lymph node dissection and mobilization of the stomach, the stomach is pulled down to free the posterior aspect of the esophagus and the right side of the gastric cardia. The anterior and posterior branches of the vagus nerve are severed, and the esophagus is mobilized up to about 6 cm. The duodenum is transected using an endoscopic linear stapler, and the esophagus is transected >3 cm away from the upper border of the tumor (Fig. 8.39). The OrVil™ catheter stapling anvil is slowly passed

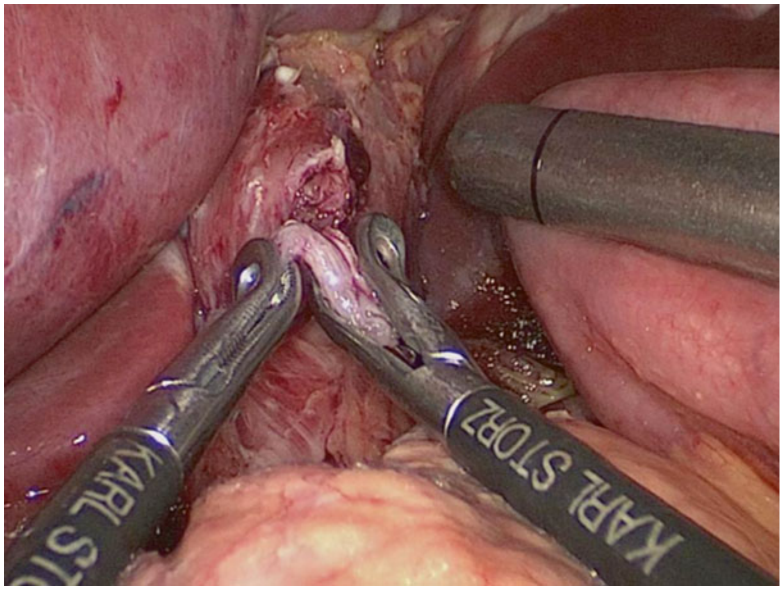

Fig. 8.31 One limb of the stapler is first inserted into the hole on the jejunum

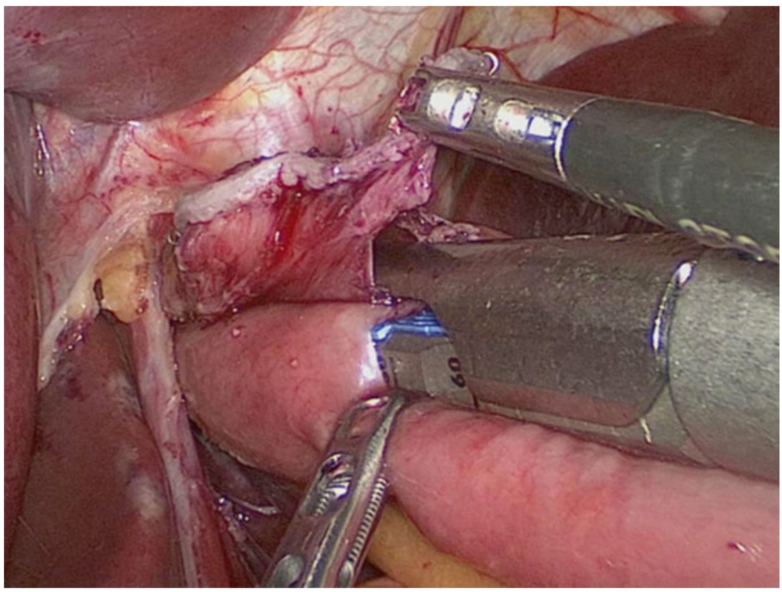

Fig. 8.32 The stapler is fired to perform the side-to-side esophagojejunostomy

transorally by the experienced anesthetist through the larynx to the stapled esophageal stump. Sufficient lubrication of the catheter and the anvil is necessary before placement, and the back of the patient's neck should be lifted. It must be confirmed that the spherical surface of the anvil faces the patient's palate when inserting the catheter. After the anvil enters the esophagus, the gasbag of the endotracheal tube is evacuated to facilitate the passage of the anvil into the esophagus with the help of a laryngoscope. A small hole that only allows the passage of the tube is created by an ultrasonic knife in the stapled esophageal stump (Fig. 8.40). Then the tube is pulled out into the abdominal cavity through the hole until the white plastic rubber ring is fully revealed (Fig. 8.41). The entire process should be gentle and slow rather than rough and hard. In case of resistance,

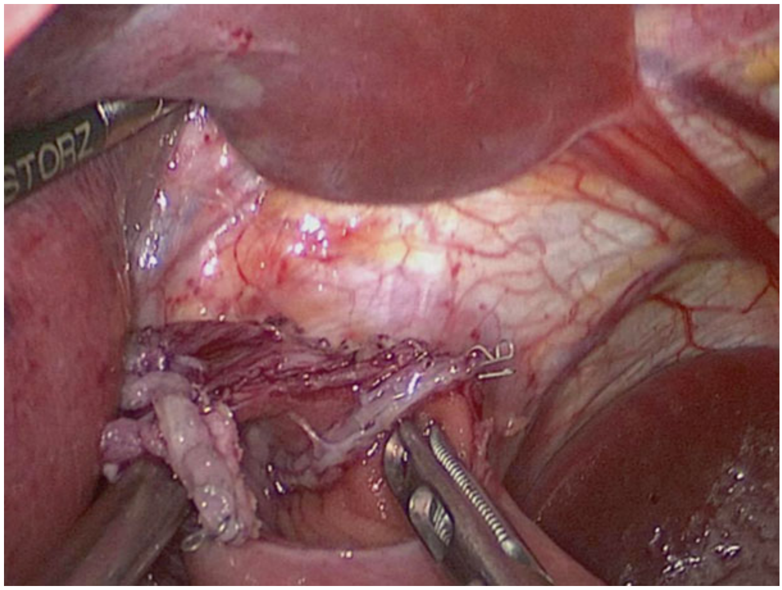

Fig. 8.33 Check the anastomosis via the common stab incision

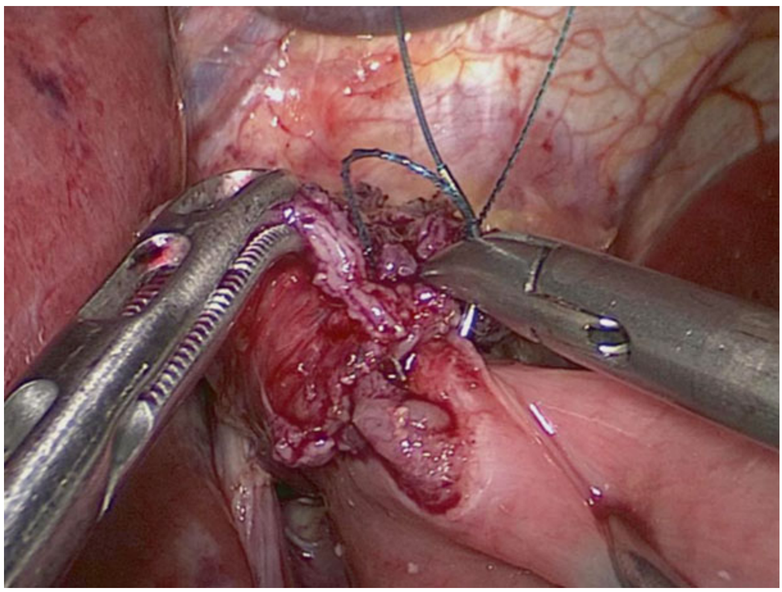

Fig. 8.34 The incision is closed using the laparoscopic suture

a little traction forces are adequate to prevent damage to the esophageal lining. The connecting thread between the orogastric tube and the anvil is cut (Fig. 8.42), and the anvil head attaches to the esophageal stump. The grasper then clamps the white part of the tube to remove it from the major hand port (Fig. 8.43). A 4–5-cm longitudinal incision is made at the midline on the epigastrium, and a wound protector is placed. The stomach is removed through the incision for pathological examination. The mesenteric border of the jejunum located 20 cm distal to Treitz's ligament is denuded up to about 1 cm, and this segment of the jejunum is then transected. The proximal jejunal stump is sutured. A 25-mm OrVil™ circular stapler is inserted into the distal jejunum and is introduced into the abdominal cavity through the minilaparotomy (Fig. 8.44).

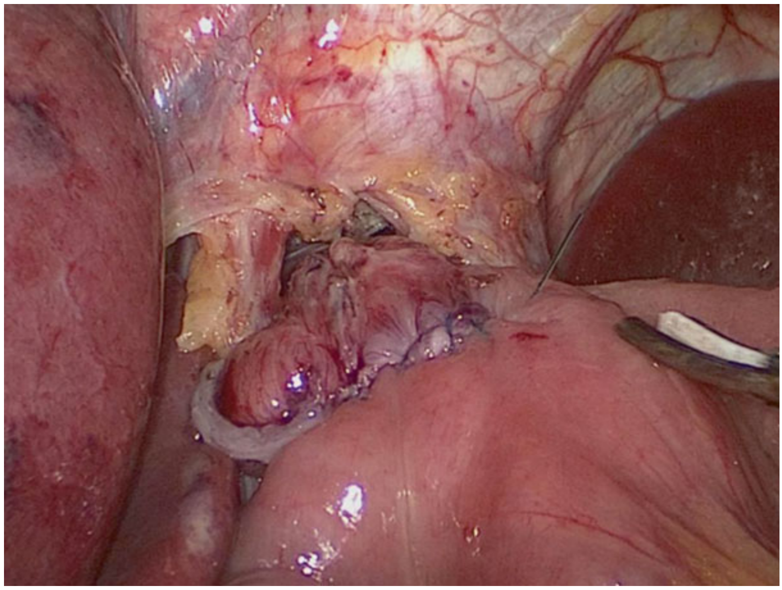

Fig. 8.35 The esophago-jejunostomy is completed

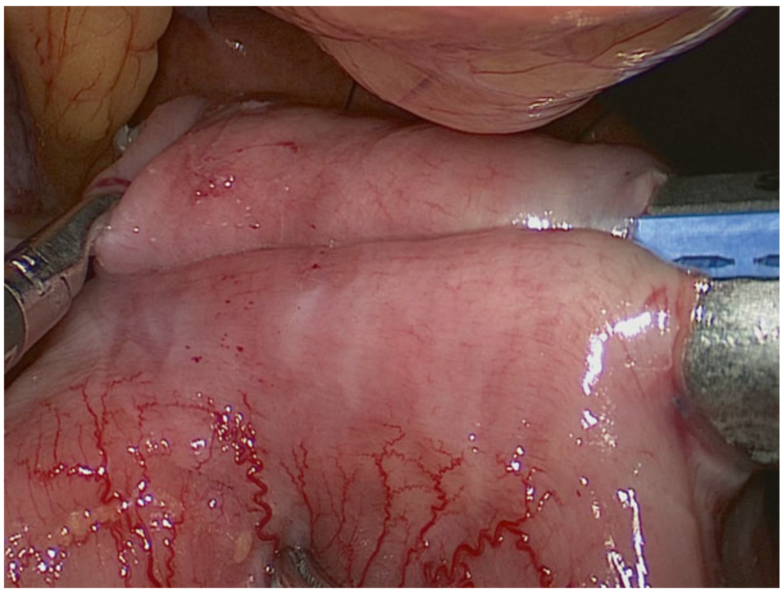

Fig. 8.36 The stapler is fired to create a side-to-side jejunojejunostomy

The pneumoperitoneum is reestablished. The anvil is connected to the circular stapler under total laparoscopy (Fig. 8.45), to create an end-to-side esophageal jejunostomy (Fig. 8.46). The distal jejunal stump is intracorporeally closed using a linear stapler.

Using the ultrasonic scalpel, small holes are made on the proximal jejunal stump and the antimesenteric border of the distal jejunal stump about 40 cm distal to the esophageal jejunostomy. Each limb of the 45-mm stapler is introduced into the jejunal lumens to perform a side-to-side jejunojejunostomy, and a common stab incision is created. After checking for no bleeding points and intestinal mucosa injury, the common stab incision is closed using a laparoscopic suture to complete the side-to-side jejunojejunostomy. We summarize clinical data of 28

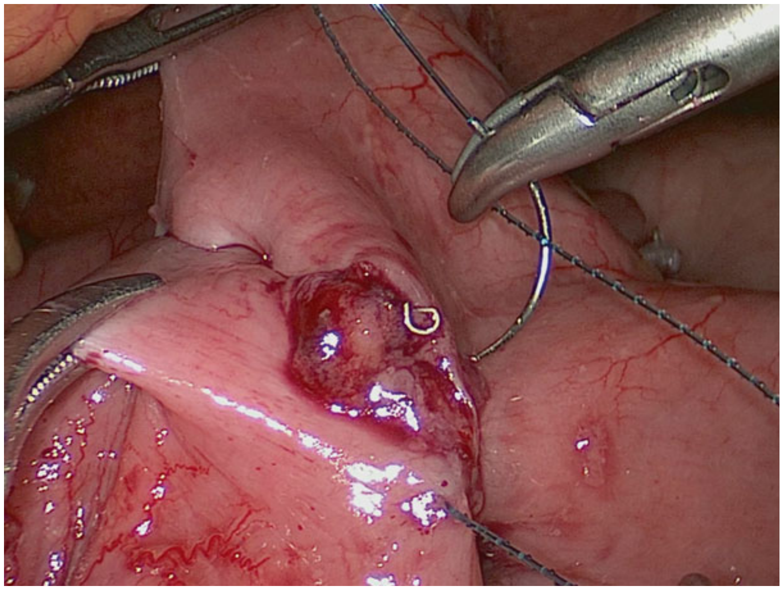

Fig. 8.37 The common stab incision is closed using a laparoscopic suture

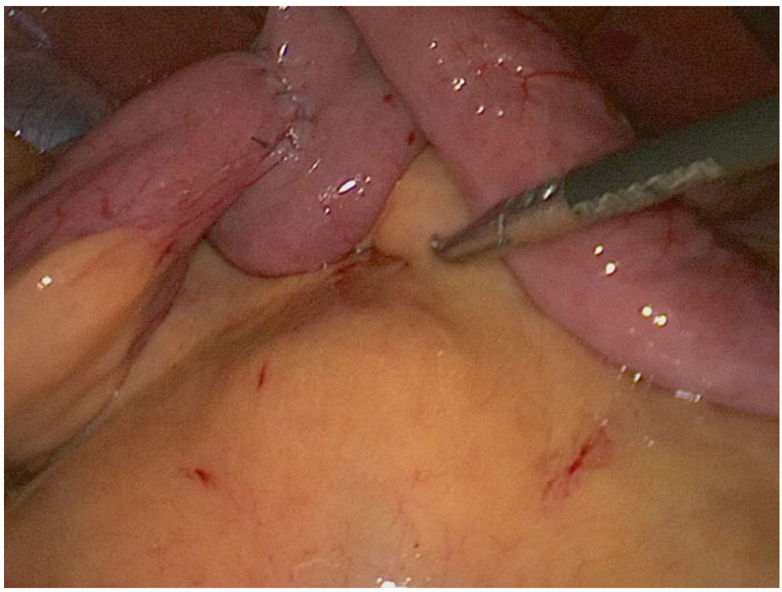

Fig. 8.38 The side-to-side jejunojejunostomy is completed

patients with gastric fundus and cardia cancer who underwent laparoscopic total gastrectomy with a Roux-en-Y-esophagojejunostomy anastomosed with OrVil™ and show that surgeries are successfully performed in all patients without conversions to open. Mean operative time and blood loss were 143 min and 70 ml, respectively. Mean number of LNs is 36.4 per patient. During the follow-up with a median of 28.6 months (24–36 months), no complications, such as recurrence, anastomosis stenosis, and reflux esophagitis, are observed. Thus, we consider that the use of the OrVil™ is technically feasible and relatively safe. It can reduce the difficulty of reconstruction without increasing the risk of postoperative complications and recurrence.

In conclusion, reconstruction of the digestive tract after laparoscopic gastrectomy faces great

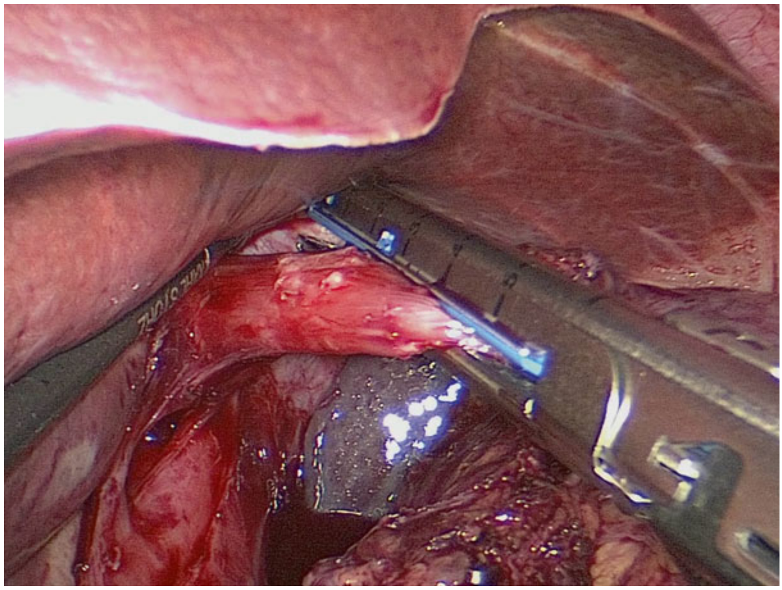

Fig. 8.39 The esophagus is transected using a linear stapler

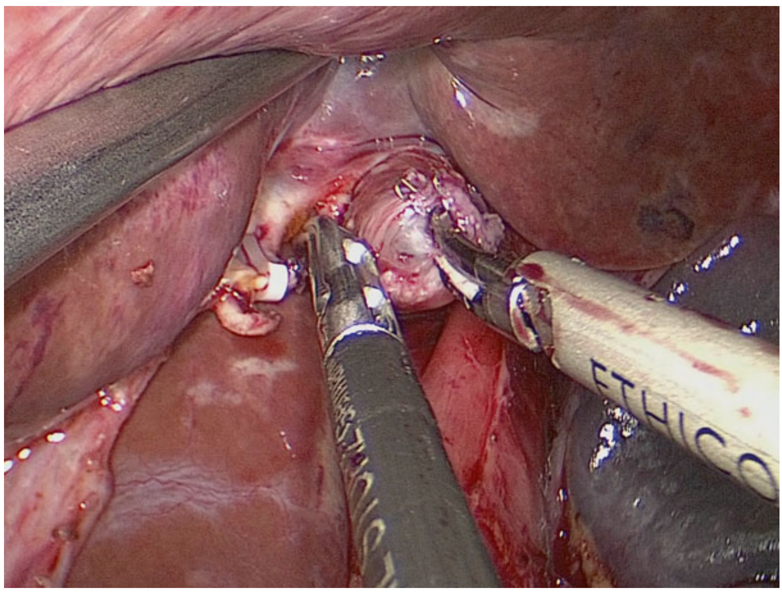

Fig. 8.40 A small hole is created in the stapled esophageal stump

challenges because of the high demand for minimal invasion and quality of life. Choosing a proper reconstruction method to minimize postoperative complications is the basic requirement in laparoscopic gastrectomy for gastric cancer. However, given the specificity and technical difficulty of digestive tract reconstruction after laparoscopic gastrectomy, it is unnecessary to pursue blindly the success and perfection of laparoscopic techniques or impose totally laparoscopic reconstruction of the digestive tract. After acquiring basic experience of open surgery, surgeons should master the surgical indications for laparoscopic gastrectomy and choose a rational reconstruction method according to tumor site, TNM stage, and extent of gastrectomy, along with characteristics of laparoscopic techniques. The superiority of laparoscopic surgery, including its minimally invasive nature, can ensure good quality of life after surgery for gastric cancer.

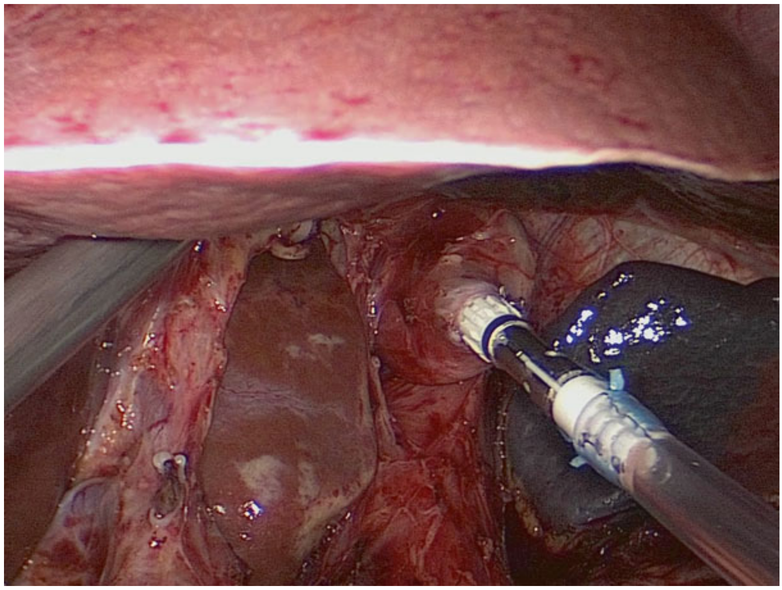

Fig. 8.41 The white plastic rubber ring is fully revealed

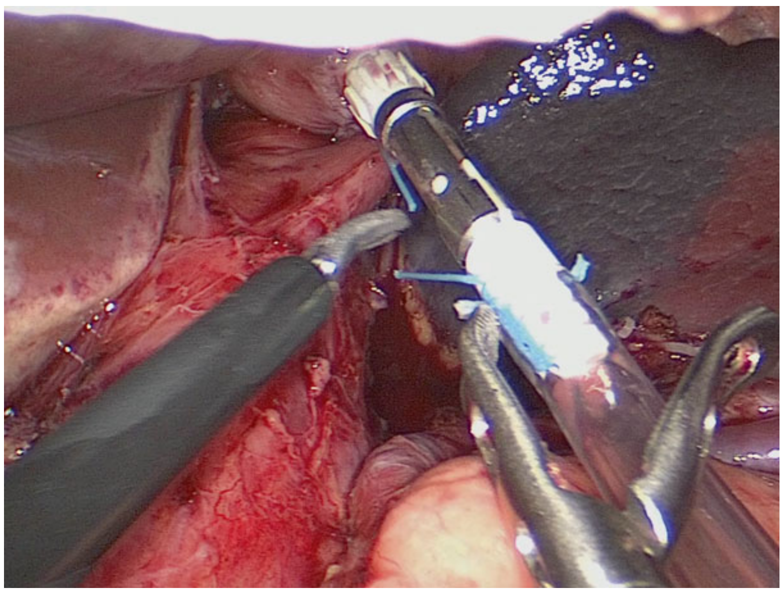

Fig. 8.42 The connecting thread between the orogastric tube and the anvil is cut

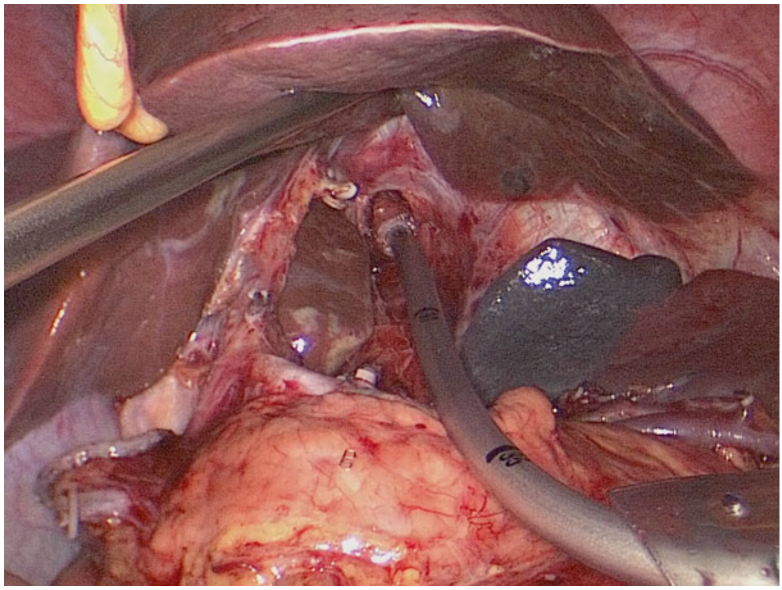

Fig. 8.43 The tube is removed from the major hand port

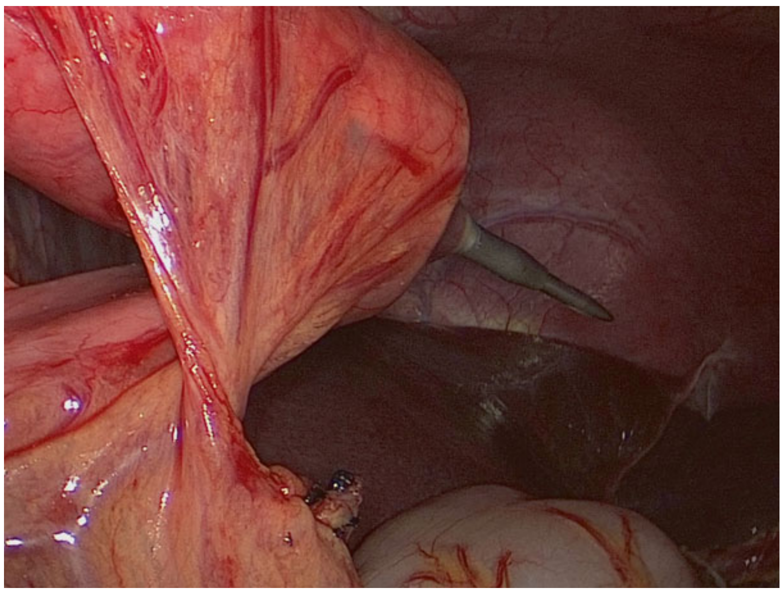

Fig. 8.44 A 25-mm OrVil™ circular stapler is introduced into the abdominal cavity through the minilaparotomy

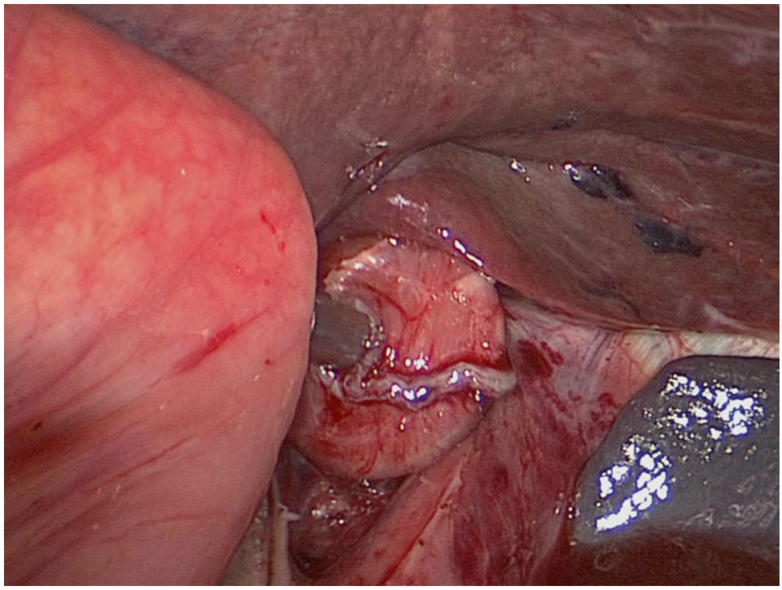

Fig. 8.45 The anvil is connected to the circular stapler under total laparoscopy

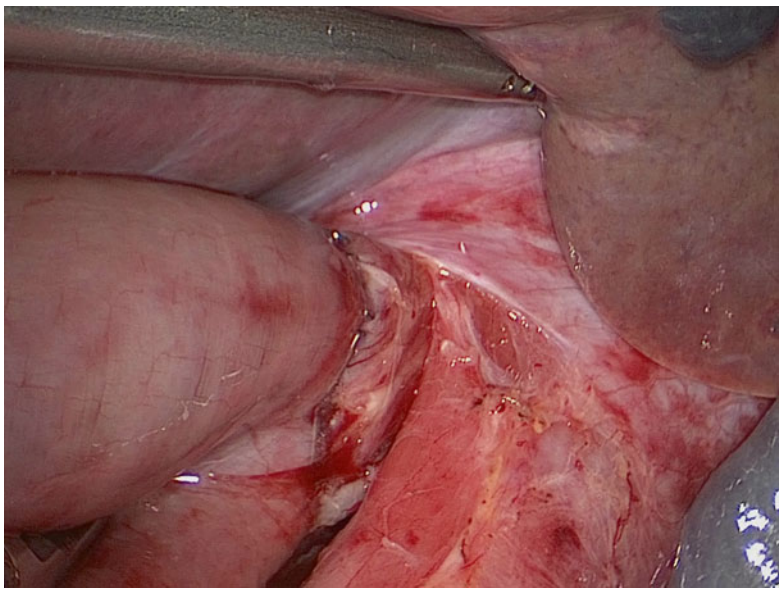

Fig. 8.46 The end-to-side esophageal jejunostomy is created

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9 Prevention and Treatment of Complications Associated with Laparoscopic Surgery for Gastric Cancer

Surgery still remains the most important treatment method for gastric cancer. With the continuous development and application of laparoscopic techniques for gastric cancer, the therapeutic range of these techniques have also been extended from early gastric cancer to advanced stage gastric cancer, and the curative effect is really inspiring. However, this surgery can only be performed by a surgeon with superior skills and extensive experiences, because of the rich vascular supply around the stomach, the complexity of the anatomical layer, and extensive lymphatic metastasis. In addition, a large number of patients with gastric cancer in China are in advanced stage, particularly those with lymph node metastasis (LNM). The safety of surgery and postoperative complications should thus be noted by all surgeons involved with minimally invasive gastrointestinal treatment. We have summarized the experiences of over 2,500 cases of laparoscopic gastric cancer surgeries, combined with the relevant literature, and discussed the reasons, classification, prevention, and treatment of the complications that occur after such surgeries.

In the Japan Society of Endoscopic Surgery (JSES) 7th, 8th, and 9th nationwide surveys, the number of laparoscopy-assisted distal gastrectomy (LADG) gradually increased (2,671 cases, 3,792 cases, and 6,651 cases, respectively), while the incidences of intraoperative (3.5 %, 1.9 %, and 1.7 %, respectively) and postoperative complications (14.3 %, 9.0 %, and 8.2 %, respectively) in LADG gradually fell [1]. In Korea, a retrospective study involving 1,485 patients from ten institutions, who had undergone laparoscopic gastrectomy (LG), found that the overall morbidity and mortality rates were 14.0 % and 0.6 %, respectively [2]. A multicenter retrospective study that included 1,331 patients with advanced gastric cancer undergoing LG was performed by the Chinese Laparoscopic Gastrointestinal Surgical Study Group (CLASS). The study reported an 11.3 % (115 patients) postoperative complication rate [3]. We enrolled 2,170 patients from our department who had received LG and found that the morbidity rate was 14.7 % (318/2,170), including major complications in 3.6 % of patients (78 cases).

9.1 Abdominal Complications Associated with Surgery

9.1.1 Intra-abdominal Bleeding

Intra-abdominal bleeding, particularly the bleeding caused by injury to large vessels, is a major complication during laparoscopic surgery and a vital reason for open conversion. Ryu et al. [4] summarized 347 patients who underwent LADG; the common hepatic artery (CHA) and splenic artery (SpA) were injured in two and one patients, respectively, and there were two cases of diffuse bleeding from the surgical field. The rate of bleeding requiring open conversion was 1.4 %

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(5/347). There are five main reasons for this complication. First, accidental injury to the adjacent vessels may occur during dissection of the lymph nodes (LNs) around the stomach. For instance, during the process of No. 8 and No. 11 LN excision, the CHA or splenic vein may be damaged; or injury to Helen's trunk, anterior superior pancreaticoduodenal vein, or colonic vein may occur when dissecting the No. 6 or No. 14v LNs. Second, insufficient identification of the vascular variation could result in hemorrhage, such as injury to the portal vein when dissection is carried out in patients without CHA, or mistaken damage to the left gastric vein (LGV) which locates at the dorsal side of the SpA when dissection of suprapancreatic LNs is performed. Third, the relevant organs and vessels are torn secondary to the application of excessive tension. For example, the spleen is torn when the greater omentum is pulled or the gastrosplenic ligament (SGL) is divided; and the LGV may be torn if the gastropancreatic fold (GPF) is elevated violently. Fourth, the anatomical plane is entered incorrectly because the layer is indistinctly identified. For instance, during the dissection of No. 6 LNs, the colonic vessels may be damaged because of incorrect entry into the plane of the transverse mesocolon. Fifth, the ultrasonic scalpel is used in an inappropriate way, such as clamping an excessive amount of tissue at one time, shearing with immoderate speed, insufficient clamping of the vessel, and other factors.

In conclusion, we consider that familiarity with the anatomical landmarks and accurate selection of the anatomical plane are crucial in preventing hemorrhage in LG. During the entire dissection process, surgery should be gradually performed from shallow to deep, enabling easy and accurate exploration of the intrafascial space. Additionally, the swollen LNs should be excised entirely to avoid bleeding from its stump. However, if vessels are injured and resultant bleeding occurs, the surgical assistant should rapidly suction blood to expose the bleeding site, while the surgeon clamps the vessel with a vascular clip to control the hemostasis. Compression with gauze is helpful for diffuse bleeding on the material organs as the pancreas, spleen, the stump of the LNs, and so on, and in uncontrollable intra-abdominal bleeding conversion to open surgery should be conducted decisively.

9.1.2 Duodenal Fistula (DF)

The DF is a major complication after radical gastrectomy. A multicenter study in Italy [5] demonstrated that out of 3,785 gastrectomies for malignant disease, a total of 68 DFs were observed (1.8 %). In addition, Orsenigo et al. [6] reported that the incidence of DF was 2.5 % (32 patients) in a study involving 1,287 patients who underwent LG and mean postoperative onset was 6.6 days. In our department, DF was present in eight patients (0.4 %) within an overall population of 2,170 patients. The main reasons for DF are as follows: first, the wall of the duodenum may be burned by the ultrasonic scalpel during the process of denuding; second, excessive tension is applied when the duodenum is severed with a linear cut stapler, leading to dropping of the suturing nail; and third, obstruction in the input loops of the jejunum results in excessive high pressure in the duodenum. Most of the DF can be cured by conservative treatment, such as abdominal cavity drainage and the use of parenteral nutrition and somatostatin. Surgical treatment can be necessary when the DF cannot be managed by the above treatments or other complications such as intra-abdominal bleeding are encountered [7].

9.1.3 Anastomotic Complications

With the development of the anastomat, incidences of anastomotic complications have been significantly reduced. Currently, anastomotic leakage, stricture, and hemorrhage are major complications related to anastomosis after gastrectomy. Of the 1,400 patients with gastric cancer who underwent gastrectomy in a study carried out by Tanizawa et al. [8], postoperative anastomotic hemorrhage was observed in 0.4 % of patients (6/1,400). Additionally, Tanimura et al. [9] evaluated 235 patients who underwent LG with D2 lymph node dissection and reported that anastomotic complications were present in 1.7 %, including leakage in two patients, anastomotic bleeding in one patient, and stricture in one patient. Our studies have shown that 1.6 % (35/2,170) of patients have suffered anastomotic complications after LG. Among these patients, bleeding, leakage, and stricture were observed in 0.5 % (11/2,170), 1.0 % (21/2,170), and 0.1 % (21/2,170), respectively. The onset of anastomotic hemorrhage usually occurs within 72 h postoperatively, mostly within 12–24 h [10]. Most of the patients can be cured by conservative treatment, while massive hemorrhage should be decisively managed by surgery. Moreover, some researchers have demonstrated that laparoscopic surgery was superior in the identification of the bleeding site, achievement of hemostasis, and evaluation of the risk of recurrent hemorrhage; it is thus the recommended treatment [11]. It has been reported that anastomotic leakage occurs in 0.5–5.9 % of patients [12–14]. From our experience, anemia and hypoproteinemia should be corrected preoperatively, and adequate blood supply and proper tension in the anastomotic stoma should be confirmed; all of these approaches facilitate the prevention of leakage. If improper anastomosis is detected after using a liner stapler, further suturing by hand should be performed to enhance it. Among patients with leakage, the majority only suffer from minor leakage which can be cured by conservative treatment. A study conducted by Kim et al. [15] has shown that, for tissue defects smaller than 2 cm in size, complete closure by means of endoscopy can be achieved in 73.1 % of patients (19/33), with an effective rate of 92.4 % (31/33). The study thus demonstrated that endoscopic treatment for anastomotic leakage smaller than 2 cm in size should be recommended. Severe leakage usually occurs in combination with an intra-abdominal abscess. Under such circumstances, unobstructed drainage should be maintained. Simultaneously, the placement of an intestinal nutrition tube in the jejunum using a gastroscope or X-rays and enteral nutrition is preferable. Anastomotic stricture after Billroth I anastomosis has been reported to occur at a rate of 1.1–8.0 % [16–19]. In addition, stricture may be associated with anastomotic leakage [20]. However, the size of stapler seems to be irrelevant regarding the incidence of stricture [21]. We should thus pay more attention to the prevention of leakage. The preferred treatment for stricture is endoscopic balloon dilation or stent implantation. Additionally, in our opinion treatment of patients with nutritional deficiency should involve placement of an endoscopic nutrition tube in the jejunum for enteral nutrition.

9.1.4 Pancreatic Fistula (PF) and Pancreatitis

Occasionally, postoperative PF and acute pancreatitis are encountered after LG. Jiang et al. [22] concluded that the incidence of postoperative PF was 0.9 % (10/1,026) in their large-scale study. Park et al. [23] reported only two patients (0.7 %) were with a fistula in a study consisting of 300 patients who underwent LG. These findings were consistent with our data (5/2,170; 0.23 %). PF and acute pancreatitis are directly related to intraoperative injury to the pancreas. For example, the lingular lobe of the pancreas or the pancreatic tail may be incorrectly regarded as LNs during the No. 6 or splenic hilar lymph node dissection, respectively. Additionally, if the functional face of the ultrasonic scalpel is placed close to the pancreas during the process of separating the pancreatic capsule, the pancreatic parenchyma may be injured. PF can cause intra-abdominal infection or an abscess with a low incidence rate, even leading to systemic infection or a massive intra-abdominal hemorrhage, endangering the patient's life. It should thus be noted by surgeons. When fistula occurs, persistent peritoneal lavage with double-sheath tube should be applied, together with the inhibition of pancreatic secretion. Surgical treatment for drainage and lavage should be performed if necessary.

9.1.5 Lymphatic Fistula (LF)

Because of the common use of the ultrasonic scalpel for shearing and separating, the incidence of postoperative LF should in theory be lower than that for conventional open surgery. In our data from 2,170 patients who had undergone LG, no major LF (with a volume >1,000 ml/24 h) was observed. We conducted a statistical analysis of the data from 1,366 patients and found that postoperative minor LF (with a volume of 30–100 ml/24 h) occurred in 4.2 % of patients (57/1,366). The occurrence of LF is strongly linked with ignorance regarding the correct management of the stump of the lymphatic vessel. Therefore, wounds in the region of the No. 7, 8, 9, and 12a LNs should be focused on and clearly checked. If ivory or gelatinous fluid is detected, meticulous suture and placement of the drainage tube is vital. LF in the majority of patients can be healed by conservative treatment, such as fluent drainage, the use of parenteral nutrition, and maintenance treatment regarding the water electrolyte balance. However, the necessity for surgical treatment should be considered with caution.

9.1.6 Ileus

The incidence of postoperative ileus following LG was significantly lower than using conventional open surgery [3]. Adachi et al. [24] reported on 49 patients undergoing LADG for early gastric cancer; of all these patients only one (2.0 %) ileus was observed. Analysis of data from our department indicated that the incidence of ileus was 1.1 % (24/2,170). Among the complicated reasons for postoperative ileus, adhesion and inflammation is the main one [25, 26]. To decrease the incidence of ileus, adequate intestinal preparation is important. It is helpful to facilitate a reduction in intra-abdominal pollution following digestive tract reconstruction, as well as to reduce the inflammatory reaction in the abdominal cavity. When the wound has achieved complete hemostasis, the hole in the mesentery should be closed. The clinician should also encourage the patient to get out of bed as early as possible for exercise and other activities. Additionally, laparoscopic surgery has been demonstrated to be an excellent precautionary measure [27]. Lee et al. [28] compared 1,002 patients who underwent LG and 629 with open gastrectomy. The incidence of ileus in the LG group (0.6 %) was significantly lower than that in the open gastrectomy group (1.1 %). If a patient is expected to suffer from ileus, their vital and abdominal signs should be closely observed. Once the ileus tends toward intestinal strangulation, it should be managed decisively by surgery.

9.1.7 Delayed Gastric Emptying

Delayed gastric emptying is an early postoperative complication following subtotal gastrectomy, and the incidence varies greatly between different centers. Ryu et al. [4] reported only one patient suffering from gastroparesis out of a total of 347 patients undergoing LG, with an incidence of 0.3 %. Conversely, Adachi et al. [24] observed two patients suffering from such a complication in an overall total of 49 patients (4.1 %). Our data showed that delayed gastric emptying was observed in 0.9 % of patients (20/2,170). The etiology for this complication is complex. It has been reported that surgical stress may excite the sympathetic nerves leading to inhibition of the gastrointestinal smooth muscle. This seems to be related to gastroparesis [10]. In therapy, conservative treatments could be adopted, including fasting, continuous gastrointestinal decompression, promoting intestinal peristalsis, and parenteral nutrition. Full communication may be useful in increasing patient confidence. Moreover, surgical treatment should be avoided after excluding mechanical obstruction.

9.2 Systemic Complications

Laparoscopic surgery has been demonstrated to have the advantage of being a minimally invasive procedure, as well as decreasing systemic complications [23, 29]. A study conducted by Lee et al. [28] demonstrated that the most frequent systemic complication following LG was pulmonary, occurring in 2.2 % of patients (22/1,002); no patients suffered from myocardial infarction and hepatic failure (0/1,002). However, in the open surgery group, the above complications were observed in 6.4 % (40/629), 0.2 % (1/629), and 0.2 % (1/629) of patients, respectively. Another prospective randomized control trail in Korea indicated that the incidence of pulmonary complications in the LG group (8.3 %) was significantly lower than that in the open surgery group (30.4 %) [30]. As a result, laparoscopic surgery has been demonstrated to be an effective measure in reducing systemic complications. The principle for the management of complications was consistent with open surgery.

9.3 Complications Associated with Pneumoperitoneum

Complications associated with pneumoperitoneum include subcutaneous emphysema, gas embolism, and hypercapnia, among others. A study by Lee et al. [28] reported that the incidence of subcutaneous emphysema was 1.2 % (2/1,002). In most patients, it resulted from incorrect insertion of the Veress needle into subcutaneous tissues, while in some of the patients the carbon dioxide emitted into the abdominal cavity spread from the port of insertion to the subcutaneous tissues. Severe emphysema may also lead to gas embolism. The hypercapnia might occur when exogenous carbon dioxide rapidly diffused into the circulatory system through the peritoneum due to its high solubility in blood and the body cannot compensate it. Therefore, the pressure in the pneumoperitoneum should not be too high (10–15 mmHg is appropriate) as to reduce the pressure gradient between the abdominal cavity and the blood. When only a small range of subcutaneous emphysema or a mild hypercapnia occurs, the surgeon could closely observe it without manipulation and try to shorten the operation time. However, if the vital signs of the patient changed during the surgery, open conversion should be performed.

9.4 Complications Associated with the Insertion of a Trocar and the Accessory Incision

Injury to the epigastric arteries, retroperitoneal vessels, or intestinal tubes during insertion of a trocar is a specific complication associated with laparoscopic surgery. Kim et al. [29] reported that bleeding at the port of insertion was present in 0.9 % of patients (2/291), but none required open conversion. No case of injury to the retroperitoneal vessels was reported. However, we experienced one case in which the inferior mesenteric artery was damaged during insertion of the observation port, and it finally led to open surgery. Therefore, although complications associated with the insertion of a trocar are seldom encountered, they may endanger the patient's life once they occur. Open conversion should be performed if necessary to achieve hemostasis. Moreover, a major hand port can be created first if adhesion is considered to be present in the midline of the abdomen. The lens is introduced into the abdominal cavity from this trocar to explore the situation. This enables safe insertion of the observation port under direct view.

Implantation metastasis at the trocar site, or the accessory incision resulting from LG, is also an important subject regarding evaluation of the feasibility of implementing laparoscopic techniques in gastrectomy. Some researchers [31] have reported that there were no significant differences in the incidence of implantation metastasis, between laparoscopic surgery and open surgery. Throughout the surgery, the specimen should be resected and removed in accordance with the principle of "no-touch" and the "en bloc resection," and the insertion port and accessory incision should be well protected. Laparoscopic surgery can be safe with these manipulations without increasing the risk of implantation metastasis.

In conclusion, LG remains as a difficult surgery that can only be performed by surgeons with extensive experience in open operations, proficient laparoscopic surgical techniques, and the courage required for reoperation. After stepping over the learning curve, LG has been demonstrated to be safe. The incidence of operation-related complications in LG is no higher, or even lower, than that in open surgery.

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