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Laparoscopic Liver Resection

Theory and Techniques

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Preface

Since the first laparoscopic cholecystectomy was performed in 1987, almost 30 years have elapsed. Although laparoscopic technique had been gradually applied in almost every area of surgery, laparoscopic liver resection (LLR) underwent a slow development all over the world since the first case was performed in 1991, especially in the first decade, mainly due to sophisticated anatomy, risk of bleeding, lack of ideal instrument, and concern for adequate margins in resection of malignant tumors. As a result, there were only a few cases of LLR performed, most of which were resections of solid tumor limited in the left lateral section or the margins and cystic fenestration, and the feasibility and efficiency of LLR had been questioned.

We have been performing LLR since 2001 and reported the first case of laparoscopic hemihepatectomy, laparoscopic right trisegmentectomy, laparoscopic modeling left lateral sectionectomy, single-incision laparoscopic liver resection, and retroperitoneal laparoscopic liver resection in China or all over the world. Based on those experiences, we established our unique technique and theory system of anatomic laparoscopic liver resection, which is characterized by precontrol of the blood supply of the to-be-resected area and prevention of bleeding, and have performed over 1000 cases of laparoscopic liver resection to date.

Benefiting from technique development and experience accumulation, in the recent 10 years, the application of minimally invasive technique in hepato-pancreato-biliary surgery had underwent rapid development, and LLR has been generally accepted after the Louisville Statement was announced in 2008. According to the literature, more than 3000 cases of LLR have been reported worldwide by 2014, and 50% of them were applied for malignant lesions. Not only the number of LLRs but also the ratio of major liver resections increased, and LLR for lesions in every segment was reported. The location of lesions was no longer considered as a contradiction for LLR anymore, and it was generally accepted that minimally invasive surgery has advantages such as smaller local trauma, milder systemic reactions, less operative blood loss, shorter hospital stay, lower morbidity, and better cosmetic results.

Despite all the achievements above, minimally invasive surgery is still not the majority of operations in hepato-pancreato-biliary surgery until now, not only in China but all over the world, and the technique varies from center to center, leading to difficulty in popularization. Thus, based on the experience of our LLR cases and the modeling or stylized surgery idea, we wrote this book, with plenty of pictures

that demonstrate the operative and technical details presented, hopefully, to serve as reference and thus facilitate other centers to perform minimally invasive surgery.

As the first English book of our team, we do know that there are still some limitations of this book, and we are more than glad to receive judgments from peers all over the world, to make this book better and benefit more patients. Also, we will publish books focusing on laparoscopic pancreatectomy and robotic hepato-pancreato-biliary surgery, which will overcome the known difficulties during writing this book and hopefully be better.

On behalf of all the surgeons in our team, I would like to express my sincere acknowledgment to Academician Wu Mengchao and Academician Huang Zhiqiang, who are my mentors and had been supporting and guiding our team to perform minimally invasive surgery. We also would like to thank all the colleagues from the Department of Anesthesiology, Department of Nursing, Department of Intensive Care Unit, Department of Radiology, and so on, who helped us a lot to perform the surgeries. And thanks to all the patients, for trusting us and for being supportive to our writings.

Beijing, China Rong Liu

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Laparoscopic Anatomical Hepatectomy

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Abstract

Over the past 20 years, laparoscopic liver resection (LLR) has gone through a stirring process of innovation, development, and exploration. LLR nowadays is almost as important as OLR,. As an evolving surgical technique, LLR has its own inherent problems too. Laparoscopic anatomical hepatectomy (LAH), instead of laparoscopic regular hepatectomy, according to our experience, stands for the laparoscopic regional resection of hepatic tumor or hepatic segment(s), based on the regional control of blood supply. In this chapter, we will discuss what is LAH, its advantages and disadvantages and some key techniques.

Over the past 20 years, laparoscopic liver resection (LLR) has gone through a stirring process of innovation, development, and exploration (Fig. 1.1). In some resections (e.g., hepatic left lateral lobectomy), LLR is even expected to replace open liver resection (OLR) to become the gold standard procedure, just as laparoscopic cholecystectomy once did (Chang et al. 2007). Upon the whole, LLR nowadays is almost as important as OLR, with obvious superiorities including less blood loss and shorter length of hospital stay.

According to our experience, there are three key factors worthy of more attention in current practices: appropriate selection of indications and patients, full understanding of surgical instruments, and standardization of the procedure (Dagher et al. 2009).

As an evolving surgical technique, LLR has its own inherent problems even with the impressive improvement in the instruments and clinical experience. The wholly new surgical perspectives, pneumoperitoneum environment, special operative instruments, and other features together indicate that LLR might have its unique regularities different from those of OLR. The surgical experience of performing OLR can not help the surgeons to perform LLR directly. In some cases, the shackle of the old concept in OLR might lead to disastrous consequences in LLR. It is reasonable to adopt more stringent indications in LLR than in OLR. The size and

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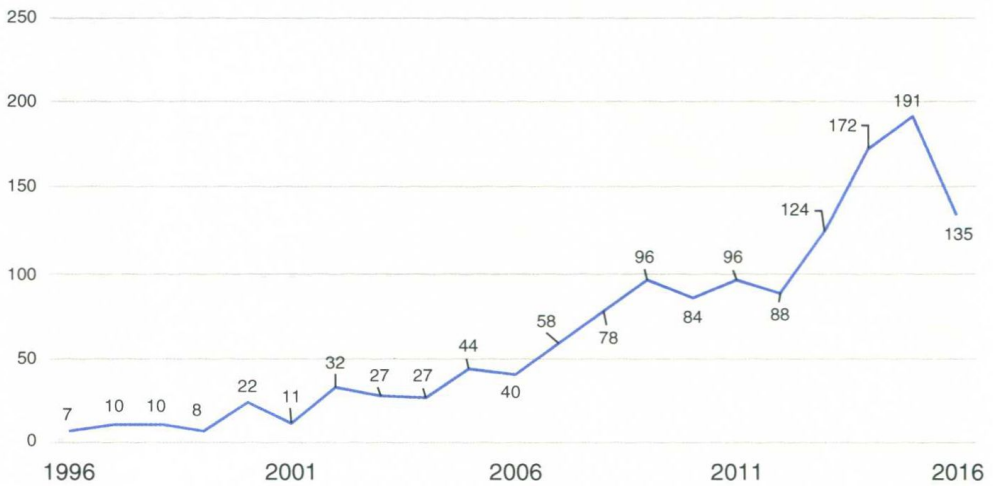

Fig. 1.1 The dramatically increased number of literatures about LLR

location of a liver tumor, and its spatial relationship with the liver hilum, major hepatic vessels and inferior vena cava, should be carefully reviewed before surgery. If a clear transection plane can be determined laparoscopically, LLR is preferred. Tumor size alone has not been the contraindication of LLR anymore. However, the choice between LLR and OLR should not change the consequent size of resection distinctly. Laparoscopic right hepatectomy resection is relatively easier than right posterior sectionectomy (Segments 6+7). If right posterior sectionectomy is sufficient for the lesion, open surgery should be adopted rather than laparoscopic right hepatectomy resection.

The newly published international consensus has given a panoramic understanding of this issue (Wakabayashi et al. 2015). Due to the lack of the tactile sensation, the cutting planes of liver resection were mainly determined by the preoperative imaging, landmark of the liver, and intraoperative navigation, rather than the hands of surgeons. Just like two sides of a coin, theoretically, LLR has advantages in surgical oncology for its essence of "no-touch" techniques. The full assessment of its surgical and oncological long-dated outcomes is still in progress. On the other hand, the advanced surgical instruments have played a much more important role in LLR than OLR. OLR could be performed using the simple crush-clamp technique without any energy device. The whole history of LLR has progressed on the basis of improvement of various energy equipments and stapling apparatuses. Laparoscopic surgeons must have full knowledge of the strength and limitations of tools available. This is the key to give full play to the devices and to avoid any unwanted complication.

Meanwhile, there exists a high imbalance in the practice of LLR geographically and individually. Some leading surgeons have already successfully completed the anatomically accurate segmentectomy of all the Couinaud segments, which almost eliminated the absolute technical contraindications of LLR (Ishizawa et al. 2012). In most of the other hospitals, LLR remains to be a technically challenging surgery

and the peripheral non-anatomic liver resections are more preferred to perform laparoscopically. LLR has not become a standardization operation, because the complications may be more difficult to control laparoscopically than the procedure itself. The relative contraindications of LLR are changed with the advances of surgeons' techniques. There is still a long way to achieve the standardization and promotion of LLR.

1.1 What is LAH?

Laparoscopic anatomical hepatectomy (LAH), instead of laparoscopic regular hepatectomy, according to our experience, stands for the laparoscopic regional resection of hepatic tumor or hepatic segment(s), based on the regional control of blood supply (Fig. 1.2), which is more technical complicated than open anatomical hepatectomy. Generally speaking, it means a surgical idea that we have to control the blood supply before resection of the tumor. For regular resection, LAH means effective inflow and outflow blood control before resection, and for irregular resection, it means effective feeding vessel control before resection.

LAH often requires more special techniques. To better expose the target region and critical anatomic structure of the liver, the patient position and trocar distribution should be arranged jointly and flexibly, which leads to a series of innovations such as trans-thoracic LAH (Hallet et al. 2015) and retroperitoneal LLR (Hu et al. 2011). Laparoscopic intraoperative ultrasonography is important for laparoscopic anatomical hepatectomy, especially for those less experienced surgeons, which is the last chance for a surgeon to confirm the intrahepatic structure before parenchyma dissection, including the location of the tumor and its spatial relationship with the major hepatic vessels, tumor-bearing portal pedicles, and landmark hepatic vein.

Anatomical hepatectomy (AH) has three technique characteristics: identification and transection of the portal pedicle, ischemic line-guided parenchyma dissection, and full exposure of related hepatic vein in the raw surface of the remnant liver. It is generally believed that REAL anatomical hepatectomy should possess these three features indispensably.

In our opinion, the three characteristics are not identical in terms of their importance. Identification and transection of the portal pedicle is the most fundamental step for anatomical hepatectomy, and usually constitutes the basis for the other two characteristics. Only if the portal pedicle is identified, the subsequent ischemic line could be revealed. The process of hepatic vein exposure is essential to the establishment of the cutting plane and parenchyma dissection. This is the most essential characteristic of anatomical hepatectomy.

With the understanding of the above, the concept of LAH could be expanded, with the main focus on the extent of resection, besides complete resection of the Couinaud segments and their combination. Wakabayashi brought up "laparoscopic limited anatomical resection" (Yoon et al. 2013), and used the limited anatomic sub-segmental resection to replace the central bisegmentectomy. The merits of LAH, such as less

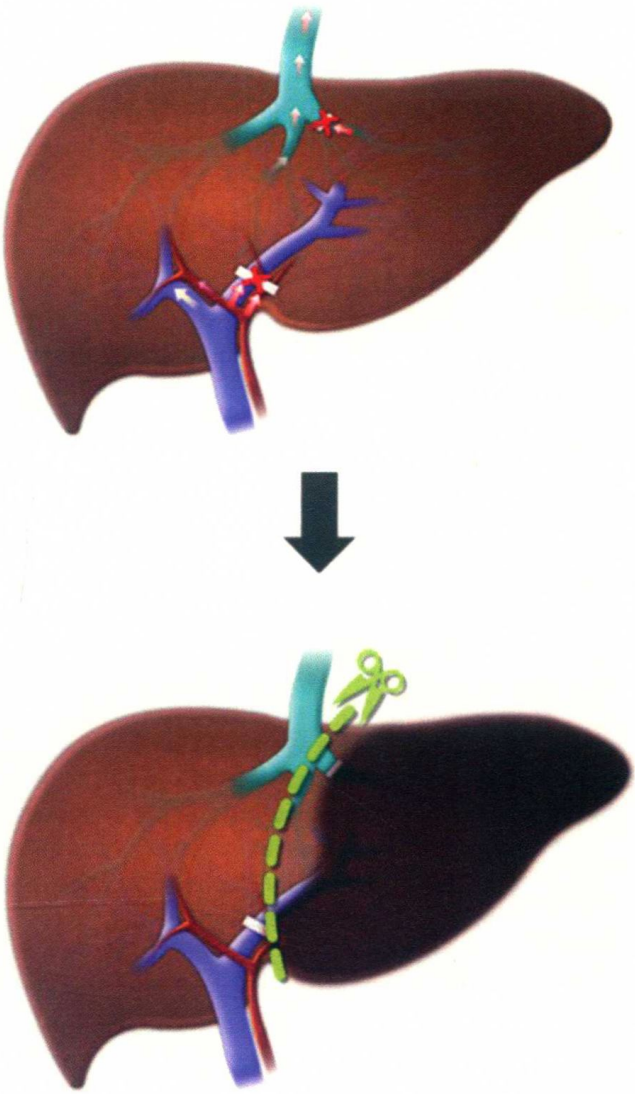

Fig. 1.2 The scheme of LAH

blood loss and clear cutting boundaries, have been inherited, while more normal liver parenchyma is preserved. Takahashi defined the subunit of Couinaud segments as a cone unit (Yamamoto et al. 2014). Each cone unit contains a single tertiary Glissonean branch and its territory parenchyma. Couinaud segments consist of three or four cone units. The idea deepened the understanding of the nature of LAH. Actually, exposure of the hepatic vein may be adopted by non-anatomic partial hepatectomy to guarantee the enough margin in LLR (Yoon et al. 2013).

According to our practical experience, to expose the full landmark hepatic vein is relatively demanding than identification of the portal pedicle and parenchyma dissection. If those surgeons with less experience recklessly dissect the parenchyma around the main hepatic vein, uncontrollable bleeding might be caused, which is more difficult to fix by the same surgeon laparoscopically. There essentially exist some

compromises due to the level of current laparoscopic surgical practice. In fact, sufficient margin may play a more important role than exposure of the entire hepatic vein.

LAH should be a clinically feasible and flexible strategy, rather than to just find the boundaries and root according to the Couinaud liver segments. Laparoscopic anatomic hepatectomy is not equivalent to laparoscopic segmental resection or all sorts of their combination.

1.2 Why Choose LAH?

The role of LAH is built on its surgical and oncological values.

LAH could reduce intraoperative blood loss, decrease the incidence of postoperative biliary leak and other complications, minimize the loss of normal liver tissue, accelerate postoperative recovery, and provide the possibility of repeated liver resection. The parenchyma dissection by LAH is accompanied with a linear "vessel-less" plane. This decreases the injury possibility of the small branches of artery, portal vein, and bile duct. The irregular multidimensional transection plane of the non-anatomic liver resection could cause more unpredictable vessel injuries. Through a segment-based liver resection and its variants, we could preserve as much normal parenchyma as possible while ensure a enough surgical margin. The adequate margin is the key to prevent tumor recurrence, while enough liver preservation contributes a lot to postoperative recovery, especially for those with liver cirrhosis. LAH also causes less postoperative abdominal adhesions. Once tumor relapse occurs, repeated LAH could be performed. Most importantly, LAH can be used for tumors located at any region only if it is suitable for resection as discussed above, including those centrally located tumors (Yoon et al. 2013).

The patients of hepatocellular carcinoma (HCC) benefit markedly from anatomic hepatectomy oncologically. HCC has the pathologic features of spreading along the portal vein. Through complete resection of the liver section or segment with its portal pedicles, anatomic hepatectomy eliminates the potential intrahepatic metastasis of HCC as much as possible. The overall survival of HCC could be improved by anatomic hepatectomy (Hasegawa et al. 2005). It is well believed that the patients with metastatic tumor, such as colorectal liver metastasis (CRLM), may benefit less from anatomic hepatectomy than from HCC (Kokudo et al. 2001). However, there are some exceptions. For those CRLM's location is deep, LAH could prevent the parenchymal division from the positive margin. The tumor boundary could turn out to be fuzzy after the neoadjuvant chemotherapy. LAH could then become a more reasonable and reliable choice to guarantee sufficient surgical margin than non-anatomic hepatectomy.

LAH has the same inherited oncological value as the traditional open anatomic hepatectomy. Meanwhile, LAH also involves almost all the necessary techniques for laparoscopic non-anatomic hepatectomy, which in turn makes it become the fundamental technique for all laparoscopic liver resection. The standards of these basic techniques are relatively high and worthy of promoting.

1.3 Key Issues and Technique Details

1.3.1 Identification of Portal Pedicles and Root of Hepatic Vein

The main hepatic vessel control approaches, including the portal pedicles and root of hepatic vein, have been shown in Fig. 1.3. The simultaneous control of portal pedicles and hepatic vein, as the inflow and outflow vessels respectively, is the classic pattern of "bloodless" hepatectomy.

There are essentially three approaches for identification and transection of the portal pedicles: hilar access approach, Glissonean pedicle approach, and fissural approach (Yamamoto et al. 2014).

The hilar access approach means the dissection is in the sheath between the hepatoduodenal ligament and hilar plate. It is an extrahepatic approach without dissection of the liver parenchyma. With this approach, the secondary branches of the liver artery, portal vein, and bile duct could be dissected and controlled separately. The hepatic parenchyma could be often dissected and surgeon should try to control the tertiary branches of the hilus vessels at the same time. The hilar access approach is a delicate and demanding surgical procedure. Due to the common variations of hepatic artery (Figs. 1.4 and 1.5) and bile duct, the dissection in the fascia could be dangerous. The injuries to the hilus artery and portal vein might cause drastic consequences.

The hilar access approach was used mainly in the early stage of LAH. It has been considered to be time consuming and difficult to master. This technique may be more suitable for radical lymphadenectomy of the liver hilus rather than the liver resection itself.

The Glissonean pedicle approach can be achieved with or without parenchyma dissection. The extrahepatic approach (usually for hemihepatectomy and sectionectomy) is relatively easier than the intrahepatic approach (usually for segmentectomy), and thereby determines that the segmentectomy is more challenging than the major hepatectomy. Due to the essence of extra-fascial dissection, the Glissonean pedicle approach is much safer than the hilar access approach for less incidence of injury to the hilar vessels (Yamamoto et al. 2014).

The extrahepatic Glissonean pedicle approach is commonly used in the secondary branches near the hilus. The Glisson's capsule between the hilar plate and liver substance is incised, with the help of gentle opposite traction of the quadrant lobe and hepatoduodenal ligament. The confluence of secondary portal pedicles was then exposed and easy to manipulate. A common scenario is that the confluence of anterior and posterior portal pedicle is revealed at same time. After transection of one of the secondary portal pedicles, the relevant ischemic demarcation line becomes observable.

The intrahepatic Glissonean pedicle approach is usually used in the segmentectomy such as the segments 2, 4a, 5, 6, 7, and 8. When the portal pedicles of the segment are hard to control out of the liver substance, the parenchyma is dissected along an assumed boundary line to find the root of the portal pedicles. This line could be roughly determined with the help of the hepatic surface landmark or

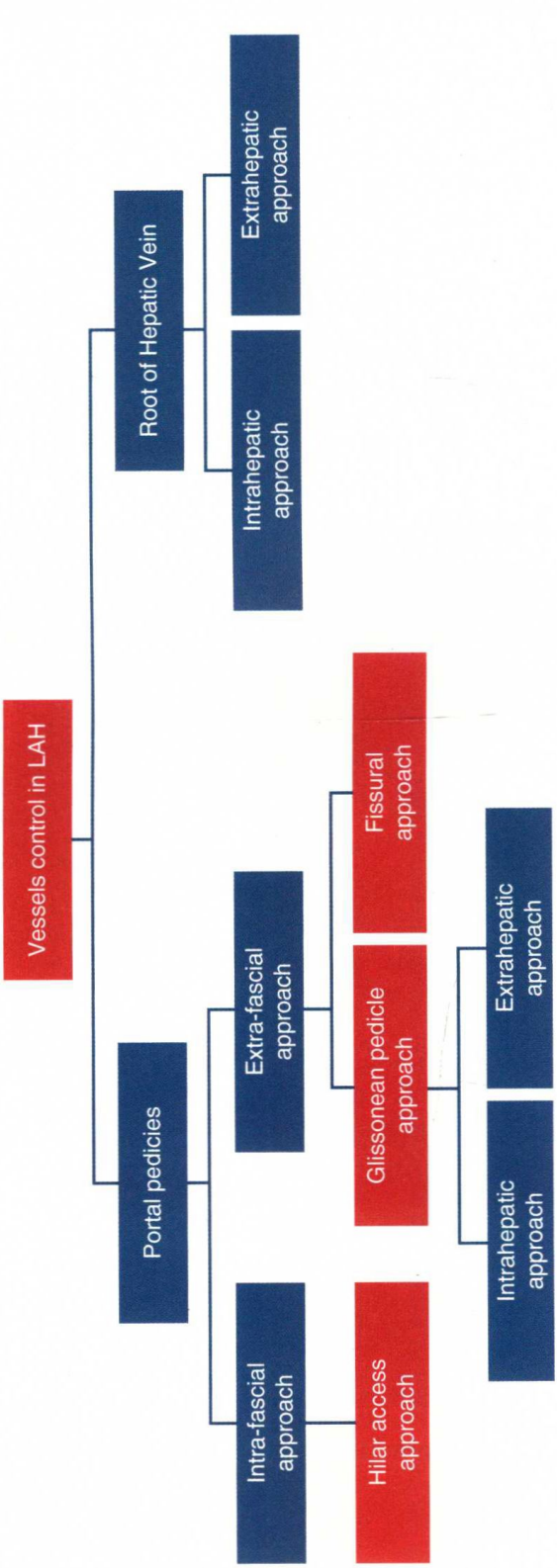

Fig. 1.3 Classification of main vessel control approaches of LAH