

**Review**

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# Laparoscopic Liver Resection for Hepatocellular Carcinoma: Korean Experiences

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**Key Words**

Laparoscopy · Liver resection · Hepatocellular carcinoma

**Abstract**

The development of laparoscopic liver resection (LLR) has been slow due to technical difficulties. Therefore, LLR has been limited to easily accessible lesions. Recently, this procedure has been well applied to hepatocellular carcinoma. However, until now, the indications for LLR have been tumors in the peripheral portion of the anterolateral segments of the liver (segments II, III, V and VI and the inferior part of IV according to the classification of Couinaud). Due to the growing interest in LLR, there have been many attempts to apply this technique in difficult locations. The lesions in the posterior or superior part of the liver (segments I, VII, VIII and the superior part of IV), which are considered to be poor indications for LLR, have been reported to be successfully operated on by laparoscopic surgery. Accordingly, this laparoscopic approach has become similar to open surgery in many ways. One of the major advancements of LLR is anatomic liver resection including major and minor resection. Laparoscopic mono- and bisegmentectomies have also become possible with growing experience. There are a variety of monosegmentectomies and bisegmentectomies. The common representatives of bisegmentectomies are left lateral sectionectomy, right anterior sectionectomy and right posterior sectionectomy. The common operative types of monosegmentectomies are S4, S5, and S6 monosegmentectomies, etc. Central bi-sectionectomy will also be discussed. The Glissonian approach has been useful for these types of anatomic liver resection. The difficulty of controlling hemorrhage has been overcome by performing meticulous surgical techniques with newly developed instruments, and intraoperative sonography has been used to locate the lesions and guide the resection plane even for deep-seated or invisible lesions. Further accumulation of experience and technical refinements will make these challenging procedures more reproducible and safer.

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## Introduction

The indications for laparoscopic liver resection (LLR) have been changed a lot since its introduction. In the early stages of LLR, this procedure was generally only used for benign diseases. With the increasing knowledge about this procedure, the indications have moved to malignant diseases as well, including hepatocellular carcinoma (HCC) and colorectal liver metastasis. The extent of resection has also become wider with time. Initial procedures have been tumorectomy or left lateral sectionectomy. Recently, major liver resections, such as right and left hemihepatectomies, have been performed more frequently [1–5]. Another new trend in LLR is segment-oriented anatomic liver resection. As patients with HCC have concomitant chronic liver disease and cirrhosis, it is desirable to resect the liver as minimal as possible. Therefore, limited resection may be beneficial to these patients. If this limited resection can be performed in anatomic ways, it is also beneficial from an oncologic point of view [2, 5–7].

Currently, the laparoscopic left lateral sectionectomy is regarded as the standard treatment option. It will take a long time for LLR to become a standard procedure for HCC [8]. For LLR to become a standard procedure in HCC, more extended indications as well as outcomes and advanced techniques comparable to those of open surgery are required. In this article, the current status and future perspectives on LLR for HCC will be discussed.

## Indications

### *Extension of Indications for Diagnosis*

LLR may be applicable for both benign and malignant diseases. For benign conditions, LLR can be easily applicable as there is no concern about oncologic safety. Therefore, benign conditions of malignant potential, such as hepatocellular adenomas, intrahepatic duct stones, and so on [9, 10], can be indicated. For malignant disease, oncologic safety should be considered before applying operative techniques. LLR would be acceptable as the standard treatment for metastatic liver diseases from colorectal malignancies and noncolorectal malignancies in selected patients [8, 11, 12].

In HCC, resections remain the first-line treatment for compensated cirrhosis in many centers [8]. LLR has become a good option for the treatment of HCC. However, LLR for cirrhotic patients is still not widely adopted [13, 14]. Many reports have suggested that LLR for small HCC is associated with similar or reduced morbidity in cirrhotic patients compared with an open resection [15–17]. There may be an advantage of LLR over open liver resection in that the former does not interrupt the collateral vessels on the abdominal wall [14]. Laparoscopic resection of hepatocellular cancers in a cirrhotic liver is feasible and safe in experienced centers, and follow-up data from a few study groups have suggested that the long-term oncologic outcome has not been compromised by the laparoscopic approach compared with open resection [2, 4, 8, 18, 19].

### *Extension of Indications for Tumor Location*

The application of LLR has been limited to easily accessible lesions, namely, tumors in the peripheral portion of the liver and those located in the anterolateral segments (segments 2, 3, 5 and 6, and the inferior part of segment 4 according to the classification of Couinaud) [7, 20, 21]. Most surgeons believe that LLR is not well indicated when the lesion is located in the posterior or superior part of the liver (segments 1, 7 and 8, and the superior part of segment 4) [7, 16, 20, 22]. Most of the reported cases have been peripheral lesions located in the anterolateral segments. Accordingly, only peripheral lesions on the anterolateral

segment of the liver were indicated, and deep tumors on the right side were not well indicated [20]. With increased experience and an improvement in laparoscopic instruments, it has been recently attempted to apply the laparoscopic procedure in difficult locations of the liver.

Although LLR on the right side has been a demanding operation, right-sided LLRs were shown to be feasible and safe in our institutes [1]. When the lesion is located on the right and posterior side of the liver, resection of this segment is occasionally necessary. Although a right posterior sectionectomy is regarded as difficult even in open surgery, totally laparoscopic right posterior sectionectomy has recently been reported to be feasible [5]. As discussed above, the locations of the liver can be divided into the anterolateral and posterosuperior parts. The posterosuperior part of the liver is difficult to access as there are concerns about significant bleeding during parenchymal transections when an LLR is performed. In our study, when comparing postoperative outcomes between lesions in the posterosuperior and anterolateral parts, the outcomes of LLR for tumors located in the posterosuperior part is comparable with those of tumors located in the anterolateral part of the liver [23]. When 82 LLRs for tumors were analyzed, there was no significant difference in various parameters of perioperative outcomes between the anterolateral and the posterosuperior group.

#### *Extension of LLR to Large, Centrally Located and Multiple Tumors*

Patients with tumors that are either large, central, multiple, bilateral or in close proximity to the liver hilum, and major hepatic veins or the inferior vena cava are not presently candidates for a laparoscopic approach in most centers [8].

Large hepatic tumors (>5 cm) have been considered to be contraindicated for an LLR regardless of their location because of both the possibility of tumor rupture during manipulation of the liver and the difficulty of liver mobilization due to the insufficient space between the tumor and the peritoneum [24].

With increasing experience, there may be more reports on the application of LLR for tumor larger than 5 cm. Recently, there has been a report of an LLR for a tumor larger than 5 cm [25, 26]. Indications concerning tumor size may vary depending on the location of the tumor. When a large tumor is located in the left lateral section, the indications for a tumor size less than 5 cm should be applied strictly. However, when the tumor is located in a deep portion of the right side of the liver, the indications for the tumor size can be extended because the possibility of a tumor rupture decreases.

Tumors adjacent to the main portal pedicle or inferior vena cava as well as tumors located in central lesions adjacent to the major hepatic vein are considered a contraindication [24]. When a tumor is located in the vicinity of major or large vessels, there is a high probability of bleeding when these vessels are injured during operation. In addition, when the tumor is located close to major vessels, it may be difficult to obtain an adequate margin when treating HCC. The controversies about the clinical significance of the width of the resection margin still exist as the survival outcome with a negative margin is not significantly different from that with a wide margin [1, 2, 27]. With accumulated experience, LLR can be cautiously performed in selected patients with centrally located tumors that are close to the hepatic hilum, major hepatic veins or the inferior vena cava.

Vibert et al. [28] reported that a laparoscopic resection of HCC can be considered if there are fewer than 3 nodules, especially in patients with compensated cirrhosis. Several recent reports have suggested that liver resections for multiple HCCs may be justified if all the tumors can be completely removed and adequate liver function can be preserved postoperatively [28]. If multiple hepatic tumors can be resected curatively, various treatment options, including a multimodality treatment, can be selected. Therefore, single major liver

resections, multiple minor liver resections and minor liver resections with interventions, including transarterial chemoembolization and radiofrequency ablation, can be selected according to the tumor characteristics. Accordingly, LLR will be regarded as an optional treatment for multiple hepatic tumors.

## Operative Outcomes Comparable to Open Surgery

### *Surgical and Oncologic Outcomes*

A few meta-analytic studies have compared outcomes of LLR and open liver resection [18, 19]. Simillis et al. [29] analyzed 8 nonrandomized studies and concluded that LLR is comparable to or better than open liver resection in terms of intraoperative blood loss and the length of hospital stay. Nguyen et al. [30] reported that LLR had similar or reduced mortality (0.3%) and morbidity (10.5%) compared with open liver resection. There was no significant difference in overall and disease-free 5-year survival rates for HCC between open and laparoscopic hepatectomies, a finding which is similar to that of other studies [18, 19]. In our institutions, outcomes after LLR for HCC have similar or better results than those reported in previous studies: 90.4% for 3-year overall survival and 60.4% for 3-year disease-free survival [2]. The outcomes for HCC also seem to be comparable with those found in many other studies. However, until the oncologic safety is definitively shown with a randomized clinical trial, skepticism about the use of LLR for cancer will remain [8].

### *Anatomic Liver Resection*

Anatomic hepatic resections have been reported to have better survival outcomes than nonanatomic resections because the former resect all the liver parenchyma of the potential tumor-bearing portal pedicles and allow for the complete removal of possible venous tumor thrombi. Therefore, when the lesion is confined to a localized part of the liver, anatomic resection is theoretically preferable to nonanatomic resection. Major LLRs, such as right and left hemihepatectomy, are anatomic resections. Laparoscopic anatomic segmental and subsegmental resections using the Glissonian pedicle transection method have also been reported [5]. Careful dissection and control of the Glissonian pedicle makes anatomic LLRs, including major and minor LLRs, as feasible an operation as an open hepatectomy.

When a tumor spreads over both the left medial and right anterior sections, a central bisectionectomy can be substituted for an extended right or left hemihepatectomy. This procedure for a centrally located tumor has an advantage in that the tumor-free volume of the liver can be preserved as much as possible when compared with an extended right or left hemihepatectomy. In particular, these procedures are beneficial in patients with compromised liver function. Totally laparoscopic central bisectionectomy for HCC has also been reported to be feasible. As patients with HCC usually have liver cirrhosis or poor liver function, it is usually desirable to minimize the volume of the resection and to preserve as much liver volume as possible. This volume-preserving strategy is applied even when performing laparoscopic surgery. With this principle, laparoscopic monosegmentectomy is also feasible. Isolated S4 and S5 segmentectomies have the advantage of preservation of the remaining liver volume compared with left hemihepatectomy, especially in those patients with compromised liver functions [3].

## Propagation of the Procedure to Young Surgeons

In the early era of LLR in Korea, several experienced hepatic surgeons attempted to perform the advanced technique of LLR. Subsequently, some Korean hepatic surgeons interested in laparoscopic liver surgery organized the Korean Laparoscopic Liver Surgery Study Group (KLLSG). Through a learning course provided by the KLLSG, knowledge of the surgery has been disseminated and more hepatic surgeons in Korea have started to perform LLR. This has made the KLLSG one of the world's leading groups in the practice of advanced LLR. Furthermore, by publishing detailed procedure descriptions with multimedia and holding the meeting in conjunction with the international association, this study group's activity provides the opportunity to share individual experiences and enables cross-training among members [3, 4].

## Conclusion

The indications for LLR are expanding with accumulated experience. Therefore, LLR can be applied in selective cases of various benign and malignant diseases, for tumors regardless of their locations, numbers or previous operation history. Operative morbidity and mortality of LLR are comparable with those of open surgery; in addition, anatomic resection is feasible, including major hepatic resections and segmental/subsegmental hepatic resections.

The remaining limitations of LLR will be overcome if advanced techniques of LLR are more widely applicable and more experience is gained. Therefore, the extension of minimally invasive surgery in hepatic disease is ongoing and will be accomplished in the near future.

## Acknowledgement

This study was supported by a grant from the Korea Healthcare Technology Research and Development Project Ministry of Health and Welfare, Korea (A102065).

## Conflict of Interest

No conflict of interest.

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