Outcomes of Laparoscopic Liver Resection for Lesions Located in the Right Side of the Liver

Jai Young Cho, MD, PhD; Ho-Seong Han, MD, PhD; Yoo-Seok Yoon, MD, PhD; Sang-Hyun Shin, MD

Hypothesis: Laparoscopic right-sided liver resection may be feasible and safe.

Design: Retrospective analysis.

Setting: Department of surgery at a university hospital.

Patients: Of 103 consecutive laparoscopic liver resections performed from May 1, 2003, to April 30, 2007, 46 patients underwent a right-sided laparoscopic liver resection. Six operations required conversion (13%) to open surgery. Overall, data from 40 patients with benign liver tumors (n=2), intrahepatic duct stones (n=3), liver metastasis from colorectal cancer (n=8), and hepatocellular carcinomas (n=27) were analyzed.

Main Outcome Measures: Feasibility and operative outcome.

Results: The operations included 12 major resections (5 right hemihepatectomy and 7 right posterior sectionectomy) and 28 minor resections (14 segmentectomy and 14 tumorectomy). No operative mortality, subsequent operation, or life-threatening complications occurred. Overall, 11 patients (28%) experienced complications; 2 had bile leakage, 6 had perihepatic fluid collection, 2 had prolonged ascites, and 1 had pleural effusion. All recovered after conservative management. The mean operation time was 300 minutes, the mean blood loss was 620 mL, and the mean hospital stay was 11 days. For lesions located at segment VII or VIII (n=15), the mean operation time and amount of blood loss in those receiving a minor liver resection were similar to those who received a major resection (P=.21 and .88, respectively).

Conclusion: Although greater technical refinement is required for a minor resection in the superior part of the right side of the liver, laparoscopic right-sided liver resection is feasible and safe.


Unlike a laparoscopic cholecystectomy, the application of laparoscopy has not been fully accepted for liver resection because of the technical difficulty associated with parenchymal transection, hemostasis at the transection plane, the risk of air embolism, and limitations of exploring the deeper regions of the liver.1,2 The initial laparoscopic liver procedures included biopsies,4 tumor staging, and the fenestration of nonparasitic liver cysts. Advances in laparoscopic instruments and the increased experience with laparoscopic and hepatic surgery have encouraged surgeons to apply laparoscopic methods to the management of a number of hepatic tumors. However, its feasibility is limited to patients who require limited resections localized to the left side of the liver (segments II-IV according to the classification of Couinaud).

Recently, with the improvement in laparoscopic techniques and the development of new technologies, reports of successful procedures such as right hemihepatectomy,5 isolated caudate lobe resection,6 and right posterior sectionectomy7 have been published, with the current data showing that the limitations of laparoscopic liver resection are being overcome. The primary aim of the present study was to examine the operative outcome and technical considerations of laparoscopic liver resection for lesions located in the right side of the liver (segments V-VIII).

METHODS

PATIENT SELECTION CRITERIA

A laparoscopic liver resection was performed only in patients in whom an open hepatectomy was clearly indicated. An anatomical right hemihepatectomy or right posterior sectionectomy was considered when it was presumed that it would be difficult to obtain a free surgical margin with a minor resection for a tumor located in the upper segment (Couinaud segment VII or VIII) and when the remaining liver functional capacity was expected to be adequate.

The presence of symptoms, the danger of rupture, and the uncertainty of diagnosis were the indications for resection of benign liver tumors. For patients with hepatocellular carcinoma (HCC), the absence of coagulopathy and...
the presence of an adequate hepatic reserve were important prerequisites. For patients with an intrahepatic duct (IHD) stone, the indications for a liver resection were the presence of an IHD stricture and atrophy of the diseased liver parenchyma. Similar to the patients with cirrhosis undergoing open surgery, a minor liver resection was the preferred type of resection for patients with an indocyanine green 15-minute clearance retention rate of more than 20%, a platelet count of less than 100,000/µL, a serum albumin level of less than 3.5 g/dL, and a total bilirubin level greater than 1.5 mg/dL. (to convert platelets to ×10^9/L, multiply by 1; serum albumin to grams per liter, multiply by 10; and bilirubin to micromoles per liter, multiply by 17.104). For metastatic liver tumors from colorectal cancer, a liver resection was indicated when the indications for a liver resection were the presence of an IHD stricture and atrophy of the diseased liver parenchyma. Similar to the patients with cirrhosis undergoing open surgery, a minor liver resection was the preferred type of resection for patients with an indocyanine green 15-minute clearance retention rate of more than 20%, a platelet count of less than 100,000/µL, a serum albumin level of less than 3.5 g/dL, and a total bilirubin level greater than 1.5 mg/dL. (to convert platelets to ×10^9/L, multiply by 1; serum albumin to grams per liter, multiply by 10; and bilirubin to micromoles per liter, multiply by 17.104). For metastatic liver tumors from colorectal cancer, a liver resection was indicated when there was no evidence of extrahepatic disease.

Each patient provided informed consent for the laparoscopic procedures before surgery, and the procedure was approved by the institutional review board of Seoul National University. A right hemihepatectomy or right posterior sectionectomy was defined as a major resection. A segmentectomy or tumorectomy was defined as a minor resection. Injury of the large branches of the hepatic vein or the major hepatic vein itself in this area can lead to massive bleeding that is difficult to control during laparoscopic surgery. Therefore, right posterior sectionectomies were regarded as major liver resections for the analyses used in this study.

SURGICAL TECHNIQUE

The surgical techniques used for laparoscopic liver resection at our institution have been previously described.7,8 The procedure was performed with the patient under general anesthesia and placed in a supine position or a 15° semilateral position with the lower limbs apart. The operating surgeon stood between the two lower limbs of the patient. After creating a 10-mm umbilical port, a pneumoperitoneum was established and maintained below 12 mm Hg to reduce the potential risk of an air embolism (Figure 1). A 45° laparoscope or flexible laparoscope was used.

Usually, for an anatomical right hemihepatectomy or a right posterior sectionectomy, the right side of the liver was fully mobilized from the inferior vena cava as much as possible and multiple small hepatic veins were divided. The portal pedicles were dissected outside the liver parenchyma, and the portal branch, the arterial branch, and the bile duct were then separated. The arterial and portal branches were clipped and divided. The portal branch was divided with a linear stapler if it was too large for clips to be applied. Occasionally, an anatomical major liver resection was performed using the Glissonian approach. With the Glissonian approach for right posterior sectionectomy, hilar dissection was performed to free the right and left Glisson pedicles at the inferior surface of the quadrate lobe. Subsequently, the right Glisson pedicle was further dissected into anterior and posterior Glisson pedicles. Each of these 2 Glisson pedicles was separately isolated. The posterior Glisson pedicle was extraparenchymally divided en masse with a linear stapler. No prior inflow vascular control, such as the Pringle maneuver, was used for a segmentectomy or nonanatomical resection.

The superficial hepatic parenchyma was transected using a harmonic scalpel (Ethicon Endo-Surgery, Inc, Cincinnati, Ohio), and the deeper portion of the parenchyma was dissected using a laparoscopic Cavitron ultrasonic surgical aspirator (CUSA, Valleylab Inc, Boulder, Colorado). Once the specimen was completely detached, it was inserted into a protective bag and extracted through an incision that was created by extending the wound at the epigastric port. After careful hemostasis, a fibrin glue sealant (Greenplast; Green Cross Corp, Seoul, Korea) was sprayed onto the raw surface. After irrigating the surgical field, a Silastic drain was inserted and the wound was closed in layers.

STATISTICAL ANALYSIS

The continuous, normally distributed variables are represented as the mean (SD), and discontinuous variables are expressed as the median (range). Continuous variables in each group were compared by an independent sample t test, and the categorical variables were compared using the χ² test. Nonparametric analysis was performed using the Mann-Whitney test and a Fisher exact test. All analyses were performed using SPSS statistical software for Windows, version 11.0 (SPSS Inc, Chicago, Illinois). P < .05 was considered statistically significant.

RESULTS

STUDY POPULATION THAT MET INCLUSION CRITERIA

Between May 1, 2003, and April 30, 2007, 207 consecutive liver resections were performed at our hospital. A laparoscopic procedure with curative intent was attempted in 103 patients (49.8%). Among them, laparoscopic liver resection for lesions located in the right side of the liver was performed in 46 patients. During the laparoscopic liver resection, a conversion to an open hepatectomy occurred in 6 patients (13%). All 6 patients had HCC. No difference in the conversion rate was found by the location of the tumor (P = .38). The reasons for conversion included bleeding (n = 2), poor localization of the HCC (n = 2), or a suboptimal resection margin (n = 2). Two patients with HCC complicated by cirrhosis had a conversion for bleeding that occurred from the large branch of the portal vein or hepatic vein during a right hemihepatectomy. In those 2 patients, the bleeding was not urgent, but control of the bleeding was difficult because of poor visibility in the deeper portions of the liver. Another 2 patients experienced conversion to a laparotomy before transecting the liver parenchyma because of poor localization of a small HCC.
under laparoscopic ultrasonography; an open right posterior sectionectomy was performed in both cases. The remaining 2 patients with an HCC immediately after completing the laparoscopic right posterior sectionectomy had their procedures converted to a laparotomy because of the positive macroscopic surgical margin. In these patients, additional liver resection was performed to achieve an optimal margin for both patients.

**INDICATIONS FOR LAPAROSCOPIC LIVER RESECTION**

During the study period, a totally laparoscopic right-sided liver resection was performed successfully in 40 patients. Figure 2 shows the location of the lesions. Fifteen tumors were located in the superior part of the right lobe. The mean (SD) patient age was 56.3 (11.3) years (range, 23-82 years), and 29 were men. The indications for the resection were a benign liver tumor (n=2), an IHD stone (n=3), liver metastases from colorectal cancer (n=8), and HCC (n=27).

In the 2 patients with benign tumors, 1 had a rapidly growing peripheral hemangioma with the danger of rupture, and 1 had a tumor that mimicked focal nodular hyperplasia with an uncertain diagnosis. Of the 3 patients with an IHD stone, an incidental small cholangiocarcinoma, 3 mm in diameter, was detected during the postoperative pathologic examination in 1 patient after an anatomical right hemihepatectomy, for whom no further surgery was performed postoperatively.

Seven of 8 patients had undergone a liver resection for a metachronous single liver metastasis from colorectal cancer with a mean interval of 13 months after radical colorectal surgery. The remaining 1 patient with a liver metastasis underwent a simultaneous laparoscopic tumorectomy for a metastatic lesion in the left lateral segment and a radical anterior resection of the sigmoid colon. In this patient, another metachronous liver metastasis was detected 11 months after the first operation, and there was no evidence of an extrhepatic malignant neoplasm. Therefore, another metachronous liver metastasis was detected 11 months after the first operation, and there was no evidence of a subsequent laparoscopic liver resection of the segment VI lesion was performed with curative intent.

The main indication for a liver resection in this study was an HCC. Table 1 gives the preoperative and histologic data for the 27 patients with HCC. Twenty-four of 27 patients had liver cirrhosis, and the remaining 3 patients had hepatitis B virus–related chronic liver disease. Four of 24 patients with cirrhosis had Child B or C cirrhosis, and their indocyanine green 15-minute clearance retention rate exceeded 20%. In 3 patients with HCC, satellite nodules were detected preoperatively. All were approximately 1 cm in the same affected segment and confirmed by laparoscopic ultrasonography. They were completely resected together with the main index tumor.

**TYPES OF LIVER RESECTIONS**

Table 2 lists the types of liver resection performed in this study. A minor liver resection was the preferred type of resection for patients with moderate to severe cirrhosis or superficial lesions located between the 2 segments. In all 3 patients with an IHD stone, an anatomical right hemihepatectomy (n=2) and right posterior sectionectomy (n=1) were performed for complete removal of the IHD abnormality. A nonanatomical tumorectomy (n=6) with a wide surgical margin was the preferred type of resection in the 8 cases of liver metastases. A right hemihepatectomy was performed in 3 patients with chronic liver disease or early cirrhosis for a deep-seated HCC. A right posterior sectionectomy was performed in 5 patients with tumors located between segments VI and VII. A segmentectomy was per-

![Figure 2. Locations of the treated lesions according to the Couinaud classification. The numbers in circles are the number of lesions in each corresponding segment. The numbers in squares are the number of lesions for conversion. Three patients with an intrahepatic duct stone were excluded from this figure.](//)
formed in 12 patients for peripheral HCC in segments V (n=3), VI (n=4), VII (n=1), and VIII (n=4). A nonanatomical tumorectomy was performed for peripheral HCC in the 4 patients with Child B or C liver cirrhosis.

INTRAOPERATIVE AND POSTOPERATIVE OUTCOME

No operative mortality, subsequent operation, or life-threatening complications occurred. No evidence of air embolism during or after surgery was found. The overall mean (SD) operation time was 299.9 (131.1) minutes (range, 80-630 minutes), and the mean (SD) estimated blood loss was 619.5 (412.7) mL (range, 20-1800 mL). An intraoperative transfusion was required in 13 patients (32%). No difference was seen in the mean operation time or estimated blood loss in comparisons of the indications for liver resection (P=.16 and .48, respectively). The mean (SD) surgical time for a right posterior sectionectomy (423.6 [120.7] minutes) was significantly longer than that for the other types of liver resections (P=.008), but there was a similar mean estimated blood loss regardless of the type of resection (P=.24).

For a resection of tumors located in the superior part of the right liver (n=15), the mean (SD) operation time for a minor liver resection, including a segmentectomy and tumorectomy (n=6; 321.7 [61.9] minutes), was similar to that of a major liver resection, including a right posterior sectionectomy and right hemihepatectomy (n=9; 393.3 [110.0] minutes; P=.21). Moreover, the mean estimated blood loss in a segmentectomy or tumorectomy (709.1 [408.5] mL) was even higher than that of a right posterior sectionectomy or right hemihepatectomy (600.0 [244.9] mL), but this difference was not statistically significant (P=.88).

The mean (SD) hospital stay was 10.9 (6.2) days (range, 5-38 days), and there was no difference between the indications for surgery (P=.90). The mean pathologic margin for the tumors was 10.6 mm (range, 1-50 mm). In this study, 11 patients (27.5%) experienced complications after surgery. No statistically significant difference was observed in the rate of complications (P=.97), operation time (P=.79), estimated blood loss (P=.51), or number of intraoperative transfusions (P=.64) between the laparoscopic and open liver resection groups. Bile leakage was observed in 2 patients after a right posterior sectionectomy. One patient with an IHD stone had a bile leak from a cystic duct stump and recovered after endoscopic retrograde biliary drainage. The other case of bile leakage occurred in a patient with HCC at the cut surface of the remnant liver; a surgical drain was left in place for 10 days after surgery. Postoperative intraabdominal fluid collection was observed in 6 patients, and percutaneous drainage was required in 4 patients. Two patients with liver cirrhosis had prolonged ascites after a limited resection for HCC, but they recovered after short-term use of diuretics. One case was a symptomatic pleural effusion that occurred in a patient with an IHD stone after a right hemihepatectomy, and the patient was discharged on the 13th postoperative day after percutaneous drainage. All postoperative complications were managed conservatively without the need for additional surgery.

COMPARISON OF SURGICAL OUTCOME WITH OPEN LIVER RESECTION

During the same study period, open right-sided liver resection was performed in 42 patients. The indications for resection were liver metastases from colorectal cancer (n=19), HCC (n=22), and biliary cystadenocarcinoma (n=1). The preoperative characteristics of patients with HCC, including mean patient age (P=.55), the distribution of sex (P=.91), and the severity of underlying liver disease (P=.56), were similar in the laparoscopic and open liver resection groups (P>.55). However, the mean (SD) tumor size in patients with HCC in the open group was significantly larger than that in the laparoscopic group (3.4 [1.4] mm vs 6.8 [4.3] mm; P=.91). Table 2 lists the types of open liver resection performed during the same study period.

Of 42 open liver resections, 12 complications (28.6%) occurred after surgery. No statistically significant difference was observed in the rate of complications, operation time, estimated blood loss, and number of intraoperative transfusions between the laparoscopic and open liver resection (P>.56). However, the mean (SD) duration of hospital stay in patients who underwent a laparoscopic liver resection was significantly shorter than in those who received an open resection (10.9 [6.2] days vs 13.8 [6.8] days; P=.008).

| Table 2. Types of Laparoscopic vs Open Liver Resection Performed in the Present Study |
|---------------------------------|-----------------|-----------------|-----------------|-----------------|
| Resection Type                  | Laparoscopy, No. | HCC (n=27) | Open, No. | HCC (n=22) |
|                                | Overall (n=40)   |                 |                 |                 |
| Major resection                 |                 |                 |                 |                 |
| Right hemihepatectomy           | 5               | 3               | 16             | 12             |
| Right posterior sectionectomy   | 7               | 5               | 2              | 2              |
| Right anterior sectionectomy    | 0               | 0               | 3              | 3              |
| Minor                           |                 |                 |                 |                 |
| Segmentectomy                   | 14              | 12              | 9              | 3              |
| Tumorectomy                     | 14              | 7               | 12             | 2              |

Abbreviation: HCC, hepatocellular carcinoma.
Tumors located in the posterior and superior segments (segments VII and VIII) and deep-seated tumors in the right lobe are considered poor candidates for laparoscopic liver resection because adequate laparoscopic exposure is difficult and the tumor is often adjacent to major blood vessels. Previous studies have demonstrated the feasibility and safety of laparoscopic liver resections. Only a few studies have compared the short-term outcomes of a laparoscopic resection with a conventional resection. To our knowledge, this study is the largest series reported to date to examine the feasibility of laparoscopic liver resection in the right side of the liver. In some centers, laparoscopic procedures are routinely used for a left lateral sectorectomy in selected patients. In the near future, the policy for managing liver tumors may shift to a laparoscopic resection.

In the present study, the conversion to an open hepatectomy occurred in 6 patients with liver cirrhosis, with a relatively low rate of conversion (13%). Two cases of conversion caused by bleeding from a large branch of a major vessel were encountered during a right hemihepatectomy. The other 4 conversions were decided on before liver transection (poor tumor localization under ultrasonography) or after the completion of the liver resection (positive gross surgical margin). Gigot et al emphasized the potential risk of insufficient tumor clearance with respect to the resection margin when the laparoscopic approach was used for a liver resection. This concern is clearly related to the lack of digital palpation during the laparoscopic procedure, and this limitation can be overcome by the routine use of laparoscopic ultrasonography, which will allow determination of a precise transection line in relation to the tumor margin.

These results demonstrate that operative time and estimated blood loss of a minor liver resection were similar to those of a major liver resection in patients when the tumors were located in the superior part of the right liver. This finding suggests that a minor liver resection in segment VII or VIII was as difficult as a major resection. This finding is consistent with reports by others. During a segmentectomy or tumor resection for tumors located in the superior part of the right liver (segment VII or VIII), there is some difficulty with surgical field exposure and with manipulating the working instruments. In addition, the transection line can be curved or angulated, which makes the transection of the parenchyma more difficult.

Overall, this report outlines the feasibility and the short-term outcomes of right-sided laparoscopic liver resection. The laparoscopic resection was performed more frequently in patients with smaller tumors than in those who underwent an open resection. A matched comparison of surgical outcomes for laparoscopic liver resection compared with those of open resection could not be performed in this series. However, our results showed that laparoscopic liver resections were associated with reduced hospital stay and had a similar complication rate compared with open liver resection.

In conclusion, a laparoscopic liver resection for right-sided liver lesions is technically feasible and safe. Although further technical refinement is necessary for minor resections, including segmentectomy and tumorectomy in the superior part of the right liver, the lesions located in the right side of the liver may be good candidates for a laparoscopic resection in selected patients.