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Initial Experiences with Laparoscopy-assisted and Total Laparoscopy for Anatomical Liver Resection: A Preliminary Study

Although laparoscopic surgery has become more popular, its technical difficulties have limited the applications of this technique to liver surgery. We report here on our experience with liver resection with using the laparoscopy-assisted (Lap-Assist) and total laparoscopic (Total-Lap) methods. From April 2001 to June 2003, a total of 20 laparoscopic anatomical resections of the liver were retrospectively reviewed. These were comprised of 10 cases in which the Lap-Assist method was used (these were performed during the early study period), and 10 cases in which the Total-Lap was used (these were done in the later study period). In the Lap-Assist group, the following resections were performed: 7 cases of left lateral sectionectomy, a case of left hemihepatectomy, a case of right hemihepatectomy and a case of open conversion. In the Total-Lap group, 6 cases of left hemihepatectomy and 4 cases of left lateral sectionectomy were performed. The sizes of the incisions were 8.7 cm and 4.6 cm, respectively, (p=0.000). There were no differences in the operation times, the transfusion amounts, the starting days of the patients' diets, the complication rates or the durations of the hospital stay between the two groups. Both the laparoscopy-assisted method and the total laparoscopic method are feasible to use for performing anatomical liver resection.

Key Words : *Laparoscopy; Liver; Liver Resection*

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INTRODUCTION

Laparoscopy has become an integral component of surgical procedures because it offers a shorter postoperative course, better cosmesis and less pain than the conventional methods (1). However, anatomical resection of the liver via laparoscopy is still being performed in only a limited number of institutions (2-7). The reason for this is presumed to be the technical difficulty of the procedure and the intraoperative hazards of bleeding and gas embolism (2).

Laparoscopic liver resection may be performed either as a laparoscopy-assisted surgical procedure or as total laparoscopy. Laparoscopy-assisted liver resection has the advantages of reducing the risk of air embolism. It is also more convenient for the surgeons who are already familiar with open surgery because the procedure can be performed through a small abdominal incision during the parenchymal dissection of the liver. Total laparoscopic liver resection is technically more complicated and it has a higher risk of air embolism, although it retains the advantage of having to make a small sized wound.

We have gained experience in both Lap-Assist and Total-Lap for liver resection. Initially, we adopted the Lap-Assist method, and then we changed to Total-Lap. This study was performed to evaluate the feasibility of using the two methods for laparoscopic liver resection.

MATERIALS AND METHODS

Patients

From April 2001 to June 2003, 20 cases of liver resection were performed via laparoscopy at Ewha Women's University Mokdong Hospital and at Seoul National University Bundang Hospital. Among these, 10 cases during the early period of the study were performed by the Lap-Assist method. In April 2002, we changed to the Total-Lap method and the remaining 10 cases were operated on with using this method.

In all cases, the patients and their relatives received comprehensive information concerning the operation methodology and they all agreed to the procedure.

The inclusion criteria for laparoscopic liver resection were: 1) intrahepatic duct stone disease with indications for liver resection such as severe intrahepatic ductal stricture, impacted stones, liver abscess or tumor; 2) hepatocellular carcinoma without cirrhosis. However, hepatocellular carcinomas larger than 5 cm were excluded from the study because the oncologic safety of laparoscopic resection has not yet been solidly confirmed (2, 5).

In the Lap-Assist group, there were 6 cases of intrahepatic duct stone disease and 4 cases of hepatocellular carcinoma, of which 2 cases had their diagnosis changed interoperatively to cholangiocarcinoma. The Total-Lap group was comprised of 10 cases of intrahepatic stone disease. There was a single case of open conversion in the Lap-Assist group, and this case was excluded from the group comparisons. The medical records of all the cases were retrospectively reviewed. The Student t-test and Fisher's exact test were used for the statistical analysis.

Lap-Assist method

Under general anesthesia, the patient was placed in the supine position. The first 10-mm trocar (Versaport®, Autosuture, USSC) was inserted into the umbilical port after the creation of the pneumoperitoneum, which was used to route the telescope. The second and third 10-mm trocars were inserted in the midline at the subxiphoid area and in the midclavicular line below the right costal margin in each case, with consideration of the later extensional incision being made between the two ports that were used for mini-laparotomy. The fourth 10-mm port was inserted in the anterior axillary line below the right costal margin (Fig. 1A).

Dissection at the porta hepatis was performed to isolate the common bile duct, the hepatic artery and the portal vein. After ligation with Endoclip®, the respective branches of these structures were severed. Then, a mini-laparotomy incision was made at the right subcostal area between the second and third trocars. The length of incision was approximate 9 cm (Fig. 1B). The lateral fourth trocar was used as a traction or working port. After the incision had been made, the abdominal wall was lifted with a Thomson® retractor to obtain an adequate operative field. When the liver dome was not adequately visualized, the telescope that had been originally inserted at the umbilical port was inserted through a direct mini-laparotomy incision for a better view of the operative field. The Ligasure vessel sealing system (Ligasure®, Valley-Lap Corp., Boulder, Colorado, U.S.A.) and an Autosonix generator (Autosonix®, Autosuture Corp., Boulder, Colorado, U.S.A.) were mainly used for dissection of the liver parenchyma. The major vessels or hepatic veins were transected with using a linear stapler (Endo-vascular GIA®). After complete dissection of the liver parenchyma, the specimen was inserted into a vinyl bag to avoid having it contact the other sites, and then the bag was extracted through the mini-laparotomy incision. After bleeding control was done and any leakage was stopped, fibrin sealant was sprayed on the raw liver surface. In cases of stone disease, additional exploration of the bile duct was performed with a choledochoscope, and a T-tube was inserted into the common bile duct. A silastic drain was inserted to the subhepatic area through the lateral port.

Total-Laparoscopy method

Using the method described above, the first trocar was inserted. The intraabdominal pressure was maintained at 12 mmHg with CO_2. To resect the left liver, the second 10 mm trocar was inserted 2 cm left of the midline and at least 7 cm from the first trocar at the subxiphoid area. The third 10 mm trocar was inserted at the anterior axillary line below the right

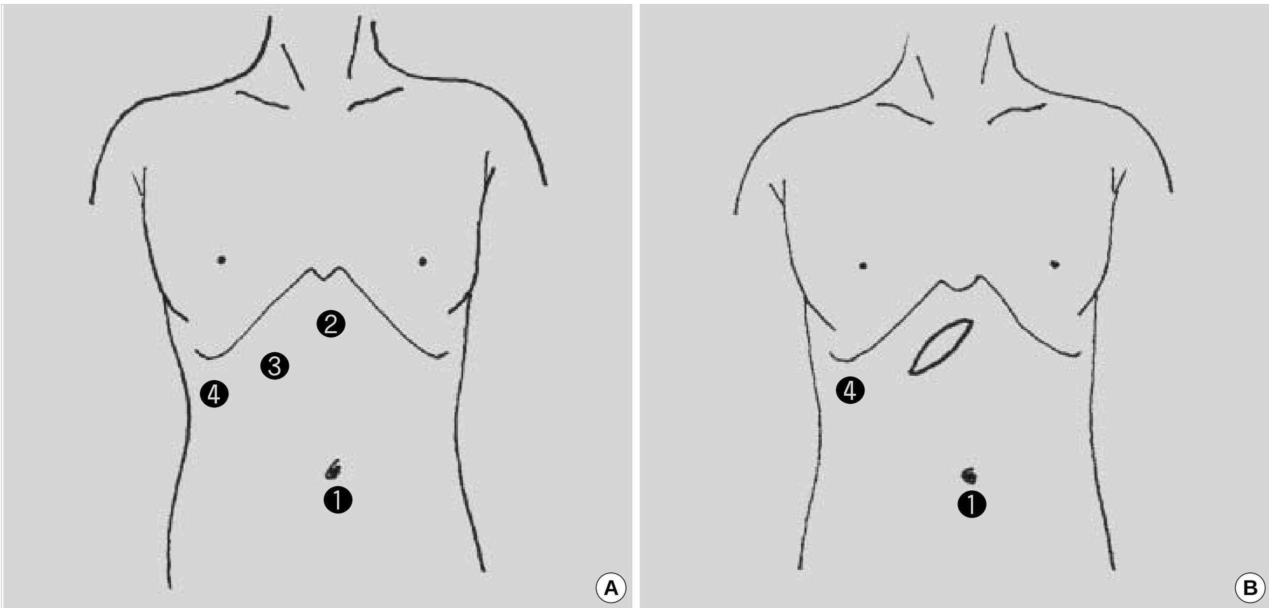

Fig. 1. The diagram for the position and extensional incision of the ports that were used for the laparoscopy-assisted method. (A) The initial position of the trocars before the parenchymal dissection. (B) The extensional incision between the two ports that were used for parenchymal dissection.

costal margin. The fourth 12 mm trocar was inserted between the second and third trocar about 3 cm caudal to the third trocar (Fig. 2). The operator initially stood at the left side of the patient during the dissection of the porta hepatis. The branches of the hepatic artery and the portal vein were transected before the dissection of the parenchyma to minimize bleeding and to mark the resection line by identifying the ischemic margin. Intraoperative ultrasonography was also performed for determining the resection line and confirming the major vessels. The intraabdominal pressure was decreased to 8 mmHg just before parenchymal dissection to reduce the risk of air embolism. The operator then moved to the right side of the patient for performing the parenchymal dissection. The second trocar was used as a traction port, and the third and fourth trocars were used as working ports during the parenchymal dissection. A fan retractor was used as a retractor for the liver parenchyma. The main instruments used for the dissection were a Ligasure®, an Autosonix® and a Linear stapler. During the dissection of the parenchyma, small ducts or vessels were managed or coagulated with the Ligasure® or Autosonix® or by using a simple electrocoagulator; the medium sized vessels or the ducts below 5 mm in diameter were ligated with using an Endoclip®; endovascular GIA was used for the larger vessels and ducts. After completion of the dissection, the specimen was inserted into a vinyl bag and it was extracted though a small incision about 4.5 cm in length, which was an extension from the second port. After bleeding control and confirmation that there was no leakage, fibrin sealant was sprayed on the raw liver surface. In case of stone disease, laparoscopic exploration of the common bile duct was performed with a choledochoscope for stone removal. A T-tube was then inserted into the common bile duct and the distal end of the tube was extracted out through the fourth port. A silastic drain was inserted into the subhepatic area through the third trocar site.

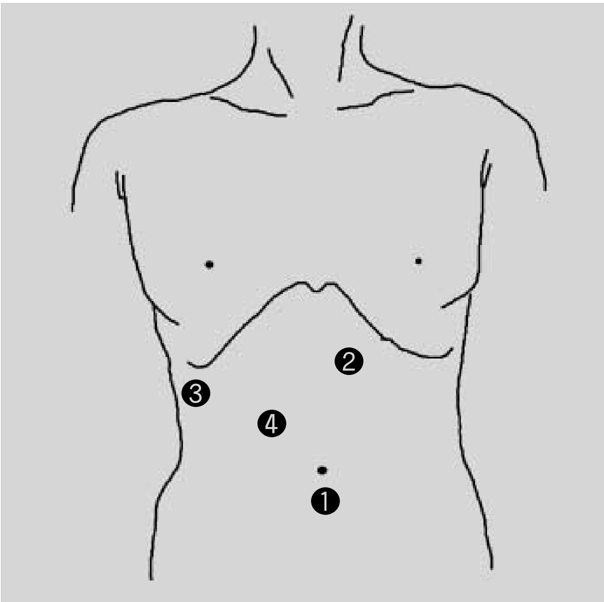

Fig. 2. Diagram for the position of the trocars that were for total laparoscopic hepatectomy.

RESULTS

The mean age of the Lap-Assist group and the Total-Lap group were 60.7 (±15.8) and 51.5 (±11.4) yr old, respectively. The corresponding male to female ratios was 1:0.67 and 1:4, respectively.

In the Lap-Assist group, there were 7 cases of left lateral sectionectomy, a case of left hemihepatectomy, a case of right hemihepatectomy and a case of open conversion and liver biopsy. Among the 7 left lateral sectionectomy cases, one case was a cholangiocarcinoma that was located in the left lateral section of the liver and it had invaded into the lesser curvature of the stomach; this was treated by laparoscopy-assisted left lateral sectionectomy and partial gastric wedge resection. The case of open conversion and liver biopsy was also a cholangiocarcinoma with multiple small liver metastases, and these tumors were not detectable preoperatively. In the Total-Lap group, there were 6 cases of left hemihepatectomy and 4 cases of left lateral sectionectomy. There was no conversion to open surgery in this group (Table 1).

The mean operation time was 351.1 min in the Lap-Assist group and it was 458.0 min in the Total-Lap group (p=0.092).

Table 1. The types of liver resections performed in both groups

	Laparoscopy-assist group	Totally laparoscopic group
Left lateral sectionectomy	7	4
Left hemihepatectomy	1	6
Right hemihepatectomy	1	0
Open conversion	1*	0

*, Open biopsy due to unresectable cholangiocarcinoma.

Table 2. Outcomes of the both operations

Operation type (Number of patient)	Laparoscopy assisted group (9)	Totally laparoscopic group (10)	p value
Operation time (min)	351.0 (±137.7)	458.0 (±123.0)	0.092
Amount of transfusion (units)	1.8	0.3	0.154
Starting day of postoperative diet (day)	3.7	3.7	0.937
Morbidity (n)	3†	0	0.087
Mortality (n)	0	0	-
Hospital stay (days)	16.4	11.5	0.137
Size of incision* (cm)	8.7	4.6	0.000‡

*, the incisions were made for mini-laparotomy with laparoscopy-assisted method, and for the extraction of the specimen with the totally laparoscopic method; †, 2 cases of atelectasis and 1 case of minimal bile leakage, and both were resolved with conservative management; ‡, p<0.05, statistically significant.

During the operation, a blood transfusion was performed in 4 cases of the Lap-Assist group and in 2 cases of the Total-Lap group, and the mean amount of transfusion was 1.8 units and 0.3 units, respectively (p=0.154). For both the groups, the postoperative diet was started at 3.7 days after the procedures (p=0.937). Postoperative complications occurred in 3 cases in the Lap-Assist group (30%). There were 2 cases of atelectasis and a single case of mild bile leakage; these complications were resolved by conservative management. The postoperative hospital stay was 16.4 days and 11.5 days in the respective groups (p=0.137). There was no evidence of air embolism and there were no mortalities. The mean size of the incisions were 8.7 cm and 4.6 cm, respectively (p= 0.000). During the follow-up period, all patients were in good conditions without disease recurrence (Table 2).

DISCUSSION

The laparoscopic procedures for liver disease were initially done to stage tumors and to treat nonparasitic cysts, such as for performing an unroofing procedure (8-11). Gagner et al. (12) reported on the first partial laparoscopic liver resection. The approach of laparoscopic surgery for liver resection during its early development was confined to wedge resection or non-anatomical resection (13, 14). However, with the advances in the instrumentation, the equipment and the surgeon's skills, the range of resection has widened to include major hepatectomy (15, 16).

The indications of laparoscopic liver resection include a focal benign liver mass such as focal nodular hyperplasia, adenoma, hemangioma and harmatoma, and focal malignant liver cancer including metastatic cancer and small hepatomas (2, 5, 16-19). In this study, the main indication for liver resections was intrahepatic duct stone disease. In Asia, including Korea, Japan and Hong Kong, there is a higher incidence of intrahepatic duct stone disease than is seen in the West. If intrahepatic duct stone is associated with severe stricture of the intrahepatic duct (i.e., impacted stone, liver abscess or tumor), liver resection is then indicated (17, 20-23). Therefore, these problems could also be viewed as the indicators for laparoscopic liver resection.

Until the oncologic safety of the procedure is confirmed, we have to be very cautious about applying the laparoscopic technique to malignant disease. However, there have been a small number of reports supporting the oncologic safety of laparoscopic liver resection. Therefore, this technique could be applied in a limited number of cases such as metastatic carcinoma or small sized hepatocellular carcinomas (2, 5). In the present study, we excluded those cases having large hepatocellular carcinoma (i.e., larger than 5 cm). Intrahepatic cholangiocarcinoma is not generally accepted as an indication for laparoscopic liver resection because adequate lymph node dissection cannot be achieved laparoscopically (24-26). Two cases of cholangiocarcinoma were included in our series, and both of them had been preoperatively diagnosed as hepatocellular carcinoma. If cholangiocarcinoma is suspected intraoperatively, it is better to convert to open surgery for instituting the proper treatment that includes lymph node dissection (24-26). For the case of the cholangiocarcinoma in this series, the tumor was found to have invaded the gastric wall, and we decided that lymph node dissection was unnecessary. Therefore, we continued with the laparoscopy-assisted palliative lateral sectionectomy along with partial resection of the stomach. The remaining case was an open conversion case in which only a liver biopsy was performed.

The techniques of laparoscopic liver resection are classified into three methods: total laparoscopic surgery with the creation of a pneumoperitoneum (2, 4, 7, 18, 19, 27), the abdominal wall lifting method with or without the creation of a pneumoperitoneum (4, 5, 28) and hand-assisted laparoscopic liver resection (29). The abdominal wall lifting method may not provide adequate intraabdominal visualization for complex hepatic resection. In our experience, the Lap-Assist operation permits a poorer operative field than does the Total-Lap operation. On the other hand, the conventional pneumoperitoneum method may increase the risk of inducing gas embolism (1). There have been a number of recent reports concerned air embolism during laparoscopic surgery (1, 28, 30). Although the risk of air embolism has to be addressed in laparoscopic surgery (1, 31), it has not been reported to occur during laparoscopic liver resection. Ricciardi et al. (1) have reported that air embolism can be prevented by elevating the intrahepatic pressure and by decreasing the hepatic tissue blood flow during the laparoscopic liver resection. We attempted to reduce the risk of air embolism by decreasing the intra-abdominal CO_2 pressure from 12 mmHg to 8 mmHg during the parenchymal dissection in Total-Lap liver resection. In this present study, there was no incidence that air embolism had occurred any patient in either group.

Pringle's maneuver is frequently used to reduce the amount of bleeding that occurs during laparoscopic liver resection (2, 4, 16, 19, 27); however, Pringle's maneuver was not used in this study. We ligated and transected the branches of the portal vein and the hepatic artery on the side to be resected before we performed the parenchymal dissection. Some authors have reported that selective hepatic vascular exclusion is more effective than performing the Pringle maneuver (32, 33).

Four to seven trocars are usually used in Total-Lap liver resection (2-4, 7, 18, 27, 34), and we used 4 ports in all cases, although a surgeon can use as many trocars as he deems necessary.

The mean operation time of 351.1 (240-625) min in the Lap-Assist group and 458.0 (290-600) min in the Total-Lap group were somewhat longer than that reported in other studies (2-4). One of the reasons for the longer operation times in this study was that majority of the cases were intrahepatic duct stone disease; thus, this malady requires additional procedures such as bile duct exploration, lithotripsy with choledochoscopy and the insertion of a T-tube. In addition, the occasional inflammation of the liver parenchyma and the adhesion to the surrounding tissue made it difficult to perform dissection of the liver. Nevertheless, we expect that the operation time will be shortened as we gain more experience. In our study, the Total-Lap method had a tendency for a longer operation time than the Lap-Assist method. Although we do not know the precise reasons for this, the meticulous and time-consuming ligation of the small hepatic veins, which was done during parenchymal dissection to minimize the risk of embolism, may have affected the results.

Postoperative complications have been reported in 5% to 43% of the laparoscopic liver resections (2, 4, 16, 19), and these rates are similar the rates observed in this series of 30% and 0% for the Lap-Assist group and the Total-Lap group, respectively. These complications were minor in nature, such as atelectasis and some transient minimal bile leakage. Moreover, the complication rates for liver resection via open surgery are reported to be 4.9-23.8% (35). When we consider the comparable complication rates and the benefits of minimal surgery, we can suggest with confidence that the Lap-Assist and Total-Lap methods are helpful options for performing anatomical liver resection.

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