

Single center experience of laparoscopic hepatectomy: the comparison of perioperative outcomes between early and late period

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Backgrounds/Aims: The aim of this study is to clarify the safety and feasibility of laparoscopic hepatectomy, through comparing the early and late periods of perioperative outcomes. **Methods:** We retrospectively analyzed 138 patients who underwent laparoscopic hepatectomy from January 2003 to June 2011, at Yeungnam University Hospital. We divided the total patients to early period (from January 2003 to February 2007, n=49) and late period (from March 2007 to June 2011, n=89) groups and compared the perioperative outcomes including the mean operation time, intraoperative blood loss, postoperative hospital stay, intensive care unit (ICU) stay, and duration of liver function test (LFT) normalization. **Results:** The mean operation time was 308 minutes (range: 140-510) in the early group and 193 minutes (range: 40-350) in the late period group ($p < 0.001$). The mean intraoperative blood loss was 171 ml (range: 50-1,200) in the early and 44 ml (range: 0-400) in the late group ($p = 0.005$). The postoperative hospital stay was 9.7 days (range: 4-31) in the early and 6.8 days (range: 2-9) in the late period ($p < 0.001$). The ICU stay hour was 21.6 hours (range: 0-120) in the early and 2.8 hour (range: 0-24) in the late period ($p < 0.001$). The duration of LFT normalization was 5.7 days (range: 0-39) in the early and 2.1 days (range: 0-20) in the late period ($p = 0.003$). The perioperative outcomes in the late period were better than the early period, which showed a statistically significant difference. **Conclusions:** Laparoscopic hepatectomy is feasible and can be safely performed in selected patients but requires a long experience in open liver resection and mastery of laparoscopic surgical skills. (*Korean J Hepatobiliary Pancreat Surg 2012;16:7-12*)

Key Words: Laparoscopy; Hepatectomy; Outcome

INTRODUCTION

Laparoscopy has become an integral component of surgical procedures because it offers a shorter postoperative course, better cosmetics, and less pain than the conventional methods.^{1,2} The progressive growth in the popularity of laparoscopic surgery and the widespread acceptance of laparoscopic cholecystectomy has encouraged surgeons to apply laparoscopic methods to the management of number of hepatic tumors.³ Unfortunately, application of laparoscopy to liver resection has been slowed due to technical difficulties. The difficulties include maintaining hemostasis at the transection plane, controlling hemorrhage, and exploring deeper regions of the liver.³ Despite these initial obstacles, Gagner and Rheault⁴ reported first two cases of non-anatomical laparoscopic liver resection in 1992. The first laparoscopic anatomical resection (left

lateral segmentectomy) was performed by Azagra et al. in 1996.⁵ Over the past 15 years, liver resections were introduced to clinical practice based on case series. It demonstrated the usual benefits of minimally invasive procedures, without loss of efficacy of the operations. However, the feasibility of laparoscopic liver surgery was better acknowledged following a prospective study by Cherqui et al.⁶ Recently, with improvements of surgical technology, devices and further accumulated experiences, even major hepatectomy has been attempted by laparoscopic method.

The aim of this study is to clarify the safety and feasibility of laparoscopic liver resection, via a comparison between the early and late period perioperative outcomes.

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METHODS

Patients

One hundred forty two patients who underwent laparoscopic liver resections from January 2003 to June 2011 at Yeungnam University Hospital were collected for this study. Among them, 4 patients undergoing an open conversion were excluded. Finally, 138 patients were included for the purpose of this study. Initial diagnosis was made by laboratory examinations and radiologic findings, including abdominal ultrasonography (USG), computed tomography (CT) and magnetic resonance imaging (MRI).

Laboratory examinations were included such as, complete blood count, albumin, bilirubin, liver enzyme, prothrombin time (PT), activated partial thromboplastin time (aPTT), and Indocyanine Green (ICG) R15. The number of study patients in the early period (from January 2003 to February 2007) and the late period groups (March 2007 to June 2011) were 49 and 89, respectively.

Surgical techniques

All procedures were performed under the general anesthesia with endotracheal tube insertion, after obtaining informed consent. All resections were performed with supine position. Pneumoperitoneum was established by open technique, and intra-abdominal carbon dioxide gas pressure was set at 12 mmHg to prevent gas embolism. A 10 mm 0° flexible laparoscope was placed through the umbilical port for abdominal exploration. Additional 5 or 12 mm-sized trocars were placed at particular sites, depending on the location of the liver lesion. In case of major hepatectomy, the control of portal pedicles was usually performed before parenchyma dissection of the liver to identify parenchyma dissection line and to reduce bleeding. Arterial branches were clipped with hemolock clips and then divided. The portal branch was divided with hemolock clips or an endoscopic linear stapler. The common bile duct was dissected as high as possible, without any duct section injury. The hilar plate was divided and sutured above the biliary convergence after the completion of parenchyma dissection or before it. The hepatic vein was dissected free but not divided before parenchymal division. Hepatic transection was initiated according to the line of demarcation, visualized on Glisson's capsule, directed to the axis of the inferior vena cava. In the case

of non-anatomical resection, the resection line was marked at the liver surface by electrocautery, following ultrasonographic examination to locate the tumor and the supply vessels, demonstration of satellite nodules, and demarcation of an adequate tumor-free margin. The capsule was divided by the use of Harmonic scalpel[®] or Ligasure[®] and deep within the liver parenchyma and a Cavitron ultrasonic aspirator (CUSA) was used to define the vascular structures. Minor vessels and bile ducts were divided using the Harmonic scalpel[®], diathermy, and clips. Larger vessels were divided with an endoscopic linear stapler or hemolock clips. During the operation, central venous pressure (CVP) was maintained, with 3 cmH₂O or less, if possible.

Statistical analysis

For comparing both period groups of laparoscopic liver resection, variables included preoperative laboratory examination such as, complete blood count, albumin, bilirubin, liver enzyme, PT, aPTT, ICG R15, and mean operation time, intraoperative blood loss, postoperative hospital days, intensive care unit (ICU) stay days, and finally, the duration of liver function test (LFT) normalization and postoperative complications.

The data are presented as a median (range) or a number (percentage). We used Fisher's exact test to compare proportions between the groups. For comparison of continuous variables, the Mann-Whitney test was used. A $p < 0.05$ was considered statistically significant. We used analysis software SPSS v.12.0.

RESULTS

Patient characteristics

The laparoscopic liver resections of the early and late period groups were 49 patients and 89 patients, respectively. The sex and preoperative laboratory findings were similar in both periods. The older age ($p=0.09$) and co-morbid disease ($p=0.06$) were more common in the late period than that of the early period without statistically difference (Table 1). Liver disease was benign in 35 and malignant in 103 cases. Malignant disease was more common in the late period (early: 37.2% vs. late: 73.8%). The most common benign disease was intrahepatic bile duct stone (54.3%) in both periods. Hepatocellular carcinoma

Table 1. Clinical and laboratory findings between the early and late periods

	Early period (n=49)	Late period (n=89)	<i>p</i> -value
Sex (male/female)	22/27	63/26	0.73
Age (year) : mean (range)	55.9 (41-81)	60.7 (39-78)	0.09
Co-morbidity	15 (30%)	51 (57%)	0.06
Cardiovascular disease	7 (47%)	26 (51%)	
Diabetes mellitus	3 (20%)	10 (20%)	
Viral hepatitis B or C	5 (33%)	15 (29%)	
Preoperative laboratory findings (mean (range))			
Hemoglobin (g/dl)	12.2 (10-16)	13.1 (11-15)	0.83
Platelet ($10^3/\mu\text{l}$)	144 (140-490)	132 (120-443)	0.96
Serum total bilirubin (mg/dl)	0.77 (0.3-1.5)	0.9 (0.1-1.6)	0.99
Serum albumin (g/dl)	3.9 (3-5)	4.0 (3.1-4.8)	0.56
Prothrombin time (%)	85 (81-111)	89 (84-118)	0.44
Activated partial thromboplastin time (sec)	32 (25-40)	35 (22-41)	0.74
ICG R15 (%)	9.0 (4-14)	9.2 (5.2-18)	0.99

ICG R15, indocyanine green retention test at 15 minutes

Table 2. Clinicopathological features of liver lesions in the early and late periods

	Early period (n=49)	Late period (n=89)	<i>p</i> -value
Benign	22 (45%)	13 (15%)	0.08
Hemangioma	2 (9%)	1 (7.5%)	
Adenoma	1 (4.5%)	0 (0%)	
Focal nodular hyperplasia	1 (4.5%)	1 (7.5%)	
Intrahepatic duct stone	11 (50%)	8 (61%)	
Cyst	7 (32%)	3 (24%)	
Malignancy	27 (55%)	76 (85%)	0.09
Hepatocellular carcinoma	22 (81%)	52 (68%)	
Intrahepatic cholangiocarcinoma	2 (7%)	4 (6%)	
Metastasis from colon cancer	3 (12%)	20 (26%)	
Mean tumor size (cm), range	3.5 (1.2-4)	3.0 (1-4.1)	0.88
Mean number of tumor (range)	1.2 (1-2)	1.2 (1/2)	> 0.99
Tumor location			
Segment 5 or 6	29 (59%)	46 (51%)	> 0.99
Left lateral section	15 (30%)	30 (34%)	0.65
Right posterior section	5 (11%)	13 (15%)	0.43

(71.8%) was the most common malignant disease in both periods (Table 2). Tumor size, number and locations were similar in both periods.

Types of laparoscopic liver resection

The operation type was categorized into minor resection (wedge resection, segmentectomy, sectionectomy) and major resection (right and left hemihepatectomy). In the early and late periods, the percentage of wedge resection was 27% and 33% ($p=0.27$); segmentectomy was 10% and 20% ($p=0.09$), sectionectomy was 29% and 25% ($p=0.50$); left hemihepatectomy was 12% and 9% ($p=0.82$); right hemihepatectomy was 22% and 13% ($p=0.74$); and the percentage of major liver resection was 34% and

22% ($p=0.99$), respectively. There was no significant difference in the operation type between both groups (Table 3).

Perioperative outcomes

The overall mean operation time was 308 minutes (range: 140-510) in the early period and 193 minutes (range: 40-350) in the late period ($p<0.001$) (Table 4). In each type of the operation, mean operation time of wedge resection or segmentectomy was 130 minutes and 115 minutes ($p=0.005$), respectively, sectionectomy was 252 minutes and 233 minutes ($p=0.004$), left hemihepatectomy was 330 minutes and 318 minutes ($p=0.004$), and right hemihepatectomy was 360 and 330 minutes ($p=$

Table 3. Extents of laparoscopic liver resections between the early and late periods

	Early period (n=49)	Late period (n=89)	<i>p</i> -value
Minor liver resection	39/49 (66%)	71/89 (78%)	0.75
Wedge resection	16 (27%)	30 (33%)	0.27
Segmentectomy	6 (10%)	18 (20%)	0.09
Sectionectomy	17 (29%)	23 (25%)	0.5
Major liver resection	10/49 (34%)	18/89 (22%)	> 0.99
Left hemihepatectomy	7 (12%)	8 (9%)	0.82
Right hemihepatectomy	3 (22%)	10 (13%)	0.74

Table 4. The comparison of intraoperative and postoperative outcomes between the early and late periods (mean values and range)

	Early period	Late period	<i>p</i> -value
Overall operation time (minute)	308 (140-510)	193 (40-350)	< 0.001
Blood loss (ml)	171 (50-1,200)	44 (50-400)	0.005
Postoperative hospital stay (days)	9.7 (4-31)	6.8 (2-9)	< 0.001
ICU stay (hours)	21.6 (0-120)	4.8 (0-24)	< 0.001
Duration of LFT normalization (days)	5.7 (0-39)	2.1 (0-20)	0.003

LFT, liver function test

Table 5. The comparison of operation time between the early and late periods

	Early period (minutes)	Late period (minutes)	<i>p</i> -value
Wedge resection or segmentectomy	130	115	0.005
Sectionectomy	252	233	0.004
Left hemihepatectomy	330	318	0.004
Right hemihepatectomy	360	330	0.005

0.005), in early period and late period, respectively (Table 5). The mean intraoperative blood loss was 171 ml (range: 50-1,200) in the early and 44 ml (range: 0-400) in the late ($p=0.005$). In the late period, the mean operation time and intraoperative blood loss were significantly less than the early period (Table 3). The postoperative hospital stay was 9.7 days (range: 4-31) in the early and 6.8 days (range: 2-9) in the late period ($p<0.001$). The ICU stay hour was 21.6 hours (range: 0-120) in the early and 2.8 hours (range: 0-24) in the late period ($p<0.001$). The duration to LFT normalization was 5.7 days (range: 0-39) in the early and 2.1 days (range: 0-20) in the late period ($p=0.003$). The intraoperative and postoperative outcomes in the late period were better than the early and it showed a statistical difference (Tables 4, 5).

Postoperative complications

The overall postoperative complication was 16% and 3% in the early and the late periods, respectively, with statistical difference (Table 6). Further, surgical and medical complications were significantly more common in the early period than in the late period. Wound infection and pulmonary complication were common in both periods. Postoperative bile leakage and renal insufficiency were not documented in either period. There was no perioperative death in both periods.

DISCUSSION

The widespread success of laparoscopic cholecystectomy has opened new frontiers and led to the application of laparoscopic techniques, to a wide variety of more complex surgical procedures. However, laparoscopic liver surgery has been slow to develop because of perceived technical difficulties.⁷⁻¹⁰ Since the first laparoscopic liver resection was performed in 1992,⁴ laparoscopic liver resection has been widely discussed with debate focusing on the feasibility, safety, oncological efficiency and surgical indications.¹¹⁻¹⁴ The first two issues were addressed early in the first part of this decade¹⁵⁻¹⁷ and oncological efficiency has been recently demonstrated.¹⁸

The gradual trend toward bloodless surgery in tradi-

Table 6. Postoperative complications

	Early period (n=49)	Late period (n=89)	<i>p</i> -value
Surgical complications	4/49 (8%)	2/89 (2%)	0.005
Wound infection	3	2	
Bleeding	1	0	
Bile leakage	0	0	
Medical complications	4/49 (8%)	1/89 (1%)	0.002
Heart failure	2	0	
Renal failure	0	0	
Pulmonary complication	2	1	
Total	8/49 (16%)	3/89 (3%)	0.004

tional techniques of hepatic resection, greater experience with laparoscopic surgery, with improvements in video equipment, laparoscopic instrumentation, and surgical skills have led hepatobiliary surgeons to attempt laparoscopic management in the application of various hepatic lesions. Their results were not as bad as expected- no worse than those of open surgery.^{1,19-23}

In malignant disease, achievement of a tumor-free margin, while resecting a malignant neoplasm, is of importance due to the limits of the laparoscopic liver resection. Some studies reported the same rate of negative surgical margins after laparoscopic and open liver resections. An European multicenter study showed that there was no evidence that the use of a laparoscopic technique increases the risk of local recurrence or port-site metastases.^{8,10} Further, using intraoperative laparoscopic ultrasound helps to demarcate the line of resections and compensates for the loss of tactile sensation.

According to some studies, mortality of laparoscopic surgeries are almost the same when comparing with large case series of open major liver resection, and thus the oncologic goals like complete resections are maintained.²⁴⁻²⁶ In our study, in the late period, the portion of old age, patient with comorbidity, and malignant tumor were more than in the early period. It is due to the widening of indication of laparoscopic liver resection in addition to the improvements of the surgical techniques and devices.

One of the main concerns during hepatectomy is minimizing blood loss and avoidance of blood transfusion.^{27,28} In our experience, laparoscopic surgery may provide better visualization of deep vascular structures and more precise and accurate surgery. To avoid injury to the hepatic veins during manipulation of secondary hilar structures, caution should be paid and the hepatic veins should be

transected in the parenchyma using clips or endoscopic linear stapler. In the early stage of laparoscopic hepatectomy, bleeding during parenchymal transection, due to a lack of effective devices, is another important cause of blood loss. However, there are many advancements made recently in the devices for dividing the parenchyma, including an ultrasonic scalpel, microwave tissue coagulator, Ligasure[®], water jet dissector, CUSA, and argon beam coagulator. According to our experience, using a LigaSure[®] and Harmonic scalpel[®] to transect the liver, it facilitates good hemostasis, less effusion, clear anatomy, and minor damage to liver function. The mean blood loss was 171 ml in the early and 44 ml in the late period. In the late period, with the improved instruments and experience, intraoperative bleeding was less than in the early period.

There are now numerous excellent devices for dividing the parenchyma, including ultrasonic scalpel, microwave tissue coagulator, water jet dissector, LigaSure[®], CUSA, argon beam coagulator, and TissueLink. Furthermore, accumulated operation skill and experience, is perhaps the biggest component.^{10,29} In our study, operation time was shortened in the late period (193 minutes) compared with those in the early period (308 minutes). And postoperative hospital days (early 9.7 days, late 6.8 days), postoperative ICU stay (early 21.6 hours vs. late 4.8 hours) and duration for LFT normalization (early 5.7 days vs. late 2.1 days) were also shortened in the late period than in the early period. Postoperative complication was less in the late period (3%) than in the early period (16%). Further, postoperative death was not seen in both periods. Therefore, laparoscopic liver resection has many benefits than disadvantages. In addition, with accumulated experience and development of better devices, laparoscopic liver re-

section can be performed safely and further indications can be made.

In conclusion, laparoscopic liver surgery can be safely performed but requires a long experience in open liver resection and mastery of laparoscopic surgical skills. It can be performed with excellent results in selected patients, even when major hepatectomy is required. It has benefits including less pain, minimal scar, less hospital and ICU stay. We expect laparoscopic liver resection to develop more in the future, as a promising new surgical method, which significantly improves patients' quality of life.

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