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Multimodality laparoscopic liver resection for hepatic malignancy – From conventional total laparoscopic approach to robot-assisted laparoscopic approach

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ABSTRACT

Introduction: Laparoscopic liver resection can either be total laparoscopic or hand-assisted laparoscopic approach. The recent introduction of robotic surgical systems has revolutionized the field of minimally invasive surgery. It was developed to overcome the disadvantages of conventional laparoscopic surgery. The role of robotic system in laparoscopic surgery was not well evaluated yet. The aim of this cohort study was to evaluate the outcome of multimodality approach of laparoscopic liver resection for hepatic malignancy

Methods: From January 1998 to August 2010, all patients with hepatic malignancy underwent laparoscopic liver resection were included. A prospectively collected data was analyzed retrospectively.

Results: During the study period, a total of 56 patients with hepatic malignancies (hepatocellular carcinoma, HCC, $n = 42$; colorectal liver metastases, CLM, $n = 14$) underwent laparoscopic liver resection in our surgical unit. The majority of cases were performed by hand-assisted laparoscopic approach, $n = 31$ (55.3%) and the remainder were with total laparoscopic approach, $n = 10$ (17.9%) and robot-assisted laparoscopic approach, $n = 15$ (26.8%). The median operation time was 150 min (range, 75–307 min). The median blood loss during surgery was 175 ml (range, 5–2000 ml). Two patients (3.6%) needed open conversion and one patient (1.8%) needed to be converted to hand-assisted laparoscopic approach. The morbidity rate was 14.3%. There was no procedure-related death. 89.3% of patients had R0 resection and 10.7% of patients had R1 resection. The median hospital stay was 6.5 days (range, 2–13 days).

The 1-year, 3-year, and 5-year disease-free survival rates for HCC were 85%, 47%, and 38%, respectively. The 1-year, 3-year, and 5-year overall survival rates for HCC were 96%, 67%, and 52%, respectively. The 1-year, and 3-year disease-free survival rates for CLM were 92% and 72%. The 1-year, and 3-year overall survival rates for CLM were 100% and 88%, respectively.

Conclusions: Multimodality approach of laparoscopic liver resection of hepatic malignancy was feasible, and safe in selected patients. It was associated with a low complications rate. The mid-term and long-term survival outcome was favorable also.

1. Introduction

The development of minimally invasive surgery over the last two decades has a great impact on the surgical practice. Laparoscopic liver resection also becomes possible with the availability of new instruments that allow a relatively bloodless liver transection. The advantages of laparoscopic liver resection are those of minimally invasive surgery, such as early recovery, shorter hospital stay, and better cosmetic outcome.[1] The post-operative course after laparoscopic liver resection may also be improved in patients with cirrhosis because the abdominal wall is preserved, kinetics of the diaphragm are improved, collateral venous drainage is better and there is less post-operative ascites. However, the role of laparoscopic liver resection for hepatic malignancy is still unclear because of the uncertainty of the long-term results, and the fear of compromising the oncological resection. Available long-term survival data about laparoscopic liver resection for hepatic malignancy in the literature are limited still.[2–8]

Traditionally, laparoscopic liver resection can either be total laparoscopic or hand-assisted laparoscopic approach.[1] Techniques of hand-assisted laparoscopic has been attempted to bridge the gap between open and conventional total laparoscopic approach. The recent introduction of robotic surgical systems has revolutionized the field of minimally invasive surgery.[9] It was developed to overcome the disadvantages of conventional laparoscopic surgery.

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However, the role of robotic system in laparoscopic surgery was not well evaluated yet.

The aim of the present cohort study was to evaluate the clinical outcome of multimodality approach of laparoscopic liver resection for hepatic malignancy.

2. Materials and methods

A prospective data collection of laparoscopic liver resection was initiated in our surgical center in 1998. The study population was a consecutive series of patients with hepatic malignancy who underwent conventional total laparoscopic liver resection, hand-assisted laparoscopic liver resection or robot-assisted laparoscopic liver resection in a tertiary referral center from January 1998 to August 2010. Robotic surgery was started in May 2009 in our hospital. Our programme of robot-assisted laparoscopic liver resection was started in June 2009. During the study period, a total of 42 patients with hepatocellular carcinoma (HCC) and 14 patients with colorectal liver metastases (CLM) underwent laparoscopic liver resection in our surgical unit.

The choice of conventional total laparoscopic liver resection, hand-assisted laparoscopic liver resection or robot-assisted laparoscopic liver resection was determined by the surgeon's preference. With the introduction of robotic system, almost all those suitable tumors for laparoscopic resection were performed by robot-assisted approach.

All patients had a chest X-ray, ultrasonography (USG) of abdomen, contrast computed tomography (CT) scan of abdomen and/or positron emission tomography (PET) scan. Laboratory blood tests including hepatitis B surface antigen, antibodies to hepatitis C, serum alpha-fetoprotein (AFP), carcinoembryonic antigen (CEA), serum albumin, total bilirubin, aspartate aminotransferase, alanine aminotransferase and prothrombin time were obtained and the Pugh's modification of Child's criteria was determined. Further investigations were performed only when there was clinical suspicious of extrahepatic metastases. Radiologic studies were reviewed in a multidisciplinary case management meeting held weekly.

The selection criteria included normal liver or Child's A cirrhosis, tumor size less or equal to 5 cm, and tumor located at anterio-inferio-lateral segments (Couinaud segments 2, 3, 4b, 5, 6) for laparoscopic resection. Solitary exophytic tumor $>$ 5 cm accessible to the laparoscopic approach was considered also. All procedures were performed by consultant surgeons with expert in hepatobiliary and laparoscopic surgery after obtaining informed consent. After operation, all patients were followed up with serial AFP, or CEA assay, and USG or CT scan of the abdomen was performed every 3–6 months.

2.1. Operative procedure of laparoscopic liver resection

The patient was placed in Lloyd-Davis position. The chief surgeon operated between patient's legs with assistants on each side. Preoperative laparoscopic staging was performed first before liver resection. A sub-umbilical open technique was used to insert a 10 mm port, and pneumoperitoneum was established with carbon dioxide insufflation to a maximum pressure of 12 mmHg. Using a 30° laparoscope, the liver surface, porta hepatic and peritoneal surface were inspected. A second access port was inserted in the right upper quadrant at the mid-clavicular line under video guidance. The laparoscopic USG (7.5 MHz; Aloka, Wallingford, Connecticut) was inserted through this port and was placed in contact with the liver and the porta hepatis. Apart from the preoperative staging and assessment of liver functional reserve, the subsequent plane of transection could then be easily determined. The planned transection plane was marked on the liver surface by diathermy.

The conventional total laparoscopic liver resection was performed with a 10-mm camera port, one 12-mm operative port and two/three 5-mm operative ports. The da Vinci® S Surgical System (Intuitive Surgical Inc., Sunnyvale, CA) was used for all robot-assisted procedures. A 12-mm camera port, 12-mm operative port, and three working 8-mm robotic ports were utilized. The trocar insertion sites depended on the location of the hepatic lesion. For hand-assisted laparoscopic liver resection, the position of Gelport (Applied Medical Resources Corp, Rancho Santa Margarita, California) was governed by the position of patient and the type of liver resection. A 7-cm long transverse incision (based on the palm size of the operating surgeon) was made at the right side of abdomen, slightly above the level of the umbilicus. The incision should not be directly over the pathology or too close to the laparoscope, otherwise the visual field and the range of movement would be very limited. One 12-mm operative port and two/three 5-mm operative ports were used. The surgical technique was as follows. The ligaments attaching the liver were divided, e.g. left triangular ligament for left lateral sectionectomy and right triangular ligament for right liver pathology. The falciform ligament was routinely transected with the aid of LigaSure (Valleylab, Boulder, Colorado)) and the stump was grasped for retraction. For selected patients with good liver functional reserve, Pringle maneuver was used to apply intermittent vascular control to reduce blood loss. To accomplish this, the a vascular lesser omentum was divided and a vascular sling was passed around the hepatoduodenal ligament. If vascular control was required, the tension could be tightened and retained as needed. After these preliminary steps and provided the central venous pressure was optimal ($<$5 cm H2O), parenchymal resection was carried out using a Harmonic Scalpel (UltraCision; Ethicon, Cincinnati, Ohio) and ultrasonic surgical aspirator (Sonopet UST2000; M&M Co Ltd, Tokyo, Japan). Minor vessels and bile ducts were controlled with bipolar scissors. Application of either a titanium clip or endostapler was used for the main vascular branches and bile ducts. At the completion of the parenchymal transection, the raw surface was inspected for any bile leak or oozing and such areas were plicated with 2/0 polypropylene. An argon beam coagulator was also used to achieve hemostasis from any oozing surface. During the use of argon beam coagulator, surgeons and anesthetists should be aware that there is a potential to develop a gas embolism and that adequate precautions should be taken to prevent this such as selecting a low flow setting on the argon beam coagulator and adequate venting of the abdomen through chimneys in laparoscopic ports to maintain safe pressures of between 8 and 12 mmHg. All specimens were retrieved inside a protective bag.

2.2. Statistical method

Prospectively collected data, including intraoperative parameters, post-operative complications, hospital mortality, and disease progress, were analyzed. Overall survival and disease-free survival were measured from the date of operation to the time of death and to the time when recurrent tumor was first diagnosed, respectively. Survival analysis was estimated by the Kaplan–Meier survival method.

3. Results

During the study period, a total of 56 patients with hepatic malignancies (HCC, $n = 42$; CLM, $n = 14$) underwent laparoscopic liver resection in our surgical unit. These 56 resections were carried out on 39 male and 17 female patients with median age of 60 years old (rang, 35-82). Three resections were carried for the indication of recurrent HCC. The demographic data and preoperative status of the 56 patients were shown in Table 1 and Table 2. The median preoperative AFP level was 9.1 (range, 1.7–112290) ng/mL. The median preoperative CEA level was 7.5 (range, 1–92.8) ng/mL. The median follow-up period was 16.9 months (range, 1–142.5 months).

3.1. Intraoperative results

Surgical procedures and operative details were shown in Tables 3 and 4. The majority of cases were performed by hand-assisted laparoscopic approach, $n = 31$ (55.3%) and the remainder were with total laparoscopic approach, $n = 10$ (17.9%) and robot-assisted laparoscopic approach, $n = 15$ (26.8%). The median operation time was 150 min (range, 75–307 min). Only 2 major hepatectomy (3.6%) was performed. The rest of hepatectomy was minor resection. The median blood loss during surgery was 175 ml (range, 5–2000 ml). Only 6 patients (10.7%) needed post-operative blood transfusion. Two procedures (3.6%) need to be converted to open approach and one procedure (1.8%) needed to be converted to hand-assisted laparoscopic approach. One patient in the conventional total laparoscopic group underwent left lateral sectionectomy for HCC needed open conversion because of injury to the branch of left hepatic vein, which resulted in moderate bleeding, and the patient underwent immediate hemostasis and liver resection. The other patient in conventional total laparoscopic

Table 1
Characteristics of the 42 patients with HCC.

Sex ratio (M:F)	31:11
Age [mean ± SD]	58.2 ± 10.4
Liver status	
Liver cirrhosis (n)	40
Non-cirrhotic liver (n)	2
Hepatitis status	
Hepatitis B carrier (n)	39
Hepatitis C carrier (n)	2
Recurrent HCC	3
Preoperative liver function of cirrhotic liver	
Pugh's modification of Child's grade A	40