Safety and Effectiveness Evaluation of A Two-Handed Technique Combining Harmonic Scalpel and Laparoscopic Peng's Multifunction Operative Dissector in Laparoscopic Hemihepatectomy

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Research

Keywords: Laparoscopic hemihepatectomy, Harmonic scalpel, Laparoscopic Peng's multifunction operation dissector, Two-handed technique

Posted Date: February 5th, 2021

DOI: <https://doi.org/10.21203/rs.3.rs-189868/v1>

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Abstract

Objectives

This study was designed to evaluate the safety and effectiveness of a two-hand technique combining harmonic scalpel (HS) and laparoscopic Peng's multifunction operative dissector (LPMOD) in patients who underwent laparoscopic hemihepatectomy (LHH).

Methods

We designed and conducted a case-control study nested in a prospectively collected laparoscopic liver surgery database. Patients who underwent LHH for liver parenchyma transection using HS + LPMOD were defined as cases (n = 98) and LPMOD only as controls (n = 47) from January, 2016 to May, 2018. Propensity score matching (1:1) between the case and control groups was used in the analyses.

Results

The case group had significantly less intraoperative blood loss in mL (169.4 ± 133.5 vs. 221.5 ± 176.3 , $P = 0.03$) and shorter operative time in minutes (210.5 ± 56.1 vs. 265.7 ± 67.1 , $P = 0.02$) comparing to the control group. The conversion to laparotomy, postoperative hospital stay, resection margin, the mean peak level of postoperative liver function parameters, bile leakage rate and others were comparable between the two groups. There was no perioperative mortality.

Conclusions

We demonstrated that the two-handed technique combining HS and LPMOD in LHH is safe and effective which is associated with shorter operative time and less intraoperative blood loss compared with LPMOD alone. The technique facilitates laparoscopic liver resection and is recommended for use.

Introduction

Massive bleeding is a big challenge for hepatic resection, especially hemihepatectomy. It is a cause of death during the surgery and hemorrhage after the surgery and affects prognosis as well. Increased intraoperative bleeding during liver surgery has been reported to have a negative impact on postoperative recovery and prognosis [1]. Massive blood loss during liver surgery is related to the high risk of postoperative mortality and recurrence of hepatocellular carcinoma. Massive intraoperative blood loss may lead to longer time of systemic hypoperfusion and affects oxygen delivery to vital organs [2]. In addition, perioperative blood transfusion due to massive blood loss is associated with worse survival outcomes in postoperative patients [3, 4]. Therefore, techniques which can help minimize bleeding during the hepatic resection are demanded to be developed.

With the development of laparoscopic techniques, laparoscopic liver resection has widely been carried out with the expansion of surgical indications [5, 6]. Laparoscopic hemihepatectomy (LHH) has recently been paid more attention to by surgeons and patients for its less postoperative pain and quicker postoperative recovery. Safe and effective parenchyma transection is a critical step in LHH, which is depended on the efficient management of the parenchyma division and hemostasis. Previous studies have compared the clinical benefits of different methods

in open liver resection [7, 8]. No standardized or best method, however, has been proposed for LHH to date and the best instruments for transecting the laparoscopic liver parenchyma are still controversial.

In January, 2016, we began combining harmonic scalpel (HS) and laparoscopic Peng's multifunction operative dissector (LPMOD) (HS + LPMOD) during laparoscopic liver transection. The operator held HS by the left hand and LPMOD by the right hand, which we named as a two-handed technique of LHH. After a period of adaptation, reduction of blood loss and shortened operative time were observed by using this two-handed technique during LHH. We believe this surgical technique would directly benefit patients with liver diseases, especially liver cancer. Therefore, we designed and conducted this study to explore the safety and feasibility of combining LPMOD and in laparoscopic hemihepatectomy (LHH).

Methods

Study design and patients

We designed and conducted a case-control study nested in a laparoscopic liver surgery database which data were prospectively collected. All data of clinical and demographic information for all patients were collected through medical records system in the Sir Run Run Shaw Hospital at Zhejiang University School of Medicine. All data were entered into the database by Dr. JHZ. Any patients who had laparoscopic hemihepatectomy (LHH) completed during the time period of January, 2016 to May, 2018 were eligible for this study. Patients who underwent LHH during the study period by two-handed liver surgery technique - HS + LPMOD were defined as cases and LPMOD only as controls. In order to avoid the biases from different surgical methods, patients with the liver wedge resection, liver segment resection and extended hemihepatectomy were excluded from this study. The flow chart of patient selection from the database in this study was shown in Figure 1. From the prospective liver surgery database, we identified 642 cases had LHH during the study period of which 145 cases were included for this study and 497 cases were excluded due to unclear hepatectomy type (n = 32), missing hepatectomy type (n = 10), partial hepatectomy (n = 330), and 125 segmental hepatectomy (n = 125). Of these 145 patients, 98 had HS + LPMOD and 47 had LPMOD only for liver parenchyma transection.

Surgical procedures

Several critical surgical instruments used in LHH were shown in Figure 2. Patients were placed in the supine position. Three surgeons including one primary surgeon and two assistants were needed. The primary surgeon stood on the left side of the patient. Carbon dioxide pneumoperitoneum was set at 10–14 mmHg. LHH was routinely performed with a four-port method (Figure 3). The observation port was placed above the umbilicus (A: 10 mm diameter); the main operating port was put below the xiphoid process (B: 12 mm diameter) and on the right collarbone midline (C: 12 mm diameter); and the assistant port was put on the right axillary front-line (D: 5 mm diameter).

Following routine laparoscopic exploration, intraoperative sonography was used to confirm the extent of diseases and relationship of important vessels, which can also guide the appropriate parenchyma transection plane. Hepatoduodenal ligament occlusion was performed routinely to occlude the hepatic inflow for 10 minutes and released for 5 minutes[9]. All devices were operated according to the recommendations for LHH.

In the HS + LPMOD group, the surgeon held HS by the left hand (Figure 3C trocar) and LPMOD by the right hand (Figure 3B trocar) to divide the parenchyma. The HS was applied to crack liver capsule approximately 2 cm away from the superficial liver tissues (Figure 2C), while the LPMOD was simultaneously used to expose, electrically coagulate and suction. Alternated operation of two hands was performed to cut and crash the liver parenchyma in different parts of the transection plane (Figure 2D). Vessels less than 3 mm were directly sealed by HS. Liver parenchyma hemorrhage was managed by LPMOD.

In the LPMOD only group, the device was inserted through B trocar (Figure 3), the technique for LHH was described previously in our institution [10]. Briefly, liver parenchyma is crashed and aspirated, then intrahepatic ducts and vessels can be dissected and preserved safely for clipping or ligation (Figure 2D). Vessels less than 3 mm would be electrically coagulated by LPMOD.

In both groups, the vessels larger than 3 mm were cut by HS after clipping by Hem-lock or titanium clip on the remnant side. Laparoscopic linear staples were adopted to seal hepatic pedicles or some hepatic veins which were larger than 10 mm. Suture was performed to accomplish hemostasis if necessary. An abdominal drainage tube was routinely placed in all patients.

A list of critical clinical factors related to LHH, including the type of liver resection, intraoperative blood loss, blood transfusion, operative time, conversion to laparotomy, postoperative hospital stay, hospital mortality, resection margin, postoperative bile leakage, and postoperative liver function. The evaluation of postoperative liver function was assessed by measurements of postoperative mean peak level of alanine aminotransferase (ALT), aspartate transaminase (AST), total bilirubin (TBIL) and prothrombin time (PT). For the purpose of this study, we defined biliary fistula as bilious drainage lasting more than 7 days after the surgery [11].

Statistical analysis

All analyses were performed using the SPSS 22.0 statistical software. Continuous variables were expressed by mean and standard deviation (SD) and categorical variables were expressed by number and percentage for each category. Paired-sample t test or Wilcoxon rank-sum test was used for continuous variables. And Pearson Chi-square test or Fisher's exact test was used for categorical data. To eliminate some potential biases due to confounding factors, propensity score matching (PSM) technique was used. A matching ratio of 1 to 1 was used based on the "nearest neighbor" method [12]. The propensity scores were estimated using logistic regression which included the following variables: age, sex, body mass index (BMI), American Society of Anesthesiologists (ASA) score, level of serum alpha-fetoprotein (AFP), liver cirrhosis and tumor characteristics (number and size). After 1 to 1 matching, 47 patients were included in the analyses in each group which had similar baseline and pathological characteristics. P value < 0.05 was considered as statistically significant.

Results

Baseline characteristics between the case group of having HS + LPMOD (n = 98) and the control group of having LPMOD only (n = 47) in LHH are shown in Table 1. There was 54 and 25 cancer patients confirmed with histopathological diagnosis in the case and control group, respectively. The two groups were similar in terms of sex, histopathologic malignancy, ASA score, AFP, liver cirrhosis, and common pathological characteristics. The

case group was older ($P = 0.03$) and had less BMI ($P = 0.02$) than the control group but the significant differences in age and BMI between the two groups disappeared after PSM.

The mean intraoperative blood loss was significantly less in the HS + LPMOD group compared with that in the control group of having LPMOD only during LHH (158.5 ± 124.2 vs. 221.5 ± 176.3 with a $P < 0.01$ before PSM; and 169.4 ± 133.5 vs. 221.5 ± 176.3 with a $P = 0.03$ after PSM) shown in Table 2. In addition, the HS + LPMOD group had a significantly shorter operative time in minutes than that in the LPMOD only group (202.4 ± 47.5 vs. 265.7 ± 67.1 with $P < 0.01$ before PSM; and 210.5 ± 56.1 vs. 265.7 ± 67.1 with $P = 0.02$ after PSM). There were no differences in blood transfusion rate, conversion to laparotomy, postoperative hospital stay, resection margin, perioperative hospital mortality and others between the two groups either before or after PSM.

The postoperative hepatocyte injury parameters increased dramatically after the surgery, but no significant differences were observed in the mean peak level of ALT, AST, TBIL and PT (liver function parameters) between the two groups either before or after PSM (Table 3). A lower bile leakage rate (7.1% before and 6.4% after PSM) was found in the HS + LPMOD group compared with that (8.5%) in the LPMOD only group but the difference was not statistically significant ($P = 0.77$ before and $P = 0.69$ after PSM). The bile fistula was resolved following a short course of drainage and antibiotic therapy. There were no perioperative deaths in both groups.

Discussions

Our study found that our two-handed technique combining HS and LPMOD in LHH had significantly reduced intraoperative blood loss and shortened operative time than using LPMOD only did. Our findings indicated the two-handed technique of combining HS and LPMOD was safer and more effective in LHH which benefits more to patients, including quicker physical recovery and better prognosis, than LPMOD only was. Synergistic combinations of the advantages of different hepatectomy tools instead of individual hepatectomy technique per se not only optimize the surgical procedures but also improve the safety and effectiveness of challenging hemihepatectomy through reducing intraoperative blood loss and shortening operative time which substantively increase the survival rate with better prognosis of patients with liver diseases, especially cancer patients.

In 2005, Aloia T et al. [13] first reported a two-surgeon technique, the primary surgeon and the secondary surgeon used two instruments to finish parenchyma division and hemostasis during the hepatectomy. Using the ultrasonic dissection (UD) device, the primary surgeon directed the dissection from the patient's left side. Simultaneously, the secondary surgeon operated the saline linked cautery (SLC) device from the patient's right side. Aloia TA showed that the use of the two-surgeon technique with UD plus SLC in hepatic resection resulted in shorter operative time and a reduction in the duration of hepatoduodenal ligament occlusion, while the postoperative liver function and complications rate were similar to that of using UD alone group. Mitsuhsa Takatsuki [14] claimed that the blood loss and donor complications in living donor hepatectomies significantly reduced when using the two-surgeon technique with Cavitron Ultrasonic Surgical Aspirator (CUSA) and SLC, while the early graft function and postoperative recipient survival didn't present significant difference between the two groups. This finding was most likely owing to two factors: a) less time being required for exchanging surgical instruments for dissection and coagulation leading to the acceleration of operation process; b) the active participation of two surgeons during the parenchyma transection promoting the efficiency (rather than one active surgeon cutting and coagulating with an assistant retracting and suctioning) [15].

Accurate hemostasis is the key to successfully accomplish laparoscopic liver resection, and this requires a tacit cooperation between the primary surgeon and assistants. Recent years, more and more scholars have used the two-surgeon technique to optimize the surgical procedure of LHH, and have found that it can notably increase the efficiency of liver transection, shorten the operative time and reduce intraoperative blood loss [13-15]. But it is known more difficult to set up a great cooperation between the two surgeons in LHH if it is an open surgery. The learning curve is steep and the assistant needs long time training.

Inspired by the two-surgeon technique, our well-practiced surgeon team started applying our two-handed technique, which combined LPMOD and HS to complete laparoscopic liver parenchyma transection. The primary surgeon stood on the left side of the patient, and conducted HS by the left hand and LPMOD by the right hand. Alternated operation of two hands was performed to cut and crash the liver parenchyma in different parts of the transection plane. The two-handed technique is equivalent to a small operation team but accidental hemorrhage can be managed more accurately and quickly by the primary surgeon's two hands than two different surgeons. The instructions for the two-handed operation are issued by the primary surgeon, which is more precise and does not lead to any misunderstanding which may occur between two surgeons when using the two-surgeon technique. The advantages of two-handed technique can be fully utilized by the surgeon during the operation without any exchanging or passing instruments frequently between two surgeons, which speeds up the surgical process and optimizes the operation. The application of the two-handed technique has no strict requirements for the operator's surgical position. The authors routinely stand on the left-hand side of the patient whether performing a left or right hepatectomy. In order to better master the two-handed technique, surgeons are required to train the weak hand to adapt HS operation manner. For example, if someone's the right hand is dominant, the left hand is required to have some practices in order to cooperate with the right hand during the surgery. Surgeons are required to spend some time training the coordinated cooperation between the two hands. Emphasis on the training of the primary surgeon's two-handed technique doesn't mean that assistant surgeons can be ignored. Assistant surgeons play a critical role in the field of vision exposure and assist the primary surgeon's operation.

To our knowledge, this is the first study to have evaluated the safety and effectiveness of the two-handed technique of combining HS and LPMOD together for parenchyma transection in LHH. With similar baseline demographics and tumor characteristics, the two-handed technique significantly reduced blood loss and shortened operative time compared with the control group of having LPMOD only. The requirement of blood transfusion, conversion to laparotomy, as well as the length of postoperative hospital stay and resection margin were comparable between the two groups. Furthermore, there was no perioperative hospital mortality in both groups. The postoperative liver function parameters increased dramatically after surgery, but no significant differences were observed between the two groups.

This study found that the intraoperative blood loss was significantly reduced in the two-handed technique group compared with the LPMOD only group. Hemorrhage during laparoscopic hemihepatectomy is mainly due to damage of the hepatic vein or branches inside the liver parenchyma [16]. Our two-handed technique can manage accidental hemorrhage without delay because this technique combines the superiority of small vessels seal function of HS and liver parenchyma hemostasis function of LPMOD. It has been shown that massive blood loss is related to an increased risk of death and recurrence after radical resection since serious intraoperative bleeding may facilitate tumor hematogenous spread, which could result in the recurrent tumor [17, 18]. Combined with other techniques or devices, intraoperative blood loss can be significantly reduced. Low CVP anesthesia during hepatectomy is also essential to decrease the bleeding amount [19].

This study revealed that the operation time was significantly shorter in the two-handed technique group than that in the LPMOD only group. This can be explained by the fact that in the LPMOD only group, dissection of the vessels during liver parenchyma transection requires a supplementary procedure (cut by harmonic scalpel after clipping on the remnant side) to control bleeding at the cutting plane, which cost extra time, but in the two-handed technique group, HS can seal and occlude the small vessel simultaneously when LPMOD exposes the duct. Therefore, the use of LPMOD combined with HS would shorten the operation time by saving the time needed to switch tool to ligate vessels at the cutting plane.

There was no difference in the mean peak level of postoperative liver function measured by ALT, AST, TBIL and PT between the two groups. The complication of bile leakage during hemihepatectomy may be affected by the tools chosen for parenchyma transection. In the two-handed technique group, bile leakage occurred in 3 patients (6.4%) who were followed to be treated by long-time drainage without other invasive intervention. The incidence of bile leakage was comparable between the two groups (6.4% in the HS + LPMOD vs. 8.5% in the LPMOD only group) after PSM.

Besides, there was no perioperative death in both groups. Therefore, our data suggested that the two surgical techniques are both suitable to perform safe and efficient LHH with a similar complication profile and comparable short-term outcomes but the two-handed technique is better considering less intraoperative blood loss and shorter surgery time.

There are some limitations in this study. Firstly, this is a case-control study that is a retrospective study, so some selection bias might be concerned but it is minimized by applying PSM in the analyses and or controlled by that the study is nested in a prospectively collected database. Secondly, only patients having LHH were included in this study which results may not be generalized to other types of liver resection such as wedge resection and anatomical segmentectomy that were excluded in this study. Thirdly, surgeons are required to take some time to get trained and practiced if they want to use this technique. Up to date, we used this two-handed technique mostly in LHH. Future studies are needed to test the safety and effectiveness of the two-handed technique in other types of liver resection.

This study has some strength. This two-handed technique has extensively been tested in 98 patients, not a small sample size, with different liver diseases including cancers, benign tumors, liver cirrhosis, and others in more than two years. In addition, our findings are adjusted for some confounding factors including critical clinical and demographic factors since our study design is a case-control study design. That the study is nested in a prospectively collected database and using PSM in the analyses help control and or at least minimize potential biases from collected risk factors. Therefore, our results are valid and this two-handed technique can be used for other patient populations around the world.

In conclusion, this study shows the new two-handed technique combining HS and LPMOD is safer and more effective in LHH which benefits more to patients than other individual laparoscopic hepatectomy technique. Although no single instrument is available to effectively complete the division and hemostasis during laparoscopic liver parenchyma transection, we can combine the strengths of different hepatic transection instruments together to create a new technique like our two-handed technique. Our two-handed technique in LHH can synergize the advantages of different hepatectomy tools, improve hepatic transection efficiency, optimize surgical procedures, reduce intraoperative blood loss, and shorten operative time. We strongly recommend the application of this technique in other laparoscopic hepatectomy institutions.

Abbreviations

HS: harmonic scalpel; LPMOD: laparoscopic Peng's multifunction operative dissector; LHH: laparoscopic hemihepatectomy; ALT: alanine aminotransferase; AST: aspartate transaminase; TBIL: total bilirubin; PT: prothrombin time; PSM: propensity score matching; BMI: body mass index; AFP: alpha-fetoprotein.

Declarations

Acknowledgements:

The authors thank all colleagues of the department of general surgery in Sir Run Run Shaw Hospital of Zhejiang University.

Authors' contributions:

XL, YLL and contribute to the conception and design of the study, JWC and JHZ contribute to analysis and interpretation of data. JWC, YYX, GXJ contribute to drafting the article. The authors read and approved the final manuscript.

Funding:

This research is supported by grants from the National Natural Science Foundation of China (Grant No. 82072625) and Zhejiang Major Medical Science and Technology Plan supported by Health Commission of Zhejiang Province (Grant No. WKJ-ZJ-2030)

Availability of data and materials:

All data are available without restriction. Researchers can obtain data by contacting the corresponding author.

Ethics approval and consent to participate:

This study was approved by the ethics committee of Sir Run Run Shaw Hospital. Written informed consent was obtained from all participants.

Consent for publication:

Written informed consent was obtained from all patients enrolled in the investigation. The study protocol conformed to the ethical guidelines of the 1975 Declaration of Helsinki and the guidelines of the regional ethical committees of Sir Run Run Shaw Hospital, School of Medicine, Zhejiang University, China.

Competing interests

The authors declare that they have no competing interests.

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Tables

Table 1 Demographic and pathologic factors before and after propensity score matching among the patients in the study						
	Entire cohort			Propensity-matched cohort		
	HS+LPMOD (n = 98)	LPMOD (n = 47)	P value	HS+LPMOD (n = 47)	LPMOD (n = 47)	P value
Age, mean (SD)	58.6 (11.1)	55.7 (11.8)	0.03*	56.4 (10.7)	55.7 (11.8)	0.36
Sex			0.20			0.41
Male, n (%)	65 (66.3)	26 (55.3)		22 (46.8)	26 (55.3)	
Female, n (%)	33 (33.7)	21 (44.7)		25 (53.2)	21 (44.7)	
BMI, mean (SD)	21.1 (2.2)	22.7 (2.4)	0.02*	21.8(1.9)	22.7 (2.4)	0.34
ASA, n (%)			0.99			0.90
I	28 (28.6)	13 (27.7)		15 (31.9)	13 (27.7)	
II	60 (61.2)	29 (61.7)		27 (57.4)	29 (61.7)	
III	10 (10.2)	5 (10.6)		5 (10.6)	5 (10.6)	
AFP, n (%)			0.23			0.81
Increased ($\geq$ 400 ng/mL)	15 (15.3)	11 (23.4)		12 (25.5)	11 (23.4)	
Not increased ($<$ 400 ng/mL)	83 (84.7)	36 (76.6)		35 (74.5)	36 (76.6)	
Histopathologic diagnosis			0.89			0.95
Colorectal carcinoma	14 (14.3)	5 (10.6)		5 (10.6)	5 (10.6)	
Hepatocellular Carcinoma	36 (36.7)	19 (40.4)		20 (42.6)	19 (40.4)	
Cholangiocarcinoma	4 (4.1)	1 (2.1)		2 (4.3)	1 (2.1)	
Benign	38 (38.8)	20 (42.6)		19 (40.4)	20 (42.6)	
Other	6 (6.1)	2 (4.3)		1 (2.1)	2 (4.3)	
Cirrhosis, n (%)	16 (16.3)	10 (21.3)	0.47	12 (23.4)	10 (21.2)	0.63
Pathologic characteristic						
Number of tumors, n (SD)	1.5 (0.3)	1.2 (0.5)	0.32	1.3 (0.3)	1.2 (0.5)	0.54
Largest Tumor size, cm (SD)	6.1 (3.5)		0.46	6.1 (3.3)	5.8 (2.8)	0.62

Abbreviations: AFP, alpha-fetoprotein; ASA, American Society of Anesthesiologists; BMI, body mass index; SD, standard deviation. HS, Harmonic Scalpel. LPMOD, Laparoscopic Peng's multifunction operative dissector.

Table 2 Operative factors before and after propensity score matching among the patients in the study						
	Entire cohort			Propensity-matched cohort		
	HS + LPMOD (n = 98)	LPMOD (n = 47)	P value	HS + LPMOD (n = 47)	LPMOD (n = 47)	P value
Hemihepatectomy			0.58			0.68
Left	59	21		28	26	
Right	39	21		19	21	
Blood loss, mL (SD)	158.5 (124.2)	221.5 (176.3)	0.001*	169.4 (133.5)	221.5 (176.3)	0.03*
Blood transfusion, n (%)	26 (26.5)	13 (27.7)	0.72	14 (29.8)	13 (27.7)	0.82
Operative time, minutes (SD)	202.4 (47.5)	265.7 (67.1)	0.001*	210.5 (56.1)	265.7 (67.1)	0.02*
Conversion to laparotomy, n (%)	5 (5.1)	3 (6.4)	0.75	4 (8.5)	3 (6.4)	0.69
Postoperative hospital stay, days (SD)	14.1 (9.4)	13.7 (9.4)	0.80	14.0 (8.7)	13.7 (9.4)	0.83
Hospital mortality, n (%)	0	0	-	0	0	-
Resection margin\$			0.97			1.00
R0	96	46		46	46	
R1	2	1		1	1	
R2	0	0				

Abbreviations: HS, harmonic scalpel; LPMOD, laparoscopic Peng's multifunction operative dissector; SD, standard deviation.

\$ R0: No microscopically identifiable tumor remnants, R1: microscopically identifiable tumor remnants R2: macroscopically identifiable tumor remnants

Table 3 Postoperative Variables before and after propensity score matching						
	Entire cohort			Propensity-matched cohort		
	HS+LPMOD(n=98)	LPMOD(n=47)	P value	HS+LPMOD(n=47)	LPMOD(n=47)	P value
Bile leakage n (%)	7 (7.1)	4 (8.5)	0.77	3(6.4)	4(8.5)	0.694
Liver functions						
Mean peak AST $\bar{x}\pm SD\bar{x}$	253.8 (146.4)	316.7 (187.8)	0.33	260.8(156.5)	316.7(187.8)	0.431
Mean peak ALT $\bar{x}\pm SD\bar{x}$	237.2 (126.1)	280.7 (223.6)	0.21	242.0(143.2)	280.7(223.6)	0.232
Mean peak total bilirubin $\bar{x}\pm SD\bar{x}$	27.0 (4.7)	29.7 (5.5)	0.65	27.3(3.6)	29.7(5.5)	0.703
Mean peak prothrombin time $\bar{x}\pm SD\bar{x}$	15.3 (3.4)	15.1 (2.5)	0.24	15.2(3.1)	15.1(2.5)	0.262

HS, Harmonic Scalpel. LPMOD, Laparoscopic Peng’s multifunction operative dissector. ALT, alanine transaminase; AST, aspartate transaminase;

Figures

Figure 1

Flow diagram of patient selection.

Figure 2

Some critical surgical instruments used in laparoscopic hemihepatectomy (LHH). A: harmonic scalpel (HS); B: laparoscopic Peng's multifunction operative dissector (LPMOD); C: Liver parenchyma transection was started with HS; D: liver parenchyma is crashed and divided by LPMOD combined with HS and intrahepatic ducts and vessels were observed.

Figure 3

The trocar positions in laparoscopic hemihepatectomy (LHH). The observation port was put above the umbilicus (A: 10 mm diameter), the main operating port was put below the xiphoid process (B: 12 mm diameter) and on the right collarbone midline (C: 12 mm diameter), and the assistant port was put on the right axillary front-line (D: 5 mm diameter).