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Safety and Feasibility of Laparoscopic Liver Resection with the Clamp-Crush Method Using the BiSect

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Background: Various energy devices are available for resection of the liver parenchyma during laparoscopic liver resection (LLR). We have historically performed liver resections using the Cavitron Ultrasonic Surgical Aspirator (CUSA). More recently, we have used new bipolar forceps (BiSect; Erbe Elektromedizin GmbH, Tübingen, Germany) to perform clamp-crush dissection with good results. The BiSect is a reusable bipolar forceps with a laparoscopic dissecting forceps tip and both an incision mode and coagulation mode. We evaluated the perioperative clinical course of patients who underwent LLR using the clamp-crush method with the BiSect compared with the CUSA.

Methods: This single-center case control study involved patients with liver metastasis from colorectal cancer who underwent LLR using either the BiSect or CUSA at our hospital from January 2019 to December 2022. We performed the LLR using CUSA from January 2019 to early October 2020. After introduction of the BiSect in late October 2020, we used BiSect for the LLR.

Before surgery, the three-dimensional liver was constructed based on computed tomography images, and a preoperative simulation was performed. We evaluated the results of LLR using the BiSect versus the CUSA and assessed the short-term results of LLR.

Results: During the study period, we performed partial liver resection using the BiSect in 26 patients and the CUSA in 16 patients. In the BiSect group, the median bleeding volume was 55 mL, the median operation time was 227 minutes, and the median postoperative length of hospital stay was 9 days. In the CUSA group, the median bleeding volume was 87 mL, the median operation time was 305 minutes, and the median postoperative length of hospital stay was 10 days. There were no statistically significant differences in the clinical course including bile leakage, bile duct stenosis, and post operative hospital stay between the two groups.

Conclusions: Compared with LLR using the CUSA, the clamp-crush method using the BiSect in LLR is a safe and useful liver transection technique. Further study should be conducted to clarify whether BiSect is safe and useful in LLR for patients with other tumor types and patients who undergo other procedures. (J Nippon Med Sch 2024; 91: 108–113)

Key words: laparoscopic liver resection, clamp-crush method, new energy device

Introduction

Among the surgical treatments of choice for liver tumors, recent advances in laparoscopic surgical procedures have been revolutionary. Laparoscopic liver resection (LLR) is comparable to conventional open surgical procedures in that the amount of bleeding during surgery is similar

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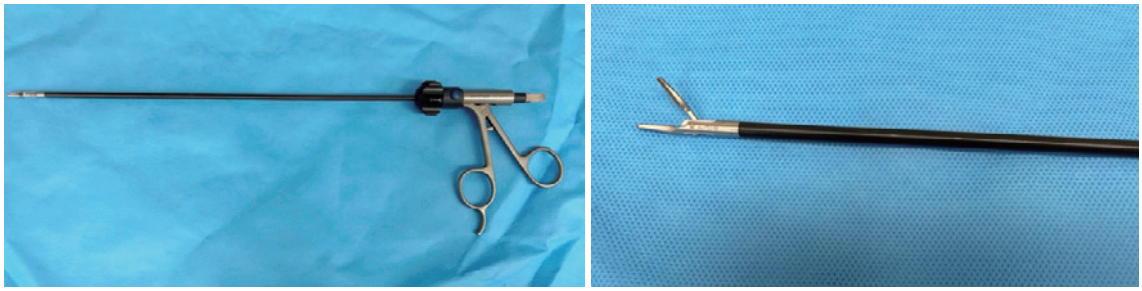

Fig. 1 The BiSect is a reusable bipolar forceps with a Maryland-shaped tip.

and benefits are obtained with respect to postoperative wound pain, cosmesis, and the postoperative length of hospital stay[1,2]. The number of cases of highly difficult LLR, such as sectionectomy and hemihepatectomy, is expected to increase in future[3]. LLR procedures range from partial liver resection to anatomical liver resection and can be performed multiple times in the same patient, either during a single operation or over different procedures. To date, laparoscopic hepatic parenchymal transection has relied on energy devices and staplers rather than the open approach because the clamp-crush technique, the gold standard technique used in the open approach, is difficult to apply laparoscopically.

Various energy devices are used for parenchymal transection of the liver in laparoscopic hepatectomy depending on the institution and operator. The absence of a gold standard technique is one of the reasons why many facilities that will introduce LLR in the future have difficulty deciding which techniques and devices to use. Various methods, such as the clamp-crush method, Cavitron Ultrasonic Surgical Aspirator (CUSA) method[4,5], and water jet method, are used during LLR worldwide. Among them, the clamp-crush method and the CUSA method are popular, and a randomized controlled trial comparing these two methods showed no difference in the operation time, bleeding volume, or perioperative complications[6–9]. Our hospital recently adopted a new energy device, a bipolar forceps called BiSect (Erbe Elektromedizin GmbH, Tübingen, Germany) (**Fig. 1**), to perform the clamp-crush method during laparoscopic hepatic parenchymal transection. In the present study, we analyzed the perioperative clinical course of LLR using the BiSect.

Materials and Methods

Patients

All LLR procedures performed in this study were covered by the Japanese national health insurance system. The ethics committee of our institute approved the use of the BiSect in LLR. Written informed consent was obtained from all patients.

The inclusion criteria for this study were as follows: (1) the tumor type was a metastatic liver tumor from colorectal cancer, and the number of the tumor was one or two, and (2) the LLR procedure was partial hepatectomy. LLR was performed using the BiSect or the CUSA in 42 patients in our department from January 2019 to December 2022 (male:female ratio, 23:19; median age, 66 years). We performed the LLR using CUSA from January 2019 to early October 2020. After introduction of the BiSect in late October 2020, we used BiSect for the LLR. As mentioned above, laparoscopic partial hepatectomy was performed in all patients with liver metastasis of colorectal cancer. The main operator was M.Y. in almost all cases; in other cases, M.Y. attended as an instructor. We divided the patients into two groups: the BiSect group (n = 26) and the CUSA group (n = 16). We evaluated the results of LLR using the CUSA versus the BiSect and assessed the short-term results of LLR. Postoperative complications are defined as a condition which needs any therapeutics (Clavien-Dindo Classification Grade 2 ≦)

Summary of Surgical Procedure of LLR with the BiSect

Prior to liver resection, safety was taken into consideration by constructing a three-dimensional liver using the SYNAPSE VINCENT system (Fujifilm, Tokyo, Japan) based on preoperative computed tomography images and performing a preoperative simulation. Patients undergoing LLR were placed in the supine position. The BiSect described in this report is mainly used for liver transection. It is a reusable bipolar forceps with incision and coagulation modes, and energy transfer is transmitted via two footswitches. The CUSA is also used for liver transection as previously reported[4]. Automatic sutures were used for vascular treatment during systematic hepatectomy.

Although the Pringle maneuver in LLR is different in each institution, we prefer to use a tourniquet to block

inflow blood circulation by passing two 5-mm tetron tapes through the hepatoduodenal mesentery. A Phicon drain (Fuji Systems, Tokyo, Japan), which is a tanicket, is inserted through the EZ Access port (Hakko Medical, Osaka, Japan) in the navel.

The clamp-crush method that we perform during LLR is the same as that for open liver resection. First, the tumor is confirmed by laparoscopic ultrasound, and marking is performed on the hepatic capsule of the planned hepatic transection line with a monopolar soft coagulation forceps. Next, the BiSect is used to perform hepatic transection of the surface layer <5 mm from the hepatic capsule along the marking. The superficial part of the liver contains many thin blood vessels and can be dissected using the BiSect without major bleeding (**Fig. 2**). Any bleeding that occurs is stopped with monopolar soft coagulation[10].

After excision of the surface layer of the liver, liver transection is performed by crushing the parenchyma of the liver with the clamp-crush method. Hepatic blood flow blockage by the Pringle maneuver is performed in all cases. The surgeon performs liver transection with the BiSect in the right hand and holds a suction tube with soft coagulation function in the left hand.

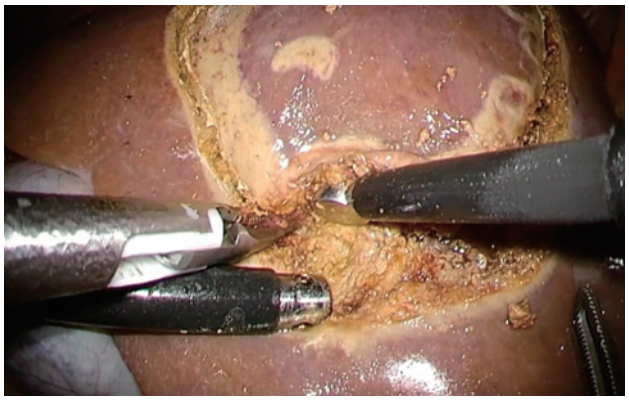

Fig. 2 After marking the dissection line of the liver, the BiSect is used to incise the surface layer of the liver.

The main technical points of the clamp-crush method are to advance the tip of the forceps to the site at which no resistance is felt and then crush the tissue and carefully treat the exposed thin blood vessels. Exposed thick vessels (>3-mm) can be dissected with the BiSect in incision mode after clipping, and thin vessels (<3-mm) other than those in Glisson's capsule can be dissected with the BiSect in coagulation mode[10](**Fig. 3a, b**). Even if part of a blood vessel is exposed after the hepatic parenchyma is crushed, immediate vascular treatment is not necessarily required. After thorough evaluation, the blood vessels should be treated as required.

Statistics

The data were analyzed and compared between the BiSect group and the CUSA group using Excel statistics. The Mann-Whitney U test was used for continuous data, and the chi-square test was used for categorical data.

Results

Baseline characteristics including gender, age, BMI, condition of ASA-PS in all 42 patients are presented in **Table 1**. Also, tumor characteristics, such as synchronous/metachronous, size, the number of tumors, and preoperative chemotherapy, are presented in **Table 1**. Although there is a tendency that ratio of the patients who underwent preoperative chemotherapy in BiSect group is less 7/19 vs. 7/9 and the median diameter of the tumor is less in CUSA group [22.5(1.5-3.5) vs. 1.7(0.7-2.8)], no significant difference in any characteristic was observed between the two groups.

We examined whether there were any differences in the operative outcomes. There was no statistically significant difference in the median intraoperative bleeding vol-

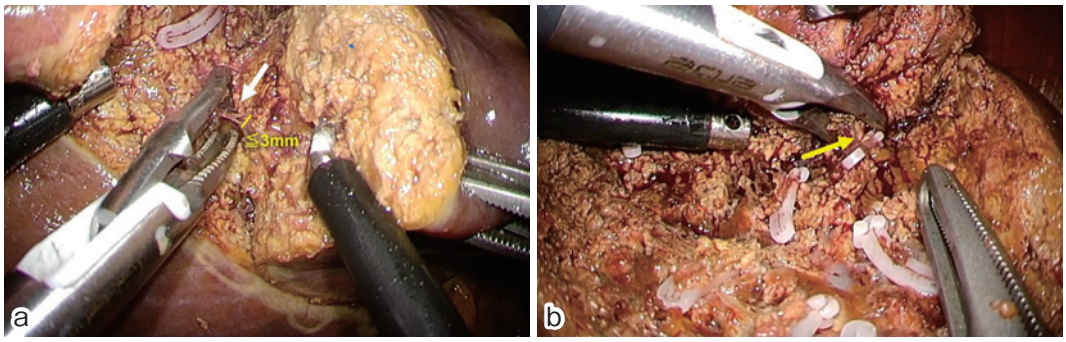

Fig. 3 (a) Vessels of >3 mm (Arrow) are clipped and dissected using the coagulation mode of the BiSect. (b) Vessels of ≤3 mm (Arrow) can be dissected without clipping using the coagulation mode of the BiSect.

Table 1 Background characteristics

	BiSect	CUSA
Number of patients	26	16
Gender (male/female)	12/14	11/5
Age, median (range)	66.5 (38-84)	68 (47-80)
BMI, median (kg/m^2)	24.9 (17-28)	23.5 (22-26)
ASA-PS (I/II/III)	5/19/2	5/10/1
Preoperative Chemotherapy (Yes/No)	7/19	7/9
No. of tumor (1/2)	21/5	12/4
Diameter of the tumor, median (cm)	2.5 (1.5-3.5)	1.7 (0.7-2.8)
Synchronous/Metachronous	2/24	1/15
Pathology of non-ancerous liver parenchyma		
Normal liver	26	16

The table shows the underlying characteristics of 26 and 16 patients who underwent laparoscopic liver resection with the BiSect and CUSA, respectively. Data were collected from January 2019 to December 2022 in our institute.

Table 2 Operation time and blood loss

	BiSect	CUSA	p
Bood loss (mL), median (range)	55 (0-850)	87 (0-600)	0.44
Operation time (min), median (range)	227 (117-474)	305 (159-620)	0.19

Data are shown as median (range). Statistical analysis was performed with the Mann-Whitney U test.

Table 3 Postoperative complications and duration of hospital stay

	BiSect	CUSA	p
Bile leakage, n (%)	0	0	NA
Bile duct stenosis, n (%)	0	0	NA
Post operative hospital stay, median (range)	9 (7-17)	10 (7-21)	0.42

Date are shown as n (%) for bile leakage and bile duct stenosis and as median (range) for the duration of the hospital stay. Statistical analysis was performed with the chi-square test for postoperative complications and with the Mann-Whitney U test for the duration of the hospital stay.

ume [55 (0-850) vs. 87 (0-600) mL, p = 0.44] or median operation time [227 (117-474) vs. 305 (159-620) min, p = 0.19] between the two groups (**Table 2**). We also examined whether there were any differences in the postoperative clinical course between the two groups. Postoperative bile leakage and bile duct stenosis were not observed in either group[11] (**Table 3**). Moreover, the median postoperative hospital stay was comparable between the two groups [9 (7-17) vs. 10 (7-21) days, p = 0.42]. These data indicate the feasibility and safety of LLR using the BiSect.

Discussion

Delicate operation of the forceps is important when performing the clamp-crush method in liver resection. When performing the clamp-crush method using Péan forceps during open surgery, the distance between the point of effort (the fulcrum) and the point of action is short; thus, the sense of the operator's hand is easily transmitted directly. However, when performing the clamp-crush method during laparoscopic surgery, the distance from the fulcrum to the point of action is long; therefore, slight movement of the hand causes a large deviation at the tip of the forceps, and a more delicate operation is thus required. Additionally, when crushing the liver parenchyma using the BiSect, care must be taken because the tip of the jaw is one-sided, similar to many other devices.

The clamp-crush method in LLR requires some experience to learn, but it is a simple procedure[12,13]. An important point of the clamp-crush method is that if resistance

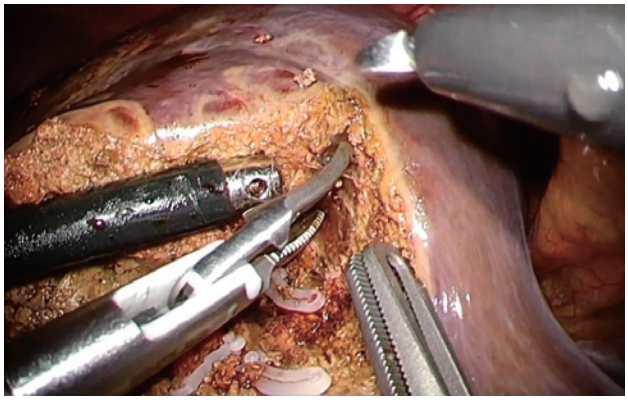

Fig. 4 The clamp-crush method demonstrates its superiority when the BiSect enters the intersegmental plane, which is an avascular layer.

is felt while pushing with the forceps, pushing should be stopped and the direction should be changed. In particular, one-third to one-half of the BiSect from the tip of the jaw is used to crush and incise the liver parenchyma in small steps in coagulation mode (**Fig. 4**). Additionally, when cutting tissue or blood vessels, it is important to step on the footswitch before pinching the tissue with the tip of the jaw of the BiSect. In some cases, the footswitch is turned on after sandwiching the tissue, and in other cases, the tissue cannot be separated even when the power is turned on.

Although the rise in the temperature of the blade differs depending on the type of energy device, the tip is very hot immediately after use. Therefore, when performing continuous crushing or vascular treatment, the surgeon must pay close attention to thermal damage to the surrounding tissue. In particular, thermal damage to the hepatic vein and around the main Glisson capsule causes postoperative bleeding and bile leakage[13–15]. According to our results (**Table 2, 3**), the procedure around Glisson's capsule using the BiSect can be safely performed.

In this study, although there was no statistically significant difference, the patients who underwent LLR with the BiSect had less blood loss and a shorter operation time than those treated with the CUSA (**Table 2**). The BiSect hepatic transection method also has the advantage of a shorter device replacement time because vascular treatment can be performed without changing the forceps. All of the above points illustrate that the BiSect might be more effective than many other energy devices when performing LLR. In our opinion, technical improvements may enable an even shorter operation time than in our present data.

In the future, robotic hepatectomy is expected to become the mainstream technique, representing further evolution beyond LLR. Robotic hepatectomy involves parenchymal transection of the liver with bipolar forceps, which is the same as transection by LLR. Therefore, the BiSect is considered to be an energy device suitable for facilities that are considering the introduction of robotic hepatectomy in the future.

Use of the BiSect also helps to reduce medical costs. In particular, the BiSect is a reusable bipolar forceps that can be used about 30 times. Medical costs can thus be reduced by implementing reusable equipment.

Few reports to date have described use of the BiSect for hepatic transection in LLR; however, the safety and usefulness of the forceps have been partially explained in the present report. Further study should be conducted to clarify whether the BiSect is safe and useful in LLR for patients with other tumor types, such as hepatocellular carcinoma or biliary tract tumors, and for patients who undergo other procedures, including sectionectomy, hemihepatectomy, and more extended liver resection.

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Conflict of Interest: None declared.

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