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The Superficial Precoagulation, Sealing, and Transection Method: A "Bloodless" and "Ecofriendly" Laparoscopic Liver Transection Technique

Osamu Itano, MD, PhD,† Naruhiko Ikoma, MD,*†‡ Hidehiro Takei, MD,§ Go Oshima, MD, PhD,† and Yuko Kitagawa, MD, PhD, FACS**

Background: Minimizing blood loss is an important aspect of laparoscopic liver resection. Liver transection is the most challenging part of liver resection, but no standard method is available for this step at present. Herein, we have introduced the superficial precoagulation, sealing, and transection (SPST) method, a potentially "bloodless" and "ecofriendly" laparoscopic liver transection technique involving reusable devices: the VIO soft-coagulation system; VIO BiClamp (bipolar electrosurgical coagulation); Olympus SonoSurg (ultrasonic surgical system); and CUSA (ultrasonic aspirator). Furthermore, we have reported the short-term outcomes of laparoscopic liver transection with the SPST method.

Methods: The study included 14 consecutive patients who underwent laparoscopic partial liver resection with the SPST method at a single institution between August 2008 and June 2010.

Results: The median operative time was 201 minutes (range, 97 to 332 min) and the median blood loss was 5 mL (range, 5 to 250 mL). There was no requirement for blood transfusion, no intraoperative complications, and no cases of conversion to open laparotomy. There were no liver transection-related complications such as postoperative bile leakage, bleeding, or infection. All surgical margins were negative, with a mean margin of 4.6 mm, and no local recurrence was observed at an average follow-up of 37.6 months.

Conclusions: The SPST method is a simple, efficient, and cost-effective surgical technique for laparoscopic liver resection. It is associated with low intraoperative blood loss and good short-term outcomes. We recommend that the SPST method should be used as a standard technique for laparoscopic liver transection (Supplemental Digital Content 1, http://links.lww.com/SLE/A103).

Key Words: laparoscopic liver resection, precoagulation, VIO soft-coagulation system, VIO BiClamp, SonoSurg, reusable devices

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From the *Department of Surgery, School of Medicine, Keio University; †Endoscopic Surgery Center, Eiju General Hospital, Tokyo, Japan; ‡Department of Surgery, University of Texas Health Science Center at Houston, Houston, TX; and §Department of Pathology and Genetic Medicine, The Methodist Hospital, Houston, TX.

O.I. and N.I. contributed equally.

The authors declare no conflicts of interest.

Reprints: Osamu Itano, MD, PhD, Department of Surgery, School of Medicine, Keio University, 35 Shinanomachi, Shinjuku-ku, Tokyo 160-8582, Japan (e-mail: itano@z8.keio.jp).

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Significant advancements in the design of laparoscopic instruments and in surgical techniques have expanded the indications for laparoscopic liver resection over the last 2 decades.[1–5] However, intraoperative bleeding is still a major concern and is the main reason for conversion to open laparotomy, which causes higher postoperative morbidity and mortality.[1,6,7] Moreover, intraoperative blood transfusion is reported to be a negative predictor of disease-free and overall survival in patients with hepatocellular carcinoma.[8] The most important factor for improved outcomes in laparoscopic liver resection is reduced blood loss, or possibly "bloodless" surgery, and liver transection is the most challenging part of the procedure in this regard. Therefore, the establishment of a simple and safe laparoscopic liver transection method is essential for further use of laparoscopic liver resection as a standard technique. However, no standardized method has been proposed for laparoscopic liver transection to date, and therefore surgeons operate on the basis of their individual experience.[9] Herein, we introduce an original laparoscopic liver transection technique—the superficial precoagulation, sealing, and transection (SPST) method—as a potential standard method for laparoscopic liver transection.

PATIENTS AND METHODS

A total of 14 consecutive patients who underwent pure laparoscopic partial liver resection with the SPST method from August 2008 to June 2010 at a single institution were enrolled in this study. The study population comprised 13 men and 1 woman, with a median age of 70 years (range, 53 to 84 y). Their preoperative diagnoses were as follows: hepatocellular carcinomas, 10 cases; and liver metastases from colorectal cancer, 4 cases. The Child-Pugh scores were A for 10 and B for 4 patients (Table 1). We did not include anatomic resection in this study so as to simply assess liver transection, because anatomic resection requires other technical procedures such as division of Glissonian pedicles, which can cause bleeding, bile leakage, or other complications. Resectability was determined by the following tests to exclude multiple tumors within the liver and/or extrahepatic metastasis and to assess the anatomic location: computed tomography with intravenous contrast, ultrasonography, and magnetic resonance imaging. All patients provided written informed consent for treatment and the academic use of the patient information.

Surgical Technique: The SPST Method

The technique consists of 4 steps that are repeated during liver transection (Fig. 1).

TABLE 1. Patient Background Characteristics

Age (y)	70 (53-84)
Male/female (n)	13/1
Diagnosis (n)	
Hepatocellular carcinoma	10
Rectal cancer metastasis	1
Colon cancer metastasis	3
Liver function/virus/alcohol (n)	
Cirrhosis on pathology	7
Fibrosis on pathology	3
Child-Pugh score	
A	10
B	4
Hepatitis B	3
Hepatitis C	3
Alcoholic hepatitis	2
Tumor location (n)	
S1	1
S2	1
S3	3
S4	2
S5	1
S5/6	1
S6	1
S7	3
S8	1

Values are the average ± SD or median (range).

Step 1: Superficial Precoagulation From the Liver Surface

First, we perform superficial precoagulation on the transection line of the liver from its surface (Fig. 1). A paddle-type electrode, known as the IO electrode, with the VIO 300D system (ERBE Elektromedizin, Tübingen, Germany) is used in the Soft-Coagulation mode with the effect level of 6 and a maximum output of 80 W. Saline solution is dropped at the tip of the IO electrode. During this step, the superficial parenchyma is coagulated to a depth of approximately 5 mm.

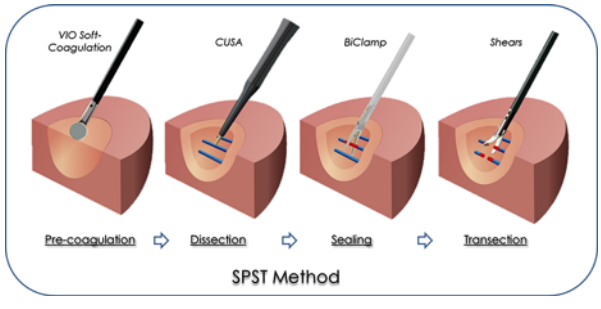

FIGURE 1. Schema of the steps of the superficial precoagulation, sealing, and transection (SPST) method. *Step 1*: Superficial precoagulation on the transection line of the liver from its surface, with the VIO soft-coagulation system. *Step 2*: Dissection of the liver parenchyma by CUSA (ultrasonic aspirator), which exposes the string-like structures of vessels and bile ducts. *Step 3*: Sealing with BiClamp (bipolar electrosurgical coagulation). *Step 4*: Transection with shears. Steps 3 and 4 can be substituted by SonoSurg (ultrasonic surgical system), which provides transection with simultaneous sealing if the vessels or bile ducts are small enough.

Step 2: Exposure of Vessels and Bile Ducts by Using an Ultrasonic Aspirator

Second, we dissect the liver parenchyma using the Cavitron Ultrasonic Surgical Aspirator system (CUSA; Valleylab, Boulder, NY), which exposes the string-like structures of the vessels and bile ducts (Fig. 1).

Steps 3 and 4: Sealing and Transection

Finally, before the transection, all vessels and bile ducts across the transection line need to be sealed with one of the sealing devices: BiClamp, SonoSurg, or Endo-Clip. Bipolar electrosurgical coagulation (BiClamp), which is a part of the VIO 300D system, is used to seal vessels with a diameter < 5 mm. As the BiClamp is purely a sealing device and does not transect tissue, laparoscopic shears are required for cutting (Fig. 1). If the vessels are < 3 mm, SonoSurg (Olympus, Tokyo, Japan)—an ultrasonic surgical system—can be used to transect vessels and seal them simultaneously. In vessels or bile ducts with diameters > 5 mm, clips are applied before transection.

RESULTS

The median operative time was 201 minutes (range, 97 to 332 min), and the median blood loss was 5 mL (range, 5 to 250 mL; 5 mL blood loss was considered as "uncountable blood loss"; Table 2), without the use of the Pringle maneuver in any case. There was no requirement for blood transfusion, no intraoperative complications, and no requirement for conversion to laparotomy. Two patients (14%) had a postoperative complication of pulmonary edema associated with low cardiac function and leg ischemia because of severe peripheral vascular disease, but no liver transection-related complications such as bile leakage or postoperative bleeding were observed. The pathologic diagnosis was the same as the preoperative diagnosis for all 14 cases. The mean tumor size was 2.5 ± 1.6 cm, and the mean surgical margin was 4.6 ± 4.2 mm. No patient was found to have a positive surgical margin on microscopic examination. Microscopy findings for background liver showed that 7 patients had cirrhosis and 3 patients had fibrosis. None of the patients had peritoneal carcinomatosis, port-site recurrence, or local recurrence during an average follow-up of 37.6 months.

TABLE 2. Operative Outcome

Tumor size (cm)	2.5 ± 1.6
Surgical margin positive (n)	0
Surgical margin (mm)	4.6 ± 4.2
Estimated blood loss (mL)	5 (5-250)
Blood transfusion (n)	0
Conversions to laparotomy (n)	0
Complication (n)	
Postoperative bleeding	0
Bile leak	0
Surgical site infection	0
Pulmonary edema	1
Leg ischemia	1
Peritoneal carcinomatosis	0
Port-site recurrence	0

Values are the average ± SD or median (range).

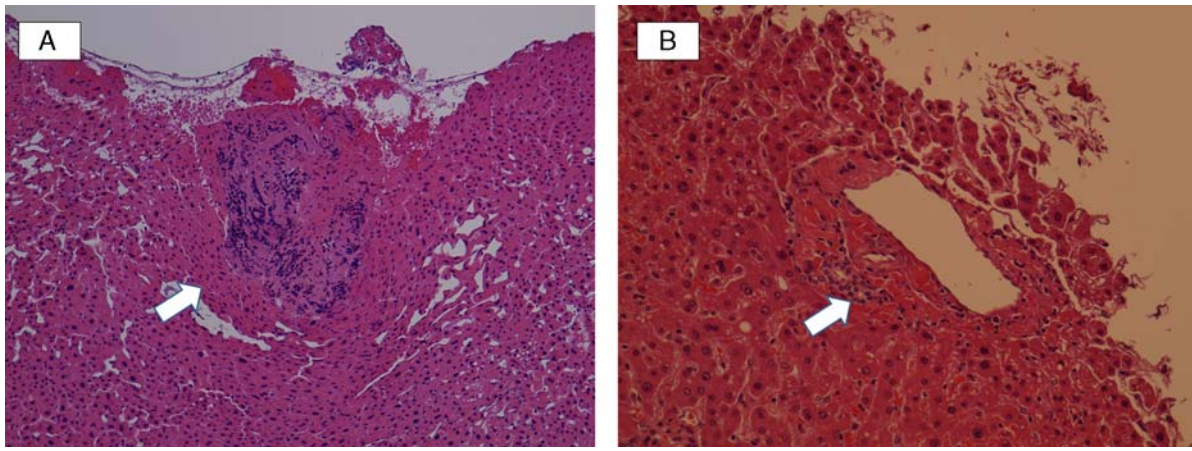

FIGURE 2. Histologic features of the transected liver surface with (A) or without (B) precoagulation and sealing. A, A collapsed portal triad (arrow) with surrounding distorted hepatocytes. B, An intact portal triad (arrow) and surrounding hepatocytes.

DISCUSSION

The first step of this SPST method is precoagulation, which prevents oozing during dissection and provides a bloodless clear view for easily performing the procedure steps. VIO Soft-Coagulation system, which is reported to be efficient for liver resection as well as pancreatic resection,[10–12] limits the voltage to 200 pV and prevents the development of sparks and thereby the carbonization of tissue. This Soft-Coagulation system provides shrinkage and occlusion of microvessels and bile ducts with a diameter < 1 mm, which possibly prevent hemorrhage and biloma. The depth of precoagulation provided by this system is estimated as 5 mm, which leaves 2 to 3 mm of the coagulated sealed surface (Fig. 2A). Care should be taken to avoid performing precoagulation to an excessive depth to prevent liver tissue necrosis, which can cause unnecessary liver damage and/or necrosis.[13] Another benefit of using this system is the ability to adjust the transection to complex and curved dissection planes, which is often required in enucleation and partial resection of tumors adjacent to large vessels.

The second step of the procedure is liver parenchymal dissection with the CUSA, which exposes the string-like structures of the small vessels and bile ducts. Because the liver parenchyma, which includes microvessels, is precoagulated in step 1, the subsequent dissection step can be bloodless. This bloodless vision enables a more accurate surgical procedure, which prevents the tearing of small vessels and bile ducts. CUSA also has a mild aspiration function, which means that its use combines well with the VIO soft-coagulation system as it requires a saline drip on its tip.

Steps 3 and 4 involve secure sealing of all small vessels by using a sealing device and without tearing them. We use SonoSurg for vessels with a diameter < 3 mm and BiClamp for vessels with a diameter < 5 mm. BiClamp is also reported to preserve the strength of the elastic fibers of vessels and bile ducts and prevents delayed hemorrhage and bile leakage.[14] Clips or staplers can be used for larger vessels and/or bile ducts.

The other benefit of SPST method is the ecofriendly aspect: CUSA, VIO Soft-Coagulation, VIO BiClamp, and SonoSurg are all reusable by autoclave sterilization. Similar devices can be used in a modified SPST method, for example, TissueLink[15] instead of Soft-Coagulation, Ligasure[14] instead of BiClamp, and Harmonic scalpel[16] instead of SonoSurg. However, these devices are disposable and expensive.

In the present study, the SPST method yielded very good results, particularly in terms of decreased blood loss. Bearing in mind the mean tumor size of 2.5 cm and the mean surgical margin of 4.6 mm, if we assume that the tumor is located in the flat surface of the liver, then the transection area would have a radius of 3.0 cm, which gives a surface area as large as 57 cm^2. As our study included 4 patients with a Child-Pugh score of B and 7 patients with pathologic evidence of cirrhosis, the estimated blood loss in our study (median, 5 mL; range, 5 to 250 mL) was lesser than that reported in other studies.[7,17]

In conclusion, the SPST method can provide potentially bloodless laparoscopic liver transection. This enables safe laparoscopic liver resection in an ecofriendly manner by using reusable instruments. This bloodless laparoscopic liver resection avoids the need for blood transfusion, and this may lead better oncological outcomes.[1] We propose that the SPST method described here should become a standard technique for laparoscopic liver transection. The potential advantages of this procedure should be evaluated in a comparative study on a large number of patients with long-term follow-up.

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