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/A105).

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

Surgical Technique: The SPST Method

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

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.
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, 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. 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. This Soft-Coagulation system provides shrinkage and occlusion of microvessels and bile ducts, thereby preventing the tearing of them. We use CUSA also has a mild aspiration function, which means that its use combines well with the VIO soft-coagulation system. 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. 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 instead of Soft-Coagulation, Ligasure instead of BiClamp, and Harmonic scalpel 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 cm². 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.

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. 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.

REFERENCES

1. Nguyen KT, Gamblin TC, Geller DA. World review of laparoscopic liver resection—2804 patients. Ann Surg. 2009;250:831–841.
2. Itano O, Oshima G, Maeda S, et al. Laparoscopic-assisted right hepatectomy and caudate lobectomy with portal reconstruction for hilar cholangiocarcinoma. J Laparoendosc Adv Surg Tech B. 2011;21. Videocopy: Runtime of video: 7 mins 51 secs.
3. Itano O, Chiba N, Maeda S, et al. Laparoscopic-assisted limited liver resection: technique, indications and results. J Hepatobiliary Pancreat Surg. 2009;16:711–719.
4. Buell JF, Cherqui D, Geller DA, et al. World Consensus Conference on Laparoscopic Surgery. The International position on laparoscopic liver surgery. The Louisville Statement, 2008. Ann Surg. 2009;250:825–830.
5. Kluger MD, Viganò L, Barroso R, et al. The learning curve in laparoscopic major liver resection. Hepatobiliary Pancreat Sci. 2013;20:131–136.
6. Mostaedi R, Milosevic Z, Han HS, et al. Laparoscopic liver resection: current role and limitations. *World J Gastrointest Oncol*. 2012;4:187–192.
7. Dagher I, Proske JM, Carloni A, et al. Laparoscopic liver resection: results for 70 patients. *Surg Endosc*. 2007;21:619–624.
8. Shiba H, Ishida Y, Wakiyama S, et al. Negative impact of blood transfusion on recurrence and prognosis of hepatocellular carcinoma after hepatic resection. *J Gastrointest Surg*. 2009;13:1636–1642.
9. Mbah NA, Brown RE, Bower MR, et al. Differences between bipolar compression and ultrasonic devices for parenchymal transection during laparoscopic liver resection. *HPB (Oxford)*. 2012;14:126–131.
10. Itoh S, Fukuzawa K, Shitomi Y, et al. Impact of the VIO system in hepatic resection for patients with hepatocellular carcinoma. *Surg Today*. 2012;42:1176–1182.
11. Hirokawa F, Hayashi M, Miyamoto Y, et al. A novel method using the VIO soft-coagulation system for liver resection. *Surgery*. 2011;149:438–444.
12. Nakagawa Y, Tsuchida A, Saito H, et al. The VIO soft-coagulation system can prevent pancreatic fistula following pancreatectomy. *J Hepatobiliary Pancreat Surg*. 2008;15:359–365.
13. Ogata S, Kianmanesh R, Varma D, et al. Improvement of surgical margin with a coupled saline-radio-frequency device for multiple colorectal liver metastases. *J Hepatobiliary Pancreat Surg*. 2005;12:498–501.
14. Nii A, Shimada M, Ikegami T, et al. Efficacy of vessel sealing system for major Glisson bundles and major bile ducts. *J Hepatobiliary Pancreat Surg*. 2008;15:522–527.
15. Koffron AJ, Stein JA. Laparoscopic liver surgery: parenchymal transection using saline-enhanced electrosurgery. *HPB (Oxford)*. 2008;10:225–228.
16. Aldrighetti L, Pulitano C, Arru M, et al. Ultrasonic-mediated laparoscopic liver transection. *Am J Surg*. 2008;195:270–272.
17. Santambrogio R, Aldrighetti L, Barabino M, et al. Laparoscopic liver resections for hepatocellular carcinoma. Is it a feasible option for patients with liver cirrhosis? *Langenbecks Arch Surg*. 2009;394:255–264.