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REVIEW ARTICLE

Laparoscopic liver resection using a bipolar vessel-sealing device: LigaSure®

DOUGLAS P. SLAKEY

Department of Surgery, Tulane University School of Medicine, New Orleans, LA, USA

Abstract
Achieving safe outcomes when performing laparoscopic liver surgery requires that the surgical team be expert in the techniques of liver surgery and in the application of appropriate technologies and devices. No other device is capable of effectively providing hemostasis, control of bile duct branches, and dividing parenchyma in every circumstance encountered during major hepatic resections. Therefore, liver surgeons use a variety of surgical technologies and instruments based on their judgment and experience and the individual nature of the operative procedure. Vessel-sealing technology has established itself as useful in liver surgery, for both open and laparoscopic cases. This paper reviews experience with a bipolar, vessel-sealing device (LigaSure®, ValleyLab, Inc., Boulder, Colorado) and its application to laparoscopic liver surgery.

Key Words: *liver resection, bipolar vessel-sealing device, laparoscopic, bile leakage, blood loss*

Introduction

Improvements in laparoscopic techniques and the development of technologies applicable to laparoscopic surgery have led to an increase in laparoscopic liver surgery. Single-center case series have been reported with increasing frequency in recent years, major hepatic lobe resections are no longer uncommon in specialized, high-volume centers. Laparoscopic hepatic resections have been reported for benign and malignant disease in normal and cirrhotic liver, and even for donor hepatectomies [1–5]. Nonetheless, laparoscopic liver resection remains the purview primarily of high volume, specialized centers performing a large number of both laparoscopic and open hepatectomies. Many surgeons and referring physicians remain skeptical about the ability to safely and completely resect liver lesions laparoscopically.

No consensus exists as to the best, most reliable and safest technique for laparoscopic liver resection, and surgeons tend to report individual preference for technique and equipment. The aspect of laparoscopic hepatic resection that most impacts operative safety, morbidity and mortality is parenchymal dissection. Just as with open hepatic resection, laparoscopic techniques have been described using many different devices. Laparoscopic instruments that have been used for liver and other solid organ procedures include ultrasonic dissectors, argon beam coagulators, linear staplers, and both microwave and radiofrequency coagulators. As published by most authors, a combination of devices is typically used, and surgical experience and judgment are critical factors in their choice. In this paper, a review of the use of a bipolar, vessel-sealing device (LigaSure®, ValleyLab, Inc., Boulder, Colorado) is reported, as well as the author's personal experiences.

Device and technique

The LigaSure® device uses radiofrequency energy delivered through a complex, computer-controlled algorithm which constantly measures resistance and alters output energy to produce a modulated current that denatures protein and elastin in vessel walls. The vessel-sealing technology combines physical compression with radiofrequency energy, and incorporates a brief cool-down period to produce a distinctive translucent seal, resulting from the fusion of collagen and elastin in the vessel walls. This technology seals

Correspondence: Douglas P. Slakey, Department of Surgery, Tulane University School of Medicine, 1430 Tulane Avenue (SL-22), New Orleans, LA 70112, USA. Tel: 504 988 2317. Fax: 504 988 1874. E-mail: dslakey@tulane.edu

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vessels to at least 7 mm in diameter. Vessels sealed with the LigaSure® device can withstand more than three times systolic pressure.

The use of the LigaSure® device for hepatic resection has been described in several studies [6–10]. Early studies demonstrated the importance of a crushing technique when using the device for hepatic parenchymal transection [6]. In this technique, the parenchyma is forcefully grasped between the jaws of the LigaSure® device of which there are several models for both open and laparoscopic approaches. All the LigaSure® models use the same generator. For laparoscopic hepatic resection the favored LigaSure® device is the 10 mm Atlas, which has a U-shaped electrode and a central cutting blade. The device is activated by depressing a foot pedal and the jaws of the device are gradually closed by the surgeon. As the device is closed, a blanched area of parenchyma extending approximately 1 mm outside the active electrode is developed. The rate of crushing (closing the jaws) is modulated by the surgeon such that width of the blanched area remains constant. When the jaws are in proximity and the intervening parenchyma has been crushed between the jaws of the device, enough pressure is applied to the device handle to activate the ratcheted locking mechanism. Simultaneously, the device will cycle off at this time. The device should then be recycled by depressing the foot pedal and allowing the energy cycle to repeat. This recycling after the jaws of the LigaSure® Atlas are approximated ensures that any vessel or bile duct within the jaws will be completely sealed.

The LigaSure® device produces minimal eschar and minimizes adjacent tissue damage due to thermal spread. When compared with other laparoscopic devices used for hepatic parenchymal dissection, the LigaSure® device demonstrates a lower mean temperature. For example, in a study by Kim et al., the mean temperature of the harmonic scalpel was $121.3^{\circ}C \pm 9.7^{\circ}C$ in liver, the LigaSure® $76^{\circ}C \pm 2.9^{\circ}C$, and a plasma trisector $83.7^{\circ}C \pm 2.4^{\circ}C$ [12]. In the peritoneum, the harmonic scalpel can develop a mean temperature of $195.9^{\circ}C$ compared to the LigaSure®, which develops a mean temperature of $88.9^{\circ}C$.

In our experience, the minimally lateral thermal spread results in very little charring of the cut parenchymal surface. Additionally, there is little trauma imposed by the device itself, except directly between the jaws. These factors result in a relatively clean plane of resection that makes for easy identification of small vessels and bile duct branches, facilitating closure by repeat sealing or cautery as appropriate. Our observations are similar to those published by other authors [8–11,13].

The LigaSure® device is particularly useful in non-anatomic dissections and in the major parenchymal dissection of anatomic resections. In our hands, we use a combination of LigaSure® and endovascular stapler to manage hepatic vasculature. For all laparoscopic liver surgery, an intra-operative duplex ultrasound is essential to identify the plane of resection. Initially, the ultrasound is used to determine the optimal line of resection necessary to achieve an adequate surgical margin, and the relative location of major intrahepatic vasculature. Duplex ultrasound should be used frequently during laparoscopic resection, especially major hepatic resections, because the geometry of the plane of resection, tumor, and major vessels relative to the laparoscopic ports changes as the plane of resection progresses. This is largely due to rotation of the portion of liver being resected during the dissection. Because of the possibility of vasculature becoming distorted, relative to laparoscopic instrument position during the dissection, repeat duplex ultrasound during the dissection is important. While the LigaSure® can be used to crush parenchyma and seal small to medium vessels, when large intrahepatic vessels are identified, the endovascular stapler should be used, and duplex ultrasound aids in determining which technique is best.

When performing a major hepatic resection, a right or left lobectomy, laparoscopically, authors have proposed a variety of methods to deal with portal structures and hepatic veins. The LigaSure® device lends itself well to the "Glissonean" approach of stapling the portal pedicle *en masse* [14]. This technique involves dissection of the entire sheath of the respective portal triad that extends into the liver. The Glissonean approach requires division of a substantial amount of hepatic tissue to reach the pedicle, which is surrounded by a sheath derived from Glisson's capsule. The LigaSure® is perfectly suited for this dissection. When the correct plane is reached the portal pedicle can be stapled using an endovascular linear stapling device. This technique can eliminate the need for a Pringle maneuver and reduce intra-operative hemorrhage.

Clinical experience

A meta-analysis of papers comparing laparoscopic versus open hepatic resections was recently published by Simillis et al. [1]. The authors analyzed eight non-randomized previously published studies. They found a significant reduction in blood loss and hospital length of stay in the laparoscopic surgery patients. There was no difference in operative time or adverse events.

The effectiveness of the LigaSure® vessel-sealing device has been demonstrated in several published reports. The device has been used successful in both cirrhotic and non-cirrhotic patients, and authors have reported effective hemostasis. One exception was an early report of the LigaSure® device being unreliable in providing adequate hemostasis in cirrhotic livers [15]. In these cases, the device was not activated prior to crushing the parenchyma. In addition, the degree

of portal hypertension, platelet count and degree of coagulopathy were not quantified. There is no doubt that patient selection for laparoscopic liver resection is important, just as for any operative procedure involving the liver.

The device has been associated with a very low rate of bile leakage [6,8,9]. The majority of series report no bile leakage. An early porcine study from our laboratory in which each animal had a post-operative hepatobiliary iminodiacetic acid (HIDA) scan on day two, no bile leakage was identified, operative times were significantly lower than with conventional surgical methods, and blood loss was also significantly reduced [6].

A report by Romano et al., demonstrated no post-operative hemorrhage or bile leak in 30 consecutive patients, another indication of the effectiveness of the device in sealing small bile duct branches [10]. A case control study by Lee et al., demonstrated similar operative times and resection margins, but significantly less blood loss, earlier resumption of diet, less pain medication requirement, and shorter hospital stay in the laparoscopic group [2].

A comparison study of three laparoscopic instruments, ultrasonic dissector, ultrasonic shears and vessel sealing has been reported in a porcine model [12]. The ultrasonic dissector was associated with the longest operating times. The vessel-sealing system was effective in producing excellent hemostatis and short operating times. A randomized study comparing vessel sealing (LigaSure®) to ultrasonic shears harmonic scalpel was recently published [9]. In this study by Campagnacci et al., 24 patients having open hepatic resections were randomized to one of the two surgical instruments for parenchymal transaction. The vessel sealing LigaSure® group had less blood and bile loss, and a shorter hospital stay.

Conclusions

The LigaSure® device is effective for both open and laparoscopic liver resection. Vessel-sealing technology is advantageous because of the ability to seal arteries, veins, and bile duct branches, resulting in simultaneous reduction of blood loss and bile leak. Minimization of lateral thermal spread and reduced limited eschar formation can facilitate parenchymal resection.

Laparoscopic liver resection is clearly an advanced procedure and will likely remain largely confined to tertiary referral centers. Successful laparoscopic liver surgeons must be competent in the application of appropriate devices and vary their use depending upon the circumstances of each individual patient and operative procedure. Consequently, the surgeon practicing laparoscopic liver surgery must have the support of the hospital in having all necessary laparoscopic devices available when needed. Only if these criteria are met laparoscopic liver surgery can be safely practiced.

References

[1] Simillis C, Constantinides VA, Tekkis PP, Darzi A, Lovegrove R, Jiao L, et al. Laparoscopic versus open hepatic resections for benign and malignant neoplasms – A Meta-analysis. Surgery 2007;141:203–11.

[2] Lee KF, Cheung YS, Chong CN, Tsang YYY, Ng WWC, Ling E, et al. Laparoscopic versus open hepatectomy for liver tumours: a case control study. Hong Kong Med J 2007;13: 442–8.

[3] Ardito F, Tayar C, Laurent A, Karoui M, Loriau J, Cherqui D. Laparoscopic liver resection for benign disease. Arch Surg 2007;142:1188–93.

[4] Soubrane O, Cherqui D, Scatton O, Stenard F, Bernard D, Branchereau S, et al. Laparoscopic left lateral sectionectomy in living donors: safety and reproducibility of the technique in a single center. Ann Surg 2006;244:815–20.

[5] Koffron AJ, Auffenberg G, Kung R, Abecassis M. Evaluation of 300 minimally invasive liver resections at a single institution: less is more. Ann Surg 2007;246:385–92; discussion 392–4.

[6] Constant DL, Slakey DP, Campeau RJ, Dunne JB. Laparoscopic nonanatomic hepatic resection employing the LigaSure device. JSLS 2005;9:35–8.

[7] Jersenius U, Fors D, Rubertsson S, Arvidsson D. Laparoscopic parenchymal division of the liver in a porcine model: comparison of the efficacy and safety of three different techniques. Surg Endosc 2007;21:315–20.

[8] Romano F, Franciosi C, Caprotti R, Uggeri F, Uggeri F. Hepatic surgery using the LigaSure vessel sealing system. World J Surg 2005;29:110–2.

[9] Campagnacci R, De Sanctis A, Baldarelli M, Di Emiddio M, Organetti L, Nisi M, et al. Hepatic resections by means of electrothermal bipolar vessel device (EBVS) LigaSure V: early experience. Surg Endosc 2007;21:2280–4.

[10] Romano F, Garancini M, Caprotti R, Bovo G, Conti M, Perego E, et al. Hepatic resection using a bipolar vessel sealing device: technical and histological analysis. HPB 2007;9:339–44.

[11] Sakamoto Y, Yamamoto J, Kokudo N, Seki M, Kosuge T, Yamaguchi T, et al. Bloodless liver resection using the monopolar floating ball plus LigaSure diathermy: preliminary results of 16 liver resections. World J Surg 2004;28:166–72.

[12] Kim FJ, Chammas MF Jr, Gewehr E, Morihisa M, Caldas F, Hayacibara E, et al. Temperature safety profile of laparoscopic devices: harmonic ACE (ACE), LigaSure V (LV), and plasma trisector (PT). Surg Endosc 2007;22:1464–9; accepted 29 August 2007.

[13] Sahin DA, Kusaslan R, Sahin O, Akbulut G, Ozen OA, Dilek ON. Comparison of LigaSure, SurgRx, and suture techniques in intra-abdominal adhesions that occur after liver resection in rats: an experimental study. Int Surg 2007;92:20–6.

[14] Figueras J, Lopez-Ben S, Llado L, Rafecas A, Torras J, Ramos E, et al. Hilar dissection versus the "Glissonean" approach and stapling of the pedicle for major hepatectomies: a prospective, randomized trial. Ann Surg 2003;238:111–9.

[15] Horgan PG. A novel technique for parenchymal division during hepatectomy. Am J Surg 2001;181:236–7.