



Hepatic Surgery Using the Ligasure Vessel Sealing System

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Published Online: December 9, 2004

Abstract. Blood loss, a well-known risk factor for morbidity and mortality during liver resection, occurs during parenchymal transection, so many approaches and devices have been developed to limit bleeding. Surgical technique is an important factor in preventing intraoperative and postoperative complications. The aim of the present study was to determine whether the bipolar vessel sealing device allows a safe and careful liver transection, achieving a satisfactory hemostasis thus reducing blood loss and related complications.

A total of 30 consecutive patients (18 male, 12 female with a mean age of 63 years) underwent major and minor hepatic resection in which the bipolar vessel sealing device was used without routine inflow occlusion. A crush technique followed by energy application was used to perform the parenchymal transection. No other devices were applied to achieve hemostasis. The bipolar vessel sealing device was effective in 27 cases of hepatic resection. It failed to achieve hemostasis in three patients, all of whom had a cirrhotic liver. Median blood loss was 250 ml (range: 100–1600 ml), and intraoperative blood transfusions were required in five patients (17%). Mean operative time was 200 minutes (range: 140–360 minutes). There was no clinical evidence of postoperative hemorrhage, bile leak, or intraabdominal abscess. The postoperative complication rate was 17%. The bipolar vessel sealing device is a useful tool in standard liver resection in patients with a normal liver parenchyma, but its use should be avoided in cirrhotic livers.

limiting the volume of intravenous fluids. Several techniques have been developed for safe and careful parenchymal dissection. In addition to blunt dissection using the “finger fracture” technique [13], various devices have been used: unipolar cautery, standard bipolar cautery, harmonic scalpel and ultrasonic dissectors, water jet dissection, stapling devices, laser systems, and the floating ball apparatus developed by Tissuelink. With these techniques, resection has become quite safe and major blood loss is uncommon. Because none of these devices can achieve complete hemostasis during dissection, blood vessels and biliary tract branches need to be clipped or sutured. It would be desirable to have a quick and reliable mean of transecting the parenchyma without using clips or ligatures, avoiding routine use of inflow occlusion. The purpose of our study was to present our experience with a bipolar vessel-sealing device (Ligasure Valleylab Inc, Boulder, CO); (Fig. 1), which has been shown to permanently occlude blood vessels as large as 7 mm in diameter. After experimental and clinical experience [14] we applied this technique in 30 consecutive patients undergoing liver resection.

Materials and Methods

Despite standardized techniques for liver resections, the surgical death rate ranges from 4% to 20% [1–3]. Intraoperative blood loss remains a major concern for surgeons operating on the liver [4–6]. It is associated with higher rate of postoperative complications and shorter long-term survival [7, 8]. Most blood loss during liver resection occurs during parenchymal transection. Multiple approaches have therefore evolved to reduce hemorrhage in this phase of the procedure. Three main types of strategies have been developed: (1) limit blood flow through the liver by prophylactic vessel occlusion, (2) reduce hepatic vein pressure [9], and (3) prevent blood loss from vessels along the plane of the parenchymal transection. Techniques that limit blood flow may limit antegrade flow (Pringle maneuver), eventually leading to stoppage of retrograde flow (total vascular occlusion) [10, 11] and vascular preconditioning [12]. Central venous pressure may be kept at a low level by means of hypotensive anesthetics and by

In this prospective study we gained experience with the bipolar vessel-sealing device (BVSD) during hepatic resection with 30 patients. The study was begun in January 2002 and completed in July 2003. The terminology for liver anatomy and resection used is the Brisbane 2000 terminology of the International Hepato-Pancreato-Biliary Association [15]. The initial steps of the procedure were performed in a standard fashion, according to the type of resection being performed. Isolation, occlusion, and transection of the portal pedicle was performed in patients undergoing right hepatectomy (segment 5 to 8) or right trisectionectomy (segments 4 to 8). In these cases the liver was also dissected off the inferior vena cava, and the right hepatic vein was isolated and ligated. In patients undergoing bisegmentectomies (2 Couinaud segments), segmentectomies (one Couinaud segment), or nonanatomical resections, no preliminary dissection of blood vessels was performed. Inflow occlusion was used only if blood loss during parenchyma transection exceeded 500–1000 ml, according to age, preoperative hematocrit values, and cardiac and hemodynamic status. Low central venous pressure was not used. The liver capsule was incised with electrocautery to outline the



Fig. 1. The Ligasure vessel-sealing system device.

Table 1. Patient Characteristics and Surgical Procedures

Patients no.	30
Males/females	18/12
Median age (ranges)	63 (38/74)
Indications	
Colorectal metastases	19
Hepatocellular carcinoma	6
Echinococcal cysts	2
Gallbladder cancer	1
Metastatic melanoma	1
Metastatic neuroendocrine tumor	1
Surgical procedures	
Right hepatectomies	5
Right trisegmentectomy	1
Bisegmentectomy 2-3	9
Other bisegmentectomies	5
Segmentectomies	6
Cystopericystectomies	2
Nonanatomical resections	2
Median operative time, min (range)	200 (140-360)
Median blood loss, ml (range)	250 (100-1600)
Intraoperative blood transfusions	5 (17%)
Postoperative morbidity	5 (17%)

plane of dissection. The underlying liver tissue was then divided using the Ligasure (Fig. 1). The blades of the device were inserted carefully into the parenchyma and the enclosed tissue was crushed several times before applying power. This has the effect of dispersing the hepatic soft tissue from between the blades of the clamp, leaving the intact vessels behind. The device was released (although several times a second application of power was used before realizing the good hemostasis), and the vessels were cut with scissors under direct vision. Once the clamp was removed care was taken to cut within the edges of the coagulated tissue considering that the coagulated tissue line is approximately 2 to 3 mm long and slightly curved. At the conclusion of the resection, the cut surface of the liver was explored for bile leaks, which were sutured if identified. Hemostasis was checked and eventually achieved with the BVSD along the bare surface of the liver remnant. No other hemostatic agents or devices were employed.

Results

The Ligasure vessel-sealing system has been used in 30 consecutive hepatic resections. Patients were 18 males and 12 females

(median age; 63 years; range: 38–74 years). Indications were as follows: 19 metastatic colorectal cancers, 6 hepatocellular carcinomas, 2 echinococcal cysts, and 1 each metastatic neuroendocrine tumor, metastatic melanoma, and gallbladder cancer. Patient characteristics, indications, and surgical procedures performed are summarized in Table 1. The BSVD was effective in 27 of these procedures, requiring transection through normal or near-normal hepatic parenchyma. In three cases of hepatocellular carcinoma associated with Child-Pugh B cirrhosis, the device was ineffective in achieving bloodless parenchymal transection, and the technique was abandoned because of high blood loss. Hemostasis was achieved with sutures and clips. Inflow occlusion (Pringle maneuver) was used in 12 (40%) of these patients; the occlusion never lasted longer than 40 minutes (30 minutes in cirrhotic patients). Intraoperative median blood loss was 250 ml (range: 100–1600 ml), and intraoperative blood transfusions were required in 5 patients (17%). Three of the 5 patients had a cirrhotic liver and required a change of the technique of resection to control hemorrhage. Another 4 patients were transfused in the perioperative period. Persistent bleeding after parenchymal transection was treated, when BVSD was ineffective, using 4/0 polypropylene sutures. Transection of the liver tissue using the device was quite rapid in all the cases, with the exception of the cirrhotic livers where the Ligasure failed to achieve hemostasis. Mean operative time was 200 minutes (range: 140–360 minutes). Although this is not a comparative study, duration of surgery does not seem to have been longer than that reported in literature with other techniques of transection [16, 17]. There was no clinical evidence of postoperative bile leak or intrabdominal abscess. There were no cases of postoperative hepatic insufficiency, and seven patients (23%) reported postoperative complications, as follows: 2 urinary tract infections, 2 right pleural effusions associated with pneumonia, 1 atrial fibrillation, 1 prolonged ileus, and 1 prolonged ascites at the drain site. The 30-day mortality was zero in this series.

Discussion

Improved techniques for liver resection, better monitoring during anesthesia, and introduction of a number of technical devices have resulted in reduction in perioperative morbidity and mortality associated with blood loss, even though liver surgery still remain a challenging procedure [18]. Moreover, intraoperative blood loss and the subsequent need for blood transfusion are considered significant risk factors for increased complication rates, poor postoperative outcome, and a shorter disease-free survival [19–21]. Also, intraoperative tissue damage associated with the technique of parenchymal dissection, seems to affect patient outcome. For these reasons, technical improvement should be considered possible and desirable. Our prospective series of hepatic resections demonstrates, as previously reported in two articles [22, 23], that the Ligasure vessel-sealing system is a safe and effective instrument for transection of liver parenchyma. It is able to permanently seal hepatic veins and arteries up to several millimeters in diameter, without additional devices or clips and knots. Moreover, intrahepatic biliary radicals smaller than segmental branches appeared to be well sealed by the BVSD. In fact no bile leaks were reported in our series. The Ligasure seems to be a good alternative when compared with other devices such as the harmonic scalpel, which seems to be related to an increased incidence of biliary fistulas [24]. With the Ligasures, the cut sur-

face appears even and brownish, making identification of biliary leaks or persistent bleeding easy to detect and suture. The instrument is easy to handle and its application does not require a long learning curve [25]. One of the advantages previously reported [23] and useful during hepatic surgery is the modest trauma that the Ligasure produces and the controlled dissection of tissues that it permits. Lateral thermal spreading and conduction are significantly lower compared with electrocoagulation, ultrasound scalpels, and laser [26], and the surgeon's view is not impaired by the pressure of smoke. The area of coagulation outside the clamps seems to extend approximately 1 mm on either side. Taking into account the known correlation of the extent of intraoperative tissue damage, healing complications, and postoperative septic complications, we see here one of the important advantages of this device.

Blood transfusions were infrequent in our series with the BVSD, with 17% of patients transfused intraoperatively, a lower rate than in major series reported in literature. DeMatteo et al. reported a large series in which 38% of patients received intraoperative transfusions [27], and Nuzzo et al. reported, reported a 41% rate of blood transfusion [28] during resection with inflow occlusion. Many of our patients did not have an underlying cirrhosis, which may explain the minimal need for blood replacement during hepatic resections; nevertheless our results seem favorable when compared to literature reports. One concern about this instrument remains. In our experience, BSVD fails to achieve a satisfactory hemostasis during transection of cirrhotic parenchymas. This device was abandoned during liver resection in three cirrhotic patients, because of uncontrollable blood loss. We believe that hard liver parenchyma, as in cirrhotic patients, made the crushing technique difficult, and the hepatic tissue between the blades of the device may have dispersed the power applied, causing vessels to bleed. Ligasure works particularly poorly in cirrhotic patients and seems to be unable to achieve a correct hemostasis, requiring the use of alternative techniques.

Operative time do not differ from that usually reported in similar series. The Ligasure vessel-sealing system seems to be usefull device for limiting blood loss and postoperative bile leak in patients who underwent hepatic surgery, and it does not appear to contribute to abscess formation. Otherwise it is cumbersome in cirrhotic livers.

References

- Rees M, Plant G, Wells J, et al. One hundred and fifty hepatic resections: evolution of a technique towards bloodless surgery. *Br. J. Surg.* 1996;83:1526–1529
- Doci R, Gennari L, Bignami P, et al. Morbidity and mortality after hepatic resection of metastases from colorectal cancer. *Br. L. Surg.* 1995;82:377–381
- Belghiti J, Hiramatsu K, Benoist S, et al. Seven hundred hepatectomies in the 1990s: an update to evaluate the actual risk of liver resection. *J. Am. Coll. Surg.* 2000;191:38–46
- Gozetti G, Mazziotti A, Grazi L, et al. Liver resection without blood transfusion. *Br. L. Surg.* 1995;82:1105–1110
- Cunningham JD, Fong Y, Shriver C, et al. One hundred consecutive hepatic resections: blood loss, transfusion and operative technique. *Arch. Surg.* 1994;129:1050–1056
- Jarnagin WR, Gonen M, Fong Y, et al. Improvement in perioperative outcome after hepatic resection: analysis of 1803 consecutive cases over the past decade. *Ann. Surg.* 2002;236:397–406
- Navarra G, Spalding D, Zacharoulis D, et al. Bloodless hepatectomy technique. *HPB Surg.* 2002;4:95–97
- Torzilli G, Makuuchi M, Midorikawa Y, et al. Liver resection without total vascular exclusion: hazardous or beneficial? An analysis of our experience. *Ann. Surg.* 2001;233:167–175
- Melendez JA, Arslan V, Fischer ME, et al. Perioperative outcomes of major hepatic resections under low central venous pressure anesthesia: blood loss, blood transfusion and the risk of perioperative renal dysfunction. *J. Am. Coll. Surg.* 1998;187:620–625
- Grazi G, Mazziotti A, Jovine E, et al. Total vascular exclusion of the liver during hepatic surgery: selective use, extensive use or abuse?. *Arch. Surg.* 1997;132:1104–1109
- Belghiti J, Noun R, Malafosse R, et al. Continuous versus intermittent portal triad clamping for liver resection: a controlled study. *Ann. Surg.* 1999;229:369–375
- Clavien PA, Yadav S, Sindram D, et al. Protective effects of ischemic preconditioning for liver resection performed under inflow occlusion in humans. *Ann. Surg.* 2000;232:155–162
- Tranberg KG, Rigotti P, Brackett KA, et al. Liver resection: a comparison using ND-Yag laser, an ultrasonic surgical aspirator, or blunt dissection. *Am. J. Surg.* 1998;158:368–373
- Romano F, Caprotti R, Franciosi C, et al. Laparoscopic splenectomy using Ligasure. A preliminary experience. *Surg. Endosc.* 2002;16:1608–1611
- The Brisbane Terminology of Liver Anatomy and Resections. *HPB. Surg.* 2000;2:333–339
- Takenaka K, Kawahara N, Yamamoto K, et al. Results of 280 liver resection for hepatocellular carcinoma. *Arch. Surg.* 1996;131:71–76
- Allen PJ, Jarnagin WR. Current status of hepatic resections. *Adv. Surg.* 2003;37:29–49
- Parikh AA, Gentner B, Wu TT, et al. Perioperative complications in patients undergoing major liver resection with or without neoadjuvant chemotherapy. *J. Gastrointest. Surg.* 2003;7:1034–1044
- Nash G, Walles W. Influence of postoperative morbidity on long-term survival following liver resection for colorectal metastasis. *Br. J. Surg.* 2003;90:1131–1136
- Stephenson KR, Steinberg SM, Hughes KS, et al. Perioperative blood transfusions are associated with decreased time to recurrence and decreased survival after resection of colorectal liver metastases. *Ann. Surg.* 1988;208:679–687
- Makuuchi M, Takayama T, Gunven P, et al. Restrictive versus liberal blood transfusion policy for hepatectomies in cirrhotic patients. *World. J. Surg.* 1989;13:644–648
- Horgan PG. A novel technique for parenchymal division during hepatectomy. *Am. J. Surg.* 2001;181:236–237
- Strasberg SM, Drebin JA, Linehan D. Use of bipolar vessel-sealing device for parenchymal transection during liver surgery. *J. Gastrointest. Surg.* 2002;6:569–574
- Kim J, Ahmad SA, Lowy AM, et al. Increased biliary fistulas after liver resection with the harmonic scalpel. *Am. Surg.* 2003;69:815–819
- Kennedy JS, Shanahan PL, Taylor KD, et al. High-burst strength, feed-back controlled bipolar vessel sealing. *Surg. Endosc.* 1998;12:876–878
- Heniford TB, Matthews BD, Sing RF, et al. Initial results with an electrothermal bipolar vessel sealer. *Surg. Endosc.* 2001;15:799–801
- DeMatteo RP, Fong Y, Jarnagin WR, et al. Recent advances in hepatic resections. *Semin. Surg. Oncol.* 2000;19:200–207
- Nuzzo G, Giulianta F, Giovannini I, et al. Hepatic resection in non-mothermic ischemia. *Surgery* 1996;120:852–858