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REVIEW

Current role of bloodless liver resection

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Abstract

Liver resections are demanding operations which can have life threatening complications although they are performed by experienced liver surgeons. Recently new technologies are applied in the field of liver surgery, having one goal: safer and easier liver operations. The aim of this article is to address the issue of bloodless liver resection using radiofrequency energy. Radionics, Cool-tip™ System and Tissue Link are some of the devices which are using radiofrequency energy. All information included in this article, refers to these devices in which we have personal experience in our unit of liver surgery. These devices take advantage of its unique combination of radiofrequency current and internal electrode cooling to perform sealing of the small vessels and biliary radicals. Dissection is also feasible with the cool-tip probe. For the purposes of this study patient sex, age, type of disease and type of surgical procedure in association with the duration of parenchymal transection, blood loss, length of hospital stay, morbidity and mortality were analyzed. Cool-tip RF device may provide a unique, simple and rather safe method of bloodless liver resections if used properly. It is indicated mostly in cirrhotic patients with challenging hepatectomies (segment Ⅷ, central resections). The total operative time is eliminated and the average blood loss is significantly decreased. It is important to note that this technique should not be applied near the hilum or the vena cava to avoid damage of these structures.

Key words: Bloodless liver resection; Radiofrequency; Cool-tip; Tissue link; Hepatectomy

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INTRODUCTION

Bleeding after liver resection remains a significant factor affecting prognosis. The concept of introducing new bloodless techniques to facilitate surgical resection of liver tumors have stimulated hepatobiliary surgeons. This has taken the form of vascular occlusion of the inflow (Pringle), the outflow or both (total vascular exclusion). Ischemic preconditioning or hemi-hepatic inflow vascular occlusion are alternative methods better tolerated in patients with cirrhosis. Although vascular occlusion techniques have been proven effective to control intraoperative bleeding, the pathophysiologic effects are still poorly analyzed and difficult to predict for patients with decreased hepatic reserve[1-5].

PATHOPHYSIOLOGIC EFFECTS OF VASCULAR OCCLUSION

The Pringle maneuver places the surgical candidate at a high risk for liver damage due to ischemia and subsequent postoperative liver failure[4,5]. The spectrum of mechanism leading to ischemia-reperfusion (I-R) injury is large and involves metabolic and mitochondrial changes as adenosine triphosphate depletion, Kupffer cell activation, release of reactive oxygen species, cytokine secretion and microcirculatory disturbances. Granulocytes have been strongly suggested to play a key role in the amplification of I-R injury ending in apoptosis, necrosis and organ failure[6,7]. A recent paper by Kukita showed that the Pringle maneuver in hepatectomy caused remnant liver injury in a pig model by expression of iNOS, a marker related to I-R injury[8].

THE USE OF RADIOFREQUENCY DEVICES IN LIVER RESECTION

Recent efforts have aimed to perform bloodless liver resections in the setting of parenchymal transection with new sophisticated devices[9-14] avoiding inflow occlusion. The Cool–tip radiofrequency device (Radionics, Tyco Healthcare) and the Tissue Link equivalent both use radiofrequency energy transmitted through the electrode to the adjacent liver parenchyma causing ion vibration with heat production. In fact the devices are able to achieve both necrosis of the liver tissue and sealing of blood vessels up to 3 mm in diameter by collagen fusion[9]. The saline circuit at the tip of the RF needle offers better ion agitation thus preventing charring with eschar formation.

DISCUSSION

The unique function to enhance heat conduction with a better tumoricidal effect makes these devices an advantageous tool for liver transactions. These findings lend important functional support to the concept of bloodless liver resection in cirrhotic patients and demanding segmentectomies (segment Ⅷ, central hepatectomy etc). There is also a theoretical advantage of further liver necrosis beyond the demarcation line with increase of the surgical margin as proved by enzymatic analysis in frozen liver specimens[13]. However, the effect of this amount of necrotic tissue on cirrhotic patients with limited liver remnant reserve is not clear.

From our own experience, in more than 30 liver resections in fibrotic or even cirrhotic livers with both devices, the negative effect is minimal. We noted one case of hyperbilirubinemia postoperatively in a thrombocytopenic patient with hepatitis C related cirrhosis after a segment Ⅴ-Ⅵ resection for a 5 cm single hepatocellular carcinoma (HCC). However the enzymes declined sharply the following days. In challenging segmentectomies the adjacent liver damage is not avoided but overall it is not harmful. The high postoperative aspartate aminotransferase (AST) levels reflect the coagulation-necrosis pattern at the raw surface of the remnant liver parenchyma and the maximum AST value is well correlated with the transection area[13]. It is worth noting that parenchymal degeneration is limited to the transection surface, which differs from the whole-liver ischemic damage caused by the Pringle maneuver. In addition coagulation induced by RF might be less prone to infection as we noted in our series, in opposition to ischemic necrosis due to inflow occlusion.

There is growing evidence that radio frequency (RF) is implicate in the enzymatic mechanism of cell division causing cell apoptosis[13]. In this regard, as already reported, an exciting possibility of tissue ablation beyond the histologic margins exists but needs further studies to establish its clinical effectiveness.

Complications relating to biliary tree following RF ablation are described in the literature[12]. Such complications remain to be the main problem with major resections using RF and regardless of the ultimate advantageous function of a bloodless RF device the liver surgical principles of hilar dissection should not be overlooked. There is a sense that, although the technique simplifies parenchymal transection, it cannot alter the conventional thought that such devices must only be used by experienced hepatobiliary surgeons. At the beginning of the learning curve with these new techniques we experienced two bile leaks suggesting that the dissecting sealer provides secure sealing of small bile ducts.

Even major anatomic liver resections can usually be performed without inflow occlusion and with infrequent need for blood transfusion. The results compare favorably with reports in which inflow occlusion was used routinely[2]. Most of the blood loss during major resections occurred from small branches or side holes of the middle hepatic vein. Unfortunately this anatomic structure appeared to be more difficult to visualize with the RF devises compared with CUSA or the traditional Kelly crashing technique and is correlated with similar findings pointed out by Poon[11]. However the likelihood of vessel identification is strongly affected by operator experience. Although Poon *et al*[11] suggest selective use of Tissue Link for wedge resections and segmentectomies our experience with application of both Radionics and Tissue Link in major liver resections is promising regarding blood loss and transection time. Even though the transection time appears to be longer with our approach due to the lower transection speed of the device we demonstrate better control of capillary bleeding with subsequent less total operative time. An additional advantage of the RF devices is their potential effectiveness in the laparoscopic era of liver resection although it is still premature.

OUR EXPERIENCE

In our series a total of 36 patients underwent liver resections using the Radiofrequency Cool-Tip device (Radionics, Tyco Healthcare) in the Liver Unit of Agia Olga Hospital.

Patients and methods

Twelve patients had HCC, 20 had liver metastasis from colon cancer (CRM), 1 cystic ovarian metastasis (OM) of segment Ⅲ, 1 focal nodular hyperplasia (FNH), 1 liver metastasis from renal tumor (RM) and 1 intrahepatic cholangiocarcinoma (ICC). Sixteen major and twenty minor hepatectomies have been performed using this new device. A redo hepatectomy of segment Ⅵ combined with wedge lung resection for an upper lobe metastatic lesion and a laparoscopic segment Ⅲ resection were included, both for CRM. Eight of our CRM patients had significant steatosis (> 30%) due to preoperative chemotherapy. All cases of HCC had underlying Child A cirrhosis with normal platelet counts except for a hepatitis B, C and Delta carrier with a low platelet count (PLT 84000/mL) due to mild portal hypertension and pegylated interferon treatment.

Technique

The RF device was set at 95 watts on the 480 kHz electrosurgical generator. RF should last 30-60 s to obtain a zone of tissue necrosis with a radius of 1 cm and 3 cm in depth. Once RF ablation has been completed (proven by increase tissue impedance) a common scalpel was used to divide the tissue. The probes were moved along the transection line to accomplish both dissection and liver coagulation. Small vessels < 5 mm and biliary radicles are sealed by collagen fusion although major intrasegmentary vessels (middle hepatic vein branch to segment Ⅷ) require clips or sutures.

Results

The median transection time was 44 min (range 26 to 81 min).The operative time for parenchymal transection was primarily affected due to two independent factors: (a) the raw liver surface (major hepatectomies defined as more than 3 segments resected were prolonged with median transection time 62 min and range 47 to 81 min compared to minor liver resections; median 30 min) and (b) the underlying liver disease. Radionics required more time to perform resections in cirrhotic livers (median 45 min; range 30 to 70 min) compared to the non-cirrhotic control[5] (median 30 min; range 25 to 50 min). Intraoperative blood loss was 100 mL (range 30 to 300 mL). Stitches were not placed except in the group of patients who underwent major hepatectomies or challenging segmental resections.

All patients had a postoperative increase of liver enzymes which normalized within 7 d. Serial monitoring of liver function in the first 7 postoperative days revealed peak serum aspartate aminotransferase (median 504.5 U/L, range 101 to 856 U/L) on d 1 or 3 with a rapid decline thereafter by d 7. Median peak postoperative serum bilirubin level was 1, 17 mg/dL (range 0.45 to 3.48 mg/dL).

Resected specimens were carefully examined for depth of tissue coagulation along the transection margin. Depth of tissue coagulation was 3 to 5 mm while providing an additional tumor negative margin at the resection border.

The in hospital mortality rate was zero. Procedure related complications included two bile leaks managed conservatively after major hepatectomies at the beginning of our learning curve. It is obvious that sealing of biliary radicles requires more time than vessels and therefore meticulous ablation is mandatory. No liver failure was reported in our series even in the cirrhotic group of patients. No reoperation was documented for rebleeding. The length of hospital stay ranged from 3 to 12 d with a mean value of 7 d.

We concluded that RF assisted liver resections can achieve low morbidity with minimal blood loss particularly in cirrhotic livers or challenging segmentectomies avoiding the sequela associated with the inflow occlusion techniques.

OTHER DEVICES USED IN LIVER RESECTION

A different approach for liver transection was introduced by Habbib and associates[10] with sequential RF needle insertion around the tumor until a necrotic rim is achieved. The transection of the parenchyma follows in a bloodless field. However the technique is applied much easier in the periphery of the liver compare to the hilum. Furthermore multiple insertions of the needle close to the tumor margin require superior Ultrasound (US) skills especially in demanding segmentectomies or central resections. Practically, once the ablation process starts, the sensitivity of the US to credibly detect tumor stereo tactic structure and ablation interface in real time decreases significantly.

Another interesting device introduced recently is the high frequency supported jet cutting device (HF jet) which allows rapid resections with minimal blood loss and no electrolyte disturbances. However, it is still undergoing experimental studies and it is difficult to translate experimental success to the clinical arena yet.

CONCLUSION

Although Bloodless cutting devices are promising there are several issues worth noting: (1) The techniques are still in progress and no randomization exists to compare the bloodless liver resection with the traditional approaches. (2) The bile leak rate is not reported thoroughly due to the fact that some groups use the bloodless devices combined with clips or staples and rely on intraoperative cholangiograms to early diagnose and treat. (3) Although the device provides excellent coagulation and is strongly recommended for cirrhotic patients, limited experience exists in patients with advanced cirrhosis, portal hypertension and low platelet count. (4) Sufficient data is not available with regard to liver resection in jaundiced patients with hilar cholangiocarcinoma wherein CUSA or water-jet seems to be more efficient. However, the RF devices are effective tools in a selective group of liver surgical patients. A randomized prospective trial comparing hepatectomies under intermittent Pringle maneuver or without clamping using modern equipment would be appropriate.

Although limited data regarding efficacy of the most popular transaction devices (CUSA, Hydro-Jet) including dissecting RF sealer is available the cost-effectiveness of expensive devices is not thoroughly analyzed. Two randomized controlled trials comparing clamp crushing technique versus CUSA and CUSA versus Hydrojet using inflow occlusion are published 15, 16. Both had critical limitations which included normal and cirrhotic livers. In the most recent prospective randomized study by Clavien and associates, 17 conclude that clamp crushing technique is the most efficient device in terms of resections time, blood loss and blood transfusion frequency compared with CUSA, Hydrojet and dissecting RF sealer. Pringle was applied routinely in the group of clamp crushing transection but not in the equivalent groups of bloodless liver resection. Even though Kelly crashing was proved the most cost-efficient, no marginal livers (cirrhotic, cholestatic) were included in the study.

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