The comparison of efficacy in 3 different types of pre-coagulation method for endoscopic liver resection of hepatocellular carcinoma

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Summary

Background: The control of bleeding from the liver parenchyma in laparoscopic hepatectomy is one of the important issues. In our department, the pre-coagulation method that the preceding coagulation of the resection line was done for the purpose of control of bleeding in parenchymal resection. MCT and RFA have been used for pre-coagulation. Recently, pre-coagulation by the soft coagulation that provides low voltage congelation under the control of impedance was introduced. In this study, we examined the utility of the different type of pre-coagulation in the laparoscopic hepatic resection.

Methods: The operative outcomes were compared with 55 patients who underwent laparoscopic partial hepatectomy for HCC with pre-coagulation method. The patients were divided into 3 groups depending on pre-coagulation device type, by MCT(M-EH), by RFA(R-EH), and by soft coagulation(S-EH).

Results: The background of patients in each device was not significantly different. The ratio of laparoscopic assisted operation in S-EH coagulation group is higher than the other devices. The intraoperative blood loss and operating time was not significantly different, but percent requiring blood product in M-EH group is higher than R-EH and S-EH coagulation group. Also the complication rate in M-EH group is higher than R-EH and S-EH coagulation group.

Conclusion: Pre-coagulation method by soft coagulation for laparoscopic hepatectomy represents a feasible technique with good control of bleeding. The pre-coagulation by S-EH is one of the choice which can be recommended.

Abbreviation: RFA, radiofrequency ablation; MCT, microwave coagulation therapy; HCC, hepatocellular carcinoma; HALS, hand assisted laparoscopic surgery

Key words: endoscopic hepatectomy, hepatocellular carcinoma, radio-frequency ablation, microwave coagulation therapy, soft coagulation

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Introduction

Since the first case of endoscopic hepatectomy (EH) was reported in 1992, EH for HCC has been gradually accepted in Japan. However, the intraoperative blood loss during hepatic parenchymal resection remains a major concern.

There are several surgical procedures for hepatic resection on the basis of minimizing blood loss. Prior microwave coagulation therapy (MCT) on the hepatic transection line has been introduced to control hepatic blood flow. Recently, radiofrequency ablation (RFA) has been used widely as effective and coagulative method for HCC, therefore, we developed an improved technique of endoscopic hepatic transection for HCC as radiofrequency-assisted EH (R-EH) in 2003. In both techniques, MCT and RFA were applied for hemostasis along the cutting line of the liver parenchyma before hepatectomy so that we defined this method as “pre-coagulation method”.

Recently, another new device that provides electrical coagulation has been developed. The control of the power output in accordance with the tissue impedance has improved the coagulation range and depth provides “soft coagulation” with VIO300D (ERBE Elektromedizin, Tübingen, Germany). This “soft coagulation” is very useful for the control of oozing from visceral organs. In our institution, the soft coagulation has been employed since 2006 May for liver surgery. As the feature of soft coagulation is suitable for coagulation of the liver parenchyma, we have developed another pre-coagulation method for EH by soft coagulation.

In this study, we report the experience of EH with pre-coagulation method by 3 different devices. The surgical results were evaluated in order to determine the feasibility and effectiveness of pre-coagulation method in each device for EH.

Figure 1 Pre-coagulation by soft coagulation with laparoscopic hand-assisted hepatectomy
A: CT scan demonstrated tumor located on the liver surface of section 5 (white arrow), B: The cutting line was drawn on the liver surface keeping a margin of at least 1 cm from the tumor border, C: Pre-coagulation of mono-polar electrode of soft coagulation on the cutting line, D: Additional soft coagulation during hepatic transection, E: Dry cutting liver surface after transection, F: Specimen present resected tumor and coagulative area along cutting line.
Patients and Methods

Between January 1999 and September 2009, 799 HR operations have been performed in our institute. In the same period, 80 patients underwent EH including 60 partial hepatectomy for liver tumor. Criteria for enrollment of EH were as follows: Patients with liver tumor, fewer than 3 nodules, tumors of less than 3 cm in diameter and located near the surface of the liver were entered into this study. Contraindications of EH included uncontrollable ascites, total bilirubin levels >3 mg/dL, prothrombin activity below 40%, and platelet which counts below 30,000/L.

Approaches to endoscopic hepatectomy

A laparoscopic or thoracoscopic approach was selected individually based on the tumor location. Consequently, laparoscopic and thoracoscopic approaches were selected in 76 (95%) and 4 (5%) patients, respectively.

In this study, endoscopic hepatectomy (EH) included pure endoscopic hepatectomy (PEH), hand assisted laparoscopic surgery (HALS), and endoscopy assisted hepatectomy (EAH). The selection of 3 types of endoscopic surgery was determined depending on the size of the lesion and location of the tumor. Briefly, (i) PEH: the procedure of hepatectomy was performed with completely endoscopic procedure. (ii) HALS: Dissection around liver and resection are performed endoscopically with hand-assistance. (iii) EAH: the procedure of dissection was performed endoscopically and parenchymal resection was performed with small laparotomy by open techniques. Clamping of the hepatic pedicle is not routinely performed in each procedure.

The patients were divided into 3 groups depending on pre-coagulation device type; M-EH: MCT for pre-coagulation, R-EH: RFA for pre-coagulation, S-EH: The control of parenecymal bleeding prior to hepatectomy was performed using the soft coagulation of monopolar electrode with VIO300D (ERBE Elektromedizin, Tübingen, Germany). The generator module regulates the power output in accordance with the tissue and can regulate optimal coagulation for individual tissues. The control with precisely limited power output provides coagulation without carbonization and minimal sticking of the electrode.

Surgical techniques

The M-EH and R-EH techniques for HCC have been previously described 5-8. The S-EH technique for liver transection is as follows.

The cutting line was drawn on the liver surface using electric cautery, keeping a margin of at least 1 cm from the tumor border. The tip of soft monopolar electrode was pressed against the cut surface and the hepatic resection was performed for a few seconds and thus provided in-depth coagulation.

Liver transection in the pre-coagulative area was performed using a Cavitron ultrasonic surgical aspirator (CUSA; Valleylab, Boulder, CO, USA). Pre-coagulation at the cutting line is the preferable technique to keep a dry surgical area and additional soft coagulation during hepatic transection was easily performed when the oozing from the cut surface.

In cases of HALS, about 7 cm incision was made in the mesogastrium not to be close to the adjacent ports. In case of EAH, an approximately 7 to 8 cm incision was made near liver cutting line to resect liver under direct vision. After confirming the absence of any bleeding and the absence of any bile leakage, a drain was inserted into the transected surface of the residual liver.

Postoperative complications were diagnosed clinically and radiologically. The medical records at our institution were reviewed and the data are expressed as the mean ± SD or as a range. The statistical software package StatView (SAS Institute Inc. Cary, NC), version 4.5 for windows, was used for the statistical analysis. A P value less than 0.05 was considered significant.

Results

Between January 1999 and September 2009, total of 57 cases of HCC underwent a laparoscopic partial hepatectomy. Except for 2 cases in which pre-coagulation was not performed, 55 cases were analyzed. The patients were divided into 3 groups: 12 M-EH, 19 R-EH and 24 S-EH groups. Demographic data of the clinical characteristics of the 55 pa-
Patients in M-EH, R-EH and S-EH are shown in Table 1. There was no significant difference in the average ages, the male:female patient ratios, the ratios of hepatitis B and hepatitis C among 3 EH group.

As for liver function, there was no significant difference in the count of platelets, indocyanine green retention test (ICGR), and liver damage A/B classified according to the classification of primary liver cancer by the Liver Cancer Study Group of Japan 10) in the patient’s background data.

### Table 1  Patient’s characteristics of laparoscopic hepatic partial resection in each pre-coagulation method

<table>
<thead>
<tr>
<th></th>
<th>M-EH</th>
<th>R-EH</th>
<th>S-EH</th>
<th>p value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Age (years)</td>
<td>61.1</td>
<td>61.1</td>
<td>64.0</td>
<td>NS</td>
</tr>
<tr>
<td>M/F</td>
<td>8/4</td>
<td>13/6</td>
<td>16/8</td>
<td>NS</td>
</tr>
<tr>
<td>HBs ag positive (%)</td>
<td>41.6</td>
<td>25.0</td>
<td>18.7</td>
<td>NS</td>
</tr>
<tr>
<td>HCV ab positive (%)</td>
<td>50.0</td>
<td>47.3</td>
<td>41.6</td>
<td>NS</td>
</tr>
<tr>
<td>Plts (×10^4/μL)</td>
<td>13.5 ± 4.7</td>
<td>14.6 ± 7.9</td>
<td>13.3 ± 4.7</td>
<td>NS</td>
</tr>
<tr>
<td>ICG R15 (%)</td>
<td>16.9 ± 7.7</td>
<td>15.6 ± 13.2</td>
<td>13.8 ± 7.1</td>
<td>NS</td>
</tr>
<tr>
<td>Liver damage (A/B)</td>
<td>102</td>
<td>172</td>
<td>222</td>
<td>NS</td>
</tr>
</tbody>
</table>


### Table 2  Operative characteristics of laparoscopic hepatic partial resection in each pre-coagulation method

<table>
<thead>
<tr>
<th></th>
<th>M-EH</th>
<th>R-EH</th>
<th>S-EH</th>
<th>p value</th>
</tr>
</thead>
<tbody>
<tr>
<td>PEH/HALS/EAH</td>
<td>3/6/3</td>
<td>0/15/4</td>
<td>3/4/17</td>
<td>&lt;0.05</td>
</tr>
<tr>
<td>Tumor size (mm)</td>
<td>24.6 ± 8.9</td>
<td>24.8 ± 6.9</td>
<td>23.7 ± 8.1</td>
<td>NS</td>
</tr>
<tr>
<td>Tumor number (range)</td>
<td>1.3 (1-5)</td>
<td>1.2 (1-3)</td>
<td>1.2 (1-2)</td>
<td>NS</td>
</tr>
<tr>
<td>Operative time (min)</td>
<td>337.5 ± 114.3</td>
<td>309.8 ± 80.2</td>
<td>309.9 ± 76.5</td>
<td>NS</td>
</tr>
<tr>
<td>Blood loss (g)</td>
<td>534.7 ± 922.1</td>
<td>279.1 ± 394.9</td>
<td>172.4 ± 142.2</td>
<td>NS</td>
</tr>
<tr>
<td>Blood transfusion rate (%)</td>
<td>8.3</td>
<td>0</td>
<td>0</td>
<td>NS</td>
</tr>
</tbody>
</table>

PEH: pure Endoscopic hepatectomy, HALS: hand assisted laparoscopic surgery, EAH: endoscopy assisted hepatectomy

### Surgical data

Table 2 provides a summary of surgical characteristics data regarding the surgical methods in each device. Totally, the type of endoscopic resection included a PEH (n = 6), HALS (n = 25), and EAH (n = 24). The ratio of EAH in S-EH group is higher than the other devices, significantly (p<0.05). Mean operative times were 309.8 min (range, 185-508) in R-EH and 309.9 min (range, 182-492) in S-EH, respectively. Mean blood loss in M-EH, R-EH and S-EH were 534.7g (range, 5-3327), 279.1g (range, 15-1600) and 172.4g (range, 5-524), respectively. Red blood cells (RBC) for 1 patient (8.3%) and flesh frozen plasma (FFP) for 3 patients (25%) were necessary in M-EH. In contrast, no blood products were needed in R-EH and S-EH.

### Mortality and Morbidity

There was no mortality in the each EH group, whereas the M-EH group had post operative adverse events. Overall 3 patients (5.4%) experienced an adverse event (Table 3). Post operative complications developed in 25% (3 of 12) of the M-EH groups and less seen in the R-EH and S-EH groups (0 %). Biliary leakage is the most frequent complication after the hepatic resection, but no biliary leakage occurred within the same period in each pre-coagulation groups. All patients in M-EH group recovered well and returned to normal activities within 1 month.

There were no specific complications related to endoscopic surgery, such as seeding of tumor cells or port-site re-
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The mean postoperative hospital stay was 18 (range 7-47) days in M-EH, 10 (range 8-14) days in R-EH, and 10 (range 7-16) days in S-EH.

Table 3  Adverse events after endoscopic hepatectomy by each pre-coagulation method

<table>
<thead>
<tr>
<th></th>
<th>N (%)</th>
<th>Adverse events</th>
</tr>
</thead>
<tbody>
<tr>
<td>Total</td>
<td>3 (5.4)</td>
<td>Renal failure</td>
</tr>
<tr>
<td>M-EH</td>
<td>3 (5.4)</td>
<td>Surgical site infection</td>
</tr>
<tr>
<td>R-EH</td>
<td>0 (0)</td>
<td>Arm nerve paralysis</td>
</tr>
<tr>
<td>S-EH</td>
<td>0 (0)</td>
<td>None</td>
</tr>
</tbody>
</table>

Discussion

Because of the increased demand for less invasive treatment, the use of laparoscopic surgery for hepatectomy has developed. The intraoperative blood loss during hepatic parenchymal resection still remains a major concern. In our department, to prevent parenchymal oozing, pre-coagulation method with RFA was used and the outcome has been successful but the single-use device was not cost effective and one of the disadvantage of RFA methods. In our institute, the devices of soft coagulation have been employed since 2006 May and those devices are reusable so that it is relatively cost effective. In our study, mean blood loss in S-EH tends to be lower than mean blood loss in M-EH and R-EH. No blood products, such as RBC or FFP were needed in S-EH. Perioperative blood transfusions were risk factors of recurrences (24-26) and cause immunosuppressive effects.

The Soft coagulation has improved the coagulation range and depth by the control of the power output in accordance with the tissue impedance, but the problem of heat injury in association with pre-coagulation remains another concern. Postoperative complications in EH include bleeding, bile leakage, massive ascites, gas embolism, intestinal damage and port-site hernias has been reported. In our study, no bile leakage has been occurred in all EH groups and postoperative complications occurred in 0 % in R-EH and S-EH, so far. Moreover, there were no specific complication related to endoscopic surgery, such as seeding of tumor cells or port-site recurrence.

In conclusion, pre-coagulation by soft coagulation is an effective and minimally invasive procedure and feasible technique for EH. Further investigation is required to assess long-term prognosis in large number of HCC patients.

References