Laparoscopic liver resection assisted with radiofrequency


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Abstract

Background: Radiofrequency-assisted laparoscopic liver resection is reported.

Methods: Patients suitable for liver resection were carefully assessed for laparoscopic resection. Patient and intraoperative and postoperative data were prospectively collected and analyzed.

Results: Eighteen patients underwent laparoscopic liver resection. All operations were performed without vascular clamping and consisting of tumorectomy (n = 9), multiple tumorectomies (n = 2), segmentectomy (n = 2), and bisegmentectomies (n = 2). Mean blood loss was 121 ± 68 mL, and mean resection time was 167 ± 45 minutes. There was no need for perioperative or postoperative transfusion of blood or blood products. One patient developed pneumothorax during surgery as a result of direct puncture of pleura with the radiofrequency probe, and 1 patient had transient liver failure and required supportive care after surgery. The mean length of hospital stay was 6.0 ± 1.5 days. At follow-up, those with liver cancer had no recurrence.

Conclusions: Radiofrequency-assist laparoscopic liver resection can decrease the risk of intraoperative bleeding and blood transfusion. © 2007 Excerpta Medica Inc. All rights reserved.

Keywords: Laparoscopic liver resection; Liver resection technique; Liver tumours; Radiofrequency

Since the advent of laparoscopic cholecystectomy [1], minimally invasive procedures, performed on many organs, have been introduced in recent years [2–4]. In liver surgery, laparoscopy was initially used only for minor procedures, such as biopsy and staging of liver tumor [5,6] or fenestration of nonparasitic liver cysts [5]. However, in the last few years this technique has been increasingly used for liver resection [7–11].

Liver resection remains a high-risk procedure with significant morbidity and mortality rates. Intraoperative bleeding and perioperative blood transfusion are usually considered to be the major reasons affecting these rates [11–13]. Various methods—including the use of cavitron ultrasonic aspirator (CUSA), harmonic scalpel, bipolar forceps, or scissors—are now available for minimizing intraoperative blood loss related to parenchyma transection in both open and laparoscopic resections [14–16]. These methods are usually used in combination with hepatic pedicle clamping to achieve satisfactory intraoperative haemostasis because none of these techniques is effective in preventing intraoperative bleeding on its own. Despite these modern technologies, hemorrhage still remains the main problem frequently encountered during transaction of liver parenchyma [17]. In laparoscopic liver surgery, access to the liver is limited through, and control of intraoperative bleeding is inevitably difficult. Conversion to an open procedure is often imminent to achieve hemostasis and to complete resection when bleeding occurs.

Radiofrequency-assisted liver resection was originally described for “bloodless” liver resection without the need for vascular clamping or the use of suture, surgical knots, or clips [18]. Because of this unique feature, it would seem ideal to use this device for laparoscopic liver resection. The current study examined the feasibility and results of this technique in laparoscopic liver resection.

Patients and Methods

Between November 2001 and April 2004, a total of 321 patients were deemed suitable for liver resection. However,
only 18 patients were included for laparoscopic resection based on our selection criteria of good general condition (American Society of Anesthesiologists (ASA) score 1 or 2), normal liver function tests, and tumor located in the peripheral segments of liver (stages II, III, IVb, V, or VI) (Table 1). The surgeries were performed at the hepatobiliary units of Hammersmith Hospital (London, UK) and the Hospital Universitaire de Hautepierre (Strasbourg, France).

After general anesthesia was induced, open technique to creation the pneumoperitoneum was used to avoid possible damage to intra-abdominal organs as a result of adhesions from previous abdominal surgery. Pneumoperitoneum was maintained throughout the procedure on a high flow rate with carbon dioxide at a pressure of 12 mm Hg. The operation was performed using three 12-mm ports and one 5-mm port along the subcostal margin, depending on the site of the liver tumor. In general, two 12-mm ports were inserted to 1 side and one 12-mm port and one 5-mm port to the other. Any perihepatic and peritoneal adhesions related to previous laparotomy were divided to allow examination of the entire abdomen for either local recurrence at the primary site of previous colorectal resection or for peritoneal deposits. Afterward, intraoperative ultrasound (IOUS) was performed in all cases to obtain further information on the extent of disease and the anatomic relationship between the tumor and the surrounding portal pedicles and hepatic venous branches.

Radiofrequency (RF)-assisted liver resection technique has been described previously for the open approach [19]. In brief, a “cooled tip” RF probe with a 500-kHz RF generator (model RFG-3D: Radionic Europe, Wettwden, Belgium) was used to produce coagulative necrosis along a line of intended division of liver parenchyma without vascular clamping of either portal triads or major vessels. Compared with the open approach, in which the whole resection line was coagulated before cutting, the liver parenchyma was progressively transected with a pair of scissors after each RF application in the laparoscopic approach. The RF probe, which measured 25 cm long, was introduced either percutaneously or by way of a 5-mm port. For lesions located at the inferior part of liver that were accessible through a 5-mm port, the probe was introduced by way of this port. However, for tumors located over the dome or the posterior part of liver beneath the rib cage, percutaneous insertion of the probe in the intercostal space directly over or inferior to the tumor was done. Before starting RF, IOUS was used to mark the resection margin with diathermy on the surface of liver. Then the RF probe was inserted first to the most difficult part of the intended plane of transection in the deepest and farthest areas from the surface of liver, under the guidance of IOUS, to ensure correct positioning of the probe to avoid any inadvertent damage to any vascular or vital structures and at the same time allow an adequate resection margin. This was done before starting RF to prevent interference of ultrasonic images from RF. To complete the transection of liver parenchyma along the ablated plane, a pair of laparoscopic dissection scissors was used. Finally, extraction of the specimen was done, whenever possible, with an endobag (Endocatch, Autosuture, United States Surgical Cooperation, Norwalk, CT) by enlarging a port-site incision. For a large specimen that would not fit in an endobag, 2 adjacent ports were jointly opened to retrieve the tissue through this open incision. A 20-French gauge drain (Smiths Medical International Ltd., Hythe, Kent, UK) was routinely placed close to the resection margin.

Patient details, including preoperative and postoperative liver function tests, haemoglobin, and platelet levels were recorded. The following measurements and data were also documented: operative time, defined as the time taken to complete surgery; ablation and transection time, defined as the time taken to complete liver parenchyma transection after radiofrequency ablation; use or not of the Pringle manoeuvre; total blood loss as measured from the amount of aspirates in vacuum suction; and transfusion requirement with either red blood cells or blood products, including platelets, fresh frozen plasma, or albumin. Postoperative data, including morbidity, mortality, and length of hospital stay, were also collected.

**Results**

Eighteen patients were considered suitable for liver resection; the mean age of 55 – 12 years. Characteristics of tumours and surgical procedures are listed in Tables 1 and 2. Two patients with a final histologic diagnosis of focal nodular hyperplasia underwent resection because of a preoperative uncertainty of diagnosis on biopsy. Three patients with colorectal liver metastases (16%) had their resection converted to open soon after laparoscopy because of extensive adhesions around the liver from previous colonic surgery.
(n = 2) and identification of additional lesions in the posterior part of the liver on IOUS (n = 1).

None of 15 patients who had undergone laparoscopic liver resection had Pringle’s manoeuvre during surgery. The types of liver resection included tumorectomy (n = 9), multiple tumorectomies (n = 2), segmentectomy (n = 2), and bisegmentectomies (n = 2) (Table 2). The average size of the resected tumor measured 32 ± 23 mm. Total blood loss was 121 ± 68 mL (range 0 to 190 mL). No patients received intraoperative transfusion of red blood cells or blood products. Average operative time was 213 ± 59 minutes, and the average actual resection time was 167 ± 45 minutes (Table 2). In 8 cases, laparoscopic cholecystectomy was also performed because of a close proximity of the tumor to the gallbladder.

Although no deaths occurred after surgery, 2 patients developed complications: 1 had intraoperative right pneumothorax as a result of direct puncture of pleura with the RF probe, and the other, who underwent resection for hepatocellular carcinoma and cirrhosis, had transient liver failure with ascites after surgery. The first patient was managed by insertion of a chest drain after surgery, and the second required treatment with paracentesis, albumin infusion, and diuretics for 7 days. All patients had transient abnormal liver function tests immediately after liver resection, which normalized by approximately postoperative day 7 (Table 3).

The average length of hospital stay was 6 ± 1.5 days. At mean follow-up of 9.8 ± 6.2 months, none of the patients with malignancy developed recurrence at the resection margins. However, 1 patient who underwent left lateral hepatectomy for colorectal liver metastases was found to have a new deposit in segment VII just 5 months after laparoscopic liver resection and underwent repeat resection with a conventional open approach.

### Comments

Careful preoperative staging and selection of patients are the keys to success in laparoscopic surgery for cancer [9]. The size and location of the liver tumor is fundamentally important in determining the feasibility of resection with laparoscopic approach. Although no reports exist on major liver resection [10], we believe that laparoscopic technique can only be performed safely for reasonably small tumours located peripherally. For resection of large liver tumours, the liver must be mobilized completely, and the risk of bleeding is high, especially for those tumours that are deeply seated, posteriorly located in the right hepatic lobe, or close to the portal bifurcation. In the current series, patients who required segmentectomy or left lateral hepatectomy without major hepatectomy were considered suitable for laparoscopic resection.

Intraoperative bleeding and/or technical difficulties are the common reasons to convert to open procedure during laparoscopic surgery. In this series, none of the 15 patients were converted to open procedure during surgery from either technical problems or intraoperative bleeding related directly to liver resection. However, 3 cases were converted to open procedure immediately after laparoscopic because of extensive adhesions around the liver and an unexpected finding of additional tumors on IOUS.

The benefits of the laparoscopic approach over open surgery, such as decreased postoperative analgesia requirement, shorter delay to oral intake after surgery, and a decreased hospital stay, are well known. In our series, it was indeed true in that patients were mobilized more quickly and had a much shorter duration of hospital stay (6 days) compared with those undergoing open resection (10 to 14 days), which is consistent with other reported series [20]. The risk of tumor seeding during laparoscopic surgery has long been debated in the literature. The potential mechanisms for this event include direct contamination from technical errors during laparoscopic resection, cell exfoliation, or cytokine activation secondary to pressure effects from pneumoperitoneum [21]. In this series, none of patients developed either port-site or intraperitoneal metastases at postoperative follow-up. Promotion of tumor growth by carbon dioxide gas insufflations has also been indicated against the application of laparoscopic technique for oncologic surgery [22–24]. However, clinical data suggest that the incidence of recurrence between laparoscopic and conventional open operation for cancer is similar, and the immune system may also be better preserved in patients undergoing laparoscopic rather than open surgery [23,25,26]. In a recent prospective randomised study, Lacy showed better long-term survival in patients who underwent laparoscopic resection for colonic cancer than those who underwent open resection [27].

Fong et al [28] described a number of problems related to laparoscopic liver resection, including difficulty in identifying tumor margins and mobilizing the live, in addition to the inherited problems of dense adhesion from previous surgery for primary cancer. In this series, the liver was not completely mobilized to the same degree as for open resection because of our selection criteria for this group of patients and also the characteristic nature of this laparoscopic technique. Lifting created by a combination of falciiform ligament and adhesions on the surface of liver with pneumoperitoneum was often found useful in assisting exposure and transection of liver parenchyma during resection. Although previous abdominal surgery should not be considered as a contraindication for laparoscopic liver resection, meticulous surgical technique and care are crucial to prevent any inadvertent damage to abdominal organs during induction of pneumoperitoneum and insertion of ports. However, adhesion was a major reason in our series for conversion to open procedure and accounted for 2 out of 3 converted cases.

### Table 3

Liver function tests after RF-assisted laparoscopic liver resection

<table>
<thead>
<tr>
<th>Liver function tests</th>
<th>Before surgery</th>
<th>Postoperative day 1</th>
<th>Postoperative day 3</th>
<th>Postoperative day 7</th>
</tr>
</thead>
<tbody>
<tr>
<td>ALT</td>
<td>33 ± 22†</td>
<td>319 ± 194†</td>
<td>151 ± 86†</td>
<td>40 ± 25</td>
</tr>
<tr>
<td>AST</td>
<td>32 ± 20</td>
<td>327 ± 198†</td>
<td>75 ± 53†</td>
<td>45 ± 28</td>
</tr>
<tr>
<td>Albumin (g/l)</td>
<td>41 ± 6</td>
<td>32 ± 6†</td>
<td>36 ± 5†</td>
<td>38 ± 4</td>
</tr>
<tr>
<td>Bilirubin (umol/l)</td>
<td>11 ± 3</td>
<td>17 ± 7†</td>
<td>15 ± 7†</td>
<td>12 ± 2</td>
</tr>
</tbody>
</table>

ALT = alanine transaminase; AST = aspartate transaminase.

† P < .05.
Biertho et al [29] previously reported a review of 186 laparoscopic liver resections performed between 1991 and 2001 and concluded that it would be feasible and safe to perform laparoscopic liver resection in a group of selected patients at an established hepatobiliary centre with highly trained surgeons in advanced laparoscopic techniques; however, this should only be applied for minor resections involving less < 2 segments. Their reported mortality and morbidity rates were .5% and 16% in 1991 and 2001, respectively, with a conversion rate of 7%. In our series, 1 patient developed pneumothorax during surgery, and this was directly related to the resection technique. Afterward, insertion of the radiofrequency probe was changed to by way of an established port. The other patient had post-transsection transient liver failure and required medical management although he had a good functional reserve and had been carefully examined before surgery.

Since our first description of radiofrequency ablation for unresectable liver cancer, we have expanded the role of radiofrequency in liver surgery from mere ablation to actual liver resection [30,18,19]. This technique has now been applied for laparoscopic liver resection. The result has shown that this is a safe and feasible technique for laparoscopic liver resection and has little intraoperative blood loss and zero transfusion of either blood or blood products during or after surgery. Although only a small number of cases are reported here, we believe this technique should be considered as one of the methods for laparoscopic liver resection.

References