Robotic versus laparoscopic resection of liver tumours

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Abstract

**Background:** There are scant data in the literature regarding the role of robotic liver surgery. The aim of the present study was to develop techniques for robotic liver tumour resection and to draw a comparison with laparoscopic resection.

**Methods:** Over a 1-year period, nine patients underwent robotic resection of peripherally located malignant lesions measuring <5 cm. These patients were compared prospectively with 23 patients who underwent laparoscopic resection of similar tumours at the same institution. Statistical analyses were performed using Student’s t-test, χ²-test and Kaplan–Meier survival. All data are expressed as mean ± SEM.

**Results:** The groups were similar with regards to age, gender and tumour type (P = NS). Tumour size was similar in both groups (robotic −3.2 ± 1.3 cm vs. laparoscopic −2.9 ± 1.3 cm, P = 0.6). Skin-to-skin operative time was 259 ± 28 min in the robotic vs. 234 ± 17 min in the laparoscopic group (P = 0.4). There was no difference between the two groups regarding estimated blood loss (EBL) and resection margin status. Conversion to an open operation was only necessary in one patient in the robotic group. Complications were observed in one patient in the robotic and four patients in the laparoscopic groups. The patients were followed up for a mean of 14 months and disease-free survival (DFS) was equivalent in both groups (P = 0.6).

**Conclusion:** The results of this initial study suggest that, for selected liver lesions, a robotic approach provides similar peri-operative outcomes compared with laparoscopic liver resection (LLR).

Keywords

laparoscopic surgery, liver, resection, robotic

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Introduction

The advantages of laparoscopic surgery have been shown in multiple operative procedures1–3 and its safety in resections for malignancy has been demonstrated.4–7 Over the past decade, laparoscopic liver resection (LLR) has been shown to be feasible8,9 but despite various techniques having been described, there are still some limitations to obtaining adequate visualization and meticulous manipulation of the tissues as a result of a two-dimensional view and awkward laparoscopic instrumentation.

Robotic surgical technology was developed to overcome these limitations and the aim of the present study was to investigate the feasibility of robotic liver tumour resection.

Methods

Between October 2008 and September 2009, nine patients underwent robotic resection of peripherally located lesions measuring <5 cm in the liver. These patients were compared with 23 patients who underwent laparoscopic resection of similar tumours at the same institution. The selection of either approach depended on the availability of equipment and familiarity of the surgeon with the robotic procedure. Patients with malignant lesions were followed-up with quarterly computed tomography (CT) scans of
the chest, abdomen, pelvis and tumour markers. Patient demo-
graphics, tumour type and size, operative time, estimated blood
loss (EBL), resection margin, complications, length of hospital
stay and disease-free survival (DFS) were documented. Data were
collected into an independent review board approved database.
Statistical analyses were performed using Student’s $t$-test, $\chi^2$-test
and Kaplan–Meier survival. All data are expressed as mean ±
SEM.

**Surgical procedure**

Our laparoscopic technique has been described previously. The
robotic procedures were undertaken with the patient in a supine
position. The port placement is slightly different for this
approach. The procedures were performed using three trocars for
the robotic instruments and a 12-mm trocar for the first assistant
(Fig. 1). The robotic trocars were triangulated based on the loca-
tion of the tumour. The robotic camera port (12 mm) was
inserted about 20 cm away from the tumour, and 10 cm from the
working robotic ports (8 mm). Robotic Maryland forceps were
employed with bipolar energy and Prograsp forceps in each
robotic arm. The robot is brought in from the right or left shoul-
der of the patient, depending on the location of the tumour. The
first assistant port is placed at least 5 cm inferior and lateral to the
nearest robotic port in order to prevent collisions of instruments
(Fig. 2). A precoagulation technique was employed where the
parenchymal transaction line is pre-coagulated either with a
bipolar or unipolar energy source first. Robotic Maryland forceps
are used to mimic the finger fracture of the parenchyma exposing
the vascular and biliary structures, which are divided subsequently
by the first assistant using a combination of Harmonic scalpel,
clips, scissors or stapler under guidance by the surgeon on the
console with the 3-D view allowing delineation of all these struc-
tures (Fig. 3). After resection is finished, the robot is undocked
and the operation is completed laparoscopically by removing the
specimen and obtaining haemostasis. Tissuelink is also used for
haemostasis on the liver bed. A drain is left in place for most
resections.

**Results**

The groups were similar with regards to age, gender, tumour type
and tumour size ($P = NS$). Procedure types were similar in both

![Figure 1 Operative photo showing the port sites before docking of the robot](image1)

![Figure 2 Operative photo showing instrumentation after docking of the robot](image2)

![Figure 3 Intra-operative photo showing robotic parenchymal transection in a patient with a tumour in segment 5](image3)
groups. There was no difference between the two groups with regards to operative time, EBL and resection margin (Table 1). Conversion to an open operation was only necessary in one patient in the robotic group as a result of parenchymal bleeding after resection and none in the laparoscopic group. Resection margins were negative for a tumour at the time of resection. Complications were seen in 11% of the robotic and 17% of the laparoscopic procedures. These included intra-operative bleeding requiring conversion to open in the robotic group and two instances of post-operative clostridium difficile colitis and one of post-operative ileus in the laparoscopic group.

Patients were followed up for a mean of 14 months and DFS and overall survival were similar in both groups (Fig. 4). Eight patients developed tumour recurrence in the liver during follow-up [2, robotic; 6, laparoscopic (P = 0.9)]. All of these represented new tumour recurrence except for one local recurrence, which was in a patient with hepatocellular carcinoma (HCC) in the robotic group who developed multifocal tumour recurrence 6 months after resection.

**Discussion**

To our knowledge, this is the largest study to compare robotic liver resection with the conventional laparoscopic technique. Laparoscopic techniques for liver resection are increasing in popularity. With increasing experience for both benign and malignant liver lesions LLR has resulted in comparable and, in some aspects, better outcomes compared with those undergoing open surgery. Moreover, financial benefits regarding overall costs compared with open liver resection have also been demonstrated in the literature. Although there are many technical differences in the laparoscopic approach in the literature, LLR is reported to have lower morbidity, intra-operative blood loss, blood transfusion rate, need for post-operative analgesic drugs and shorter hospital stay compared with open liver resection.

Robotic surgery has received increased attention as a result of advancements in its technology. Although introduced into in the late 1990s, robotic surgery has not stimulated enthusiasm outside the specialties of urology, gynaecology and cardiac surgery. Earlier studies in general surgery have showed longer operative times and higher costs as major drawbacks of the technology. With the refinement of the technology, easier set up, better image quality and smaller robotic systems, there has been a recent interest in using the robot for general surgical laparoscopic procedures such as LLR.

**Table 1** Comparison of clinical and operative parameters in each group

<table>
<thead>
<tr>
<th></th>
<th>Robotic</th>
<th>Laparoscopic</th>
<th>P</th>
</tr>
</thead>
<tbody>
<tr>
<td>Age</td>
<td>66.6 ± 6.4 years</td>
<td>66.7 ± 9.6 years</td>
<td>NS</td>
</tr>
<tr>
<td>Gender</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Women/Men</td>
<td>2/7</td>
<td>11/12</td>
<td>NS</td>
</tr>
<tr>
<td>Tumour size</td>
<td>3.2 ± 1.3 cm</td>
<td>2.9 ± 1.3 cm</td>
<td>NS</td>
</tr>
<tr>
<td>Tumour type</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Colorectal metastasis</td>
<td>4</td>
<td>14</td>
<td>NS</td>
</tr>
<tr>
<td>Hepatocellular Cancer</td>
<td>3</td>
<td>7</td>
<td></td>
</tr>
<tr>
<td>Others</td>
<td>2</td>
<td>2</td>
<td></td>
</tr>
<tr>
<td>Surgical procedure</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Segmental liver resection</td>
<td>6</td>
<td>12</td>
<td>NS</td>
</tr>
<tr>
<td>Left lateral sectionectomy</td>
<td>3</td>
<td>11</td>
<td></td>
</tr>
<tr>
<td>Margin</td>
<td>11 ± 8 mm</td>
<td>14 ± 10 mm</td>
<td>NS</td>
</tr>
<tr>
<td>Operative time</td>
<td>258.5 ± 27.9 mn</td>
<td>233.6 ± 16.4 mn</td>
<td>NS</td>
</tr>
<tr>
<td>EBL</td>
<td>136 ± 61 cc</td>
<td>155 ± 54 cc</td>
<td>NS</td>
</tr>
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EBL, estimated blood loss.

Others include one sarcoma metastasis and one cholangiocellular cancer in the Robotic and one gastrointestinal stromal tumour metastasis and one carcinoid tumour metastasis in the laparoscopic group.

![Figure 4](image-url)
as complex hepatopancreatobiliary cases, rectal surgery and thyroidectomy.10–13

LLR techniques have evolved differently compared with the open approach. Traditional open resection depends on individual dissection and ligation/division of vascular and biliary structures; whereas, laparoscopic resection has relied on staplers and pre-coagulation instruments, such as monopolar and bipolar radio-frequency devices. Robotic technology has an opportunity to mimic open surgery, because of the image quality and dexterity of the instruments. The robotic camera platform is stable and provides a realistic 3-D image to the operating surgeon at the console with excellent visualization of the operative field.14,15 Robotic instruments provide seven degrees of safe freedom with multi-articulated hand-like motions and a hand-tremor filtering system facilitating both gentle and precise dissection within a narrow and remote field.16 In the present study, we have found the robotic system satisfactory in identifying and dealing with vascular and biliary structures distinctly and individually.11 This enables a very precise dissection and safe parenchymal division.

We have also found the laparoscopic hook TissueLink effective for haemostasis in our technique. This device involves the use of RF energy with a saline infusion, which provides an excellent quality of haemostasis on the liver parenchyma in our experience. As a result of the additional RF effect, it also has the potential to contribute to the surgical margin in malignancy cases.

The drawback of the robotic technique is that there is significant dependence on the first assistant. The practice of undertaking the procedure with two staff surgeons has been beneficial as the possibility of requiring to convert to an open procedure is reduced by having an experienced first assistant.

However, the lack of access to a 3-D view did result in occasional intra-operative confusion for the first assistant. The detail to which the surgeon can identify small vascular structures differs considerably than for the first assistant on the laparoscopic monitor. Therefore, we believe that there is a need to develop better quality monitors or 3-D monitors for the first assistant.

The additional cost incurred by the robot is a concern when justifying its use. Although a case-by-case cost analysis was not done, the robotic instrumentation in general adds $500 per case to the laparoscopic equipment cost. The cost of buying the equipment and annual service fees are an additional financial burden of robotic procedures. These can be reduced with heavy utilization of the robot by the other surgical specialties at our institution.

In the present study, peri-operative outcomes were similar between robotic and conventional liver resection groups, with the robotic procedures taking about 25 min longer. We believe that this additional time is related to the learning curve of the surgical team, including unfamiliarity of operating room staff to the new technology and set-up.

In conclusion, the results of this initial study suggest that, for selected liver lesions, the robotic approach provides similar peri-operative outcomes compared with the LLR, but with better visualization and dexterity. The robotic approach merits further attention because of its potential to mimic open liver resection.

Conflicts of interest
Drs Berber and Chalikonda are consultants to Intuitive Surgical, Inc.

References