# Robotic Liver Resection as a Bridge to Liver Transplantation

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## ABSTRACT

**Background:** The surgical robotic system is superior to traditional laparoscopy in regards to 3-dimensional images and better instrumentation. Robotic surgery for hepatic resection has not yet been extensively reported. The aim of this article is to report the first known case of liver resection with the use of a robot in France.

**Methods:** A 61-year-old male with hepatitis C liver cirrhosis and hepatocellular carcinoma was referred for surgical treatment. Preoperative clinical evaluation and laboratory data disclosed a Child-Pugh class A5 patient. Magnetic resonance imaging showed a 3.4-cm tumor in segment III. Liver size was normal, and there were not signs of portal hypertension. Five trocars were used.

**Results:** Liver transection was achieved with Harmonic scalpel and bipolar forceps without pedicle clamping. Hemostasis of raw surface areas was accomplished with interrupted stitches. Operative time was 180 minutes. Blood loss was minimal, and the patient did not receive transfusion. The recovery was uneventful, and the patient was discharged on the fifth postoperative day without ascites formation.

**Conclusion:** The robotic approach may enable liver resection in patients with cirrhosis. The da Vinci robotic system allowed for technical refinements of laparoscopic liver resection due to 3-dimensional visualization of the operative field and instruments with wrist-type end-effectors.


**Key Words:** Hepatocellular carcinoma, Robotic liver resection.

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## INTRODUCTION

The development of minimally invasive surgery has led to an increase in laparoscopic hepatic resection. Particularly for hepatocellular carcinoma (HCC), in which the possibility of repetitive surgery for cancer recurrence or liver transplantation is high, the laparoscopic approach results in less postoperative adhesion than with open abdominal surgery, decreasing the difficulty of dissection in future operations.

However, laparoscopy is limited by 2-dimensional imaging and restricted instrument motion. Advanced computer technology has been developed to overcome these limitations. The surgical robotic system provides 3-dimensional images, allowing surgeons to operate with advanced vision. Moreover, the robotic system utilizes Endo-Wrist, an instrument with a 360-degree range of motion.

Currently, Intuitive Surgical, Mountain View, CA, USA, is the only company to produce a robotic surgical device.[1] There have been few reports discussing the indications of robotic surgery in hepatobiliary procedures, and robotic surgery in hepatic resection has not been extensively reported. Herein, we present the first case of da Vinci robotic liver resection reported in France, "the land of laparoscopy."

## METHODS

A 61-year-old male (JT) with a 30-year history of hepatitis C was admitted to the hospital for HCC in segment III of the liver. Serum alpha-fetoprotein (AFP) level was 150UI/mL. The patient had liver cirrhosis corresponding to Child-Pugh class A5, and the Indocyanine Green retention rate at 15 minutes (ICG-R 15) was 1.3%. The computed tomography (CT) scan and magnetic resonance imaging (MRI) revealed a 3.4-cm single mass in segment III consistent with HCC **(Figure 1)**.

### Surgical Technique

While under general anesthesia, the patient was placed in a supine position, and 5 trocars were used. Pneumoperitoneum to 13mm Hg was established. A 12-mm trocar for the robotic camera was placed above the umbilicus by the

**Figure 1.** CT scan (B) shows a 3.4-cm mass consistent with HCC in segment III. HCC: hepatocellular carcinoma.

Hasson method (open technique). Three additional 8-mm trocars were placed at the left upper quadrant (LUQ), epigastric, and right upper quadrant (RUQ) areas under the optic guidance, respectively. A 10-mm trocar for an assistant was also placed at the LUQ area. The 4-arm da Vinci surgical robot system was brought into position and docked following port placement. The operator moved to the console to control the robotic arms. The assistant on the patient's left side changed the robotic instruments and performed intraoperative ultrasonography through the 10-mm LUQ trocar site **(Figure 2)**.

A 30° robotic camera was used. After exploration of the abdominal cavity, intraoperative ultrasonography was used to examine the remaining liver to search for undetectable lesions and obtain adequate surgical resection margins. The undissected round ligament was used to retract the liver. The liver was mobilized by cutting the left triangular ligament and lesser omentum. Parenchymal division proceeded from the anterior edge of the liver by Harmonic scalpel and bipolar electrocautery. The small vessels and bile ducts exposed during parenchymal dissection were ligated and divided by clipping. The Glisson's pedicles of segments III was clamped and divided by suture technique. Pringle's maneuver was not applied during the entire procedure. A closed suction drain catheter was placed in the left subhepatic space. The specimen was placed in an endoscopic retrieval bag and removed through a midline mini-laparotomy incision (length: 5cm) extending from the port site.

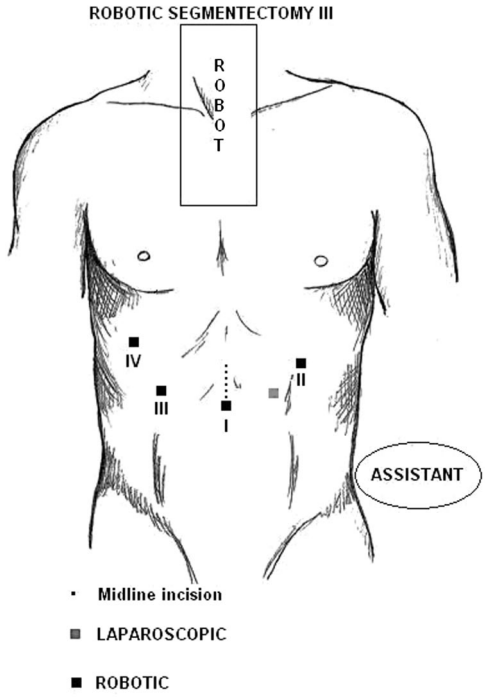


**Figure 2.** Trocar placement.

### Postoperative Course and Outcomes

The postoperative period was uneventful (**Table 1**). After the hepatic resection, the hospitalization lasted for 5 days although recovery was observed at postoperative day 3. A clear liquid diet was started on postoperative day 1. Pathological examination demonstrated a 3.5-cm HCC without capsular invasion and focal micro-vessel invasion. The resection margin was free of carcinoma, and the distance was 0.9cm. After 4 months, the patient was doing well, without HCC recurrence on CT scan **(Figure 3)**. The AFP level was 6UI/mL.

## DISCUSSION

Robotic surgery enables the surgeon to control the robotic system and to perform more precise and complex operations. The da Vinci Surgical System provides operators with (1) intuitive translation of the instrument handle to the tip movement, (2) visualization with 3-dimensional images and stable camera platform, (3) scaling, (4) tremor filtering, (5) coaxial alignment of eyes, hand, and tool tip images, (6) Endo-Wrist with a 360-degree range of motion, (7) comfortable, ergonomically ideal operating position, and (8) the possibility of remote site surgery.[1–4]

Robotic liver surgery provides access to fine structures of the liver and allows surgeons to see delicate blood vessels

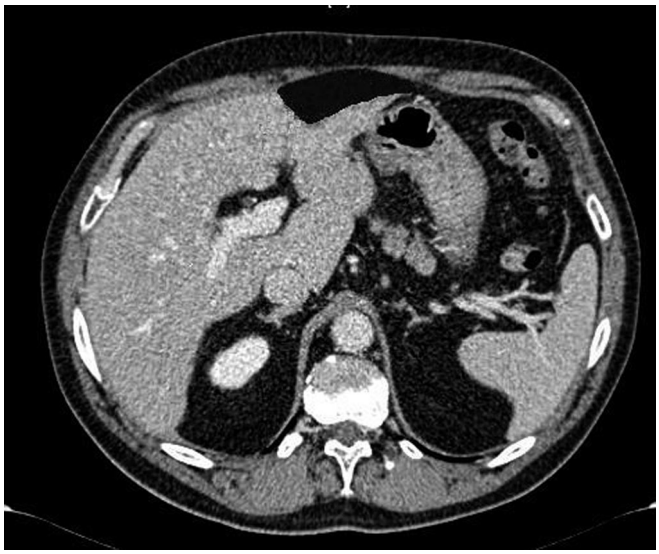

**Figure 3.** The CT-scan after 4 months of follow-up did not show HCC recurrence.

**Table 1.**
Operative and Postoperative Outcomes

| | |
|---|---|
| Port Location Camera | Above the umbilicus<br>Assistant: LPU |
| | Cannula: RUQ, LUQ, RPU[a] |
| Operative Time* (min) | 178 |
| Blood Loss (mL) | 230 |
| Transfusion (unit) | 0 |
| Associated Procedures | Cholecystectomy (lithiasis) |
| Hospital Stay (days) | 5 |
| Time to Start Diet | |
| Liquid | First day |
| Solid | Second day |
| Complications | None |

[a]RUQ=Right Upper Quadrant; LUQ=Left Upper Quadrant; RPU=Right Paraumbilical; LPU= Left Paraumbilical. *Operative time for surgery.

and bile ducts. Three-dimensional vision offers the advantage of improved depth perception and accuracy.[5] Furthermore, the robotic system involves minimal intraoperative manipulation of the tumor mass, resulting in less trauma and risk of cancer dissemination.

However, robotic surgery has several limitations: (1) high cost, (2) lack of tactile sense, (3) lack of training systems, (4) heavy robotic arms and equipment, (5) time-consuming setup, and (6) difficulty in converting to open surgery.[2,3,6] Furthermore, the da Vinci system is not attached to the operating table, requiring undocking to change table position. When perilous circumstances such as massive bleeding occur, the assistant can compress bleeding focus with laparoscopic instruments until conversion to open surgery. Problems will most likely be resolved as computer-enhanced technology continues to develop and surgeons accumulate experience.

Currently, the da Vinci robotic system is applied to almost every surgical procedure. Evaluation of robotic-assisted surgery in other fields such as prostate cancer or colorectal disease was proven to be safe and feasible. Oncological and functional outcomes are promising.[4,7–10] In the laparoscopic era, no controlled randomized clinical trials have been performed comparing laparoscopy with open hepatic resection in terms of safety, feasibility, and efficacy. Simillis et al[11] investigated laparoscopic versus open hepatic resection for hepatic cancer through a meta-analysis and concluded that operative blood loss and duration of hospital stay were significantly reduced after laparoscopic surgery and that there was no difference in postoperative adverse events or the extent of oncological clearance. Vibert et al[12] concluded after 10 years of experience in performing laparoscopic liver surgery that the results of laparoscopy are similar to those of laparotomy, suggesting that the laparoscopic approach could be used for major hepatectomy also in case of malignancy. Moreover, Chang et al[13] advocate that laparoscopic left lateral sectionectomy for benign or malignant neoplasm is safe and feasible and can be considered as a routine approach in select patients. However, there have been few reports about robotic hepatic resection.

In our experience, operative time was longer due to unfamiliarity with robotic instruments and setup time. However, the length of time required will continue to decrease as surgeons become more familiar with the procedure. In patients with small malignant tumors and benign diseases, robotic resection is feasible. Furthermore, we expect that accumulating experience will make it possible to safely perform other hepatectomies. We found shorter length of hospital stays, earlier start of oral feeding and less pain after robotic surgery compared to open surgery for liver resection.

From the oncologic point of view, the potential benefits of a minimally invasive approach in terms of curability, recurrence, and long-term survival are inconclusive.[14] Nevertheless, to perform anatomical resection with safe resection margins, intraoperative laparoscopic ultrasonography

is indispensable and guarantees precise segmental tumor location and adjacent vascular or biliary involvement excluding adjunctive lesions.[15]

## CONCLUSION

The da Vinci robotic hepatic resection can open a new horizon of treatment strategies and overcome the limitations of laparoscopic surgery. In the near future, the use of robots is expected to increase in the treatment of malignant tumors of the liver as a minimally invasive surgery.

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