Transplant International

Transplant International ISSN 0934-0874

CASE REPORT

Robot-assisted right lobe donor hepatectomy

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Keywords

living donation, liver transplantation, right lobe, robotic surgery.

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Conflicts of Interest

The authors have declared no conflicts of interest.

Received: 1 August 2011

Revision requested: 21 August 2011

Accepted: 25 September 2011

Published online: 27 October 2011

doi:10.1111/j.1432-2277.2011.01373.x

Summary

Recent advances in robotic surgical technology have enabled application to complex surgical procedures. Following extensive institutional experience with major robotic liver resections, we determined that it was safe to apply this technology to right lobe donor hepatectomy (RLDH). The procedure was performed using the Da Vinci Robotic Surgical System, in an entirely minimally invasive fashion, during which the liver graft was safely extracted through a limited lower abdominal incision. Both donor and recipient recovered well, without acute complications. To our knowledge, this is the first case reported in the literature. The technical feasibility of this minimally invasive approach is demonstrated, exemplifying the novel exciting opportunities offered by robotic technology.

Introduction

Living donor liver transplantation (LDLT) has become an accepted clinical practice in selected transplant centers. Currently, the right hepatic lobe is the preferred graft for most of the adult LDLT. However, right lobe donor hepatectomy (RLDH) is also the most risky operation among all the donor operations, and has been associated with significant morbidity and mortality (~0.4%) [1]. Therefore, RDLH should only be undertaken by experienced surgical teams, after full disclosure of the risks have been explained to the potential donor. Recently, Koffron *et al.* [2,3] have reported a series of laparoscopic-assisted RLDH with excellent results, in terms of decreased morbidity and safety. In this series, the donor hepatectomy was performed with a "hybrid" technique, performing relevant parts of the procedure with standard open technique through an upper midline incision.

At the University of Illinois at Chicago, we have gained extensive institutional experience in fully robotic major hepatic resections with excellent results, in terms of outcomes and complication rates (over 90 total robotic minor and major hepatectomies, performed since 2002 [4,5]). On the basis of our favorable experience, we felt confident in applying this innovative technique to RLDH. Herein, we describe the first report of a live donor right hepatectomy utilizing minimally invasive robotic technique.

Case report

A 61-year-old man with hepatitis C cirrhosis complicated by hepatocellular carcinoma (5 cm in diameter) was referred to our institution for liver transplantation. The patient's brother, a 53-year-old healthy man, volunteered to donate the right lobe of his liver. Anatomic evaluation

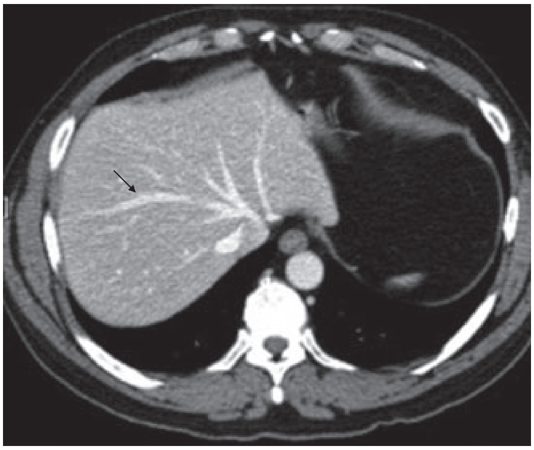

Figure 1 The hepatic veins anatomy showing the middle hepatic vein with its tributary branches, including the large branch, from the liver segment 8, reconstructed during the back table (arrow).

of the liver, which included magnetic resonance cholangiopancreatography (MRCP) and triphasic contrast CT scan with 3D reconstruction, showed normal hepatic hilum anatomy. The hepatic veins anatomy was characterized by the finding of a larger than normal tributary branch from the middle hepatic vein, draining the eighth liver segment (Fig. 1). The calculated graft versus body weight ratio of the recipient was 1.02% (1008 ml/99 Kg).

The possibility of using minimally invasive robotic technique for RLDH was discussed during the process of informed consent. All technical aspects and safety issues were explained, emphasizing the fact that the robotic approach had never been used before for RLDH. Subsequently, the ethics committee of the hospital evaluated the donor in accordance with the previously published standard protocol [6]. The donor agreed to proceed with the planned RLDH using robotic technique.

The donor was placed in supine semi-lithotomy position, and reverse Trendelenburg position was used with some rotation to the left. After placement of laparoscopic trocars (Fig. 2), the Da Vinci-S^{R} robotic surgical system (Intuitive Surgical, Inc, Sunnyvale, CA, USA) was installed. After removal of gallbladder, the right hepatic artery and the right portal vein were dissected free, and hepatic duct was isolated and transected, 1 cm from the bifurcation (transection was performed according to the pre-operative MRCP that showed normal anatomy of the biliary tree); the right hepatic duct stump was over-sewn with absorbable suture (Fig. 3). The retrohepatic caval dissection was started using the fourth arm of the robot to retract the right lobe along an upward direction. Before starting the parenchyma transaction, an ultrasound scanning was performed, and it demonstrated that the middle hepatic vein was composed of three tributary branches. The transection of the parenchyma was started with robotic Harmonic scalpel (Fig. 4). There was no inflow clamping at any point of the procedure. During the parenchymal transection, the large tributary of the middle hepatic vein, which seemed to be draining the segment 8, was identified and divided between Hemolock clips. To optimize the exposure and minimize the warm ischemia

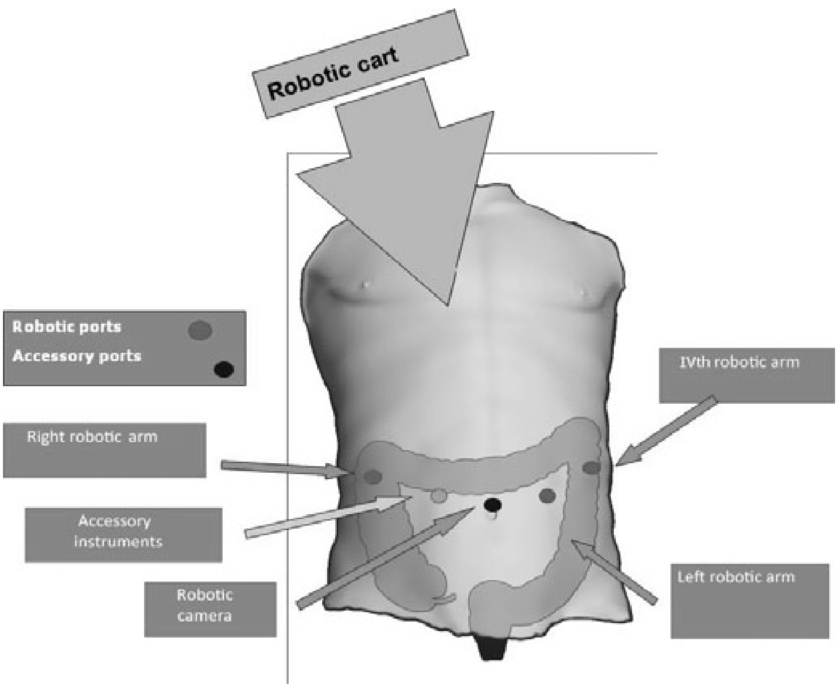

Figure 2 Position of the trocars used for robotic and laparoscopic instruments.

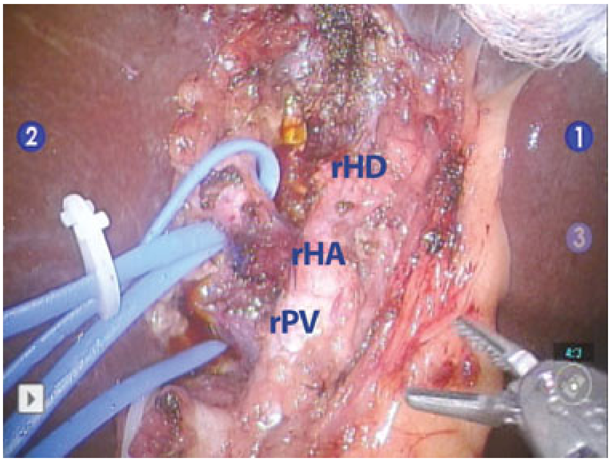

Figure 3 Stumps of right hepatic duct oversewn with absorbable suture on the donor side and remaining open on the recipient side (rHD: right hepatic duct; rPV: right portal vein; rHA: right hepatic artery).

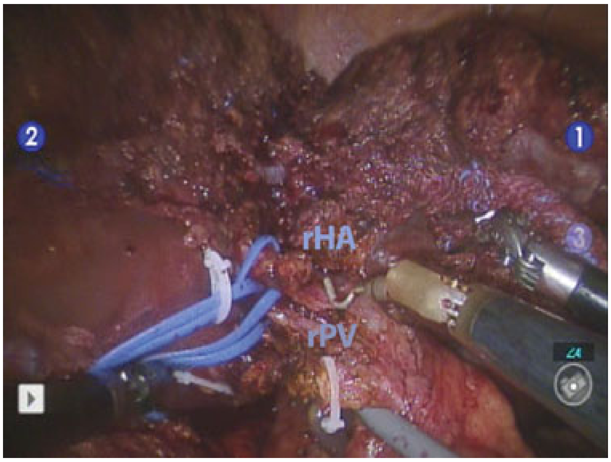

Figure 4 Transection of the parenchyma (rHA: right hepatic artery; rPV: right portal vein).

time, a 7-cm sub-umbilical midline laparotomy was made for hand assistance (Fig. 5). At this point, the origin of the right hepatic artery was clipped and transected. Thereafter, the right portal vein was transected using Endo-GIA vascular stapler, about 2 cm from the bifurcation. Finally, the right hepatic vein was transected with an Endo-GIA vascular stapler. The right lobe was gently removed through the minilaparotomy. A LapDic device was used for temporary closure of the incision, and pneumoperitoneum was re-established. The right hepatic artery stump was over-sewn with 5-0 Prolene. Two Jackson-Pratt drains were placed, and the mini-laparotomy as well as the 12-mm port incisions was closed with absorbable suture. The patient did not require any blood transfusion. The length of the donor's procedure was 8 hours with blood loss of 350 ml.

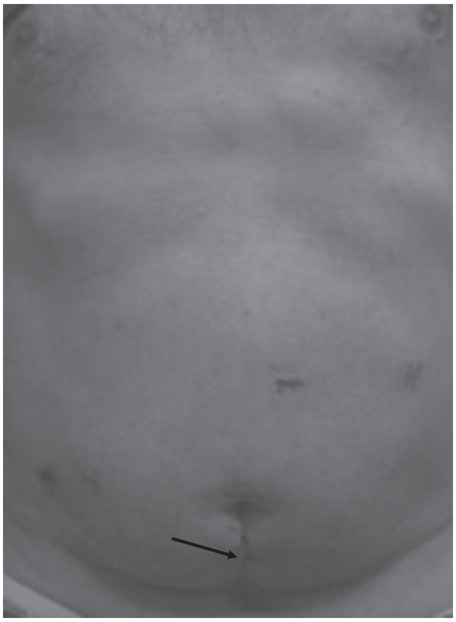

Figure 5 Incisions performed for hand-assisting (arrow) and trocars placement.

On the back table, the large tributary of the middle hepatic vein draining the segment 8 was incorporated with the main right hepatic vein, using a venous graft obtained from the recipient's inferior mesenteric vein. The liver graft was successfully implanted, with a cold and warm ischemia time of 25 and 35 mins, respectively. The biliary and portal reconstructions were performed in an end-to-end fashion. The arterial reconstruction was performed in the end-to-end fashion, between the right hepatic arteries of the donor and the recipient.

Clinical course

The postoperative course of the donor was uneventful. He was discharged home on the fifth postoperative day. Liver function tests became normalized by the eighth postoperative day (Total Bilirubin: 1.0 mg/dl; AST/ALT: 32/26 U/l; INR: 1.02).

However, upon routine CT scan 6 months after the procedure, a short stenosis of the main trunk of the donor portal vein was noticed (Fig. 6). Possible reasons for this include either angulation of the portal vein caused by hepatic regeneration or formation of a band of scar tissue. Given the normal CT angiogram at 1 month, we do not believe that the reversible portal vein stricture was related to intraoperative injury. The 70% stenosis of the main trunk of the portal vein was easily dilated through a percutaneous transhepatic approach. During 1-year follow-up, the donor was fully active and enjoys normal liver function.

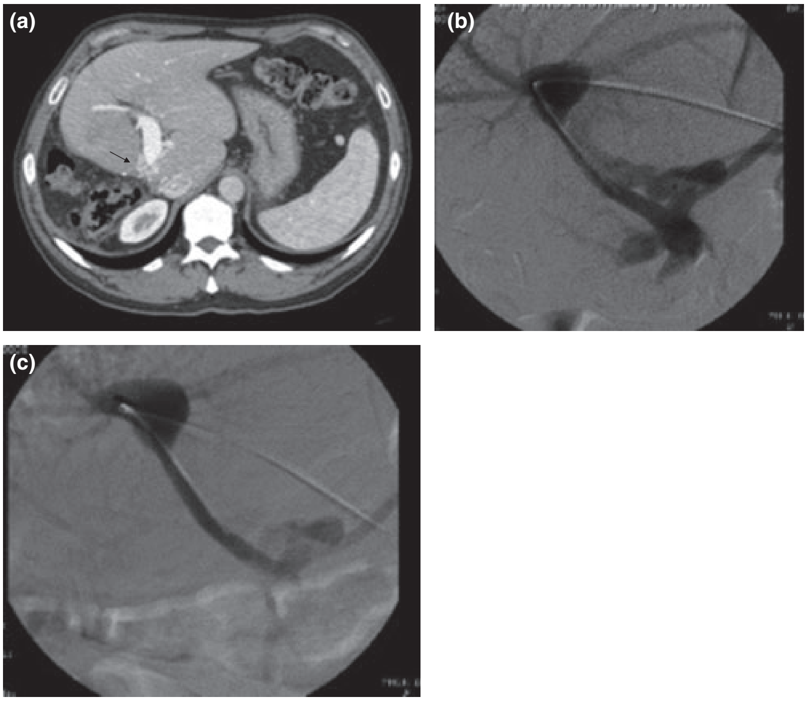

Figure 6 CT Portal vein stricture and percutaneous portal vein angioplasty of the donor a. There is a narrowing of the portal vein at approximately the location of the normal bifurcation with cavernous transformation (arrow). The portal vein reconstitutes distally, and demonstrates a near normal intrahepatic appearance. (b, c) A 8 mm balloon was used to angioplasty the portal vein stricture. Follow-up portogram was performed.

The recipient was discharged home on postoperative day 8; following normal ultrasound and HIDA scan. The patient maintains good hepatic allograft function 1 year after the transplant.

Discussion

In 1995, Ratner *et al.* [7] introduced the concept of minimally invasive kidney graft procurement using a fully laparoscopic technique. This important development has been rapidly adopted by the majority of the kidney transplant centers in the USA. The decreased pain and disability associated with kidney donation through a minimally invasive surgical approach has improved the acceptance among potential donors, and most likely, has contributed to the marked increase of living donor kidney transplants in the USA during the last decade.

In addition, laparoscopic techniques have been successfully applied, more recently, to pancreas graft procurement by Gruessner *et al.* [8] and to left lateral segmentectomy for pediatric living donor liver transplant by Soubrane *et al.* [9]. The University of Illinois at Chicago has pioneered the use of robotic technology for living donor nephrectomy and combined distal pancreatectomy/nephrectomy for living donor simultaneous pancreas–kidney transplant, with excellent results [10,11].

As a minimally invasive approach, robotic technology has some hypothetical advantages over traditional laparoscopy.

Specific to the donor hepatectomy, the stable magnified field, 3-D vision, and enhanced instrument articulation facilitate the vascular and biliary dissection of the right pedicle, and this helps in deciding the point of transection; the ability of the fourth robotic arm to support the right lobe of the liver allows for easy identification and proper suturing of the accessory hepatic veins during the caval phase; the enhanced ability for suture ligation of venous bleeders minimizes the blood loss during the parenchymal transection.

Although the length of surgery was longer than that normally required for open right donor hepatectomy, it must be considered that the complicated venous anatomy prolonged the total operating time.

The potential advantage of full robotic hepatectomy would be the new possibility to perform a sub-umbilical incision. We preferred to perform a sub-umbilical 7-cm incision instead of an upper midline incision, as the one described by Koffron *et al.*, with the aim to decrease the pain and the risk of pulmonary complication associated with the latter. This case, in our opinion, marks a successful beginning that demonstrates the technical feasibility of the robotic surgery in the setting of RLDH.

A word of caution must be provided in relation to the level of expertise needed to consider this approach.

In conclusion, we believe that the advantage of avoiding a painful sub-costal or upper midline incision and the potential for a faster return to normal daily activities for the living donor is significant enough to warrant further evaluation of this innovative strategy.

Authorship

PCG: responsible for concept/designed study. IT and FB: drafted the article. HJ: performed concept/designed study. MS and JO: carried out critical revision of the article. EB: responsible for study design and critical revision of the article.

Funding

No funding source applicable for this manuscript. The manuscript was not prepared or funded by a commercial organization.

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