Surg Endosc (2018) 32:514–515
https://doi.org/10.1007/s00464-017-5733-4

VIDEO

Preliminary trial of augmented reality performed on a laparoscopic left hepatectomy

Priyanka Phutane[1] · Emmanuel Buc[1,2,3] · Karine Poirot[1,2] · Erol Ozgur[1] · Denis Pezet[2] · Adrien Bartoli[1] · Bertrand Le Roy[1,2]

Received: 29 December 2016 / Accepted: 14 July 2017 / Published online: 8 August 2017

Abstract
Background Laparoscopic liver surgery is seldom performed, mainly because of the risk of hepatic vein bleeding or incomplete resection of the tumour. This risk may be reduced by means of an augmented reality guidance system (ARGS), which have the potential to aid one in finding the position of intrahepatic tumours and hepatic veins and thus in facilitating the oncological resection and in limiting the risk of operative bleeding.
Methods We report the case of an 81-year-old man who was diagnosed with a hepatocellular carcinoma after an intraabdominal bleeding. The preoperative CT scan did not show metastases. We describe our preferred approach for laparoscopic left hepatectomy with initial control of the left hepatic vein and preliminary results of our novel ARGS achieved postoperatively. In our ARGS, a 3D virtual anatomical model is created from the abdominal CT scan and manually registered to selected laparoscopic images. For this patient, the virtual model was composed of the segmented left liver, right liver, tumour and median hepatic vein.
Results The patient's operating time was summed up to 205 min where a blood loss of 300 cc was recorded. The postoperative course was simple. Histopathological analysis revealed the presence of a hepatocellular carcinoma with free margins. Our results of intrahepatic visualization suggest that ARGS can be beneficial in detecting the tumour, transection plane and medial hepatic vein prior to parenchymal transection, where it does not work due to the substantial changes to the liver's shape.
Conclusions As of today, we have performed eight similar left hepatectomies, with good results. Our ARGS has shown promising results and should now be attempted intraoperatively.

Keywords Laparoscopic hepatectomy · Guidance system · Left hepatectomy

Our presentation concerns an 81-year-old man who presented a hemorrhagic hepatocellular carcinoma of the left liver treated successfully by arterial embolization. The patient was scheduled for a left hepatectomy.

For this intervention, the patient is placed on the operating table in supine position, with legs spread apart. The table is titled in 30° reverse trendelenburg position.

The pneumoperitoneum is insufflated through a trocar which will be used to place the camera 5 cm in the right and above the umbilicus. A 12-mm main manipulator port is placed 5 cm above the umbilicus.

The abdominal cavity is thoroughly inspected for evidence of metastatic disease. As we can see, because of bleeding, we had to divide the omentum from the tumour. Before the parenchymal transection, we use to divide first

Electronic supplementary material The online version of this article (doi:10.1007/s00464-017-5733-4) contains supplementary material, which is available to authorized users.

✉ Emmanuel Buc
ebuc@chu-clermontferrand.fr

[1] UMR Auvergne CNRS 6284, Faculty of Medicine from Clermont-Ferrand, 28 Place Henri Dunant, 63000 Clermont-Ferrand, France

[2] Department of Digestive and Hepatobiliary Surgery, Estaing Hospital, CHU Clermont-Ferrand, 1 Place Lucie et Raymond Aubrac, 63003 Clermont-Ferrand, France

[3] Department of HPB surgery, Clermont-Ferrand University Hospital Estaing, 1 Place Lucie et Raymond Aubrac, 63003 Clermont-Ferrand Cedex, France

the right hepatic artery and the right portal vein. To limit bleeding during transection, we start the procedure by placing a tourniquet around the hepatic pedicle for further Pringle manoeuver if necessary. A rope surrounding the hepatic pedicle exited through the port below the right costal margin. The left hepatic artery is approached from the left of the hepatic pedicle. The branch artery of segment 4 is also divided between two hemo-lock clips. Then the left portal vein is dissected.

After its complete dissection, the left hepatic artery is clamped and ultrasonography is performed to prevent the accidental section of contralateral right hepatic artery. The artery is divided between two hemo-lock clips. Then, the left the portal vein is dissected; another ultrasonography control is performed after clamping the left portal vein, followed by the left hepatic vein ligation between hemo-lock clips.

The left hepatic lobe is mobilized by sectioning of the left triangular and left coronary ligaments.

The anterior aspect of the left hepatic vein is dissected above the liver on the front side of the vena cava. Then its posterior aspect is dissected posteriorly above the Arantius' ligament. We can see the left diaphragmatic vein, which drains laterally into the left hepatic vein.

Then the left hepatic vein is encircled with a tape.

A cholecystectomy is performed with sectioning of the cystic artery and cystic duct between two hemo-lock clips.

At this stage, we show how augmented reality guidance can be used to help remove the left liver. We can see the abdominal CT scan of the patient with the segmented regions. The objective is to correctly locate the position of the tumour intraoperatively. This will guide the surgeon for this part of the intervention. We generated a 3D model of the liver including the tumour, the median hepatic vein and the right and the left liver. This is achieved by the segmented volumetric CT scans. Here we see the right liver. We can see a small branch of the median hepatic vein draining the left liver which will also be removed.

Augmented reality guidance can assist the surgeon in intrahepatic navigation. In this case, augmented reality was achieved by superimposing the obtained 3D model over the operating image. This allows the surgeon to see the tumour, median hepatic vein and the transection plane. The main technical challenge is to register correctly the 3D model onto the laparoscopy image. This is difficult because the liver is very deformable, whilst in that case the 3D model is rigid.

The start of parenchymal transection may be more accurate with the assistance of augmented reality, through the intrahepatic virtual visualization of the tumour and the median hepatic vein. The guidance system cannot yet offer real-time monitoring of imaging of the tumour during transection. We are currently working on that step, but there is still a gap during transection, due to the large deformation of the liver. The hepatic vein from segment 8 was seen with the guidance system before transection and is sectioned between the two hemo-lock clips. Then the left hepatic vein is stapled using an Endo GIA automatic staple system.

After parenchymal transection, the left bile duct is sewn up. To control any possible biliary leakage, we perform a blue test through the cystic duct. Then we remove the transcystic tube at the end of the operation.

The specimen is put in an endobag and taken out through a Pfannenstiel incision.

No abdominal drain was placed. The operating time was 205 min. The postoperative course was simple, and the patient was discharged on postoperative day 6. The patient was recurrence free after 1 year of follow-up.

Thank you

Compliance with ethical standards

Disclosures Drs. Phutane, Buc, Poirot, Ozgur, Pezet, Bartoli and Le Roy have no conflicts of interest or financial ties to disclose.