Laparoscopic Microwave Ablation and Portal Vein Ligation for Staged Hepatectomy (LAPS): A Minimally Invasive First-step Approach

To the Editor:

We read with great interest the article by Dr Schnitzbauer et al,[1] describing a multicenter study on "ALPPS" (Associating Liver Partition and Portal vein ligation for Staged hepatectomy) that laid a milestone in liver surgery, leaving behind the "resectability" concept and moving on to the aspect of volume of future liver remnant (FLR).

Several modifications to the technique initially described by Schlitt et al were recently reviewed by Donati et al,[2] who summarized problems, criticisms, advantages, and indications related to this novel surgical technique.

The laparoscopic approach for the first step of ALPPS and the totally laparoscopic ALPPS approach have been recently described[3,4] advocating the use of minimally invasive techniques in limiting adhesions, consequently incurring fewer risks at the second step, making it easier and faster to perform.

van Lienden et al[5] observed the development of newly grown portoportal collateral vessels from segment 4 to segment 5 or 8 before liver resection by performing a intraoperative portography after right portal vein ligation (PVL). The newly developed flow induced less efficient hypertrophy of the left nonoccluded lobe than by right portal vein embolization. Microwave thermal ablation/coagulation (MWA) represents a safe and effective treatment option for primary and metastatic liver malignancy[6] and was originally developed in Asia in the 1980s for intraoperative hemostasis during liver resections.[7]

On the basis of our single-center experience (2009–2013) on more than 500 laparoscopic MWA cases for hepatocellular carcinoma and liver metastases (unpublished data), we have developed a novel ALPPS variation associating minimally invasive laparoscopic PVL and MWA on the future transection plane without in situ splitting. This allowed complete and satisfactory hypertrophy of the nonoccluded FLR (avoiding the development of portoportal shunts) and an easier second step (liver resection) in a patient with hepatocellular carcinoma and alcoholic hepatopathy. This novel, modified procedure was presented at the Liver Surgery Video Session of Società Italiana di Chirurgia (Italian Surgical Society) meeting in Turin, Italy, October 2013, and to our knowledge is the first described case performed with this technique.

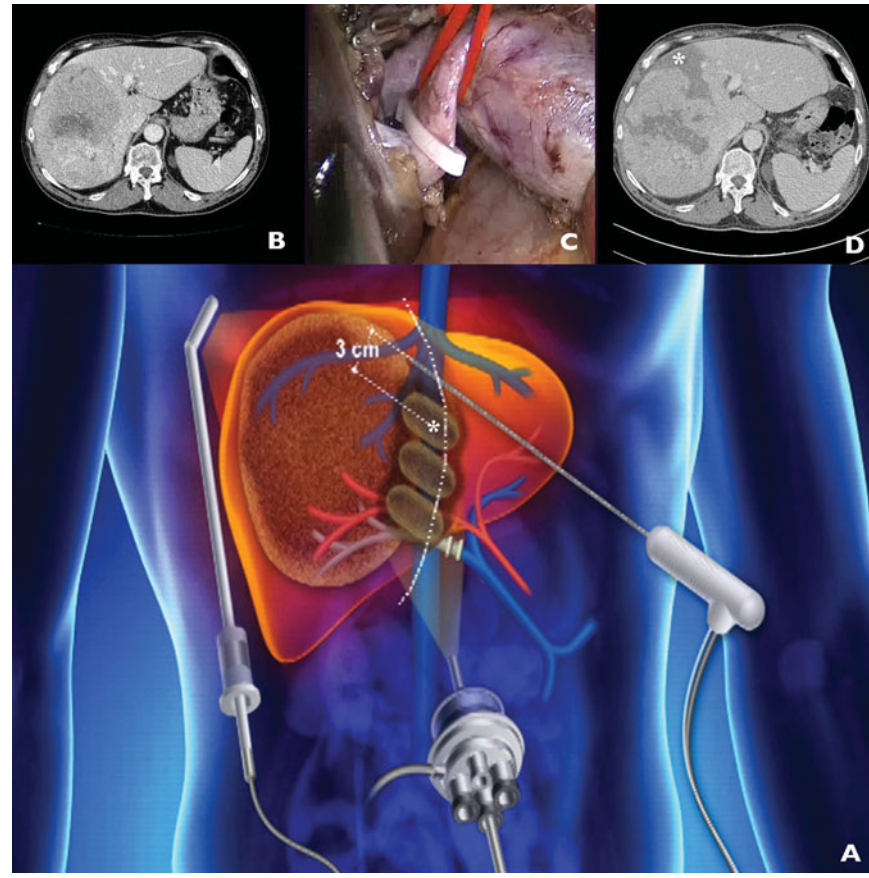

FIGURE 1. A, LAPS procedure scheme: laparoscopic PVL and MWA of the future resection plane (*). B, Preoperative CT scan of the patient with 20-cm right lobe liver mass infiltrating the right and median hepatic veins and the right hepatic artery and the right portal vein. C, Laparoscopic right segmental portal branch ligation using vascular clips. D, Postoperative day 9 CT scan after laparoscopic PVL and MWA. The left hepatic lobe hypertrophied to 693 cm^3. Asterisk in the figure shows the avascular groove (future resection plane).

A 66-year-old man (weight, 75 kg; height, 170 cm; body mass index, 26 kg/m^2) was admitted to our Liver Surgery Unit with a diagnosis of asymptomatic 20-cm right lobe liver mass (pathology showed hepatocellular carcinoma, Edmonson G1) infiltrating the right and median hepatic veins and the right hepatic artery and the right portal vein (Fig. 1B). The α-fetoprotein level was 58.4 ng/mL, with a nearly normal liver function test. Considering the need for a right extended hepatectomy (resection of segments 4-5-6-7-8), a liver volumetric computed tomographic (CT) scan was performed that showed an FLR (segments 2-3 and 1) of 390 cm^3 (16% of 2400 cm^3 of the total liver volume).

Given the nonadequate FLR, we decided to perform a laparoscopic selective right PVL associating MWA on segment 4 as a first step to minimize the risk of neoplastic left lobe invasion and to limit portoportal shunts. The development of shunts is known to impair FRL hypertrophy, as described by Schnitzbauer et al. This first operation consisted of a 4-trocar laparoscopic approach. After the induction of the pneumoperitoneum and abdominal exploration, right segmental portal branches were identified and ligated using vascular clips (Fig. 1C).

With the use of intraoperative laparoscopic ultrasound guidance, the future

Disclosure: The contents have not been published or submitted for publication elsewhere. The authors have no conflict of interest to declare. The final manuscript was seen and approved by all authors.
The study received no financial support.

ISSN: 0003-4932/14/26102-e0042
DOI: 10.1097/SLA.0000000000000606

transection plane was identified and marked with monopolar cautery; MWA antenna was then infixed into the parenchyma, positioning it at the right of the transection plane, applying a 5-minute ablation cycle (power output: 60 W). This maneuver was repeated step by step every 3 cm, proceeding from the inferior liver margin to the suprahepatic veins (Fig. 1A). This technique creates an avascular separation and a necrotic groove between the cancer and the FRL in the future transection plane.

The duration of the operation was 2 hours, and the procedure did not require any blood supplies or laparotomic conversion; a plastic drain was placed at the end of the surgery, and no intensive care admission was necessary.

The second operation was performed 10 days after the laparoscopic PVL and MWA. The preoperative volumetric CT scan showed a satisfactory left hepatic hypertrophy (FLR volume = 693 cm^3) and the presence of a hypointense avascular groove between the tumor and the FLR (Fig. 1D).

Minimal adhesions were found during the laparotomy; the right hepatic artery and right portal vein segmental branches were easily identified and divided; a bloodless parenchymal transection was bluntly performed with both scissors and an ultrasound Harmonic scalpel, with clear macroscopic evidence of portoportal shunt coagulation (transection time = 35 minutes). The right biliary duct was clearly identified and divided during parenchymal transection; median and right hepatic veins were divided with a vascular stapler. Finally, right extended hepatectomy was performed. The total operation time was 215 minutes.

The patient was admitted for overnight observation in the intensive care unit. He experienced postoperative mild complications (fever and mild ascites), which required medical treatment (Clavien-Dindo grade II), and was discharged on postoperative day 12 after resection.

We are presenting this case because our first operation step (laparoscopic PVL and MWA of the future resection plane) seems to be easier and faster than previously described techniques, allowing for a quick recovery of the patient's general functions and could offer, in our opinion, some advantages compared with the traditional ALPPS such as:

1. no need for intensive care admission,
2. no need for blood transfusions,
3. minimal risk of biliary fistula, and
4. lower risk of abdominal infection,

and offering some advantages during the following step (liver resection):

1. easier second operation due to lack of adhesions, and
2. safer liver resection along an avascular groove.

The association of PVL and MWA creates an avascular groove between the cancer and the FLR. Furthermore, it avoids the formation of interlobar portoportal shunts and thus should protect from tumor progression with FLR invasion. Moreover, the pathophysiological events connected with the blockage of the portoportal shunts could enhance the FLR hypertrophy, as suggested by Schnitzbauer et al. We believe that a faster and easier minimally invasive first-step approach could minimize some surgical risks resulting in less complications and thus shorter hospital stay.

According to our knowledge, this is the first case described of minimally invasive laparoscopic PVL associated with MWA on the future hepatic resection plane for the treatment of extended liver tumors. We have named this surgical procedure "LAPS" (Laparoscopic microwave Ablation and Portal vein ligation for Staged hepatectomy). Randomized clinical trials will be necessary to test this new minimally invasive surgical approach. To this end, our institution has recently started a phase 1 study to test the safety and efficacy of LAPS in patients with locally advanced liver tumors. Finally, this surgical approach could be of benefit only in selected cases and should be performed in tertiary high-volume experienced liver centers.

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Intraoperative Functional Liver Remnant Assessment With Indocyanine Green Clearance: Another Toehold for Climbing the "ALPPS"

To the Editor:

We read with intense interest the initial experience shared by Schnitzbauer et al[1] regarding the novel ALPPS procedure that *a*ssociates *l*iver *p*artition with *p*ortal vein ligation for *s*taged hepatectomy. The major advantage of this approach is the rapid liver regeneration in the future liver remnant. A median volumetric gain of 74% (range, 21%–192%) was observed in this study at a median of 9 days. Other authors have since reported median volumetric gains on computed tomography (CT) ranging from 63% to 82%.[2–6] However, whether this rapid volume gain correlates to functional gain remains unknown.[6,7] This is of greater concern in the setting of abnormal parenchyma after chemotherapy, particularly in older patients. The use of noninvasive real-time indocyanine green (ICG) clearance performed intraoperatively may allow quantitative assessment in determining the appropriate surgical procedure.

ICG is a nontoxic fluorescent dye that, after intravenous injection, is completely eliminated into bile without enterohepatic recirculation. Its clearance can be measured at the bedside noninvasively using pulse spectrophotometry. It has long been in use for liver function testing in the setting of liver surgery.[8–11] Patients with a preoperative plasma disappearance rate (PDR) less than 17.6%/min were noted to be at high risk of liver failure after hemihepatectomy in one study.[8] ICG clearance on the first postoperative day with a PDR less than 7%/min has also

Disclosure: The authors declare no conflicts of interest and no source of funding.
DOI: 10.1097/SLA.0000000000000608