

## ALPPS Procedure with the Use of Pneumoperitoneum

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### ABSTRACT

**Background.** A new method for liver hypertrophy was recently introduced, the so-called associating liver partition and portal vein ligation for staged hepatectomy (ALPPS) procedure. We present a video of an ALPPS procedure with the use of pneumoperitoneum.

**Methods.** A 29-year-old woman with colon cancer and synchronous liver metastasis underwent a two-stage liver resection by the ALPPS technique because of an extremely small future liver remnant.

**Results.** The first operation began with 30 min pneumoperitoneum. Anatomical resection of segment 2 was performed, followed by multiple enucleations on the left liver. The right portal vein was ligated and the liver partitioned. The abdominal cavity was partially closed, and a 10 mm trocar was left to create a pneumoperitoneum for additional 30 min. The patient had an adequate future liver remnant volume after 7 days, but she was not clinically fit for the second stage of therapy, so it was postponed. She was discharged on day 7 after surgery. The second stage took place 3 weeks later and consisted of an en-bloc right trisectionectomy extended to segment 1. The patient recovered and was discharged 9 days after second-stage surgery. Postoperative CT scan revealed an enlarged remnant liver.

**Conclusions.** The ALPPS procedure is a new revolutionary technique that permits R0 resection even in patients with massive liver metastasis. The use of pneumoperitoneum during the first stage is an easy tool that may prevent

hard adhesions, allowing an easier second stage. This video may help oncological surgeons to perform and standardize this challenging procedure.

Surgical resection is the only curative modality of treatment in patients with colorectal liver metastases. Although multiple and bilobar metastases are correlated with the worst prognosis, this condition should not be considered a contraindication to hepatic resection, because even in this situation, surgery is still the only curative treatment.<sup>1–3</sup> The most common strategy for these patients is to perform neoadjuvant therapy followed by two-stage hepatectomy with minor resections on the left lateral liver (future liver remnant, FLR) combined with right portal vein occlusion as the first stage, followed by right trisectionectomy.<sup>2</sup> However, insufficient FLR volume may preclude liver resection even after portal vein occlusion. To overcome this problem, a new method to increase liver hypertrophy before extended hepatectomy was recently described by a German multicenter study and validated by the group of de Santibañes and Clavien.<sup>4–7</sup> This method produced disruption of intrahepatic portal collaterals and resulted in hypertrophy of 62–80 % of FLR in only 6 or 7 days. However, there may have been some technical differences between those cases, perhaps related to the extent of liver disease. As a result of these technical differences, de Santibañes and Clavien recently proposed a new acronym, ALPPS, which stands for Associating Liver Partition and Portal vein ligation for Staged hepatectomy. The ALPPS procedure combines the associated liver partition with a ligation of the portal vein in a two-stage liver resection. Thus different procedures that use the same principle—liver partitioning and portal vein ligation for staged hepatectomy—can be combined under the same acronym, ALPPS.<sup>5–9</sup>

This video demonstrates an ALPPS procedure with special emphasis on our solution to diminishing hard adhesions during the second stage. It is common

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knowledge that laparoscopy may reduce adhesions.<sup>10,11</sup> Our previous experience with two-stage laparoscopic liver resection and totally laparoscopic ALPPS procedures demonstrated that laparoscopic rehepatectomy has been greatly facilitated by the lack of adhesions, and it has been possible to use the same trocar incisions.<sup>12,13</sup> Therefore, our solution was to use CO<sub>2</sub> pneumoperitoneum before and after liver partitioning.<sup>14</sup>

## METHODS

A 29-year-old woman with colon cancer and synchronous liver metastasis was referred for treatment. This young patient was completely asymptomatic except for one episode of rectal bleeding. She underwent colonoscopy that disclosed a 4 cm ulcerated lesion in the sigmoid colon. All laboratory and liver function tests were normal, and CT scan revealed massive dissemination of metastasis in the liver. The multidisciplinary decision was to provide a short course of neoadjuvant chemotherapy (FOLFOXIRI), followed by reevaluation by the surgical team if no objective response was obtained. CT scan revealed a marked response after chemotherapy, but the number and localization of metastases still precluded any possibility of complete liver resection using standard techniques. The surgical decision was to perform a two-stage liver resection via the ALPPS technique.<sup>7</sup> Volumetry revealed an extremely small FLR (329 mL, or 0.43 % of total body weight), and therefore a longer time to acquire sufficient liver remnant was to be expected. It was thus decided to use CO<sub>2</sub> pneumoperitoneum before and after liver partitioning. The first stage comprised resection of segment 2, multiple enucleations of segment 3, right portal vein ligation preserving glissonian pedicle of segment 3, and ligation of the middle hepatic vein sparing left hepatic vein branch to segment 3. The second stage comprised right trisectionectomy en bloc with caudate lobe, preserving part of segment 4b. The second stage was completed with the removal of the primary colon cancer. The removal of the primary lesion was left for the second stage because the first stage usually results in a more systemic inflammatory response than the second stage.

## RESULTS

The first operation began with 30 min pneumoperitoneum, followed by an inverted L-shape incision and exploration of the abdominal cavity for occult metastasis. Resection of segment 2 was performed by the intrahepatic Glissonian technique.<sup>15</sup> Multiple enucleations on segment 3 were performed with intraoperative ultrasound used to guide, locate, and help preserve the portal pedicle from

segment 3 and to spare the left hepatic vein branch to segment 3. The right portal vein is ligated, and the liver is divided along the falciform ligament, sparing part of segment 4b. The middle hepatic vein is ligated but not divided. Hemostatic tissue is left between the partitioned livers. The abdominal cavity is partially closed, and a trocar was left to create a 12 mm Hg CO<sub>2</sub> pneumoperitoneum over 30 min. After that time, closure was completed.

The patient recovered well but experienced a progressive increase of prothrombin time, reaching an INR of 3.4 at day 3 after surgery. The albumin level was also diminished, and the patient presented universal edema. Other liver function tests were slightly abnormal but within expected parameters. First-week postoperative CT scan revealed enough FLR enlargement (528 mL, or 0.7 % of total body weight), but the temporary liver dysfunction raised some suspicion that the liver regeneration was not adequate, and patient did not feel fit enough to undergo the new procedure. She was presenting anasarca (10 kg of extra weight), postprandial fullness, and mild dyspnea (pleural effusion and dilutional anemia). As recently pointed out by Dokmak and Belghiti, liver regeneration should not be based on a volumetric basis alone; therefore, we decided to postpone the scheduled second stage (which was initially scheduled for the same hospitalization), and patient was discharged on day 7 after surgery to be treated as an outpatient.<sup>16</sup>

The patient's liver function tests gradually returned to normal levels after 3 weeks (INR 1.6, 1.3, and 1.1, and total bilirubin 0.57, 0.51, and 0.21 mg/dL on days 7, 14, and 21, respectively). After 3 weeks, the patient's general condition had improved, and her condition was considered suitable to permit the second stage to be performed. New CT scans revealed a FLR of 854 mL (1.14 % of total body weight). The second stage took place 3 weeks after the first operation and consisted of an en-bloc right hepatectomy extended to segment 4a and the caudate lobe. Segment 4 did not present any sign of necrosis or biliary leakage. This may be a result of the particularity of this case, where the transection line preserved part of segment 4b, and segment 4a was largely resected at the first stage. The right main Glissonian pedicle was transected with a stapler according to our previously published technique.<sup>9</sup> The intrahepatic technique avoids tedious dissection of the hilar structures that may be hazardous during reoperation. The second stage was performed in 3 h, and the patient did not receive blood transfusions. Estimated blood loss was 360 mL. During the second stage, the lack of hard adhesions was remarkable. Whenever present, adhesions were avascular, easily lysed, and did not bleed. There were also fewer adhesions between the two cut surfaces. The use of bioactive sealants clearly played an important role, but we did not use this sealant in every case, and the lack of adhesions

was noted in other cases without the sealant.<sup>17</sup> The patient recovered uneventfully and was discharged on day 9 after surgery. CT scan after the second stage revealed an enlarged remnant liver (1,194 mL, or 1.59 % of total body weight).

## CONCLUSIONS

The ALPPS procedure is a revolutionary new technique that permits R0 resection to be achieved, even in patients with massive liver metastasis. The timing between the two stages in our case was longer than that used by other authors. We did not encounter major adhesions, and the use of CO<sub>2</sub> pneumoperitoneum may have played an important role. Experimental and clinical studies have demonstrated an antiadhesion effect of the CO<sub>2</sub> insufflation.<sup>10,11</sup> This report and our previous experience corroborate this effect.<sup>12,13</sup> The use of pneumoperitoneum during the first stage is an easy tool that may prevent hard adhesions, thus allowing an easier second stage. Although this procedure has recently proved popular, there are still very few detailed descriptions of this procedure, and to our knowledge, ours is the first multimedia article to illustrate this technique. This video may help oncological surgeons perform and standardize this challenging procedure.

**DISCLOSURE** Drs. Machado, Surjan and Makdissi have no conflicts of interest or financial ties to disclose.

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