Evaluation of CT volumetry in associating liver partition and portal vein ligation for staged hepatectomy (ALPPS)

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Learning objectives

• To describe the surgical technique.
• To evaluate the role of CT volumetry in indicating ALPPS.
• To illustrate the imaging findings after surgery.
Background

The main limiting factor for major liver resections is the remaining liver volume, referred to as future liver remnant (FLR). The critical minimum FLR has been estimated to be approximately 25% in normal livers, and 40% in cirrhotic livers. In cases with an insufficient FLR volume, portal vein embolization (PVE) generally has been performed to induce compensatory hypertrophy of the remnant liver and to increase safety of major hepatectomy. Meanwhile, 10-20% of the cases become unresectable because of tumor progression or insufficient remnant liver hypertrophy. Recently has been reported a novel strategy of associating liver partition and portal vein ligation for staged hepatectomy (ALPPS), which is performed in two steps and induced marked and rapid remnant liver hypertrophy.
Findings and procedure details

Procedure details:

Volumetric measurements of FLR using computed tomography (CT) were obtained before surgery. In 7 patients FLR-TLV ratio were < 25%, determining the indication for ALPPS. CT scans were performed on postoperative day 6, after liver transection and portal vein ligation. We observed significantly increases in FLR and extended right hepatectomies were successfully performed in all cases.

Findings:

Surgical resection is the only curative therapeutic option in patients with primary or metastatic hepatic malignancies. Posthepatectomy liver failure is a feared complication in patients who underwent extensive liver resections. The main limiting factor for major liver resections is the remaining liver volume, referred to as future liver remnant (FLR). FLR is usually expressed as the ratio of the remnant liver volume (RLV) and the total functioning liver volume (TFLV). The TFLV is calculated using the following formula: total liver volume (TLV)-tumor volume (TV)=TFLV. The critical minimum FLR has been estimated to be approximately 25% in normal livers, and 40% in cirrhotic livers. In cases with an insufficient FLR volume, portal vein embolization (PVE) generally has been performed to induce compensatory hypertrophy of the remnant liver and to increase safety of major hepatectomy. Previous PVE studies demonstrated that FLR volume increased by 20-50% within a 3 to 7-week interval between PVE and hepatectomy. However, various conditions, including hepatitis, cholestasis, and chemotherapy, are reported to affect remnant liver hypertrophy. Meanwhile, 10-20% of the cases become unresectable after such an interval because of tumor progression or insufficient remnant liver hypertrophy.

Recently has been reported a novel strategy of associating liver partition and portal vein ligation for staged hepatectomy (ALPPS), which induced marked and rapid remnant liver hypertrophy. The procedure is performed in two steps. The first consists on ligation of the right portal vein branch. Subsequently, total or nearly total parenchyma dissection along the falciform ligament is performed, including the middle hepatic vein. A plastic bag is used to cover the right extended lobe, and the abdomen is drained and closed. The second one is performed after six to twelve days interval. A CT is performed and the procedure in completed by relaparotomy. The plastic bag is removed from the right-extended libe. The right artery, right bile duct and the right hepatic vein are divided. The
extended right lobe is removed. Drain is placed at the resection surface, and the abdomen is closed.

CT scans were performed with a 64-section scanner. We used a multisection CT protocol to acquire two image sets at late arterial portal venous phase (40 seconds) and hepatic venous phase (70 seconds) after the administration of 1.5 mL per kilogram of body weight of nonionic contrast material. The volumes were measured pre and post-first step on the scans obtained during the hepatic venous phase.

A radiologist traced the contours of all liver sections by using the mouse. The workstation automatically calculated the number of pixels included within the traced contours on each section and provided the cross-sectional area of the liver on a section-by-section basis. The circumscribed areas were then automatically multiplied by the CT section thickness, yielding an approximate volume for each liver section, and the volumes of all sections were summed to give the selected liver volume.

On preoperative CT scans, we measured the total liver volume, the future liver remnant volume and the FLR-TLV ratio. The liver remnant volume was also measured on post-first step CT scans (figures 1, 2, 3, 4 and 5).

The main limiting factor for major liver resections is the future liver remnant volume. In ALPPS approach, the portal vein ligation associated with in situ splitting is able to induce accelerated hypertrophy (contrary to portal vein embolization or ligation which need three to eight weeks to induce hypertrophy). The nearly total parenchymal dissection induced a median hypertrophy of 74% (with a median time interval to have hypertrophy effect of nine days) which is markedly above the range that can be achieved by portal vein ligation or portal vein embolization alone.
Fig. 1: Multiple colorectal cancer liver metastases involving segments VIII, VII, V, VI and IV, with tumor-free left lateral liver lobe.

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Fig. 2: Preoperative CT volumetric measurement. Future liver remnant (FLR) (B) to total liver volume (TLV) (A) ratio ≤ 25%, determining the indication for ALPPS.

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Fig. 3: CT scan was performed on postoperative day 6, after liver transection and portal vein ligation. Segmental resection of hepatic metastases involving segment IV (*), liver transection line (yellow arrow) and right portal vein ligation (red arrowhead).

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Fig. 4: Significantly increase in FLR. FLR (D) to TLV (C) ratio was 30%. Extended right hepatectomy was successfully performed.

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**Fig. 5:** Follow-up CT scan after complete procedure showing remnant liver volume.

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Conclusion

The safety of oncological liver surgery in patients who underwent extensive resections increases if future liver remnant volume (FLRV) is calculated by using CT-volumetry. Experienced radiologists in collaboration with hepatobiliary surgeons are needed in order to select patients who might benefit from this procedure.


