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## Case Report

# Additional hepatic artery embolization after liver venous deprivation for right hepatectomy: A case report <sup>☆,☆☆</sup>

Anh T Pham<sup>a</sup>, Quoc H Dang<sup>b</sup>, Cuong M Truong<sup>a</sup>, Phuong H Trinh<sup>a</sup>, Lam D Vu<sup>c</sup>,  
Thinh D Nguyen<sup>c</sup>, Thang Q Tran<sup>c</sup>, An TM Nguyen<sup>d</sup>, Khue K Dang<sup>d,\*</sup>

<sup>a</sup> Department of Hepatobiliary Surgery, Vietnam National Cancer Hospital, Hanoi 100000, Vietnam

<sup>b</sup> Hanoi Medical University, Hanoi 100000, Vietnam

<sup>c</sup> Radiology Department, Thanh Nhan Hospital, Hanoi 100000, Vietnam

<sup>d</sup> College of Health Sciences, VinUniversity, Hanoi 100000, Vietnam

## ARTICLE INFO

## Article history:

Received 14 March 2024

Revised 22 May 2024

Accepted 26 May 2024

## Keywords:

Portal vein embolization  
Hepatic vein embolization  
Liver resection  
Liver failure

## ABSTRACT

Post hepatectomy Liver Failure (PHLF) is a fatal complication, especially after major liver resection. Insufficient remnant liver volume is a common cause of postoperative liver failure. Many strategies have been applied to induce the remnant liver hypertrophy: Portal vein embolization (PVE), PVE combined with hepatic vein embolization (LVD), two staged liver resection, Associated liver partition with portal vein ligation for staged hepatectomy (ALPPS).

We present a case of a 39-year-old male patient who underwent LVD for preoperative liver hypertrophy. After LVD, the patient underwent additional artery embolization, and the patient's remaining liver volume increased by 63.2% in 7 weeks. The patient underwent a right hepatectomy and was discharged after 10 days, with no complications of postoperative liver failure. Simultaneous portal and hepatic vein embolization is a technique that has been applied recently because it can significantly promote the speed and extent of liver hypertrophy before major liver resection compared to portal vein embolization procedure alone. In this case, additional hepatic artery embolization may be an important factor lead to hypertrophy of the remnant liver, thereby shortening the waiting time for surgery and reducing the risk of tumor progression. Liver venous deprivation is safe and feasible to perform. Additional hepatic artery embolization may accelerate the hypertrophy of the remnant liver.

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<sup>☆</sup> Competing Interests: The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

<sup>☆☆</sup> Funding: The study did not receive external funding.

\* Corresponding author.

E-mail address: [khuedang.md@gmail.com](mailto:khuedang.md@gmail.com) (K.K. Dang).

<https://doi.org/10.1016/j.radcr.2024.05.078>

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## Introduction

Hepatocellular carcinoma (HCC) is one of the most common malignant tumors with high mortality rates worldwide. In Vietnam, with the development of multidisciplinary management, there are many therapeutic methods to treat liver cancer have been applied such as liver resection, liver transplantation, transcatheter arterial chemoembolization (TACE), radiofrequency ablation (RFA), etc. Among these, liver resection is still the first treatment option for HCC.

Post hepatectomy liver failure (PHLF) is a fatal complication, especially after major hepatectomy. In certain cases, when major liver resection is hampered due to inadequate volume of the Future liver remnant (FLR), portal vein embolization (PVE) to induce liver hypertrophy is a technique that has been applied worldwide for many years, contributing to the expansion of liver resection indication by improving surgical outcomes [1]. Associating liver partition and portal vein ligation for staged hepatectomy (ALPPS) may be a viable alternative option in cases of insufficient FLR. However, this method has many limitations because patients have to undergo 2-staged hepatectomy and thus increasing the risk of surgical complications.

Recently, the method of simultaneous portal and hepatic vein embolization (liver venous deprivation - LVD) has been proposed as an alternative to PVE, increasing the safety and efficiency in terms of liver hypertrophy [2]. In comparison to ALPPS surgery, LVD is considered as safer procedure [3]. In Vietnam—a lower-middle-income country with limited equipment, LVD is a new technique which has not widely applied yet. We herein present the a case of additional hepatic artery embolization performed after simultaneous portal and hepatic vein embolization to induce liver hypertrophy prior to right hepatectomy at our center.

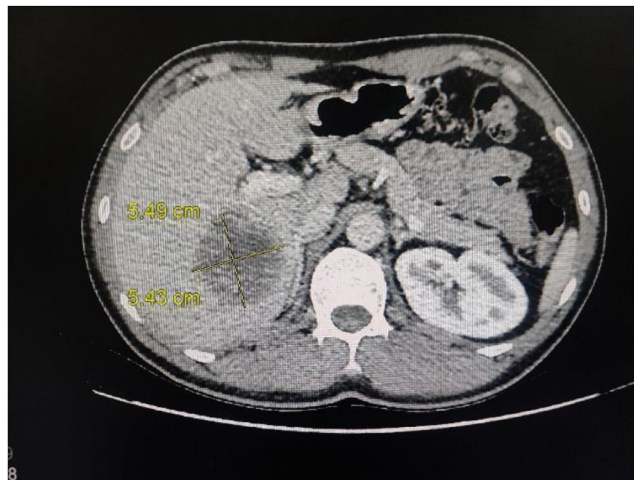
## Case report

This case presentation follows SCARE guideline [4].

A 39-year-old male patient with past medical history of treated chronic hepatitis B, admitted to the hospital due to right lower quadrant abdominal pain. No fever, no digestive disorders. On physical examination, the patient has an optimal body habitus (BMI: 21.22), normal vital signs with heart rate: 80 bpm and blood pressure: 120/70 mmHg, no palpable lymphadenopathy, soft and non-distended abdomen, no palpable abdominal mass, no hepatosplenomegaly. Abdominal CT scan findings on October 27, 2023 were consistent with HCC, in the right liver lobe.

At the time of diagnosis, laboratory findings were as follows: AFP > 3000 ng/mL, AST/ALT: 61/101 U/L, normal liver function, and HBsAg positive. Other blood tests, including complete blood count, coagulation studies, comprehensive metabolic panel, and serology tests, were within normal limits.

However, the remaining liver volume/weight ratio was 378cc/65 kg, approximately 0.58, which was inadequate for right hepatectomy (Fig. 1). To increase FLR, the patient under-



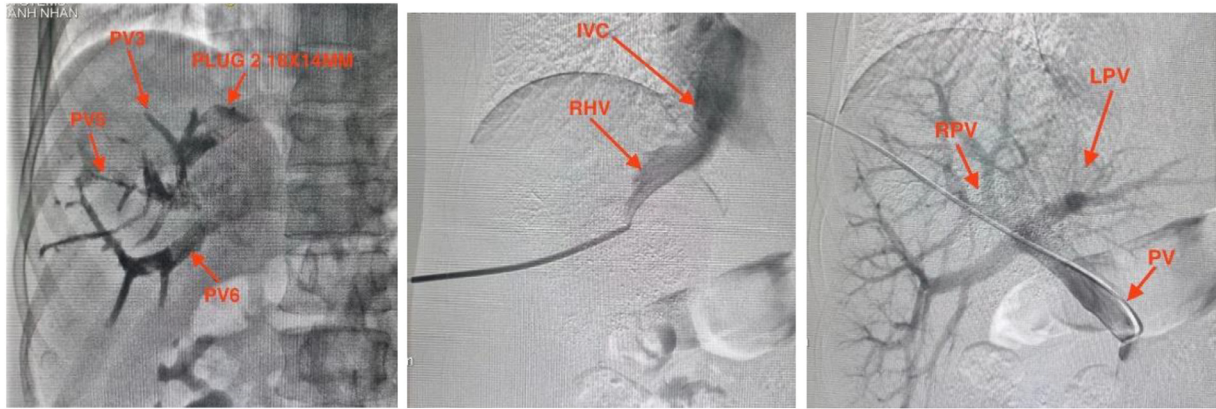
**Fig. 1 – The tumor in the initial image is 5.5 × 5.4 cm in diameter, located within the right lobe.**

went TACE on November 10, 2023, followed by LVD on November 17, 2023. Afterward, re-evaluation showed that the tumor still has blood supply, additional right hepatic artery embolization was performed on December 4, 2023.

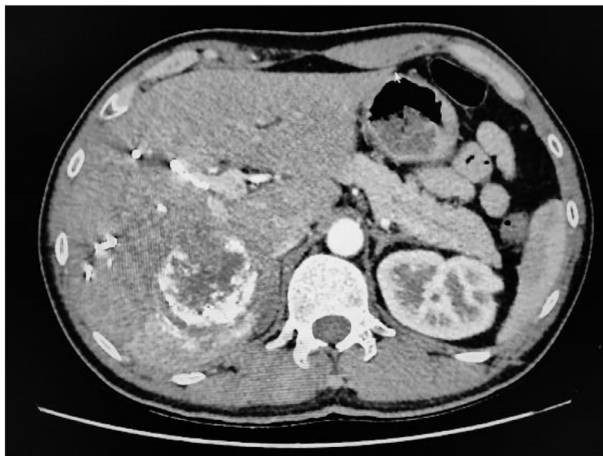
LVD procedure was performed under local anesthesia and sedation. Portal vein embolization (PVE) was performed first, followed by hepatic vein embolization (HVE) in the same stage. Distal branches of the right portal vein and the right hepatic vein were accessed using 16G x 5.25 Angiocath catheter (Angiocath™ BD, Sandy, UT, USA) under ultrasound guidance. After successful approach to portal vein and hepatic vein, 5F and 8F vascular sheaths were introduced into the right portal vein and hepatic vein, respectively. Selective embolization of the right portal vein branches was performed using a mixture of N-butyl-cyanoacrylate (NBCA, Histoacryl) and lipiodol. After PVE procedure, the right hepatic vein was embolized with an 18 × 14 mm Amplatzer Vascular Plug II (St. Jude Medical, Saint Paul, Minnesota, USA) via the transhepatic approach, the distal branches of the right hepatic vein and the access tract were embolized with the mixture of NBCA and lipiodol (Figs. 2–4).

Four weeks after the LVD procedure, the patient underwent a follow-up abdominal CT scan. There was an increase by 16.7% of the remaining left liver volume to 441 cc. The ratio of remaining liver volume (cc) to body weight (kg) was 441cc/65kg, approximately 0.68%, which was still insufficient for a major hepatectomy surgery. In addition, the tumor was still vascularized on the CT scan (Fig. 5). Therefore, we decided to perform an additional artery embolization on December 4, 2023.

The follow-up abdominal CT scan was performed on December 21, 2023 (34 days after LVD). The right liver was mostly occupied by the tumors with its satellite nodules with hyperattenuating signs of embolization agents. The main portal vein was dilated with a diameter of 21 mm, and the left portal vein was patent. The left liver volume was 615cc. The ratio of remaining liver volume (cc) to body weight (kg) was 615cc/65kg, approximately 0.95, which was sufficient for hepatectomy (Figs. 6 and 7).



**Figs. 2,3,4 – Portal vein and Hepatic vein embolization procedures and post procedural imaging (PV, portal vein, IVC, inferior vena cava, RPV, right portal vein, LPV, left portal vein, RHV, right hepatic vein).**



**Fig. 5 – The tumor still has residual after the first TACE, the right portal vein embolization materials can be seen in the image.**

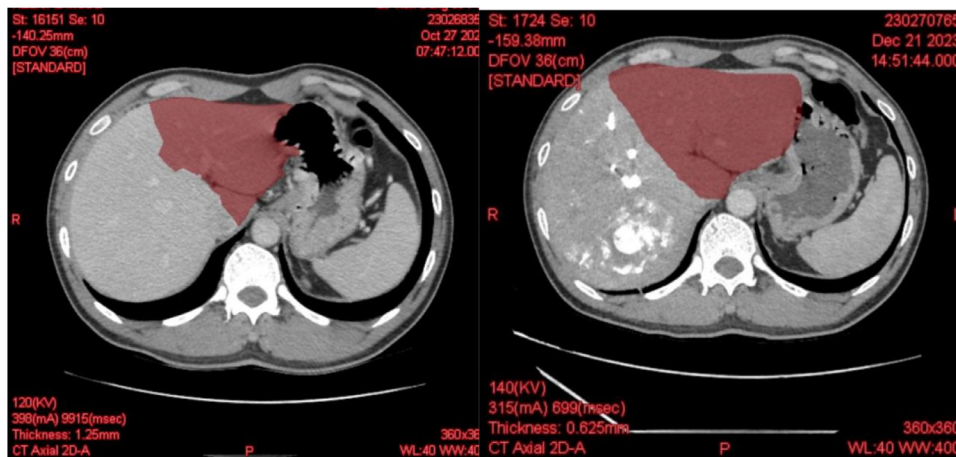
On December 25, 2023, an open right hepatectomy was performed and the abdominal cavity was approached with a 30cm J-shaped incision. Intraoperatively, neither ascites nor peritoneal metastasis was seen. The liver appeared to be mild fibrosis, the right liver had two tumors that measured about 5 cm and 7 cm in diameter. The left liver was hypertrophy without lesion. Cholecystectomy was performed, followed by selective control of the right hepatic pedicle using the Takasaki method. The liver hanging maneuver was performed, facilitating anatomic right hepatectomy with preservation of the middle hepatic vein (Fig. 8). Postoperative histopathological results confirmed the diagnosis of hepatocellular carcinoma with histologic grade 3 in macrotrabecular growth pattern accompanied by satellite nodules. The postoperative course was uneventful. The patient was discharged 10 days after surgery.

## Discussion

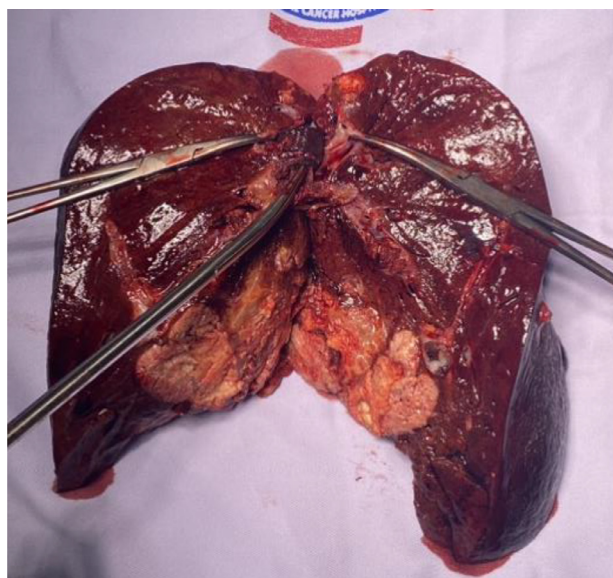
Major hepatectomy in general, is a complex surgery with high risk of complications. Post hepatectomy liver failure (PHLF) is the leading cause of death after major hepatectomy. Despite major improvements in outcomes after major hepatectomy due to advanced techniques and management applied in intensive care unit (ICU), PHLF remains one of the most serious complications of this surgery.

One of the important causes of postoperative liver failure is insufficient remaining liver volume. Many methods have been proposed to address this problem. Preoperative portal vein embolization (PVE) was first introduced by Makuuchi et al. in 1984. While there is no consensus statement about the standardized FLR, PVE is generally considered when the FLR volume is <20%-25% of total liver volume (TLV) or <0.6% of body weight (BW) in patients with healthy livers [5]. However, after PVE, compensatory increases in hepatic arterial blood flow to the embolized liver lobe can reduce the degree of hypertrophy. A combination of hepatic vein embolization (which blocks blood flow out of the liver) and PVE can significantly reduce perfusion to the embolized liver lobe and increase the regeneration of the remaining liver.

Liver venous deprivation (LVD), a method that embolizes both the portal vein and hepatic vein at the same time, has been used in recent years. Studies have shown that this method is relatively safe while it can achieve a greater degree of liver hypertrophy and reduce waiting time for surgery, thereby increasing the proportion of patients who are eligible to undergo surgery after embolization. According to Bertrand Le Roy et al., the mean liver hypertrophy rate was 31.9% in the PVE group and 51.2% in the PVD group. The mean growth rate was 19%/week in the LVD group and 8%/week in the PVE group. Multivariate analysis showed a statistically significant difference with  $P = .004$ . The increase in the FLR/TLV ratio before and after embolization was 10% in the LVD group and 7.5% in the PVE group, showing a significant difference. The average follow-up CT scan after intervention was 26 days in the LVD



**Figs. 6,7 – FLR volumetry before LVD (378 cc on October 31, 2023) and after LVD with additional hepatic artery embolization (617 cc on December 21, 2023).**



**Fig. 8 – Gross morphology of the tumor with embolization materials within the right hepatic vein.**

group and 27 days in the PVE group. The patients were able to undergo hepatectomy cases after intervention was 81% in the LVD group compared to 76% in the PVE group [2].

Another method for liver parenchyma augmentation-assisting surgery is Associating liver partition and portal vein ligation for staged hepatectomy (ALPPS). In comparison to LVD, this method provides a faster rate of hypertrophy and increases the proportion of patients who are eligible for hepatectomy. However, LVD improves intra-operative parameters (the amount of blood loss and surgical time) and reduces hospital length of stay [2]. Liver volume is reassessed 28 days after LVD compared to liver volume 8 days after ALPPS stage 1. The increase in FLR after LVD is 63%, compared to 56% in ALPPS group. The average regeneration rate is faster in the ALPPS group compared to LVD group. The hospital length of stay was

shorter in the LVD group with 15 days compared to 23 days in the ALPPS group, not counting the hospital length of stay for the LVD procedure [3].

In this case, the patient was diagnosed with HCC and had chronic hepatitis and liver cirrhosis background. About 4 weeks after LVD, a follow-up CT scan revealed insufficient remaining liver volume for safe right hepatectomy and identified that the tumor was still vascularized. Therefore, an additional hepatic artery embolization was performed. After 3 weeks, the left liver volume increases 40%, reaching 617cc after 7 weeks. Compared to the study by Le Roy B. et al. on 72 patients showing a 3-week FLR increase rate of 51.2% and 31.9% for the LVD and PVE groups respectively, our study observed a slower liver regeneration rate. However, the study population in Le Roy B.'s study mainly consisted of patients with colorectal liver metastases or bile duct tumors with non-cirrhotic livers, while in our study, the patient has underlying chronic liver disease. The hypertrophy rate after additional artery embolization had markedly accelerated, confirming the mechanism discussed by Le Roy et al that the compensatory blood flow to the embolized lobe can reduce hypertrophy efficiency [6].

This raises the question whether further evaluation and additional artery embolization should be performed after PVE or LVD in patients who do not achieve the expected hypertrophy while the tumor still has blood supply. Our results suggest that it is a safe technique, offering a higher rate of hypertrophy compared to PVE alone. However, further studies with larger sample sizes or randomized comparisons are needed to confirm the safety and efficacy of this procedure.

## Conclusion

LVD is a safe and feasible technique that can be performed in hepatobiliary surgery centers. LVD is expected to bring about higher efficiency in inducing liver hypertrophy before major hepatectomy than traditional PVE technique, by reducing in-

traoperative blood loss, operative time, and hospital length of stay compared with ALPPS. However, in some cases, the liver hypertrophy is not enough for a major hepatectomy surgery, additional hepatic artery embolization can accelerate the regeneration of remnant liver while limiting tumor progression during the waiting period for surgery.

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### Patient consent

Complete written informed consent was obtained from the patient for the publication of this study and accompanying images.

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### Ethical approval

Ethical approvals were waived because this case report is a review of literature with a retrospective case report on one patient. Written informed consent was obtained from the patient for publication and any accompanying figures contain no personal information that could identify the patient.

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### Credit authorship contribution statement

**Anh T Pham:** Main surgeon, Oversee the project, final approval of the manuscript. **Quoc H Dang:** Methodology, Writing - original draft. **Cuong M Truong:** Methodology, Writing - original draft. **Phuong H Trinh:** Writing draft. **Lam D Vu:** Methodology. **Thinh D Nguyen:** Methodology. **Thang Q Tran:** Writing draft. **An TM Nguyen:** proofread, editing English. **Khue K Dang:** Editing draft, prepare manuscript to submit.

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### Provenance and peer review

Not commissioned, externally peer-reviewed.

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