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# Left Gastric Vein Direct Anastomosis as Alternative to Portal Flow Reconstruction in Liver Transplantation

Raquel Lima Sampaio, MD,* Gustavo Rego Coelho, MD, PhD,*†‡ Denissa Ferreira Gomes Mesquita, MD,*†‡ Carlos Eduardo Lopes Soares, BM,*† and José Huygens Parente Garcia, MD, PhD*†‡

**Introduction:** The most relevant limiting factor for performing end-to-end anastomosis is portal vein thrombosis (PVT), which leads to challenging vascular reconstructions. This study aimed to analyze a single center's experience using the left gastric vein (LGV) for portal flow reconstruction in liver transplantation (LT).

**Methods:** This retrospective observational study reviewed laboratory and imaging tests, a description of the surgical technique, and outpatient follow-up of patients with portal system thrombosis undergoing LT with portal flow reconstruction using the LGV. This study was conducted at a single transplant reference center in the northeast region of Brazil from January 2016 to December 2021.

**Results:** Between January 2016 and December 2021, 848 transplants were performed at our center. Eighty-two patients (9.7%) presented with PVT, most of whom were treated with thrombectomy. Nine patients (1.1% with PVT) had extensive thrombosis of the portal system (Yerdel III or IV), which required end-to-side anastomosis between the portal vein and the LGV without graft, and had no intraoperative complications. All patients had successful portal flow in Doppler ultrasound control evaluations.

**Discussion:** The goal was to reestablish physiological flow to the graft. A surgical strategy includes using the LGV graft. According to our reports, using LGV fulfilled the requirements for excellent vascular anastomosis and even allowed the dispensing of venous grafts. This is the largest case series in a single center of reconstruction of portal flow with direct anastomosis with the LGV without needing a vascular graft.

**Keywords:** liver transplantation, portal flow reconstruction, portal vein thrombosis

## INTRODUCTION

The portal vein is responsible for 70% of the liver's blood supply and almost half its oxygen supply.[1] Therefore, establishing adequate inflow through the portal vein is crucial for successful liver transplantation (LT).

In most cases, end-to-end anastomosis occurs between the portal veins of the recipient and the donor. The most relevant limiting cause of end-to-end anastomosis is the presence of portal vein thrombosis (PVT), which sometimes leads to the need for complex and challenging vascular reconstructions. Among patients with liver cirrhosis, PVT is a common complication and can be found in 10% to 15% of this group.[1,2]

Thus, preoperative diagnosis and accurate surgical planning are essential to avoid the disastrous consequences of transplantation. PVT can be classified based on the time or anatomical extent and the presence of collaterals. In the context of LT, the most widely used PVT classification is Yerdel et al's.[3]

The first successful transplantation in a patient with PVT was reported by Shaw et al in 1985 and is no longer a contraindication to transplantation. Since then, vascular techniques have been improved to enable the success of LT in this group of patients, although they are still considered high risk.[4]

This study aimed to report a single center's experience using the left gastric vein (LGV) for portal flow reconstruction in LT.

## METHODS

### *Study Population*

A retrospective observational study reviewed laboratory and imaging tests, a description of surgical techniques, and outpatient follow-up of patients with portal system thrombosis undergoing LT with portal flow reconstruction using the LGV. This study was conducted at a single transplant reference center in the northeast region of Brazil from January 2016 to December 2021. The Ethics Committee of the Institution (number 5.187.244) approved the study.

During this period, 848 transplants were performed, with 82 having a diagnosis of PVT, among which reconstruction of the portal flow was performed with the LGV in 9 patients. All patients with PVT included in this report were diagnosed using abdominal computed tomography or magnetic resonance imaging performed within 6 months before transplantation.

All patients with confirmed PVT were retrospectively classified into 4 grades according to the extent of thrombosis, as described by Yerdel et al. According to Yerdel et al's classification,[5,6] 5 patients had grade IV PVT and the others were grade III. The decision to use the LGV was made preoperatively, with the consent of the entire multidisciplinary team.

*From the *Gastrointestinal Surgery Department, Walter Cantídio University Hospital, Fortaleza, CE, Brazil; †Department of Liver Transplantation, Walter Cantídio University Hospital, Fortaleza, CE, Brazil; and ‡Department of Liver Transplantation, São Carlos Hospital, Fortaleza, CE, Brazil.*

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*Research data supporting this publication are included within the article and supporting materials. For further information, please contact raquellsampaio@gmail.com.*

*Reprints: Raquel Lima Sampaio, Gastrointestinal Surgery Department, Walter Cantídio University Hospital, Pastor Samuel Munguba Street, 1290 - Rodolfo Teófilo, Fortaleza, CE 60430-37, Brazil. E-mail: raquellsampaio@gmail.com.*



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A multidisciplinary committee performed the preoperative classification of PVT with an expert radiology team. The inclusion criteria were patients with an indication for LT, with grade III or IV portal thrombosis, with a LGV of adequate caliber, without technical conditions to use another tributary to reestablish portal flow. Patients with PVT grade IV who did not have collateral veins to provide portal drainage or adequate diameter shunt had LT contraindicated.

### *Assessment of Risk Factors for PVT and Outcomes Analysis*

The potential risk factors for PVT[7] included etiology, age, sex, primary disease or Child–Turcotte–Pugh score, average model for end-stage liver disease (MELD) score, previous treatment for portal hypertension (splenectomy, shunt operation, transjugular intrahepatic portosystemic shunt, or sclerotherapy), and presence of malignancy.

Direct biliary anastomosis was performed in all patients related to biliary reconstruction. Thrombectomy attempts were only performed in patients with grade III PVT. Primary LGV anastomosis was performed in patients with a preoperative diagnosis of grade IV PVT, as shown in Table 1. The intraoperative flow was not analyzed with a flow probe. Postoperative portal flow assessment was routinely performed by Doppler ultrasound (US) on the first day posttransplant and at hospital discharge.

We do not routinely use chemical thromboprophylaxis in our service. According to our protocol, all patients receive aspirin (started when the platelet count was above 50,000/mm$^3$) for 6 months after the transplant.

Postoperative complications (postoperative bleeding, biliary complications, PVT or stenosis, hepatic artery complications, infection, and rejection) and postoperative laboratory markers (prothrombin time, bilirubin, and aspartate transaminase) were evaluated. In-hospital mortality and patient survival rates were also analyzed.

The patients were followed up for a median of 17 months (6–24 months). The characteristics of this series are presented in Tables 1 and 2.

## RESULTS

Between January 2016 and December 2021, 848 transplants were performed at our center. Eighty-two patients (9.7%) presented with portal thrombosis, most of whom were treated with thrombectomy. Nine patients (1.1%) had extensive thrombosis of the portal system (Yerdel III or IV) and required anastomosis between the portal vein and the LGV.

Among the patients, 8 (89%) were male; the mean age of patients was 58 ± 9.56 years (40–69 years). The MELD score of each patient at the time of transplantation is reported in Table 1. Alcoholic cirrhosis was diagnosed in 6 cases (67%). In addition, 6 patients received special status due to hepatocellular carcinoma (67%), hepatic encephalopathy (17%), and refractory ascites (17%) (Table 1).

According to Yerdel et al's classification, 5 patients (55%) had grade IV PVT, while the others had grade III without adequate flow after thrombectomy (Table 1). All 9 patients performed end-to-side anastomosis without graft between the LGV and portal vein and had no intraoperative complications (Fig. 1).

All patients had successful portal flow in Doppler US control evaluations. Radiological control with computed tomography was performed in selected patients (Fig. 2). In our study, none of the patients who underwent portal reconstruction using the LGV had any complications related to the anastomosis. None of them had rethrombosis or gastrointestinal bleeding.

**TABLE 1.**

**Clinical Features of Patients and Follow-Up Period**

| Patient | MELD | Age (yr) | Etiology | Yerdel | Primary LGV* Anastomosis | Graft Survival (d)† |
|---|---|---|---|---|---|---|
| 1 | 10 | 40 | OH + HCC | IV | Yes | 247† |
| 2 | 24 | 58 | HBV + HCC | IV | Yes | 1877 |
| 3 | 18 | 65 | OH | III | After thrombectomy failure | 1778 |
| 4 | 18 | 53 | CC | III | After thrombectomy failure | 1700 |
| 5 | 14 | 67 | OH + NASH | IV | Yes | 1015 |
| 6 | 21 | 60 | HBV + HCV + HCC | IV | Yes | 855 |
| 7 | 20 | 58 | OH | III | After thrombectomy failure | 803 |
| 8 | 20 | 52 | OH + HCC | III | After thrombectomy failure | 616 |
| 9 | 22 | 61 | OH + HCV | IV | Yes | 721 |

*The standard transplantation technique used was piggyback transplantation.

†Evaluated during the follow-up of 2 years. Patient 1 died due to HCC recurrence.

CC indicates cryptogenic cirrhosis; HBV, hepatitis B virus infection; HCC, hepatocellular carcinoma; HCV, hepatitis C virus infection; NASH, nonalcoholic steatohepatitis; OH, alcoholic cirrhosis.

**TABLE 2.**

**Evolution of Posttransplant Liver Function Tests and Injury**

| Follow-Up Time | Six Months | | | First Year | | | Second Year | | |
|---|---|---|---|---|---|---|---|---|---|
| Patient | INR | Bilirubin | AST | INR | Bilirubin | AST | INR | Bilirubin | AST |
| 1† | 2.49 | 2.18 | 69 | N/E | N/E | N/E | N/E | N/E | N/E |
| 2 | 1.1 | 0.31 | 18 | 1.1 | 1.02 | 26 | — | 0.37 | 25 |
| 3 | 1.4 | 0.87 | 16 | 1.33 | 1 | 25 | 1.14 | 0.96 | 19 |
| 4 | 1.31 | 0.83 | 31 | 1.24 | 1.39 | 20 | 1.16 | 1.29 | 23 |
| 5 | 1.53 | 0.24 | 16 | — | 0.6 | 14 | 0.95 | 0.5 | 22 |
| 6 | 1.09 | 0.66 | 19 | 1.1 | 0.44 | 16 | — | 0.52 | 44 |
| 7 | 1.23 | 0.65 | 29 | 1.1 | 0.48 | 24 | 1.1 | 0.47 | 13 |
| 8 | 1.05 | 0.5 | 23 | 0.98 | 0.5 | 27 | — | 0.56 | 19 |
| 9 | 1.0 | 0.8 | 27 | 1.0 | 12 | 36 | N/E | N/E | N/E |

ALT indicates alanine transaminase; AST, aspartate transaminase; N/E, not evaluated.

†Patient 1 died due to HCC recurrence.

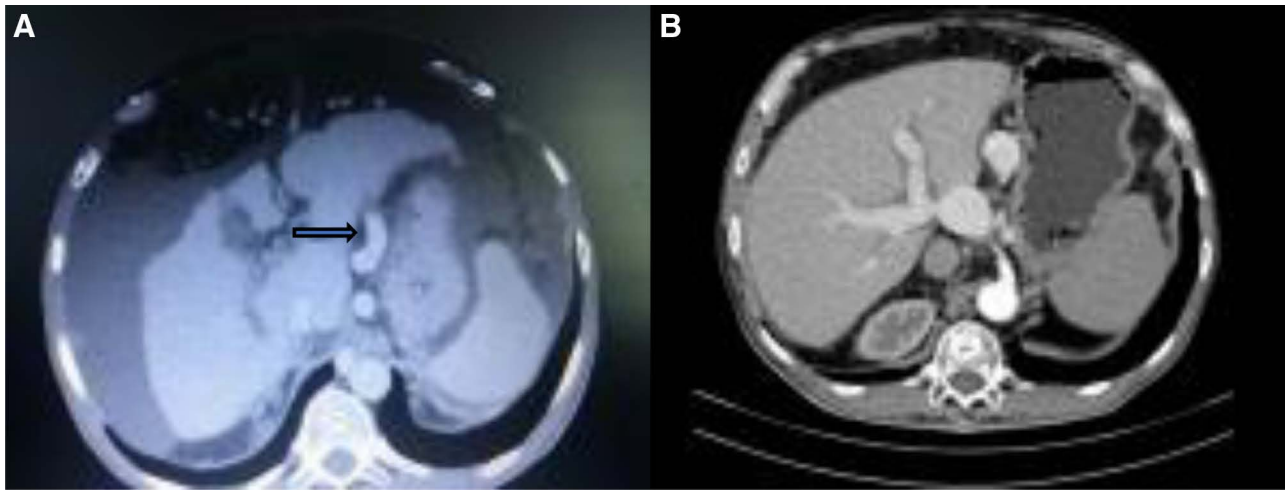


**FIGURE 1.** A, Enlarged LGV preoperatively (black arrow). B, Tomographic control of portal flow reconstruction using the LGV.

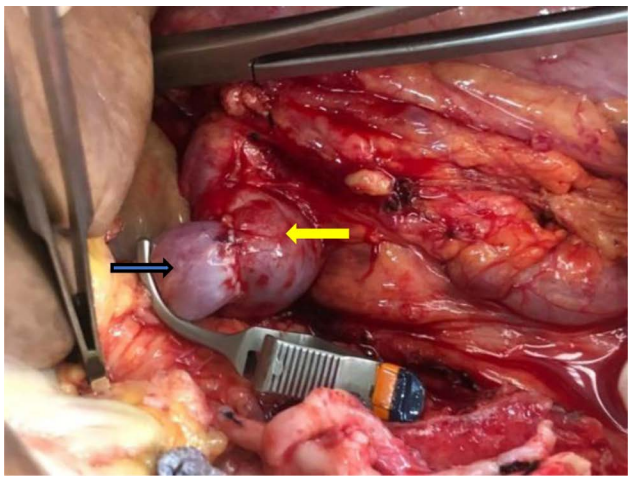

**FIGURE 2.** Intraoperative result of LGV (yellow arrow) and portal vein (black arrow) anastomosis without graft.

According to the criteria outlined by Olthoff et al[8] to determine graft dysfunction, which includes elevated levels of aspartate transaminase or alanine transaminase greater than 2000 IU/L within the first 7 days posttransplant or a total bilirubin level greater than 10 mg/dL or an INR greater than 1.6 on the seventh day postsurgery, patients 3 and 4 (22.2%) experienced early allograft dysfunction. However, they both fully recovered within 1 month posttransplant.

The transfusion requirements during the procedure, the surgical time related to the transplant, the warm and cold ischemia times, the hospital stay, and the intensive care unit stay are shown in Table 3.

One patient presented with nonthrombotic stenosis in the superior vena cava 2 months after the transplant, which was unrelated to the anastomosis. Two patients maintained posttransplant ascites. One patient had complete resolution of ascites. The other one remained with portal hypertension. However, this patient had mild posttransplant ascites without the need for paracenteses. One of the hypotheses for this situation is that despite allowing perfusion of the liver graft, the portal flow reconstruction did not lead to an entire decompression of the mesenteric-portal territory so that patients can maintain ascites.

One patient presented segmental bile duct stricture, which was adequately treated by an endoscopic approach. Three patients developed acute kidney injury (AKI): 2 of them had nondialysis AKI and 1 of them had dialytic AKI. However, all 3 fully recovered the renal function in 6 months. One case resulted in death 8 months after transplantation due to hepatocellular carcinoma recurrence. Patient 9 migrated to another state and was transferred to another group for follow-up.

## DISCUSSION

PVT is present in approximately 2% to 26% of cases on the active list for a liver transplant.[9,10] Its presence has been implicated in poor prognosis, and it was a contraindication to liver transplant.[11] However, this perspective has changed with improved surgical techniques and an understanding of the heterogeneity of PVT clinical presentation[12].

There is still controversy concerning the relationship between PVT and post-LT survival, as reported in systematic reviews.[13,14] Complete PVT is usually associated with high postoperative mortality and morbidity.[3,15,16] Two cohort studies that mainly addressed patients with Child–Pugh B or C cirrhosis revealed a 1-year cumulative incidence of PVT of 16.4% and 17.9%.[17,18] Technical difficulties increase the surgery time and lead to severe bleeding; inadequate blood flow may result in graft dysfunction, loss, and rethrombosis.[19–21]

The currently accepted classification is based on the description by Yerdel et al[3] in 4 grades, depending on the extent of PVT (Fig. 1). PVT remains the main challenge in the surgical transplantation technique because of the risk of bleeding and hemodynamic instability. Therefore, surgical skills are essential in managing PVT, and preoperative planning is crucial to avoid complications.

The goal was to reestablish physiological flow to the graft. Several surgical strategies include sectioning the affected segment and primary anastomosis, thrombectomy, superior mesenteric vein grafts, portal arterialization, cavoportal hemitransposition, renoportal anastomosis, and the use of the LGV graft.[16,22,23] Some concerns exist regarding using other tributaries for revascularization (eg, the LGV). In addition, the fragility of these dilated vessels should be taken into account.[24,25] Finally, we present 9 grade III or IV PVT cases requiring reconstruction without a venous graft.

In our study, 5 with grade IV and 4 patients with grade III PVT (after unsuccessful thrombectomy) were successfully managed by direct portal vein–LGV anastomosis with or without simple or eversion thrombectomy (Fig. 2). None of our patients had intraoperative surgical complications, and the liver grafts were adequately perfused, which was evaluated by postoperatively Doppler US as an indirect assessment.

**TABLE 3.**

**Transfusion Needs and Length of Hospitalization**

| Patient | Surgical Time (min) | CIT (min) | WIT (min) | Blood Transfusion (units) | Cell Saver (mL) | Hospital Length (d) | ICU Length (d) |
|---|---|---|---|---|---|---|---|
| 1 | 337 | 363 | 48 | 4 FFP | - | 8 | 2 |
| 2 | 482 | 454 | 38 | 4 FFP<br>8 cryoprecipitate | 300 | 8 | 4 |
| 3 | 396 | 607 | 40 | 1 RBCC/3 RBCC<br>4 FFP/2 FFP<br>1 buffy coat<br>8 cryoprecipitate | 180 | 17 | 7 |
| 4 | 400 | 500 | 30 | 6 FFP<br>7 cryoprecipitate | 940 | 7 | 2 |
| 5 | 616 | 432 | 41 | 9 RBCC<br>12 FFP<br>20 cryoprecipitate | - | 13 | 4 |
| 6 | 363 | 355 | 29 | 1 RBCC<br>1 FFP<br>7 cryoprecipitate | 200 | 8 | 4 |
| 7 | 364 | 364 | 30 | 3 RBCC<br>2 FFP<br>10 cryoprecipitate | - | 8 | 2 |
| 8 | 405 | 303 | 31 | 2 FFP<br>2 buffy coat | 740 | 7 | 2 |
| 9 | 405 | 360 | 34 | 2 FFP<br>10 cryoprecipitate | 707 | 10 | 4 |

CIT indicates cold ischemia time; FFP, fresh frozen plasma; ICU, intensive care unit; RBCC, red blood cell concentrate; WIT, warm ischemia time.

In this study, 1 patient (patient 7) had a left renal vein ligation because of a splenorenal shunt not adequate for portal reperfusion. None of the patients had significant diameter intraoperative varicose veins that required ligation. For 2 patients (patients 2 and 4), anastomosis of the hepatic artery with the iliac conduit to the infrarenal aorta was performed because of the difficulty in safely dissecting the hepatic artery due to the intense presence of collateral circulation, making it risky to dissect the recipient's hepatic artery. All others had direct hepatic artery anastomosis.

It is worth noting that this study represents the largest case series in a single center of portal flow reconstruction using direct anastomosis with the LGV dispensing a vascular graft.

According to the medical literature, the anatomic requirement for vascular anastomosis is an optimization of anastomotic openings in size and preparation.[26] Anastomosis with as large a diameter as possible is required for portal vein reconstruction to obtain good portal flow.[27]

According to our reports, using LGV shows the feasibility of this unusual approach and even allows the dispensing of venous grafts. The 1-year overall survival of patients using LGV anastomosis was 88%, matching our center's mean 1-year overall survival (87.1%).[28] Although there is no comparative group, the mean interest of this series is to report our experience and our patients' outcomes using LGV as an anatomic feasible vascular alternative in patients with extensive PVT since the portal vein–variceal anastomosis is a challenging physiological nonanatomical technique of portal vein inflow reconstruction used and described rarely.[29]

During the 2-year follow-up (median time of 17 months), none of the patients reported portal vein–LGV vascular anastomosis complications. Surgical experience in managing PVT improved the postoperative outcome and played an essential role in avoiding excluding these patients, particularly in unfavorable conditions (high MELD scores or other severity criteria).

In conclusion, this is the largest series from a single center in the literature on LT using the LGV without vascular graft to restore portal flow in patients with PVT. Our results suggest that the LGV is a safe, simple, and effective alternative to be considered in the surgical planning of patients with severe PVT. However, we suggest a larger meta-analysis study on this procedure for acceptance on a larger scale as a plausible alternative for pretransplant surgical planning in this patient profile.

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