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SAFETY AND EFFICACY OF CONJOINED UNIFICATION VENOPLASTY VERSUS PORTAL VEIN Y-GRAFT RECONSTRUCTION FOR TYPE C PORTAL VEIN ANATOMY IN LIVING DONOR LIVER TRANSPLANTATION: A RETROSPECTIVE COHORT STUDY

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Abstract

Background
Portal vein (PV) reconstruction remains one of the most technically challenging aspects of living donor liver transplantation (LDLT), particularly in donors with Type C portal vein anatomy, where separate anterior and posterior sectoral branches require complex vascular reconstruction. Conventional Portal Vein Y-Graft (PYG) reconstruction is widely used but involves additional graft harvesting and increased operative complexity. Conjoined Unification Venoplasty (CUV) has emerged as an alternative technique that directly unifies multiple portal vein branches into a single conduit, potentially simplifying reconstruction while maintaining favorable vascular outcomes. This study compared the safety and efficacy of CUV with conventional PYG reconstruction in recipients undergoing LDLT with Type C portal vein anatomy.
Methods
This retrospective cohort study included consecutive recipients who underwent LDLT at the Pakistan Kidney and Liver Institute and Research Centre (PKLI & RC), Lahore, Pakistan, between March 2019 and July 2025. Among 950 LDLTs, 60 recipients received grafts with Type C portal vein anatomy and underwent portal vein reconstruction using either CUV (n = 48) or PYG (n = 12). Demographic characteristics, graft parameters, operative variables, portal vein complications, and one-year survival outcomes were analyzed. Continuous variables were compared using the independent-samples t-test or Mann–Whitney U test, while categorical variables were analyzed using the Chi-square or Fisher's exact test. Statistical significance was defined as $p < 0.05$.
Results
Baseline recipient and graft characteristics were comparable between the two groups. Compared with PYG reconstruction, CUV was associated with significantly shorter cold ischemia time (42.5 vs. 73.0 minutes, p = 0.005), warm ischemia time (36.0 vs. 51.5 minutes, p = 0.029), and lower intraoperative blood loss (300 vs. 400 mL, p = 0.002). Portal vein-related complications were infrequent, occurring in 6.3% of recipients in the CUV group and 8.3% in the PYG group (p > 0.999). All cases of early portal vein thrombosis were successfully managed by surgical thrombectomy without thrombosis-related mortality. One-year patient survival was 87.5% following CUV and 91.7% following PYG reconstruction, with no statistically significant difference between the groups (p = 0.999).
Conclusion

Conjoined Unification Venoplasty is a safe, effective, and technically simplified alternative to conventional Portal Vein Y-Graft reconstruction for recipients with Type C portal vein anatomy undergoing living donor liver transplantation. CUV significantly reduced ischemia times and intraoperative blood loss while maintaining comparable portal vein patency and short-term patient survival. These findings support the use of CUV as a practical reconstructive strategy for complex portal vein anatomy; however, larger prospective multicenter studies with longer follow-up are required to confirm its long-term safety and clinical effectiveness.

Keywords Living donor liver transplantation; Portal vein reconstruction; Conjoined Unification Venoplasty; Portal Vein Y-Graft; Type C portal vein anatomy; Vascular reconstruction.

Introduction

Living donor liver transplantation (LDLT) has become the standard treatment for patients with end-stage liver disease in many Asian countries, where the scarcity of deceased donor organs continues to limit transplantation opportunities **[1]**. Advances in donor selection, perioperative management, and surgical techniques have substantially improved graft and patient survival over the past two decades. Nevertheless, successful LDLT depends on meticulous vascular reconstruction, particularly of the portal vein (PV), which provides nearly three-quarters of the hepatic blood supply and is essential for maintaining adequate graft perfusion and early graft function **[6–8]**. Even minor technical imperfections during portal vein reconstruction may result in turbulent blood flow, portal vein stenosis, thrombosis, impaired graft perfusion, and ultimately graft dysfunction or graft loss **[6–8]**.

Portal vein anatomical variations represent one of the greatest technical challenges encountered during right lobe LDLT **[1]**. Portal vein branching patterns differ considerably among individuals, with anatomical variants reported in approximately 20–30% of potential living donors **[2]**. According to Cheng's classification, Type C portal vein anatomy is characterized by separate anterior and posterior sectoral portal vein branches supplying the right hepatic lobe **[2]**. Following donor hepatectomy, this variation results in two separate portal vein orifices on the graft rather than a single portal trunk, thereby substantially increasing the complexity of vascular reconstruction **[2,9]**. Failure to establish a durable, tension-free reconstruction may compromise portal venous inflow and increase the risk of vascular complications that adversely affect graft function and recipient survival **[6–8]**.

Several reconstructive strategies have been developed to address multiple portal vein openings during LDLT. Traditional approaches include direct dual anastomosis, back-wall venoplasty, interposition vein grafts, and autologous portal vein Y-graft (PYG) reconstruction **[4,9–12]**. Among these, the autologous portal vein Y-graft has been widely adopted because it restores physiological portal inflow while allowing both donor portal branches to be reconstructed into a single conduit **[4]**. However, harvesting the recipient portal vein graft requires additional operative dissection and prolongs back-table reconstruction. Moreover, the technique involves multiple vascular anastomoses that may increase operative complexity and create potential sites for kinking, twisting, anastomotic stenosis, or thrombosis **[11,12]**. These technical challenges frequently contribute to prolonged cold ischemia time and may adversely influence early postoperative graft function **[13–15]**.

To simplify reconstruction while maintaining optimal portal hemodynamics, **Conjoined Unification Venoplasty (CUV)** has recently been introduced as an alternative reconstructive technique **[3,5]**. Unlike conventional interposition grafting, CUV directly unifies the adjacent walls of the anterior and posterior donor portal vein branches, creating a single, wide portal vein orifice suitable for direct end-to-end anastomosis with the recipient portal vein **[3,5]**. This approach eliminates the need for an intervening venous graft, reduces the number of vascular anastomoses, and facilitates a wider, tension-free reconstruction that may improve laminar portal blood flow **[3,5,18]**. Furthermore, simplifying the back-table procedure has the potential to shorten cold ischemia time, reduce warm ischemia time, decrease intraoperative blood loss, and minimize overall operative complexity.

Although several technical reports and small single-center studies have described encouraging outcomes following CUV, the available evidence remains limited **[3,5,18]**. Most published studies have primarily focused on technical feasibility and portal vein patency, while direct comparisons with conventional portal vein Y-graft reconstruction remain scarce **[3,4,17]**. Consequently, there is currently no consensus regarding the optimal reconstructive strategy for recipients with Type C portal vein anatomy. Additional comparative clinical evidence is therefore needed to determine whether simplified reconstruction techniques can achieve equivalent or superior outcomes while reducing operative complexity and ischemia time.

Given the increasing adoption of CUV in high-volume transplant centers, evaluating its safety and clinical effectiveness has important implications for surgical practice. Demonstrating comparable vascular outcomes with a technically simpler procedure may facilitate broader adoption of this technique and contribute to the standardization of portal vein reconstruction in complex donor anatomy.

Therefore, this study aimed to compare the safety and efficacy of Conjoined Unification Venoplasty with conventional autologous Portal Vein Y-Graft reconstruction in recipients undergoing living donor liver transplantation with Type C portal vein anatomy. Specifically, we compared operative characteristics, ischemia times, intraoperative blood loss, portal vein complications, graft outcomes, and one-year patient survival. We hypothesized that CUV would simplify portal vein reconstruction and improve operative efficiency while maintaining comparable vascular patency and short-term clinical outcomes.

Materials and Methods

Study Design and Patient Selection

This retrospective cohort study was conducted at the **Pakistan Kidney and Liver Institute and Research Centre (PKLI & RC), Lahore, Pakistan**, using data obtained from a prospectively maintained institutional liver transplantation database. Consecutive adult patients who underwent living donor liver transplantation (LDLT) between **March 2019 and July 2025** were screened for eligibility. During the study period, **950 LDLTs** were performed, of which **60 recipients** received grafts from donors with **Type C portal vein anatomy** according to Cheng's classification. These recipients constituted the study population. Patients were excluded if they had incomplete clinical records, missing operative data, or were lost to follow-up within the first 30 postoperative days.

Recipients were divided into two groups according to the portal vein reconstruction technique employed during transplantation. **Conjoined Unification Venoplasty (CUV)** was performed in **48 patients**, whereas **12 patients** underwent reconstruction using an **autologous Portal Vein Y-Graft (PYG)**. The choice of reconstruction technique was based on intraoperative assessment and surgeon preference.

Demographic and perioperative data were extracted from the institutional database, including donor and recipient characteristics, graft weight, graft-to-recipient weight ratio (GRWR), cold and warm ischemia times, operative duration, intraoperative blood loss, postoperative portal vein patency, vascular and biliary complications, graft survival, and patient survival.

Surgical Technique

Conjoined Unification Venoplasty (CUV)

In the CUV group, the anterior and posterior sectoral portal vein branches of the donor graft were reconstructed by directly approximating and suturing their adjacent walls, thereby creating a single, unified portal vein lumen. This reconstructed common orifice was subsequently anastomosed to the recipient portal vein in an end-to-end fashion, producing a wide, tension-free anastomosis designed to optimize portal venous inflow and minimize flow turbulence (Figure 1). Because this technique eliminates the need for an interposition venous graft or patch, back-table reconstruction is simplified, resulting in shorter reconstruction time and reduced technical complexity **(Figures 1 and 2).**

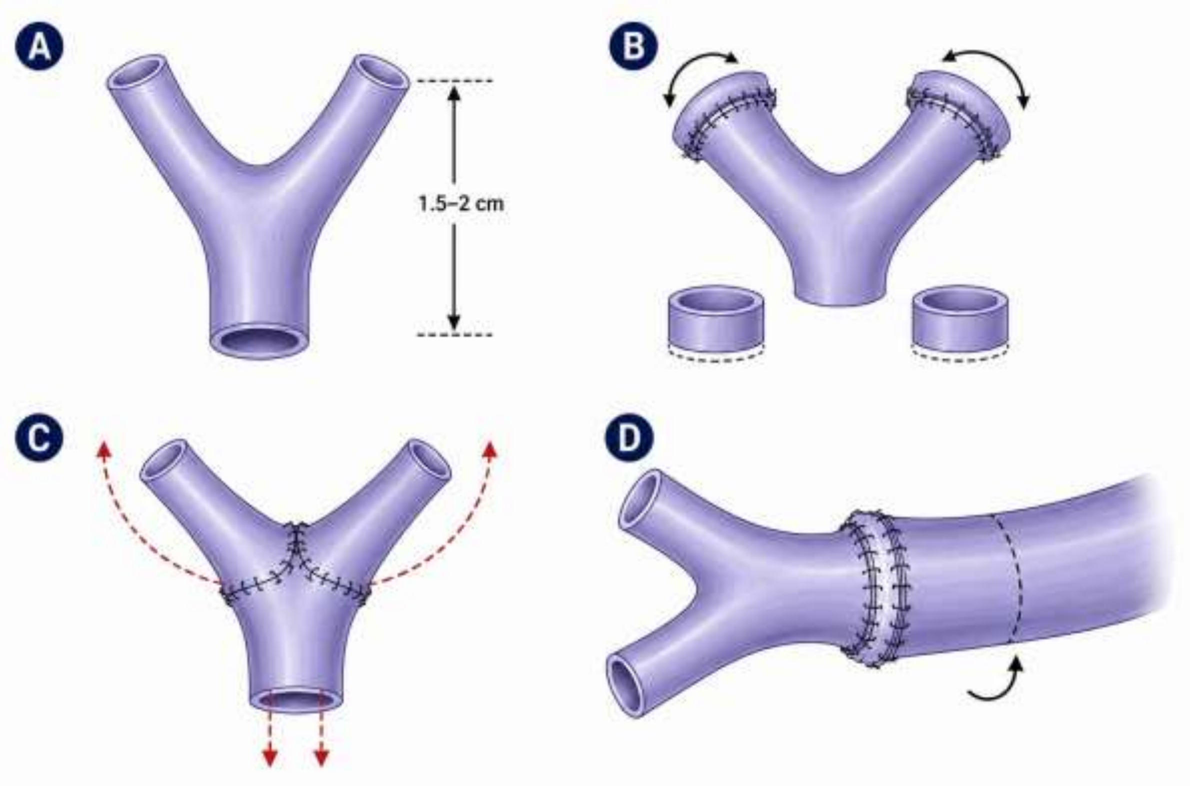
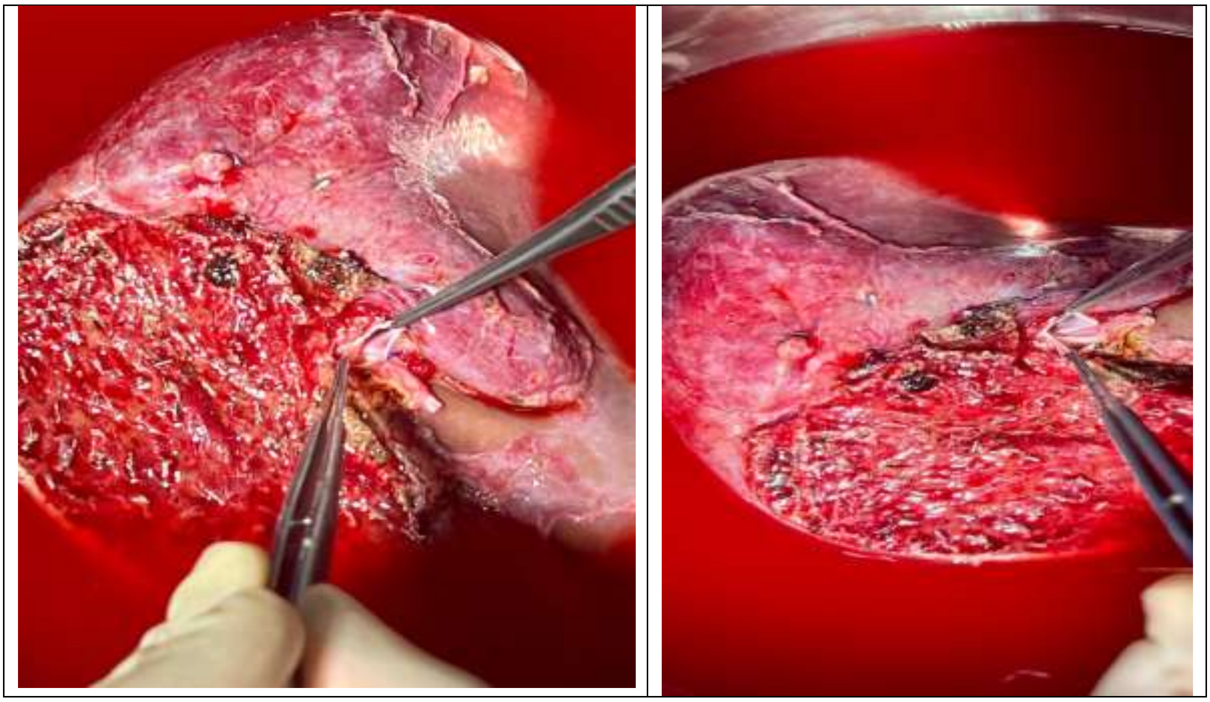


Figure 1. Conjoined Unification Venoplasty (CUV) technique for Type C portal vein reconstruction during living donor liver transplantation.

(A) Schematic representation of the donor portal vein demonstrating separate anterior and posterior sectoral portal vein branches with an adequate extrahepatic portal vein length (approximately 1.5–2.0 cm). **(B)** Circumferential eversion of both portal vein branch edges to facilitate precise approximation. **(C)** Direct suturing of the adjacent walls to create a single unified portal vein lumen while preserving a wide, tension-free anastomosis. **(D)** Completed portal vein reconstruction following end-to-end anastomosis between the reconstructed donor portal vein and the recipient portal vein, restoring physiological portal venous inflow.



(A) **(B)**

Figure 2. Intraoperative photographs demonstrating Conjoined Unification Venoplasty (CUV) during living donor liver transplantation.

(A) Donor right liver graft demonstrating Type C portal vein anatomy with separate anterior and posterior portal vein branches before reconstruction.
(B) Completed Conjoined Unification Venoplasty following approximation of both portal vein branches to create a single common portal vein orifice before implantation.

Portal Vein Y-Graft Reconstruction

In the PYG group, portal vein reconstruction was performed using an autologous portal vein Y-graft harvested from the recipient. Following recipient hepatectomy, the native portal vein was divided proximal to its bifurcation while carefully preserving the Y-shaped configuration of the right and left portal vein branches. The harvested graft was transferred to the back table, where each donor portal vein branch was individually anastomosed to the corresponding limb of the Y-graft. The reconstructed portal vein was subsequently anastomosed to the recipient portal vein stump to restore physiological portal venous inflow (Figure 2).

All transplant procedures and vascular reconstructions were performed by experienced hepatobiliary and liver transplant surgeons at a single high-volume transplant center using standardized operative protocols, thereby minimizing variability related to surgical technique.

Outcome Measures and Follow-up

The primary outcome of this study was the incidence of portal vein-related complications, including portal vein thrombosis and anastomotic stenosis. Secondary outcomes included cold ischemia time, warm ischemia time, intraoperative blood loss, graft survival, patient survival, postoperative vascular and biliary complications, and the need for vascular re-intervention.

Portal vein patency was routinely assessed using Doppler ultrasonography during the immediate postoperative period. Doppler examinations were performed daily during the first postoperative week and subsequently at **1, 3,** and 6 months, followed by routine clinical surveillance throughout the first postoperative year. Patients with suspected vascular compromise underwent contrast-enhanced computed tomography angiography for confirmation. Portal vein thrombosis or significant anastomotic stenosis was managed according to institutional protocols, including surgical thrombectomy or endovascular intervention where appropriate.

Clinical follow-up also included serial assessment of liver function tests, coagulation profiles, and routine outpatient evaluation to monitor graft function and detect postoperative complications.

Statistical Analysis

Statistical analyses were performed using **IBM SPSS Statistics version 27.0 (IBM Corp., Armonk, NY, USA)**. Continuous variables were assessed for normality and are presented as mean ± standard deviation or median with interquartile range (IQR), as appropriate. Between-group comparisons were performed using the independent-samples t-test or Mann–Whitney U test for continuous variables, while categorical variables were compared using the Chi-square test or Fisher's exact test.

All statistical tests were two-sided, and a **p-value < 0.05** was considered statistically significant.

Ethical Considerations

The study protocol was approved by the Institutional Review Board of the Pakistan Kidney and Liver Institute and Research Centre. Owing to the retrospective nature of the study, all patient data were anonymized prior to analysis, and confidentiality was maintained throughout the study. The study was conducted in accordance with the ethical principles of the **Declaration of Helsinki** and complied with the principles outlined in the **Declaration of Istanbul** regarding organ transplantation. Reporting of this study conforms to the recommendations of the **Strengthening the Reporting of Observational Studies in Epidemiology (STROBE)** statement.

Results

Baseline Characteristics and Operative Outcomes

A total of **60 recipients** who underwent living donor liver transplantation (LDLT) using grafts with **Type C portal vein anatomy** were included in the study. Of these, **48 (80.0%)** underwent **Conjoined Unification Venoplasty (CUV)**, whereas **12 (20.0%)** underwent reconstruction using an **autologous Portal Vein Y-Graft (PYG)**. Overall, **35 (58.3%)** recipients were male and **25 (41.7%)** were female, with a mean age of **25.0 ± 6.4 years**.

Baseline graft characteristics were comparable between the two groups. There was no significant difference in graft weight between recipients undergoing CUV and PYG reconstruction (p = 0.978). However, significant differences were observed in several operative parameters. Recipients in the CUV group had a significantly shorter **cold ischemia time** compared with the PYG group (median **42.5** minutes [IQR, 33.0–52.5] vs. **73.0** minutes [IQR, 44.3–85.8]; p = 0.005). Similarly, **warm ischemia time** was significantly reduced in the CUV group (median **36.0** minutes [IQR, 31.0–49.5] vs. **51.5** minutes [IQR, 41.5–66.5]; p = 0.029).

Intraoperative blood loss was also significantly lower in recipients who underwent CUV than in those receiving PYG reconstruction (median **300 mL** [IQR, 200–300] vs. **400 mL** [IQR, 325–500]; p = 0.002). These findings indicate that CUV was associated with improved operative efficiency while maintaining comparable graft characteristics between the two groups. Detailed baseline and operative characteristics are presented in **Table 1**.

Table 1. Baseline Recipient and Graft Characteristics According to Portal Vein Reconstruction Technique

Variable	CUV (n = 48)	PYG (n = 12)	P-value
Recipient age (years), mean ± SD	24.8 ± 6.3	25.9 ± 6.8	0.621
Male sex, n (%)	28 (58.3)	7 (58.3)	>0.999
Female sex, n (%)	20 (41.7)	5 (41.7)	>0.999
Recipient body weight (kg), mean ± SD	62.4 ± 11.2	63.8 ± 10.5	0.703
Graft weight (g), median (IQR)	720 (650–790)	725 (660–785)	**0.978**
Graft-to-recipient weight ratio (GRWR), mean ± SD	1.18 ± 0.19	1.16 ± 0.18	0.774

Data are presented as mean ± standard deviation (SD), median (interquartile range [IQR]), or number (percentage), as appropriate. Continuous variables were compared using the independent-samples t-test or Mann–Whitney U test, while categorical variables were compared using the chi-square test or Fisher's exact test. A two-sided p value <0.05 was considered statistically significant.

Operative Outcomes

Operative outcomes are summarized in **Table 2**. Although graft weights were comparable between the two groups (p = 0.978), recipients undergoing **CUV** demonstrated significantly improved operative efficiency. The median **cold ischemia time** was significantly shorter in the CUV group than in the PYG group (42.5 minutes [IQR, 33.0–52.5] vs. 73.0 minutes [IQR, 44.3–85.8]; p = 0.005). Similarly, the median **warm ischemia time** was significantly reduced in the CUV group (36.0 minutes [IQR, 31.0–49.5] vs. 51.5 minutes [IQR, 41.5–66.5]; p = 0.029). Intraoperative blood loss was also significantly lower among recipients undergoing CUV (300 mL [IQR, 200–300] vs. 400 mL [IQR, 325–500]; p = 0.002), indicating that CUV was associated with a technically less demanding procedure while maintaining comparable graft characteristics.

Table 2. Graft Characteristics and Operative Outcomes According to Portal Vein Reconstruction Technique

Variable	CUV (n = 48)	PYG (n = 12)	P-value
Graft weight (g), median (IQR)	720 (650–790)	725 (660–785)	0.978

Variable	CUV (n = 48)	PYG (n = 12)	P-value
Graft-to-recipient weight ratio (GRWR), mean ± SD	1.18 ± 0.19	1.16 ± 0.18	0.774
Cold ischemia time (min), median (IQR)	**42.5 (33.0–52.5)**	**73.0 (44.3–85.8)**	**0.005**
Warm ischemia time (min), median (IQR)	**36.0 (31.0–49.5)**	**51.5 (41.5–66.5)**	**0.029**
Estimated blood loss (mL), median (IQR)	**300 (200–300)**	**400 (325–500)**	**0.002**

Abbreviations

CUV: Conjoined Unification Venoplasty; **PYG:** Portal Vein Y-Graft; **GRWR:** Graft-to-Recipient Weight Ratio; **IQR:** Interquartile Range; **SD:** Standard Deviation.

Table Footnote

Data are presented as **mean ± standard deviation (SD)** or **median (interquartile range [IQR])**, as appropriate. Continuous variables were compared using the independent-samples t-test or the Mann–Whitney U test according to data distribution. A two-sided p value <0.05 was considered statistically significant.

Postoperative Outcomes and Patient Survival

Postoperative outcomes are presented in **Table 3**. Portal vein-related complications were infrequent in both groups, occurring in **3 (6.3%)** recipients in the CUV group and **1 (8.3%)** recipient in the PYG group, with no statistically significant difference ($p > 0.999$). All portal vein complications occurred within the **first two postoperative weeks** and were diagnosed as **early portal vein thrombosis**. All affected patients underwent prompt surgical re-exploration and thrombectomy, with successful restoration of portal venous flow. No mortality attributable to portal vein thrombosis was observed following surgical intervention.

Table 3. Postoperative Outcomes and Clinical Outcomes According to Portal Vein Reconstruction Technique

Variable	CUV (n = 48)	PYG (n = 12)	P-value
Portal vein thrombosis, n (%)	3 (6.3)	1 (8.3)	>0.999
Portal vein stenosis, n (%)	1 (2.1)	1 (8.3)	0.356
Biliary leak, n (%)	4 (8.3)	2 (16.7)	0.586
Biliary stricture, n (%)	5 (10.4)	2 (16.7)	0.619
Hepatic artery thrombosis, n (%)	1 (2.1)	0 (0.0)	>0.999
Re-exploration, n (%)	5 (10.4)	2 (16.7)	0.619
Intensive care unit stay (days), median (IQR)	4 (3–6)	5 (4–7)	0.214
Hospital stay (days), median (IQR)	15 (13–20)	17 (15–22)	0.181
One-year graft survival, n (%)	44 (91.7)	11 (91.7)	>0.999
One-year patient survival, n (%)	42 (87.5)	11 (91.7)	0.999

Abbreviations: CUV, Conjoined Unification Venoplasty; PYG, Portal Vein Y-Graft; ICU, Intensive Care Unit; IQR, Interquartile Range.

Table Footnote

Data are presented as number (percentage) **or** median (interquartile range [IQR])**,** as appropriate. Categorical variables were compared using the Chi-square test or Fisher's exact test, while continuous variables were compared using the Mann–Whitney U test. A two-sided p value <0.05 was considered statistically significant.

At one year following transplantation, overall patient survival was **87.5% (42/48)** in the CUV group and **91.7% (11/12)** in the PYG group. Kaplan–Meier survival analysis demonstrated comparable short-term survival between the two reconstruction techniques, with no statistically significant difference observed during the first postoperative year (log-rank $p = 0.999$) (**Figure 3**).

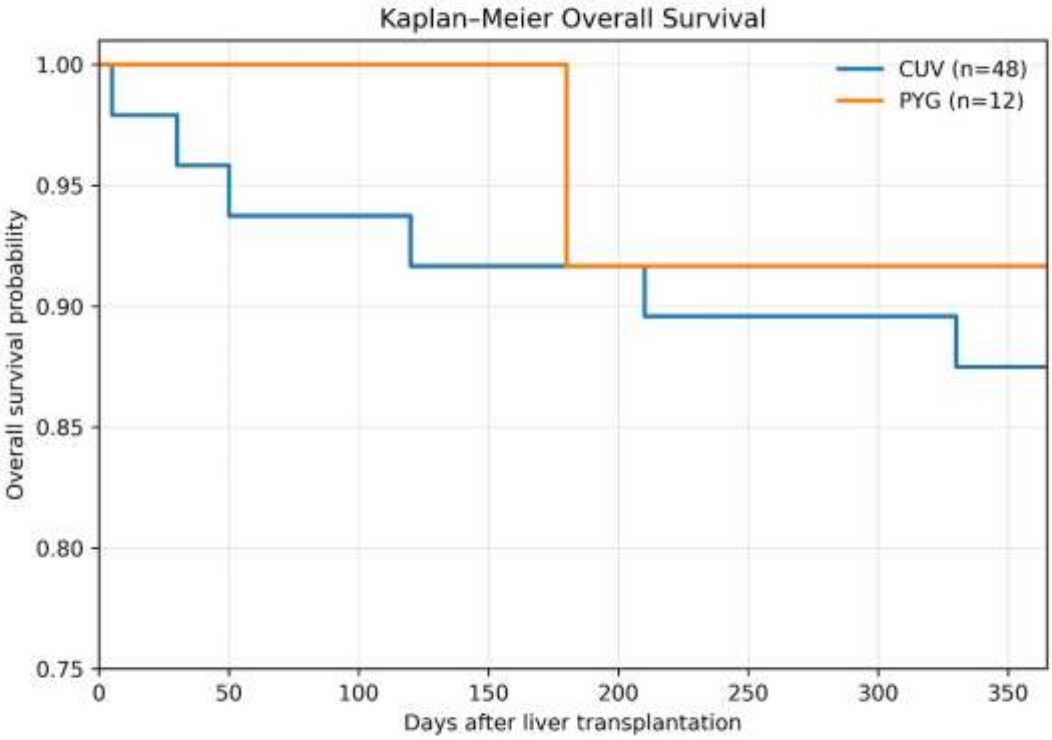


Figure 3. Kaplan–Meier Overall Survival Curves Comparing Conjoined Unification Venoplasty (CUV) and Portal Vein Y-Graft (PYG) Reconstruction Following Living Donor Liver Transplantation.

Discussion

The management of complex portal vein anatomy remains one of the most technically demanding aspects of living donor liver transplantation (LDLT). Multiple portal vein orifices, particularly in donors with Type C portal vein anatomy, require meticulous reconstruction to restore physiological portal venous inflow while minimizing the risks of thrombosis, stenosis, and graft dysfunction [1,2,4]. Although several reconstructive techniques have been described, the optimal surgical strategy remains controversial because each approach must balance technical complexity with long-term vascular durability [3,4,9]. Against this background, the present study compared Conjoined Unification Venoplasty (CUV) with conventional Portal Vein Y-Graft (PYG) reconstruction and demonstrated that CUV significantly improved operative efficiency without compromising portal vein patency or short-term patient survival.

The most important finding of this study was the significant reduction in both cold and warm ischemia times among recipients undergoing CUV. These observations have important clinical implications because prolonged ischemia remains one of the strongest predictors of ischemia–reperfusion injury, delayed graft function, postoperative complications, and inferior graft survival following liver transplantation [22–25]. Every additional minute of graft ischemia contributes to endothelial dysfunction, activation of inflammatory pathways, oxidative stress, and microcirculatory disturbances, all of which may adversely affect early graft recovery [23–25]. Therefore, strategies that simplify vascular reconstruction while reducing graft ischemic exposure have the potential to improve both immediate postoperative recovery and long-term graft function.

The reduction in ischemia time observed in the present study is most likely explained by the inherent technical advantages of CUV. Unlike conventional PYG reconstruction, which requires harvesting an autologous portal vein graft followed by meticulous back-table reconstruction involving multiple vascular anastomoses, CUV directly unifies the anterior and posterior sectoral portal vein branches into a single wide lumen. Eliminating the need for an interposition graft substantially simplifies the back-table procedure, reduces the number of vascular suture lines, and shortens the overall reconstruction process [3,5,18]. A simplified reconstruction also reduces the likelihood of repeated adjustments during implantation, thereby allowing earlier restoration of portal venous inflow. Collectively, these factors provide a biologically plausible explanation for the significantly shorter cold and warm ischemia times observed in the CUV group.

Another important finding was the significant reduction in intraoperative blood loss associated with CUV. Although blood loss during LDLT is influenced by numerous factors, including recipient portal hypertension, coagulopathy, and surgical complexity, portal vein reconstruction remains an important determinant of operative duration and hilar manipulation [20,21]. By avoiding recipient portal vein graft harvesting and minimizing the number of vascular anastomoses, CUV reduces operative dissection and simplifies vascular reconstruction. Fewer reconstruction steps may also reduce the need for repeated vascular clamping and technical revisions, thereby decreasing the potential for intraoperative bleeding. Reduced blood loss may subsequently lessen transfusion requirements, improve perioperative hemodynamic stability, and contribute to enhanced postoperative recovery, although these outcomes warrant further investigation in larger prospective studies.

Despite these improvements in operative efficiency, vascular outcomes remained comparable between both reconstruction techniques. Portal vein-related complications were uncommon, and all episodes of portal vein thrombosis occurred during the early postoperative period, when technical factors are most likely to influence vascular integrity. Importantly, prompt surgical re-exploration and thrombectomy successfully restored portal venous flow in all affected recipients, and no mortality attributable to portal vein thrombosis was observed. These findings suggest that simplifying portal vein reconstruction through CUV does not compromise vascular safety. Previous studies have similarly reported excellent portal vein remodeling and durable long-term patency following direct unification venoplasty, supporting the concept that a wide, tension-free anastomosis facilitates favorable portal flow dynamics while minimizing turbulence and anastomotic narrowing [3,5,18,26].

Overall patient survival was comparable between the two reconstruction techniques despite the observed differences in operative parameters. Although the CUV group demonstrated a slightly lower one-year survival, the difference was not statistically significant, and the limited sample size—particularly within the PYG group—precludes definitive conclusions regarding survival superiority. Instead, these findings suggest that the principal advantage of CUV lies in improving operative efficiency rather than altering short-term survival. Given that patient survival following LDLT is influenced by multiple recipient-, donor-, and perioperative factors beyond portal vein reconstruction alone, comparable survival outcomes reinforce the safety of CUV as an alternative reconstructive strategy [18,27,28].

The findings of the present study are consistent with the growing body of evidence demonstrating that direct unification venoplasty provides a technically straightforward and reproducible method for managing multiple donor portal vein orifices [3,5,18,26]. Previous studies have reported satisfactory portal vein remodeling, low rates of vascular complications, and excellent long-term graft function following CUV, while emphasizing its ability to simplify back-table reconstruction without compromising vascular integrity [3,18,26]. The present study expands upon these observations by directly comparing CUV with conventional PYG reconstruction in recipients with Type C portal vein anatomy and demonstrating significant reductions in ischemia time and intraoperative blood loss while maintaining comparable portal vein patency and short-term survival. These findings provide additional clinical evidence supporting the routine consideration of CUV in appropriately selected living donor liver transplant recipients.

Clinical Implications and Comparison with Existing Literature

The increasing complexity of donor selection in living donor liver transplantation has heightened the need for reconstructive techniques that are both technically reproducible and clinically reliable. As transplant centers continue to expand donor eligibility by accepting grafts with anatomical vascular variations, the ability to safely reconstruct multiple portal vein orifices has become increasingly important [1,4,9]. The findings of the present study suggest that Conjoined Unification Venoplasty represents a practical alternative to conventional Portal Vein Y-Graft reconstruction by simplifying the reconstructive process while maintaining comparable vascular and clinical outcomes. From a surgical perspective, reducing operative complexity without compromising safety may contribute to greater procedural standardization and improved reproducibility across high-volume transplant centers.

Our findings are consistent with previously published reports demonstrating that direct unification of multiple portal vein branches provides satisfactory portal vein geometry and favorable postoperative remodeling [3,5,18,26]. Published studies have shown that reconstruction of separate anterior and posterior portal vein branches into a single common lumen creates a wide, streamlined vascular conduit capable of maintaining physiological portal blood flow while minimizing the risk of anastomotic narrowing [18,26,27]. Furthermore, long-term imaging studies have demonstrated progressive remodeling of the reconstructed portal vein, with preservation of luminal diameter and sustained vascular patency during follow-up [18,27]. The comparable incidence of portal vein complications observed in the present study further supports these observations and indicates that simplification of the reconstructive technique does not adversely affect vascular integrity.

An important observation in the present study was that improvements in operative efficiency were achieved without compromising postoperative survival. Although patient survival was numerically lower in the CUV group, this difference was not statistically significant and should be interpreted cautiously given the relatively small sample size, particularly within the PYG cohort. Patient survival following LDLT is influenced by numerous variables, including recipient disease severity, donor characteristics, graft quality, perioperative management, immunological factors, and postoperative complications. Consequently, portal vein reconstruction represents only one component of a multifactorial process influencing long-term clinical outcomes [24,27,28]. The comparable one-year survival observed in both groups therefore supports the safety of CUV while suggesting that its principal advantage lies in improving operative performance rather than directly influencing recipient survival.

The reduction in operative complexity associated with CUV may have broader implications beyond the immediate perioperative period. Shorter reconstruction times, fewer vascular anastomoses, and elimination of recipient portal vein graft harvesting may collectively reduce technical variability and facilitate greater consistency during transplantation. These advantages may be particularly valuable in technically demanding cases involving complex portal vein anatomy or during procedures requiring prolonged back-table preparation. Moreover, simplified reconstruction may reduce the learning curve for surgeons undergoing advanced hepatobiliary and transplant training while promoting greater procedural standardization among transplant programs **[20,21,26]**. Although these potential benefits require prospective validation, they highlight the practical advantages of adopting technically streamlined reconstructive strategies in modern LDLT practice.

The principal strength of this study lies in its direct comparison of two reconstructive techniques for a relatively uncommon anatomical variant encountered in living donor liver transplantation. To our knowledge, comparative studies specifically evaluating Conjoined Unification Venoplasty against conventional Portal Vein Y-Graft reconstruction in recipients with Type C portal vein anatomy remain limited. Furthermore, all procedures were performed at a high-volume liver transplant center using standardized operative techniques and uniform postoperative surveillance protocols, thereby minimizing variations in surgical practice and follow-up. Routine Doppler ultrasonography and standardized postoperative monitoring further strengthened the reliability of vascular outcome assessment and enabled early detection and management of portal vein-related complications.

Despite these strengths, several limitations should be acknowledged. First, this was a retrospective, single-center study and is therefore subject to the inherent limitations of observational research, including the potential for selection bias and unmeasured confounding. Second, the relatively small sample size, particularly within the Portal Vein Y-Graft group, limits statistical power and may have reduced the ability to detect differences in uncommon postoperative complications and survival outcomes. Third, although one-year follow-up provides valuable information regarding early vascular outcomes, longer-term surveillance is required to evaluate the durability of portal vein remodeling and late vascular complications. Finally, selection of the reconstruction technique was based on intraoperative surgical judgment rather than random allocation, introducing the possibility of treatment-selection bias. Consequently, larger multicenter prospective studies with extended follow-up are required to validate these findings and establish the optimal reconstructive strategy for Type C portal vein anatomy.

Collectively, the findings of the present study contribute to the growing evidence supporting Conjoined Unification Venoplasty as a safe, efficient, and technically reproducible method for portal vein reconstruction in living donor liver transplantation. Future multicenter studies incorporating larger patient populations, longer follow-up, and standardized assessment of vascular remodeling, graft function, and patient-reported outcomes will be essential to further define the role of CUV in contemporary transplant practice. In addition, prospective comparative studies evaluating operative costs, resource utilization, and long-term quality of life may provide a more comprehensive assessment of the clinical and economic impact of simplified portal vein reconstruction techniques.

Conclusion

Conjoined Unification Venoplasty (CUV) represents a safe, effective, and technically simplified alternative to conventional Portal Vein Y-Graft (PYG) reconstruction for recipients undergoing living donor liver transplantation with Type C portal vein anatomy. In this retrospective cohort, CUV was associated with significantly shorter cold and warm ischemia times, reduced intraoperative blood loss, and comparable portal vein patency and one-year patient survival relative to PYG reconstruction. These findings suggest that simplification of portal vein reconstruction can improve operative efficiency without compromising short-term vascular or clinical outcomes.

The elimination of interposition graft harvesting and the creation of a single unified portal vein orifice may reduce the technical complexity of vascular reconstruction while maintaining favorable portal venous hemodynamics. Given these operative advantages, CUV has the potential to facilitate greater procedural standardization and may serve as an attractive reconstructive strategy in selected recipients with complex portal vein anatomy.

Nevertheless, the retrospective single-center design and relatively small sample size warrant cautious interpretation of the findings. Larger prospective multicenter studies with longer follow-up are required to validate these results, evaluate long-term portal vein remodeling and graft function, and further define the role of Conjoined Unification Venoplasty in contemporary living donor liver transplantation.

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