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Modified allogeneic great saphenous vein cold-stored in custodiol for neo-MHV reconstruction in right-lobe living-donor liver transplantation: Early patency in a single-center retrospective cohort

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ABSTRACT

In right-lobe living-donor liver transplantation (LDLT), adequate venous outflow of the anterior sector (V5/V8 tributaries) is critical to prevent congestion and early graft dysfunction. The choice of conduit for V5/V8 outflow reconstruction with creation of a neo-middle hepatic vein (MHV) remains a practical limitation, especially in the setting of a shortage of deceased-donor vascular allografts. The aim of this study was to describe the technical feasibility and early patency of a modified allogeneic great saphenous vein (GSV) cold-stored in custodiol and to explore its outcomes relative to recipient portal vein and prosthetic conduit cohorts. We conducted a retrospective single-center comparative cohort study covering the period from 2014 to 2025. Adult recipients aged 18-60 years who underwent right-lobe LDLT with V5 and/or V8 outflow reconstruction using a neo-MHV conduit were included: recipient PV (n = 63), prosthesis (n = 11), modified GSV (n = 16). The primary endpoint was obstruction of the re-constructed V5/V8 outflow through the neo-MHV conduit within 45 days, classified as early (≤ 7 days) or late (> 7 days). Patency was assessed by serial Doppler ultrasound and/or contrast-enhanced imaging. Time-to-event analysis was performed using the Kaplan-Meier method. Overall outflow obstruction within 45 days was observed in 25.4% of the recipient PV group, 45.5% of the prosthesis group, and 6.2% of the modified GSV group (p = 0.063). In an exploratory Firth logistic regression adjusted for calendar year and selected baseline and graft characteristics, the overall association between conduit type and 45-day outflow obstruction was not statistically significant (p = 0.318). The probability of obstruction-free patency on day 7 was 0.804, 0.727, and 0.938, respectively; by day 45, it was 0.733, 0.468, and 0.938, respectively. Observed group-level differences included shorter cold ischemia time (38 [35; 42] min; p = 0.001), a shorter anhepatic period (42 [26; 61] min; p < 0.001), and lower blood loss (1,200 [775; 1,500] mL; p = 0.006) in the modified GSV group. Postoperative hospital stay was also shorter (18 [15; 21] days; p = 0.011), and peak AST, ALT, and INR values were lower (p = 0.039, p = 0.021, and p = 0.027, respectively). The rate of any postoperative complications did not differ significantly (p = 0.439). In-hospital mortality was 19.0% in the recipient PV group, 36.4% in the prosthesis group, and 0% in the modified GSV group (p = 0.053). In this retrospective and temporally heterogeneous cohort, modified allogeneic GSV was technically feasible and demonstrated encouraging early neo-MHV conduit patency. Because conduit allocation was non-random, the groups were small and noncontemporaneous, and important baseline and procedural differences were present, the observed associations cannot be attributed to conduit materi-al and do not establish superiority. Further prospective evaluation is warranted.

Keywords: liver transplantation, reconstruction, hepatic vein, great saphenous vein, allogeneic venous graft, early venous outflow obstruction

INTRODUCTION

Living-donor liver transplantation (LDLT) remains a key option in the setting of deceased-donor shortage and high demand for transplantation [1, 2]. In adult right-lobe LDLT, adequate venous outflow from segments V and VIII is essential because interruption of major middle hepatic vein (MHV) tributaries may cause anterior-sector congestion, impair graft regeneration, and contribute to early graft dysfunction despite an acceptable graft-to-recipient weight ratio [3-6]. Therefore, V5/V8 outflow reconstruction through creation of a neo-MHV is an important technical component of right-lobe LDLT.

Against this clinical background, the key technical issue is the choice of conduit for V5/V8 outflow reconstruction with creation of a neo-MHV. Options include the use of recipient vascular segments (including the portal vein), autologous venous grafts, cryopreserved vascular allografts, and synthetic prostheses (e.g., ePTFE) [7].

Each approach has obvious strengths and trade-offs. Biological materials may be preferable in terms of infectious complication profile, but they are often limited by availability and may require additional time at the implantation stage [8].

Synthetic conduits are technically convenient and amenable to standardization, but they are associated with specific risks in a potentially contaminated field and require particularly careful patient selection and monitoring [9].

Donor-organ shortage has long been recognized as a constraint on the development of liver transplantation services in Kazakhstan [10]. In our institutional setting, limited access to deceased-donor vascular allografts created a practical need for a reproducible biological conduit that does not depend on cadaveric vascular donation.

One such solution may be an allogeneic great saphenous vein (GSV) obtained during elective vascular surgery, cold-stored custodiol solution, and modified for use as a larger-caliber neo-MHV conduit. The approach is technically attractive, however, early conduit patency is essential for successful V5/V8 outflow reconstruction [11], and the clinical performance of this specific modified allogeneic conduit remains insufficiently characterized.

The aim of this study was to describe the technical feasibility and early patency of a modified allogeneic GSV cold-stored in custodiol and to explore its outcomes relative to recipient portal vein and prosthetic conduit cohorts. We hypothesized that modified allogeneic GSV would be technically feasible and would provide acceptable early neo-MHV conduit patency as a biological option for V5/V8 outflow reconstruction.

MATERIALS AND METHODS

Study Design and Setting

A single-center comparative cohort study with retrospective analysis of registry data was performed. The database was formed based on materials from the department of hepatopancreatobiliary surgery and liver transplantation of the A. N. Syzganov National Scientific Center of Surgery (Almaty, Kazakhstan). The observation period and surgeries performed covered 2014-2025.

Data Source and Formation of the Analytical Cohort

The study database was derived from the institutional liver transplantation registry of the department of hepatopancreatobiliary surgery and liver transplantation, A. N. Syzganov National Scientific Center of Surgery. The registry includes consecutive liver transplantation procedures performed at the center and contains demographic data, indication for transplantation, preoperative laboratory values, liver disease severity indices, graft characteristics, intraoperative technical variables, venous reconstruction details, postoperative imaging follow-up, vascular complications, and in-hospital outcomes. For the present study, registry data were cross-checked against operative records, anesthesia charts, laboratory records, and postoperative imaging reports to confirm completeness of key variables. Only cases with sufficient information on venous reconstruction type and early postoperative patency assessment were eligible for the final analysis.

For the present analysis, we screened all liver transplantation procedures performed between January 2014 and December 2025. The source cohort included 103 consecutive cases in which V5 and/or V8 outflow reconstruction with creation of a neo-MHV had been performed. After exclusion of deceased-donor liver transplantation (n = 8) and recipients outside the predefined adult age range of 18-60 years (n = 5), 90 right-lobe LDLT cases remained for the final analysis.

Conduit selection was based on real-world surgical decision-making and depended on venous anatomy, conduit availability, surgeon preference, and calendar period. In particular, the modified GSV technique was adopted predominantly in the later years of the study period, whereas prosthetic reconstruction was used more often in earlier years.

Inclusion criteria:

- recipient age 18-60 years,
- right-lobe LDLT,
- V5 and/or V8 outflow reconstruction with creation of a neo-MHV, and
- availability of sufficient data to assess neo-MHV conduit patency, outflow obstruction, and early clinical outcomes.

Exposure was defined by the conduit material used for V5/V8 outflow reconstruction with creation of a neo-MHV (**Figure 1**):

1. Recipient PV – use of the recipient's venous material (portal vein as a conduit), n = 63,
2. Prosthesis – use of a synthetic vascular prosthesis, n = 11, and
3. Modified GSV – use of an allogeneic modified GSV, cold-stored in custodiol, n = 16.

The choice of material was based on clinical indications, anatomical conditions, availability, and time period.

Preparation of the Allogeneic Modified GSV

Allogeneic venous segments were obtained from patients undergoing elective surgical treatment of lower-limb varicose vein disease. Venous segments were considered suitable for use if they were macroscopically intact, free of visible inflammation or thrombosis, and of sufficient length and wall quality to allow modification and use as a neo-MHV conduit. Segments with gross degenerative change, inadequate caliber, or technical unsuitability for reconstruction were not used.

Use of the material was carried out in accordance with the institution's current procedures for documentation, patient information, and biological safety. Preservation was performed in custodiol (HTK) solution at +3 … +5 °C for up to 21 days.

To construct a wider conduit suitable for a common V5/V8 outflow channel, the GSV was divided into two equal-length segments. Each segment was opened longitudinally to create a venous panel. The two panels were aligned and sutured edge-to-edge along both longitudinal margins, forming a larger-caliber tubular conduit. This modification was intended to

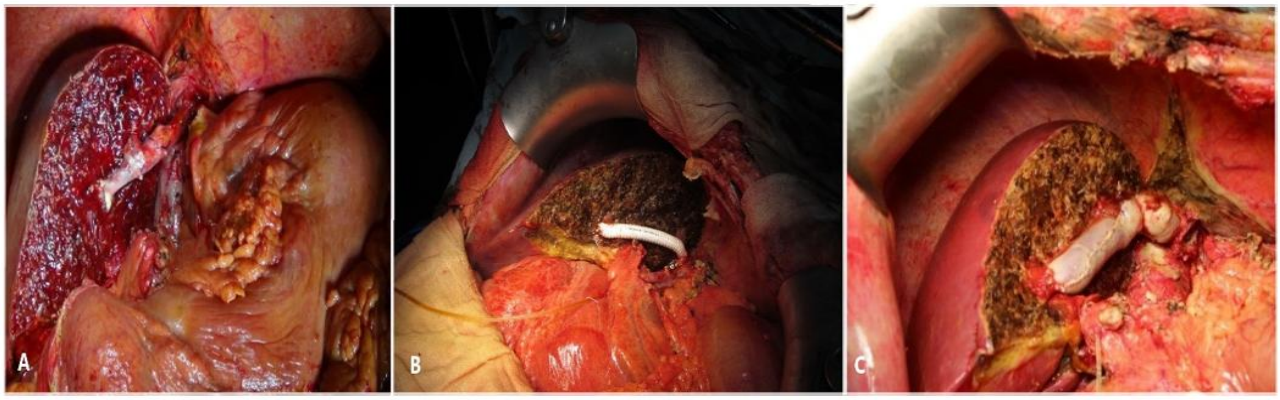

Figure 1. Representative intraoperative views of V5/V8 outflow reconstruction using different neo-MHV conduit materials: (A) a recipient portal vein conduit; (B) a ring-reinforced expanded polytetrafluoroethylene (ePTFE) vascular graft; and (C) an allogeneic modified great saphenous vein (each panel shows the final conduit configuration used to reconstruct the outflow of the V5 and/or V8 tributaries) (the authors' own photographs)

increase the effective conduit circumference, provide a more uniform lumen, and improve size matching with the V5/V8 tributaries and the recipient venous outflow.

Preoperative Planning and Surgical Technique

All donors underwent contrast-enhanced abdominal CT with liver volumetry. For preoperative planning of reconstruction, three-dimensional reconstructions of venous anatomy were used when available to assess V5/V8 drainage into the MHV system. Standard donor selection criteria included an expected future liver remnant > 30% and GRWR > 0.7.

Rationale for Conduit Selection and Procedural Standardization

The indication for reconstruction of V5 and/or V8 tributaries followed the center's standard surgical principles for right-lobe LDLT and was based on preoperative imaging and intraoperative assessment of venous drainage. For the purposes of this study, "clinically significant flow" was defined as drainage through a tributary with a diameter > 5 mm on preoperative imaging and/or marked back-bleeding during graft perfusion, indicating a relevant risk of anterior sector congestion if left unreconstructed. Cases meeting these criteria underwent V5/V8 outflow reconstruction with creation of a neo-MHV.

The technical steps of V5/V8 outflow reconstruction were standardized with respect to the indication for reconstruction, back table construction of the neo-MHV conduit, and intraoperative duplex ultrasound verification of venous patency before completion of the operation. However, the final choice of conduit material was individualized according to anatomical suitability, conduit availability, and operative context.

Recipient portal vein was used when autologous venous material of adequate length and caliber was available and could be harvested without compromising the recipient procedure. A ring-reinforced expanded polytetrafluoroethylene (ePTFE) vascular graft (GORE-TEX® Vascular Graft, W. L. Gore & Associates, Inc., Flagstaff, AZ, USA) was used when immediate reconstruction was required and no suitable biological conduit was available. Modified allogeneic GSV was preferred when a biological conduit of sufficient caliber was available, particularly in the setting of limited access to deceased-donor vascular allografts and when avoidance of synthetic material was considered desirable.

Reconstruction of Venous Outflow in the Recipient

V5 and/or V8 tributaries meeting the predefined reconstruction criteria were included. The neo-MHV conduit, which served as the common outflow channel, was constructed on the back table. The basic configuration consisted of an end-to-end anastomosis between V5 and the conduit, when V5 was present as the main anterior-sectoral tributary, followed by an end-to-side anastomosis of V8 to the conduit. Alternative configurations were used when required by individual venous anatomy. Additional tributaries meeting the predefined reconstruction criteria were anastomosed to the lateral surface of the conduit. The distal end of the neo-MHV conduit was anastomosed to the recipient venous system according to the center's standard technique. Inferior hepatic veins providing significant venous drainage were anastomosed separately to the inferior vena cava. Intraoperative venous outflow was verified in all cases using duplex ultrasound before completion of the operation.

Postoperative Follow-Up and Diagnosis of Vascular Events

Patency of the reconstructed V5/V8 outflow and vascular complications were assessed using serial Doppler ultrasound and, when clinically indicated, contrast-enhanced CT. Intraoperative and postoperative ultrasonographic verification was based on the presence of a continuous color Doppler signal and detectable venous spectral flow across the neo-MHV conduit without abrupt interruption. Obstruction was suspected in the presence of absent or markedly reduced flow signal, focal narrowing at the anastomotic site with disturbed flow pattern, newly detected intraluminal echogenic material compatible with thrombosis, or indirect signs of impaired venous drainage of the anterior sector. When ultrasound findings were equivocal or clinically discordant, contrast-enhanced imaging was used for confirmation.

Postoperative antithrombotic management was guided by coagulation status and the presence of active bleeding in accordance with the national perioperative liver transplantation protocol. Routine heparin prophylaxis was not administered in patients with hypocoagulation. In patients with normocoagulation or hypercoagulation and no evidence of bleeding during the first 8 postoperative hours, intravenous

unfractionated heparin was initiated at 5,000 IU/day and adjusted according to coagulation parameters, followed by low-molecular-weight heparin. Acetylsalicylic acid was subsequently administered in the absence of active bleeding, clinically relevant coagulopathy, or severe thrombocytopenia. Platelet count, conventional coagulation parameters, and thromboelastography were monitored. Antithrombotic management did not differ according to the type of neo-MHV conduit.

Results were recorded in the registry form. Management of vascular complications (anticoagulation, interventional procedures, reoperation) was extracted from registry fields and classified into broader categories when data were available.

Variables and Endpoints

Baseline characteristics included age, sex, height, body weight, BMI, as well as liver disease severity indices (MELD, child-Pugh, and ALBI score), etiology (aggregated categories), presence of hepatocellular carcinoma (HCC), portal vein thrombosis before transplantation, preoperative laboratory parameters (total bilirubin, INR, creatinine, sodium, albumin, platelets, hemoglobin, leukocytes), and comorbidities. The ALBI score was calculated from baseline serum albumin and total bilirubin using the conventional formula: ALBI = (log10 bilirubin [µmol/L] × 0.66) + (albumin [g/L] × -0.085).

V5/V8 Outflow Reconstruction Pattern

By type of venous drainage, cases were categorized as isolated V5, isolated V8, or combined V5+V8.

Primary Endpoint

The primary endpoint was obstruction of the reconstructed V5/V8 outflow through the neo-MHV conduit within 45 days. Outflow obstruction was classified as early (≤ 7 days), late (> 7 days), or overall (any event within 45 days).

Secondary Outcomes

Secondary outcomes included any postoperative complications, biliary complications, length of postoperative hospital stay, in-hospital mortality, and biochemical markers of early graft injury and liver function. Preoperative (baseline) liver-related laboratory variables were analyzed separately from postoperative variables. Baseline variables included total bilirubin, INR, albumin, and ALBI score. Postoperative biochemical follow-up included peak AST, ALT, INR, total bilirubin, and lactate during the index hospitalization, as well as bilirubin and INR values on postoperative day 7 when available. Small-for-size syndrome (SFSS) was analyzed as a potential clinical outcome with mandatory assessment of completeness of registration.

Pretransplant Clinical Assessment

In addition to standard baseline variables, the pretransplant clinical profile was further characterized by performance status, comorbidities, concomitant medications, and relevant treatment history. Performance status was assessed preoperatively using the Eastern Cooperative Oncology Group (ECOG) scale. Recorded comorbidities included diabetes mellitus, ischemic heart disease and/or chronic heart failure, arterial hypertension, chronic kidney disease, and previous abdominal surgery. Concomitant medications documented before LT included non-selective beta-blockers, diuretics, antiplatelet and/or anticoagulant therapy, antiviral therapy for HBV/HCV, and antidiabetic treatment. Relevant treatment history included prior transarterial chemoembolization, radiofrequency ablation, or other HCC-directed treatment, previous portal venous intervention, pre-LT intensive care unit stay, and dialysis or renal replacement therapy before transplantation.

Statistical Analysis

Descriptive and unadjusted analyses were performed using IBM SPSS Statistics version 22.0. Firth bias-reduced logistic regression was performed using R software. ECOG performance status was included in the multivariable model as a categorical variable with three levels (ECOG 0, 1, and ≥ 2), with ECOG 0 as the reference category. Continuous variables were summarized as median [Q1; Q3], and categorical variables as n (%). Because the study groups were unequal in size, particularly in the prosthesis subgroup, and several continuous variables demonstrated skewed distributions, between-group comparisons for continuous variables were performed using the non-parametric Kruskal-Wallis test. Categorical variables were compared using Pearson's χ^2 test or Fisher's exact test, as appropriate.

Binary outcomes were predefined as dichotomous yes/no variables and included: any outflow obstruction within 45 days, early outflow obstruction (≤ 7 days), late outflow obstruction (> 7 days), any postoperative complications, biliary complications, SFSS, and in-hospital mortality. For these binary outcomes, effect sizes were reported as risk ratios, risk differences, and odds ratios (ORs) with 95% confidence intervals (CIs); ORs are presented in **Appendix A**. Rare postoperative vascular events with sparse counts, including hepatic vein thrombosis, portal vein thrombosis, and hepatic artery thrombosis, were summarized descriptively and were not used for pairwise effect-size estimation.

To address potential confounding by calendar period and baseline differences between the conduit groups, multivariable analyses were performed for the primary endpoint of neo-MHV outflow obstruction within 45 days. Because only 22 primary-endpoint events occurred, including one event in the modified GSV group, Firth bias-reduced logistic regression was used to reduce small-sample and separation-related bias. Model 1 included conduit type and calendar year of transplantation, with calendar year entered as a continuous variable. Model 2 additionally included age, HCC status, ECOG performance status, graft weight, baseline serum sodium, hemoglobin, and ischemic heart disease and/or chronic heart failure. Recipient portal vein was used as the reference category. Continuous covariates were entered on their original scales, while HCC status and ischemic heart disease and/or chronic heart failure were entered as binary variables. Results are reported as ORs with 95% profile-likelihood CIs. Overall p-values for conduit type were obtained using penalized likelihood-ratio tests comparing models with and without the conduit-type terms. Given the limited number of outcome events relative to the number of covariates, model 2 was considered exploratory.

Baseline liver-related laboratory variables were analyzed separately from postoperative biochemical variables. Time-to-obstruction characteristics were analyzed using the Kaplan-Meier method. Missing data were not imputed. A two-sided significance level of $p < 0.05$ was used for all analyses.

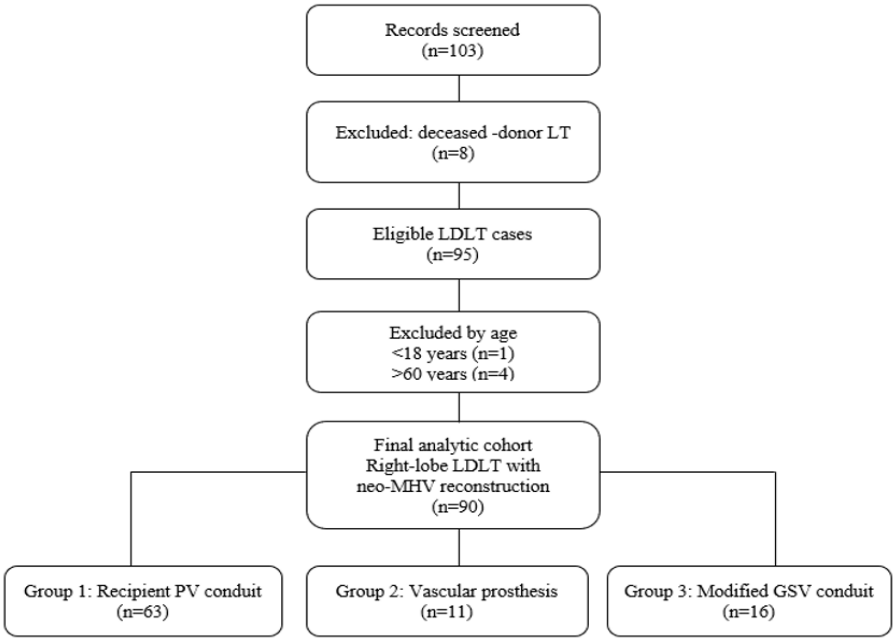

Figure 2. Study flow diagram (screening, exclusions, and analytic cohort) (created by the authors)

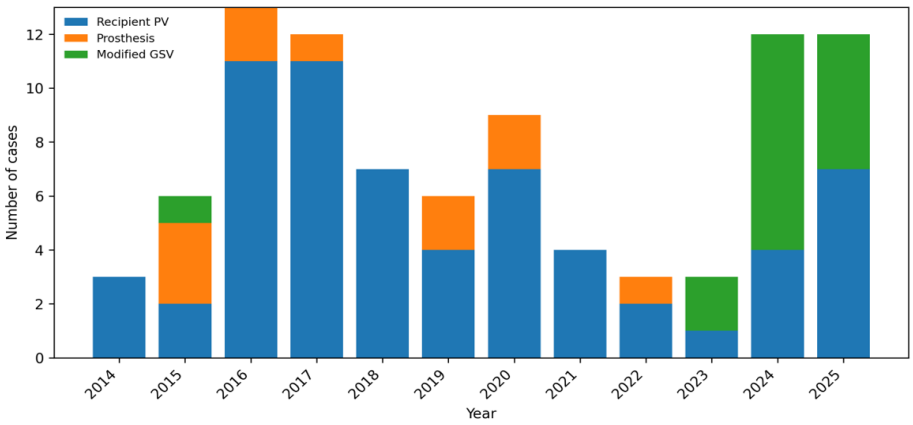

Figure 3. Annual distribution of included right-lobe LDLT cases with V5/V8 outflow reconstruction by conduit group, 2014-2025 (the counts represent cases included in the present analytical cohort and do not represent the total annual volume of liver transplantation at the center) (created by the authors)

RESULTS

A total of 90 right-lobe LDLT recipients who underwent V5 and/or V8 outflow reconstruction using a neo-MHV conduit were included in the analysis: recipient PV (n = 63), prosthesis (n = 11), and modified GSV (n = 16) (**Figure 2**).

According to the distribution by years (**Figure 3**), the use of modified GSV mostly pertains to the late observation period: the highest concentration of procedures occurred in 2024-2025 (8 and 5 cases, respectively), whereas the prosthesis group is represented predominantly in earlier years and is absent in 2023-2025.

Baseline characteristics overall demonstrated clinically comparable severity of liver failure, but with differences in a number of parameters (**Table 1**).

Table 1. Baseline characteristics of recipients by reconstruction group

Characteristic	Recipient PV (n = 63)	Prosthesis (n = 11)	Modified GSV (n = 16)	p-value
Demographics				
Age, years	42.0 [35.0; 48.5]	52.0 [46.5; 55.5]	47.0 [39.5; 51.0]	0.019 *
Male sex	27 (42.9%)	5 (45.5%)	12 (75.0%)	0.069
Height, cm	167.0 [159.0; 174.0]	163.0 [161.0; 167.5]	176.0 [169.0; 181.5]	0.012 *
Weight, kg	70.0 [56.5; 75.0]	58.0 [54.5; 69.0]	73.0 [67.5; 78.5]	0.035 *
BMI, kg/m^2	23.4 [21.4; 26.2]	22.0 [20.2; 25.1]	23.2 [22.4; 25.0]	0.599
Disease severity				
MELD score	17.0 [13.5; 21.0]	17.0 [11.5; 18.5]	14.5 [12.0; 18.8]	0.307
Child-Pugh class				0.629

Table 1 (Continued).

Characteristic	Recipient PV (n = 63)	Prosthesis (n = 11)	Modified GSV (n = 16)	p-value
A	4 (6.3%)	1 (9.1%)	1 (6.2%)	
B	38 (60.3%)	5 (45.5%)	12 (75.0%)	
C	21 (33.3%)	5 (45.5%)	3 (18.8%)	
ALBI score	-1.31 [-1.58; -1.05]	-1.38 [-1.60; -1.12]	-1.52 [-1.74; -1.34]	0.214
Etiology category				0.108
HBV/HDV-related	43 (68.3%)	6 (54.5%)	12 (75.0%)	
Mixed viral (HBV/HDV + HCV)	0 (0.0%)	1 (9.1%)	1 (6.2%)	
HCV-related	2 (3.2%)	2 (18.2%)	2 (12.5%)	
Autoimmune/cholestatic	13 (20.6%)	2 (18.2%)	1 (6.2%)	
Other rare	5 (7.9%)	0 (0.0%)	0 (0.0%)	
HCC	3 (4.8%)	6 (54.5%)	1 (6.2%)	< 0.001 *
Portal system risk factors				
Portal vein thrombosis before transplantation	7 (11.1%)	2 (18.2%)	2 (12.5%)	0.803
Baseline laboratory parameters (preoperative)				
Total bilirubin, μmol/L	63.0 [33.5; 103.0]	48.0 [31.0; 85.5]	47.0 [36.0; 79.0]	0.616
INR	1.7 [1.4; 1.9]	1.7 [1.6; 1.9]	1.5 [1.4; 1.7]	0.401
Creatinine, μmol/L	72.0 [62.5; 88.0]	74.0 [67.0; 79.5]	64.0 [56.5; 69.5]	0.139
Sodium, mmol/L	134.0 [132.0; 137.0]	138.0 [135.0; 140.0]	138.0 [136.8; 142.0]	< 0.001*
Albumin, g/L	29.0 [26.5; 33.0]	29.0 [27.5; 30.0]	30.5 [28.8; 32.8]	0.148
Platelets, × 10^9/L	66.0 [50.5; 87.5]	53.0 [37.5; 70.5]	59.5 [47.0; 72.8]	0.131
Hemoglobin, g/L	106.0 [98.0; 115.5]	106.0 [100.0; 110.5]	112.5 [108.0; 122.0]	0.044*
WBC, × 10^9/L	3.3 [2.8; 4.5]	3.2 [3.0; 3.8]	3.9 [2.2; 5.7]	0.892
Comorbidities				
Diabetes mellitus	1 (1.6%)	0 (0.0%)	0 (0.0%)	0.805
Ischemic heart disease/chronic heart failure	17 (27.0%)	7 (63.6%)	15 (93.8%)	< 0.001*
Arterial hypertension	7 (11.1%)	0 (0.0%)	0 (0.0%)	0.197
Chronic kidney disease	6 (9.5%)	0 (0.0%)	1 (6.2%)	0.536

Note. *Statistically significant at p < 0.05

Table 2. Expanded pretransplant clinical profile, ECOG performance status, concomitant medications, and relevant treatment history by reconstruction group

Characteristic	Recipient PV (n = 63)	Prosthesis (n = 11)	Modified GSV (n = 16)	p-value
Performance status				0.016*
ECOG 0	11 (17.5%)	1 (9.1%)	6 (37.5%)	
ECOG 1	40 (63.5%)	4 (36.4%)	9 (56.2%)	
ECOG ≥ 2	12 (19.0%)	6 (54.5%)	1 (6.2%)	
Comorbidities				
Diabetes mellitus	1 (1.6%)	0 (0.0%)	0 (0.0%)	0.805
Ischemic heart disease and/or chronic heart failure	17 (27.0%)	7 (63.6%)	15 (93.8%)	< 0.001*
Arterial hypertension	7 (11.1%)	0 (0.0%)	0 (0.0%)	0.197
Chronic kidney disease	6 (9.5%)	0 (0.0%)	1 (6.2%)	0.536
Previous abdominal surgery	9 (14.3%)	2 (18.2%)	2 (12.5%)	0.916
Concomitant medications before LT				
Non-selective beta-blockers	44 (69.8%)	7 (63.6%)	11 (68.8%)	0.919
Diuretics	46 (73.0%)	8 (72.7%)	10 (62.5%)	0.704
Antiplatelet and/or anticoagulant therapy	6 (9.5%)	2 (18.2%)	3 (18.8%)	0.490
Antiviral therapy for HBV/HCV	41 (65.1%)	7 (63.6%)	12 (75.0%)	0.735
Antidiabetic treatment	1 (1.6%)	0 (0.0%)	0 (0.0%)	0.805
Relevant treatment history				
Prior TACE/RFA or other HCC-directed treatment†	2 (3.2%)	5 (45.5%)	1 (6.2%)	< 0.001*
Previous portal venous intervention	4 (6.3%)	1 (9.1%)	1 (6.2%)	0.942
Pre-LT ICU stay	8 (12.7%)	3 (27.3%)	1 (6.2%)	0.277
Dialysis/renal replacement therapy before LT	2 (3.2%)	0 (0.0%)	1 (6.2%)	0.668

Note. *Statistically significant at p < 0.05

Age was higher in the prosthesis group (52.0 [46.5; 55.5] years) compared with recipient PV (42.0 [35.0; 48.5]) and modified GSV (47.0 [39.5; 51.0], p = 0.019). The modified GSV group had larger anthropometric measures [169.0; 181.5] cm and weight [67.5; 78.5] kg/ (p = 0.012 and p = 0.035, respectively), while BMI did not differ between groups (p = 0.599).

Groups differed mainly in performance status and selected pretransplant clinical characteristics. The prosthesis group more often had poorer functional status (higher proportion of ECOG ≥ 2), whereas the modified GSV group more often had ECOG 0. The prevalence of ischemic heart disease and/or chronic heart failure also differed significantly between groups. Concomitant medication use was generally comparable. Prior HCC-directed treatment was substantially more frequent in the prosthesis group, consistent with the higher proportion of HCC in that subgroup (**Table 2**).

Table 3. Graft and intraoperative characteristics

Characteristic	Recipient PV (n = 63)	Prosthesis (n = 11)	Modified GSV (n = 16)	p-value
GRWR	1.00 [0.90; 1.20]	1.00 [1.00; 1.15]	1.00 [0.90; 1.20]	0.699
Graft weight, g	670 [605; 748]	718 [613; 735]	756 [722; 859]	0.011*
Cold ischemia time, min	65 [42; 106]	92 [33; 150]	38 [35; 42]	0.001*
Warm ischemia time, min	40 [22; 55]	32 [18; 46]	24 [20; 33]	0.062
Anhepatic phase, min	103 [52; 155]	130 [66; 165]	42 [26; 61]	< 0.001*
Operation duration, min	758 [670; 840]	780 [635; 915]	660 [600; 785]	0.157
Estimated blood loss, mL	1,500 [1,000; 3,000]	3,000 [1,750; 3,350]	1,200 [775; 1,500]	0.006*
ABO compatibility				
Identical	52 (82.5%)	8 (72.7%)	12 (75.0%)	
Compatible	9 (14.3%)	3 (27.3%)	4 (25.0%)	
Incompatible	0 (0.0%)	0 (0.0%)	0 (0.0%)	
Missing/unclear	2 (3.2%)	0 (0.0%)	0 (0.0%)	

Note. *Statistically significant at p < 0.05

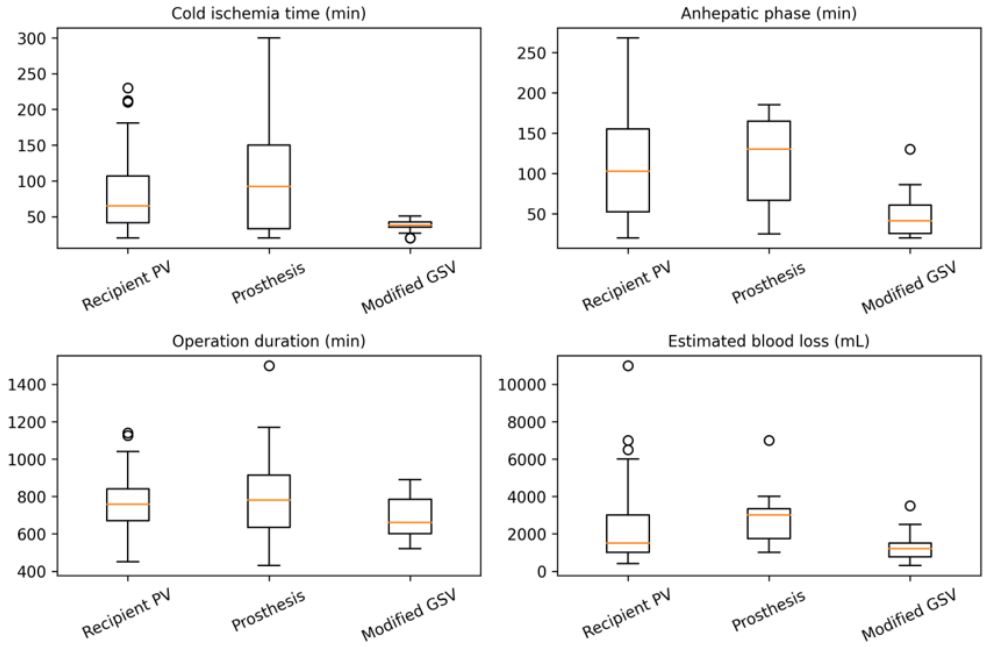

Figure 4. Key intraoperative variables across groups (boxplots) (created by the authors)

The groups did not differ in liver disease severity by MELD (p = 0.307) or child-Pugh distribution (p = 0.629). A significant difference was found in the incidence of HCC: 54.5% (6/11) in prosthesis versus 4.8% (3/63) in recipient PV and 6.2% (1/16) in modified GSV (p < 0.001).

Among preoperative laboratory parameters, sodium (p < 0.001) and hemoglobin (p = 0.044) differed significantly. Regarding comorbidities, the prevalence of CAD/CHF differed markedly: 27.0% in recipient PV, 63.6% in prosthesis, and 93.8% in modified GSV (p < 0.001).

Intraoperative parameters and graft characteristics showed the most pronounced differences (**Table 3**). Graft weight was higher in the modified GSV group-756 [722; 859] g versus 670 [605; 748] g in recipient PV and 718 [613; 735] g in prosthesis (p = 0.011). Cold ischemia time was minimal with modified GSV-38 [35; 42] min, whereas in recipient PV it was 65 [42; 106] min, and in prosthesis it was 92 [33; 150] min (p = 0.001). The anhepatic period also differed substantially: 42 [26; 61] min in mdified GSV versus 103 [52; 155] min in recipient PV and 130 [66; 165] min in prosthesis (p < 0.001).

Blood loss volume was lower with modified GSV-1200 [775; 1,500] mL, higher with prosthesis – 3,000 [1,750; 3,350] mL, and intermediate in recipient PV-1,500 [1,000; 3,000] mL (p = 0.006). At the same time, GRWR remained comparable (p = 0.699), and operative time did not differ statistically (p = 0.157).

In **Figure 4**, these differences are presented as distributions of key parameters (cold ischemia, anhepatic period, operative time, blood loss), with a clear shift toward lower values in the modified GSV group.

The distribution of V5/V8 outflow reconstruction patterns by drainage type (isolated V5, isolated V8, or V5 + V8) did not differ significantly between the groups (p = 0.276) (**Table 4**). Exploratory comparison likewise did not suggest a consistent interaction between drainage pattern and conduit type with respect to early outflow obstruction. Given the limited subgroup counts, particularly in the prosthesis group, these analyses were considered hypothesis-generating and were not overinterpreted. However, clinically meaningful differences were observed in the incidence of outflow obstruction.

Overall outflow obstruction was observed in 25.4% (16/63) in the recipient PV group, 45.5% (5/11) in the prosthesis group, and only 6.2% (1/16) in the modified GSV group (p = 0.063). Early outflow obstruction (≤ 7 days) was 19.0%, 27.3%, and 6.2%, respectively (p = 0.332), while late outflow obstruction (> 7 days) was 6.3%, 18.2%, and 0% (p = 0.174).

Table 4. neo-MHV reconstruction pattern and early outflow complications/patency (≤ 45 days)

Characteristic	Recipient PV (n = 63)	Prosthesis (n = 11)	Modified GSV (n = 16)	p-value
Venous drainage pattern of neo-MHV reconstruction				0.276
Isolated SgV (V5)	14 (22.2%)	5 (45.5%)	7 (43.8%)	
Isolated SgVIII (V8)	15 (23.8%)	2 (18.2%)	4 (25.0%)	
Combined SgV + SgVIII (V5 + V8)	34 (54.0%)	4 (36.4%)	5 (31.2%)	
Hepatic vein thrombosis (postoperative)				0.645
Yes	2 (3.2%)	0 (0.0%)	0 (0.0%)	
Treatment of hepatic vein thrombosis (among HV thrombosis cases)				
Not specified/none recorded	2 (100.0%)	-	-	
Early outflow obstruction (≤ 7 days)				0.332
Yes	12 (19.0%)	3 (27.3%)	1 (6.2%)	
Late outflow obstruction (>7 days)				0.174
Yes	4 (6.3%)	2 (18.2%)	0 (0.0%)	
Any outflow obstruction within 45 days				0.063
Yes	16 (25.4%)	5 (45.5%)	1 (6.2%)	
Day of outflow obstruction among affected cases, days	4 [3; 7]	5 [2; 20]	3 [3; 3]	0.842
Portal vein thrombosis (postoperative)				0.645
Yes	2 (3.2%)	0 (0.0%)	0 (0.0%)	
Missing data for postoperative PVT				
Missing	0 (0.0%)	0 (0.0%)	1 (6.2%)	
Hepatic artery thrombosis (postoperative)				0.645
Yes	2 (3.2%)	0 (0.0%)	0 (0.0%)	
Treatment of hepatic artery thrombosis (among HAT cases)				
Intervention and/or reoperation	1 (50.0%)	-	-	
Treatment performed (details not recorded)	1 (50.0%)	-	-	

Table 5. Association between conduit type and neo-MHV outflow obstruction within 45 days

Conduit type	Obstruction, n/N (%)	Crude OR (95% CI)	Model 1: year-adjusted OR (95% CI)	Model 2: multivariable-adjusted OR (95% CI)
Recipient portal vein	16/63 (25.4)	1.00 (reference)	1.00 (reference)	1.00 (reference)
Prosthesis	5/11 (45.5)	2.45 (0.66-9.12)	1.87 (0.41-8.52)	1.54 (0.28-8.41)
Modified GSV	1/16 (6.2)	0.20 (0.02-1.60)	0.34 (0.04-3.12)	0.41 (0.04-4.05)
Overall conduit effect, p-value	-	0.063[1]	0.214[2]	0.318[2]

Note. [1]Overall unadjusted comparison between the three conduit groups & [2]Overall p-value for the joint effect of conduit type in the regression model

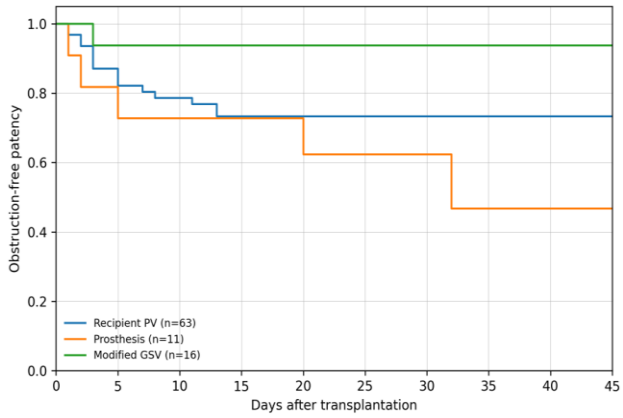

Figure 5. Kaplan-Meier curves for obstruction-free patency of the reconstructed V5/V8 outflow within 45 days (created by the authors)

In the unadjusted analysis, the crude OR for neo-MHV outflow obstruction was 2.45 (95% CI 0.66-9.12) for prosthesis and 0.20 (95% CI 0.02-1.60) for modified GSV, with recipient portal vein used as the reference category. Neither estimate was statistically significant. After adjustment for calendar year, the corresponding ORs were 1.87 (95% CI 0.41-8.52) and 0.34 (95% CI 0.04-3.12), respectively. In the multivariable-adjusted model, the estimates were further attenuated to 1.54 (95% CI 0.28-8.41) for prosthesis and 0.41 (95% CI 0.04-4.05) for modified GSV. The overall association between conduit type and 45-day outflow obstruction was not statistically significant in either the year-adjusted model (p = 0.214) or the multivariable-adjusted model (p = 0.318) (**Table 5**).

Additional effect-size estimates for the secondary binary outcomes are provided in **Appendix A**.

Among patients with outflow obstruction, the median time to event was comparable: 4 [3; 7] days in the recipient PV group, 5 [2; 20] days in the prosthesis group, and 3 [3; 3] days in the modified GSV group (p = 0.842). On day 7, the estimated probabilities of obstruction-free patency were 0.804, 0.727, and 0.938 in the recipient PV, prosthesis, and modified GSV groups, respectively. By day 45, the corresponding estimates were 0.733, 0.468, and 0.938, respectively (**Figure 5**).

Early postoperative outcomes are presented in **Table 6**. The rate of any complications did not differ significantly: 41.3% (recipient PV), 45.5% (prosthesis), 25.0% (modified GSV), p = 0.439.

Biliary complications occurred in 19.0% of the recipient PV group, 27.3% of the prosthesis group, and 6.2% of the modified GSV group (p = 0.332). Postoperative hospital stay was shorter in the modified GSV group (18 [15; 21] days) than in the recipient PV group (26 [18; 36] days) and the prosthesis group (34 [25; 48] days) (p = 0.011). The modified GSV group had the lowest median peak AST, ALT, and INR values: 177 [125; 251] U/L, 163 [129; 289] U/L, and 2.08 [1.85; 2.43], respectively (p = 0.039, p = 0.021, and p = 0.027). Peak total bilirubin and lactate

Table 6. Postoperative course and peak biochemical markers

Characteristic	Recipient PV (n = 63)	Prosthesis (n = 11)	Modified GSV (n = 16)	p-value
Postoperative hospital stay, days	26 [18; 36]	34 [25; 48]	18 [15; 21]	0.011*
Peak AST after LT, U/L	257 [160; 387]	265 [215; 490]	177 [125; 251]	0.039*
Peak ALT after LT, U/L	284 [170; 472]	301 [200; 518]	163 [129; 289]	0.021*
Peak lactate after LT, mmol/L	2.9 [2.7; 4.2]	3.2 [2.9; 4.2]	2.8 [2.4; 3.7]	0.174
Peak INR after LT	2.62 [2.01; 3.87]	2.80 [2.35; 3.10]	2.08 [1.85; 2.43]	0.027*
Peak total bilirubin after LT, µmol/L	111 [80; 150]	155 [88; 210]	104 [83; 131]	0.661
Any postoperative complications	26 (41.3%)	5 (45.5%)	4 (25.0%)	0.439
Biliary complications	12 (19.0%)	3 (27.3%)	1 (6.2%)	0.332
SFSS	6 (9.5%)	2 (18.2%)	0 (0.0%)	0.251
Retransplantation	0 (0.0%)	0 (0.0%)	0 (0.0%)	-
In-hospital mortality	12 (19.0%)	4 (36.4%)	0 (0.0%)	0.053

Note. *Statistically significant at $p < 0.05$

Table 7. Baseline and early postoperative liver function profile by reconstruction group

Variable	Recipient PV (n = 63)	Prosthesis (n = 11)	Modified GSV (n = 16)	p-value
Baseline total bilirubin, µmol/L	63 [33.5; 103]	48 [31; 85.5]	47 [36; 79]	0.616
Peak total bilirubin after LT, µmol/L	111 [80; 150]	155 [88; 210]	104 [83; 131]	0.661
Postoperative day 7 bilirubin, µmol/L	86 [56; 121]	118 [72; 176]	68 [49; 97]	0.084
Baseline INR	1.7 [1.4; 1.9]	1.7 [1.6; 1.9]	1.5 [1.4; 1.7]	0.401
Peak INR after LT	2.62 [2.01; 3.87]	2.80 [2.35; 3.10]	2.08 [1.85; 2.43]	0.027*
Postoperative day 7 INR ǂ	1.62 [1.38; 1.88]	1.81 [1.55; 2.09]	1.39 [1.28; 1.58]	0.041*

Note. ǂData are presented for patients with available postoperative day 7 measurements & *Statistically significant at $p < 0.05$

did not differ significantly among the groups ($p = 0.661$ and $p = 0.174$, respectively). In-hospital mortality was 19.0% (12/63) in the recipient PV group, 36.4% (4/11) in the prosthesis group, and 0% (0/16) in the modified GSV group; the between-group difference did not reach statistical significance ($p = 0.053$) (**Table 6**).

Baseline liver-related laboratory variables were analyzed separately from postoperative biochemical follow-up. Preoperative total bilirubin and INR did not differ significantly among the groups ($p = 0.616$ and $p = 0.401$, respectively). During the early postoperative period, median peak INR was lowest in the modified GSV group ($p = 0.027$), whereas peak total bilirubin did not differ significantly among the groups ($p = 0.661$). Among patients with available postoperative day 7 measurements, bilirubin levels did not differ significantly among the groups ($p = 0.084$), whereas INR differed overall, with the lowest median value observed in the modified GSV group ($p = 0.041$) (**Table 7**).

DISCUSSION

The principal contribution of the present study is the demonstration that a modified allogeneic GSV cold-stored in custodiol can be used as a biological conduit for V5/V8 outflow reconstruction when conventional vascular allografts are unavailable. In this retrospective cohort, the modified GSV technique was technically feasible and showed encouraging early neo-MHV conduit patency. However, the study groups were small, unequal, non-randomized, and temporally separated. Therefore, the observed between-group differences should be regarded as exploratory and do not establish the superiority of modified GSV over recipient portal vein or prosthetic conduits.

These observations fit within the modern concept of right-lobe LDLT [12], where venous outflow of segments V and VIII is key to preventing anterior-sector congestion and maintaining early graft function. The literature consistently emphasizes that significant V5/V8 tributaries to the MHV, usually ≥5 mm or showing pronounced outflow during perfusion, should be reconstructed to prevent venous congestion of segments V/VIII and the associated impairment of regeneration and early graft dysfunction [12, 13].

The risk of a functionally small graft may persist even with an acceptable GRWR if a significant volume of parenchyma remains under venous hypertension [11]. The performance of a neo-MHV conduit may depend not only on the conduit material but also on its caliber, venoplasty design, anastomotic configuration, and size matching with the venous openings [12, 14, 15]. Autologous GSV has previously been used for hepatic venous outflow reconstruction and venoplasty in LDLT, including quilt and sleeve-patch configurations [16-18].

In the present technique, longitudinal modification of the GSV was intended to increase the effective conduit circumference, create a wider and more uniform channel capable of accommodating multiple V5/V8 tributaries, and reduce abrupt caliber mismatch, anastomotic tension, and kinking. However, the present study did not isolate the effect of the panel modification from patient selection, operative workflow, or calendar era. Its proposed technical advantages should therefore be regarded as plausible rather than proven.

Synthetic prostheses, including ePTFE conduits, are technically available and convenient, but the literature describes specific risks, including infectious complications, migration, and rare adverse events involving adjacent hollow organs [19, 20]. Previous studies have reported variable patency outcomes for synthetic conduits, potentially reflecting differences in conduit configuration, follow-up duration, and clinical context [4, 21, 22]. In the present study, interpretation of the prosthesis group is particularly limited by its small sample size, earlier calendar period, and substantial baseline and procedural differences.

Previously reported conduit options for V5/V8 outflow reconstruction include cryopreserved iliac vein or other vascular homografts, recipient portal-vein segments, and synthetic ePTFE conduits. Cryopreserved iliac vein grafts

provide biological tissue with suitable handling characteristics, but their use requires tissue-bank availability and dedicated cryopreservation and thawing procedures [23]. Recipient portal-vein grafts avoid synthetic material and have been reported as a feasible strategy when other vascular grafts are unavailable [24]. However, recipient portal-vein material becomes available only after recipient hepatectomy. ePTFE conduits are immediately available and standardized, and a randomized clinical trial found similar early neo-MHV conduit patency with recipient portal vein and ePTFE conduits [7]. Thus, the novelty of modified allogeneic GSV lies primarily in providing a locally available biological alternative rather than in demonstrated superiority over established conduit options.

The differences in cold ischemia, warm ischemia, and anhepatic time should not be interpreted as direct effects of conduit material. Cold ischemia begins at donor graft cross-clamping and is influenced by the overall sequence of donor procurement, back-table preparation, recipient hepatectomy, and graft implantation. Recipient portal-vein material generally becomes available only after completion of recipient hepatectomy, whereas a pre-prepared GSV or prosthetic conduit can be available before graft implantation. The most relevant conduit-specific variable would be the time required for neo-MHV conduit construction and anastomosis, but this interval was not recorded separately in the retrospective database. Consequently, the contribution of conduit preparation and suturing time could not be determined. The observed differences in warm ischemia and anhepatic time may also reflect operative workflow, accumulated experience, and later-era procedural standardization rather than a material-specific effect.

The greater total blood loss observed in the prosthesis group may have reflected a more difficult recipient hepatectomy or other unmeasured procedural factors rather than an effect of the prosthetic conduit itself. Phase-specific blood loss and a standardized measure of recipient hepatectomy complexity were not available. Therefore, blood loss should be regarded as a potential confounding procedural characteristic rather than a conduit-dependent outcome.

Although absolute graft weight was higher in the modified GSV group, GRWR was comparable among the three groups. The absence of a statistically significant difference in SFSS and the small number of events preclude any protective interpretation. SFSS and early biochemical recovery are multifactorial and may be influenced by graft size and quality, portal inflow, venous outflow, ischemic injury, recipient condition, and perioperative management. Consequently, the lower AST, ALT, and INR values observed in the modified GSV group should be considered exploratory associations and cannot be independently attributed to conduit selection.

An additional concern is the close relationship between conduit type and calendar era. The modified GSV technique was used predominantly in 2024-2025, whereas prosthetic reconstructions were concentrated in earlier years. Therefore, accumulated surgical experience and possible changes in operative standardization, anesthesia, critical care, perioperative management, and postoperative vascular surveillance may have contributed to both patency and postoperative outcomes. The crude association between modified GSV use and lower ORs of neo-MHV outflow obstruction was attenuated after adjustment for calendar year and selected baseline and graft characteristics. The adjusted point estimate remained below 1.0, but the confidence interval was wide and included the null value. The estimate for prosthesis was also attenuated after adjustment. This attenuation is consistent with partial confounding by calendar-era effects, patient selection, graft characteristics, and institutional learning. Residual confounding remains possible because conduit selection was strongly associated with the treatment period and the groups had limited temporal and clinical overlap. The findings therefore support the technical feasibility of modified GSV and justify further evaluation but do not demonstrate superiority over recipient portal vein or prosthetic conduits.

An important practical aspect of this work is the description of a regionally feasible conduit-supply strategy based on allogeneic GSV obtained during elective vascular surgery and preserved in custodiol. In settings with limited access to deceased-donor vascular allografts, this approach may represent a pragmatic biological alternative, although its broader applicability requires further validation.

The use of allogeneic GSV also raises specific safety considerations, including donor screening for transmissible infections, aseptic procurement and processing, donor-recipient ABO relationships, potential alloimmune sensitization, maintenance of cold-chain conditions, and possible late conduit degeneration. Evidence concerning the importance of ABO compatibility is limited and indirect. A retrospective study of cryopreserved arterial allografts found no significant association between ABO mismatch and thrombosis, stenosis, rupture, aneurysmal degeneration, or secondary patency [25]. In contrast, a peripheral bypass series using cadaveric saphenous vein allografts reported better limb salvage with donor-recipient ABO compatibility [26]. These findings were obtained from arterial or peripheral vascular reconstructions and cannot establish immunologic equivalence or define matching requirements for cold-stored GSV used in immunosuppressed liver transplant recipients. Evidence from non-hepatic vascular reconstruction is therefore inconsistent and should not be directly extrapolated to the present conduit.

In the present study, GSV segments were stored in custodiol at +3 to +5 °C for up to 21 days. However, the retrospective dataset did not permit systematic evaluation of donor-derived infection risk, donor-specific antibodies, cellular immune responses, ABO-related effects, late conduit degeneration, or the completeness of cold-chain documentation during storage and transport. Accordingly, the present findings are restricted to early clinical patency and do not establish long-term biological or immunologic safety.

Given the high proportion of LDLT in Kazakhstan and limited access to deceased-donor vascular allografts [27], an allogeneic modified GSV preserved in custodiol may be considered a feasible regional option for V5/V8 outflow reconstruction in selected cases. This interpretation should remain focused on technical feasibility rather than comparative superiority.

A randomized comparison would provide the strongest evidence regarding conduit-specific effects but may be difficult because of the limited number of eligible cases and differences in operative workflow between conduit strategies. A contemporaneous prospective multicenter cohort with standardized measurement of neo-MHV conduit construction and anastomosis time, ischemic intervals, recipient hepatectomy complexity, phase-specific blood loss, graft characteristics, anticoagulation management, conduit safety,

and long-term patency may represent a more feasible next step. Taken together, the present findings support modified allogeneic GSV as a technically feasible biological conduit and provide a basis for further prospective evaluation, but they do not demonstrate superiority over recipient portal vein or prosthetic conduits.

Limitations

This study is limited by its retrospective single-center design, small and markedly unequal groups, sparse outcome events, and non-random, period-dependent conduit selection. Modified GSV was used predominantly during the later era, whereas prosthetic grafts were not used in 2023-2025; therefore, conduit type was closely associated with surgical experience, operative standardization, perioperative care, and postoperative surveillance. Baseline and graft-related imbalances were addressed in exploratory Firth regression analyses but could only be partially controlled because of the small number of outcome events, wide confidence intervals, and limited temporal and clinical overlap between the groups. Procedural differences, including ischemic intervals and blood loss, remained potential sources of residual confounding. The time required specifically for neo-MHV conduit construction and anastomosis, phase-specific blood loss, and a standardized measure of recipient hepatectomy difficulty were unavailable. Although absolute graft weight differed, GRWR was comparable, and the SFSS and biochemical analyses were underpowered and exploratory. The study was not designed to evaluate donor-recipient ABO-related effects associated with GSV use, alloimmune sensitization, donor-derived infection risk, or late conduit degeneration. These findings support technical feasibility and hypothesis generation but do not establish the superiority of modified GSV.

CONCLUSION

Modified allogeneic GSV cold-stored in custodiol is a feasible biological conduit for V5/V8 outflow reconstruction with creation of a neo-MHV in right-lobe LDLT, particularly when conventional vascular allografts are unavailable. The encouraging early neo-MHV conduit patency observed in this cohort warrants further evaluation, but the retrospective, non-randomized, and temporally heterogeneous comparison does not establish superiority over recipient portal vein or prosthetic conduits.

Author contributions: Zhambyl Ospan: conceptualization, data curation, formal analysis, investigation, methodology, project administration, validation, visualization, writing – original draft, writing – review & editing; **Maxat Doskhanov:** conceptualization, investigation, methodology, software, visualization, writing – original draft, writing – review & editing; **Bolatbek Baimakhanov:** investigation, methodology, resources, writing – review & editing; **Remzi Emiroglu:** resources, supervision, validation, writing – review & editing; **Shokan Kaniyev:** data curation, investigation, software, writing – review & editing; **Serik Tileuov:** investigation, writing – review & editing; **Shynar Tanabayeva:** data curation, formal analysis, writing – review & editing; **Ildar Fakhradiyev:** conceptualization, funding acquisition, methodology, project administration, resources, supervision, validation, writing – review & editing. All authors have agreed with the results and conclusions.

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Ethical statement: This study was approved by the Local Ethics Committee of the A. N. Syzganov National Scientific Center of Surgery on 17 October 2025 with approval number 4. Access to the registry data was provided in a de-identified format for statistical analysis. Written informed consent for surgical treatment was obtained from all patients. Procedures for handling biological material (including allogeneic venous grafts) were performed in accordance with the institution’s internal requirements for documentation and biosafety.

AI statement: The authors stated that no AI tools were used for data analysis, statistical processing, figure generation, or interpretation of results. The authors retain full responsibility for the integrity, originality, and scientific accuracy of the work.

Declaration of interest: No conflict of interest is declared by the authors.

Data sharing statement: Data supporting the findings and conclusions are available upon request from the corresponding author.

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APPENDIX A

Table A1. Effect size estimates (RRs and ORs with 95% CIs) for binary outcomes comparing reconstruction conduits

Outcome	RR GSV vs. PV (95% CI)	OR GSV vs. PV (95% CI)	RR GSV vs. prosthesis (95% CI)	OR GSV vs. prosthesis (95% CI)
Any obstruction ≤ 45 days	0.25 (0.04-1.72)	0.20 (0.02-1.60)	0.14 (0.02-1.06)	0.08 (0.01-0.84)
Obstruction ≤ 7 days	0.33 (0.05-2.27)	0.28 (0.03-2.29)	0.23 (0.03-1.76)	0.18 (0.02-1.95)
Obstruction > 7 days	0.47 (0.03-8.71)	0.42 (0.02-7.89)	0.14 (0.01-2.54)	0.10 (0.00-2.43)
Any postoperative complications	0.61 (0.26-1.42)	0.47 (0.14-1.56)	0.55 (0.22-1.36)	0.40 (0.11-1.47)
Biliary complications	0.33 (0.05-2.27)	0.28 (0.03-2.29)	0.23 (0.03-1.76)	0.18 (0.02-1.95)
SFSS	0.31 (0.02-5.23)	0.24 (0.01-4.63)	0.15 (0.01-2.73)	0.12 (0.01-2.98)
In-hospital mortality	0.15 (0.01-2.46)	0.10 (0.01-1.74)	0.06 (0.00-0.98)	0.04 (0.00-0.88)