THE EFFECTIVENESS OF THE FUNCTIONING OF RECONSTRUCTED HEPATIC VEINS USING VARIOUS TYPES OF MATERIALS IN TRANSPLANTATION OF THE RIGHT LOBE OF THE LIVER FROM A LIVING DONOR

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Abstract

Background. In adult living donor liver transplantation with the right lobe, the venous outflow of the anterior sector is typically restored during the procedure to form a neo-middle hepatic vein. Restoring the middle hepatic vein for the drainage of the anterior sector is critically important for achieving optimal graft function. Various conduits are used for this reconstruction, such as synthetic and biological grafts (e.g., the recipient's portal vein, vessels from a deceased donor, and modified great saphenous vein). However, the selection of the best option remains a topic of discussion. This study evaluates the effectiveness of using biological and synthetic grafts for MHV reconstruction.

Materials and methods. A retrospective analysis of outcomes was conducted in patients who underwent transplantation of a modified right liver lobe due to end-stage liver disease from 2011 to 2024.

Results. A transplantation of modified right liver lobes was performed on 80 patients. In 69 cases, the reconstruction of the hepatic veins was carried out using a biological graft, while in 11 cases, a synthetic graft was used. Statistically significant differences were noted in mortality and the postoperative period. No significant differences were found in the frequency of intraoperative complications.

Conclusion. Our study demonstrates that the use of a biological graft for the reconstruction of the hepatic veins of segments 5 and 8 is more effective than the application of a vascular prosthesis.

Introduction

Liver transplantation from a living donor (LDLT) is a critical treatment method for end-stage liver diseases, especially in regions where there is a shortage of organs from deceased donors.[1] LDLT is a viable alternative, though it is technically more complex and requires a profound understanding of the anatomy of the donor's liver, careful preoperative preparation, and meticulous surgical intervention. The resection of parenchyma from the donor liver must be performed in such a way as to ensure not only a suitable liver graft and sufficient volume of the remaining liver but also to preserve the graft with healthy vascular and biliary structures.[2]

The selection of the graft in LDLT is a fundamental process that takes into account not only the metabolic needs of the recipient and the preservation of the anatomical integrity of the graft but also the volume of the donor organ, which is crucial for ensuring donor safety.[2] In adult patients, the size of the graft is a structural limitation since a graft from the left lobe typically constitutes less than 40% of the total liver volume, which may be inadequate to ensure an appropriate match between the donor and recipient sizes.[2]

In LDLT, the most common procedure is the transplantation of the right liver lobe (RL), and many centers employ a technique in which the middle hepatic vein (MHV) trunk is preserved on the donor side.[3] When considering the standard approach to performing right hemihepatectomy, if the MHV is not included in the graft, this provides greater safety for the donor compared to extended right hemihepatectomy, where the MHV is part of the graft.[4] The problem is that in LDLT using an RL graft without MHV, there can be extensive congestion in the graft, such that after reperfusion, venous outflow from the right anterior sector to the MHV may be compromise.[5].

The right hepatic vein drains separately into the inferior vena cava (IVC), while the middle and left hepatic veins typically have a common trunk in 65-85% of patients. The MHV drains the central part of the liver and receives tributaries from segments 4, 5, and 8.[6] During the transplantation of the RL of the liver, it is important to consider the potential reconstruction of significantly larger veins from segments 5 and 8 (over 5 mm in diameter) to avoid congestion in the anterior sector of the transplant.[7] Impairment of venous drainage from the transplant is one of the main causes of liver failure in the postoperative period.[8]

To ensure the integrity of the transplant function, adequate venous drainage of the transplant is as important as blood supply to the liver. Therefore, to achieve optimal outcomes for both the transplant and the recipient, it is necessary to reconstruct all hepatic veins (HV) during the transplantation of the RL of the liver.

The aim of this study is to investigate the effectiveness of using the great saphenous vein for the reconstruction of the hepatic veins in right lobe liver transplantation.

Materials and Methods

This is cross-sectional study of the observational retrospective-prospective study involving patients with end-stage liver disease who received treatment at the Hepatopancreatobiliary Surgery and Liver Transplantation Department of the A.N. Syzganov Scientific Center of Surgery from 2011 to 2024.

From December 2011 to August 2024, a total of 297 liver transplants (LT) were performed in adults and children. Among these, 268 (90.2%) were from living donors, including 50 (18.6%) liver transplants in children and 29 (9.8%) from deceased donors. Of the adult population, 218 liver transplants were performed, with the right lobe used in 178 cases. Reconstruction of the hepatic veins of segments 5 and 8 during right lobe liver transplantation was performed in 80 cases (44.9%). Reconstruction of the hepatic veins can indeed be justified for patients with hepatic vein diameters greater than 5 mm and a graft-to-recipient weight ratio (GRWR) of less than 1. These criteria allow for the selection of the most suitable candidates for the procedure, thereby ensuring higher chances of a successful outcome and minimizing complications.

Inclusion criteria:

Age between 18 and 60 years

Gender: male and female

Type of graft: RL with reconstruction of HV from segments 5 and 8

Voluntary consent of the patient to participate in the research study.

Exclusion criteria:

Pediatric transplantation

Transplantation from a deceased donor

Type of graft: left lobe, whole liver, RL without reconstruction of HV from segments 5 and 8.

Ethical approval. The clinical trial protocol, the informed consent form, and the information sheet were approved by the Local Bioethics Committee of the National Scientific Surgery Center named after A.N. Syzganov (protocol of meeting №4 dated November 10, 2023).

Statistical analysis. Data were analyzed using IBMSPSS Statistics software (IBMSPSS Inc.). Numerical variables were expressed as mean ± SD and categorical variables as numbers and percentages. Nonparametric statistics were performed for dataset analysis. Between-group comparisons were assessed for numerical variables, and the

Chi-square test was used for categorical variables. P value ≤0.05 was considered statistically significant. The analysis of the main risk factors and their corresponding causal relationships was assessed by calculating the Odds Ratio (OR): OR=1 means that the odds are equal in both groups; OR>1 means that the event is directly related and has a chance of occurring in the first group; OR<1 means that the event has an inverse relationship and chance to occur in the second group.

Results

Depending on the material used for the reconstruction of the HV of segments 5 and 8, the patients (n=80) were retrospectively divided into two groups. In the first group, reconstruction of the HV of segments 5 and 8 was performed using biological grafts in 69 (86.25%) cases (recipient portal vein (PV) n=60, modified great saphenous vein (GSV) n=7, vessels from post-mortem donors n=2). The second group of patients completed the reconstruction of the HVof segments 5 and 8 using vascular prostheses in 11 (13.75%) cases. All patients underwent transplantation of the RL of the LDLT. The study was approved by the local ethics committee. Written informed consent was obtained from all patients prior to the operation.

To perform differential and topical diagnosis, a comprehensive examination was conducted, including general clinical and biochemical laboratory methods, ultrasound, magnetic resonance cholangiography, and CT of the abdominal organs.

Surgical intervention in both recipients and donors was standardized for the entire group of patients. As the standard protocol for donor selection, we chose grafts with a future liver remnant (FLR) >30% and a GRWR> 0.7. The veins of segments V and VIII, which join the MHV, were separated. During the preparation of the graft on the back table, the anterior sectoral veins of the graft were reconstructed using various materials. A neo-vein was formed by performing an end-to-end anastomosis on the main vein of segment V (V5), followed by an end-to-side anastomosis on the vein of segment VIII (V8). Furthermore, all veins larger than 5 mm in diameter or with significant outflow during static perfusion were side-to-side anastomosed to create a neo-MHV. The distal end of the neo-MHV was connected to the MHV in the graft. If present, significant lower HV were anastomosed separately to the IVC. In all cases, intraoperative duplex scanning was performed, and satisfactory results were achieved before closure.

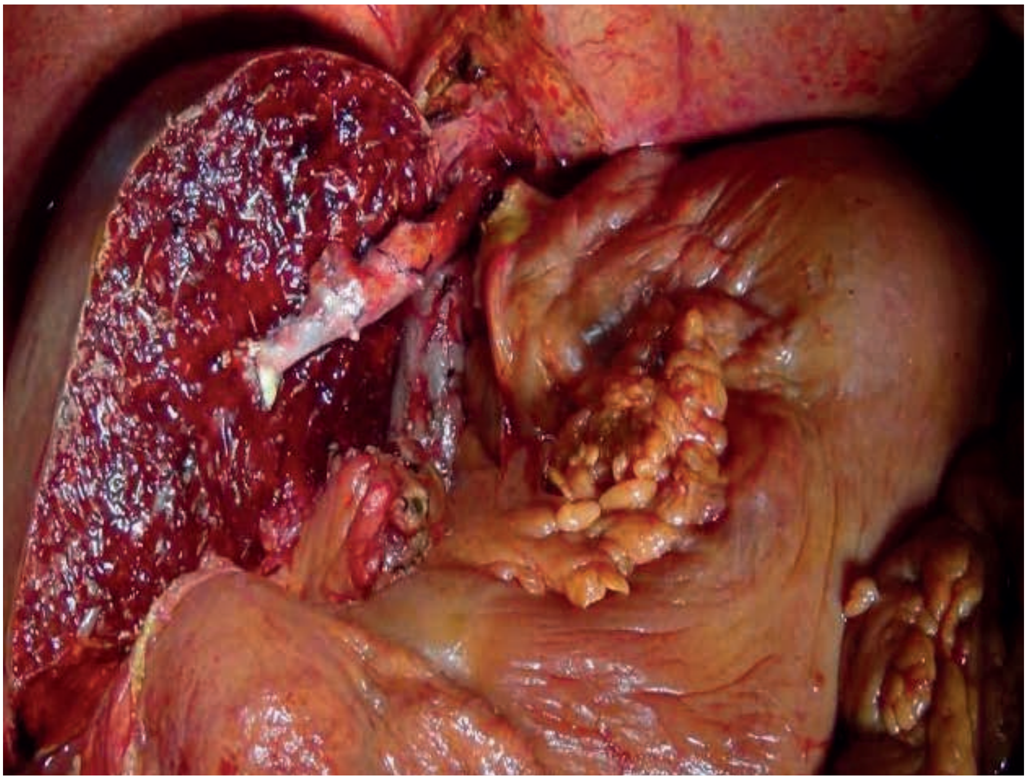

Figure 1. Reconstruction of the hepatic veins of segments 5 and 8 using the recipient's PV.

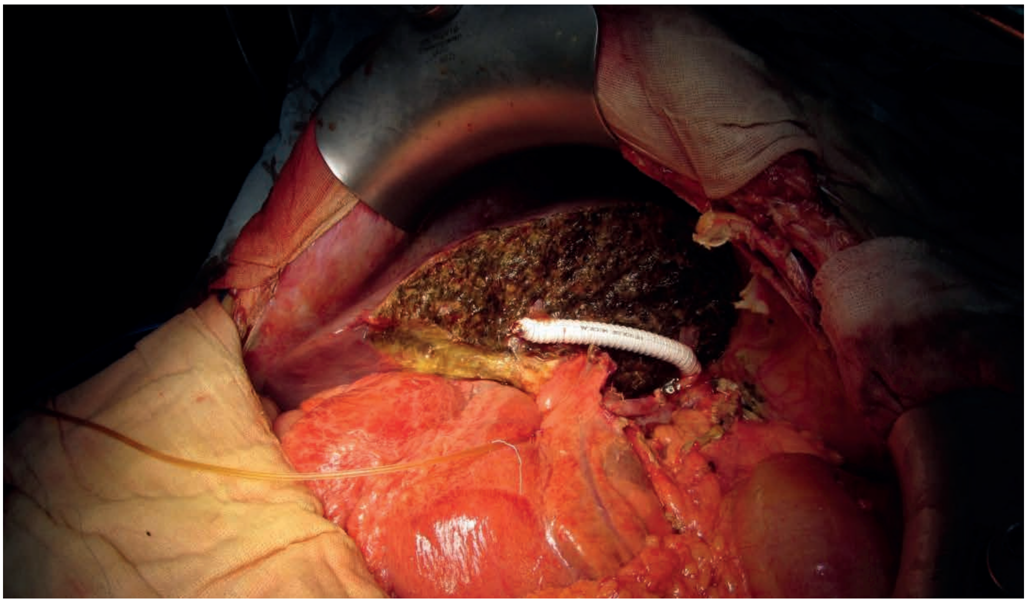

Figure 2.
Reconstruction of the hepatic veins of segment 5 using a vascular prosthesis.

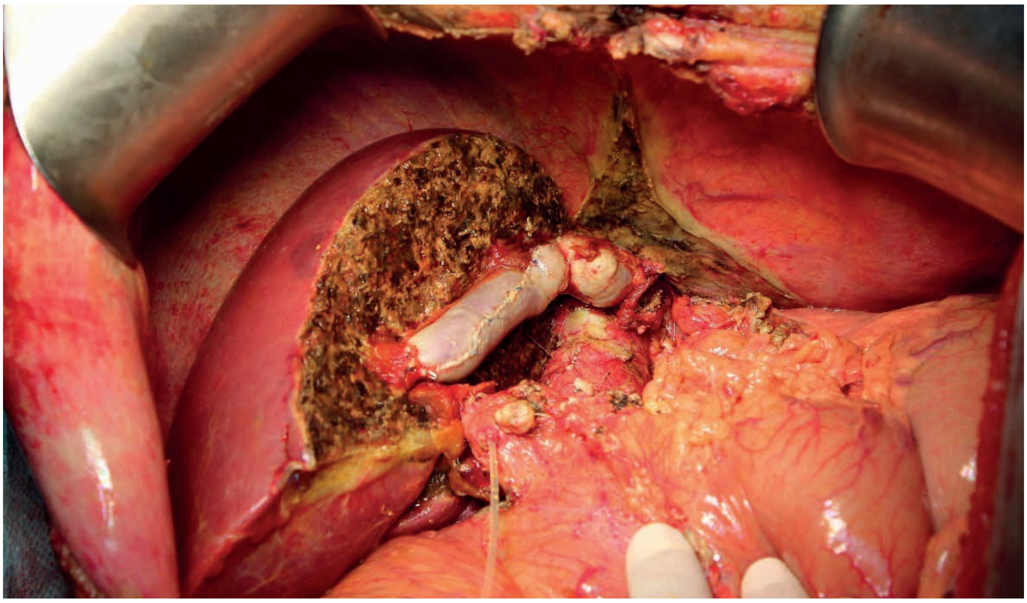

Figure 3.
Reconstruction of the hepatic veins of segments 5 and 8 using a modified GSV.

Eighty patients who underwent LDLT due to end-stage liver disease were included in our study. Their demographic, operative, and intraoperative data are presented in Table 1.

Table 1.
General and clinical Characteristics

Character-istics	Reconstruction with		t-statistic	Chi-squared	95%CI	P value
	a bio graft n=69	a vascular prosthesis n=11				
Age (years)	43.1±8.5	49.4 ±8.7	2.276 [α]	-	[0.7;11.8]	0.026*
Gender (%)						
Male	33 (41.3%)	5(6.3%)	-	2.230 [β]	[11.3;52.8]	0.135
Female	36(45.0%)	6(7.5%)	-	2.951 [β]	[5.2;54.8]	0.086
MELD	17.5±4.9	20.0±3.6	1.620	-	[0.5;5.6]	0.109
Ischemia (min)						
Cold	87.8±46.1	105.1±45.9	1.157	-	[12.5;47.1]	0.251
Thermal	37.8±16.7	35.0±14.6	0.524	-	[13.4;7.8]	0.602

GRWR	1.07 ± 0.15	1.08 ± 0.17	0.202	-	[0.09;0.1]	0.841
Duration of the operation (min)	766.7 ± 107.3	827.2 ± 128.8	1.684	-	[11.0;132.0]	0.096
Volume of blood loss (ml)	2411.5 ± 1388.02	2972.7 ± 1627.3	1.216	-	[357.3;1479.7]	0.227
Graft weight	706.6±105.6	690.2±99.4	0.482	-	[84.1;51.3]	0.631
Reconstruction HV5	19 (23.8%)	5 (6.3%)	-	0.722	[28.3;40.7]	0.396
Reconstruction HV8	16 (20.0%)	2 (2.5%)	-	0.348	[48.7;41.9]	0.556
Reconstruction HV5 and HV8	34 (42.5%)	4 (5.0%)	-	2.069 ß	[13.6;54.7]	0.150
Post-op period (days)	28.7±13.7	40.7±13.7	2.698 α	-	[3.1;20,8]	0.008*

α: The value relative to the degree of freedom corresponds to a significance level <0.05;
ß: The observed frequency distribution is significantly different from its expected frequency distribution; *Statistically significant difference P≤0.05

The risk of in-hospital mortality in the second group with a vascular prosthesis was 3 (3.8%), which is not significantly higher than in the first group with a biological graft, which was 13 (16.3%), OR = 1.62, 95% CI [0.3; 6.9], P value = 0.519. The risk of postoperative complications in the second group with a vascular prosthesis was 5 (6.3%), which was the same as in the first group with a biological graft - 28 (35.0%), OR = 1.22, 95% CI [0.3; 4.4], P value = 0.761.

The chance of impaired blood flow based on control studies using Doppler ultrasound and CT angiography within 7 days in the second group with a vascular prosthesis was 2 (2.5%), which is twice as high as in the first group with a biological graft 6 (7.5%), OR = 2.333, 95% CI [0.4; 13.4], P value = 0.342.

The assessment of the chance of absent blood flow according to the control Doppler ultrasound and CT angiography data after 7 days also showed that in the second group with a vascular prosthesis, the rate was 3 times higher - 1 (1.3%), compared to the first group with a biological graft 2 (2.5%), OR = 3.350, 95% CI [0.3; 40.4], P value = 0.341.

Discussion

Transplantation of the right hepatic lobe is the most commonly performed procedure for LDLT. This procedure is believed to provide a greater likelihood of obtaining a sufficient volume of functioning graft compared to the left lobe graft, which is typically smaller in size. There are two types of RL grafts: the first is the RL graft without the main MHV.[9] The second is with the main MHV (known as the extended right lobe graft).[10] When choosing the type of graft, the main criterion is that its functional volume must be adequate to meet the metabolic needs of the recipient. A consensus has been reached regarding a standardized methodology for obtaining the RL graft, which includes preserving the MHV in the donor for safety, provided that the expected volume of the donor's remaining liver is considered sufficient (preferably more than 35%).[11] However, transplantation of the RL of the LDLT without the main MHV can lead to congestion of segments 5 and 8 of the graft or the right anterior sector due to impaired outflow, which raises certain concerns.[12]. Grafts without the main MHV that are larger in size are more susceptible to damage or small graft syndrome under congestive conditions. Even with an adequate RL GRWR, ideally exceeding 0.8, a non-functioning area of the right anterior sector may require further assessment prior to surgery.[13]

The transplantation of the right hepatic lobe without reconstruction of the HV of segments 5 and 8 may lead to early graft dysfunction, resulting in hemodynamic disturbances, increased levels of liver parameters, and insufficient liver regeneration. To prevent congestion in the anterior sectors, several technical modifications have been developed. The Toronto team described a case demonstrating the reconstruction of partial MHV using the recipient's renal vein as a bridging graft to the IVC.[14,15] *The Asan Medical Center group in Korea* has made the most significant contribution to expanding the application of RL graft while simultaneously enhancing donor safety. In their landmark study, Lee and colleagues were the first to address the problem of anterior sector overload and its impact on graft function.[15] They also described the clinical implications of this phenomenon for the recipient and potential solutions, including the use of intermediate vascular grafts for the anterior sector, namely the reconstruction of HV V5-V8, known as «modified RL».[16]

For the reconstruction of HV, various types of autologous and homologous venous grafts were used depending on availability, as recommended for this type of venous reconstruction (e.g., internal iliac vein, umbilical vein, internal jugular vein, renal vein, PV, aorta and its branches, as well as IVC, etc.).[17,18] Additionally, the use of vascular prostheses is well-established. Synthetic vascular grafts have their unique features, advantages, disadvantages, and patency rates: 72.4% at one week, 42.1% at three months, and 24.1% at twelve months[15] Preoperative planning is critical as it ensures easy access to native or prosthetic grafts during the surgery.

Lee et al. in their study compared two groups, depending on the material used for reconstructing the drainage of the anterior sector, using biological grafts n = 252 (recipient's veins, recipient's arterial grafts, vessels from post-mortem donors) versus synthetic grafts n = 177 (vascular prostheses). The patency rate in the first group after one week was 61.9%, and after three months was 46.8%. In the second group, the patency rate after one week was 72.4% and after three months was 42.1%.[15] The study by Li et al. showed that synthetic grafts had better early patency (at one week), but after three months, the patency turned out to be lower than that of biological grafts. *Durairaj et al.* also compared two groups, one using the recipient's PV n = 62 and the other using vascular prostheses n = 60. The patency rate in the first group after two weeks was 93.5% and after three months was 85.5%; in the second group, it was 90% after two weeks and 81.7% after three months.[19] In our study, the patency rate using biological grafts was 91.4% after one week and 88.6% after two weeks, while the patency rate for vascular prostheses was 81.9% after one week and 72.8% after two weeks. Our study demonstrates that the use of biological grafts shows a significantly higher level of patency compared to grafts made from synthetic materials.

It is currently widely accepted that all HV of segments 5 and 8 with a diameter greater than 5 mm should be reconstructed.[20] If there are multiple veins V5 or V8, neighboring tributaries may be combined into a single orifice. It could also be assessed during the donor operation after the clamping of the artery and the corresponding hepatic vein, resulting in the formation of a dark zone of blood accumulation at the drainage site. When performing reconstruction using both native and prosthetic grafts, with careful surgical technique, early patency rates (within 1 month) range from 80% to 100%, which is critical for graft regeneration.[2] Long-term patency of intermediate grafts for hepatic veins V5 and V8 is not a major concern, as late graft occlusion typically has limited clinical consequences.[21]

Limitations: This cross-sectional analysis was conducted mainly based on the results of a retrospective analysis, however, a long-range analysis requires a wide coverage of patients before and after liver transplantation from a living donor for prospective material collection and data analysis.

What's known? Reconstruction of the hepatic veins of segments 5 and 8 of the right lobe liver transplant requires precise execution of the surgical technique. Venous outflow directly affects the function of the graft and the general condition of the recipient. Adequate reconstruction of the hepatic veins determines the outcome of the right lobe liver transplant.

What's new? The results of the reconstruction of the use of a vascular prosthesis or with a bio graft depend on factors such as age, time of cold ischemia and MELD, which affects the risk of impaired blood flow in the transplant in the early and late postoperative periods.

Conclusion

Taking into account that this study recorded a higher patency rate of biological grafts compared to vascular prostheses, we believe that biological grafts should be considered the preferred option for reconstruction using neo-MHV during RL liver transplantation from a living donor. The higher patency rate of biological grafts compared to vascular prostheses may indicate better functional outcomes and a lower incidence of complications. Larger studies are required.

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