Comparative study for the outcome of living donor liver transplantation in patients with portal vein thrombosis in comparison to patients without portal vein thrombosis

Original Article

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ABSTRACT

Background: Portal vein thrombosis (PVT) is a relative contraindication in living donor liver transplantation (LDLT). We monitored the outcome of adult patients with PVT in comparison to patients without PVT in LDLT..

Methods: This study is a retrospective cohort study. LDLTs that were performed at Liver Transplantation Unit in Air Forces Hospital and Nasser Institute, between January 2016 and June 2022 were evaluated. 176 cases were divided into two groups according to the presence of PVT, group A included 55 recipients who had PVT compared with group B including 121 recipients without PVT..

Results: In our study (N = 176), postoperative PV complications was recorded in 11 (6.3 %) cases. Five case in each group had postoperative PVT (9.8 % vs. 4.1 %), respectively and a single case of PV stenosis (0.8 %) was documented in non-PVT group. All patients who develop early postoperative PV (n = 3/10) complications unfortunately died because of it, unlike those who developed late PV complications, their 1 year survival rate was 70 % of cases and the overall mortality rate in patients developed PV complications was 40 %.

Conclusion: PVT is established not to be a contraindication for LT but needs complex procedures and sophisticated techniques and Surgeons should be aware of these techniques to restore adequate portal flow in transplant for recipients with PVT.

Keywords: Liver transplantation, living donor, portal vein thrombosis, reconstruction, survival, thrombectomy.

Received: 05 March 2024, **Accepted:** 18 March 2024, **Publish:** 07 July 2024

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ISSN: 1110-1121, July 2024, Vol. 43, No. 3: 988–999 © The Egyptian Journal of Surgery

INTRODUCTION

Recently, liver transplantation (LT) was settled to be a real breakthrough in surgery as the only curable treatment to deal with fatal liver diseases. Living donor liver transplantation (LDLT) as a treatment for end-stage liver disease (ESLD) is the only available option in Egypt owing to the inactive deceased donor program[1].

Due to the intricacy and surgical difficulties of the transplant process, portal vein thrombosis (PVT) was regarded as a strict contraindication for LT until the early 1980s[2]. According to reports, people who were assessed or had liver transplants had a 5 – 26 % incidence of PVT. Within a year, de novo PVT was detected in 7.5 – 8.5 % of the individuals on the transplantation list[3].

Short-term graft outcomes after LDLT have improved significantly after refining the graft selection process and progress in surgical approaches[4].

In order to ensure that the liver graft receives enough portal vein (PV) flow for optimal function after transplantation, novel surgical techniques have been developed for recipients with PVT. These techniques include nonphysiological PV reconstruction (cavoportal hemitransposition, renoportal anastomosis and arterialization of PV flow) as well as physiological PV reconstruction (thrombectomy, interposition venous grafts and mesoportal jump grafts)[5]. As a result, individuals who have PVT are no longer delisted from LT. Nonetheless, there is ongoing discussion over the best PV reconstruction for patients with PVT in LT.

DOI: 10.21608/EJSUR.2024.274273.1008

AIM

Our center has not considered PVT a relative contraindication since 2015, whether mild or severe. Our current study aimed to compare the outcome of patients with and without PVT as a primary outcome. Secondary outcomes of the study included morbidity in patients with and without PVT after LDLT and risk factors of mortality after LDLT to patients with PVT.

PATIENT AND METHOD

Study design

The current study is a retrospective cohort study. During this study, LDLTs that was performed at Liver Transplantation Unit in Air Forces Specialized Hospital and Nasser Institute for Research and Treatment, Cairo, Egypt, between January 2016 and June 2022 were evaluated and included in the cohort study.

All recipients of LDLT were divided into two groups according to the presence or absence of PVT. The severity of PVT is defined according to the Yerdel's classification (Table 1). Group B includes patients with PVT diagnosed preoperatively by ultrasound (US) duplex or computed tomography (CT) portography or diagnosed intraoperatively.

All patients underwent evaluation and preparation for the surgery according to the center protocol. During evaluation, any patient diagnosed with malignant PVT was excluded from the transplant program. The anatomy of the vessels of the liver and the grading pf PVT if present was confirmed using noninvasive contrast-enhanced CT angiography or magnetic resonance imaging was also performed in patients with renal dysfunction or a contraindication to the contrast medium used in CT and biliary anatomy was assessed using MRCP.

All patients above 18 years old eligible for LDLT with RLG without middle hepatic vein (MHV), fulfilling the criteria of transplantation according to the center protocol and approved by the transplantation multidisciplinary committee were included.

Pediatric transplants as well as patients with grade VI PVT according to the Yerdel's classification were excluded from the study. Patients who underwent double organ transplants (liver and kidney) and dual liver transplants were also excluded.

The recipients' age, sex, blood type, hepatopathy, preoperative laboratory and imaging test results, diagnosis of hepatocellular carcinoma, model for end-stage liver disease (MELD) score, Child–Pugh score, BMI and graft to recipient weight ratio (GRWR) were abstracted. Intraoperatively variables and reports of surgical procedures included the following: warm ischemia time, cold ischemia time and operative time, intraoperative blood loss, successful thrombectomy, collateral ligation, number of bile ducts, method of reconstruction and intraoperative duplex reading were recorded.

Postoperatively outcome included the following: postoperative duplex reading, morbidity (Hepatic artery thrombosis, recurrent PVT, biliary leak or stricture), postoperative laboratory trends and postoperative complications. The electronic medical records (clinical and follow-up information) of the study sample were used to collect the data of the control retrospective group (B) and there were no missing data and prospectively maintained in transplant databases in both centers. The complication experienced by each patient was recorded according to the Clavien–Dindo classification.

All interventions were done by a team of surgeons with experience in hepatobiliary and liver transplant surgery. All authors are surgeons and all contributed to the study. The last two authors are staff surgeons with special dedication to hepatobiliary surgery and LT and have more than 18 years of experience. At least one of them was always present at the interventions. PV thrombectomy and reconstruction were done by these two surgeons throughout the whole study.

Ethics

Informed consent was obtained from every recipient before recruitment in the study and after explaining the purpose and procedures and use of anonymized patient data for scientific purposes were taken. The approval from the ethical committees of both institutes as well as the approval of the supreme committee of organ transplant, MOH, Egypt was taken case by case.

The study was approved from the research ethics committee at Faculty of Medicine, Ain Shams University and General Surgery department has approved your study protocol from the ethical point of view. The Faculty of Ain Shams University, General Surgery Department research ethics committee is organized and operated according to guidelines of the international council on harmonization (ICH) and Islamic organization for medical sciences (IOMS). The United States Office for human research protection and United States code of Federal Regulations operates under federal-wide assurance No.IRB-0006379.

Before LDLTs, all patients were informed at local transplant boards of potentially increased risks owing to preexisting PVT if the patient had PVT in the preoperative imaging studies.

Treatment and procedures

All recipients preoperatively diagnosed with PVT were evaluated. The use of low molecular weight heparin as a prophylactic treatment was not used routinely at both centers.

During the recipient hepatectomy, after the caudal dissection of the PV as much as possible, the connective tissues around the PV were dissected as low as possible up to the upper margin of the pancreas and cutting the PV distally, the PV lumen was carefully observed and loose thrombi were removed. By opening the portal clamp, the portal flow was observed and evaluated subjectively.

As many cases of PVT are discovered intraoperatively at time of transplantation, eversion thrombectomy (Figure 1) is the standard technique for removal of PV thrombus at time of transplant.

Figure 1: Eversion thrombectomy.

The PV will be transected high in the hilum and the walls will be grasped with tonsil clamps. Gentle traction will be applied to the edge of the thrombus with a clamp and a plane between the thrombus and vessel endothelium will be gently developed.

During thrombectomy, the middle finger of the left hand of the surgeon is used to push the PV against the pancreas to control the inflow allowing the surgeon to dissect the thrombus more deeply and offering better control of bleeding during thrombectomy than applying a vascular clamp beside offering a tactile sense of the thrombus.

In some cases, with a well-organized, chronic thrombus densely adherent to the vessel wall, the intima will be also separated from the media of the vein wall. In situations where the thrombus cannot be completely removed, it might require sharp transection once the obstructive segment has been freed.

After completion of the thrombectomy, PV was gradually dilated using Hegar dilators size 12 especially if we found stenosis in the PV trunk above the confluence of the splenic vein and to insure complete thrombus removal.

The PV should be flushed at the completion of the thrombectomy to assess inflow and eliminate residual fragments of thrombus. An end-to-end anastomosis between donor and recipient PV may then be performed.

Duplex is used to quantify velocity through the reconstructed vein. If velocity is inadequate, portal venous velocity may be further improved with ligation of a pre-existing spontaneous portosystemic shunt or a large collateral vessel (eg, splenorenal shunt or coronary vein). PV pressure monitoring was not done routinely for all patients specially if the intraoperative PV velocity is below 120 cm/s and when the PV pressure read greater than or equal to 20 mmHg, PV modulation was carried out accordingly.

Also if the portosystemic shunts such as splenorenal shunts, gastroesophageal shunts and mesocaval shunts are identified on preoperative imaging, these collateral vessels are interrupted to prevent blood from being redirected away from the transplant.

In some cases, extraction of the thrombus may only be possible by PV resection: excision of the thrombus with a portion of the PV. Thrombectomy is unlikely to be a feasible option if the PV is a fibrotic remnant with cavernous transformation or if the thrombus is completely occlusive and involves the splenic-superior mesenteric vein (SMV) confluence. Other sources of inflow must be considered in these circumstances.

If more proximal mesenteric venous tributaries are patent (SMV or SMV branch), then a jump (interposition) graft may be performed to the donor PV. Choice of graft material was a synthetic ringed vascular graft (eg, polytetrafluoroethylene (PTFE)) (Figure 2) or The Contegra Conduit (Figure 3) which is a bovine jugular vein preserved in buffered glutaraldehyde. The conduit is rinsed per instruction using an isotonic saline solution and in our situation the pulmonary valves have to be removed before usage (Medtronic, Minneapolis, USA).

Figure 2: Polytetrafluoroethylene (PTFE).

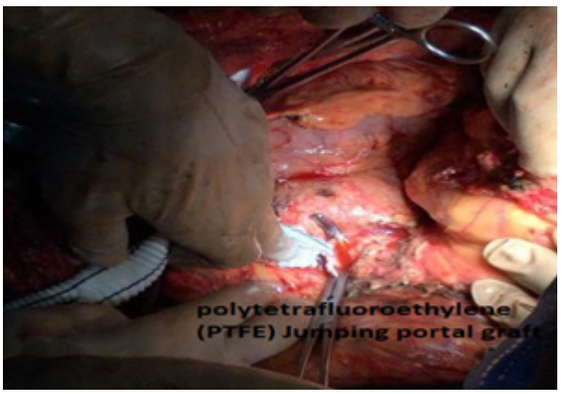

Figure 3: The Contegra Conduit.

The postoperative vascular patency was checked routinely daily postoperative for the first week and twice weekly thereafter using Doppler ultrasound and if vascular insufficiency was suspected, a computed tomography with angiographic reconstruction was performed.

All recipients regardless the presence of PVT or not had to receive prophylaxis acetylsalicylic acid 81 mg/day as long as the platelet count is above 30 000 platelets per microliter and we prefer to delay the low molecular weight heparin in patients with PVT to be started after stabilization of the patient if there was no evidence of bleeding and INR below 2.5 and to be started at prophylactic dose and continued for 6 months postoperative or if the portal velocity dropped below less than 20 cm/s any time through the postoperative course.

When we find a partial recurrence of PVT, continuous venous administration of heparin is started, aiming the value of APTT as twice the control and if complete PVT the patient was immediacy explored. After stabilization of the condition anticoagulation was tailored individually either by low-molecular-weight heparin or oral anticoagulants.

Follow-up

All patients were followed-up for at least 6 months; during the hospital stay daily laboratory and radiological assessment was done during the first 2 weeks then twice weekly until discharge. After discharge, follow-up was scheduled once weekly for the first three months then once monthly for the following 3 months then every 3 months afterwards. Patients were asked every visit postoperatively for abdominal ultrasound and duplex together with routine laboratory data and immunosuppressive drug level. Follow-up contrast-enhanced CT with angiography was done only if necessary and as a part of the complete workup 12 months after LDLT or based on the patient's condition. The day of final follow-up was January 31st, 2021.

Statistical analysis

Recorded data were analyzed using the statistical package for social sciences, version 23.0 (SPSS Inc., Chicago, Illinois, USA). The quantitative data were presented as mean ± SD and ranges when their distribution was parametric (normal) while non-normally distributed variables (nonparametric data) were presented as median with inter-quartile range (IQR). Also, qualitative variables were presented as number and percentages. Data were explored for normality using Kolmogorov–Smirnov and Shapiro–Wilk Test.

The following tests were done:

(a) Independent-samples t-test of significance was used when comparing two means and Mann–Whitney U test: for two-group comparisons in nonparametric data.

(b) The Comparison between groups with qualitative data was done by using χ^2 test and Fisher's exact test instead of χ^2 test only when the expected count in any cell is less than 5.

(c) The confidence interval was set to 95 % and the margin of error accepted was set to 5 %. So, the P value was considered significant as the following:

Probability (P value)

a) *P* value less than or equal to 0.05 was considered significant.

b) *P* value less than or equal to 0.001 was considered as highly significant.

c) *P* value greater than 0.05 was considered insignificant.

RESULTS

As our center started the LDLT program in 2015, we had sufficient data to analyze the risks and outcomes of transplanting hepatic patients with pre-existing PVT. Therefore, we designed this study accordingly. Between January 2016 and June 2022, we performed 227 cases of LDLT grafts. We excluded 85 recipients due to the

following: 47 pediatric cases, 3 cases of dual liver graft and a single case that underwent a domino liver transplant. All patients were finished at least 6 months of follow-up.

We aimed our study to determine if the pre-existing PVT, as an added risk factor in the LDLT procedure, increases the risk of postoperative mobility and mortality. We applied our study to 176 patients who were divided into two groups: pre-existing PVT group and the non-PVT group where the outcome of LDLT was compared between two groups while controlling for patient characteristics.

The two groups were comparable in age with the Mean ± SD in each of the pre-existing PVT group and non-PVT group was 56.04 ± 8.67 compared with 53.75 ± 11.19, respectively (Table 1), as there was no statistically significant difference between the groups with *P* value (*P* = 0.193).

Sex description also showed comparable (Table 1), in pre-existing PVT group were 46 (83.6 %) male patients and nine (16.3 %) female patients compared with non-PVT group 96 (79.3 %) patients and 25 (20.6 %) patients were male and female, respectively, there was no statistically significant difference between the groups with P value (*P* = 0.186). While, there was no statistically significant difference between groups according to weight (kg), BMI, blood group, MELD, Child class and score and patients underwent splenectomy before transplant with *P* value (*P* > 0.05).

The majority of patients were HCV (65.4 %) in pre-existing PVT group (n = 36) compared with (61.1 %) in non-PVT group (n = 74), followed by HCC was (34.5 %) in pre-existing PVT group (n = 19) compared with (42 %) in non-PVT group (n = 42), then cryptogenic was (23.6 %) in pre-existing PVT group (n = 13) compared with (19.8 %) in non-PVT group (n = 24), there was no statistically significant difference between groups, with *P* value (*P* > 0.05 NS) (Table 1).

Table 1: Preoperative patients' demographic data of the pre-existing portal vein thrombosis group and non- portal vein thrombosis group:

	PVT group N = 55	Non-PVT group N = 121	Test value	*P* value	Significance
Sex					
Female	9 (16.3)	25 (20.6)	1.748	0.186	NS
Male	46 (83.6)	96 (79.3)			
Age (years)					
Mean ± SD	56.04 ± 8.67	53.75 ± 11.19	1.71	0.193	NS
Range	16 – 71	20 – 75			
Etiology (n, %)					
HCV[1]	36 (65.4)	74 (61.1)	0.745	0.388	NS
HCC[2]	19 (34.5)	42 (34.7)	0.031	0.860	NS
Cryptogenic	13 (23.6)	24 (19.8)	0.801	0.371	NS
HBV[3]	3 (5.4)	6 (4.95)	0.089	0.765	NS
Autoimmune	4 (7.2)	6 (4.95)	0.067	0.796	NS
NASH[4]	2 (3.6)	6 (4.95)	0.067	0.796	NS
PBC[5]	1 (1.8)	4 (3.30)	0.187	0.796	NS
BCS[6]	3 (5.4)	1 (0.82)	2.062	0.151	NS
PSC[7]	0	3 (2.47)	1.238	0.266	NS
CHF[8]	1 (1.8)	1 (0.82)	0.455	0.500	NS
Alcoholic	0	1 (0.82)	0.408	0.523	NS
Caroli's Syndrome	0	1 (0.82)	0.408	0.523	NS
Coeliac disease	0	1 (0.82)	0.408	0.523	NS
Fulminant Failure	0	1 (0.82)	0.408	0.523	NS
Hemochromatosis	0	1 (0.82)	0.408	0.523	NS
Hyperoxaluria	0	1 (0.82)	0.408	0.523	NS
Wilson disease	0	1 (0.82 %)	0.408	0.523	NS
Child classification					
A	10 (18.18)	20 (16.52)	0.684	0.623	NS
B	25 (45.45)	50 (41.32)	0.598	0.579	NS
C	20 (36.36)	51 (42.14)	0.611	0.711	NS
Child score					
Mean ± SD	8.92 ± 2.18	9.11 ± 2.37	0.246	0.620	NS
Range	5 – 15	5 – 15			
MELD					
Mean ± SD	15.24 ± 5.09	15.61 ± 5.33	0.183	0.670	NS
Range	8 – 28	6 – 33			
Splenectomy (n, %)	4 (7.2)	2 (1.6)	0.364	0.547	NS

Using: t-Independent Sample t-test for Mean ± SD.
Using: χ^2: Chi-square test for Number (%).
P value greater than 0.05 is insignificant; *P* value less than 0.05 is significant; *P* value less than 0.001 is highly significant.
[1]Hepatitis C virus. [2]Hepatocelluar carcinoma. [3]Hepatic B virus.
[4]Nonalcoholic steatohepatitis. [5]Primary biliary cirrhosis.
[6]Budd Chiari syndrome. [7]Primary sclerosing cholangitis.
[8]Congenital hepatic fibrosis.

Table 2 showed that according to operative characteristics in pre-existing PVT group, it was mean of GRWR (0.97 ± 0.77); operative time (hrs.) (8.89 ± 1.73); blood loss (1633.3 ± 871). While in non-PVT group, the mean of GRWR (0.86 ± 1.31); operative time (h) (8.95 ± 2.04); blood loss (1572.8 ± 951.6) and it showed no statistically significant difference in the operative data ($P > 0.05$). As for the mean PV velocity (cm/sec) in pre-existing PVT group was 67.94 ± 28.02 for the patients group compared with 71.71 ± 25.12 for the non-PVT group; there was no statistically significant difference between groups, with *P* value ($P = 0.389$).

Table 2: Operative characteristics and outcomes of the pre-existing group and non- portal vein thrombosis portal vein thrombosis group:

	PVT group N = 55	Non-PVT group N = 121	Test value	*P* value	Significance
Type of Graft (n, %)					
Left lobe	3 (%)	10 (%)	0.684	0.623	NS
Right lobe	50 (%)	110 (%)	0.598	0.579	NS
Right lobe +MHV1	2 (%)	1 (%)	0.611	0.711	NS
Operative time (h)					
Mean ± SD	8.89 ± 1.73	8.95 ± 2.04	0.032	0.859	NS
Range	6.3 – 16	5.3 – 15.4			
GRWR[2]					
Mean ± SD	0.97 ± 0.77	0.86 ± 1.31	0.007	0.934	NS
Range	0.7 – 1.5	0.71 – 2.4			
Collateral ligation (n, %)	2 (3.64)	1 (0.83)	3.234	0.072	NS
PV anastomosis (n, %)					
LPV to MPV	3 (5.5)	10 (8.3)	0.745	0.233	NS
RPV to MPV	45 (81.8)	108 (89.3)	0.031	0.698	NS
Others[3]	7 (12.7)	3 (2.4)	0.801	0.045	S
PV velocity (cm/s)					
Mean ± SD	67.94 ± 28.02	71.71 ± 25.12	0.744	0.389	NS
Range	23 – 150	23 – 140			
Blood loss (ml)					
Mean ± SD	1633.3 ± 871	1572.8 ± 951.6	0.153	0.696	NS
Range	300 – 5000	127 – 5000			
Blood products transfusion (n, %)	39 (76.5)	92 (74.2)	0.100	0.752	NS
ICU stay (days)					
Mean ± SD	7.88 ± 4.82	7.44 ± 4.15	0.364	0.547	NS
Range	1 – 29	3 – 30			
Hospital stay (days)					
Mean ± SD	24.20 ± 12.45	24.39 ± 14.76	0.007	0.934	NS
Range	1 – 73	2 – 89			

Using: t-Independent Sample t-test for Mean ± SD.
Using: χ^2: Chi-square test for Number (%).
P value greater than 0.05 is insignificant; *P* value less than 0.05 is significant; P value less than 0.001 is highly significant.
[1]Middle hepatic vein.
[2]Graft recipient weight ratio
[3]Other = either anastomosis using a graft or right anterior and posterior PV with venoplasty.

On stratifying the classification and treatment of the pre-exciting PVT used (Table 3), two cases with pre-exciting PVT received no treatment as the thrombus was intrahepatic and removed with the explanted liver. Thrombectomy was a successful option of treatment in 87.4 % of cases; 35 cases (94.6 %, n = 35/37) were grade I, 7 (100 %) cases were grade II and 6 cases (54.5 %, n = 6/11) were grade III. Five cases with PVT grade III were treated with a jump graft; 2 cases (3.6 %, n = 2/55) with mesoportal synthetic vascular graft, a single case (1.8 %, n = 1/55) with mesoportal Contegra graft and 2 cases (3.6 %, n = 2/55) with cavoportal Contegra graft.

Table 3: Classification and treatment of the pre-exciting portal vein thrombosis:

Treatment	Grade I n = 37/55	Grade II n = 7/55	Grade III n = 11/55	Total n = 55
No treatment (n, %)	2/37 (5.4)	0	0	2 (3.6)
Thrombectomy (n, %)	35/37 (94.6)	7 (100)	6/11 (54.5)	48 (87.4)
Mesoportal synthetic vascular graft (n, %)	0	0	2/11 (18.2)	2 (3.6)
Mesoportal Contegra graft (n, %)	0	0	1/11 (9.1)	1 (1.8)
Cavoportal Contegra graft (n, %)	0	0	2/11 (18.2)	2 (3.6)
Total (n, %)	37/55 (67.3 %)	7/55 (12.7)	11 (20)	55

Using: χ^2: Chi-square test for Number (%).

In our study (N = 176), postoperative PV complications was recorded in 11 (6.3 %) cases. Five case in each group had postoperative PVT (9.8 % vs. 4.1 %), respectively and a single case of PV stenosis (0.8 %) was documented in non-PVT group. In subanalysis of this group of patients with postoperative PVT (Table 5) all patients with jump grafts passed smoothly post-transplant except in patient with a mesoportal synthetic graft who developed PVT after 2 years and was managed with anticoagulation and he is alive and well. Anticoagulation was the treatment of choice in 70 % of cases (n = 7/10) with postoperative PVT and the rest of the patients (30 %) underwent exploration and PV thrombectomy, one of them also had resection of gangrenous intestine and ileostomy. All patients who developed early postoperative PV (n = 3/10) complications unfortunately died because of it, unlike those who developed late PV complications, their 1 year survival rate was 70 % of cases (n = 7/10) and the overall mortality rate in patients who developed PV complications was 40 %, 4 out of 10 cases.

Table 5: Patients with post-transplant Portal vein complications:

Case	Graft	Grade	Reconstruction	Complication	Time	Treatment	Outcome
1	RLG[1]	No PVT	RPV to MPV	Post-transplant PVT	5 months	Anticoagulation	Alive
2	RLG	No PVT	RPV to MPV	Post-transplant PVT	7 months	Anticoagulation	Alive
3	RLG	No PVT	RPV to MPV	Post-transplant PVT	3 years	Anticoagulation	Died POD 1125
4	RLG	Grade I	RPV to MPV	Post-transplant PVT	6 months	Anticoagulation	Alive
5	RLG	No PVT	RPV to MPV	Post-transplant PVT + PV stenosis	8 months	Anticoagulation	Alive
6	RLG	No PVT	RPV to MPV	Post-transplant PVT	4 months	Anticoagulation	Alive
7	RLG	Grade III	Mesoportal synthetic graft	Post-transplant PVT	2 years	Anticoagulation	Alive
8	RLG	Grade III	RPV to MPV	Post-transplant PVT	4 day	Exploration and PV thrombectomy	Died POD 5
9	RLG	Grade I	RPV to MPV	Post-transplant PVT	2 day	Exploration and PV thrombectomy + resection of gangrenous intestine + ileostomy	Died POD 3
10	RLG	Grade I	RPV to MPV	Post-transplant PVT	13 day	Exploration and PV thrombectomy	Died POD 14

1Right liver graft.

The 1-year survival (Table 6) in the whole study was 80.7 % with no statistical difference between the two groups 76.4 % (n = 42) and 82.6 % (n = 100), respectively with a *P* value of 0.369. The PV complication-related mortality was high significant in the pre-existing PVT group reaching 23.1 % (n = 3/13) with no related cases in non-PVT group (*P* = 0.000).

Table 6: Comparing 1 year survival between the pre-existing portal vein thrombosis group and non-portal vein thrombosis group according to the cause of mortality:

	PVT group N = 55	Non-PVT group N = 121	Test value	*P* value	
1 year survival	42/55 (76.4)	100/121 (82.6)	0.800	0.369	NS
Cause of mortality					
PVT related	3/13 (23.1)	0/21 (0.0)	12.301	0.000	HS
Non PVT related	10/13 (76.6)	21/21 (100)	1.010	0.315	NS

The highest postoperative complication (Table 7) recorded in both groups was BAS 23.6 % (n = 13) versus 19.8 % (n = 24) showing no statistically significant difference (*P* = 0.371). The only significant complication recorded was the postoperative sepsis being higher in the pre-existing PVT group (21.8 %, n = 12) compared with (8.3 %, n = 10) with a *P* value of 0.035.

Table 7: Postoperative complications between the pre-existing portal vein thrombosis group and non-portal vein thrombosis group:

	PVT group N = 55	Non-PVT group N = 121	Test value	*P* value	
Rejection (n, %)	4 (7.3)	4 (3.3)	0.455	0.500	NS
Biliary complication (n, %)					
BAS[1]	13 (23.6)	24 (19.8)	0.801	0.371	NS
Cholangitis	2 (3.6)	4 (3.3)	0.187	0.796	NS
Bile leakage	4 (7.3)	9 (7.4)	0.801	0.371	NS
HAT[2] (n, %)	2 (3.9)	2 (1.6)	0.862	0.353	NS
HV stenosis (n, %)	0	1 (0.83)	0.332	0.565	NS
Hemorrhage (n, %)	3 (5.5)	5 (4.1)	0.089	0.765	NS
Relapartomy (n, %)	6 (10.9)	8 (6.6)	0.067	0.796	NS
Sepsis (n, %)	12 (21.8)	10 (8.3)	4.565	0.035	S
AKI (n, %)	1 (1.8)	5 (4.1)	0.187	0.796	NS
DVT (n, %)	0	1 (0.83)	0.332	0.565	NS

Using: t-Independent Sample t-test for Mean ± SD.
Using: χ^2: Chi-square test for Number (%).
P value greater than 0.05 is insignificant; *P* value less than 0.05 is significant; *P* value less than 0.001 is highly significant.
[1]Biliary anastomotic stricture.
[2]Hepatic artery thrombosis.

DISCUSSION

The current investigation did not find a statistically significant difference in survival between individuals getting LDLTs who had PVT and did not. Adverse consequences from PVT include decreased hepatic function, ascites and bleeding from esophageal varices. LDLT of PVT patients is still a technically challenging process. Pre-exciting PVT incidence in the current research was 31.25 %, which is greater than in the majority of publications. In 2000, Yerdel[6] reported an incidence ranging from (4.02 – 12.6 %), whereas Kuriyama *et al*.[2] reported an incidence of 10.9 %. The policy of our center, which accepts patients with PVT and does not see it as a relative contraindication may explain this.

Since it was released in 2000, the Yerdel categorization of PVT has gained widespread acceptance and usage. Of the 55 individuals in the pre-exciting PVT group in the current study, 37 (67.3 %) had PVT known as grade I, 7 (12.7 %)

as grade II and 11 (20 %) as grade III. Yerdel Grades 1, 2 and 3 thrombosis cases have been successfully treated with eversion thrombectomy[7]. Dumortier *et al*. reported that 37 of the 38 PVT patients (Yerdel grade I/II in 36 and grade III in 2) underwent eversion thrombectomy and 37 of them (97.4 %) successfully restored their portal flow[8] but they added that this approach must be ruled out if the thrombosis extends to the SMV or if the PV is reduced to a fibrotic vessel remnant.

Song and colleagues, from Korea reported in 2016 that eversion thrombectomy is possible in all patients with success rate of 98 % (55/56) even cases with grade 3 PVT underwent successful thrombectomy[9].

In regard to recipient PV whom the diameter of PV is often too small for donor PV because of combined PV stenosis related to chronic organized thrombus or the quality of recipient PV wall is poor and paper thin from trauma during dissection and thrombectomy, interposition or jump grafts are to be considered[10].

In 1990, Burdick *et al*.[11] reported the first bridge graft (jump graft) using a donor iliac vein graft, which tunneled over the pancreas and under the stomach to the region of the liver hilum to provide portal inflow.

In our patients with grade 3 PVT, we used a mesoportal synthetic vascular graft in two patients, mesoportal Contegra graft in a single patient and cavoportal Contegra graft in two patients. According to our knowledge using the Contegra graft is an innovative surgical technique that was not previously reported for the treatment of recipients with PVT. We introduced if it is difficult to find appropriate vein grafts and reconstruct the PV in LDLTs than in deceased donor liver transplantation (DDLT), an option not available in Egypt. We faced three cases in which the recipient PV was not reconstructable either due to poor wall or failed to establish a good portal flow after thrombectomy. We overcome this by using a jump graft synthetic in 2 cases and Contegra graft in 1 case.

Care should be taken for coexistent sizable portosystemic collaterals, which might be the cause of portal flow steal and PV rethrombosis and result in failure of the implanted liver graft[10]. We did need to augment the portal flow by ligating the collaterals in three patients; two of which were in the pre-exciting PVT group guided by the portal pressure measurement and the PV velocity. This manoeuver failed to restore portal flow in two cases a condition solved by the use of cavoportal Contegra graft was used in these two cases.

According to a research conducted in Turkey in 2022 by Kirimker *et al*.[7], they advise using interposition grafts anastomosed to either a big collateral or a proximal SMV for physiological reconstructions. Nonphysiological reconstructions with renoportal anastomosis, cavoportal anastomosis or portal arterialization are further possibilities if physiological reconstruction techniques are unable to supply enough flow after establishing lack of portal steal through porto-systemic collaterals. According to Bonnet *et al*., there are three ways to sustain the transplanted lobe blood inflow: cavoportal hemitransposition[12], renoportal anastomosis[13] and arterialization of PV flow via a donor splenic artery[14]. Nevertheless, Hibi *et al*. found that nonphysiological PV reconstructions, as previously discussed, had worse long-term prognoses and were linked to increased complication rates[5].

Mori *et al*., recommended the use of the PV system, such as the PV, the SMV or even collateral vessels, for anastomoses with the PV of liver grafts, because portocaval hemitransposition and PV arterialization aims to supply nonanatomical blood to liver grafts without the influx of hepatotrophic factors from the intestines and the release of portal hypertension. He also described the use of the dilated left gastric vein as a collateral vein as an inflow using a vein graft in a side-to-end fashion then subsequently anastomosed to the PV as a last resort to save portal flow. In our study, we do not prefer to use the collaterlas as an inflow to the PV because of its thin wall and the unpredicted flow direction giving a high probability of steal phenomena to occur[15].

PV rethrombosis was recorded in 5 cases in each group (Table 4). All patients who revealed de novo PVT after LDLT were recoded late in the follow-up period (between 4 months and 3 years) and were treated with anticoagulation and are alive and well except one who died after 1125 days from other cause rather can PV related complication. Early rethrombosis (2, 4 and 13 days postoperative) was recorded in 3 cases in the pre-exciting PVT group and they died the next day following diagnosis. On the other hand, in the same group when late rethrombosis was diagnosed (6 months and 2 years) the outcome, the management plan and the outcome was similar to the non-PVT group. We also noticed that the PVT related morality was not related to the grade of the PVT confirmed and managed intraoperatively (Table 4).

Kirimker and colleagues compared the outcomes of patients with grade 1 PVT and higher grade PVTs and found that the survival was comparable and this is primarily related to the proper choice of treatments according to the degree of thrombosis[7].

The current study showed that the overall 1-year survival was nearly similar in both patients with or without pre-exciting PVT. This is due to the effectiveness of management plans bringing all grades of PVT to similar survival rates. Although the PVT related morality was highly significant between the two groups, still the number of patients three versus no mortality between the two groups respectively could not be considered a solid evidence.

In 2015, Xingshun *et al*. reported a systematic review and meta-analysis that found a decreased 1-year survival rate after LT in recipients with PVT, especially complete PVT[16]. However, they concluded that the detrimental effect of PVT on the survival of LT recipients was inconclusive among the high-quality studies.

When Hibi *et al.* compared the prognosis following LT between 1205 recipients without PVT and 149 recipients with PVT who underwent reestablished physiological portal inflow, they found that there were no appreciable differences in survival between complete and partial PVT as long as physiological portal flow was restored (1 year: 87 % vs. 82 %; 5 years: 74 % vs. 68 %)[5].

Regarding LDLT, Mori *et al.* found good survival rates in PVT patients and Yerdel grade I in 15, II in 20, III in 12 and IV in one patient with pre-existing PVT (n = 48) had post-transplant survival rates at 1 year and 5 years near to recipients without PVT (n = 234); (1 year: 81 % vs. 77 %; 5 years: 81 % vs. 73 %)[15].

Kuriyama *et al*. found that there was no statistically significant difference in the rates of posttransplant overall survival at 1 and 5 years between patients who had and did not have PVT (1 year: 78.6 % vs. 78.1 %; 5 years: 50.0 % vs. 65.0 %; P ¼.163)[2].

CONCLUSION

PVT is not an absolute contraindication for LT, though it demands technically a more difficult operation and advanced technique. Several techniques are available to reestablish sufficient portal flow in transplant recipients with PVT and surgeons should be familiar with these techniques. It is important to select the appropriate venous grafts and route to achieve successful PV reconstruction, resulting in a prognosis comparable to that of recipients without PV. We propose our innovative strategy using Contegra graft as the potential method for PV reconstruction in adult LDLT for patients with PVT.

LIMITATION

Our study had several limitations. This is a single-center study; therefore, the results may not be generalizable to other transplant centers. Second, our study is of a retrospective analysis, over a long period where we had to compare the results to a historical group of patients. Another limitation is the small sample size regarding the PV-related complications and method of reconstruction which limited the power of the study and hindered the statistical capacity to do multivariate a nalysis.

Table 4: Postoperative PV complications between the pre-existing portal vein thrombosis group and non- portal vein thrombosis group:

	PVT group N = 55	Non-PVT group N = 121	Test value	*P* value	Significance
Portal vein complication (n, %)					
Post-transplant PVT	5 (9.8)	5 (4.1)	0.223	0.135	NS
PV stenosis	0	1 (0.8)	0.408	0.523	NS

DEFINITION

Yerdel classification of portal vein thrombosis	
Grade 1	Minimally or partially thrombosed PV, in which the Thrombus is mild or, at the most, confined to less than 50 % of the vessel lumen with or without minimal extension into the SMV.
Grade 2	> 50 % occlusion of the PV, including total occlusions, with or without minimal extension into the SMV.
Grade 3	Complete thrombosis of both PV and proximal SMV. Distal SMV is open.
Grade 4	Complete thrombosis of the PV and proximal as well as distal SMV.

PV, portal vein; SMV, superior mesenteric vein.

CONFLICTS OF INTEREST

There are no conflicts of interest.

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