ORIGINAL ARTICLE

Complications of polytetrafluoroethylene graft use in middle hepatic vein reconstruction in living donor liver transplantation: a retrospective, single-centre, long-term, real-world experience

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SUMMARY

In living donor liver transplantation (LDLT) of the right lobe, polytetrafluoroethylene (PTFE) grafts may be used for anterior drainage. This study aimed to determine the risk factors of PTFE graft-associated complications. Data from patients who underwent LDLT of the right lobe with middle hepatic vein reconstruction using PTFE grafts between January 2005 and December 2012 were retrospectively reviewed. Among 360 patients, PTFE graft-associated complications occurred in 17 patients (group B) (4.7%); recipients without these complications comprised group A (95.3%). The 1-, 6- and 12-month patency rates were significantly lower in group B ($P < 0.001$, $P = 0.002$ and $P = 0.007$). In group B, eight patients (47.1%) required surgical intervention, three patients (17.6%) suffered from infectious complications, and 14 patients (82.4%) experienced PTFE graft migration into the adjacent organs, namely the common bile duct ($n = 3$, 17.6%), stomach ($n = 1$, 5.9%), duodenum ($n = 5$, 29.4%) and jejunum ($n = 5$, 29.4%). The proportion of recipients who underwent hepaticojejunostomy, had abdominal adhesions and received interventions in/around the liver after LDLT was higher in group B ($P < 0.001$). Although the incidence of PTFE graft-associated complication is low, close long-term follow-up is needed, especially in patients with risk factors.

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Key words
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Introduction

During living donor liver transplantation (LDLT), anterior segment drainage reconstruction in the right liver graft is an important step during back-table preparation for preventing congestion and graft dysfunction [1–3]. Considering that intrahepatic venous collaterals are expected to develop by day 7 after LDLT using the modified right liver graft, middle hepatic vein (MHV) reconstruction allows for a fully functional liver graft by draining the hepatic venous blood under short-term conditions of low blood pressure, especially for the first week after transplantation [1,3,4]. For MHV reconstruction, grafts can be composed of any material of suitable

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length and diameter; therefore, several surgeons have tested various kinds of grafts for MHV reconstruction, including autologous grafts, allografts, or synthetic grafts [polytetrafluorethylene (PTFE), Dacron] [1,5–9]. However, in Asia, the supply of cryopreserved vascular grafts is limited due to a limited number of deceased donor transplantations. Although autologous veins can also be obtained from the recipients, this procedure increases the surgical complexity, operation time and blood loss. Hence, in many transplant centres, including ours, PTFE grafts have been used for the reconstruction of MHV tributaries with acceptable patency rates and excellent graft outcomes [1–3,5].

Although the safety of PTFE grafts in LDLT has been proven, infection remains one of the major concerns of synthetic graft use. Moreover, in recent years, hollow viscous migration of the PTFE graft (a rare yet clinically important complication) has been reported [5–8]. Graft migration into the surrounding hollow viscous organs may lead to peritonitis or septicaemia due to infection of the graft, thereby increasing the risk of mortality. Therefore, timely diagnosis and prompt management is necessary to remove the migrated graft. However, there are limited data on the long-term experience and the influencing factors of hollow viscous PTFE graft migration. Therefore, in this retrospective analysis, we assessed the complication profiles of PTFE graft use. We also aimed to describe the significant factors of PTFE graft complications in LDLT recipients.

Materials and methods

This was a retrospective, single-centre study based on a comprehensive prospective database on patients who underwent primary LDLT using right liver grafts with reconstruction of the MHV tributaries using PTFE grafts from January 2005 to December 2012. The inclusion period was set to secure sufficient long-term follow-up. The mean follow-up duration was 103.8 ± 30.0 months. A previous study reported that organ injury by PTFE grafts was a delayed-onset complication [10]. Therefore, patients in whom the follow-up periods were <1 year were excluded to evaluate the long-term outcomes of organ injury caused by PTFE grafts after LDLT. The study protocol was approved by the Institutional Review Board of the Seoul National University Hospital (IRB No. 2003-184-1112). The requirement for informed consent was waived due to the retrospective nature of the study.

Surgical technique

A main MHV branch having a diameter >5 mm was clamped with a temporary clip and divided during parenchymal dissection. Few MHV branches having diameters <5 mm were sacrificed to avoid numerous complex anastomoses. During back-table preparation, the drainage area of the MHV branches was carefully examined, and the size of the graft for reconstruction was decided. While thin-walled expanded PTFE (ePTFE) grafts having internal diameters of 6 or 7 mm (GORE-TEX; W.L. Gore & Associates, Inc., Newark, DE, USA) were mostly used, all recipients using a PTFE graft, regardless of the size (diameter: 6–8 mm) or the ring type were included in this study. The longitudinal dimension of the recipient right hepatic vein (RHV) opening was measured, and an additional incision was made distally to create an orifice larger than the longitudinal length of the graft RHV. An incision, whose length corresponded to the transverse dimension of the common opening of the graft RHV and the PTFE grafts, was then made horizontally into the inferior vena cava [1] (Fig. 1).

Postoperative evaluation of MHV branch patency

The LDLT recipients were closely monitored according to the institutional follow-up guidelines. During the first week after operation, liver Doppler was performed daily to detect any hepatic blood flow and graft abnormalities. The recipients then underwent multiphase dynamic liver computed tomography (CT) 1–2 weeks, 1 month and 4 months after the surgery to evaluate graft tissue perfusion, venous outflow and graft regeneration. Subsequently, CT was performed according to the clinical course of each patient.

Definition and analysed variables

In this study, we defined PTFE graft-associated complications as complications directly associated with PTFE graft interposition (including graft migration into the adjacent organs) and infectious complications entailing abscess formation around the PTFE graft.

Data on the demographic characteristics, preoperative diagnosis and postoperative course were reviewed. In postoperative data, complications that were not directly related to the PTFE graft included biliary complications, fluid collection or haematoma formation around the liver graft and vascular complications that required interventions/surgery or resulted in graft dysfunction.

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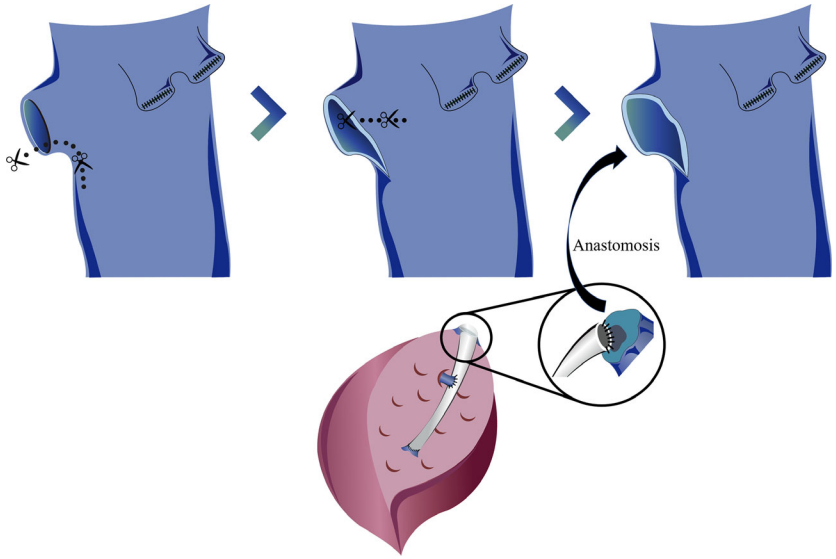

Figure 1 Preparation of the orifice at the recipient inferior vena cava for the anastomosis of the common opening between the graft right hepatic vein and the polytetrafluoroethylene graft.

The clinical symptoms, diagnostic tools used and progress of the recipients after diagnosis of complications were recorded. The patency rate of the PTFE graft was defined as the percentage of PTFE graft that was patent on sonography or CT without intraluminal thrombosis after implantation [1].

Statistical analyses

Data were analysed using the Statistical Package for the Social Sciences 25.0 software (IBM Corp, Armonk, NY, USA), and a *P*-value of <0.05 was considered statistically significant. Continuous variables were compared using the Mann–Whitney *U*-test, while categorical variables were compared using the χ^2 test and the Fisher's exact test, as appropriate. Patient survival, graft survival and PTFE graft occlusion-free survival were determined by Kaplan–Meier survival analysis, and patient groups were compared using the log-rank test.

Results

During the 8-year study period, we performed LDLT surgeries in 545 patients, of which 387 underwent surgery with the right liver graft and required MHV reconstruction using the PTFE graft. Of these, 26 patients

Table 1. Comparison of variables according to the incidence of complications.

	Group A (*n* = 343)	Group B (*n* = 17)	*P*-value
Age (years, mean ± SD)	51.6 ± 9.5	52.6 ± 7.1	0.721
Follow-up duration (months, mean ± SD)	106.7 ± 25.1	46.3 ± 29.1	<0.001
MELD score (mean ± SD)	19.1 ± 7.9	22.2 ± 11.3	0.439
Intraoperative variables			
Hepaticojejunostomy formation (*n*, %)	12 (3.5)	5 (29.4)	<0.001
Abdominal adhesion (*n*, %)	38 (11.1)	7 (41.2)	<0.001
PTFE graft-related variables			
Expanded PTFE graft (*n*, %)	330 (96.2)	16 (94.1)	0.684
Diameter (mean ± SD)	6.7 ± 0.5	6.6 ± 0.5	0.539
Patency rate (*n*, %)			
1 month	304 (88.6)	10 (58.8)	<0.001
6 months	186 (54.2)	3 (17.6)	0.002
12 months	145 (42.3)	2 (11.8)	0.007

MELD, model for end-stage liver disease; PTFE, Polytetrafluoroethylene; SD, standard deviation.

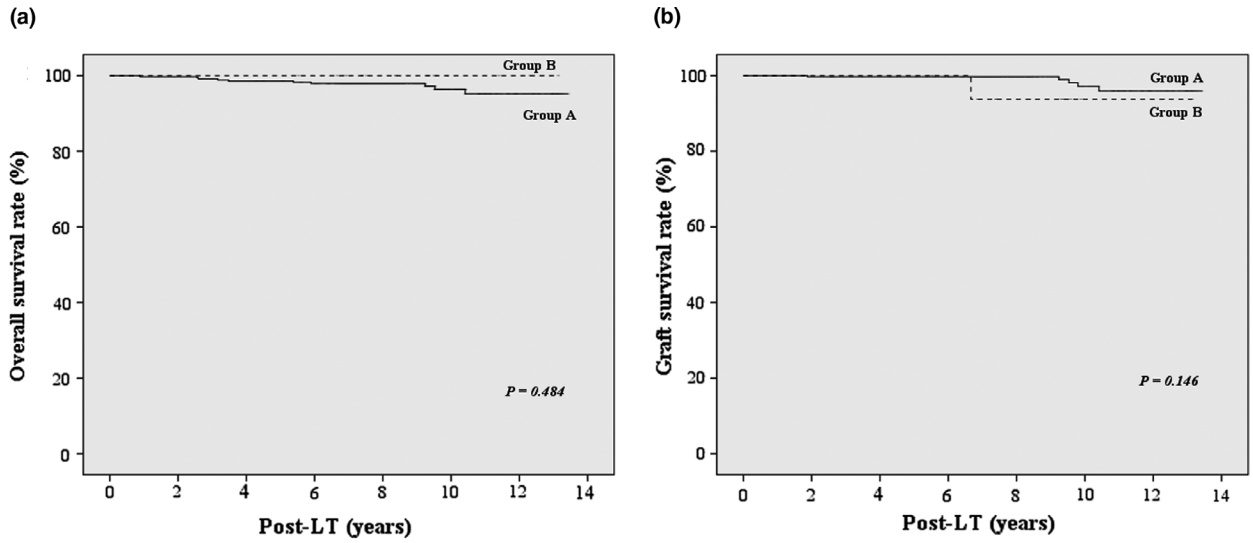

Figure 2 Kaplan–Meier analysis of (a) overall survival and (b) graft-related survival in group A and group B.

with <1-year of follow-up and one patient who received a cryopreserved graft were excluded, and 360 patients were finally included in this study. There were 268 men (74.4%) and the mean age was 51.6 ± 9.4 years. The most common primary diagnosis was of hepatitis B virus cirrhosis (251/360, 69.7%). The mean model for end-stage liver disease score was 19.3 ± 8.1. The patency rates of the PTFE grafts were 87.2%, 52.5% and 40.8% at 1, 6 and 12 months after LDLT, respectively.

Polytetrafluoroethylene graft-associated complications occurred in 17 patients (4.7%); therefore, the entire cohort was classified into two groups: group A (n = 343, recipients with PTFE graft-associated complications) and group B (n = 17; recipients with complications). These groups were compared on the basis of the demographic, intraoperative and PTFE graft-related variables and the patency rates of PTFE. Hepaticojejunostomy was performed more frequently, and abdominal adhesions were more common in group B as compared to in group A ($P < 0.001$; Table 1). The 1-month, 6-month and 12-month patency rates were significantly lower in group B than in group A (58.8% vs. 88.6%, $P < 0.001$; 17.6% vs. 54.2%, $P = 0.002$; 11.8% vs. 42.3%, $P = 0.007$).

The 1-, 5- and 10-year overall survival rates were 99.7%, 98.6% and 95.1%, respectively (Fig. S1a). There were no significant differences in the overall survival between groups A and B ($P = 0.484$; Fig. 2a). Although all graft failure cases were observed in group B, there were no statistically significant differences in the graft survival between both groups ($P = 0.146$; Fig. 2b). The 1-, 5- and 10-year graft survival rates were 100.0%, 99.7% and 97.0%, respectively (Fig. S1b). The 6-month, 1-, 5- and 10-year PTFE graft occlusion-free survival rates were 54.2%, 40.3%, 32.5% and 29.6%, respectively (Fig. 3a). The occlusion-free survival rates were significantly higher in group A than in group B ($P < 0.001$; Fig. 3b).

The postoperative complications that were not directly associated with the PTFE graft and required interventions were analysed. Among these, biliary complications, especially biliary stricture, were the most common complications in both groups. The incidence of biliary stricture and leakage was higher in group B than in group A (stricture: 76.5% vs. 19.5%, $P < 0.001$; leakage: 29.4% vs. 0.3%, $P < 0.001$). Fluid collection around the liver and bleeding or haematoma formation were also more frequent in group B as compared to in group A [fluid collection: 47.1% vs. 5.8% ($P < 0.001$); haematoma/bleeding: 29.4% vs. 5.0% ($P = 0.002$)]. Vascular complications including postoperative stenosis of the portal vein, hepatic vein, or hepatic artery were similar between the two groups ($P = 0.312$). Percutaneous transhepatic biliary drainage (PTBD) insertion, endoscopic retrograde biliary drainage (ERBD) insertion and percutaneous drainage (PCD) insertion were performed significantly more frequently in group B than in group A ($P < 0.001$; Table 2).

In group B, infectious complications were noted in three patients (17.6%), while PTFE migration into the adjacent organs occurred in 14 patients (82.4%) (Fig. S2). Furthermore, injuries of the common bile duct (CBD), stomach, duodenum and jejunum occurred in three (17.6%), one (5.9%), five (29.4%) and five

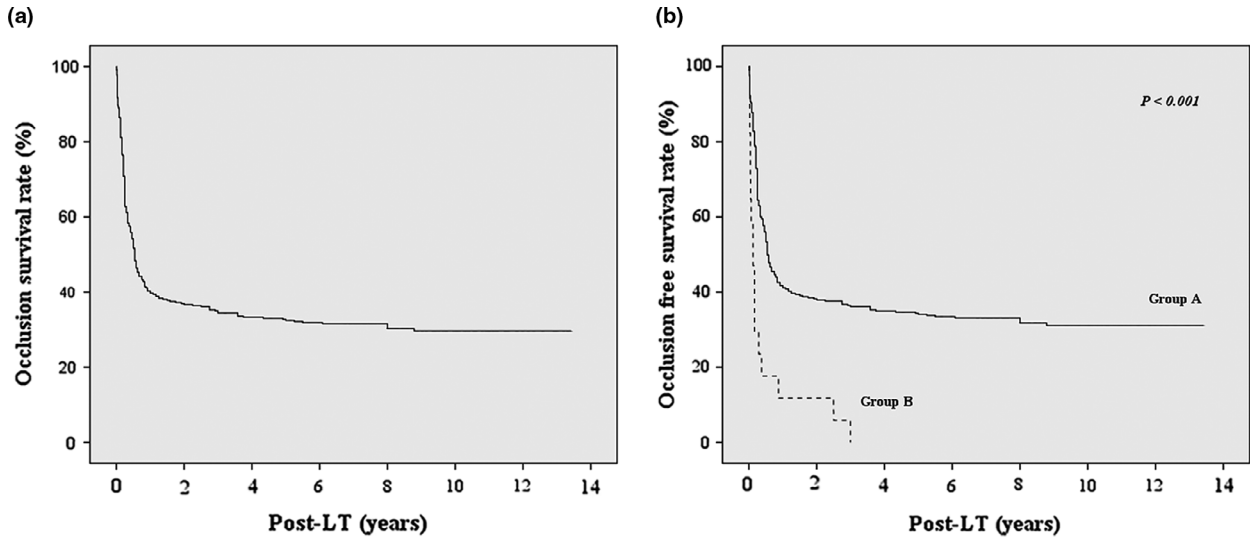

Figure 3 Kaplan–Meier analysis of polytetrafluoroethylene graft occlusion-free survival rate in (a) all patients and in (b) group A and group B.

Table 2. Comparison of postoperative complications and interventions according to the incidence of complications.

	Group A (*n* = 343)	Group B (*n* = 17)	*P*-value
Complications (*n*, %)			
Biliary stricture	67 (19.5)	13 (76.5)	<0.001
Bile leakage	1 (0.3)	5 (29.4)	<0.001
Fluid collection around graft	20 (5.8)	8 (47.1)	<0.001
Vascular complications	18 (5.2)	2 (11.8)	0.312
Bleeding or haematoma	17 (5.0)	5 (29.4)	0.002
Postoperative intervention (*n*, %)			
PTBD	46 (13.4)	11 (64.7)	<0.001
ERBD	45 (13.1)	8 (47.1)	<0.001
PCD	15 (4.4)	8 (47.1)	<0.001
Vascular	16 (4.7)	2 (11.8)	0.256
Reoperation	48 (14.0)	4 (23.5)	0.307
Mortality (*n*, %)	9 (2.6)	0	0.348

ERBD, endoscopic retrograde biliary drainage; PCD, percutaneous drainage; PTBD, percutaneous transhepatic biliary drainage.

(29.4%) patients, respectively. Among these, eight patients (47.1%) required surgical, endoscopic or radiological interventions (Table 3). The median interval between LDLT and the detection of PTFE graft-associated complications was 35 months (range: 8–128 months). Three patients required surgery due to uncontrolled abscess formation around the PTFE graft (patient numbers 1, 2 and 3). One patient (patient 3) experienced sepsis, which resulted from an intestinal fistula that developed from abscesses around the PTFE graft (Fig. 4). Patient 4 presented with persistent dyspepsia. During a follow-up CT examination performed 128 months after LDLT, a thrombotic PTFE graft showed unusual migration and penetration into the duodenum (Fig. 5a). Endoscopic examination revealed that the PTFE graft had completely penetrated the duodenum (Fig. 5b). Therefore, the graft was removed by an endoscopic grasping device (Fig. 5c). Three patients developed PTFE graft-related CBD injury (patient numbers 5, 6 and 7). These patients required biliary interventions to resolve the biliary stricture caused by PTFE graft penetration. Patient 5 recovered uneventfully after ERBD insertion, 33 months after LDLT. Patient 6 complained of abdominal pain in the right upper quadrant and an itching sensation due to the penetration of the PTFE graft into the CBD. Although PTBD was performed several times from 35 months after LDLT, CBD injury eventually resulted in graft failure, requiring

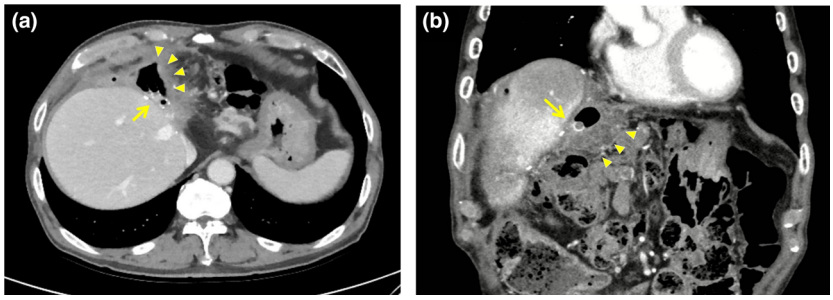

Figure 4 Computed tomography image of patient 3. An air-filled cavity (arrow heads) is observed having thick granulation tissue around the obliterated polytetrafluoroethylene graft (arrow) along the hepatic resection margin. (a) Axial image, (b) coronal image.

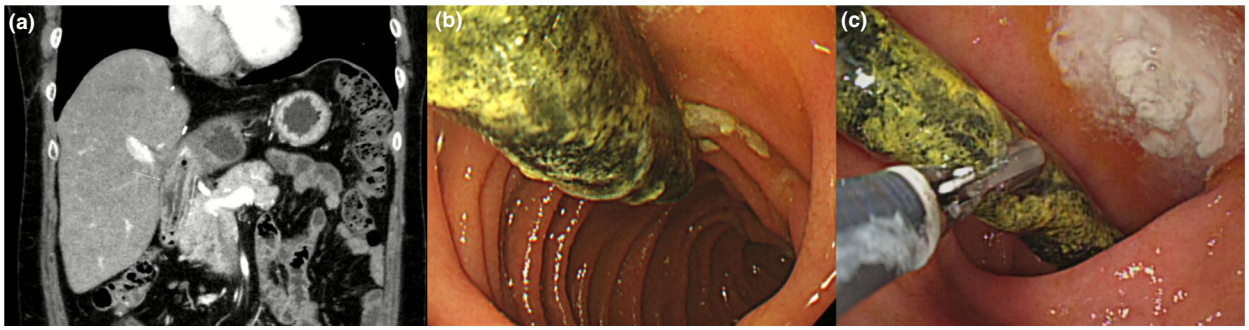

Figure 5 Diagnosis and treatment of patient 4. (a) Esophagogastroduodenoscopy revealing that the polytetrafluoroethylene (PTFE) graft was freely exposed in the duodenal lumen. (b) Computed tomography scan showing the migration of the PTFE graft into the duodenum (arrow). (c) Endoscopic removal of the migrated PTFE graft from the duodenum.

retransplantation about 4 years after the identification of that injury. Patient 7 required surgical treatment. The CBD-penetrating PTFE graft was removed, and a hepaticojejunostomy was performed. During the first week after re-exploration, the patient developed a biliary stricture, and a PTBD tube was inserted. The patient recovered uneventfully and was discharged with a PTBD tube in place. The laboratory values for liver function were within the normal limits, and the tube was removed after 2 months without any further complications. In patient 8, the PTFE graft was totally detached from the liver surface and penetrated the small bowel completely. It migrated into the jejunostomy site, leading to obstructive ileus. Exploratory laparotomy was performed immediately, which restored the incarceration of the small bowel without PTFE graft removal. The migrated PTFE graft was identified inside the small intestine. The patient recovered uneventfully.

Among the nine other patients in group B, PTFE graft had penetrated the duodenum in four patients, hepaticojejunostomy loop in four patients and stomach antrum in one patient. While two patients complained of mild discomfort, dyspepsia and abdominal pain, there were no symptoms specifically associated with PTFE graft-related organ injuries in most of these patients. Thus, nine patients did not undergo any treatment, and there were no episodes requiring surgical interventions or aggressive treatments thereafter.

Discussion

It has been hypothesized that acute thrombotic occlusion of the PTFE graft increases the peri-graft inflammation, which in turn increases the adhesion of the graft to an adjacent organ, thereby promoting graft migration [11]. A previous study described that early occlusion at 1 or 4 months after LDLT was less frequent in patients without organ injuries from PTFE grafts [10]. Our study demonstrated significant differences in the 1-, 6- and 12-month PTFE graft patency rates between patients with PTFE graft-associated complications and those without these complications (Table 4). There were significant differences in the PTFE graft occlusion-free survival rates between the two groups as well. Although occlusion of the PTFE grafts did not compromise the function of the transplanted liver, it can be inferred that this occlusion is associated with the organ injuries caused by PTFE grafts.

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Table 3. Characteristics of patients treated for PTFE graft-associated complications.

Patient no.	1	2	3	4	5	6	7	8
Age/gender (years)	61/male	60/male	61/male	38/female	63/male	46/male	48/female	51/male
Cause of LDLT	HBV-LC, HCC	HBV-LC, HCC	HBV-LC, HCC	Primary biliary cholangitis	HBV-LC, HCC	HBV-LC, HCC	HBV-LC, HCC	HBV-LC, HCC
Interval between LT and detection of complications	8 months	55 months	65 months	128 months	33 months	35 months	29 months	63 months
Status of injury	Abscess formation around PTFE graft	Abscess formation around PTFE graft and PCD tip	Abscess formation around PTFE graft with intestinal fistula	PTFE graft penetrates into duodenal bulb	PTFE graft located in CBD	PTFE graft penetrates into CBD	PTFE graft penetrates into CBD	PTFE graft located in jejeunostomy with obstructive ileus
Presenting symptoms and sign	Fever, LFT abnormality	Epigastric pain	Fever, right upper quadrant pain, dyspepsia	Dyspepsia	Fever, LFT abnormality	Right upper quadrant pain, Itching sensation, LFT abnormality	Fever, dyspepsia, LFT abnormality	Right upper quadrant pain
Management	Segment 8 segmentectomy and PTFE graft removal	Removal of PTFE graft and PCD insertion	Removal of PTFE graft	Endoscopic removal of PTFE graft	ERBD insertion	PTBD insertion	Removal of PTFE graft and hepaticojejunostomy formation	Exploratory laparotomy
Outcome	Biliary stricture: multiple intervention and antibiotics	Recovered well	Recovered well	Recovered well	Recovered well	Graft failure: retransplantation	Biliary stricture at hepaticojejunostomy: multiple intervention	Recovered well (PTFE graft was presumed to be excreted by defecation)

CBD, common bile duct; ERBD, endoscopic retrograde biliary drainage; BV, hepatitis B virus; HCC, hepatocellular carcinoma; LC, liver cirrhosis; LDLT, living donor liver transplantation; LFT, liver function test; LT, liver transplantation; PCD, percutaneous drainage; PTBD, percutaneous transhepatic biliary drainage; PTFE, polytetrafluoroethylene.

Table 4. Characteristics of studies referenced.

Studies	Incidence	Follow-up duration (months, mean ± SD)	Intervals between LDLT and diagnosis of PTFE graft-associated complications	Risk factors reported
Kim *et al.*, 2011 [10]	1.96% (4/204)	31.4 ± 13.3	23–41 months	Early occlusion of PTFE, Postoperative interventions
Hsu *et al.*, 2017 [11]	1.52% (4/262)	–	5–24 months	Early occlusion of PTFE
Sultan *et al.*, 2018 [13]	–	–	30 months	Postoperative intervention (repeated ERCP)
Ha *et al.*, 2014 [20]	0.46% (1/215)	–	6 months	–
Our literature	4.72 (17/260)	103.8 ± 30.0	8–128 months	Early and delayed occlusion of PTFE, abdominal adhesion, Postoperative interventions, Hepaticojejunostomy

ERCP, endoscopic retrograde cholangiopancreatography; LDLT, living donor liver transplantation; PTFE, polytetrafluoroethylene; SD, standard deviation.

In the LDLT operative field in recipients, abdominal adhesions were frequently found to be caused by a history of previously performed interventions, such as transcatheter arterial chemoembolization, operation and radiation therapy. Because existing adhesions can affect the duration and extent of later surgeries [12], thereby resulting in severe postliver transplantation (LT) inflammation, it can be assumed that these existing adhesions could be associated with the PTFE graft-associated complications. This study also showed that the proportion of patients with abdominal adhesions was higher in the group that had PTFE graft-associated complications than in the group that did not have these complications, which is in line with our hypothesis.

The postoperative complications and interventional treatments undertaken were other influencing factors of PTFE graft-associated complications. In several cases with biliary complications and perihepatic fluid collection or haematoma formation after LDLT, repeated percutaneous or endoscopic interventional treatments may be undertaken, and these could distort the shape and location of the PTFE grafts. Previous studies have reported that the postoperative insertion of interventional devices into the biliary tract, perihepatic space, or bowel played a major role in the causation of thrombotic synthetic graft-associated injuries to the adjacent organs (Table 4) [10,13]. Similarly, our study showed significant differences in the incidence of PTBD, ERBD and PCD insertion between the group with PTFE graft-associated complications and the group without these complications. Therefore, it is necessary to pay close attention to potential PTFE graft injuries when performing perihepatic procedures for post-LT complications. On the other hand, there were no significant differences in the incidence of vascular complications and perihepatic procedures between the two groups.

Historically, biliary anastomosis has been termed the 'Achilles heel' of liver transplantation [14]. Complications such as strictures, leakages, fistulae and infections have led to the evolution of new technical methods [15]. Biliary reconstruction was formerly limited to Roux-en-Y hepaticojejunostomy LDLT [16–18]. Duct-to-duct biliary reconstruction is currently considered as a standard procedure in adult LDLT for the following reasons: (i) Duct-to-duct biliary reconstruction does not require intestinal manipulation, serving as an anatomical barrier to the reflux of enteric contents into the biliary tract, and may theoretically decrease the risk of ascending cholangitis; (ii) compared to hepaticojejunostomy, duct-to-duct biliary reconstruction is technically faster and easier to perform; and (iii) anatomical

bilioenteric continuity enables a good endoscopic access postoperatively [19]. Based on these advantages, it could be inferred that hepaticojejunostomy produced more severe adhesions and inflammations by intestinal manipulation, longer procedural times, and reflux of enteric contents into the biliary tract. Thus, we hypothesized that hepaticojejunostomy could be an influencing factor for PTFE graft-associated complications, and the proportion of patients receiving hepaticojejunostomy was higher in the group with complications than in the group without complications.

Subgroup analysis was additionally performed to identify any differences the effect of PTFE graft rings among patients using nonringed ($n = 346$) and ringed PTFE grafts ($n = 14$). There were no differences not only in the 1-, 6- and 12-month PTFE graft patency rates (nonringed PTFE graft vs. ringed PTFE graft; 87.6% vs. 78.6%, $P = 0.402$; 52.3% vs. 57.1%, $P = 0.723$; 40.2% vs. 50.0%, $P = 0.498$), but also in the incidence of PTFE graft-associated complications (4.6% vs. 7.1%, $P = 0.498$) between the two subgroups. Another additional analysis comparing 360 patients who required MHV reconstruction using PTFE grafts with 65 patients who did not require MHV reconstruction showed that there were no significant differences in the survival ($P = 0.117$) and incidences of biliary stricture ($P = 0.659$), biliary leakage ($P = 1.000$), fluid collection ($P = 0.261$), vascular complications ($P = 0.447$) and bleeding or haematoma formation ($P = 0.585$) between the two groups.

In our experience with long-term follow-up, the rates of complication directly related to PTFE grafts was 4.7% (17/360). Complications requiring interventions occurred in 2.2% of the patients (8/360), with a mortality rate of 0%. This incidence is the highest among previous studies; the previously reported incidences ranged from 0.46% (1/215) to 1.96% (2/204) [10,11,20]. This difference may be attributed to the much longer duration of follow-up in our study as compared to that reported in these previous studies. Furthermore, compared to previous studies, the intervals between LDLT and the diagnosis of PTFE graft-associated complications were much longer in our study as well, ranging from 8 to 128 months (Table 4). In accordance with this, it can be assumed that complications related to PTFE grafts can occur not only within the short-term period after LDLT, but also in the long-term period, and at a greater level of severity. Thus, we need to be aware of this possibility.

Although this study reported meaningful results, there are several limitations. First, this was a retrospective study. Second, the sample size was relatively small. However, to our knowledge, this is the study with the largest sample size and the longest follow-up ever reported using prospectively collected data. We expect risk factors suggested in this study to be revealed as strong indicators of PTFE graft-associated complications in a future study with a larger number of patients.

Because PTFE graft-associated complications could be easily detected on CT images, regular contrast-enhanced CT is the best modality for the early detection of graft-related complications, including infection and suspected gastrointestinal tract penetration. In our study, clinical signs and symptoms were dependent on the injured organs and the extent of injury. In cases of fever or abdominal discomfort of unknown aetiology and abnormal laboratory values of the liver function tests, it is necessary to suspect PTFE graft-associated complications. To reduce the risks of tissue reaction induced by a PTFE graft in LDLT, antiadhesive agents can be applied on the hepatic surface. In addition, an omental patch can be introduced as a buffer between the PTFE graft and the adjacent organs, especially the gastrointestinal tract.

In conclusion, PTFE graft-associated complications in LDLT are uncommon occurrences. Our results were consistent with that of a previous study, in which PTFE graft occlusion and previous interventional treatments after LDLT in and around the liver affected the incidence of PTFE graft-associated complications. We suggest that intraabdominal adhesion findings and hepaticojejunostomy be considered as new risk factors of PTFE graft-associated complications in LDLT patients. To prevent unexpected infection and organ injury due to PTFE grafts, further precautions should be taken when these risk factors are identified.

Authorship

HYW: performed the research, collected the data, analysed the data and drafted the manuscript. SKH: designed and performed the research, collected the data, analysed the data and drafted the manuscript. J-HC and J-ML: collected the data. YC, N-JY, K-WL and K-SS: revised the manuscript critically for important intellectual content.

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Conflict of interest

The authors of this manuscript have no conflicts of interest to declare.

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None.

SUPPORTING INFORMATION

Additional supporting information may be found online in the Supporting Information section at the end of the article.

Figure S1. Kaplan–Meier analysis of (a) overall survival and (b) graft-related survival in all patients.

Figure S2. Computed tomography images of patients whose polytetrafluoroethylene (PTFE) grafts: showed migration (a, b); showed detachment and migration (c–g); showed distal migration in the common bile duct (h–k); showed migration into the HJ loop (l); showed detachment from the liver and migration to the adjacent small bowel (m–o; thrombosed PTFE grafts); and PTFE grafts showed migration to the antrum or duodenal bulb area.

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