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ORIGINAL ARTICLE

In adult-to-adult living donor liver transplantation hepaticojejunostomy shows a better long-term outcome than duct-to-duct anastomosis*

Nam-Joon Yi, Kyung-Suk Suh, Jai Young Cho, Choon Hyuck Kwon and Kuhn Uk Lee

Department of Surgery, Seoul National University College of Medicine, Chongno-Gu, Seoul, Korea

Keywords
adult-to-adult living donor liver transplantation, biliary complication, duct-to-duct biliary reconstruction, living donor liver transplantation, Roux-en-Y hepaticojejunostomy.

Correspondence
Kyung-Suk Suh MD, PhD, Department of Surgery, Seoul National University College of Medicine, 28 Yongon-Dong, Chongno-Gu, Seoul 110-744, Korea. Tel.: 82-2-2072-3789; fax: 82-2-766-3975; e-mail: kssuh@plaza.snu.ac.kr

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Summary

Roux-en-Y hepaticojejunostomy (RYHJ) has been the standard biliary reconstruction in adult-to-adult living donor liver transplantation (ALDLT). Recently, duct-to-duct anastomosis (DD) has been introduced. This study compared the outcomes of RYHJ and DD. For 4 years, 74 recipients underwent ALDLT and were followed up for at least 2 years. The patients were divided into three groups, RYHJ group ($n = 18$), DD with a stent (DD + S) group ($n = 35$), and DD without a stent (DD − S) group ($n = 21$). Overall, biliary complications were developed in 32.4% patients. The biliary complication rate was 11.1%, 48.5% and 33.3% in RYHJ, DD + S and DD − S groups, respectively ($P = 0.047$). Bile leaks occurred in 28.5% of DD + S group. The incidence of biliary stricture was 5.3%, 20.2% and 28.6% in RYHJ, DD + S and DD − S group, respectively. Most complications (83.3%) were resolved nonsurgically. RYHJ has a better long-term outcome than DD in ALDLT. Subgroup analysis of DD group showed that DD − S group had no bile leaks, but still had a higher incidence of bile duct strictures. However, because this study was a retrospective review there are limitations in analyzing the data and confirming the conclusion. A randomized-prospective study will be needed to confirm these findings.

Introduction

In the early history of liver transplantation, biliary reconstruction was a leading cause of surgical morbidity and mortality [1]. Dr Calne [2] characterized biliary reconstruction as the 'Achilles' heel' in liver transplantation. As the complication significantly affected recipient quality of life, and was occasionally the cause of graft and patient loss, various biliary reconstruction innovations have been introduced and have resulted in a dramatic reduction in the morbidity and mortality associated with biliary reconstruction over the past 10 years in whole liver transplantation [3,4].

However, in the more recently developed living donor liver transplantation, particularly in adult-to-adult cases, biliary complications remain the leading cause of postoperative problems [5]. Moreover, because there are no standard biliary reconstruction techniques in adult-to-adult living donor liver transplantation (ALDLT), recent reports have shown a wide range of biliary complication rates. Biliary anastomosis in ALDLT has usually been accomplished by using Roux-en-Y hepaticojejunostomy (RYHJ). The recently reported RYHJ complication rates have ranged from 8% to 26% in ALDLT [6–9]. Duct-to-duct anastomosis (DD) has recently become the preferred technique in many transplant centers that deal with many cases of

ALDLT [6,10–15], because it is convenient, reduces the operative time, abolishes the need for intestinal manipulation, preserves the normal physiologic sphincter mechanism, and allows easier endoscopic access to the biliary tract. Reports on early biliary complications have shown an incidence of 8–30% after DD, which is equivalent to the complication rate of RYHJ in ALDLT [6,10–15]. However, few studies have addressed the substantial number of patients with late biliary complications of DD in ALDLT. The aim of this study was to compare the long-term biliary complications after DD performed with or without a stent along with those encountered after RYHJ in ALDLT.

Patients and methods

Patients

Between January 1999 and December 2002, 74 patients underwent ALDLT at the Seoul National University Hospital. In the early period of our living donor liver transplantation program, RYHJ was the preferred method of biliary reconstruction in adult and in pediatric recipients. However, from December 18, 2000, RYHJ was switched to DD for adult recipients. The contraindications for performing DD in our institution were: primary sclerosing cholangitis, common bile duct dilatation (diameter >1.5 cm), or definite injury of the recipient's bile duct because of a dissection during the recipient's hepatectomy, previous upper abdominal surgery, or radiologic intervention such as transarterial chemoembolization. In addition, it was impossible to use recipient's bile duct when there was no bleeding at its cut end before the anastomosis or it was too short for a direct DD without tension. During the study period, RYHJ was performed in 18 patients (RYHJ group) and DD was performed in 56 patients (DD group). In the first 35 patients in DD group, DD was performed over a T-tube in 29 or over an internal stent in six (DD + S group). DD was performed without a stent in the later 21 patients (DD − S group).

Two physicians prospectively collected the preoperative, intraoperative, and postoperative data of the recipients. The clinical characteristics of these recipients are listed in Table 1. Both groups were similar in terms of age, sex, original liver disease, model for end-stage liver disease (MELD) score at the time of the transplant, graft–recipient weight ratio, number of bile ducts in the graft, the age of the donors and ischemic time ($P > 0.05$). In DD group, a left graft was used less often ($P = 0.001$) and the mean operative time ($P = 0.014$) and follow up period ($P = 0.000$) was shorter than in RYHJ groups. This is because in our ALDLT program, RYHJ was performed in the early period and DD was performed in the late period.

A bile leak was defined by the clinical symptoms, abnormal laboratory test, or image study, requiring opening of the T-tube, endoscopic treatment, radiologic intervention or surgery. Bile leaks were diagnosed by T-tube cholangiography, endoscopic retrograde cholangiopancreatography, percutaneous transhepatic biliary drainage, or percutaneous drainage. A bile duct stricture was defined by the clinical symptoms, abnormal laboratory test, or imaging study requiring endoscopic treatment, radiologic intervention, or surgery. Bile duct strictures were confirmed by T-tube cholangiography, endoscopic retrograde cholangiopancreatography, or percutaneous transhepatic biliary drainage in the uncertain cases after ultrasound or a computed tomographic (CT) scan [3,16]. An early complication was defined as a bile leak or a bile duct stricture occurring within 3 months of transplant, and a late complication as one that occurred at more than 3 months [16]. The data according to the type of biliary reconstruction included the following: the type of biliary complication, the number of bile ducts in the graft, the complication site, the time to the complication diagnosis, management, number of interventions, the follow up duration, and the results of management.

Table 1. Demographic characteristics of the 74 adult recipients.

	RYHJ group ($n = 18$)	DD group ($n = 56$)	*P*-value
Recipients age (years)	46.7 ± 10.1	47.7 ± 8.4	0.679
Sex (male:female)	13:5	47:9	0.307
Original disease			0.620
Viral hepatitis	16	48	
Cholestatic liver disease	1	–	
Others	1	8	
MELD score	29.9 ± 8.5	22.7 ± 8.7	0.625
Types of graft			0.001
Rt or Rt extended	12	53	
Lt or Lt extended	6	3	
Graft–recipient weight ratio (%)	1.02 ± 0.44	1.06 ± 0.24	0.656
Number of bile duct in the graft			0.155
Single	11	42	
Multiple (≥2)	7	14	
Donor age (years)	28.1 ± 9.0	31.4 ± 8.9	0.178
Total ischemic time (min)	105.3 ± 22.6	115.2 ± 35.7	0.274
Cold ischemic time (min)	55.9 ± 19.4	71.2 ± 33.2	0.068
Warm ischemic time (min)	49.4 ± 15.0	44.1 ± 13.0	0.155
Operative time (min)	631.3 ± 149.4	551.6 ± 104.2	0.014
Duration of follow up (months)	56.7 ± 12.8	38.5 ± 7.8	0.000

RYHJ, Roux-en-Y hepaticojejunostomy; DD, duct-to-duct anastomosis; MELD, model for end-stage liver disease; Rt, right; Lt, left.

Evaluation of donor bile duct

A donor hepatectomy was performed using the previously described procedure [17]. Intraoperative cholangiography

was routinely performed using an undiluted radiologic contrast agent introduced via the cystic duct to precisely identify the bile duct anatomy. After the hilum of the donor had been explored gently, an examination of the intraluminal status and the bile duct bifurcation was performed using a probe.

Biliary reconstruction in the recipient

Biliary reconstruction was made after completing vascular anastomosis under loupe magnification (3.5 times).

In RYHJ, a Roux jejunal limb was brought through the transverse mesocolon to reach the graft bile duct. Biloenteric anastomosis was performed in an interrupted fashion using a 6-0 polydioxane (PDS®, Ethicon, NJ, USA). After completing the posterior row, a radiopaque tube (which was small enough to be inserted easily into the hepatic duct orifice) with two or three side holes, was inserted into the graft duct. The length of the tube was approximately 1 cm, and it was placed within the graft duct and jejunal lumen to serve as an internal stent for the anastomosis. The stent was anchored at the anastomosis site using a 6-0 PDS.

In cases of DD, the periductal connective tissue was preserved as much as possible in order to protect the axial periductal microcirculation during the recipient bile duct dissection. A hilar dissection method was designed, which involved a dissection of the hilum starting from its top in the recipient (Fig. 1a). The bile duct of the recipient was not clamped, but selected above the bifurcation in order to maintain blood supply. The hepatic artery was also ligated at the top of the hilum, and the portal vein was clamped separately at the bottom using a vascular clamp (Fig. 1b). The recipient bile duct was divided well above the bifurcation providing sufficient length for tension-free anastomosis. Bleeding from the bile duct stump of the recipient was confirmed before the anastomosis. End-to-end choledochocholedochostomy was performed using a 6-0 PDS in an interrupted manner. In 29 recipients in DD, the proximal tip of the T-tube was laid over the anastomosis and the exit site of the T-tube was distal to the anastomosis in the recipient's common bile duct. In six recipients in DD, the internal stent was inserted throughout the anastomosis. In 21 recipients in DD, neither the T-tube nor the internal stent was used in an attempt to avoid implant-related complications. Intraoperative cholangiography was performed routinely after DD.

Post-transplant management of recipients

The maintenance immunosuppressive regiment used during the study period consisted primarily of a calcineurin inhibitor and corticosteroid. In the patients with a T-tube, T-tube cholangiography was routinely performed between days 7 and 14 after surgery. The T-tube remained in place for a minimum of 3 months, and T-tube cholangiography was routinely performed before removing the tube.

Statistical analysis

The significances of the differences were determined by a chi-square, ANOVA, and by binary logistic regression using SPSS 10.0. The data are reported as the mean ± SD. A P-value of <0.05 was considered significant.

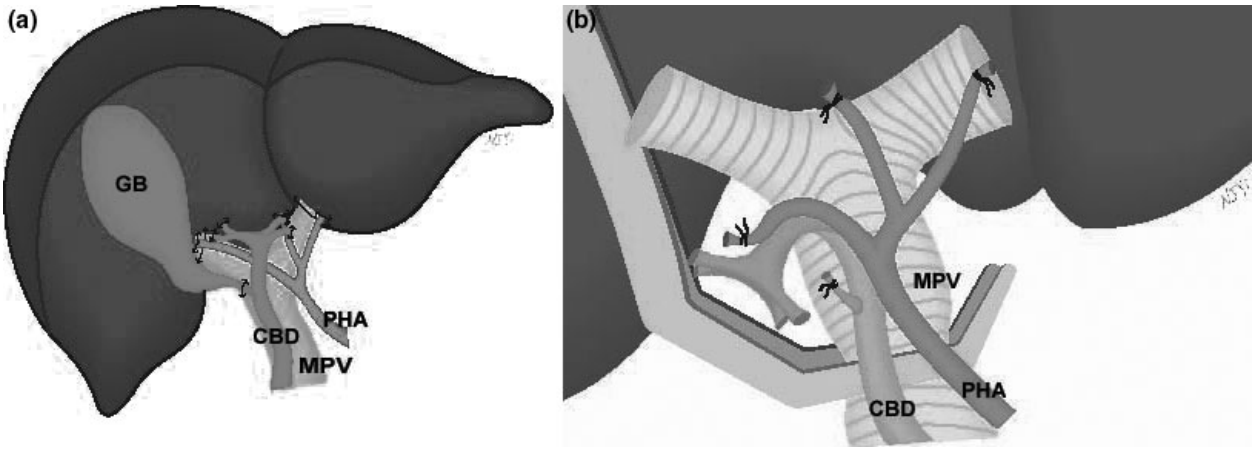

Figure 1 A new method of hilar dissection in order to reduce fibrotic healing. (a) Hilar dissection in recipient hepatectomy. Dissection of the hilum was started from its top above the bifurcation of the hilar structures. GB, gall bladder; MPV, main portal vein; PHA, proper hepatic artery; CBD, common bile duct. (b) A selected clamp technique during hilar dissection in the recipient. The bile duct was not clamped, but selected above the bifurcation to maintain blood supply. The hepatic artery was also ligated at the top of the hilum without clamping, and the portal vein was separately clamped at the bottom with a vascular clamp.

Results

Biliary complications occurred in 24 of the 74 patients (32.4%). There were no biliary complication-related deaths. There were three late deaths (4.0%) due to two recurrences of hepatocellular carcinoma and one traffic accident more than 2 years after the transplant. Early morbidities occurring within 3 months of the transplant except for biliary complications were 68 cases in 43 patients; 27 renal insufficiencies, 10 cases of prolonged ascites or abnormal fluid collection, nine neurotoxicities, seven acute cellular rejections, five herpes infections, four cases of hepatic venous stenosis, three cases of sepsis, and three pneumoniae. Eleven patients underwent reoperation because of intraperitoenal bleeding ($n = 10$) and hepatic vein stenosis ($n = 1$). Late morbidities occurring at more than 3 months after the transplant except for biliary complications were 16 cases in 13 patients; nine recurrences of the original disease including hepatocellular carcinoma, three chronic renal insufficiencies, one meningeal tuberculosis, one fungal infection, one renal cell carcinoma, and one hepatic artery obstruction.

There were no differences between the incidence of biliary complications according to the recipients' age ($P = 0.476$), donors' age ($P = 0.313$), original disease ($P = 0.658$), MELD score ($P = 0.919$), types of graft ($P = 0.785$), graft–recipient weight ratio ($P = 0.635$), bile duct number ($P = 0.494$), total ischemic time ($P = 0.057$), cold ischemic time ($P = 0.065$), warm ischemic time ($P = 0.072$), operative time ($P = 0.465$), and morbidity ($P = 0.273$).

The incidences of biliary complications in RYHJ (two cases in two of 18 patients, 11.1%) and DD groups (24 cases in 22 of 56 patients, 42.9%) were significantly different ($P = 0.026$). RYHJ group showed a better outcome than DD group. Bile leaks were only noted in DD group (10 of 56 patients, 17.9%). Six of the 10 bile leaks were occurred after removing the T-tube. The incidence of bile duct strictures was 5.6% (one of 18 patients) in RYHJ group and 23.2% (13 of 56 patients) in DD group. The results were also analyzed according to DD subgroups; RYHJ group ($n = 18$), DD + S group ($n = 35$), and DD − S group ($n = 21$). The incidences of biliary complications were 11.1% in RYHJ group, 48.5% (17 cases in 15 of 35 patients) in DD + S group, and 33.3% (seven cases in seven of 21 patients) in DD − S group, which was significantly lower in RYHJ group than in the others ($P = 0.047$). Ten bile leaks were encountered in DD + S group alone (28.6%). The incidence of a bile duct stricture was 5.6% in RYHJ group, 20.0% (seven of 35 patients) in DD + S group, and 28.6% (six of 21 patients) in DD − S group. Bile leaks were encountered in DD + S group only and there was a higher incidence of late biliary strictures in both DD + S and DD − S groups. The hepatic blood flow was well preserved in all patients except for a previously described case in RYHJ group. In DD group, there was one case of obstruction of the right posterior duct due to a ligation of the missing bile duct during the donor operation (Table 2).

Table 2. Incidence of biliary reconstruction complications according to biliary reconstruction type.

	Bile leak, *n* (%)	Bile duct stricture, *n* (%)	Others, *n* (%)	Total, *n* (%)
RYHJ group ($n = 18$)	–	1 (5.6)	1 (5.6)	2 (11.1)
DD group ($n = 56$)	10 (17.9)	13 (23.2)	1 (1.8)	24 (42.9)
DD + S ($n = 35$)	10 (28.5)	7 (20.0)		17 (48.5)
DD − S ($n = 21$)	–	6 (28.6)	1 (4.8)	7 (33.3)

RYHJ, Roux-en-Y hepaticojejunostomy; DD, duct-to-duct anastomosis; DD + S, duct-to-duct anastomosis with a stent; DD − S, duct-to-duct anastomosis without a stent.

Table 3 summarizes the details of the two bile duct strictures in RYHJ group. A bile duct stricture at the biliary anastomosis site was noted in a 44-year-old male (patient 1) who had suffered from hepatitis B-related liver cirrhosis (HBV-LC). He recovered well after the transplant without major morbidity except for biliary stricture at 27 months after the transplant. He underwent percutaneous

Table 3. Details of biliary complications in RYHJ group.

Patient	Types of graft	Bile duct number	Site	Time to complication (months)	Management (number of times of intervention/evaluation)	Duration of follow up (months)	Result
1	Lt extended	1	Anastomosis	27	PTBD with balloon plasty (6/31) → revision of RYHJ	60	Cured
2	Rt extended	2 (RA, RP) → ductoplasty	RP, diffuse	14	Conservative	63	Recurrent cholangitis

RYHJ, Roux-en-Y hepaticojejunostomy; PTBD, percutaneous transhepatic biliary drainage; RA, right anterior duct; RP, right posterior duct; Rt, right; Lt, left.

transhepatic balloon plasty several times but developed a restenosis. Finally, a RYHJ revision was performed. Patient 2 was a 48-year-old male patient who had suffered from HBV-LC. When the procurement of an extended right liver was complete, the right posterior duct and the right anterior duct of the graft were separate. The same variation was noted in the right hepatic artery. He experienced early postoperative sepsis and neurotoxicity associated with the immunosuppressant but recovered. He had a late obstruction of the right posterior hepatic artery and diffuse right posterior duct stricture 14 months after the transplant. He was suffering from recurrent cholangitis and was treated conservatively with antibiotics. Table 4 summarizes the details of biliary complications in DD group.

Early bile leaks occurred at the anastomosis site in four patients (patients 3–6) in DD + S group. They did not experience early morbidity except for bile leaks and associated symptoms. Although they were treated with tube opening and endoscopic or percutaneous drainage, patients 3 and 4 progressed to late strictures at the anastomosis site. Bile leaks after removing the T-tube occurred in six patients (patients 7–12) in DD + S group and were treated nonsurgically. There were no major morbidities in these patients.

Seven bile duct strictures were noted in DD + S group. Two of them (patients 13 and 14) suffered from early biliary complications and other post-transplant morbidities. A 46-year-old male (patient 13) who had suffered from HBV-LC and hepatocellular carcinoma showed neurotoxicity associated with the immunosuppressant at POD 5 and bile duct stricture on T-tube cholangiography at anastomosis site at POD 10, which was successfully resolved using endoscopic balloon plasty. The other one was noted in a 52-year-old male (patient 14) who had suffered from HBV-LC. He had a right liver graft with two bile ducts, a right anterior duct and posterior duct, which had been anastomosed to the recipient's common hepatic duct as a common orifice. Bile duct stricture at the anastomosis site of the right posterior duct was noted on T-tube cholangiography at POD 10 but there were no symptoms. He underwent reoperation because of intraperitoneal bleeding at POD 12. He suffered from cholangitis 1 month after the transplant and was treated with percutaneous transhepatic balloon plasty. There was no more major morbidity in these patients during the follow up period.

The other five patients (patients 3, 4, 15–17) of DD + S group had late bile duct stricture. Patient 17 died from a traffic accident and patient 4 developed a *de novo* hepatitis B infection. The biliary strictures in three patients were resolved by percutaneous transhepatic balloon plasty, although two (patients 3 and 15) required surgical conversion to RYHJ. Patient 15 was a 51-year-old male who had suffered from HBV-LC. His graft had two bile ducts, the main right hepatic duct and B5. They were anastomosed to the recipient common hepatic duct as a common orifice with separate internal stents. He recovered well except for the biliary stricture at the anastomosis site of both the main right duct and B5 on the CT scan 5 months after the transplant. He underwent percutaneous transhepatic balloon plasty once, but he requested surgical correction. Patient 3, who required surgical correction, was a 45-year-old female who had suffered from HBV-LC and a hepatocellular carcinoma. She had recovered from the early bile leak at anastomosis site and there was no other major morbidity. However, the leak progressed to a bile duct stricture at the anastomosis site. She had undergone percutaneous transhepatic balloon plasty several times but developed restenosis. Finally, a RYHJ revision was performed.

Six late bile duct strictures were noted in DD − S group. Two of them experienced late morbidities; nephrectomy because of renal cell carcinoma (patient 23) and diabetic nephropathy and variceal bleeding (patient 18). All the bile duct strictures were resolved with percutaneous transhepatic balloon plasty.

There was one case of a missing duct during the donor hepatectomy (patient 24). A 46-year-old male patient, whose original disease had been HBV-LC, had suffered from cholangitis 2 weeks after the transplant. The donor in this case had a trifurcation of the bile duct, which was misinterpreted as a normal biliary anatomy in the preoperative study. The right posterior duct of the graft was missed and was ligated during the donor operation. He was initially treated with a percutaneous drainage procedure but finally underwent surgical relief of the right posterior duct and RYHJ.

Overall, most biliary complications (84.6%, 22 of the 26 complications in 24 patients) were resolved using nonsurgical management. The surgical management of a biliary complication was required in three bile duct strictures and in one case of a missing duct.

Discussion

In the early period of DD in ALDLT, biliary complications were more common in DD group (60%) than in RYHJ group (20%) [8]. Recently, the early biliary complication rates for DD were comparable with those of RYHJ in ALDLT [5,10–14]. The Tokyo group reported that their biliary complication rate in DD was <10% [10]. Moreover, because DD has many advantages, it has recently become the preferred method of a biliary reconstruction for ALDLT and for deceased donor liver transplantation in many transplantation centers.

Table 4. Details of biliary complications of duct-to-duct anastomosis.

Patient	Types of graft	Bile duct number and type of a stent	Site	Time to complication (months)	Management (times of intervention)	Duration of follow up (months)	Result
Leakage from the anastomosis site in DD + S group							
3	Rt	1, T-tube	Anastomosis	<1	Tube opening, PCD (1/2), PTBD (1/1)	42	Progression to late stricture
4	Rt	1, internal stent	Anastomosis	<1	PCD (3/6), ERCP (1/3), PTBD (2/8)	39	Progression to late stricture
5	Lt	1, internal stent	Anastomosis	<1	PTBD (1/9)	38	Cured
6	Rt	1, internal stent	Anastomosis	2	PCD (1/2), PTBD (1/5)	39	Cured
Leakage from the tube removal site in DD + S group							
7	Rt	1, T-tube	Tube removal site	4	ERCP (1/2)	41	Cured
8	Rt	1, T-tube	Tube removal site	7	ERCP (1/2)	39	Cured
9	Rt	1, T-tube	Tube removal site	7	Conservative	42	Cured
10	Rt	1, T-tube	Tube removal site	7	PTBD (1/2)	37	Cured
11	Lt extended	1, T-tube	Tube removal site	8	Conservative	49	Cured
12	Rt	2 (RA, RP) → ductoplasty, T-tube	Tube removal site	9	PCD (1/2)	36	Cured
Early stricture in DD + S group							
13	Rt	1, T-tube	Anastomosis	<1	ERCP with balloon plasty (1/1)	41	Improved
14	Rt	2 (RA, RP) → ductoplasty, T-tube	Anastomosis, RP	1	PTBD with balloon plasty (1/2)	36	Improved
Late stricture in DD + S group							
4	Rt	1, T-tube	Anastomosis	5	PTBD with balloon plasty (1/3)	39	Improved
15	Rt	2 (Rt main duct, B5) → ductoplasty, internal stent	Anastomosis, both	5	PTBD with balloon plasty (1/4) → RYHJ	33	Cured
16	Rt	2 (RA, RP) → ductoplasty, T-tube	Anastomosis, both	7	PTBD with balloon plasty (1/5)	34	Improved
17	Rt	1, T-tube	Anastomosis	8	PTBD with balloon plasty (6/17)	42	Improved
3	Rt	1, T-tube	Anastomosis	17	PTBD with balloon plasty (2/4) → RYHJ	42	Cured
Late stricture in DD − S group							
18	Rt	1, no stent	Anastomosis	5	PTBD with balloon plasty (1/6)	31	Improved
19	Rt	1, no stent	Anastomosis	6	PTBD with balloon plasty (1/5)	24	Improved
20	Rt	1, no stent	Anastomosis	7	PTBD with balloon plasty (1/5)	32	Improved
21	Rt	2 (RA, RP) → ductoplasty, no stent	Anastomosis, RP	8	ERCP (1/4), PTBD with balloon plasty (1/3)	26	Improved
22	Rt extended	2 (RA, RP) → separate anastomosis, no stent	Anastomosis, RP	12	PTBD with balloon plasty (2/6)	29	Improved
23	Rt extended	1, no stent	Anastomosis	16	PTBD with balloon plasty (2/5)	29	Improved
Ligation of the missing duct of the graft in DD − S group							
24	Rt extended	2 (RA, RP), no stent	RP	<1	PTBD (1/3) → RYHJ	24	Cured

DD + S, duct-to-duct anastomosis with a stent; DD − S, duct-to-duct anastomosis without a stent; PTBD, percutaneous transhepatic biliary drainage; RYHJ, Roux-en-Y hepaticojejunostomy; ERCP, endoscopic retrograde cholangiopancreatography; PCD, percutaneous drainage; RA, right anterior duct; RP, right posterior duct; Rt, right; Lt, left.

However, the number of biliary complications remained significant at approximately 20% in DD group in most transplant centers [5,6]. The mean follow up period in these studies was <1 year and still short. Late biliary complications can developed more than 1 year after a transplant. The present study suggested that DD was associated with a higher rate of biliary complications than RYHJ after a long-term follow up in ALDLT. The results of the Hong Kong group were similar to this study. Their recent biliary complication rate in RYHJ group was 8% [9], which was lower than the 24% in DD group [15]. Moreover, the follow up period of DD group (median 13 months) was significantly shorter than in RYHJ group (median 32 months).

Theoretically, an internal stent including a T-tube, should reduce the rate of anastomotic strictures and lead to biliary decompression. T-tube drainage also allows easy radiologic access to the biliary tree and monitoring of the biliary flow quality. However, in practice, the T-tube and the internal stent have been sources of complications in well designed large clinical series. Therefore, the authors have advocated a nonsplinted biliary reconstruction, because one source of complication could be eliminated by not placing the T-tube [18,19]. In the present study, bile leaks were only observed in DD group, particularly in those recipients receiving the internal stent or T-tube. Therefore, DD + S was changed to DD − S in order to avoid tube-associated complications. Subsequently, no bile leak has been encountered, and the early outcomes of nonstented DD have been excellent.

Therefore, bile duct stricture at the anastomosis site became a major concern in DD − S group. It was not related to other morbidities in this study. It was reported that the stricture at the anastomosis site might be related to fibrotic healing as a result of a focal microcirculation disturbance at the anastomosis of the recipient duct [10]. In order to reduce these disturbances, the preservation of the periductal connective tissue and a tension-free anastomosis may be the key for a successful reconstruction. After a late stricture aroused concerns in DD + S group, as well as a selective clamp technique of the recipient bile duct and hepatic artery, the right hepatic artery was not used for the right graft and vice versa, if at all possible, in order to improve the blood supply to the anastomosis site (Fig. 2). DD − S using the selective clamp technique and the contralateral arterial anastomosis is more frequently used as a biliary reconstruction method despite of the graft type. RYHJ is performed in cases where the condition of the recipient bile duct is poor. However, the contralateral arterial anastomosis technique was not used in this series.

Although biliary complications were originally managed surgically, nonsurgical approaches such as endoscopic or percutaneous procedures have become more popularity over the last decade [5]. Several studies have shown that endoscopic and percutaneous accesses provide a useful and reliable method for diagnosis and treatment even in living donor liver transplantation [1,4,5,16,20,21]. Importantly, the present study also found that nonsurgical interventional measures were usually used for the primary treatment for biliary complications. At least once nonsurgical method in biliary complications was attempted. After that, the treatment modality was determined according to the response to the nonsurgical management and the patients' desire. The frequency of nonsurgical intervention ranged from one to six times. Treatment of 23 of 26 biliary complications was tried by radiologic or endoscopic intervention. The other three were conservatively treated. Sixteen of 23 biliary complications were corrected at the first or the second time of intervention.

Because this study was retrospective review, the group size and graft types were different between the two groups. There was a significantly higher share of left liver grafts in RYHJ group. This is because a left liver graft and RYHJ was more frequently used in the early period of our ALDLT program [22,23]. However, there was no difference in the other clinical findings that could be used to differentiate RYHJ group from DD group; such as number of graft ducts, graft-recipient weight ratio, MELD score, or donor age.

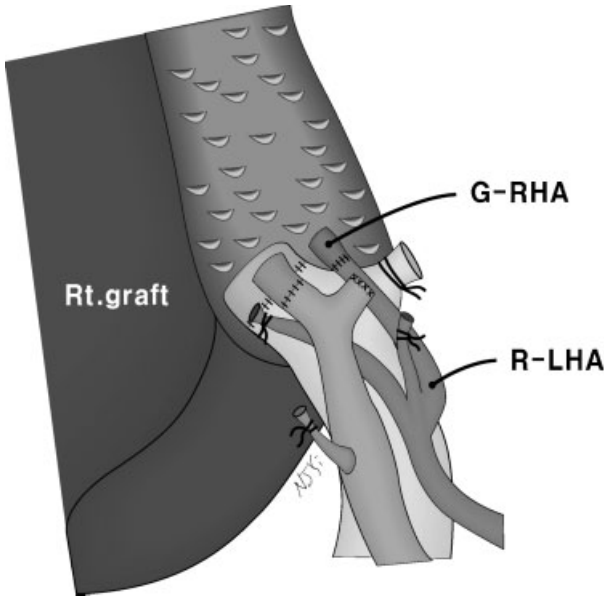

Figure 2 Contralateral arterial anastomosis in the recipient. To improve blood supply to the anastomosis site, the right hepatic artery was not used for the right graft and vice versa. Rt graft, right graft; G-RHA, the right hepatic artery of the graft; R-LHA, the left hepatic artery of the recipient.

Conclusion

The RYHJ group showed a better long-term outcome than DD group in ALDLT. Subgroup analysis of DD group showed that DD − S group had no bile leaks and early bile duct strictures, but still had a higher incidence of late bile duct strictures. However, because this study was a retrospective review there are limitations in analyzing the data and confirming the conclusion. A randomized-prospective study will be needed to confirm these findings.

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