Graft Selection Strategy in Adult-to-Adult Living Donor Liver Transplantation: When Both Hemiliver Grafts Meet Volumetric Criteria

Takeshi Kurihara,[1] Tomoharu Yoshizumi,[1] Yoshihiro Yoshida,[1] Toru Ikegami,[1] Shinji Itoh,[1] Norifumi Harimoto,[1] Mizuki Ninomiya,[1] Hideaki Uchiyama,[1] Hirohisa Okabe,[1] Koichi Kimura,[1] Hirofumi Kawanaka,[1,2] Ken Shirabe,[1] and Yoshihiko Maehara[1]

[1]Department of Surgery and Science, Graduate School of Medical Sciences, Kyushu University, Fukuoka, Japan; and [2]Clinical Research Institute, Beppu Medical Center, Beppu, Japan

To ensure donor safety in living donor liver transplantation (LDLT), the left and caudate lobe (LL) is the preferred graft choice. However, patient prognosis may still be poor even if graft volume (GV) selection criteria are met. Our aim was to evaluate the effects of right lobe (RL) donation when the LL graft selection criteria are met. Consecutive donors (n = 135) with preoperative LL graft volumetric GV/standard liver volume (SLV) of ≥35% and RL remnant of ≥35% were retrospectively studied. Patients were divided into 2 groups: LL graft and RL graft. Recipient's body surface area (BSA), Model for End-Stage Liver Disease (MELD) score, and the donor's age were higher in the RL group. The donor's BSA and preoperative volumetric GV/SLV of the LL graft were smaller in the RL group. The predicted score (calculated using data for graft size, donor age, MELD score, and the presence of portosystemic shunt, which correlated well with graft function and with 6-month graft survival) of the RL group, was significantly lower if the LL graft were used, but using the actual RL graft improved the score equal to that of the LL group. Six-month and 12-month graft survival rates did not differ between the 2 groups. In patients with a poor prognosis, a larger RL graft improved the predicted score and survival was equal to that of patients who received LL grafts. In conclusion, graft selection by GV, donor age, and recipient MELD score improves outcomes in LDLT.

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Abbreviations: BMI, body mass index; BSA, body surface area; CT, computed tomography; FHF, fulminant hepatic failure; GRWR, graft-to-recipient weight ratio; GV, graft volume; HBV, hepatitis B virus; HCC, hepatocellular carcinoma; HH15, the clearance index of Tc-GSA; ICU, intensive care unit; LC, liver cirrhosis; LDLT, living donor liver transplantation; LHA, left hepatic artery; LHL15, hepatic uptake ratio of Tc-GSA; LL, left lobe; MELD, Model for End-Stage Liver Disease; MHV, middle hepatic vein; NASH, nonalcoholic steatohepatitis; PBC, primary biliary cirrhosis; POD, postoperative day; PSC, primary sclerosing cholangitis; PT, prothrombin time; RL, right lobe; SFSS, small-for-size syndrome; SLV, standard liver volume; TB, total bilirubin; Tc-GSA, technetium-99m galactosyl-human serum albumin; V5, hepatic vein draining segment 5; V8, hepatic vein draining segment 58.

Address reprint requests to Tomoharu Yoshizumi, M.D., Ph.D., Department of Surgery and Science, Graduate School of Medical Sciences, Kyushu University, 3-1-1 Maidashi, Higashi-ku, Fukuoka 812-8582, Japan. Telephone: +81-92-642-5469; FAX: +81-92-642-5482; E-mail: yosizumi@surg2.med.kyushu-u.ac.jp

Since 1994, successful adult-to-adult living donor liver transplantation (LDLT) has been performed,[1] and liver grafts from living donors have been increasingly used because of the imbalance between supply and demand. Right lobe (RL) grafts, which account for >60% of the total liver volume, are most commonly used for LDLT. More donors who donated a RL graft experienced complications from the procedure than those who donated a graft of the left and caudate lobe (LL).[2,3] Because donor safety is considered first and excessive surgery on a healthy living donor should be avoided, we routinely use the LL graft when the preoperative volumetric graft volume (GV)/standard liver volume (SLV) ratio was ≥35%.[4,5] However, even if the criterion was met, patients still had a poor prognosis. To improve the outcome of LDLT, we developed a formula for predicting early graft function after

LDLT including graft size, donor age, Model for End-Stage Liver Disease (MELD) score, and presence of portosystemic shunt. This formula correlated well with graft function and with 6-month graft survival.[6] Given this formula, we used the larger graft for those patients who were considered to have a poor prognosis.

The aim of this study was to analyze the cases of patients at our institute where the RL graft was used even when the GV/SLV of the LL graft was ≥35%.

Patients and Methods

DONOR SELECTION

Donors were selected from among candidates who volunteered to be living donors.[7,8] They were required to be within third-degree consanguinity or the spouse of the recipient and to be between 20 and 65 years of age. For donors not within the third-degree of consanguinity of the recipient, individual approval was obtained from the ethics committee of Kyushu University Hospital. Good Samaritan donation was not used. Three-dimensional computed tomography (CT) was performed for the volumetric analysis and delineation of the vascular anatomy. This study was approved by the ethics committee of Kyushu University (institutional review board approval number 27-138).

The SLV of recipients was calculated according to the formula from Urata et al.[9] The GV was predicted using CT volumetric analysis. We determined the graft type for each recipient based on the preoperatively predicted GV/SLV ratio. The LL graft was available to use when the preoperatively predicted GV/SLV ratio was ≥35%. If the remnant donor liver volume after right lobectomy was ≥35%, the RL graft was available to use. When the GV/SLV ratio of the LL graft was <35% and the donor's remnant liver volume rate after right lobectomy was <35%, the donor was rejected. Our RL selection criteria, despite the GV/SLV ratio of the LL graft, was multiple left hepatic artery (LHA) high congestion area in the remnant liver (≥50%), high recipient MELD score (≥40), high recipient body mass index (BMI; ≥30 kg/m^2), and advanced donor age (≥60 years old).

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RECIPIENTS

Between January 2005 and June 2014, 302 patients underwent LDLT at Kyushu University Hospital. In this study, 181 patients underwent LDLT with a LL graft, and 121 patients underwent LDLT with a RL graft. Among them, there were 135 donors who met the preoperatively predicted GV/SLV ratio of LL graft ≥35% and a preoperatively predicted donor's remnant liver volume rate after right lobectomy ≥35%. Patients were divided into 2 groups according to graft type: LL graft (n = 106) and RL graft (n = 29).

Indications for LDLT were hepatitis C (n = 61, including 40 with hepatocellular carcinoma [HCC]), primary biliary cirrhosis (PBC; n = 16), fulminant hepatic failure (FHF; n = 13), autoimmune hepatitis (n = 11), hepatitis B (n = 8, including 4 with HCC), cryptogenic cirrhosis (n = 7, including 3 with HCC), primary sclerosing cholangitis (PSC; n = 5), alcoholic cirrhosis (n = 5, including 2 with HCC), and others (n = 9).

SURGICAL PROCEDURES AND PORTAL INFLOW MANAGEMENT

The graft procurement technique, recipient surgery, and perioperative management of recipients, including immunosuppression regimens, have been described previously.[7,8] Our portal inflow modification consisted mainly of splenectomy and shunt ligation.[10] Simultaneous splenectomy was performed in 100 recipients to decrease portal venous pressure or to improve pancytopenia.[11] Five recipients underwent splenectomy before LDLT. We have ligated all of the identified major (≤10 mm) portosystemic shunt vessels. The shunts are controlled and left open during the anhepatic phase to minimize portal venous congestion and are ligated after reperfusion.

POSTOPERATIVE MANAGEMENT

Immunosuppression was initiated using a protocol based on either tacrolimus (Prograf; Astellas Pharma, Tokyo, Japan) or cyclosporine A (Neoral; Novartis Pharma K.K., Tokyo, Japan) with steroids. Tacrolimus was used in 83 recipients, and cyclosporine was used in

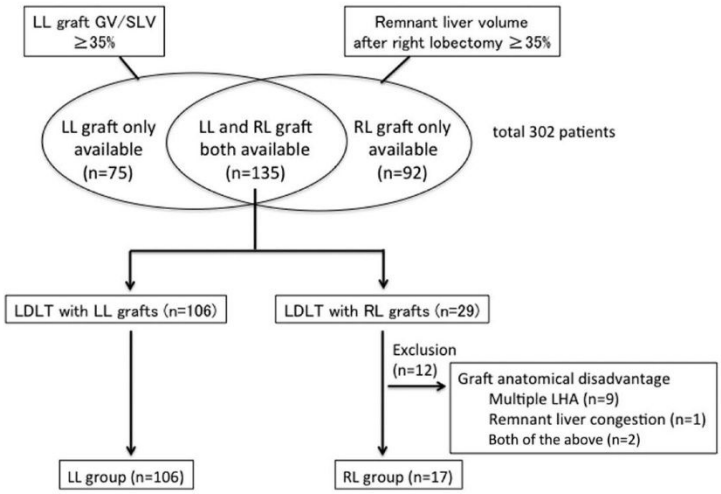

FIG. 1. Algorithms showing our graft selection procedure with reference to preoperatively predicted GV.

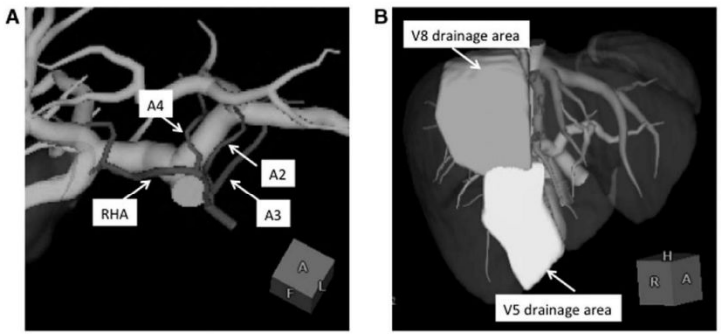

FIG. 2. Anatomically inappropriate cases in the RL group. (A) 11 patients had multiple LHAs and (B) 3 patients had a large congested area after left lobectomy and 2 patients had multiple LHAs and a large congested area.

50 recipients. Two recipients did not receive calcineurin inhibitors because of their poor postoperative courses.

The target tacrolimus trough concentration was set at 10 ng/mL for 3 months after LDLT and 5-10 ng/mL thereafter. The target trough concentration of cyclosporine A was set at 250 ng/mL for 3 months after LDLT and 150-200 ng/mL thereafter. Methylprednisolone was initiated on the day of LDLT, after which the dosage was tapered, and prednisolone was

TABLE 1. Preoperative Recipient Variables in the RL and LL Groups

Variables	Grafts: RL (n = 17)	Grafts: LL (n = 106)	*P* Value
Age, years, median (range)	53.2 (28-70)	55.2 (19-72)	0.48
Sex, male, n (%)	8 (47.0)	31 (29.2)	0.15
BMI, kg/m^2	23.2 ± 2.0	22.5 ± 0.6	0.43
BSA, m^2	1.64 ± 0.07	1.56 ± 0.02	0.02
Child-Pugh score	11.0 ± 1.2	10.1 ± 0.4	0.16
SLV*	1159 ± 48	1102 ± 18	0.02
MELD score	21.8 ± 5.3	15.7 ± 1.5	0.005
TB, mg/dL	11.7 ± 5.5	6.8 ± 1.6	0.03
Albumin, mg/dL	2.8 ± 0.2	2.8 ± 0.1	0.74
PT, %	38.9 ± 6.7	53.9 ± 3.2	<0.001
ICU management, n (%)	8 (47.1)	14 (13.2)	0.002
Hospitalization, n (%)	9 (52.9)	31 (29.2)	0.06
Portosystemic shunt, yes, n (%)	5 (29.4)	34 (32.1)	0.83
Splenectomy, n (%)	8 (47.1)	78 (73.6)	0.03

NOTE: Data are given as mean ± standard deviation unless otherwise noted.
*SLV is calculated by 706.2 × BSA + 2.4.

TABLE 2. Donor Variables in the RL and LL Groups

Variables	Grafts: RL (n = 17)	Grafts: LL (n = 106)	*P* Value
Age, years, median (range)	41.1 (20-60)	34.2 (19-61)	0.01
Sex, male, n (%)	10 (58.8)	82 (77.4)	0.12
BMI, kg/m^2	21.5 ± 1.6	22.9 ± 0.5	0.06
BSA, m^2	1.60 ± 0.05	1.73 ± 0.03	<0.001
Predicted total GV, mL	1090 ± 83	1162 ± 31	0.10
Volumetric analysis of LL graft, mL	434.2 ± 26.5	462.5 ± 13.1	0.10
Volumetric analysis of LL GV/SLV ratio, %*	37.3 ± 1.1	41.9 ± 1.0	<0.001
Volumetric analysis of LL GRWR, %	0.62 ± 0.04	0.76 ± 0.03	0.001

NOTE: Data are given as mean ± standard deviation unless otherwise noted.
*SLV is calculated by 706.2 × BSA + 2.4.

substituted for 7 days after LDLT. Prednisolone treatment was tapered and discontinued 6 months after LDLT. Mycophenolate mofetil was used in 121 recipients, beginning with 1-2 g/day on the day after LDLT; the dosage was tapered and discontinued 6 months after LDLT. Trough concentration of mycophenolate mofetil was not measured.

Patients with prolonged functional cholestasis (serum total bilirubin [TB] higher than 10 mg/dL on postoperative day [POD] 14), intractable ascites (volume of ascites greater than 500 mL on POD 14), and impairment of protein synthesis (prothrombin time [PT]–international normalized ratio greater than 1.3 on POD 14) were defined as small-for-size syndrome (SFSS).[4]

PREDICTIVE SCORES

Predictive scores were calculated from the following clinical data: donor age, GV/SLV ratio, MELD score, and the presence of a portosystemic shunt (eg, gastrorenal or splenorenal shunts). The MELD score was calculated using a formula reported by Kamath et al.[12] A portosystemic shunt was defined as a shunt shown by preoperative CT to be ≥1 cm in diameter.

The formula we have reported[6] is as follows:

Predictive score = 0.011 × graft weight (%) − 0.016 × donor age − 0.008 × MELD score − 0.15 × shunt (if present) + 1.757.

STATISTICAL ANALYSIS

Significant differences between the groups were determined using the χ^2 test, Student t test, or Mann-Whitney U test. The Kaplan-Meier method was used to calculate the survival probability for up to 6 and 12 months after LDLT. Survival between the groups was compared using a log-rank test. Variables that were used for this analysis included recipient age, recipient sex, primary prehospital status, recipient BMI, recipient body surface area (BSA), recipient SLV, MELD score, donor age, donor sex, GV/SLV ratio, presence of portosystemic shunt, and predictive score. A P value < 0.05 was considered significant. Data were expressed as the mean ± standard deviation. All statistical analyses were performed using JMP 9.0 software (SAS Institute, Cary, NC).

Results

Figure 1 shows algorithms used in graft selection of preoperatively predicted GV. LL grafts were used in 106 patients, and RL grafts were used in 29 patients. Figure 2 shows anatomically inappropriate grafts in the RL group: 11 patients had multiple LHAs; 3 patients had a large area of congestion after left lobectomy; and 2 patients had multiple LHAs and a large area of congestion. Twelve patients who received RL grafts were excluded from the study for the reasons described above.

Table 1 shows a comparison of recipients' preoperative variables between RL and LL groups. Recipient's BSA, SLV, MELD score, and need for intensive care

TABLE 3. Comparison of Outcomes Between the RL and LL Groups

Variables	Graft RL (n = 17)	Graft LL (n = 106)	*P* Value
Recipient outcome			
Operative time, minutes	856 ± 53	715 ± 19	<0.001
Bleeding, ml	6325 ± 2046	4661 ± 1401	0.38
Postoperative hospital stay, days	45.3 ± 13.2	33.3 ± 4.5	0.05
TB on POD 14, mg/dL	6.6 ± 3.0	6.2 ± 1.4	0.85
PT on POD 14, %	81.5 ± 7.6	78.3 ± 3.6	0.47
Complication, n (%)	12 (70.6)	60 (56.6)	0.27
SFSS, n (%)	0 (0.0)	7 (6.6)	0.14
Cumulative survival rate, %			0.54
6 months	96.24	90.30	
1 years	87.05	89.20	
Donor outcome			
Operative time, min	392 ± 43	395 ± 15	0.88
Bleeding, ml	485 ± 235	490 ± 67	0.71
Peak TB, mg/dL	2.7 ± 0.7	2.3 ± 0.2	0.22
Postoperative hospital stay, days	12.5 ± 1.6	11.9 ± 0.7	0.57
Complication, n (%)	3 (17.6)	25 (23.6)	0.58
Wound dehiscence	2	13	
Bleeding	1	2	
Hyperbilirubinemia		3	
Arm paresthesia		4	
Duodenal ulcer		3	
Bile leakage		1	
Hepatic infarction		1	
Colitis		1	
Labial herpes		1	

TABLE 4. Comparison of Predictive Scores Between RL Graft and LL Graft

Variables	Graft RL (n = 17)	Graft LL (n = 106)	*P* Value
Predictive score of LL graft	1.291 ± 0.106	1.496 ± 0.036	<0.001
Predictive score of actual graft	1.490 ± 0.091	1.496 ± 0.036	0.52

NOTE: Predictive score = 0.011 × graft weight (%) − 0.016 × donor age − 0.008 × MELD score − 0.15 × portosystemic shunt (if present) + 1.757.

unit (ICU) management was higher in the RL groups than in the LL group.

Table 2 shows a comparison of the donors' preoperative variables. Donor age was higher, and there were more female donors in the RL group than in the LL group. Donor BSA and volumetry analysis of the LL graft GV/SLV ratio showed that it was smaller in the RL than in the LL group.

Table 3 shows a comparison of perioperative and postoperative variables. Recipient operative time was longer in the RL group than in the LL group. Seven recipients in the LL group were diagnosed with SFSS, and 1 of them resulted in early graft loss.

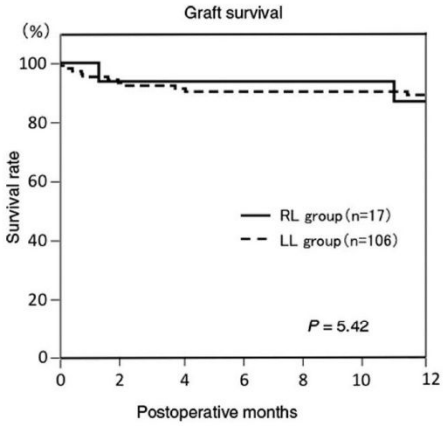

FIG. 3. The graph shows the 12-month graft survival after LDLT in the RL and LL groups. Six-month graft survival rate and 12-month graft survival rate did not differ between the 2 groups.

Table 4 shows predictive score analysis between the RL group and the LL group. If a LL graft was used, the predictive score of the RL group was lower than that in the LL group. However, using a RL graft in the RL group, the predicted score was not different from the LL group.

Figure 3 shows the 12-month graft survival after LDLT in the RL and LL groups. The 6-month graft survival rate and 12-month graft survival rate did not differ between the 2 groups.

The detailed data for recipients in the RL group are shown in Table 5, and those of 7 recipients in the LL group who developed SFSS are shown in Table 6.

Discussion

Donor safety must be the first priority when performing LDLT because the donors are originally healthy volunteers. In our initial data, using the LL graft was better in terms of donor risk than the RL graft.[2] We have considered this point previously and proposed a graft selection algorithm assuming the LL graft to be the first choice of graft type if the preoperative volumetric GV/SLV ratio can be secured.[13] However, patients with poor prognosis also exist even if the

TABLE 5. Detailed Data for Patients in the RL Group

Variables	Patient Number																	
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	
Recipients																		
Age, years	65	51	54	47	48	61	61	54	45	28	43	53	53	70	54	59	60	
Sex	Female	Male	Male	Male	Male	Male	Female	Female	Male	Female	Male	Female	Male	Female	Female	Female	Female	
Primary diagnosis	HCV HCC	Other	HBV	HBV FHF	PSC	FHF	FHF	FHF	HCV HCC	FHF	LC	HCV	EtOH HCC	HCV	PBC	Wilson's disease	NASH	
BMI, kg/m^2	18	21	21	19	16	21	28	30	30	23	23	22	26	22	22	23	30	
BSA, m^2	1.35	1.69	1.70	1.61	1.63	1.69	1.63	1.68	1.94	1.63	1.67	1.52	1.84	1.44	1.50	1.62	1.74	
SLV, mL*	954	1195	1206	1137	1152	1200	1154	1187	1375	1155	1184	1079	1303	1017	1059	1147	1193	
Child-Pugh score	10		11		8				8		12	12	10	11	12	13	14	
MELD score	17	17	10	35	10	22	19	19	9	33	45	18	16	21	21	44	15	
Portosystemic shunt	Yes	No	No	No	No	No	No	No	Yes	No	No	No	Yes	No	No	Yes	Yes	
ICU management	No	No	No	Yes	No	Yes	Yes	Yes	No	Yes	Yes	No	No	Yes	No	Yes	No	
Operation time, minutes	847	871	866	719	687	841	829	883	968	1048	930	712	748	762	830	1045	975	
Blood loss, mL	3820	12000	13426	1236	750	1334	835	2670	8252	4490	10971	9600	5106	8270	5160	10113	9500	
Splenectomy	No	No	Yes	No	No	No	No	No	Yes	No	Yes	Yes	Yes	Yes	Yes	Yes	No	
Reconstruction of MHV branches	V5+V8	V5+V8	V5+V8	Non	V5+V8	Non	V5+V8	V5	V5	V5+V8	V5+V8	Non	V5+V8	Non	V5	V8	Non	
Donors/grafts																		
Age, years	36	46	56	21	46	33	60	23	44	48	43	26	55	47	60	20	35	
Sex	Female	Female	Female	Male	Female	Male	Male	Female	Male	Male	Female	Male	Male	Female	Male	Male	Male	
ABO status	Identical	Identical	Identical	Identical	Compatible	Identical	Identical	Identical	Identical	Compatible	Compatible	Identical	Identical	Identical	Compatible	Identical	Compatible	
BMI, kg/m^2	16.5	18.6	21	20.7	21.2	18.3	23.4	31.3	19.9	23.3	21.2	20.8	22.5	24.6	17.9	21.6	23	
BSA, m^2	1.36	1.61	1.57	1.69	1.48	1.67	1.62	1.66	1.65	1.75	1.52	1.62	1.67	1.53	1.52	1.57	1.74	
Volumetry of total GV, mL	787	1137	991	1042	961	1259	1337	1012	1497	1107	992	1001	1074	898	1044	1187	1213	
Volumetry of LL GV, mL	350	460	432	401	411	453	456	418	585	468	416	400	490	366	378	466	433	
Volumetric LL GV/SLV ratio, %	36.6	38.4	35.8	35.3	35.6	37.7	39.5	35.2	42.5	40.5	35.1	37	37.5	35.9	35.6	40.5	36.7	
Volumetric LL GRWR, %	0.85	0.63	0.58	0.65	0.68	0.62	0.60	0.50	0.50	0.66	0.57	0.67	0.50	0.70	0.67	0.67	0.52	
Actual RL GV, mL	400	630	530	630	520	570	670	560	610	620	513	598	575	520	630	539	800	
Actual RL GV/SLV ratio, %	41.9	52.7	43.9	55.4	45.1	47.5	58.1	47.2	44.4	53.7	43.3	55.4	44.1	51.1	59.5	47.0	67.1	
Actual RL GRWR, %	0.93	1.04	0.86	1.17	1.00	0.93	1.02	0.79	0.71	1.02	0.83	1.09	0.77	1.02	1.19	0.90	1.13	
Predictive score	1.298	1.307	1.175	1.529	1.333	1.468	1.079	1.624	1.299	1.170	1.095	1.604	1.011	1.232	1.021	1.380	1.331	
of volumetric LL graft																		
Predictive score	1.356	1.492	1.252	1.750	1.437	1.575	1.283	1.755	1.319	1.315	1.185	1.806	1.084	1.399	1.298	1.452	1.588	
of actual RL graft																		
Graft survival																		
6 month									Loss									
12 month							Loss											

*SLV is calculated by 706.2 × BSA + 2.4.

TABLE 6. Detailed Data for Patients With SFSS in the LL Group

Variables	Patient Number						
	1	2	3	4	5	6	7
Recipients							
Age, years	53	49	55	47	45	55	54
Sex	Female	Female	Male	Female	Female	Male	Female
Primary diagnosis	HCV	HCV	HCV HCC	HCV HCC	Others	HCV	Wilson syndrome
BMI, kg/m^2	35.7	26.5	25.2	24.4	21.4	25.6	20.8
BSA, m^2	1.76	1.65	1.67	1.49	1.67	1.84	1.28
SLV, mL*	1248	1164	1182	1055	1187	1299	905
Child-Pugh score	13	10	7	13	6	12	12
MELD score	13	14	9	19	3	11	19
Portosystemic shunt	No	No	No	No	No	Yes	Yes
ICU management	No	No	No	No	No	No	No
Operation time, minutes	666	808	844	940	978	894	769
Blood loss, mL	8000	3500	7445	8828	10000	2012	3735
Splenectomy	No	No	No	Yes	No	Yes	Yes
Donors/grafts							
Age, years	24	23	27	20	48	27	57
Sex	Male	Male	Male	Female	Male	Male	Male
ABO status	Identical	Identical	Identical	Identical	Identical	Identical	Identical
BMI, kg/m^2	22.5	23.7	23.5	18.0	17.0	23.9	23.0
BSA, m^2	1.82	1.80	1.79	1.42	1.82	1.80	1.64
Volumetry of total GV, mL	1172	1165	1133	762	1292	1393	1123
Volumetry of LL GV, mL	439	462	491	379	531	580	446
Volumetric LL GV/SLV ratio, %	35.1	39.6	41.5	35.8	44.7	44.6	49.2
Volumetric LL GRWR, %	0.43	0.61	0.64	0.65	0.74	0.61	1.17
Actual LL GV, mL	490	410	420	250	400	580	432
Actual LL GV/SLV ratio, %	39.3	35.2	35.5	23.7	33.7	44.6	47.7
Actual LL GRWR, %	0.60	0.63	0.65	0.45	0.68	0.79	1.03
Predictive score of volumetric LL graft	1.655	1.713	1.710	1.679	1.457	1.578	1.084
Predictive score of actual LL graft	1.706	1.643	1.645	1.545	1.336	1.578	1.068
Graft survival							
6 month	Loss						
12 month							

*SLV is calculated by 706.2 × BSA + 2.4.

volumetric criteria are met, especially in patients with SFSS, which is a serious complication that can affect prognosis. SFSS is an issue when the LL graft is chosen because the volume of the LL graft is usually smaller than that of the RL graft. SFSS has been recognized with the widespread application of cadaveric splits or LDLT.[14] The clinical manifestations of SFSS consist of poor bile production, delayed synthetic function, prolonged cholestasis, and intractable ascites, which lead to septic complications and high mortality.[15] Living donor grafts of <40%-50% of SLV, corresponding to a graft-to-recipient weight ratio (GRWR) of 0.8%-1.0%, are associated with a particular cause of SFSS.[6,16] To prevent poor prognosis after LDLT, we derived a formula for predicting the prognosis 6 months after LDLT. If poor prognosis was predicted using the formula, we chose the larger graft, and these patients' outcomes after LDLT with the LL graft were not different from those with a RL graft.[17] In addition, the incidence of postoperative donor complications after RL hepatectomy was comparable to those after LL hepatectomy in the latest series.[18]

In this study, factors affecting whether the RL graft was chosen include a higher recipient BSA, SLV, and MELD score; a more advanced donor age; and lower donor BSA, preoperative volumetric analysis of the LL graft GV/SLV ratio, and GRWR. Appropriate size matching of the liver graft from the living donor with the recipient is essential for success. Gunay et al.[19] examined 380 patients who underwent LDLT, of whom 74 were considered obese (BMI $\geq$ 30 kg/m^2). Although the obese patients had a harder time finding suitable living donors, the complication rate, graft survival, and patient survival were all similar when comparing the obese recipients to either the overweight or normal weight recipients. This was because obese recipients had a greater body weight, but they received larger donor right liver lobes, so their mean GRWR

ratio was not significantly lower than the ratio in normal BMI recipients. In our study, although more patients were considered to be obese in the RL group, they received a larger RL graft, and no difference was observed in morbidity and mortality between the RL and LL groups. We previously reported that recipients who received grafts from older donors had a poor survival rate.[8] Han et al.[20] reported a higher incidence of arterial and biliary complications in patients receiving grafts from older donors (≥55 years) than from younger donors (<55 years). In addition, they reported significantly lower survival rates at 1 (63.4% versus 86.9%), 3 (58.5% versus 84.3%), and 5 years (44.6% versus 80.7%; $P < 0.001$) for patients receiving grafts from older donors (≥55 years) compared with younger (<50 years) donors. Kamo et al.[21] reported that the overall survival outcomes of LDLT procedures using grafts from elderly donors were significantly worse than those of procedures with younger donors. In the present study, the RL group had a higher donor age and a poor recipient status, but the survival was not significantly different because the larger graft was chosen.

Predictive scores calculated using a formula that we proposed were useful for predicting the probability of 6-month graft survival.[6] First, 28 patients underwent technetium-99m galactosyl-human serum albumin (Tc-GSA) liver scintigraphy 7 days after LDLT. The ratio of the hepatic uptake ratio of Tc-GSA (LHL15) to the clearance index of Tc-GSA (clearance index of Tc-GSA [HH15]; LHL/HH score) was correlated well with the survival probability at 6 months after the LDLT. Second, a multiple regression test was performed to establish the new formula to calculate the LHL/HH score from factors including the graft size, donor age, MELD score, and portosystemic shunt presence. A crucial feature of this formula is that it uses variables that can be obtained before performing LDLT. We previously set the cutoff value of the predictive score to 1.3 and the survival probability at 6 months after the LDLT for the group with a predictive score ≥1.3 was significantly better than that of the group with a predictive score < 1.3 (92.9% versus 78.9%; $P < 0.05$). In this study, the average predicted score for the RL group when the LL graft was used was below 1.3. However, the predicted score was improved using the RL grafts, and the actual short-term prognosis became equivalent to the LL group. The predicted score was suggested to be a potential indicator of graft selection.

In conclusion, our strategy was to first select the LL graft, and then use the larger RL grafts for patients who were expected to have a poor prognosis if the LL graft would have been used. This strategy improved the predicted score, and as a result, the prognosis after LDLT was not different between patients with LL grafts and RL grafts. Graft selection not only by GV but by donor age and recipient MELD score would also improve outcomes after LDLT.

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