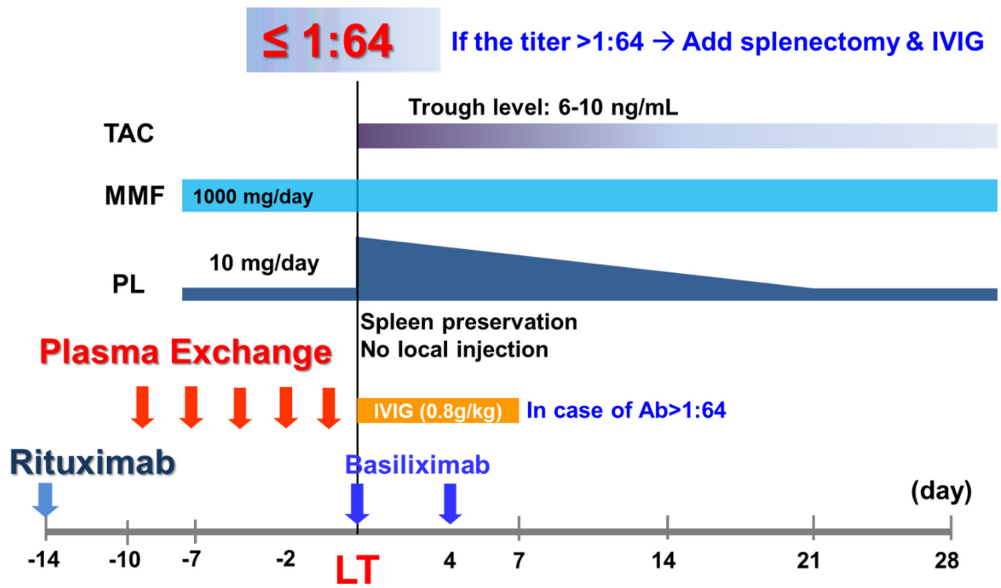
Supplementary

Appendix 1: Living donor selection

Typically, one or two candidates undergo donor assessments. The relative contraindications for potential donors include: age below 18 years or above 65 years, liver fibrosis exceeding a mild grade, expected hepatosteatosis greater than 20%, estimated remnant liver volume less than 30–35%, significant underlying medical conditions, or a history of major abdominal operation. We then, selected a suitable donor to maximize recipient benefit, using the following criteria: a graft recipient weight ratio exceeding 0.8, ABO compatibility, anatomical compatibility of the liver graft (avoiding multiple branches requiring the reconstruction), and consideration of the donor's age alongside the grade of hepatic steatosis.

Appendix 2: ABO desensitization protocol in Severance Hospital



IVIG, intravenous immunoglobulin; TAC, tacrolimus; MMF, mycophenolate mofetil; PL, prednisolone; Ab, antibody; LT, liver transplantation.

Appendix 3: Cause of withdrawal from ITT-ABOi-LDLT

Cause	N=13, n (%)
Delisted	3 (23.1)
Aggravated health condition	2 (15.4)
Improved health condition	1 (7.7)
Allocated to DDLT	5 (38.5)
Unsuitable donor	4 (30.8)
Small graft	1 (7.7)
Small residual liver volume	1 (7.7)
Fatty liver	1 (7.7)
Living donation refused by Korean Network for Organ Sharing	1 (7.7)
Desensitization failure	1 (7.7)

ITT, intention-to-treat; ABOi, ABO-incompatible; LDLT, living-donor liver transplantation; DDLT, deceased-donor liver transplantation.

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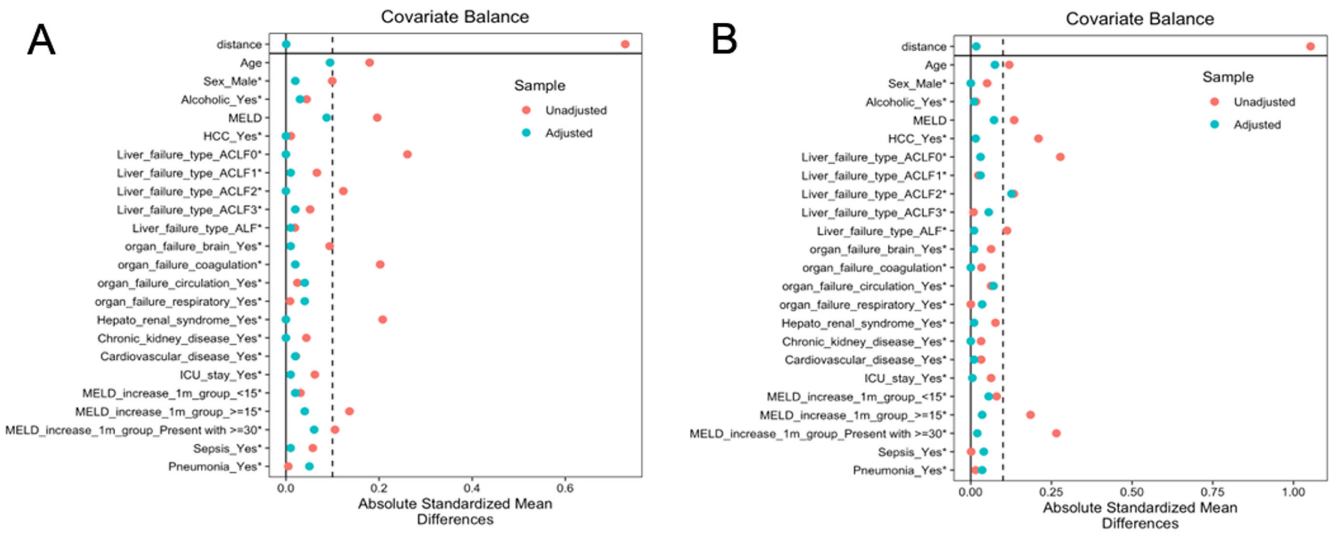
Appendix 4: Characteristics of patients who failed to complete the desensitization

Case	Donor relation	Blood matching	Initial IA-titer	Rituximab	TPE	Last IA-titer	Cause of discontinuation
Case 1	Brother	A→O	1:128	–	1	1:16	Allocated to DDLT during desensitization[†]
Case 2	Daughter	A→O	>1:1,024	375 mg/m^2	7	1:256	Desensitization failed: high anti-A titer
Case 3	Brother	B→A	1:32	375 mg/m^2	0[‡]	1:32	Aggravation of pneumonia
Case 4	Son	A→O	1:1,024	375 mg/m^2	11	1:64	Allocated to DDLT after failing desensitization due to high anti-A titer
Case 5	Spouse	AB→A	1:32	375 mg/m^2	0	–	Septic shock[§]

[†], patient underwent TPE once, then was allocated to DDLT. Despite DDLT efficacy, female patient expired due to complications from hepatic encephalopathy. [‡], due to deterioration associated with pneumonia, patient was unable to undergo TPE as intended. [§], adverse event observed 4 days after rituximab administration. IA, isoagglutinin; TPE, therapeutic plasma exchange; DDLT, deceased-donor liver transplantation.

Appendix 5: Standardized mean differences after propensity score matching, (A) between ITT-ABOi-LDLT and ITT-DDLT groups, and (B) between ITT-ABOi-LDLT and ITT-ABOc-LDLT groups



ITT, intention-to-treat; ABOi, ABO-incompatible; LDLT, living-donor liver transplantation; DDLT, deceased-donor liver transplantation; ABOc, ABO-compatible; MELD, Model for End-stage Liver Disease; HCC, hepatocellular carcinoma; ACLF, acute-on-chronic liver failure; ALF, acute liver failure; ICU, intensive care unit.

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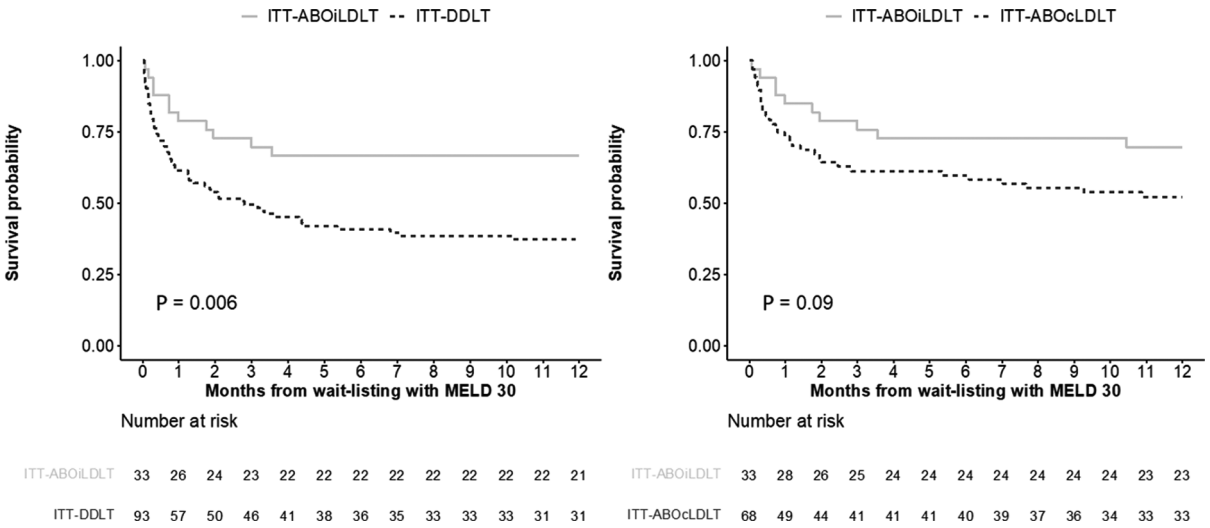
Appendix 6: One-year patient overall survival, according to treatment intention after propensity score matching



ITT, intention-to-treat; ABOi, ABO-incompatible; LDLT, living-donor liver transplantation; DDLT, deceased-donor liver transplantation; MELD, Model for End-stage Liver Disease; ABOc, ABO-compatible.

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Appendix 7: Baseline characteristics at time of liver transplantation

Variables	ABOi-LDLT (n=32)	DDLT (n=170)	P†	ABOc-LDLT (n=88)	P‡
Age (years)	53.2±10.6	51.1±11.9	0.354	49.9±9.2	0.10
Sex, male	23 (71.9)	117 (68.8)	0.893	56 (63.6)	0.53
Body mass index (kg/m^2)	24.3±3.9	23.7 [21.8–26.5]	0.871	24.0±3.9	0.72
Time from MELD 30 to LT (days)	6 [2–15]	9 [5–17]	0.076	10 [4–26]	0.06
Diabetes mellitus	8 (25.0)	42 (24.7)	>0.99	17 (19.3)	0.72
Cardiovascular disease	0 (0.0)	7 (4.1)	0.521	1 (1.1)	0.99
Pretransplant MELD	25.0 [16.5–31.0]	35.0 [30.0–40.0]	<0.001	30.5 [26.0–33.0]	0.008
Pretransplant MELD group			<0.001		0.06
<20	11 (34.4)	2 (1.2)		11 (12.5)	
20–29	9 (28.1)	40 (23.5)		25 (28.4)	
30–34	9 (28.1)	42 (24.7)		35 (39.8)	
35–39	2 (6.3)	28 (16.5)		6 (6.8)	
≥40	1 (3.1)	58 (34.1)		11 (12.5)	
Hepatocellular carcinoma	12 (37.5)	34 (20.0)	0.053	8 (9.1)	0.001
Combined transplantation	0 (0.0)	5 (2.9)	0.717	1 (1.1)	0.99
Donor age (years)	34.0 [26.5–41.0]	48.4±14.8	<0.001	31.0 [22.0–42.0]	0.43
Donor male sex	19 (59.4)	109 (64.1)	0.756	56 (63.6)	0.72
Donor body mass index (kg/m^2)	23.4±3.2	23.0 [21.0–25.1]	0.945	23.1±2.4	0.64
Graft type			<0.001		0.82
Whole liver	0 (0.0)	166 (97.6)		0 (0.0)	
Right lobe	31 (96.9)	3 (1.8)		84 (95.5)	
Left lobe	1 (3.1)	1 (0.6)		3 (3.4)	
Others	0 (0.0)	0 (0.0)		1 (1.1)	
Measured GRWR	1.1 [0.9–1.2]	3.1 [3.1–3.1]	<0.001	1.1 [1.0–1.4]	0.47
Microvesicular steatosis ≥10	6 (18.8)	56 (32.9)	0.137	13 (14.8)	0.85
Operation time (min)	667.5 [560.4–764.4]	502.0 [420.0–603.6]	<0.001	652.5 [559.8–726.0]	0.69
Cold ischemic time (min)	144.3 [114.0–183.0]	378.0 [300.0–480.0]	<0.001	131.4 [109.8–156.0]	0.23
Transfusion red blood cell (L)	2.9 [1.8–4.2]	2.7 [1.5–5.1]	0.816	2.3 [1.2–3.6]	0.18

Data are presented as mean ± standard deviation, n (%), or median (interquartile range). †, P values, ABOi-LDLT *vs.* DDLT; ‡, P values, ABOi-LDLT *vs.* ABOc-LDLT. ABOi, ABO-incompatible; LDLT, living-donor liver transplantation; DDLT, deceased-donor liver transplantation; ABOc, ABO-compatible; MELD, Model for End-stage Liver Disease; LT, liver transplantation; GRWR, graft to recipient weight ratio.

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Appendix 8: Multivariate analysis of risk factors for 1-year patient survival after LT

Variables	Compared to ABOc-LDLT		Compared to DDLT	
	HR (95% CI)	P[†]	HR (95% CI)	P[‡]
Types of LT				
ABOi-LDLT	0.85 (0.29–2.50)	0.76	1.31 (0.57–3.04)	0.52
ABOc-LDLT	Reference	–		
DDLT			Reference	–
Recipient age	1.04 (1.00–1.09)	0.055	1.03 (1.00–1.06)	0.03
Recipient body mass index			1.08 (1.02–1.15)	0.01
Alcoholic liver disease			0.61 (0.29–1.27)	0.19
Pretransplant MELD score	1.05 (0.99–1.11)	0.09	1.07 (1.02–1.12)	0.002
Hepatocellular carcinoma	1.16 (0.37–3.66)	0.80		
Organ failure[§]				
Brain	40.6 (5.82–283)	<0.001		
Respiratory	0.56 (0.09–3.58)	0.54		
Cardiovascular disease			1.79 (0.55–5.87)	0.34
Donor age	1.03 (0.99–1.08)	0.13		
Donor body mass index			1.05 (0.99–1.12)	0.13
Microvesicular steatosis ≥10			1.60 (0.91–2.81)	0.10
Transfusion, red blood cell	1.00 (1.00–1.00)	0.049	1.00 (1.00–1.00)	<0.001

[†], P values, ABOi-LDLT *vs.* ABOc-LDLT; [‡], P values, ABOi-LDLT *vs.* DDLT; [§], based on the reference (30). LT, liver transplantation; ABOc, ABO-compatible; LDLT, living-donor liver transplantation; DDLT, deceased-donor liver transplantation; HR, hazard ratio; CI, confidence interval; ABOi, ABO-incompatible; MELD, Model for End-stage Liver Disease.

Appendix 9: Causes of death in patients who received LT

Cause of death	ABOi-LDLT (n=32)	ABOc-LDLT (n=88)	DDLT (n=170)
Total of deaths	9	24	73
Infection	4 (44.4)	12 (50.0)	30 (41.1)
Graft failure	3 (33.3)	5 (20.8)	16 (21.9)
Recurred hepatocellular carcinoma	1 (11.1)	0 (0.0)	4 (5.5)
Malignancy (except recurred hepatocellular carcinoma)	0 (0.0)	1 (4.2)	2 (2.7)
Cerebrovascular accident	0 (0.0)	4 (16.7)	5 (6.8)
Bleeding	0 (0.0)	1 (4.2)	7 (9.6)
Graft *vs.* host disease	0 (0.0)	0 (0.0)	3 (4.1)
Cardiac accident	1 (11.1)	0 (0.0)	2 (2.7)
Respiratory accident	0 (0.0)	0 (0.0)	1 (1.4)
Surgical complication (not related to graft function)	0 (0.0)	0 (0.0)	1 (1.4)
Others	0 (0.0)	0 (0.0)	1 (1.4)
Unknown	0 (0.0)	1 (4.2)	0 (0.0)

Data are presented as n or n (%). LT, liver transplantation; ABOi, ABO-incompatible; LDLT, living-donor liver transplantation; ABOc, ABO-compatible; DDLT, deceased-donor liver transplantation.

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Appendix 10: Baseline characteristics before ABO desensitization

Variables	Before desensitization (n=32)	At the time of LT (n=32)
Blood matching		
A/B→O	11 (34.4)	
A/B→B/A	9 (28.1)	
AB→A/B	12 (37.5)	
IA-titer		
Within 1:32	12 (37.5)	28 (87.5)
1:64–1:128	11 (34.4)	4 (12.5)[‡]
1:256–1:512	4 (12.5)	0 (0.0)
1:1,024–1:2,048	5 (15.6)	0 (0.0)
CD19, number	69 [1–464]	1 [0–77]
CD20, number	64 [0–497]	0 [0–4]
Rituximab[†]		
375 mg/m^2	24 (75.0)	
Lower dose	8 (25.0)	
TPE[†]		
1–2	12 (37.5)	
3–6	15 (46.9)	
7–14	5 (15.6)	
Preoperative immunosuppressant		
Tacrolimus		18 (56.3)
Mycophenolate mofetil		8 (25.0)
IVIG		7 (21.9)
Basiliximab		32 (100.0)
Splenectomy		3 (9.4)[§]

Data are presented as n (%) or median [range]. [†], all patients underwent rituximab and TPE; [‡], all patients had a maximum titer of 1:64; [§], due to pancytopenia (one case), and high IgG at the time of LT (two cases, 1:64 and 1:32, respectively). A patient with a titer of 1:64 had IgM and IgG titers of 1:64. A patient with a titer of 1:32 underwent TPE on the day of operation, whereas the IgG prior to TPE was 1:128. LT, liver transplantation; IA, isoagglutinin; CD, cluster of differentiation; TPE, therapeutic plasma exchange; IVIG, intravenous immunoglobulin; IgM, immunoglobulin M; IgG, immunoglobulin G.

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Appendix 11: Desensitization and post-transplant outcomes, according to isoagglutinin titer rebound

Variables	With rebound of isoagglutinin titer (n=6)	Without rebound of isoagglutinin titer (n=26)
Preoperative		
Blood matching		
A/B→O	2 (33.3)	9 (34.6)
A/B→B/A	2 (33.3)	7 (26.9)
AB→A/B	2 (33.3)	10 (38.5)
Initial isoagglutinin titer ≥1:256	2 (33.3)	7 (26.9)
Desensitization method		
Rituximab 375 mg/m^2	5 (83.3)	20 (76.9)
TPE		
1–2	2 (33.3)	10 (38.5)
3–6	3 (50.0)	12 (46.2)
7–11	1 (16.7)	4 (15.4)
IVIG, preoperative	1 (16.7)[†]	6 (23.1)
Mycophenolate mofetil	2 (33.3)	6 (23.1)
Tacrolimus	4 (66.7)	14 (53.8)
Splenectomy	1 (16.7)	2 (7.7)
Postoperative		
Graft loss within a year	1 (16.7)	7 (26.9)
Rejection within a year	2 (33.3)[‡]	8 (30.8)
Rejection treatment		
Steroid pulse therapy	1 (16.7)	8 (30.8)
TPE	2 (33.3)	2 (7.7)

Data are presented as n (%). [†], preoperative IVIG, three times; [‡], rejection-free survival times were 6 and 7 days, respectively. TPE, therapeutic plasma exchange; IVIG, intravenous immunoglobulin.

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Appendix 12: Population of ABOi-LDLT in previous reports

Study	Year	Number of ABOi-LDLT recipients[†]	MELD score[‡]	Outcome of ABOi-LDLT in high MELD scores
Egawa H *et al.* (16)	2014	381 [88]	18 [17–66]	
Song GW *et al.* (15)	2014	149	12.5[§]	
Zhou J *et al.* (47)	2015	22	35.2±7.1	1-year survival, 40.9%
Kim JM *et al.* (48)	2016	47	10 [6–35]	
Ikegami T *et al.* (49)	2016	19	15.0±5.1	
Song GW *et al.* (50)	2016	235 [38]	12.7±5.5	
Kim JD *et al.* (51)	2016	25	16.8±7.8	
Kim JM *et al.* (52)	2018	59	10 [6–35]	
Kim SH *et al.* (53)	2018	43	11 [8–16]	
Lee WC *et al.* (24)	2022	8	39 [35–48]	1-year survival, 75%
Tajima T *et al.* (54)	2023	104 [81]	18 [14–21]	

[†], [88] represents there were 88 patients who have MELD score ≥23; [38] represents 38 patients who have MELD score ≥20; [81] represents 81 patients who have MELD score ≥13. [‡], data are presented as mean ± standard deviation or median [range]. [§], the study did not present the standard deviation of MELD score. ABOi, ABO-incompatible; LDLT, living-donor liver transplantation; MELD, Model for End-stage Liver Disease.

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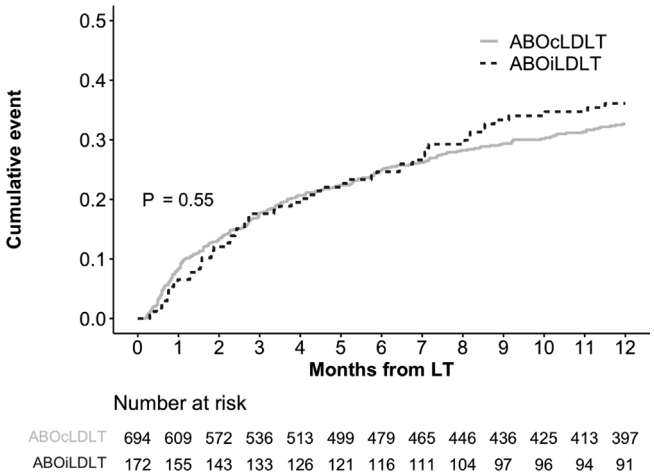
Appendix 13: Rate of biliary stricture after LT in Severance Hospital



LT, liver transplantation; ABOc, ABO-compatible; LDLT, living-donor liver transplantation; ABOi, ABO-incompatible.

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