

Outcome of Emergent ABO-Incompatible Liver Transplantation is Acceptable but at the Cost of Higher Diffuse Intrahepatic Biliary Stricture: A Single-Center, Retrospective Study

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Objective: The efficacy and clinical outcomes of emergent rituximab-based desensitization therapy in ABO-incompatible liver transplantation (ABO-I LT) remain poorly characterized. In this study, we analyzed a single-center cohort of emergency ABO-I LT recipients to delineate key clinical features and identify independent predictors of post-transplant survival.

Methods: Between January 1, 2015, and August 31, 2021, 1015 (90.2%) recipients received ABO-compatible (ABO-C) deceased donor liver transplantation (DDLT), and 110 (9.8%) received ABO-I DDLT with emergent rituximab-based desensitization.

Results: The ABO-C and ABO-I DDLT groups were followed up for 49.6 and 43.6 months, respectively. Following 1:1 propensity score matching (n=110 per group), the ABO-I group exhibited lower survival rates compared to the ABO-C group at 1, 3, and 5 years (74.0%, 68.5%, and 65.5% vs 88.0%, 83.0%, and 80.7%; $P = 0.024$). Multivariate analysis identified age > 65 years, liver cancer pre-transplantation, intraoperative blood loss > 1000 mL, and diffuse intrahepatic biliary stricture (DIHBS) as independent risk factors for patient survival. Crucially, after excluding DIHBS, survival outcomes between the two groups were comparable ($P = 0.336$).

Conclusion: Emergent ABO-I LT with an adjusted desensitization protocol is feasible but associated with inferior survival due to a higher incidence of DIHBS. This disparity underscores the need for refined strategies to mitigate DIHBS and improve ABO-I LT outcomes.

Keywords: emergent ABO-incompatible, liver transplantation, diffuse intrahepatic biliary stricture

Introduction

Liver transplantation (LT) remains the only curative treatment for patients with end-stage liver failure. However, the procedure is severely limited by a critical shortage of donor organs, especially in urgent clinical scenarios.^{1,2} While ABO-compatible (ABO-C) grafts constitute the majority of LTs, ABO-incompatible (ABO-I) LT has become more prevalent in living donor liver transplantation for patients who could not receive deceased organ donation.

However, emergencies in end-stage liver failure present a narrow window for organ donation and desensitization therapy, with patients experiencing multi-organ failure facing a 28-day transplantation-free mortality rate of 68.0–88.9%.^{3,4} In such critical situations, ABO-I LT serves as a salvage method to rescue the recipient.⁵ Consequently, pre-transplantation desensitization therapy must be administered emergently in deceased donor liver transplantation, differing significantly from protocols in living donor scenarios.

The prognosis of ABO-I LT has significantly improved with the introduction of perioperative plasmapheresis, graft-local infusion therapy, and rituximab.⁶ In emergent settings where an ABO-C liver graft is unavailable, crossing the blood type barrier becomes the only viable option. Prior to the establishment of desensitization protocols, outcomes were markedly poorer, with unacceptably high rates of graft failure (30–50%),^{7–10} patient mortality, and complications such as severe rejection, hepatic artery thrombosis, and biliary strictures.¹¹ However, with modern desensitization strategies, recent studies report comparable long-term graft and patient survival rates between ABO-C and ABO-I LT.¹² Nevertheless, postoperative complications, particularly biliary tract disorders and infections, remain critical challenges, contributing to morbidity and mortality after ABO-I LT.¹³ Given the emergent nature of ABO-I LT, the effectiveness of emergent desensitization therapy and the outcomes of ABO-I LT still remain unclear. This study aims to examine the characteristics of emergent ABO-I LT at our center and identify risk factors affecting patient survival.

Materials and Methods

Study Population

The inclusion criteria were: (1) adult recipients (≥ 18 years old); (2) recipients of deceased donor liver transplantation (DDLT) at our center between January 2015 and August 2021. The exclusion criteria were: (1) multi-visceral, split-graft, or living-donor liver transplantation recipients; (2) patients requiring re-transplantation. (3) early mortality within 1 month post-transplantation to eliminate the interference of perioperative surgical factors. A total of 1125 LT cases were identified during this period, of which 110 (9.8%) were ABO-incompatible. In liver transplantation, ABO incompatibility was defined as the donor organ's vascular endothelial cells expressing an ABO antigen that the recipient's plasma has antibodies against, for example: A to O, A to B, B to O, B to A, AB to A, AB to B, AB to O. To balance the baseline characteristics, 1:1 propensity score matching (PSM) was adopted. After PSM, 110 pairs of LT cases were enrolled into the analysis (Figure 1).

Immunosuppression Regimen

Detailed desensitization protocol and antiviral prophylaxis protocols at our institution have been published previously.¹⁴ Briefly, patients in the ABO-I LT group received a single dose of Rituximab (375 mg/m^2) and intravenous immunoglobulin (IVIG) (0.4 g/kg per day) within 24 hours before surgery. Induction therapy consisted of IVIG (0.4 g/kg per day) administered for 10 days post-transplant, along with basiliximab (20 mg) given twice on postoperative day 1 and day 4.

Maintenance immunosuppressive therapy included corticosteroids, tacrolimus, and mycophenolate mofetil (MMF). We attempted to withdraw corticosteroids within one month after transplantation.

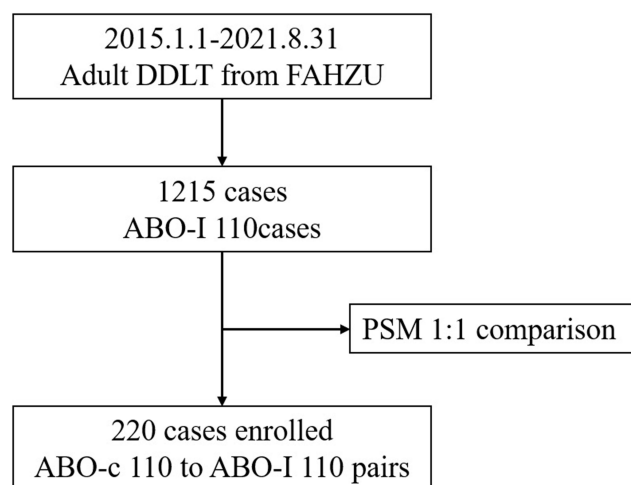


Figure 1 The flowchart of the research. During 2015.1.1–2021.8.31, a total of 1215 cases were enrolled in the research. PSM were performed to select 110 pairs of ABO-C and ABO-I cases.

Post-LT Monitoring Protocol

All recipients were transferred postoperatively to a dedicated liver transplantation (LT) intensive care unit (ICU). The day of transplantation was designated as day 0, and month 1 encompassed the first four postoperative weeks.

An institutional protocol standardized postoperative monitoring, including serial liver function tests (LFTs: weekly for 3 months, biweekly for months 4–6, then monthly), liver ultrasound (monthly for 3 months, bimonthly for months 4–6, then quarterly), and cross-sectional imaging (contrast-enhanced CT and MRCP every 3 months for 6 months, followed by CT biannually and MRCP annually). Hepatobiliary scintigraphy (HBS) was reserved for suspected biliary complications.

Diagnosis Criteria of Biliary Strictures and Diffuse Intrahepatic Biliary Strictures

Biliary strictures (BS) were definitively diagnosed by direct cholangiography (endoscopic retrograde or percutaneous transhepatic).^{15,16} Diffuse intrahepatic biliary strictures (DIHBS) was further characterized by destruction of central architectural integrity over a long segment and diffuse obliteration of peripheral ducts.¹⁷

Ethical Considerations & Organ Procurement Declare & Principles of Organ Matching

This study was conducted in accordance with the ethical principles of the Declaration of Helsinki and was approved by the Institutional Review Board of the First Affiliated Hospital of Zhejiang University School of Medicine (Approval Number: IIT20220889A). The waiver of informed consent was granted due to the retrospective nature of the study, which used de-identified data and did not influence patient treatment. All organs were voluntarily donated with documented informed consent, in full compliance with the Declaration of Istanbul. All organs are strictly matched in accordance with the matching principles of the China Organ Transplant Response System (COTRS) system.¹⁸

Statistical Analysis

Data are expressed as the mean $\pm$ standard deviation. Statistical analyses were performed using SPSS 22.0 for Windows (IBM Corp., Armonk, NY, USA). PSM was applied based on recipient age, Model for End-stage Liver Disease (MELD) score, pre-transplant hepatocellular carcinoma (HCC) status and cold ischemia time. Survival rates were estimated via the Kaplan–Meier method, with between-group comparisons assessed by the Log rank test. Continuous and categorical variables were analyzed using Student's *t*-test or Fisher's exact test, respectively. Independent risk factors for patient survival were identified through Cox regression analysis. Variables with $P < 0.10$ in univariate analysis were included in the multivariate Cox regression model.

Results

ABO-I Group Demonstrated Inferior Survival Outcomes in the Total Cohort

In the 1125-case cohort, the ABO-C group and ABO-I group differed in recipient age (50.8 ± 10.3 years vs 47.1 ± 10.5 years, $P = 0.002$), MELD score (20.7 ± 10.5 vs 30.5 ± 8.5 , $P < 0.001$), pre-transplant artificial liver support (15.9% vs 44.6%, $P < 0.001$), liver cirrhosis (75.5% vs 42.2%, $P < 0.001$), HCC (37.6% vs 20.5%, $P = 0.002$), cold ischemia time (8.86 ± 2.98 hours vs 10.03 ± 3.22 hours, $P = 0.001$), biliary complication (14.0% vs 31.3%, $P < 0.001$), biliary anastomotic stricture (10.9% vs 19.3%, $P = 0.026$), and DHBS (0.6% vs 13.3%, $P < 0.001$, Table 1). Regarding immunological complications, 8 cases (7.3%) of biopsy-proven ACR were identified in the ABO-I group within the first year post-transplantation. No cases of clinical or pathological AMR were observed. These findings underscore the efficacy of our rapid desensitization protocol in providing stable immunological outcomes. As illustrated in the Kaplan–Meier plots in Figures 2 and 3, the survival rates for both patients and grafts in the ABO-I group remain relatively stable and comparable to the ABO-C group during the first post-operative month. The statistical disparity in outcomes primarily emerges in the later stages of follow-up. For the total cohort, the 1, 3, and 5-year patient survival rates were inferior to those of the ABO-C group (74.0/68.5/65.5% vs 90.0/78.4/70.8%, $P = 0.009$, Figure 2). The 1, 3, and 5-year graft survival rates of the ABO-I group were inferior to those of the ABO-C group (73.9/64.5/61.6% vs 89.2/77.5/69.5%, $P = 0.002$, Figure 3). These results

Table 1 Baseline Demographic Characteristics Comparison Before PSM and After PSM

	Before PSM			After PSM		
	ABO-c (n=1015)	ABO-i (n=110)	P	ABO-c (n=110)	ABO-i (n=110)	P
Recipient Age (years)	50.8±10.3	47.1±10.5	0.002	46.2±9.7	47.1±10.5	0.59
Gender (Male/Female)	817/198	94/16	0.27	99/11	94/16	0.34
Re-LT	31 (3.1%)	2 (1.2%)	0.54	5 (4.8%)	2 (1.2%)	0.36
MELD	20.7±10.5	30.5±8.5	<0.001	30.3±8.5	30.5±8.5	0.86
Pre-LT ALS	161 (15.9%)	49 (44.6%)	<0.001	34 (31.3%)	49 (44.6%)	0.08
Etiology						
HBV	798 (78.6%)	89 (80.7%)	0.65	91 (83.1%)	89 (80.7%)	0.69
Cirrhosis	766 (75.5%)	46 (42.2%)	<0.001	58 (53.0%)	46 (42.2%)	0.16
HCC	381 (37.6%)	23 (20.5%)	0.002	21 (19.3%)	23 (20.5%)	0.85
Donor Age	43.5±14.3	43.5±12.7	0.97	40.8±13.3	43.5±12.7	0.19
CIT (h)	8.9±3.0	10.0±3.2	0.001	9.9±3.5	10.0±3.2	0.79
WIT (min)	14.2±7.2	14.8±7.2	0.48	15.0±7.4	14.8±7.2	0.85
Operation Time (min)	324±71	310±61	0.08	305±56	310±61	0.56
Blood loss during operation (mL)	1000 (600–1500)	1000 (800–1500)	0.49	800 (600–1500)	1000 (800–1500)	0.71
Post-LT ALS	15 (1.5%)	4 (3.6%)	0.32	5 (4.8%)	4 (3.6%)	1.00
Post-LT infection	87 (8.6%)	17 (15.7%)	0.04	11 (12.0%)	17 (15.7%)	0.50
Arterial/Portal Thrombosis	15 (1.5%)	3 (2.4%)	0.85	0 (0.0%)	3 (2.4%)	0.48
Biliary complications	142 (14.0%)	34 (31.3%)	<0.001	23 (20.5%)	34 (31.3%)	0.11
Anatomical stricture	110 (10.9%)	21 (19.3%)	0.03	21 (19.3%)	21 (19.3%)	1.00
DIHBS	4 (0.6%)	11 (13.3%)	<0.001	1 (1.2%)	11 (13.3%)	0.007

Abbreviations: ALS, artificial liver support; CIT, cold ischemia time; DIHBS, diffuse intrahepatic biliary stricture; HBV, hepatitis B virus; HCC, hepatocellular carcinoma; MELD, Model for End-stage Liver Disease; Post-LT, post-liver transplantation; Re-LT, re-liver transplantation; WIT, warm ischemia time.

suggest that while emergent ABO-I LT is a viable salvage therapy, the long-term survival remains significantly lower than that of ABO-C LT.

Application of PSM and the Survival Analysis After PSM

The MELD score, recipient age, cold ischemia time, and pre-transplant HCC have a strong impact on the prognosis of LT. These factors were strongly imbalanced between the ABO-C group and the ABO-I group. Thus, we adopted 1:1 PSM in the two groups. After PSM, these 4 factors were balanced. (Table 1). The occurrence of anatomical biliary strictures was comparable between the two groups ($P = 0.12$) after PSM. Patient survival in the ABO-I group was also to that of the ABO-C group (74.0/68.5/65.5% vs 88.0/83.0/80.7%, $P = 0.024$, Figure 2). The graft survival of the ABO-I group was also inferior to that of the ABO-C group (73.9/64.5/61.6% vs 88.0/83.0/78.8%, $P = 0.009$, Figure 3). The persistence of inferior survival in the ABO-I group after PSM, despite balanced baseline characteristics, indicates that the blood-type barrier itself is an independent driver of mortality that cannot be fully mitigated by adjusting for recipient severity or surgical factors.

Univariable Analysis and Multivariable Cox Analysis for Patient Survival

After PSM, we performed univariate and multivariate Cox regression analysis for patient survival. Univariate survival analysis showed ABO-I, recipient age > 65 years, cirrhosis, pre-transplant HCC, cold ischemia time >10 hours, blood loss >1000 mL, and DIHBS were risk factors for patient survival. Multivariate Cox analysis showed that recipient age > 65 years (Hazard ratio (HR) = 5.6; 95% confidence interval (CI) 2.1–14.5; $P < 0.001$), pre-transplant HCC (HR = 5.4; 95% CI 2.8–10.2; $P < 0.001$), blood loss >1000 mL (HR = 2.4; 95% CI 1.2–4.6; $P = 0.011$), and DIHBS (HR = 4.8; 95% CI 2.1–10.8; $P < 0.001$) were independent risk factors for patient survival (Table 2).

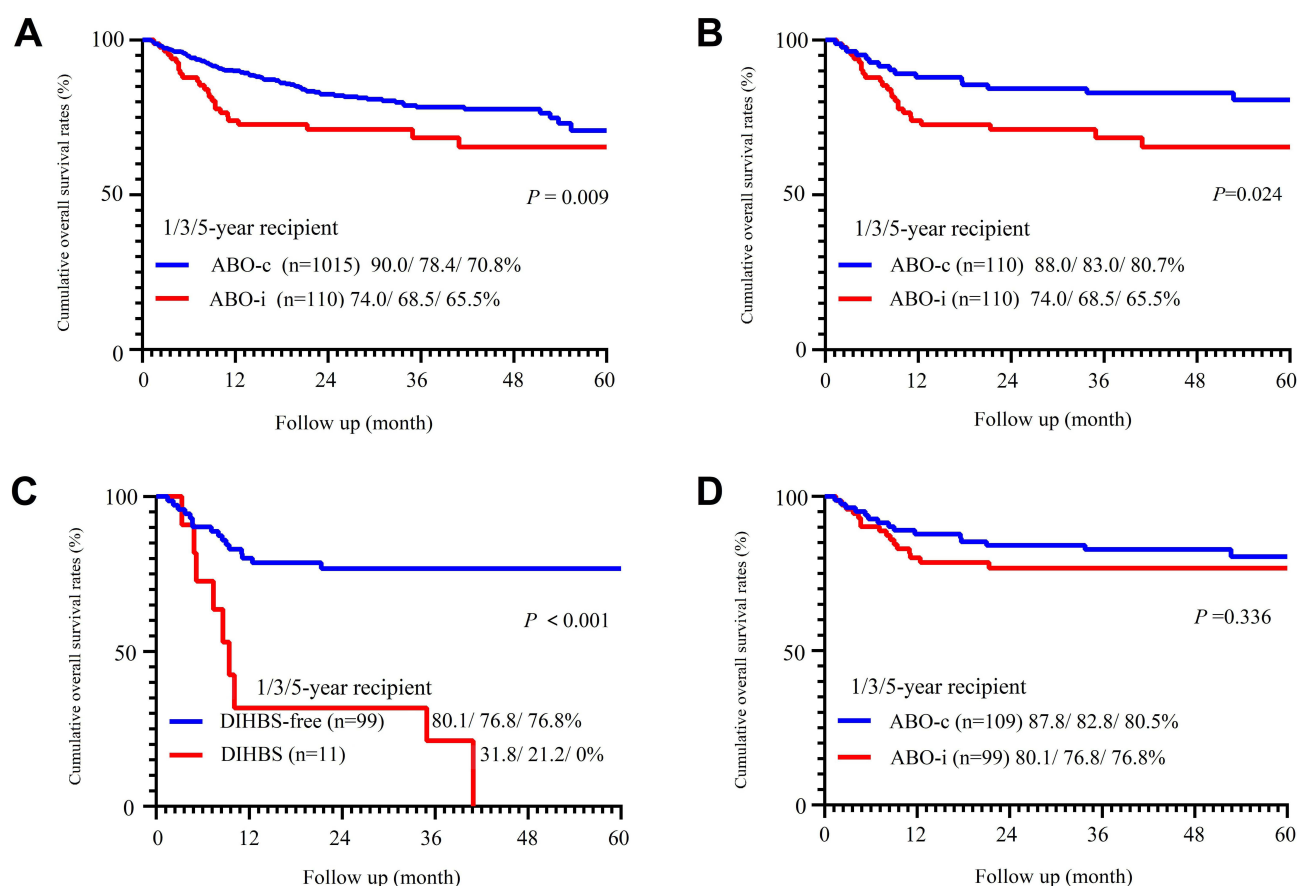


Figure 2 Kaplan-Meier plots of comparison between recipients' survival. **(A)** The 1, 3, and 5-year patient survival of the ABO-C group compared to the ABO-I group before PSM. **(B)** The 1, 3, and 5-year patient survival of the ABO-C group compared to the ABO-I group after PSM. **(C)** The 1, 3, and 5-year patient survival for the DIHBS subgroup compared to the non-DIHBS subgroup. **(D)** The 1, 3, and 5-year patient survival for the DIHBS subgroup compared to the non-DIHBS subgroup after the exclusion of DIHBS cases.

Risk Factors for DIHBS in the ABO-I Group

Based on the occurrence of DIHBS, we divided the 110 ABO-I group into a non-DIHBS subgroup and a DIHBS subgroup. Subgroup analysis showed only the MELD score was significantly higher in the DIHBS subgroup (38.2 ± 3.6 vs 29.3 ± 8.5 , $P < 0.001$). Thus, the MELD score is the only independent risk factor for DIHBS for the ABO-I group (odds ratio (OR) = 1.3, 95% CI: 1.1, 1.6, $P = 0.002$, Table 3). According to the occurrence of DIHBS for the ABO-I group, the 1, 3, and 5-year patient survival (Figure 2) and graft survival (Figure 3) for the DIHBS subgroup were significantly shorter than those in the non-DIHBS subgroup ($P < 0.001$).

For the 11 cases with DIHBS, the mean diagnosis time from liver transplantation to DIHBS was 97 ± 55 (IQR:32, 206) days. During the follow-up period, only two patients with DIHBS survived, including one patient who underwent re-transplantation. Regardless of DIHBS cases, the 1, 3, and 5-year patient survival (Figure 2) and graft survival (Figure 3) were comparable between the ABO-I and ABO-C groups ($P > 0.05$).

Discussion

ABO-I LT was implemented at our institution to address donor shortages and serve as an emergent intervention for critically ill patients lacking blood type-compatible grafts. Consequently, ABO-I LT recipients consistently exhibited higher MELD scores. Following the introduction of rituximab, accumulating evidence from global retrospective studies has increasingly supported ABO-I LT in contemporary practice.¹⁹ However, while ABO-I living donor liver transplantation (LDLT) with rituximab has demonstrated comparable survival outcomes to ABO-C LDLT—particularly in East Asia—its application in deceased donor liver transplantation (DDLT) has remained stagnant in the rituximab era.^{20,21}

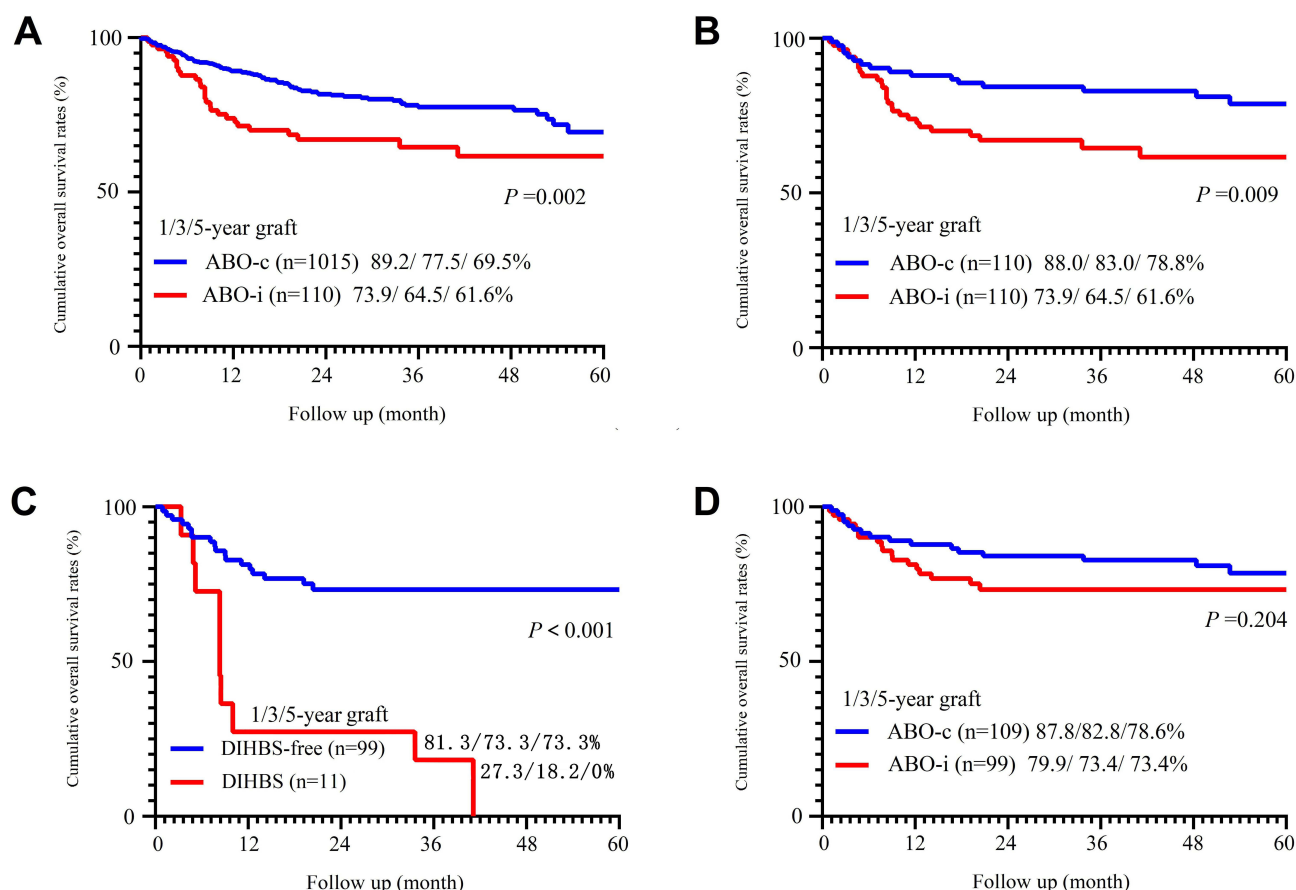


Figure 3 Kaplan-Meier plots of comparison between graft survival. **(A)** The 1, 3, and 5-year graft survival of the ABO-C group compared to the ABO-I group before PSM. **(B)** The 1, 3, and 5-year graft survival of the ABO-C group compared to the ABO-I group after PSM. **(C)** The 1, 3, and 5-year graft survival for the DIHBS subgroup compared to the non-DIHBS subgroup. **(D)** The 1, 3, and 5-year graft survival for DIHBS subgroup compared to the non-DIHBS subgroup after the exclusion of the DIHBS cases.

In this study, we compared survival rates between ABO-C and ABO-I LT recipients at our institute and identified four risk factors for post-LT survival: recipient age > 65 years, recipient pre-transplant HCC, intraoperative blood loss > 1000 mL, and post-transplant DIHBS. Following PSM, the incidence of anatomical biliary strictures was similar between ABO-C and ABO-I groups, whereas DIHBS occurrence was significantly higher in ABO-I recipients. Our results demonstrate that elevated DIHBS incidence in ABO-I LT is a critical determinant of post-transplant survival. While a recent study by Song¹² reported no significant survival disparity despite ABO incompatibility, our findings suggest potential variations attributable to differences in baseline patient characteristics, donor liver sources, and ABO-I LT management protocols. Notably, in contrast to a South Korean study where ABO-I recipients had lower MELD scores than ABO-C patients, our cohort exhibited the inverse trend. The higher MELD scores observed in our ABO-I group reflect more advanced disease severity, further compromising survival outcomes. Although MELD scoring was originally designed to predict pre-transplant survival, elevated scores also correlate with inferior post-transplant outcomes.²²

In the current era of potent desensitization regimens, particularly rituximab-based protocols, the landscape of complications following ABO-I LT has shifted significantly. As noted by experts in the field, traditional catastrophic events such as hyperacute rejection and hepatic artery thrombosis have been successfully mitigated, leaving DIHBS as the most critical and characteristic adverse complication.²³ Our findings reinforce this perspective; DIHBS emerged as the primary determinant of long-term graft failure and patient mortality. Indeed, when DIHBS cases were excluded from our analysis, the survival outcomes of the ABO-I group were comparable to those of the ABO-C group, suggesting that overcoming this specific “biliary bottleneck” is the key to further improving the efficacy of emergent ABO-I LT.

Table 2 Univariate and Multivariate Survival Analysis After PSM

Variable	Univariate	Multivariate	
	P	HR (95% CI)	P
ABO-incompatibility	0.03		
Recipient age >65	<0.001	5.6 (2.1, 14.5)	<0.001
Gender Male	0.87		
Re-LT	0.42		
MELD	0.11		
Pre-LT ALS	0.23		
HBV	0.98		
Cirrhosis	0.03		
HCC	<0.001	5.4 (2.8, 10.2)	<0.001
Donor Age	0.07		
Operation Time	0.15		
CIT>10hours	0.01		
WIT	0.25		
Blood loss >1000mL	0.001	2.4 (1.2, 4.6)	0.01
Post-LT ALS	0.73		
Post-LT infection	0.09		
Arterial/Portal Thrombosis	0.64		
Anatomical stricture	0.12		
DIHBS	<0.001	4.8 (2.1, 10.8)	<0.001

Note: Bold text indicates independent risk factors with statistical significance ($P < 0.05$) in the multivariate Cox regression model.

Abbreviations: ALS, artificial liver support; CI, confidence interval; CIT, cold ischemia time; DIHBS, diffuse intrahepatic biliary stricture; HBV, hepatitis B virus; HCC, hepatocellular carcinoma; HR, hazard ratio; MELD, Model for End-stage Liver Disease; Post-LT, post-liver transplantation; Re-LT, re-liver transplantation.

Table 3 Risk Factors Analysis According to the Occurrence of DIHBS

Variable	Non-DIHBS (n=99)	DIHBS (n=11)	P
Recipient age	46.7±10.5 (20~71)	49.3±11.1 (35~71)	0.46
Gender Male	82 (83.3%)	11 (100%)	0.35
Re-LT	0 (0.0%)	1 (9.1%)	0.13
MELD	29.3±8.5	38.2±3.6	<0.001
Pre-LT ALS	45 (45.8%)	4 (36.4%)	0.79
HBV	80 (80.6%)	9 (81.8%)	1.00
Cirrhosis	41 (41.7%)	5 (45.5%)	1.00
HCC	22 (22.2%)	1 (9.1%)	0.55
Donor age	43.0±12.1	46.7±16.3	0.37
Operation Time (min)	315±60	276±57	0.05
CIT (hours)	9.9±3.1	11.0±4.0	0.27
WIT (min)	14.7±7.0	15±8.8	0.91
Blood loss (mL)	1000 (800, 1275)	1200 (800, 1500)	0.75
Post-LT ALS	3 (2.8%)	1 (9.1%)	0.86
Post-LT infection	15 (15.3%)	2 (18.2%)	1.00
Arterial/Portal Thrombosis	3 (2.8%)	0 (0.0%)	1.00

Note: Bold text indicates risk factors with statistical significance ($P < 0.05$).

Abbreviations: ALS, artificial liver support; CIT, cold ischemia time; DIHBS, diffuse intrahepatic biliary stricture; HBV, hepatitis B virus; HCC, hepatocellular carcinoma; MELD, Model for End-stage Liver Disease; Post-LT, post-liver transplantation; Re-LT, re-liver transplantation.

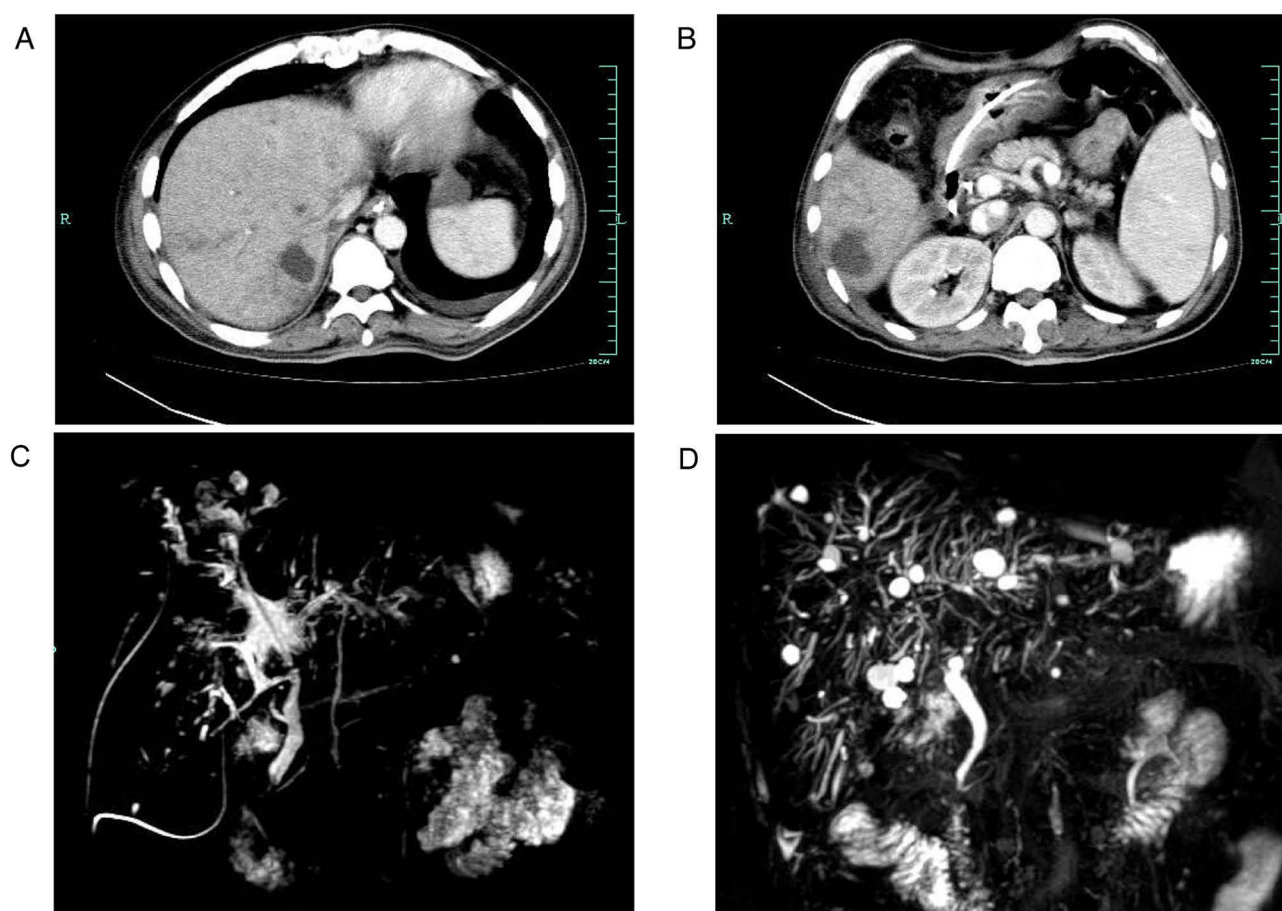


Figure 4 DIHBS cases can present with liver abscess and/or biloma on CT, with biliary trees inhibited as “deadwood appearance” on MRCP imaging. (**A** and **B**) CT scan with contrast images. Hypodensities in the liver of (**A** and **B**) represented typical liver abscesses developed after ABO-I LT secondary to DIHBS. (**C** and **D**) MRCP images of the typical “dead-wood” appearance of the injured biliary tree developed after ABO-I LT secondary to DIHBS.

Radiologically, DIHBS manifests either as liver abscesses/bilomas on CT or exhibits a distinctive “deadwood appearance” on MRCP (Figure 4). This condition, defined by multifocal strictures proximal to biliary anastomoses, carries grave clinical implications due to its strong association with refractory cholangitis, sepsis, graft failure, and poor therapeutic response,²⁴ often necessitating re-transplantation. The mechanistic underpinning of DIHBS in ABO-I LT can be attributed to the unique vulnerability of the biliary tree’s blood supply (Figure 5). Unlike the hepatic parenchyma, which receives a dual blood supply, the bile ducts are entirely dependent on the peribiliary vascular plexus (PVP).²⁵ This precarious anatomical arrangement renders the biliary epithelium highly susceptible to microvascular insults. Our clinical findings provide further evidence for this vulnerability. In our multivariate analysis, we identified that higher pre-transplant MELD scores and longer operation time were risk factors for DIHBS. We speculate that these factors create a “pre-sensitized” environment: a high MELD score often reflects systemic inflammatory stress and pre-existing endothelial dysfunction, while prolonged operation time further compromises the microcirculation of the PVP. When this “fragile” biliary system is exposed to the immunological challenges of an ABO-incompatible environment, specifically the attenuated AMR driven by residual plasma cells, the damage is compounded.^{13,26} Despite the use of Rituximab, the rebound of isoagglutinins can trigger a localized inflammatory cascade within the already compromised PVP,^{13,27} eventually leading to the distinctive “deadwood appearance” of DIHBS observed in our cohort. This “dual-hit” theory, combining baseline clinical fragility with subclinical immune injury, explains why DIHBS remains the primary cost of emergent ABO-I LT.

Several limitations of this study should be acknowledged. First, although propensity score matching was employed to minimize bias, the sample size of ABO-I LT patients (110 matched pairs) remains relatively small, which may limit the

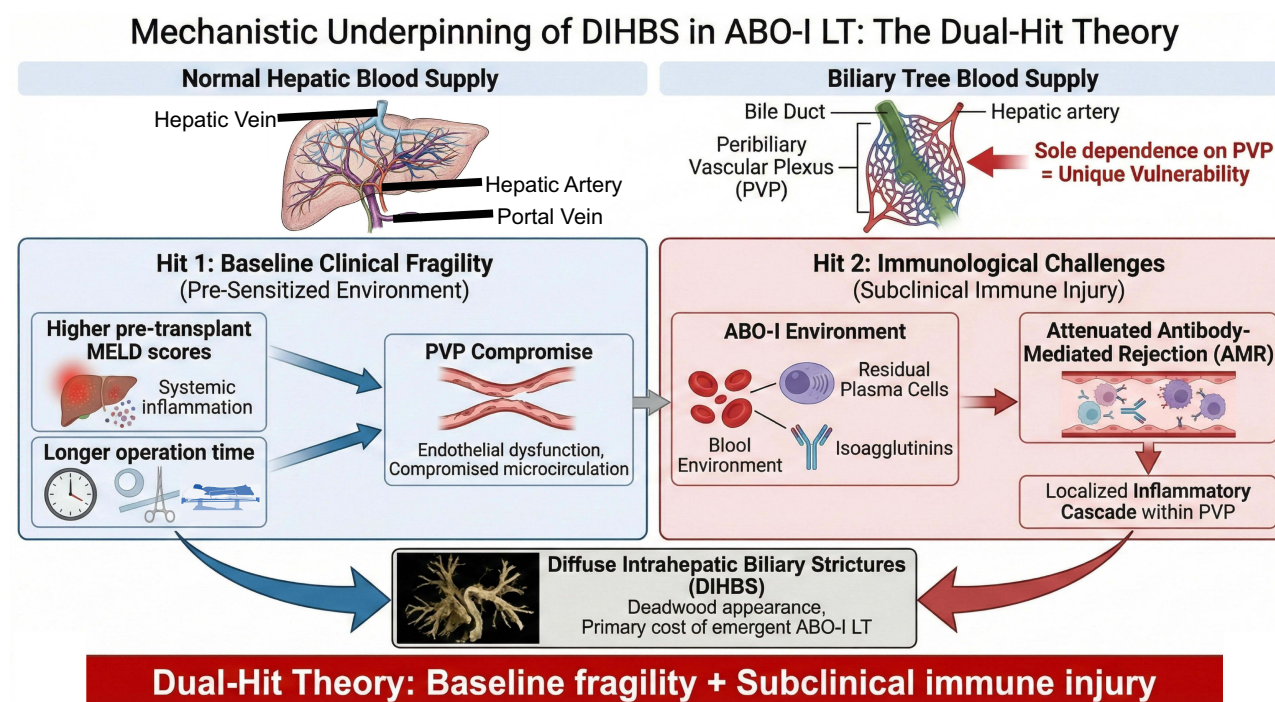


Figure 5 Pathophysiology of DIHBS after ABO-incompatible liver transplantation.

statistical power to detect subtle differences in certain secondary outcomes. Second, the retrospective, single-center design inherently introduces selection bias and may restrict the generalizability of our findings to other clinical settings. Third, this study reflects a specific institutional experience; the lack of comparison with alternative protocols for desensitization and post-procedure immunosuppression means the optimal strategy remains to be further defined. Finally, while we accounted for major confounders, unmeasured donor-related or surgical variables might still influence long-term survival. Future multi-center, prospective studies are warranted to validate these results and compare diverse therapeutic regimens.

In conclusion, our study showed that emergent ABO-I LT with a modified desensitization protocol is feasible. The survival of emergent ABO-I LT is inferior to ABO-C LT at the cost of a higher possibility of donor organ allocation. Clinicians can better select candidates and optimize perioperative management to mitigate the risk of DIHBS, thereby making emergent ABO-I LT a more viable and safer bridge to survival for patients in dire need.

Abbreviations

ABO-I, ABO-incompatible; ABO-C, ABO-compatible; CI, confidence interval; CORTS, China Organ Transplant Response System; DCD, donor after cardiac death; DDLT, deceased donor liver transplantation; DIHBS, Diffuse Intrahepatic Biliary Stricture; ESLD, end-stage liver disease; HBS, Hepatobiliary scintigraphy; HBV, hepatitis B virus; HCC, hepatocellular carcinoma; HR, hazard ratio; LT, liver transplantation; LDLT, living donor liver transplantation; MELD, Model for End-stage Liver Disease; MRCP, magnetic resonance cholangiopancreatography; PSM, propensity score matching; UNOS, United Network for Organ Sharing.

Data Sharing Statement

All data associated with this study are presented in the paper.

Author Contributions

All authors made a significant contribution to the work reported, whether that is in the conception, study design, execution, acquisition of data, analysis and interpretation, or in all these areas; took part in drafting, revising or critically

reviewing the article; gave final approval of the version to be published; have agreed on the journal to which the article has been submitted; and agree to be accountable for all aspects of the work.

Funding

This work was supported by the Central Government Guidance Funds for Local Scientific and Technological Development (grant number 2024ZY01023) and the Pioneer and Leading Goose R&D Program of Zhejiang Province (grant number 2026C02A1100).

Disclosure

The authors declare that they have no conflict of interest.

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