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Original Article

Outcomes of Donors in Living Donor Liver Transplantation: Effect of Strict Donor Selection Criteria

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ABSTRACT

Objective: To evaluate the effect of strict institutional donor selection criteria on short term safety outcomes among living liver donors undergoing hepatectomy.

Methodology: This retrospective cross-sectional study on 140 living liver donor records was conducted in the Department of Hepatopancreatobiliary (HPB) and Liver Transplant Surgery at Bahria International Hospital, Orchard, Lahore. The study was carried out from January to March 2026 after obtaining institutional ethical approval. Donors were evaluated by a multidisciplinary team and selected through a structured protocol that included clinical, biochemical, radiological, and psychosocial evaluations. Acceptable graft parameters included graft-to-recipient weight ratio (GRWR) ≥0.8 and future liver remnant (FLR) ≥30%. Those with significant comorbidities, fatty liver, abnormal liver function tests, and fibrosis were not selected for donation. Data was analyzed using Statistical Package for the Social Sciences (SPSS) version 29.

Results: The mean age of donors was 27.0±4.7 years with a mean body mass index (BMI) of 24.0±2.4 kg/m². The mean length of hospital stay was 5.0±0.7 days. Overall, early postoperative complications occurred in 3(2.1%) donors, including bile leak in 2(1.4%) cases and wound infection in 1(0.7%) case. No donor mortality was observed. Donors who developed early complications had a significantly longer hospital stay compared with those without complications (6.67±0.58 days vs 4.98±0.62 days, p <0.001).

Conclusion: The use of a meticulous donor selection protocol, combined with a multidisciplinary assessment, was associated with low complication rates, shorter hospital stays, and no donor mortality.

Keywords: *Living donors. Hepatectomy. Postoperative complications. Patient selection. Length of stay.*

INTRODUCTION

Living donor liver transplantation (LDLT) has become an important strategy for the treatment of end-stage liver disease, particularly in regions where deceased donor transplantation remains limited. In Pakistan and other low- and middle-income areas, LDLT continues to be the principal transplant pathway because of organ scarcity, delayed access to deceased donor transplantation, and a persistent burden of advanced chronic liver disease.[1] Contemporary reviews also show that LDLT offers major recipient advantages, including shorter wait times and timely access to transplantation, but these benefits are acceptable only when donor risk is minimized through rigorous evaluation and careful operative planning.[2] Unlike recipients, living donors are healthy individuals who derive no direct medical benefit from surgery. For this reason, donor safety remains the central principle of every LDLT program. Recent evidence indicates that although donor mortality is rare, donor morbidity remains clinically relevant and requires continuous attention. A recent meta-analysis confirmed that adverse donor outcomes are uncommon overall but still meaningful, underscoring the need for structured donor assessment and perioperative safeguards.[3] In addition, long term follow-up have highlighted that donor outcomes should not be judged solely by early postoperative events, but also by longer term physical and psychological wellbeing after donation.[4]

Current literature emphasizes a comprehensive multidisciplinary evaluation of potential living liver donors, including detailed history taking, laboratory testing, cardiopulmonary assessment, psychosocial evaluation, high resolution cross-sectional imaging, and precise vascular and biliary mapping with volumetric analysis prior to donor acceptance.[4] Parameters such as graft-to-recipient weight ratio (GRWR) and future liver remnant (FLR) remain central to decision-making, as they ensure adequate graft function in the recipient while maintaining donor safety. Anatomical variations of the hepatic vasculature and biliary tree are also critically assessed, as they may increase operative complexity and influence perioperative donor and recipient outcomes.[5]

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Although these core principles are widely applied across transplant centres, variations exist in the strictness of donor selection thresholds, the extent of multidisciplinary consensus, and imaging protocols used for final donor approval. Consequently, differences in institutional selection criteria may contribute to variability in reported donor outcomes across studies.[3] In countries such as Pakistan, where living donation remains the dominant transplant model, locally relevant evidence is needed to determine whether strict institutional screening protocols are associated with safe donor outcomes. The present study was therefore undertaken to evaluate short term outcomes of living liver donors selected through a structured institutional pathway and to assess whether meticulous donor selection and multidisciplinary evaluation were associated with favorable donor safety outcomes in our setting.

METHODOLOGY

This retrospective cross-sectional study was conducted from January to March 2026 at the Department of Hepatopancreatobiliary (HPB) and Liver Transplant Surgery, Bahria International Hospital, Orchard, Lahore, Pakistan. Ethical approval was obtained from the institutional review board (Letter No. IRB/BIHO/2025/09-OR, 22-12-2025). The records of all 140 eligible donors who met the institutional selection criteria and underwent hepatectomy between July 2019 and December 2025 were included.

Donors were admitted for surgery after informed written consent and completion of all required investigations & workup according to predefined, structured selection criteria (Table 1). The donor selection process was performed in a stepwise manner to ensure cost-effectiveness (Figure 1). Donor evaluation included detailed clinical assessment comprising medical and surgical history, physical examination, BMI calculation, Echocardiography (ECG), and overall fitness assessment. Baseline laboratory investigations included complete blood count (CBC), liver function tests (LFTs), renal function tests (RFTs), blood grouping & cross-matching, Hemoglobin A1c (HbA1c), coagulation profile, and viral serology for hepatitis A virus (HAV), hepatitis B virus (HBV), hepatitis C virus (HCV), hepatitis D virus (HDV), hepatitis E virus (HEV), and human immunodeficiency virus (HIV). Baseline radiological investigations included Chest X-ray (CXR), ultrasound, and Doppler scan of liver.

Radiological assessment was performed to evaluate liver anatomy and volumetry. Triphasic computed tomography (CT) enabled vascular mapping and volumetric analysis, including calculation of the GRWR and assessment of the FLR. Magnetic resonance cholangiopancreatography (MRCP) was performed to assess biliary anatomy. Transient elastography (Fibro Scan) was used to evaluate hepatic steatosis and fibrosis. Liver biopsy was performed in selected cases where steatosis or fibrosis was suspected.

Key selection criteria included age between 18 and 40 years, normal liver function tests (LFT), absence of hepatic steatosis and fibrosis, negative hepatitis and HIV serology, GRWR $\geq$0.8, and FLR $\geq$30%. Donors with up to two hepatic arteries, two portal veins, and two bile ducts were considered eligible for inclusion. Individuals with significant comorbid conditions (e.g., diabetes mellitus, cardiovascular disease), fatty liver disease, and hepatic fibrosis were excluded during donor selection.

Following completion of clinical, biochemical, and radiological evaluation, donors were assessed by a multidisciplinary team comprising transplant surgeons, hepatologists, anaesthesiologists, psychiatrists, cardiologists, and pulmonologists. Special investigations included metabolic profiling (thyroid and lipid profiles) and autoimmune screening [lupus anticoagulant and antinuclear antibodies (ANA)]. Protein C, Protein S, antithrombin III, D-dimer, and Factor V Leiden levels were performed for thrombophilia screening. Psychological evaluation ensured voluntary consent and excluded coercion. All donor hepatectomy procedures were performed by experienced transplant surgeons using standard surgical techniques. Postoperative care included intensive monitoring, early mobilization, and serial biochemical assessment.

The outcomes were assessed during a 30 day postoperative follow-up period. The primary outcomes were donor mortality and postoperative complications graded using the Clavien-Dindo system, where Grade I indicates minor deviation without treatment, Grade II requires pharmacological or blood transfusion support, Grade III requires surgical/endoscopic/radiological intervention (Grade IIIa: intervention without general anaesthesia; Grade IIIb: intervention under general anaesthesia), Grade IV represents life threatening complications requiring ICU care, and Grade V indicates death.[6] The secondary outcome was length of hospital stay.

Table 1: Institutional Donor Selection Criteria for Living Liver Donors

Parameters	Acceptable	Not Acceptable
Comorbidities	None	Hypertension, Ischemic Heart Disease, and Diabetes Mellitus
LFTs	Normal	Abnormal
Ultrasound Liver	Normal Liver	Fibrosis Fatty Liver
Liver Attenuation Index (LAI) on CT-scan	Greater than +5	<0
Liver Biopsy [for LAI (0 to +4)]	No Fibrosis Steatosis <10%	Fibrosis Steatosis >10%
GRWR	≥0.8	<0.8
FLR	≥30 %	<30%
Arterial Anatomy	Graft with one or up to two Hepatic Arteries	Graft with more than two Hepatic Arteries
Portal Vein Anatomy	Graft with one or up to two Portal Veins	Graft with more than two Portal Veins
Bile Duct Anatomy	Graft with one or up to two Bile Ducts	Graft with more than two Bile Ducts/Complex Biliary Anatomy Unsuitable for Reconstruction

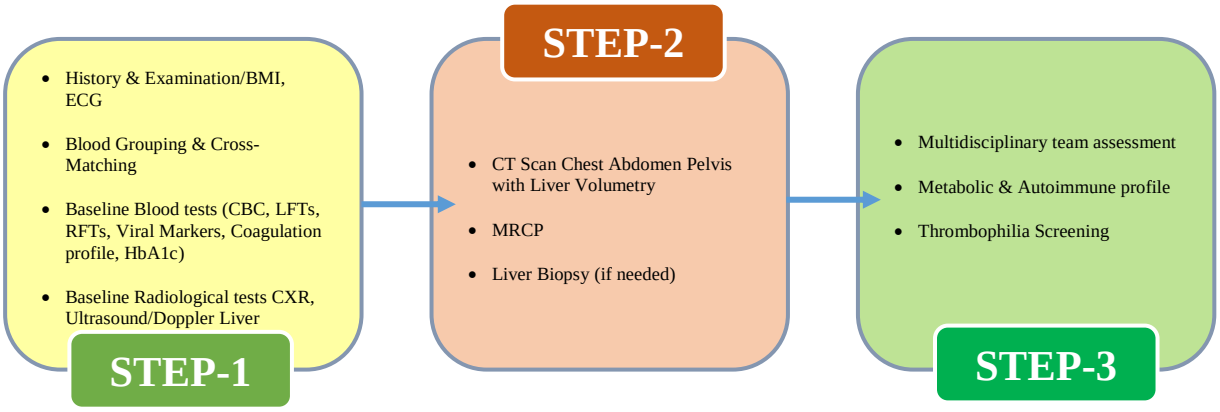

Figure 1: Stepwise Donor Evaluation Protocol for Living Donor Liver Transplantation

STATISTICAL ANALYSIS

Statistical Package for the Social Sciences (SPSS) version 29 was used to analyze the data. Continuous variables were expressed as mean±standard deviation, while categorical variables were presented as frequencies and percentages. Subgroup analysis was performed to compare donors with and without postoperative complications across variables including age, gender, BMI, FLR, GRWR, anatomical variations, and length of hospital stay. The independent t-test was used to compare continuous variables. Fisher's exact test was applied for categorical variables due to small expected cell counts. A p-value of <0.05 was considered statistically significant.

RESULTS

The mean age of the donors was 27.0±4.7 years with a mean BMI of 24.0±2.4 kg/m², mean FLR of 37.1±3.6%, and mean GRWR of 1.02±0.12. The cohort comprised 80(57.1%) males and 60(42.9%) females. Most donors had conventional vascular and biliary anatomy, including a single hepatic artery in 137(97.9%), a single portal vein in 134(95.7%), and a single bile duct in 101(72.1%) donors.

Overall, 137(97.9%) donors had no early postoperative complications. The mean hospital stay was 5.0±0.7 days, and no (0%) donor mortality was observed. Among donors who developed early postoperative complications, bile leak occurred in 2(1.4%) and wound infection in 1(0.7%). According to the Clavien-Dindo classification, both cases of

bile leak were Grade I. The wound infection was classified as Grade IIIa.

Early postoperative complications were not significantly associated with age, gender, BMI, and anatomical variation (p >0.05). Donors without complications had a mean hospital stay of 4.98±0.62 days, whereas those with complications had a significantly longer stay (6.67±0.58 days, p <0.001). Both groups showed no significant difference in mean FLR and mean GRWR. These findings indicate that although early complications were infrequent, they were associated with a clinically meaningful prolongation of hospital stay (Table 2).

DISCUSSION

Current donor safety literature continues to place donor protection at the center of LDLT practice.[7] In our study, early postoperative complications occurred in only 3(2.1%) donors, including bile leak in 2(1.4%) cases and wound infection in 1(0.7%) case. No donor mortality was observed. Xiao et al. included outcomes from 60,829 living liver donors in their meta-analysis and reported a pooled overall donor complication rate of 24.7% [95% confidence interval (CI): 21.6-28.1%]. They also reported a substantially lower mortality (0.06%) and wound related complications (0.7%) in their large cohort. These findings confirm that while adverse events in LDLT remain uncommon, they are not negligible.[3] Tuncer et al. also reported a higher overall complication rate of 11.6% (95% CI: 9.0-14.6%) with no mortality among 502 living liver donors.[6]

The present study also demonstrated that donors who developed early complications had a significantly longer hospital stay compared with those without complications (6.67±0.58 days vs 4.98±0.62 days, p <0.001). Early postoperative complications were not significantly associated with age, gender, BMI, or anatomical variation (p >0.05). Both cases of bile leak were classified as Grade I, while only one wound infection was classified as Grade IIIa, compared with 17 major complications (≥Grade IIIa) reported by Tuncer et al. Most of the complications reported in their study were wound infections, followed by bile leakage. Similar to our results, complications were associated with a significantly longer hospital stay, and no significant independent associations were reported between postoperative complication risk and graft type, remnant liver ratio, graft volume, or BMI.[6] Another review reported an overall mortality of 0 to 0.7%, overall complication rate of 7.8-71.2%, while the average length of hospital stay was from 3.9 to 14.5 days among donors.[8]

Rhu et al. reported that the 30 day complication rate of 636 donors undergoing laparoscopic living donor hepatectomy was 16.8%, with Grade IIIa and IIIb complications occurring in 4.4% and 1.9% of cases, respectively. The most frequent complication was bleeding (6.0%), while bile leakage was observed in 3.3% of cases.[9] In another review, 28 studies were compiled, and the rate of major complications (≥Grade IIIa) was 2.1% to 28%. Only one study reported that complications were associated with a significantly increased length of hospital stay, with an incidence rate ratio of 1.36 (95% CI: 1.16-1.58; p <0.001), indicating that even infrequent adverse events can affect recovery and resource use.[10]

Table 2: Comparison of Donor Characteristics between Patients with and without Early Postoperative Complications

Donor Characteristics		Donors with Complications (n=03)	Donors without Complications (n=137)	p-value
Age (Years)	**(mean±SD)**	28.67±2.89	26.96±4.75	0.538
Gender (Frequency & Percentage)	**Female**	2(66.7)	58(42.3)	0.576
	Male	1(33.3)	79(57.7)	
BMI (kg/m^2)	**(mean±SD)**	22.47±4.27	24.03±2.35	0.264
Anatomical Variation (Frequency & Percentage)	**Present**	2(66.7)	45(32.8)	0.261
	Absent	1(33.3)	92(67.2)	
Future Liver Remnant (%)	**(mean±SD)**	33.63±3.11	37.20±3.56	0.087
Graft-to-Recipient Weight Ratio		1.07±0.21	1.02±0.12	0.488
Hospital Stay (Days)		6.67±0.58	4.98±0.62	<0.001*

**Significant p-value*

In the International LDLT Registry analysis, short term donor complication rates differed substantially ($p < 0.001$) by human development index (HDI), with rates of 9.8% in very high HDI regions versus 21.9% in lower HDI regions, highlighting the sensitivity of outcomes to system level variation in practice and resources.[11] However, the early complication rate of 2.1% in our study appears favorable, likely reflecting conservative donor acceptance and careful perioperative management. Donors in this series were young and had a favorable BMI profile, and our protocol excluded significant comorbidities. This approach was consistent with current donor selection guidance, which emphasizes low risk physiology and adequate hepatic reserve.[5,12] Although broader donor criteria like inclusion of older adults are increasingly discussed, expansion should be approached cautiously. A recent systematic review and meta-analysis found no significant difference in complications and mortality between young and older donors.[13] This finding highlighted that carefully selected older living liver donors may enlarge the donor pool, but such practice still requires careful risk stratification and experienced centers.

Volumetric criteria represented a key strength of the donor selection strategy. All donors met the GRWR ≥0.8 and FLR ≥30%, with a mean GRWR of 1.02±0.12 and a mean FLR of 37.1±3.6%. Kim et al. reported that overall [Odd's ratio (OR) = 1.82; 95% CI: 1.24-2.67; p = 0.002] and minor (OR=1.88; 95% CI: 1.23-2.88; p=0.004) morbidities were significantly lower in donors with a residual liver volume ≥30% compared with those with <30%.[14] Likewise, recipient focused multicenter work has shown that lower GRWR grafts may be feasible in selected circumstances, but that does not eliminate the need for conservative donor protection in routine practice.[8]

Anatomical complexity directly affects surgical planning and reconstruction. Most donors had conventional vascular and biliary anatomy, including a single hepatic artery in 137(97.9%), a single portal vein in 134(95.7%), and a single bile duct in 101(72.1%) donors. Donors with up to two hepatic arteries, bile ducts, and portal vein variations were accepted in this study. The presence of anatomical variations was not significantly associated with postoperative complications. In contrast, Pakistani data from 400 living liver donors reported that vascular and biliary variations were common (34.2%) and therefore must be defined carefully during donor workup.[15] Broader contemporary imaging and donor evaluation reviews also emphasize that anatomical variants are frequent in otherwise healthy donors and that preoperative mapping is indispensable for safe graft procurement.[5,12] Our results suggested that selected minor anatomical variations can be managed safely when operative expertise and preoperative planning are strong.

The long term donor literature showed that donor outcomes should be evaluated not only in terms of mortality, but also through broader measures such as recovery burden, quality of life, psychosocial health, and durable symptoms after donation.[16,17] In the review by Thuluvath et al., 9.1% of donors in studies did not return to baseline physical quality of life scores for at least two years after donation.[16] The absence of donor mortality in our series should be interpreted carefully and should not be presented as evidence that donor risk is absent. A North American data spanning more than three decades and more than 11,000 living donor hepatectomies reinforce that donor death is rare, but not impossible, and that transparent reporting remains essential.[8]

CONCLUSION

A strict donor selection process combined with multidisciplinary evaluation was associated with low complication rates, shorter hospital stays, and no donor deaths in this cohort. Donors with complications had a significantly longer mean hospital stay compared to those without complications. These findings reinforce the importance of careful donor selection as a central factor in ensuring donor safety in LDLT.

LIMITATIONS & RECOMMENDATIONS

This was a retrospective, single-centered study with a relatively small number of complication events, which may limit the generalizability of the findings and restrict detailed risk factor analysis. In addition, long term donor outcomes were not assessed. Future research, particularly larger multi-centered prospective studies with extended follow-up, is recommended to confirm these results and help improve donor selection criteria.

Conflict of interest: None.

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Authors' Contributions:

M.H: Conceptualization, study design, supervision, manuscript review and final approval.

M.I.K: Data collection, donor evaluation, interpretation of results and manuscript drafting.

R.S.D: Literature review, statistical analysis and data interpretation.

M.I.A: Radiological assessment coordination, data acquisition and critical revision of manuscript.

F.H: Surgical supervision, final manuscript editing and overall coordination of the study.

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