## Title

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# Early Kidney Allograft Failure after Simultaneous Liver-Kidney Transplantation (SLKT): Evidence for Utilization of the Safety Net

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## Abstract

**Background:** With the implementation of the “Safety Net”, we aimed to determine the impact of SLKT, as compared to KALT, on kidney allograft failure(KF).

**Methods:** An analysis of the UNOS database for all adult patients who received either a SLKT or KALT from 2002–2017. The outcomes were 90-day KF and 1-year KF (as reported to UNOS, at 90- and 365-days post-kidney transplant, respectively). We compared the following groups of patients: SLKT<25 (SLKT with final MELD<25), SLKT25/35 (MELD ≥25/<35), and SLKT35 (MELD≥35) to KALT.

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**Results:** Of the 6276 patients: 1481 KALT, 1579 SLKT<25, 1832 SLKT25/35, 1384 SLKT≥35. The proportion of patients with 90-day and 1-year KF increased significantly between the KALT, SLKT<25, SLKT25/35, and SLKT≥35 groups (p<0.001, test for trend): 90-day KF:**3.3v.5.5***v.***7.3***v.***9.3%** and *1-year KF*:***5.1v.*9.4***v.***12.3***v.***14.7%.** After adjustment and compared to KALT, beginning at a MELD≥25 those undergoing SLKT had significantly higher risk of 90-day and 1-year KF: 90-day KF:SLKT25/35: HR 1.6(1.0–2.3), SLKT≥35 2.1(1.3–3.3); 1-year KF: SLKT25/35: HR 1.7(1.2–2.4), SLKT≥35 2.1(1.5–3.0).

**Conclusion:** As compared to KALT recipients, SLKT recipients with a MELD≥25 had significantly higher risk of early KF. Given the now well-established "safety net", KALT may serve as an opportunity to improve kidney outcomes in patients with a MELD≥25.

### Keywords

Renal Dysfunction; Simultaneous Liver-Kidney Transplantation; Liver Disease; Graft Failure; Liver Transplantation

## INTRODUCTION

The prevalence of chronic kidney disease (CKD) among liver transplant candidates has increased nearly 200% in recent years, most likely a manifestation of the general observed increase in kidney disease prevalence and an aging population with a greater proportion of NASH and its associated co-morbidities (i.e. diabetes mellitus and hypertension)[1]. This dramatic rise has predisposed patients to increased rates of post-liver transplant CKD and consequently impacted post-liver transplant outcomes [1–6]. In an effort to prevent the development of post-liver transplant CKD, there has been a nearly 300% increase in the utilization of simultaneous liver-kidney transplant (SLKT) (326 SLKTs in 2006 to 910 SLKTs in 2016) [7]. Despite this increase in utilization of SLKT, little is known about kidney allograft outcomes after dual-organ transplant, especially as they compare to kidney transplant after liver transplant (KALT).

To date, studies evaluating outcomes after SLKT have focused on post-liver transplant mortality. These studies reported conflicting evidence regarding the benefit of SLKT with the most optimistic studies demonstrating an average 4-month increase in survival among transplant candidates with chronic kidney dysfunction who underwent SLKT as compared to liver transplant alone, while others demonstrated no significant survival benefit [8–12]. Considering the modest benefit that has been described, it is imperative to understand the potential benefit/longevity of the kidney allograft after dual-organ transplant. In fact the one study that described kidney allograft outcomes after SLKT demonstrated a 21% rate of 90-day kidney allograft failure, defined as death or need for renal replacement therapy – a rate that is alarmingly high given the scarcity in the overall kidney donor pool [13]. Therefore, in an effort to improve outcomes after SLKT, what is needed is not only an assessment of kidney allograft outcomes but also an investigation into the determinants of poor kidney allograft outcome after dual-organ transplant.

Herein, we present a study among all patients undergoing liver and kidney transplant focused on determining the impact of SLKT on kidney allograft outcomes, particularly as

they compare to KALT. We hypothesize that given the dynamic period of liver transplant and the added complexity of dual-organ transplant, that patients undergoing SLKT, as compared to KALT, have higher rates of early kidney allograft failure.

## METHODS

### Patients

All patients undergoing kidney transplant - either simultaneous to or after liver transplant (i.e.., SLKT or KALT) - in the UNOS/OPTN registry from January 1st 2002 through August 10th 2017 were included in this study. These dates were chosen to reflect implementation of the MELD score and the latest change to the UNOS SLKT criteria. Given differences in allocation policy, patients who were less than 18 years old or listed as Status 1, including those with fulminant hepatic failure were excluded.

### Covariables

Data were obtained from the UNOS/OPTN registry as of April 6th, 2018. Using the unique identifier present in the UNOS/OPTN registry the liver transplant and kidney transplant databases were merged. The following data were collected at the time of liver transplant: demographic data, transplant date, etiology of cirrhosis, time on hemodialysis, total bilirubin, international normalized ratio (INR), serum creatinine, presence of hepatic encephalopathy (HE), presence of ascites. Cutoffs deemed to be implausible were as follows: total bilirubin ≤ 0 mg/dL, INR ≤ 0, and creatinine ≤ 0 mg/dL [14]. Observations with implausible values or missing data were omitted. Those on hemodialysis were treated as having a serum creatinine of 4 mg/dL per current allocation policy. The Model for End-Stage Liver Disease score [15] was calculated and capped at 6 and 40, per current liver allocation policy. Because we included patients in this study before the implementation of MELDNa, we used the final MELD score for this study. Etiologies of cirrhosis were grouped into the following common diagnostic categories: hepatitis C virus (HCV), nonalcoholic fatty liver disease (NAFLD, including cryptogenic cirrhosis and nonalcoholic steatohepatitis), alcohol-related cirrhosis (ALD), autoimmune etiologies (including primary biliary cirrhosis, primary sclerosing cholangitis and autoimmune hepatitis), and other etiologies of cirrhosis (any other listing code that met inclusion criteria). The following variables were utilized to calculate the liver donor risk index (LDRI)[16]: BMI, height, age, cause of death, race, organ type, share type, and cold ischemia time. Observations with missing values were replaced with the median LDRI for the respective region. The LDRI represents the best metric currently available to quantify the risk of liver allograft failure. It ranges from 0.0 to 2.0, with 1-year rates of liver allograft failure increasing from 12% to 29% as the LDRI increases from 0.0 – 1.0 to ≥ 2.0. The kidney donor risk index (KDRI)was obtained as reported to UNOS [17]. Observations with missing values were replaced with the median KDRI for the respective region. Similar to the LDRI, the KDRI represents the best metric currently available to quantify the risk of kidney allograft failure. It ranges from 0 – maximum, with 5-year allograft failure increasing from 18% if <0.79 to 37% if >1.45[17]. The kidney donor profile index (KDPI) was obtained as reported to UNOS, with a reference population of 2016. The KDPI ranks the relative risk of kidney allograft failure on a

percentile scale, such that the lowest risk kidney allografts have a KDPI closer to 1% and the highest risk kidneys have a KDPI closer to 99%.

## Comparator Groups

We defined dual-organ transplant comparator groups as follows:

- **KALT**: kidney transplant any time after liver transplant (reference group)
- **SLKT<25**: SLKT with MELD at time of dual-organ transplant < 25
- **SLKT25/35**: SLKT with MELD at time of dual-organ transplant ≥25 and <35
- **SLKT≥35**: SLKT with MELD at time of dual-organ transplant ≥35

These cut-offs were chosen because of the higher mortality established in patients with a MELD ≥35 and to ensure that there was an adequate sample size in each analytic cell [18].

## Outcomes

The primary outcome was kidney allograft loss within 90 days of kidney transplant (90-day KF). The secondary outcome was kidney allograft failure within 1 year of kidney transplant (1-year KF). We reported death-censored kidney allograft loss, defined as report to UNOS of renal-allograft failure or listing for renal transplant within both 90 days and 1-year post-kidney transplant. Patient follow-up began on the date of kidney transplant and ended at the time of report of kidney allograft failure, either from graft loss or death, to UNOS or last follow-up. We report 90 day and 1-year liver allograft outcomes in Supplementary Table 1.

## Sensitivity Analysis

On August 10$^{th}$ 2017, the OPTN implemented a new SLKT Allocation policy. This policy developed to standardize the utilization of SLKT also established a “safety net” for all liver transplant recipients, a “safety net” that was instituted to give liver transplant recipients who develop persistent renal dysfunction within 60 – 365 days after liver transplant allocation priority in the kidney allocation system. Simply put, this “safety net” was established to prevent patients with renal dysfunction at the time of liver transplantation who were not considered for SLKT from falling through the cracks under this new policy [19,20]. Therefore, in an attempt to compare outcomes of SLKT and utilization of the “safety net”, we *a priori* determined to complete a sensitivity analysis comparing SLKT and KALT within 1 year of liver transplantation.

## Statistical analysis

Continuous variables were compared between groups by Wilcoxon rank-sum or Kruskall-Wallis. Categorical variables were compared between groups by chi-squared test.

Because there may have been unknown confounders in patients undergoing SLKT, as compared to those undergoing KALT, we utilized logistic regression to determine the propensity for patients to undergo SLKT based on the following variables: age at time of liver transplant, etiology of cirrhosis, MELD at liver transplant, time on dialysis, center, and listing year. We then divided the generated propensity score into quintiles. There was

adequate overlap between the generated propensity score quintiles and the exposure, type of dual-organ transplant.

We then utilized Cox-regression analysis clustered by center to determine the association between the dual-organ transplant group and the primary and secondary outcomes. Unadjusted models were used to assess the association between covariables and the outcomes of interest. All covariables with a $p<0.2$ in univariable analysis were considered for inclusion in multivariable models. All multivariable modeling included the generated propensity score quintiles. Sequential backward selection was used to eliminate those not reaching significance of $p<0.05$. Post- kidney transplant survival rates were estimated separately using Kaplan-Meier method and compared using log-rank test. Postestimation analysis of the final multivariable model included determining the adjusted mean hazard ratio for each dual-organ transplant comparator group at 0.2 point KDRI intervals and determining the average marginal effect of dual-organ transplant comparator group on 1-year KF. To determine the MELD at which the risk of kidney allograft failure associated with SLKT exceeded the risk associated with KALT, we created a three-level variable: KALT, SLKT < MELD cut-point, and SLKT ≥ MELD cut-point. We varied this cut-point at 1 MELD point increments from 6 to 40. We then determined in the adjusted multivariable model at what MELD threshold the risk of 90d-KF in the SLKT group significantly exceeded that of KALT group.

Two-sided p-values <0.05 were considered statistically significant. Analyses were performed using Stata 15.0 statistical software (College Station, TX). This study was approved by the institutional review board at the University of California, San Francisco.

The data reported here have been supplied by the United Network for Organ Sharing as the contractor for the Organ Procurement and Transplantation Network. The interpretation and reporting of these data are the responsibility of the author(s) and in no way should be seen as an official policy of or interpretation by the OPTN or the U.S. Government.

## RESULTS

### Population Characteristics

A total of 6,276 patients received a dual-organ transplant during the study period: 4,795 (76%) SLKT and 1,481 (24%) KALT. As compared to those who underwent KALT, those who underwent SLKT were younger (56 v. 58 years, $p<0.001$), more likely to have a NASH as their etiology of cirrhosis (18 v. 15%, $p=0.002$), less likely to have hepatic encephalopathy at time of liver transplant (23 v. 29%, p,0.001), less likely to have diabetes at the time of kidney transplant (36 v. 48%, $p<0.001$), had a higher MELD at time of transplant (29 v. 26, $p<0.001$), had a lower LDRI (1.31 v. 1.44, $p<0.001$), and had a lower KDRI (1.05 v. 1.06, $p<0.001$).

Of the 4,795 who underwent SLKT, 1,579 (33%) had a MELD at transplant <25 (SLKT<25), 1,832 (38%) had a MELD at transplant ≥ 25 and <35 (SLKT25/35), and 1,384 (29%) had a MELD at transplant that was ≥ 35 (SLKT≥35). The demographics of these groups, as they compare to the KALT group are demonstrated in Table 1.

### 90-day Kidney Allograft Failure

Of the 6,276 patients who received dual-organ transplant, 398 (6%) of patients had 90-day KF and 196 (3%) had "death-censored" 90-day KF. The proportion of patients who experienced 90-day KF increased progressively as the MELD at transplant increased (*KALT* 3.3% v. *SLKT<25* 5.5% v. *SLKT25/35* 7.3% v. *SLKT≥35* 9.3%, p<0.001 test for trend). Likewise, the proportion of patients who experienced "death-censored" 90-day KF increased as the MELD at transplant increased (*KALT* 0.1 % v. *SLKT<25* 3.0% v. *SLKT25/35* 4.0% v. *SLKT≥35* 5.3%, p<0.001 test for trend).

In univariable Cox-regression adjusting for the propensity score quintiles to receive a SLKT, the following factors were significantly associated with 90-day KF: receiving a SLKT as compared to KALT (*SLKT<25*: HR 1.08 [95CI 0.71 – 1.62]; *SLKT25/35*: HR 1.51 [1.03 – 2.24]; *SLKT≥35:* HR 2.06 [1.40 – 3.04]), LDRI (1.08 per 0.1 points [1.04 – 1.10]), and KDRI (1.09 per 0.1 points [1.07 – 1.12]). In the final multivariable model, after adjusting for the propensity score quintiles to receive a SLKT, KDRI, as compared to the KALT group, the SLKT25/35 (HR 1.55 [1.03 – 2.33]) and SLKT≥ 35 (HR 2.07 [1.30 – 3.29]) groups were significantly associated with 90-day KF (Table 2).

### 1-Year Kidney Allograft Failure

Of the 6,276 patients who received dual-organ transplant, 652 (10%) of patients had 1-year KF and 351 (6%) had "death-censored" 1-year KF. The proportion of patients who experienced 1-year KF increased significantly as the MELD at transplant increased (*KALT* 5.1% v. *SLKT<25* 9.4% v. *SLKT25/35* 12.3% v. *SLKT≥35* 14.7%, p<0.001 test for trend). Likewise, the proportion of patients who experienced "death-censored" 1-year KF increased as the MELD at transplant increased (*KALT* 0.3% v. *SLKT<25* 5.3% v. *SLKT25/35* 7.6% v. *SLKT≥35* 8.9%, p<0.001 test for trend).

In univariable Cox-regression adjusting for the propensity score quintiles to receive a SLKT, the following factors were significantly associated with 1-year KF: receiving a SLKT as compared to KALT (*SLKT<25*: HR 1.16 [95CI 0.84 – 1.59]; *SLKT25/35*: HR 1.58 [1.17 – 2.14]; *SLKT≥35:* HR 2.05 [1.51 – 2.78]), diagnosis of HCV and NASH compared to alcohol (*HCV*: HR 1.46 [1.16 – 1.84]; *NASH*: HR 1.35 [1.06 – 1.72]), LDRI (1.04 per 0.1 points [1.01 – 1.06]), and KDRI (1.10 per 0.1 points [1.08 – 1.12]). In the final multivariable model, after adjusting for the propensity score quintiles to receive a SLKT, LDRI, and KDRI, the SLKT25/35 (HR 1.68 [1.19 – 2.38]) and SLKT≥ 35 (HR 2.12 [1.49 – 3.01]) groups as compared to the KALT group were significantly associated with 1-year KF (Table 3). Kaplan-Meier curves estimated risk of 1-year KF by dual-organ transplant comparator group (p<0.001 by log-rank as compared to KALT)(Figure 1). On average, compared to the KALT group, SLKT with a MELD ≥25 and <35 conferred a 339% (72 – 608%) added risk and SLKT with a MELD ≥ 35 conferred a 550% (174 – 926%) added risk of 1-year KF. We determined the threshold at which SLKT was significantly associated with higher rates of 1-year KF began at a MELD score of 25.

### Impact of Liver and Kidney Donor Quality

Despite the rising rates of 90-day KF and 1-year KF we found that patients with higher MELD at transplant received higher quality organs: L*DRI* (*KALT:* median 1.44 [IQR 1.18 – 1.77] v. *SLKT<25* 1.31 [1.13 – 1.58] v. *SLKT25/35* 1.30 [1.13 – 1.57] v. SLKT≥35 1.43 [1.18– 1.77]) and *KDRI* (*KALT:* 1.05 [0.88 – 1.29] v. *SLKT<25* 1.05 [0.92 – 1.22] v. *SLKT25/35* 1.04 [0.89 – 1.26] v. SLKT≥35 1.04 [0.88 – 1.29]) (p<0.001 test for trend). For a reference, based on median KDPI of the kidney allografts transplanted in each group the expected rate of 1-year KF would have been: *KALT:* 5.5% (versus 5.1%)*; SLKT<25:* 5.6% (versus 9.3%)*; SLKT25/35:* 5.6% (versus 12.0%)*; SLKT≥35:* 4.2% (versus 14.4%). To highlight that higher quality organs cannot reverse the risk for kidney allograft failure associated with SLKT at higher MELD scores, we plotted the contrast of the adjusted hazard ratio for SLKT group compared to the KALT group by KDRI (Figure 2). Compared to the KALT group, regardless of the KDRI, the SLKT25/35 and SLKT≥35 groups had higher rates of kidney allograft failure. We additionally compared the quality of kidneys that failed by dual-organ transplant group (Table 4).

### Comparison to Those with a KALT within 1 year of Liver Transplant

Of the 1481 patients who underwent KALT, the median time to kidney transplant was 2.7 years (IQR: 1.1 – 5.6) after liver transplantation and 368 (25%) of patients received a kidney transplant within 1 year of liver transplant. Of the 368 who had a kidney transplant within 1 year of liver transplant the rates of 90-day KF and 1-year KF were 5.4% and 8.4%, respectively. Of the same 368 patients, the rates of 90-day and 1-year “death-censored” KF were 0.3% and 1.1% respectively. Excluding those who underwent a KALT > 1 year after liver transplantation, there remained a significant trend for the rates 90- KF and 1-year KF to increase as the MELD at transplant increased (i.e. KALT v. SLKT<25 v. SLKT 25/35 v. SLKT≥35) (p=0.01 and p=0.01, respectively by test for trend). Likewise in multivariable Cox-regression analysis, receiving a SLKT≥35, as compared to KALT ≤ 1 year after liver transplant was associated with significantly higher rates of 1-year KF, after adjusting for LDRI, KDRI, propensity to receive a SLKT, and clustering on center (*SLKT≥35*: HR 1.47, 95CI 1.02 – 2.14). We found in this subgroup analysis, excluding those with a KALT > 1 year after liver transplant, that the threshold where SLKT was associated with higher kidney allograft failure than KALT, began at a MELD score of 33.

## DISCUSSION

In this study evaluating liver-kidney transplant, we aimed to determine the impact of simultaneous- versus delayed- kidney transplant after liver transplantation on early kidney allograft outcomes. We observed that the rates of both 90-day KF and 1-year KF increased nearly 3-fold as the MELD score at the time of kidney transplant increased from the KALT group to the SLKT≥35 group. Furthermore, we demonstrated that beginning at a MELD of 25 there was a significantly higher risk of early kidney allograft failure with SLKT as compared to KALT – a risk that we show was independent of the quality of the kidney allograft.

We suspect that these higher rates of early kidney allograft failure are a reflection of the complexity and associated hemodynamic instability seen in these simultaneous organ transplants. More specifically, liver transplantation reflects a dynamic period that is most tenuous in the sickest patients (i.e., those with highest MELD scores)[21,22]. Therefore, those with higher MELD scores are more vulnerable to greater intraoperative instability, longer operations, and increased operative complications. We hypothesize that the summation of these perioperative insults to the kidney allograft leads to more frequent episodes of hemodynamic instability associated with decreased kidney perfusion, resulting in ischemic injury which negatively impacts early kidney allograft outcomes. The need to minimize this early kidney allograft failure is essential, especially when considering the center variation that contributes to increased SLKT listings and the consequential removal of high-quality renal allografts from the kidney-alone transplant pool – trends that have had a deleterious effect on kidney transplant alone candidates and recipients [23–25].

We acknowledge the following limitations to this study. First, we fully acknowledge that there were inherent differences between the KALT and SLKT groups. We attempted to statistically account for these differences by adjusting for the propensity for patients to receive either a SLKT or KALT. Although such statistical techniques are imperfect, they represent the best controlling for confounding that is possible with the data available and follows procedures similarly completed in prior studies [11]. Second, we were limited by the lack of granularity of the UNOS/OPTN database where the cause of post-kidney transplant allograft failure is not available. However, by focusing on early outcomes, 90- KF and 1-year KF, we aimed to isolate the causes of kidney failure that were most likely to be related to pre-liver transplant acuity to best evaluate the impact of pre-kidney transplant MELD on kidney allograft outcomes. In doing so, though, we can only comment on early renal allograft outcomes, and in order to comment on appropriate organ allocation future studies should focus on long-term outcomes including dialysis free life-years. Finally, in order to increase the power of our study, we compared all patients who received a KALT to those who received a SLKT. That being said, with the implementation of the “UNOS Safety Net”, those who received a KALT less than 1 year after liver transplant are the most relevant. To account for this, we completed a subgroup analysis comparing the outcomes of patients who received a KALT within 1 year of liver transplant to SLKT recipients. There were no qualitative differences in our findings – receiving a SLKT at higher MELD scores is associated with significantly higher rates of early kidney allograft failure as compared to KALT.

Despite these limitations, this is the largest and one of the first studies to investigate kidney allograft outcomes after dual-organ transplant. In the context of the newly established, “UNOS Safety Net”, our findings that kidney allograft outcomes vary depending on the MELD at the time kidney transplant have important clinical implications. Specifically, in an environment of kidney allograft scarcity where effective organ utilization is paramount, deferring kidney transplantation until after liver transplantation in patients with “high” MELD scores may provide an opportunity to optimize outcomes after dual-organ transplantation and minimize the waste of organs that might be better diverted to kidney-only transplant recipients.

## Supplementary Material

Refer to Web version on PubMed Central for supplementary material.

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## Abbreviations:

| | |
|---|---|
| **SLKT** | Simultaneous Liver-Kidney Transplantation |
| **MELD** | Model for End-Stage Liver Disease |

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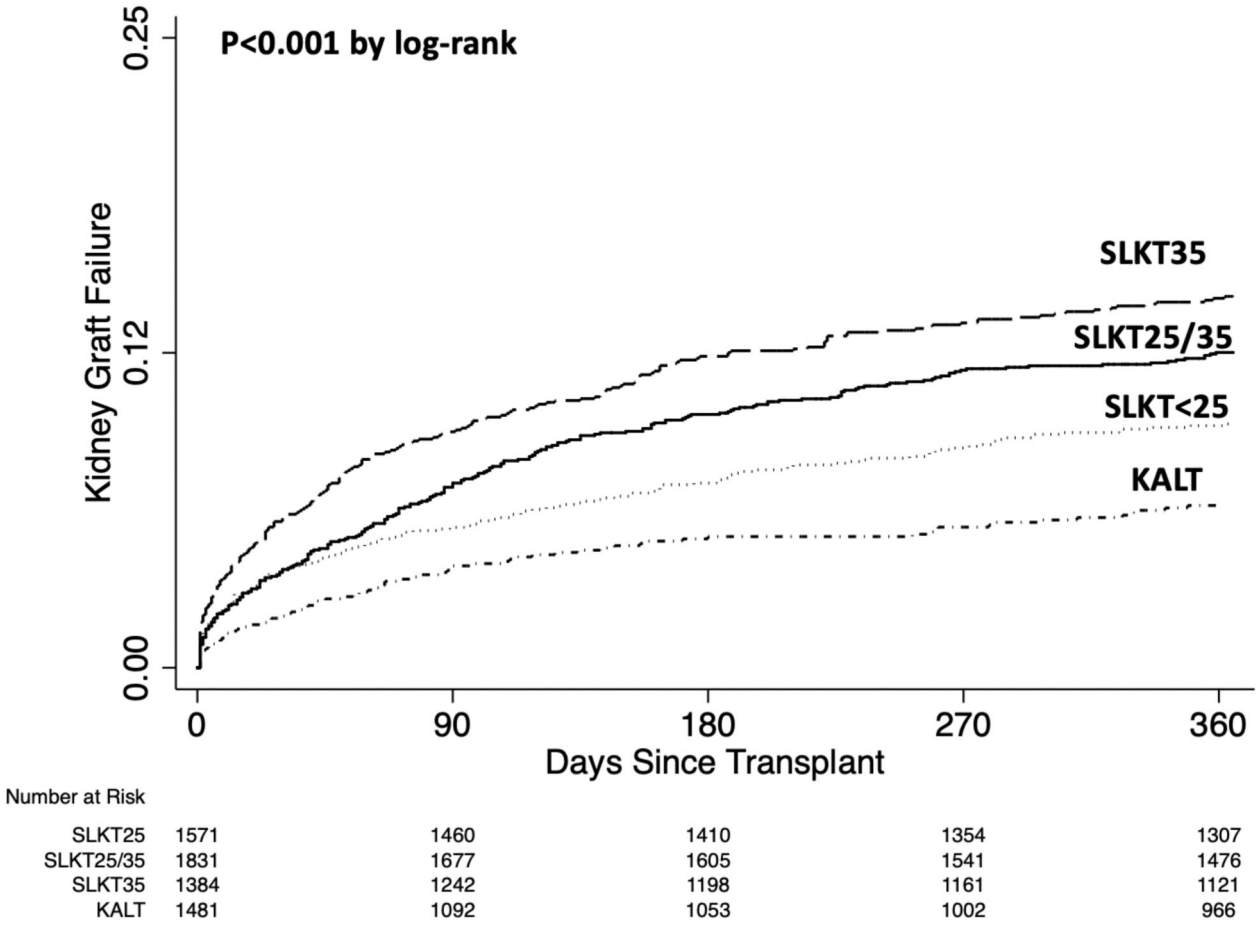


**Figure 1.**
Kaplan Meier Survival Graph for 1-Year Kidney Allograft Failure

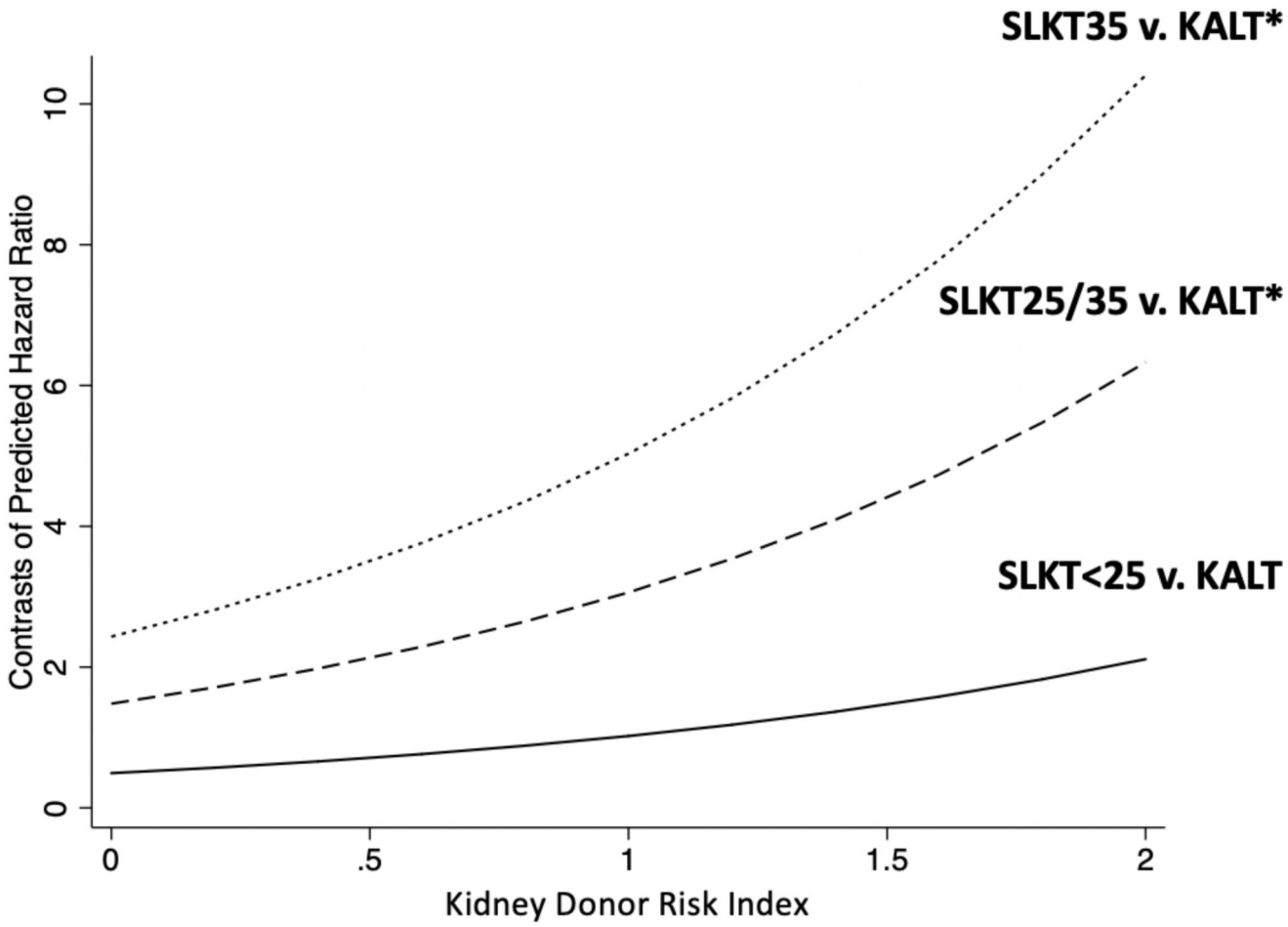


**Figure 2. Contrasts of Predicted Hazard Ratio of Dual-Organ Comparator Group and KALT by KDRI**

* indicates a significant contrast in the adjusted average HR for all values of KDRI ($p<0.05$)

**Table 1.**

Baseline Demographics of the Patients Undergoing Dual-Organ Transplant by Comparator Group

| | KALT (n = 1 481) | SLKT<25 (n = 1 579) | SLKT25/35 (n = 1 832) | SLKT≥35 (n = 1 384) | p |
|---|---|---|---|---|---|
| **Age at KTx, m(IQR)** | 58 (51 – 63) | 56 (50 – 62) | 57 (51 – 62) | 56 (49 – 62) | <0.001 |
| **Female sex, no (%)** | 497 (34) | 587 (37) | 657 (36) | 512 (37) | 0.15 |
| **Ethnicity, no. (%)** | | | | | |
| **Non-Hispanic White** | 1024 (69) | 1036 (66) | 1281 (70) | 847 (61) | <0.001 |
| **African American** | 181 (12) | 273 (17) | 214 (12) | 176 (13) | |
| **Hispanic** | 214 (14) | 200 (13) | 276 (15) | 303 (22) | |
| **Asian** | 38 (3) | 56 (3) | 35 (2) | 41 (3) | |
| **Other** | 24 (2) | 14 (1) | 26 (1) | 17 (1) | |
| **Listing diagnosis, no. (%)** | 251 (17) | | | | |
| **Alcohol** | 576 (39) | 229 (15) | 443 (24) | 365 (26) | <0.001 |
| **HCV** | 360 (24) | 559 (35) | 554 (30) | 433 (31) | |
| **NAFLD/NASH** | 182 (12) | 335 (21) | 573 (31) | 334 (24) | |
| **Autoimmune**[1] | 112 (8) | 90 (6) | 127 (7) | 144 (10) | |
| **Other** | | 366 (23) | 135 (7) | 108 (8) | |
| **Ascites, no. (%)** | 872 (59) | 677 (43) | 1187 (65) | 995 (72) | <0.001 |
| **Hepatic encephalopathy, no. (%)** | 433 (29) | 196 (12) | 433 (24) | 499 (36) | <0.001 |
| **Body Mass Index at Kidney, m(IQR)** | 29.0 (25.4 – 33.4) | 26.6 (23.4 – 31.0) | 28.2 (24.5 – 33.1) | 27.9 (24.3 – 33.0) | <0.001 |
| **MELD at LTx, m(IQR)** | 26 (19 – 35) | 21 (20 – 23) | 29 (27 – 32) | 39 (37 – 40) | <0.001 |
| **LTx Donor Risk Index, m(IQR)** | 1.4 (1.2 – 1.8) | 1.3 (1.1 – 1.6) | 1.3 (1.1 – 1.6) | 1.4 (1.2 – 1.8) | <0.001 |
| **Diabetes Mellitus at KTx, no. (%)** | 686 (48) | 539 (36) | 665 (39) | 422 (32) | <0.001 |
| **Kidney Donor Risk Index, m(IQR)** | 1.1 (1.0 – 1.2) | 1.1 (0.9 – 1.2) | 1.0 (0.9 – 1.3) | 1.0 (0.9 – 1.3) | <0.001 |
| **Kidney Donor Profile Index, m(IQR)** | 0.5 (0.3 – 0.6) | 0.4 (0.2 – 0.5) | 0.3 (0.2 – 0.6) | 0.3 (0.2 – 0.6) | <0.001 |

Hepatitis C (HCV); Non-Alcoholic Steatohepatitis (NASH); Model for End-Stage Liver Disease with Serum Sodium (MELDNa); Kidney Transplant (KTx); Liver Transplant (LTx)

**Table 2.**

Cox Regression Analysis for 90-Day Kidney Allograft Failure Adjusting for Propensity Score Quintile for SLKT

| | Univariable | | | Multivariable | | |
|---|---|---|---|---|---|---|
| | HR* | 95% CI | p-value | HR* | 95% CI | p-value |
| **Dual-Organ Txp Type** | | | | | | |
| **KALT** | - | - | - | - | - | - |
| **SLKT<25** | 1.08 | 0.71 – 1.62 | 0.73 | 1.13 | 0.72 – 1.77 | 0.61 |
| **SLKT25/35** | 1.51 | 1.03 – 2.24 | 0.04 | 1.55 | 1.03 – 2.33 | 0.04 |
| **SLKT≥35** | 2.06 | 1.40 – 3.04 | <0.001 | 2.07 | 1.30 – 3.29 | 0.002 |
| **Age per Year at KTx** | 1.00 | 0.99 – 1.01 | 0.43 | | | |
| **Female Sex** | 0.87 | 0.69 – 1.08 | 0.20 | | | |
| **Race** | | | | | | |
| **Caucasian** | - | - | - | | | |
| **African American** | 1.10 | 0.81 – 1.48 | 0.54 | | | |
| **Hispanic** | 1.16 | 0.88 – 1.54 | 0.29 | | | |
| **Asian** | 0.83 | 0.41 – 1.68 | 0.60 | | | |
| **Other** | 1.09 | 0.45 – 2.65 | 0.85 | | | |
| **LTx Listing Diagnosis** | | | | | | |
| **Alcohol** | - | - | - | | | |
| **HCV** | 1.33 | 0.99 – 1.81 | 0.06 | | | |
| **NAFLD/NASH** | 1.24 | 0.90 – 1.70 | 0.19 | | | |
| **Autoimmune**[1] | 1.18 | 0.75 – 1.86 | 0.47 | | | |
| **Other** | 1.26 | 0.86 – 1.85 | 0.23 | | | |
| **BMI per 1 kg/m$^2$ at KTx** | 0.99 | 0.97 – 1.01 | 0.35 | | | |
| **Diabetes at KTx** | 0.97 | 0.77 – 1.21 | 0.78 | | | |
| **LDRI per 0.1 points** | 1.08 | 1.04 – 1.10 | <0.001 | | | |
| **KDRI per 0.1 points** | 1.09 | 1.07 – 1.12 | <0.001 | 1.09 | 1.06 – 1.12 | <0.001 |

Non-Alcoholic Steatohepatitis (NASH); Body Mass Index (BMI); HE (Hepatic Encephalopathy); DM (Diabetes Mellitus); Kidney Transplant (KTx); Liver Transplant (LTx); Liver Donor Risk Index (LDRI); Kidney Donor Risk Index (KDRI)

*Adjusted for Propensity Score Quintiles

**Table 3.**

Cox Regression Analysis for 1-Year Kidney Allograft Failure

| | Univariable | | | Multivariable | | |
|---|---|---|---|---|---|---|
| | HR* | 95% CI | p-value | HR* | 95% CI | p-value |
| **Dual-Organ Txp Type** | | | | | | |
| **KALT** | - | - | - | - | - | - |
| **SLKT<25** | 1.16 | 0.84 – 1.59 | 0.37 | 1.23 | 0.87 – 1.73 | 0.25 |
| **SLKT25/35** | 1.58 | 1.17 – 2.14 | 0.003 | 1.68 | 1.19 – 2.38 | 0.003 |
| **SLKT≥35** | 2.05 | 1.51 – 2.78 | <0.001 | 2.12 | 1.49 – 3.01 | <0.001 |
| **Age per Year at KTx** | 1.01 | 1.00 – 1.01 | 0.19 | | | |
| **Female Sex** | 0.91 | 0.77 – 1.08 | 0.27 | | | |
| **Race** | | | | | | |
| **Caucasian** | - | - | - | | | |
| **African American** | 1.29 | 1.04 – 1.60 | 0.02 | | | |
| **Hispanic** | 1.01 | 0.81 – 1.27 | 0.91 | | | |
| **Asian** | 0.77 | 0.44 – 1.34 | 0.36 | | | |
| **Other** | 0.76 | 0.34 – 1.71 | 0.51 | | | |
| **LTx Listing Diagnosis** | | | | | | |
| **Alcohol** | - | - | - | | | |
| **HCV** | 1.46 | 1.16 – 1.84 | 0.001 | | | |
| **NAFLD/NASH** | 1.35 | 1.06 – 1.72 | 0.02 | | | |
| **Autoimmune**[1] | 0.99 | 0.68 – 1.45 | 0.98 | | | |
| **Other** | 1.15 | 0.85 – 2.86 | 0.36 | | | |
| **BMI per 1 kg/m$^2$ at KTx** | 1.00 | 0.98 – 1.01 | 0.62 | | | |
| **Diabetes at KTx** | 1.06 | 0.89 – 1.26 | 0.49 | | | |
| **LDRI per 0.1 points** | 1.04 | 1.01 – 1.06 | 0.01 | 1.04 | 1.01 – 1.06 | 0.01 |
| **KDRI per 0.1 points** | 1.10 | 1.08 – 1.12 | <0.001 | 1.08 | 1.05 – 1.10 | <0.001 |

Non-Alcoholic Steatohepatitis (NASH); Body Mass Index (BMI); HE (Hepatic Encephalopathy); DM (Diabetes Mellitus); Kidney Transplant (KTx); Liver Transplant (LTx); Liver Donor Risk Index (LDRI); Kidney Donor Risk Index (KDRI)

*Adjusted for Propensity Score Quintiles

**Table 4.**

Characteristics of the 657 Failed Kidney Allografts at 1 Year by Type of Dual-Organ Transplant

| | KALT (n = 75) | SLKT<25 (n = 149) | SLKT25/35 (n = 227) | SLKT≥35 (n = 206) | p |
|---|---|---|---|---|---|
| **Ktx Donor age, m(IQR)** | 37 (22 – 48) | 39 (25 – 50) | 41 (27 – 53) | 41 (28 – 53) | 0.03 |
| **KTx Donor Ethnicity, no. (%)** | | | | | |
| **Non-Hispanic White** | 46 (61) | 98 (66) | 157 (69) | 125 (61) | 0.68 |
| **African American** | 15 (20) | 26 (17) | 26 (12) | 27 (13) | |
| **Hispanic** | 10 (13) | 20 (13) | 35 (15) | 43 (21) | |
| **Asian** | 3 (3) | 3 (2) | 7 (3) | 7 (3) | |
| **Other** | 1 (1) | 2 (1) | 2 (1) | 4 (2) | |
| **Ktx Donor HCV, no. (%)** | 4 (6) | 15 (10) | 7 (3) | 5 (2) | 0.02 |
| **KTx Donor Final Creatinine, m(IQR)** | 1.0 (0.7 – 1.4) | 0.9 (0.7 – 1.2) | 0.9 (0.7 – 1.3) | 0.9 (0.7 – 1.3) | 0.17 |
| **KTx Donor Hypertension, no.(%)** | 18 (25) | 41 (28) | 66 (29) | 70 (34) | 0.71 |
| **KTx Donor Diabetes, no.(%)** | 13 (14) | 14 (9) | 11 (4) | 18 (8) | 0.21 |
| **KTx Expanded Donor, no.(%)** | 6 (8) | 26 (17) | 46 (20) | 44 (22) | 0.08 |
| **Kidney Donor Profile Index, m(IQR)** | 0.5 (0.2 – 0.7) | 0.5 (0.2 – 0.7) | 0.4 (0.2 – 0.7) | 0.4 (0.2 – 0.7) | 0.97 |

Kidney Transplant (KTx)