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Live Donor Liver Transplantation in the United States: Impact of Share 35 on Live Donor Utilization

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Abstract

Background: Share 35 was a policy implemented in 2013 to increase regional sharing of deceased donor livers to patients with MELD ≥ 35 in order to decrease waitlist mortality for the sickest patients awaiting liver transplantation. The purpose of this study was to determine whether LDLT volume was impacted by the shift in allocation of deceased donor livers to patients with higher MELD scores.

Methods: Using UNOS/OPTN Standard Transplant Analysis and Research files, we identified all adults who received a primary LT between October 1, 2008 and March 31, 2018. LT from October 1, 2008 through June 30, 2013 were designated as the pre-Share 35 era and July 1, 2013 through March 31, 2018 as the post-Share 35 era. Primary outcomes included transplant volumes, graft survival, and patient survival in both eras.

Results: 48,779 primary adult single-organ LT occurred during the study period (22,255 pre-Share 35, 26,524 post. LDLT increased significantly (6.8% post vs. 5.7% pre, $p<0.001$). LDLT volume varied significantly by region ($p<0.001$) with regions 2, 4, 5, and 8 demonstrating significant increases in LDLT volume post-share 35. The number of centers performing LDLT increased only in regions 4, 6, and 11. Throughout the two eras, there was no difference in graft or patient survival for LDLT recipients.

Conclusions: Overall LDLT volume increased following the implementation of Share 35 which was largely due to increased LDLT volume at centers with experience in LDLT, and corresponded to significant geographic variation in LDLT utilization.

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INTRODUCTION

One of the primary issues in solid organ transplantation is that the demand for organs substantially outpaces the supply; in 2018, approximately 13,000 patients were listed for liver transplantation (LT), and just over 8,000 liver transplants were performed across the United States (US) [1]. This discrepancy underscores a real and persistent need for additional liver grafts.

At present, liver allocation in the US proceeds according to disease severity, as reflected in the Model for End Stage Liver Disease (MELD) score. The US is comprised of 11 geographic regions and 58 donor service areas (DSAs) throughout which deceased donor livers are allocated to appropriate waitlist (WL) candidates. In June 2013, the Organ Procurement and Transplantation Network (OPTN) implemented an allocation policy entitled “Share 35”. The purpose of Share 35 was to increase regional sharing of deceased donor livers to patients with MELD ≥ 35 in order to decrease WL mortality for the sickest patients awaiting LT. Analysis at two years after Share 35 demonstrated an increase in overall LT that was consistent across all regions, an increase in overall median MELD at transplant (from 27 to 28), and slightly lower waitlist mortality [2].

Live donor liver transplantation (LDLT) comprises approximately 5% of all LT volume in the United States [3] and is highly concentrated, with only 10 US centers performing more than 10 LDLT per year [4]. In 2011, Yeh et al described geographic disparities in access to LT and found that high MELD regions were also the most likely to utilize LDLT [5]. Therefore, the purpose of this investigation was to determine the impact of Share 35 on LDLT utilization in the US. Given that the purpose of Share 35 was to increase broader sharing and to allocate more livers to the patients with the highest MELD scores, we hypothesized that LDLT would increase after the implementation of Share 35 to offset the shift in allocation of deceased donor livers to high MELD patients awaiting LT.

METHODS

Institutional review board approval was obtained prior to the initiation of this study.

Study Population

We identified adults who received a primary LT between October 1, 2008 and March 31, 2018 from the United Network for Organ Sharing (UNOS)/OPTN Standard Transplant Analysis and Research files. Recipients of multi-organ transplants, those who had priority listing status, and those with acute liver failure were excluded due to prioritization on the waiting list. Transplants from October 1, 2008 through June 30, 2013 were designated as the pre-Share 35 era and those performed from July 1, 2013 through March 31, 2018 were designated as the post-Share 35 era.

Statistical analyses

LDLT volume was quantified as counts and percentages of (1) the total LT population and (2) among LTs performed at centers with at least one LDLT, for the two respective eras of interest, pre- and post-Share 35 policy. The remainder of the analysis focused solely on the

subset of LTs performed at centers with at least one LDLT during the study period. Demographic and clinical characteristics were summarized with frequencies (percentages) and medians (interquartile ranges (IQR)) and compared by pre- and post-Share 35 using chi-square and Wilcoxon rank sum tests, as appropriate. Median MELD at transplant, LDLT volume, and number of centers performing LDLTs were summarized by UNOS region and compared across pre- and post-Share 35 eras to evaluate regional differences related to LDLT utilization.

Logistic regression was used to explore factors associated with odds of LDLT versus DDLT, quantified as odds ratios (OR). To assess center volume, we created an ordinal variable based on natural breaks in a histogram of number of LDLTs per center. Low volume centers were defined as those performing <50 LDLT during the study period, medium volume centers performed 50–100 LDLT, and high-volume centers performed >100 LDLT. To better understand the relationship between odds of LDLT and the pressure exerted by MELD at the donation service area (DSA), we identified the DSA-level median match MELD scores required to obtain a DDLT within a given DSA per Vagefi et al [6]. Each transplant recipient was assigned a DSA subgroup-specific match MELD score to represent the median match MELD score within the recipient's DSA for a DDLT of the same etiology and blood type. These DSA-level match MELD scores were categorized by sextiles at the patient level (match MELD <24, 24–25, 26–28, 29–30, 31–34, and >=35). The lowest sextile represents the DSAs with the lowest subgroup-specific median match MELD scores and the highest sextile represents the highest subgroup-specific median match MELD scores, corresponding with patients for whom Share 35 may have had a direct impact. Factors with a p-value <0.1 in the univariable (UV) logistic regression analysis were evaluated in the multivariable (MV) model, with the final model selected by backward elimination (p>0.05 for removal). Interactions between Share 35 era and (1) center LDLT volume and (2) DSA-level match MELD were evaluated to determine if the Share 35 policy had a differential impact on odds of LDLT by these factors.

The primary outcomes of interest included graft and patient survival. For graft survival, graft loss was defined as patient death or retransplant. For patient survival, the event was patient death. Post-transplant follow-up time was measured from the date of LT to death, retransplant, or last follow-up with survival censored at retransplant (for patient survival only) or last follow-up within 3 years of transplant.

Post-transplant graft and patient survival were estimated at 1 and 3 years using the Kaplan-Meier method. We compared survival between eras (pre- versus post-Share 35) using the log-rank test and evaluated differences separately for DDLT and LDLT recipients. Cox proportional hazards regression estimated hazard ratios (HR) and 95% confidence intervals (CI) for risk of graft loss and death. To assess the independent effect of pre- and post-Share 35 era on graft and patient survival, multivariable models were adjusted for an a priori set of covariates including UNOS region, gender, etiology of liver disease, characteristics at transplant (age and MELD), public insurance, and donor age. Interactions between Share 35 era and donor type (live donor vs. deceased donor) were evaluated to determine if the Share 35 policy had a differential impact on survival by donor type.

Statistical computations were executed using SAS version 9.4 (SAS Institute Inc., Cary, North Carolina).

RESULTS

During the study period, 48,779 primary adult single-organ liver transplants for non-fulminant liver disease occurred, with 22,255 occurring pre-Share 35 (21,391 deceased donors, 864 LDLT) and 26,524 post-Share 35 (24,706 deceased donors, 1215 LDLT). At centers that performed at least one LDLT, 32,967 primary adult single-organ liver transplants for non-fulminant liver disease occurred during the study period, with 15,205 occurring pre-Share 35 and 17,762 post-Share 35.

Demographic data are shown in Table 1. Compared with the pre-Share 35 era, patients transplanted in the post-Share 35 era were slightly older (57 (IQR 51–62) vs. 58 years (IQR 51–64), $p<0.001$), more likely to be Caucasian (71.2% vs. 72.3%, $p=0.001$), and more likely to have a BMI > 30 (35.2% vs. 37.3%, $p<0.001$). Post-Share 35 patients also had a slightly higher lab MELD at transplant (19 vs. 20, $p<0.001$), were less likely to have Hepatitis C virus (HCV; 42.3% vs. 34.5%, $p<0.001$), and were more likely to have cirrhosis secondary to alcoholic liver disease (ALD; 14.9% vs. 22.1%, $p<0.001$) or non-alcoholic steatohepatitis (NASH; 9.2% vs. 15.4%, $p<0.001$). After the implementation of Share 35, more LT recipients were publicly insured (44.5% vs. 38.9%, $p<0.001$) and the time on the waitlist increased slightly (4.4 months vs. 3.6 months, $p<0.001$). Among centers performing at least 1 LDLT, the utilization of donation after cardiac death (DCD) organs increased significantly after the implementation of Share 35 (8.5% post vs. 6.5% pre, $p<0.001$). The utilization of DCD livers increased significantly after Share 35 at the first, second, and third DSA level match MELD sextiles (up to MELD 28), but there was no significant difference at the higher MELD sextiles.

At all LT centers, the median waitlist time increased from 3 months (IQR 1–10) pre-Share 35 to 4 months (IQR1–11, $p<0.001$) post-Share 35. For candidates with MELD ≥ 35, waitlist time decreased in the post-Share 35 era (from 1 month to 0 months, $p<0.001$). For candidates with MELD < 35, waitlist time increased from 4 to 5 months post-Share 35 ($p<0.001$). At centers performing at least 1 LDLT during the study period, the median waitlist time was unchanged pre (4 IQR 1–10) versus post-Share 35 (4 months IQR 1–11, $p<0.001$). For candidates with MELD ≥ 35 at these centers, median waitlist time was also unchanged pre- versus post-Share 35 (1 month, IQR 0–5). For candidates with MELD < 35 at these centers, waitlist time increased from 4 to 6 months post-Share 35 ($p<0.001$).

Regional Utilization

Overall DDLT volume increased significantly in Regions 1 ($p<0.001$), 2 ($p<0.001$), 4 ($p<0.001$), 5 ($p=0.02$), and 8 ($p=0.03$) following the implementation of Share 35. LDLT volume varied significantly by region ($p<0.001$). Regions 2, 4, 5, and 8 demonstrated significant increases in LDLT utilization post-share 35 (Figure 1). Trends in median MELD score at transplant, LDLT volume quantified as the number of LDLT performed, and number of centers performing LDLT before and after the implementation of Share 35 are shown in Table 2. Across all regions, median MELD at transplant increased for DDLT. For LDLT,

median MELD at transplant increased only in regions 5, 7, and 10. The number of centers performing LDLT increased only in regions 4, 6, and 11.

Center-level and DSA Utilization

The percentage of LDLT among total liver transplant volume among centers performing LDLT increased significantly (6.8% post vs. 5.7% pre, p<0.001). UV and MV logistic regression were performed to identify factors associated with odds of undergoing LDLT versus DDLT (Table 3). In UV analysis, the odds of LDLT were significantly higher post-Share 35, for centers with 50–100 LDLT and >100 LDLT, and for all DSA-level median match MELD sextiles compared with the lowest sextile. These findings remained significant in the MV model. Odds of LDLT were significantly higher post-Share 35 (OR 1.32 (1.19–1.47), p<0.001). Compared with centers performing <50 LDLT during the study period, odds of LDLT at centers with 50–100 LDLT was OR 3.4 ([2.91–3.98], p<0.001) and centers with >100 LDLT was OR 6.8 ([5.8–7.9], p<0.001), indicating significantly increased odds of LDLT at centers performing a higher volume of LDLT. For DSA-level median match MELD analysis, compared with lowest sextile (MELD <24), patients in DSAs with MELD 24–25 were 2.7 [2.0–3.6] times more likely to undergo LDLT; patients in DSAs with MELD 26–28 were 2.8 [2.05–3.87] times more likely to undergo LDLT; patients in DSAs with MELD 29–30 were 3.2 [2.3–4.5] times more likely to undergo LDLT; patients in DSAs with MELD 31–34 were 3.8 [2.7–5.4] times more likely to undergo LDLT; and patients in DSAs with MELD >=35 were 6.5 [4.4–9.6] times more likely to undergo LDLT (all p-values<0.05). Finally, we tested for interactions between Share 35 era and LDLT center volume, and between Share 35 era and DSA-level match MELD. There was no significant interaction between Share 35 era and LDLT center volume. Specifically, the magnitude of the increased odds of LDLT in the post- versus pre-Share 35 era was similar by center volume of LDLTs (low LDLT volume OR=1.2 [1.0–1.5] compared to medium LDLT volume OR=1.3 [1.1–1.5] p=0.83, and high LDLT volume OR=1.4 [1.2–1.7] p=0.27) suggesting that the impact of Share 35 on odds of LDLT did not differ statistically by LDLT center volume. However, there was a statistically significant interaction between Share 35 era and DSA-level match MELD. Compared with the pre-Share 35 era, in the post-Share 35 era the odds of LDLT increased significantly more in the lowest (match MELD <24) and highest (match MELD >=35) sextiles (Figure 2) than in the other DSA-level match MELD sextiles.

Graft Survival

Among the two eras, there was a significant improvement in graft survival among DDLT recipients at both one and three years after transplant (90.6% vs. 87.6% and 83.6% vs. 79.4%, respectively, p-values<0.001), however there was no significant difference in graft survival among LDLT recipients (Figure 3). In multivariable Cox regression analysis (Table 4), LDLT graft was associated with increased risk of graft loss (HR 1.20, p=0.002). Post-Share 35 era was found to be protective with regard to overall graft survival (HR 0.77, p<0.001), consistent with the results observed in survival analysis stratified by era (Figure 3). No statistically significant interaction was detected between Share 35 era and donor type (p=0.56) which suggests that the impact of Share 35 on graft survival is similar for recipients of grafts from live and deceased donors. African American race (HR 1.26, p<0.001) and

public insurance (HR 1.16, p<0.001) were also associated with a significantly increased risk of graft loss.

Patient Survival

Among the two eras, there was a significant improvement in patient survival at one and three years after transplant (90.4 vs. 92.5% and 82.7% vs. 85.9%, p-values <0.001) in DDLT recipients. There was no significant difference in patient survival for LDLT pre- versus post-Share 35 (Figure 4). In multivariable Cox regression analysis, post-Share 35 era was associated with improved patient survival (HR 0.78, p<0.001) and donor type was not associated with a statistically significant difference in patient survival (HR 1.0, p=0.96). African American race (HR 1.24, p<0.001) and public insurance (HR 1.21, p<0.001) remained significantly associated with an increased risk of death. The interaction between Share 35 era and donor type (LDLT vs. DDLT) was not statistically significant (p=0.60).

DISCUSSION

This study examined the role of Share 35 in LDLT utilization and overall outcomes after LT in the US. The significant findings were as follows: 1) overall LDLT volume was higher and there were no changes in LDLT outcomes following the implementation of Share 35 (6.8% vs. 5.7%); 2) after Share 35, DDLT volume increased significantly and DDLT graft survival and patient survival improved; 3) there was significant geographic variation in LDLT utilization, with regions 2, 5, 7, and 9 performing more than 100 LDLT in the post-Share 35 era compared with pre-share 35, 4) DSA-level match MELD was significantly associated with increased odds of LDLT utilization following the implementation of Share 35.

Existing literature indicates that Share 35 has increased overall DDLT, successfully increased the volume of DDLT for patients with MELD score ≥ 35, and improved overall survival after DDLT without having a crippling effect on waitlist mortality or geographic disparities among transplant recipients. In 2016, Edwards et al. reported the two-year results of Share 35 and concluded that the policy had achieved its purpose of increasing overall transplants and transplants for patients with a MELD score ≥ 35 without compromising WL survival (84.6% pre-Share 35 vs. 84.4% post-Share 35) or post-transplant outcomes [2]. In the following year, Chow et al. evaluated waitlist mortality to understand the impact of allocating deceased donor livers to higher MELD patients and possibly depriving a local candidate of that liver. Between June 2013 and June 2015, they identified 1764 regionally shared livers corresponding to 1219 candidates who did not receive these livers in favor of regional sharing (“reprioritized”). The median MELD at export for reprioritized candidates was 31, compared with 39 for the ultimate recipients of these re-allocated livers. Of the reprioritized candidates, 76% of candidates ultimately went on to receive a DDLT within 12 months [7]. Therefore, the majority of the patients with MELD < 35, although certainly affected by the policy, do make it to transplant, and the rise in the number of patients transplanted with MELD >35 suggests there is a trickle-down effect of shifting transplant towards sicker patients.

Murken et al. analyzed the center level effect of Share 35 in order to understand whether the policy prompted national versus center level effects and to determine whether Share 35

altered decision making at the center level. They found that 25 centers accounted for 65% of the total national increase in transplants performed for patients with an allocation MELD score ≥ 35 and that this trend correlated with increased listing of patients with MELD score ≥ 35 at these centers [8]. Interestingly, not all of these transplants occurred in regions with the highest MELD at transplant, leading the authors to conclude that centers had altered their practice patterns of listing in the post-Share 35 era. In 2018, Kwong et al. showed that one-year patient and graft survival improved following the implementation of Share 35 [9]. Finally, in 2019, Bowring et al. analyzed the median incidence rate ratio of DDLT rates pre and post Share 35 and found geographic disparities in access to deceased donor livers that existed before Share 35 and persisted following the implementation of Share 35 [10]. While reinforcing the success of Share 35, this body of work also highlights the complexity of assessing changes in organ allocation, which is an amalgamation of national/regional policy, DSA distribution, center level changes, and individual surgeon choices.

Share 35 was not intended to mitigate geographic disparities in access to transplantation, but rather to allocate a scarce resource to the sickest of patients. We hypothesized that in distributing deceased donor organs to patients with the highest MELDs, there might be pressure at the center or DSA level to get lower MELD patients to LT without requiring them to endure long periods of time on the WL. Of course, one way to address this discrepancy is to utilize LDLT, and we know that there is precedence for this based on prior work that has demonstrated LDLT utilization is highest in regions with the highest MELD scores [5] and significantly more frequent in DSAs with high median MELD scores at transplant [11]. We therefore examined the odds of LDLT according to center volume and to DSA-level median match MELD scores in order to discern whether the increase in LDLT after Share 35 was related to higher LDLT volumes at centers who already had experience in LDLT or to a shift in allocation of deceased donor organs to patients with higher MELD scores after the implementation of Share 35. Center volume was selected to represent center experience with LDLT, with the assumption that greater LDLT volume corresponded to more center experience. DSA-level median match MELD scores were assessed to determine the pressure of local allocation policy by looking at the odds of LDLT over DDLT by blood type, disease etiology, and DSA.

After Share 35, there were significantly increased odds of LDLT within all three discrete levels of LDLT center volume. However, the magnitude of the odds ratios among these three groups was similar, suggesting that Share 35 did not differentially impact centers with high or low volumes of LDLT experience. We observed increased odds of LDLT in DSAs with increasing MELD scores, and identified a significant interaction between the post-Share 35 era and DSA-level median match MELD, with the highest odds of LDLT in DSAs with MELD<24 and >=35 after the implementation of Share 35. These findings suggest that after the implementation of Share 35, odds of LDLT was highest in the lowest and highest MELD DSAs. It has been established that LDLT utilization is highest in high MELD regions, so this finding is consistent with prior work [5]. However, this analysis also indicates that odds of LDLT were significantly greater in the lowest MELD DSAs after the implementation of Share 35, which suggests that as livers were allocated to patients with higher MELD scores, LDLT was used to address the deficiency of deceased donor organs in the lowest MELD DSAs.

The MELD at transplant for DDLT recipients increased significantly in all regions. In region 7, the MELD at transplant for LDLT recipients also increased significantly, however this was not the case in Regions 2, 4, 5, 8, or 10. Recent work from centers in Asia has demonstrated that satisfactory outcomes can be achieved with LDLT for high MELD (>35) patients [12], with the caveat being that these outcomes are achieved only in the hands of centers and surgeons with extensive experience. As individual US centers continue to accrue expertise with LDLT and consider expanding their practice to patients with higher MELD scores, it will be interesting to follow the trends in LDLT volume. While our national policies remain rightly focused on DDLT allocation, one can envision that a substantial and widely distributed increase in LDLT volume has the potential to dramatically alter allocation policies and waitlist dynamics, irrespective of region.

Taken in sum, the present study demonstrates a significant increase in LDLT utilization after the implementation of Share 35, with increased odds of LDLT most pronounced in the DSAs with the highest and lowest median match MELD scores. We also observed increased utilization of DCD livers in the post-Share 35 era in DSA with the lowest median match MELD scores (up to MELD 28). While we cannot claim causality, the increased utilization of LDLT and DCD in some lower MELD areas suggest a shift in organ utilization that may be related to the reprioritization of deceased donor livers for high MELD candidates. Importantly, both DDLT and LDLT survival were the same or better during the study period despite the shift in utilization, suggesting that the differential makeup of donor organs did not significantly impact outcomes. While this study is focused on allocation policy in the United States, the overarching message is important for the global transplant community: in areas with robust DDLT infrastructure, DDLT can be allocated to the sickest patients and LDLT can be successfully utilized to offset the shift in donor organs away from less sick patients without compromising graft or patient survival.

This study was subject to several limitations. First, the data analyzed here was obtained from UNOS/OPTN, and is, therefore, lacking in the granularity that would come with a single center analysis. We do believe, however, that these findings are both generalizable and comprehensive since they include data from tens of thousands of patients across the country. Second, while we observed an increase in LDLT in the post-Share 35 era, particularly in centers that were already performing LDLT, it is difficult to determine whether this reflects increased comfort of experienced surgical teams at these centers, greater need to transplant patients with lower MELD scores in high MELD regions, or some combination of these two factors. Finally, we did not separately analyze patients with exception points for HCC, as the overall transplant rates appear to be preserved in patients with exception points in the post-Share 35 era [8]. Having said this, it is conceivable that a large bolus of HCC exception patients with MELD>35 could skew the results towards improved outcome and further analysis is warranted, as the policy capping HCC exception points at 34 was not implemented until October 2015. Nevertheless, the findings are encouraging in that overall outcomes improved and LDLT utilization increased following the implementation of Share 35. As the internecine debate regarding the proposed Acuity Circles allocation change continues, we hope these findings will serve as a reminder that thoughtful evolution of our liver allocation schemes can result in positive changes that improve outcomes for our sickest patients and access for all.

CONCLUSION

Overall LDLT volume increased following the implementation of Share 35 which was largely due to increased LDLT volume at centers with experience in LDLT, and corresponded to significant regional and DSA-level variation in LDLT volume. Three-year graft and patient survival after DDLT improved significantly following the implementation of Share 35.

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ABBREVIATIONS

ALD	alcoholic liver disease
DCD	donation after cardiac death
DDLT	deceased donor liver transplant
DSA	donor service area
HCV	hepatitis C virus
HR	hazard ratio
IQR	interquartile range
LDLT	live donor liver transplantation
LT	liver transplantation
MELD	Model for End Stage Liver Disease
NASH	non-alcoholic steatohepatitis
OPTN	Organ Procurement and Transplantation Network
UNOS	United Network for Organ Sharing
US	United States
WL	waitlist

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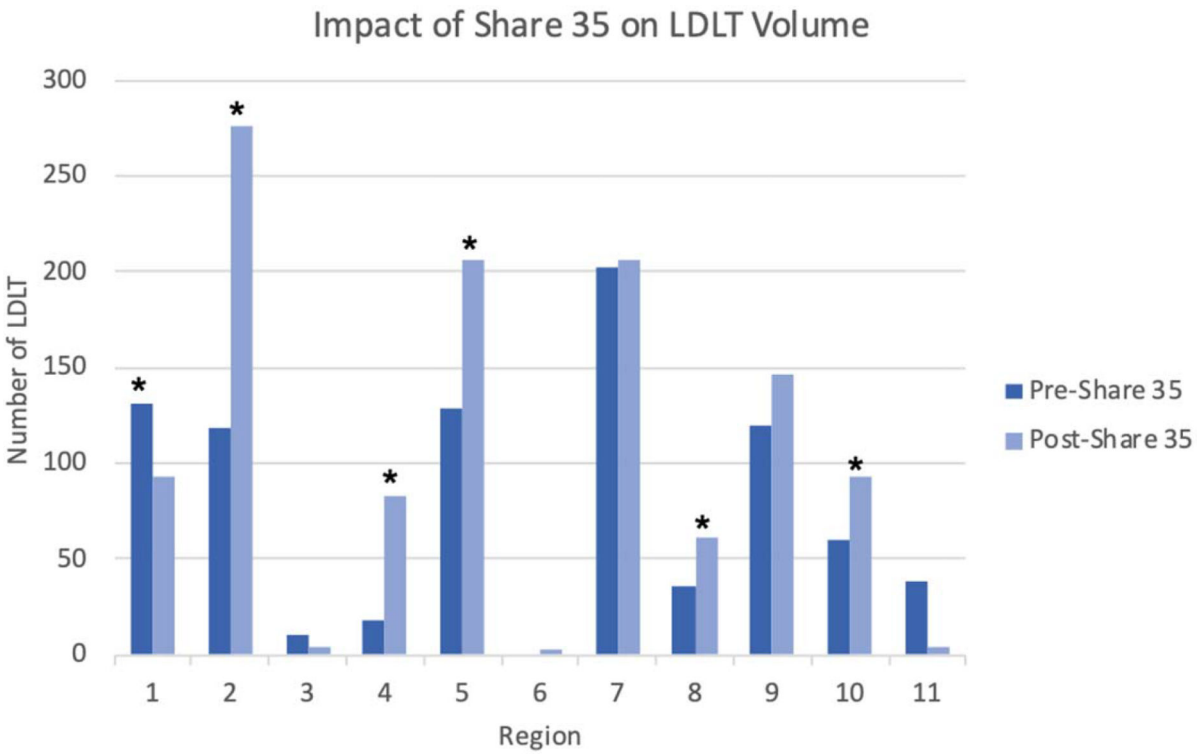

Figure 1:

LDLT volume by region before and after implementation of Share 35. Asterisk (*) denotes p-value < 0.05 for comparing the proportion of LDLT pre- and post-Share 35.

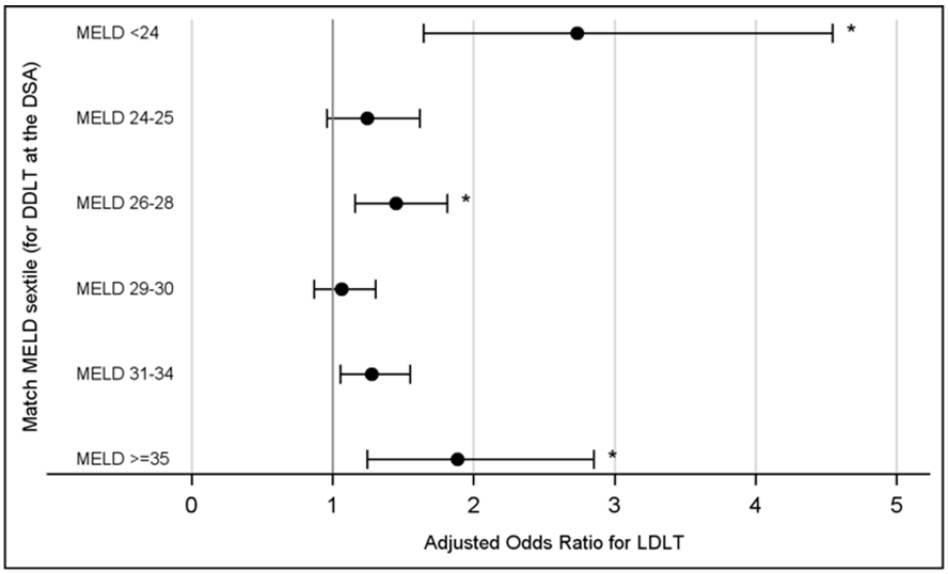

Figure 2:

Percent LDLT by center LDLT volume and DSA-level match MELD in the post-Share 35 era. Odds of LDLT were greatest at the lowest, middle, and highest match MELD sextiles in the post-Share 35 era.

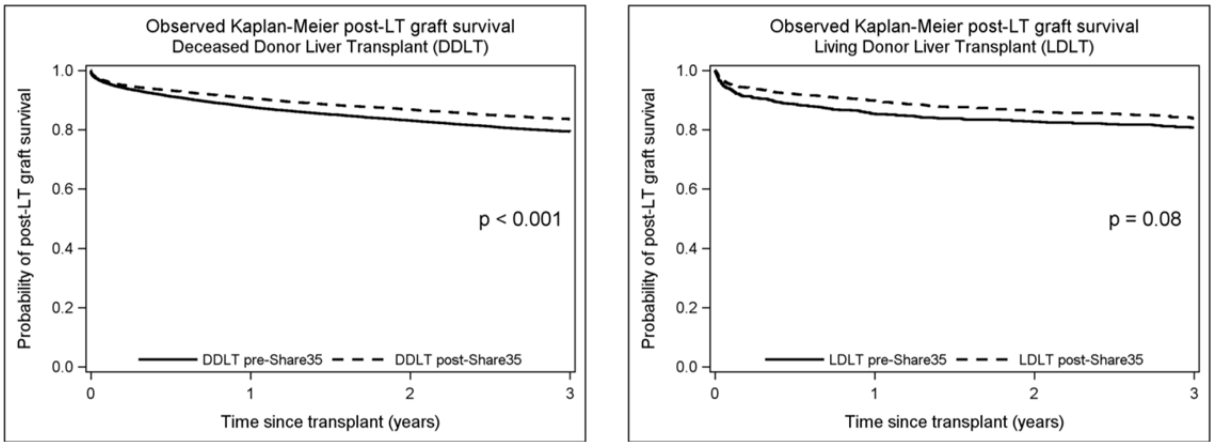

Figure 3:

Graft survival of DDLT (left, p<0.001) and LDLT (right) analyzed by era. DDLT graft and patient survival was significantly improved following the implementation of Share 35.

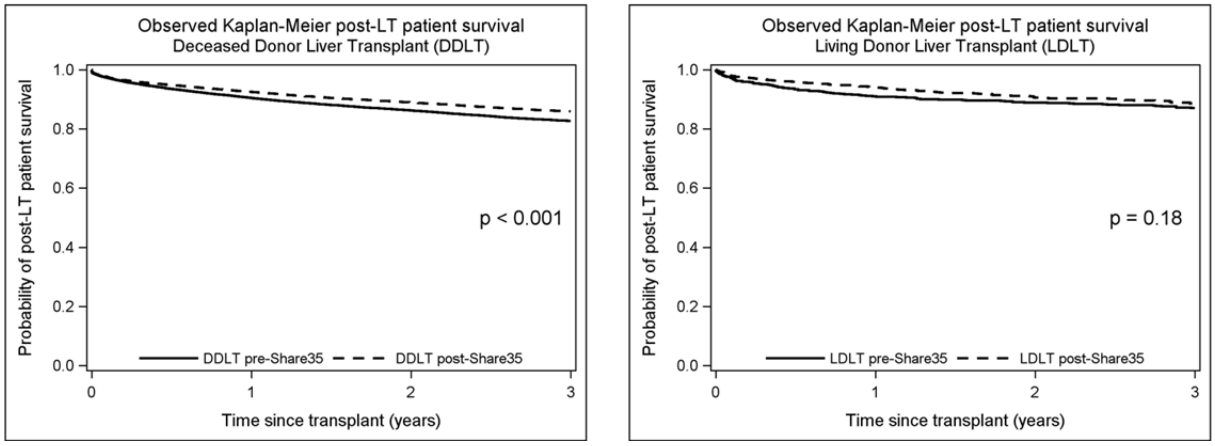

Figure 4:

Patient survival in recipients of DDLT (left, p<0.001) and LDLT (right) analyzed by era. There was no impact of Share 35 on outcomes after LDLT.

Table 1:

Demographic data stratified by era (pre versus post-Share 35) among centers that performed at least 1 LDLT.

	Pre-Share 35	Post-Share 35	P Value
N (total transplants)	15,205	17, 762	--
Number of centers performing LDLT	50	51	--
Total LDLT	5.7%	6.8%	<0.001
Age (years)	57 (51–62)	58 (51–64)	<0.001
% Male	68%	67.1%	0.086
Ethnicity (%White)	71.2%	72.3%	0.001
BMI > 30 (kg/m^2)	35.2%	37.3%	<0.001
Lab MELD	19 (13–28)	20 (12–30)	<0.001
HCV (%)	42.3%	34.5%	<0.001
EtOH (%)	14.9%	22.1%	<0.001
NASH (%)	9.2%	15.4%	<0.001
Publicly insured	38.9%	44.6%	<0.001
Time on WL (mos)	3.6 (0.9–10.4)	4.4 (0.8–11.5)	<0.001

Table 2:

Trends in median MELD score at transplant, overall and by DDLT and LDLT.

	Overall MELD			DDLT MELD			LDLT MELD		
	PRE	***POST***	***P-value***	***PRE***	***POST***	***P-value***	***PRE***	***POST***	***P-value***
All Regions	25	28	<0.001	25	28	<0.001	17	16	0.38
Region 1	26	29	<0.001	28	31	<0.001	17	14	0.13
Region 2	26	28	<0.001	27	29	<0.001	16	15	0.30
Region 3	22	25	<0.001	22	25	<0.001	17	17	1.00
Region 4	28	29	<0.001	28	29	<0.001	17	15	0.60
Region 5	31	33	<0.001	31	34	<0.001	16	17	0.58
Region 6	25	29	<0.001	25	29	<0.001	NA	22	NA
Region 7	28	29	<0.001	28	29	<0.001	17	19	0.02
Region 8	25	26	<0.001	25	27	<0.001	17	16	0.48
Region 9	28	31	<0.001	29	31	<0.001	17	15	0.12
Region 10	22	24	<0.001	22	24	<0.001	14	15	0.47
Region 11	22	25	<0.001	22	25	<0.001	17	17	0.42

Table 3:

UV and MV logistic regression models examining factors associated with odds of LDLT.

	UV		MV	
Characteristic	**OR (95% CI)**	**P**	**HR (95% CI)**	**p**
Post-Share 35 (vs. Pre-)	1.22 (1.11–1.33)	<0.001	1.32 (1.19–1.47)	<0.001
DSA-level match MELD for DDLT (ref <24)				
MELD 24–25	2.94 (2.28–3.80)	<0.001	2.66 (2.00–3.52)	<0.001
MELD 26–28	5.11 (3.99–6.54)	<0.001	2.81 (2.05–3.87)	<0.001
MELD 29–30	8.09 (6.35–10.31)	<0.001	3.19 (2.28–4.46)	<0.001
MELD 31–34	8.84 (6.96–11.24)	<0.001	3.82 (2.72–5.38)	<0.001
MELD >=35	5.80 (4.38–7.66)	<0.001	6.49 (4.39–9.61)	<0.001
Region (ref 1)				
2	0.77 (0.64–0.91)	0.003	0.74 (0.59–0.92)	<0.001
3	0.02 (0.01–0,04)	<0.001	0.07 (0.04–0.12)	<0.001
4	0.45 (0.35–0.57)	<0.001	0.51 (0.38–0.69)	<0.001
5	0.52 (0.44–0.62)	<0.001	0.45 (0.36–0.57)	<0.001
6	0.03 (0.01–0.11)	<0.001	0.08 (0.03–0.26)	<0.001
7	0.98 (0.83–1.17)	0.83	0.53 (0.43–0.65)	<0.001
8	0.35 (0.27–0.45)	<0.001	0.44 (0.33–0.59)	<0.001
9	0.85 (0.71–1.03)	0.099	0.55 (0.44–0.69)	<0.001
10	0.53 (0.43–0.66)	<0.001	0.48 (0.35–0.67)	<0.001
11	0.22 (0.17–0.28)	<0.001	0.78 (0.55–1.10)	0.16
Center Volume (ref <50 LDLT)				
50–100 LDLT	4.43 (3.92–5.01)	<0.001	3.40 (2.91–3.98)	<0.001
>100 LDLT	9.53 (8.49–10.70)	<0.001	6.77 (5.82–7.87)	<0.001
Recipient age at LT	0.97 (0.97–0.98)	<0.001	0.97 (0.97–0.98)	<0.001
Lab MELD at LT	0.94 (0.93–0.94)	<0.001	0.91 (0.90–0.91)	<0.001
Female vs Male	1.70 (1.55–1.86)	<0.001	1.57 (1.41–1.74)	<0.001
Race (ref = White)				
African American	0.31 (0.24–0.39)	<0.001	0.35 (0.27–0.46)	<0.001
Asian	0.51 (0.39–0.67)	<0.001	0.36 (0.26–0.49)	<0.001
Hispanic	0.72 (0.63–0.83)	<0.001	0.81 (0.69–0.96)	0.02
Other	0.83 (0.55–1.26)	0.34	0.85 (0.53–1.34)	0.47
Etiology (reference=HCV)				

	UV		MV	
Characteristic	**OR (95% CI)**	**P**	**HR (95% CI)**	**p**
AIH	2.44 (1.91–3.12)	<0.001	2.44 (1.81–3.30)	<0.001
ALD	1.04 (0.89–1.21)	0.66	1.19 (0.99–1.41)	0.06
HBV	0.73 (0.51–1.05)	0.09	0.78 (0.52–1.17)	0.24
NASH	1.77 (1.52–2.05)	<0.001	2.69 (2.26–3.19)	<0.001
PSC/PBC	5.19 (4.55–5.91)	<0.001	4.75 (4.04–5.59)	<0.001
Other	1.98 (1.73–2.26)	<0.001	1.69 (1.45–1.97)	<0.001
Public insurance	0.52 (0.47–0.57)	<0.001	0.62 (0.55–0.69)	<0.001
WL mos	0.99 (0.99–1.00)	<0.001	1.01 (1.00–1.01)	<0.001

Table 4:

Multivariable Cox proportional hazards models for risk of graft loss and patient death.

	Graft loss		Patient death	
Characteristic	**HR (95% CI)**	**P**	**HR (95% CI)**	**p**
Post-Share 35 (vs. Pre-)	0.77 (0.73–0.81)	<0.001	0.78 (0.74–0.83)	<0.001
LDLT vs DDLT	1.20 (1.07–1.35)	0.002	1.00 (0.87–1.15)	0.96
Region (ref 5)				
1	1.00 (0.87–1.13)	0.91	1.02 (0.88–1.18)	0.78
2	1.10 (1.0–1.22)	0.06	1.19 (1.06–1.32)	0.002
3	0.92 (0.83–1.0)	0.08	0.89 (0.80–1.00)	0.09
4	1.03 (0.91–1.18)	0.63	1.04 (0.90–1.20)	0.60
6	0.66 (0.52–0.84)	<0.001	0.61 (0.46–0.80)	<0.001
7	1.05 (0.95–1.117)	0.34	1.10 (0.98–1.23)	0.12
8	1.00 (0.88–1.13)	1.0	0.96 (0.83–1.10)	0.56
9	1.04 (0.93–1.16)	0.55	1.08 (0.96–1.22)	0.21
10	1.01 (0.89–1.14)	0.93	1.06 (0.92–1.21)	0.22
11	1.02 (0.91–1.14)	0.79	0.98 (0.86–1.12)	0.80
Recipient age at LT	1.01 (1.01–1.01)	<0.001	1.02 (1.02–1.03)	<0.001
Lab MELD at LT	1.01 (1.01–1.02)	<0.001	1.02 (1.02–1.02)	<0.001
Female vs Male	0.99 (0.93–1.05)	0.66	1.01 (0.94–1.07)	0.87
Race (ref = White)				
African American	1.26 (1.15–1.38)	<0.001	1.24 (1.13–1.37)	<0.001
Asian	1.00 (0.86–1.15)	0.95	0.84 (0.75–1.00)	0.04
Hispanic	1.01 (0.93–1.10)	0.83	1.00 (0.88–1.06)	0.47
Other	1.12 (0.88–1.42)	0.35	1.10 (0.84–1.43)	0.50
Etiology (reference=HCV)				
AIH	0.96 (0.81–1.13)	0.62	0.92 (0.76–1.10)	0.36
ALD	0.73 (0.67–0.79)	<0.001	0.69 (0.63–0.76)	<0.001
HBV	0.74 (0.62–0.88)	<0.001	0.76 (0.62–0.92)	0.76
NASH	0.84 (0.77–0.92)	<0.001	0.78 (0.70–0.86)	<0.001
PSC/PBC	0.73 (0.65–0.81)	<0.001	0.59 (0.51–0.67)	<0.001
Other	0.93 (0.86–1.00)	0.05	0.89 (0.82–0.97)	0.006
Public insurance	1.16 (1.10–1.22)	<0.001	1.21 (1.14–1.28)	<0.001
Donor age	1.01 (1.01–1.01)	<0.001	1.01 (1.00–1.01)	<0.001