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Simultaneous Liver and Kidney Transplantation in Patients Aged 70 y and Older: Proceed With Caution

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Background. The number of elderly patients aged 70 y and older with liver and kidney failure is increasing, mainly because of increasing prevalence of metabolic dysfunction-associated steatohepatitis. At present, limited data are available on the outcomes of elderly patients who fit the criteria for dual organ transplantation since the implementation of the simultaneous liver and kidney (SLK) allocation policy. **Methods.** We performed a retrospective analysis of the Organ Procurement and Transplantation Network database of adults aged 18 y and older undergoing SLK and kidney transplantation only from August 11, 2017, to December 31, 2022. We examined patient and graft survivals and compared the outcomes of the recipients aged 70 y and older undergoing SLK transplantation to those who received kidney transplant alone and kidney after liver transplant. **Results.** During the study period, there has been a significant rise in the number of patients aged 70 y and older undergoing SLK transplantation, with 6 patients undergoing SLK transplantation in 2017 and 63 in 2021. Patients aged 70 y and older had significantly lower survival with 82.9% at 1 y and 66.5% at 3 y compared with 89.3% and 78.8% in the 50–69 y age group and 93.2% and 88.6% in the 18–49 y age group, respectively. Overall, kidney allograft survival was significantly lower in the 70 y and older group, with 80.9% at 1 y and 66.4% at 3 y compared with 91.1% and 75.5%, respectively, in those undergoing kidney transplant alone. There was no difference in kidney allograft survival in those undergoing SLK and kidney after liver transplantation. **Conclusions.** Although the outcomes are inferior in recipients of SLK transplant aged 70 y and older, chronologic age should not preclude them from undergoing transplantation. Kidney transplantation after liver transplantation could be considered to avoid futile transplants.

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A simultaneous liver and kidney (SLK) allocation policy was implemented in the United States in August 2017 to standardize the practice of kidney allocation to patients with liver disease and renal failure and, thus, stabilize the numbers of SLK transplants that were steadily rising since the introduction of model for end-stage liver disease (MELD) score.[1] Before the change, a large number of high-quality kidneys with Kidney Donor Profile Indices (KDPI) of <35% were transplanted into a complex group of liver failure patients that resulted in inferior outcomes, including primary graft nonfunction in up to 20% of patients.[2] Since this change, careful monitoring of the outcomes, including patient and graft survival, and listing for a kidney transplant between 60 and 365 d after a liver transplant have occurred.[3,4]

The group of patients who were previously declined because of advanced age, now make up a group with an increasing number of patients who are undergoing transplantation.[5] Because of comorbidities, patients aged 70 y and older were less likely to undergo transplantation in the past. Recent studies demonstrated that in carefully selected patients, acceptable outcomes can be achieved. Wang et al,[6] in a recent study of the United Network for Organ Sharing (UNOS) database, showed that patients aged 70 y and older undergoing liver transplant alone had worse overall survival when compared with younger counterparts, with 88% at 1 y and 77% at 3 y versus 92% and 86%, respectively. The survival was comparable if the patients had good functional status and were not on dialysis at the time of a liver transplant. Croome et al[7] demonstrated similar overall patient survival

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between the SLK group aged 65 y and the SLK group aged less than 65 y.[7]

Little data have been published investigating the outcomes of SLK in elderly recipients after the implementation of SLK and the safety net policy. In our analysis using the OPTN database, we aimed to analyze the trend of SLK in patients aged 70 y and older after the implementation of the safety net. We examined patient and graft outcomes in patients aged 70 y and older when compared with younger counterparts. We also aimed to compare the kidney graft outcomes in those undergoing SLK versus kidney transplant alone versus kidney after liver (KAL) transplant in this age group.

MATERIALS AND METHODS

All data were from the Organ Procurement and Transplantation Network (OPTN) data released on April 7, 2023, for recipients receiving liver and kidney transplants from August 11, 2017, to December 31, 2022. Both the OPTN liver data set and the kidney data set were joined to compile the final data set for this study. The UNOS, as the contractor for the OPTN, supplied these data. The interpretation and reporting of these data are the responsibility of the authors and in no way should be seen as an official policy of or interpretation by the OPTN or the US Government. The University of Washington Human Subjects Division deems the OPTN database is de-identified and publicly available and, thus, is not data of human participants. Therefore, this study was exempt from the review of human partcipants and was exempt from approval from an ethics board.

We conducted a retrospective analysis of all adult US recipients aged 18 y and older who underwent a liver and kidney transplant. Any patient receiving a retransplant for the liver or kidney was included and the diagnosis was recorded as retransplant for the organ that was retransplanted. Patient, liver graft, and kidney graft survival were recorded. Death-censored kidney graft survival was also recorded. For those recipients receiving a liver and a kidney transplant, factors recorded included age, sex, race/ethnicity, liver diagnosis, kidney diagnosis, presence of peripheral vascular disease, associated diagnosis of hepatocellular carcinoma, body mass index (BMI), final laboratory MELD score, serum creatinine at transplantation, if on dialysis before transplantation, presence of portal vein thrombosis, previous abdominal surgery, prior location at the time of transplant (in intensive care unit [ICU], in hospital, out of hospital), on the ventilator, on life support, presence of diabetes mellitus (no, type 1, type 2, other) as recorded in OPTN files, blood type, calculated panel-reactive antibody (cPRA), days on waiting list, liver graft type (whole versus variant), and functional status. The functional status is recorded in deciles and was converted to the value of Assistance/Moribund if ≤60% of functional status and to self-care/normal if >60% of functional status. Donor factors recorded included age, sex, race/ethnicity, presence of diabetes mellitus (yes, no, or unknown) as recorded in the OPTN files, donation after cardiac death (DCD), serum creatinine, KDPI, BMI, and cold ischemia time of liver and kidney. ABO incompatibilityincompatibility was recorded between recipients and donors. Of secondary interest, the following were recorded, including delayed graft function defined as requiring dialysis in 7 d after transplantation and length of stay for transplant hospitalization.

From the OPTN files during this same time period, kidney graft survival only was collected for 2 other groups, including patients aged 70 y and older receiving a primary kidney transplant (kidney only) and those aged 70 y and older receiving a kidney as part of the safety net with KAL transplant. These allowed for kidney graft survival comparisons between those aged 70 y and older receiving a SLK transplant to those aged 70 y and older receiving a kidney only transplant or those who received a KAL transplant from the safety net.

Statistical Analysis

Continuous variables are given as medians and interquartile ranges (IQRs), and categorical variables are presented as counts and percentages. Statistical tests between variables were the Wilcoxon rank-sum test for continuous variables and the chi-square test of independence for categorical variables. Very few variables had missing data. If a variable had <1.0% missing data, the majority was given for categorical variables and the median was given for continuous variables. Few categorical variables had >1.0% missing data and unknown was recorded for these variables. Linear regression was used to determine the statistical increase in the number of transplants performed over the years. Kaplan-Meier survival analysis with the log-rank test was used to determine survival between groups. A Cox proportional hazards model was created to determine the risk factors for patient and graft survival. Because of collinearity, the recipients having diabetes mellitus were left out of the Cox models because of association with renal disease of diabetes mellitus. Donor variables of race/ethnicity, BMI, diabetes mellitus, DCD, and serum creatinine were not included in the Cox models because of these variables calculating the KDPI, which was included in the Cox model.

All results were considered significant with a P value of <0.05. Statistical analyses were performed using JMP-Pro version 17.0.0 (SAS Institute Inc, Cary, NC) and R Core Team (2022), or R: A language and environment for statistical computing (R Foundation for Statistical Computing, Vienna, Austria; https://www.R-project.org).

RESULTS

Between 2017 and 2022, there were 3800 SLK transplants performed, with 882 (22%) performed in patients aged 18–49 y, 2720 (72%) in patients aged 50–69 y, and 258 (6%) transplants performed in patients aged 70 y and older (Table 1). The number of SLK performed in the 70 y and older age group increased from 6 in 2017 to as high as 63 in 2021 (Figure 1). Across all age groups, the majority were men and of White race, with 52% being men and 68% being White in the 70 y and older age group. When compared, those younger than 70 y, 70 y and older were more likely to have MASH as a diagnosis for their liver disease with 39% compared with 8.4% in the 18–49 y age group and 27% in the 50–69 y age group, respectively. They were more likely to have diabetes as a diagnosis of their kidney disease with 22% versus 7.7% in the 18–48 y age group. The most common diagnosis of kidney failure in all 3 groups was hepatorenal syndrome (57% in the 18–49 y age group, 49% in the 50–69 y age group, and 56% in the 70 y and older age group). Peripheral vascular disease

TABLE 1.

Characteristics of the simultaneous liver and kidney recipients and donors

Characteristic	Overall (N = 3800)	18–49 y (N = 822)	50–69 y (N = 2720)	≥70 y (N = 258)	*P*[a]
Sex					**0.03**
Female	1572 (41%)	357 (43%)	1092 (40%)	123 (48%)	
Male	2228 (59%)	465 (57%)	1628 (60%)	135 (52%)	
Race/ethnicity					**<0.001**
Asian	169 (4.4%)	31 (3.8%)	133 (4.9%)	5 (1.9%)	
Black	441 (12%)	105 (13%)	320 (12%)	16 (6.2%)	
Hispanic	738 (19%)	154 (19%)	524 (19%)	60 (23%)	
Other	71 (1.9%)	25 (3.0%)	45 (1.7%)	1 (0.4%)	
White	2381 (63%)	507 (62%)	1698 (62%)	176 (68%)	
Liver diagnosis					**<0.001**
AIH	52 (1.4%)	11 (1.3%)	36 (1.3%)	5 (1.9%)	
ALF	34 (0.9%)	8 (1.0%)	25 (0.9%)	1 (0.4%)	
Cancer	276 (7.3%)	7 (0.9%)	230 (8.5%)	39 (15%)	
Cholestatic	107 (2.8%)	31 (3.8%)	67 (2.5%)	9 (3.5%)	
Cryptogenic	155 (4.1%)	24 (2.9%)	118 (4.3%)	13 (5.0%)	
Alcoholic	1218 (32%)	426 (52%)	753 (28%)	39 (15%)	
Metabolic	82 (2.2%)	36 (4.4%)	43 (1.6%)	3 (1.2%)	
MASH	895 (24%)	69 (8.4%)	725 (27%)	101 (39%)	
Other	152 (4.0%)	52 (6.3%)	92 (3.4%)	8 (3.1%)	
PCKD	248 (6.5%)	48 (5.8%)	188 (6.9%)	12 (4.7%)	
ReTx	234 (6.2%)	84 (10%)	140 (5.1%)	10 (3.9%)	
Viral	347 (9.1%)	26 (3.2%)	303 (11%)	18 (7.0%)	
Kidney diagnosis					**<0.001**
DM	721 (19%)	63 (7.7%)	601 (22%)	57 (22%)	
Hepatorenal	1936 (51%)	472 (57%)	1320 (49%)	144 (56%)	
Other	806 (21%)	200 (24%)	564 (21%)	42 (16%)	
PCKD	215 (5.7%)	45 (5.5%)	160 (5.9%)	10 (3.9%)	
ReTx	122 (3.2%)	42 (5.1%)	75 (2.8%)	5 (1.9%)	
PVD					**0.02**
No	3469 (91%)	768 (93%)	2469 (91%)	232 (90%)	
Unknown	99 (2.6%)	24 (2.9%)	68 (2.5%)	7 (2.7%)	
Yes	232 (6.1%)	30 (3.6%)	183 (6.7%)	19 (7.4%)	
Associated HCC					**<0.001**
No	3440 (91%)	807 (98%)	2428 (89%)	205 (79%)	
Yes	360 (9.5%)	15 (1.8%)	292 (11%)	53 (21%)	
BMI	27.0 (23.5–31.4)	25.9 (22.1–30.7)	27.3 (23.9–31.8)	26.3 (23.4–30.0)	**<0.001**
Final MELD laboratory	29 (23–34)	31 (24–37)	28 (23–33)	28 (23–33)	**<0.001**
Creatinine at transplant	3.10 (2.05–4.70)	3.15 (2.05–4.96)	3.14 (2.09–4.70)	2.76 (1.81–3.81)	<0.001
Dialysis before transplant					**<0.001**
No	1036 (27%)	140 (17%)	801 (29%)	95 (37%)	
Yes	2764 (73%)	682 (83%)	1919 (71%)	163 (63%)	
PVT					**<0.001**
No	3278 (86%)	750 (91%)	2318 (85%)	210 (81%)	
Yes	522 (14%)	72 (8.8%)	402 (15%)	48 (19%)	
Previous abdominal surgery					<0.001
No	1659 (44%)	423 (51%)	1139 (42%)	97 (38%)	
Unknown	80 (2.1%)	24 (2.9%)	47 (1.7%)	9 (3.5%)	
Yes	2061 (54%)	375 (46%)	1534 (56%)	152 (59%)	
Location					**0.006**
Out of hospital	2168 (57%)	425 (52%)	1597 (59%)	146 (57%)	
Hospital	963 (25%)	238 (29%)	653 (24%)	72 (28%)	
ICU	669 (18%)	159 (19%)	470 (17%)	40 (16%)	
On ventilator	125 (3.3%)	37 (4.5%)	81 (3.0%)	7 (2.7%)	**0.09**
Life support					**0.2**
No	3213 (85%)	683 (83%)	2305 (85%)	225 (87%)	
Yes	587 (15%)	139 (17%)	415 (15%)	33 (13%)	
DM					**<0.001**
No	2057 (54%)	641 (78%)	1312 (48%)	104 (40%)	

(Continued)

TABLE 1.
continued

Characteristic	Overall (N = 3800)	18–49 y (N = 822)	50–69 y (N = 2720)	≥70 y (N = 258)	P[a]
Other	35 (0.9%)	10 (1.2%)	24 (0.9%)	1 (0.4%)	
Type 1	20 (0.5%)	12 (1.5%)	8 (0.3%)	0 (0%)	
Type 2	1688 (44%)	159 (19%)	1376 (51%)	153 (59%)	
Recipient ABO					**0.2**
A	1318 (35%)	276 (34%)	945 (35%)	97 (38%)	
AB	179 (4.7%)	40 (4.9%)	128 (4.7%)	11 (4.3%)	
B	562 (15%)	108 (13%)	426 (16%)	28 (11%)	
O	1741 (46%)	398 (48%)	1221 (45%)	122 (47%)	
Function					**0.26**
Assistance Moribund	2565 (68%)	568 (69%)	1826 (67%)	171 (66%)	
Self-care normal	1179 (31%)	237 (29%)	857 (32%)	85 (33%)	
Unknown	56 (1.5%)	17 (2.1%)	37 (1.4%)	2 (0.8%)	
End cPRA	0 (0–0)	0 (0–0)	0 (0–0)	0 (0–0)	**0.5**
Days on waiting list	60 (12–235)	30 (7–150)	69 (13–249)	86 (17–319)	**<0.001**
Graft type liver					**0.4**
Variant	42 (1.1%)	8 (1.0%)	29 (1.1%)	5 (1.9%)	
Whole	3758 (99%)	814 (99%)	2691 (99%)	253 (98%)	
Donor type					
Deceased	3800 (100%)	822 (100%)	2720 (100%)	258 (100%)	
Age donor	34 (26–45)	33 (25–43)	35 (26–46)	36 (26–48)	**0.004**
Sex donor					**0.6**
Female	1468 (39%)	326 (40%)	1037 (38%)	105 (41%)	
Male	2332 (61%)	496 (60%)	1683 (62%)	153 (59%)	
Diabetes donor					**0.11**
No	3586 (94%)	778 (95%)	2568 (94%)	240 (93%)	
Unknown	40 (1.1%)	3 (0.4%)	34 (1.3%)	3 (1.2%)	
Yes	174 (4.6%)	41 (5.0%)	118 (4.3%)	15 (5.8%)	
DCD					**0.11**
No	3473 (91%)	765 (93%)	2477 (91%)	231 (90%)	
Yes	327 (8.6%)	57 (6.9%)	243 (8.9%)	27 (10%)	
Creatinine donor	0.90 (0.70–1.22)	0.90 (0.69–1.20)	0.90 (0.70–1.22)	0.90 (0.69–1.32)	**0.3**
KDPI	0.29 (0.12–0.49)	0.26 (0.11–0.46)	0.29 (0.13–0.50)	0.32 (0.14–0.55)	**0.003**
Donor race/ethnicity					**0.66**
Asian	81 (2.1%)	21 (2.6%)	55 (2.0%)	5 (1.9%)	
Black	566 (15%)	112 (14%)	420 (15%)	34 (13%)	
Hispanic	645 (17%)	147 (18%)	450 (17%)	48 (19%)	
Other	60 (1.6%)	12 (1.5%)	41 (1.5%)	7 (2.7%)	
White	2448 (64%)	530 (64%)	1754 (64%)	164 (64%)	
BMI donor calculated	26.6 (23.3–30.7)	26.1 (22.8–30.1)	26.7 (23.5–30.9)	26.4 (22.8–30.7)	**0.006**
Cold ischemia time liver	5.93 (4.85–7.15)	6.00 (4.80–7.22)	5.92 (4.88–7.16)	5.83 (4.65–6.98)	**0.5**
Cold ischemia time kidney	11 (8–19)	11 (8–20)	11 (8–19)	11 (8–19)	**>0.9**
Incompatable ABO	40 (1.1%)	12 (1.5%)	25 (0.9%)	3 (1.2%)	**0.4**
Death	586 (15%)	68 (8.3%)	459 (17%)	59 (23%)	**<0.001**
Liver failure	615 (16%)	73 (8.9%)	482 (18%)	60 (23%)	**<0.001**
Death-censored kidney	162 (4.3%)	28 (3.4%)	126 (4.6%)	8 (3.1%)	**0.2**
LOS	13 (8–23)	13 (8–22)	13 (9–23)	16 (10–28)	**0.003**
Unknown	106	26	68	12	
DGF kidney					**0.2**
No	2687 (71%)	572 (70%)	1944 (71%)	171 (66%)	
Yes	1113 (29%)	250 (30%)	776 (29%)	87 (34%)	

Data are presented as n (%) or median (IQR). Values in bold indicate statistical significance.
[a]Pearson's chi-square test; Kruskal-Wallis rank-sum test; and Fisher exact test.
AIH, autoimmune hepatitis; ALF, acute liver failure; BMI, body mass index; cPRA, calcu;ated panel-reactive antibody; DCD, donor after circulatory death; DGF, delayed graft function; DM, diabetes mellitus; HCC, hepatocellular carcinoma; ICU, intensive care unit; IQR, interquartile range; KDPI, Kidney Donor Profile Index; LOS, length of stay; MELD, model for end-stage liver disease; PCKD, polycystic kidney disease; PVD, peripheral vascular disease; PVT, portal vein thrombosis; ReTx, retransplant.

was more common in the 70 y and older age group than other groups at 7.4% compared with 3.6% and 6.7% in the other 2 groups. Forty-three percent of patients were hospitalized when transplanted, comparable with the other 2 age groups. When it came to functional status, about 67% of patients required assistance, which was similar in all age groups. Sixty-three percent of patients aged 70 y and older were on dialysis at transplant compared with 83% in the 18–49 y age group

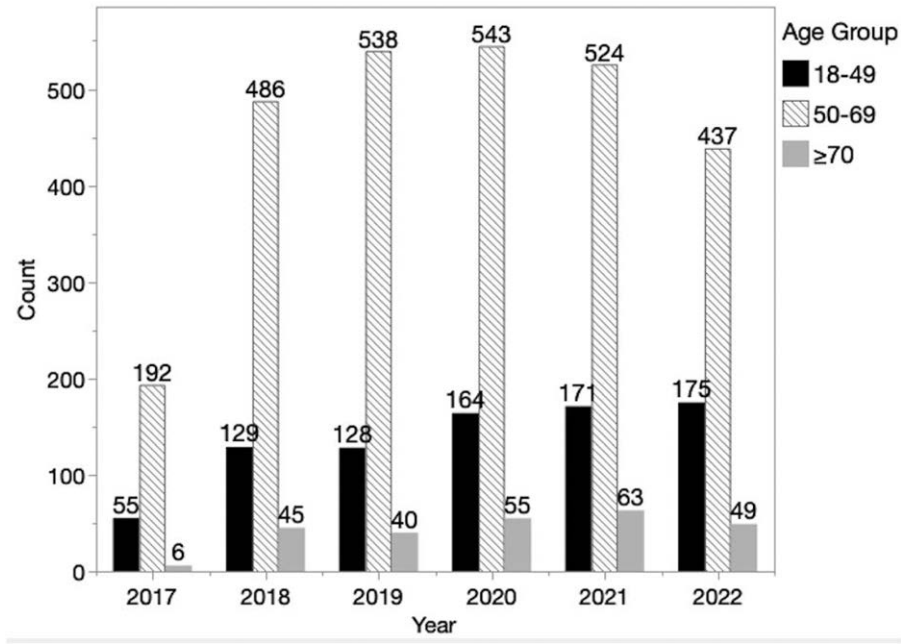

FIGURE 1. Distribution of simultaneous liver and kidney transplantation by age from 2017 to 2022.

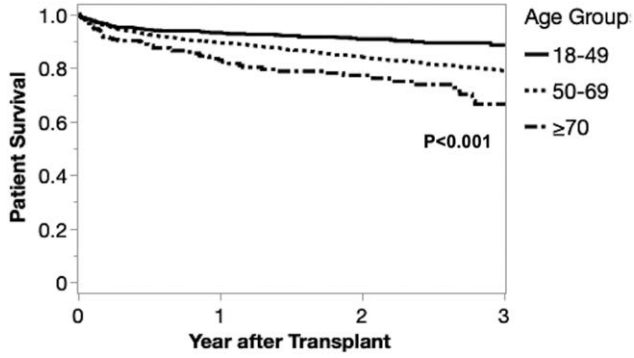

FIGURE 2. Patient survival after simultaneous liver and kidney transplant in all age groups.

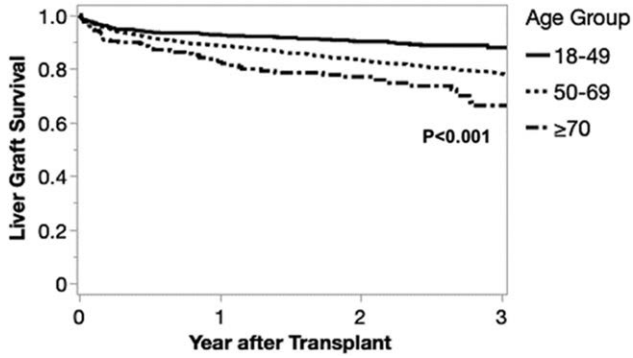

FIGURE 3. Liver graft survival after simultaneous liver and kidney transplant in all age groups.

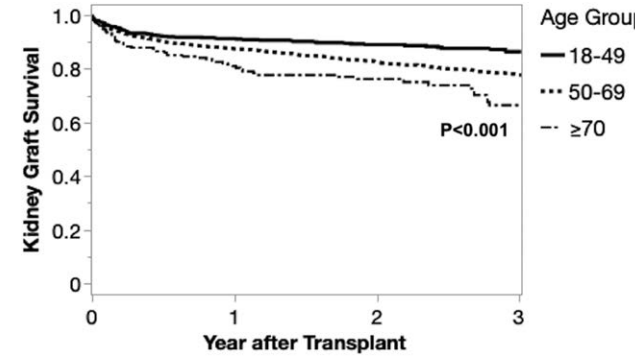

FIGURE 4. Kidney graft survival after simultaneous liver and kidney transplant in all age groups.

FIGURE 5. Death-censored kidney graft survival in all age groups after simultaneous liver and kidney transplant.

and 71% in the 50–69 y age group. The median MELD score at transplant was significantly lower in the 70 y and older age group at 28 (IQR, 23–33) compared with 31 (IQR, 24–37) in the 18–49 y age group. Length of stay postoperatively was significantly longer in the 70 y and older age group at 16 d (IQR, 10–28) when compared with the other 2 groups. Donor demographics can be found in Table 1. KDPI of the donor

TABLE 2.

Cox proportional hazard model for death-censored kidney graft survival

	Univariable			Multivariable		
Characteristic	**HZ**	**CI**	***P***	**HZ**	**CI**	***P***
Recipient						
Age group, y						
18–49	Reference					
50–69	1.32	0.87-1.98	0.19			
≥70	0.94	0.43-2.07	0.88			
Female sex	1.18	0.87-1.61	0.29			
Race/ethnicity						
Asian	1.12	0.54-2.30	0.76			
Black	0.70	0.40-1.22	0.21			
Hispanic	1.10	0.75-1.61	0.63			
Other	0.98	0.31-3.09	0.97			
White	Reference					
Kidney diagnosis						
DM	Reference					
Hepatorenal	0.98	0.85-1.48	0.93			
Other	0.96	0.60-1.56	0.88			
PCKD	0.74	0.32-1.67	0.46			
ReTx	1.36	0.60-3.08	0.46			
PVD						
No	Reference					
Unknown	1.31	0.54-3.20	0.55			
Yes	0.84	0.41-1.72	0.64			
BMI	1.03	1.01-1.06	0.02	1.03	1.01-1.06	0.01
Final MELD laboratory	1.01	0.99-1.04	0.15			
Dialysis before transplant	1.55	1.05-2.29	0.02	1.65	1.12-2.44	0.01
Location						
Out of hospital	Reference					
Hospital	0.84	0.57-1.24	0.38			
ICU	1.25	0.84-1.85	0.27			
Diabetes mellitus						
No	Reference					
Other	1.58	0.39-6.45	0.52			
Type 1	3.73	1.18-11.84	0.03			
Type 2	1.24	0.91-1.69	0.18			
Recipient ABO						
A	0.95	0.67-1.34	0.76			
AB	0.86	0.40-1.85	0.69			
B	0.78	0.47-1.27	0.31			
O	Reference					
Function						
Assistance Moribund	1.26	0.89-1.79	0.19			
Self-care normal	Reference					
Unknown	1.13	0.27-4.68	0.86			
cPRA by 10	1.06	1.01-1.13	0.04	1.06	1.01-1.12	0.03
Days waititing on dialysis	1.001	0.99-1.01	0.18			
Donor						
Age	1.04	1.03-1.05	<0.001			
Female sex	1.48	1.09-2.02	0.01			
Race/ethnicity						
Asian	1.08	0.40-2.94	0.88			
Black	1.08	0.71-1.64	0.73			
Hispanic	0.67	0.41-1.10	0.11			
Other	1.90	0.78-4.66	0.16			
White	Reference					
BMI	1.03	1.01-1.05	0.03			
Diabetes mellitus, yes vs no	3.26	2.06-5.16	<0.001			
DCD	1.07	0..62-1.86	0.80			

(Continued)

TABLE 2.
continued

Characteristic	Univariable			Multivariable		
	HZ	CI	*P*	HZ	CI	*P*
Creatinine	1.16	0.97-1.36	0.09			
KDPI	13.87	7.64-25.24	<0.001	14.01	7.69-25.57	<0.001
Cold ischemia time kidney	1.01	0.99-1.02	0.22			
Incompatable ABO	2.88	1.18-7.04	0.046			

The following variables were not placed in the final multivariable analysis. Condition of diabetes mellitus because of collinearity with diagnosis of diabetes mellitus and donor variables of age, race/ethnicity. BMI, diabetes mellitus, DCD, and serum creatinine because of these variables are used to calculate the KDPI.
BMI, body mass index; CI, confidence interval; cPRA, calculated panel-reactive antibody; DCD, donor after circulatory death; DM, diabetes mellitus; HZ, hazard ratio; ICU, intensive care unit; KDPI, kidney donor profile index; MELD, model for end-stage liver disease; PCKD, polycystic kidney disease; PVD, peripheral vascular disease; ReTx, retransplant.

kidneys was 32% in the 70 y and older age group compared with 26% in the 18–49 y age group and 29% in the 50–69 y age group.

Patients aged 70 y and older had significantly lower survival with 82.9% at 1 y and 66.5% at 3 y compared with 89.3% and 78.8% in the 50–69 y age group, respectively, and 93.2% and 88.6% in the 18–49 y age group, respectively (Figure 2). The liver allograft survival can be found in Figure 3. Overall kidney allograft survival was significantly lower in the 70 y and older group, with 80.9% at 1 y and 66.4% at 3 y compared with 87.4% in the 50–69 y age group, respectively, and 91.2% and 86.3% in the 18–49 y age group, respectively (Figure 4). Death-censored kidney graft survival was the same in all 3 groups at 1 and 3 y (Figure 5). In the univariable Cox regression analysis, predictors of lower kidney graft survival in all 3 groups of patients undergoing SLK were recipient BMI, dialysis at the time of transplant, recipient type 1 diabetes, cPRA, and donor age, female sex, BMI, diabetes mellitus status, KDPI, and incompatible ABO match. Multivariable Cox regression analysis demonstrated recipient BMI, cPRA, dialysis at transplant, and KDPI of donor as predictors of lower kidney graft survival (Table 2). When it came to patient survival in all 3 age groups, the univariable Cox regression analysis demonstrated factors including age, female sex, hepatorenal syndrome, peripheral vascular disease, MELD at transplant, dialysis before transplant, transplant from ICU, type 2 diabetes, and decreased functional status were contributors of decreased patient survival. Multivariable Cox regression analysis demonstrated factors such as age, female sex, hepatorenal syndrome, dialysis before transplant, cPRA, KDPI, cold ischemia time, decreased functional status, and transplant from ICU contributed to increased patient mortality (Table 3).

In the 70 y and older age group, kidney allograft survival was similar if the kidney transplant was combined with the liver (SLK) or performed as part of the safety net with KAL transplant with 80.9% at 1 y and 76.2% at 2 y and 87.1% and 78.4%, respectively, with KAL (Figure 6). When compared with kidney transplant alone, kidney allograft survival in the 70 y and older age group undergoing SLK was 80.9% at 1 y and 66.4% at 3 y compared with 91.1% and 75.5%, respectively (Figure 7). There was no difference in death-censored graft survival in 2 groups (Figure 8).

DISCUSSION

As life expectancy is increasing, a greater number of older adults are being considered for transplantation. Successful transplantation became possible in this higher-risk population because of advances in surgical techniques, perioperative care, and immune therapy.

The prevalence of MASH is on the rise.[8] This correlates with the rising number of older adults who are in need of liver transplantation.[9] The higher incidence of diabetes and older age are risk factors for developing kidney disease and, thus, creating an increased need for combined liver and kidney transplantation.[10] Based on our analysis of the national database, only 6 SLK transplants were performed in the group aged 70 y and older in 2016, and this dramatically increasing to 63 in 2021. There are little data in the literature on the outcomes of SLK in this aging population. Goldberg et al analyzed UNOS database from 2002 to 2018 and demonstrated that patients aged 70 y and older undergoing SLK transplant had 25% lower patient survival at 5 y compared with recipients aged 40–49 y. In this study, the unadjusted 5-y survival of SLK recipients aged 70 y and older with chronic kidney disease was 58% as compared with 69% in SLK recipients aged 70 y and older without chronic kidney disease, and both were lower compared with other younger age groups.[11] Ekser et al, in a single-center study from June 2007 to October 2018, reported on 8 patients aged 70 y and older who underwent SLK. Patient survival at 1 and 3 y was significantly lower in elderly recipients at 1 y with 60% and at 3 y with 40% when compared with younger recipients.[12]

Because of the increase in SLK transplantation, from 135 in 2000 to 731 in 2016, in 2017, UNOS implemented a new liver and kidney allocation policy in liver candidates with significant renal dysfunction.[13] Our analysis of the national database post the implementation of the safety net demonstrated that in the 70 y age group undergoing SLK transplant, patient survival was significantly lower, with 82.9% at 1 y and 66.5% at 3 y. There was no difference in death-censored kidney graft survival in any age group, including elderly. We have shown that kidney graft survival transplanted simultaneously with the liver was significantly lower when compared with kidney transplant alone in the 70 y and older group, with 80.9% at 1 y and 66.4% at 3 y compared with 91.1% and 75.5%, respectively. The lower kidney allograft survival as part of a dual transplant versus kidney transplant alone (KTA) consistently has been demonstrated. Analysis of the UNOS database between 1987 and 2006 by Locke et al[14] demonstrated a kidney graft survival of 76.1% versus 88.7% ($P < 0.001$) in the SLK transplant versus kidney transplant alone group at 1 y. Similarly, Choudhury et al[15] looked into paired kidney analysis during the period from February 2002 to December 2010 and showed that 5-y kidney graft survivals, with 64% in SLK

TABLE 3.

Cox proportional hazard model for patient survival

	Univariable			Multivariable		
Characteristic	**HZ**	**CI**	***P***	**HZ**	**CI**	***P***
Recipient						
Age group, y						
18–49	Reference					
50–69	1.92	1.49-2.48	<0.001	1.71	1.31-2.22	<0.001
≥70	3.02	2.13-4.28	<0.001	2.58	1.81-3.70	<0.001
Female sex	0.82	0.69-0.97	0.02	0.78	0.66-0.94	0.01
Race/ethnicity						
Asian	0.72	0.45-1.16	0.18			
Black	0.98	0.77-1.26	0.89			
Hispanic	1.11	0.91-1.37	0.31			
Other	0.97	0.53-1.77	0.92			
White	Reference					
Liver diagnosis						
AIH	0.41	0.12-1.40	0.16	0.28	0.09-0.87	0.03
ALF	0.96	0.40-2.30	0.92			
Malignancy	1.44	0.85-2.43	0.18			
Cholestatic	Reference					
Cryptogenic	1.75	1.01-3.05	0.049			
ETOH	0.80	0.4901.31	0.38	0.64	0.52-0.79	<0.001
Metabolic	0.39	0.14-1.05	0.06	0.39	0.16-0.92	0.03
MASH	1.35	0.83-2.19	0.23			
Other	1.16	0.65-2.09	0.62			
ReTx	1.15	0.66-2.00	0.62			
Viral	1.03	0.61-1.74	0.90	0.74	0..56-0.97	0.03
Kidney diagnosis						
DM	Reference					
Hepatorenal	0.72	0.59-0.88	0.001	0.75	0.61-0.91	0.005
Other	0.74	0.58-0.94	0.01	0.76	0.60-0.95	0.02
PCKD	0.32	0.19-0.55	<0.001	0.34	0.20-0.58	<0.001
ReTx	0.92	0.59-1.44	0.73			
PVD						
No	Reference					
Unknown	1.24	0.74-2.08	0.41			
Yes	1.41	1.04-1.92	0.03			
Associated HCC	1.35	1.07-1.71	0.02			
BMI	1.01	0.99-1.02	0.20			
Final MELD laboratory	1.01	1.001-1.02	0.03			
Dialysis before transplant	1.30	1.07-1.58	0.008	1.37	1.12-1.67	0.002
PVT	1.01	0.80-1.28	0.92			
Previous abdominal surgery						
No	Reference					
Unknown	1.26	0.67-2.37	0.47			
Yes	1.13	0.96-1.33	0.15			
Location						
Out of hospital	Reference					
Hospital	1.04	0.85-1.27	0.72			
ICU	1.46	1.19-1.79	<0.001	1.29	1.05-1.59	0.02
Diabetes mellitus						
No	Reference					
Other	0.49	0.12-1.96	0.31			
Type 1	1.28	0.48-3.44	0.62			
Type 2	1.62	1.38-1.91	<0.001			
Recipient ABO						
A	1.08	0.90-1.30	0.40			
AB	1.06	0.72-1.56	0.76			
B	1.03	0.81-1.32	0.79			
O	Reference					

(Continued)

TABLE 3.
continued

	Univariable			Multivariable		
Characteristic	**HZ**	**CI**	***P***	**HZ**	**CI**	***P***
Function						
Assistance Moribund	1.37	1.14-1.66	0.001	1.28	1.05-1.57	0.01
Self-care normal	Reference					
Unknown	2.65	1.50-4.67	<0.001	2.76	1.56-4.90	<0.001
cPRA by 10	0.96	0.92-1.01	0.07			
Days waiting	0.99	0.98-1.01	0.36			
Donor						
Whole vs variant liver graft	0.88	0.44-1.76	0.72			
Age	1.008	1.002-1.01	0.008			
Female sex	0.92	0.78-1.08	0.29			
Race/ethnicity						
Asian	0.85	0.48-1.52	0.59			
Black	0.95	0.75-1.20	0.66			
Hispanic	0.99	0.79-1.24	0.94			
Other	0.78	0.39-1.57	0.48			
White	Reference					
BMI	1.01	0.99-1.03	0.07			
Diabetes mellitus, yes vs no	1.05	0.72-1.53	0.81			
DCD	1.24	0.93-1.65	0.16			
Creatinine	1.06	0.95-1.17	0.25			
KDPI	1.56	1.11-2.17	0.01	1.58	1.13-2.19	0.007
Cold ischemia time liver	1.05	1.02-1.09	0.004	1.04	1.01-1.07	0.02
Cold ischemia time kidney	1.02	1.01-1.03	<0.001	1.02	1.01-1.03	<0.001
Incompatable ABO	0.79	0.31-1.81	0.52			

For the multivariable analysis.
Recipient DM was left out of the model because of collinearity to renal diagnosis of DM.
Donor factors left out of the model if also captured by the KDPI.
Age, race, BMI for height and weight, DM, DCD, and creatinine.
AIH, autoimmune hepatitis; ALF, acute liver failure; BMI, body mass index; cPRA, calculated panel-reactive antibody; DCD, donor after circulatory death; DM, diabetes mellitus; ETOH, alcohol-associated cirrhosis; HZ, hazard ratio; HCC, hepatocellular carcinoma; ICU, intensive care unit; KDPI, kidney donor profile index; MASH, metabolic dysfunction-associated steatohepatitis; MELD, model for end-stage liver disease; PCKD, polycystic kidney disease; PVD, peripheral vascular disease; PVT, portal vein thrombosis; ReTx, retransplant.

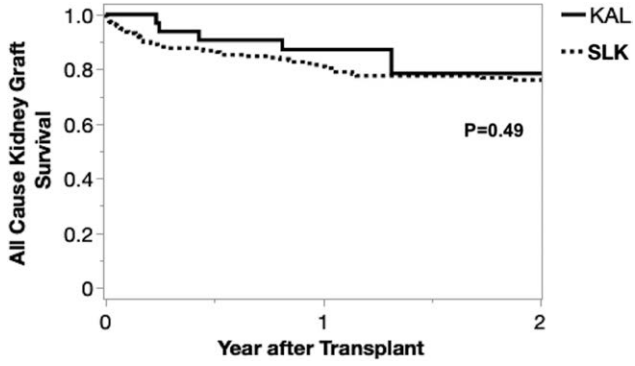

FIGURE 6. Kidney graft survival in the simultaneous liver and kidney (SLK) group compared with the kidney after liver (KAL) transplant group. Kidney transplant performed during safety net.

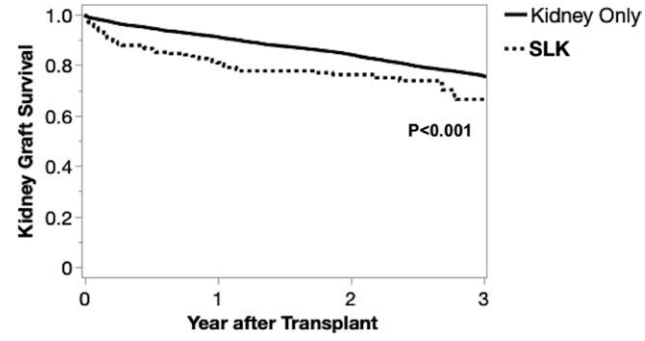

FIGURE 7. Kidney graft survival in the simultaneous liver and kidney transplant (SLK) group compared with the kidney transplant alone group.

versus 75% in KTA and patient survivals with 66% in SLK versus 81% in KTA were significantly lower in SLK versus KTA recipients of the contralateral kidney.

Our findings demonstrate that the majority of deaths and graft loss in patients aged 70 y and older undergoing SLK occurred early on posttransplant. When compared with the US older patient aged 70 y and older patient survival based on Center for Disease Control life expectancy data from 2020, we have observed that the increase in death rate occurs in the first 1 to 2 y after SLK transplantation. Thereafter, the death rate in the 70 y and older age group followed the same death rate when compared with those who did not undergo a transplant (Figure 9). Schold et al analyzed SLK transplant and compared with kidney transplant alone during a 5-y period demonstrated 1-y and 3-y posttransplant kidney graft survival for kidney-alone recipients to be 94% and 86% versus SLK recipients to be 89% and 80%, respectively, with most the difference observed at 1 y posttransplantation.[16] Cullaro et al[17] also demonstrated that SLK transplant recipients with a

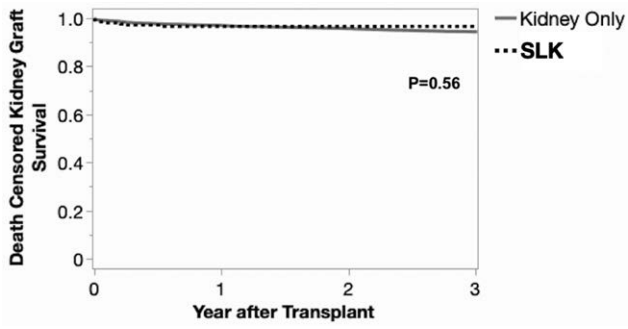

FIGURE 8. Death-censored kidney graft survival in the simultaneous liver and kidney (SLK) group vs kidney-alone group.

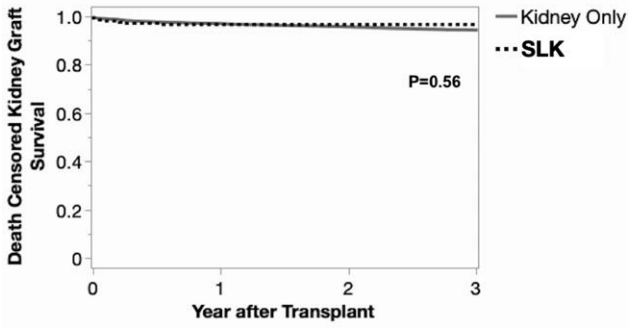

FIGURE 9. Death rate of patients aged 70 y and older in the United States based on Center for Disease Control life expectancy data from 2020 compared with those undergoing SLK transplant.

MELD score ≥25 had a significantly higher risk of early kidney failure.[17] In the era of the safety net, consideration could be given to KAL transplant that would avoid the use of kidneys in those who would not benefit from it or those who would recover kidney function after liver transplant. In our analysis, we have demonstrated that in the 70 y and older age group, kidney survival was comparable in the KAL group listed with a safety net when compared with the SLK group.

Our study has several limitations, including a relatively small sample size of recipients aged 70 y and older, short follow-up period, and retrospective study design. In addition, it also lacks granularity in the variables, including data on coronary artery disease and pulmonary hypertension as a result of using a large national database.

In conclusion, in the post SLK allocation policy and safety net era, we have demonstrated that the patient and kidney graft survival continue to be significantly lower in those who are aged 70 y and older who are undergoing dual liver and kidney transplant when compared with the younger counterparts and to the patients undergoing kidney transplant alone of the same age group. In an era of organ shortage, we must strive to optimally balance individual urgency with utilitarian benefit. Whether the current allograft and patient survival support the simultaneous use of dual organs in this population is debatable. Definitive evidence is lacking. Although age alone is not a contraindication to transplantation, further multinational studies are needed to define the criteria for and appropriateness of multiorgan transplantation in this vulnerable age group.

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