Kidneys from Older Living Donors Provide Excellent Short and Intermediate Outcomes—A Single China Center's Experience

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Background. Transplantation with kidneys from older living donors is on the rise, yet controversy still exists over whether the outcomes are as satisfactory as with kidneys from younger donors. **Methods.** We retrospectively analyzed 1009 living donor kidney transplants performed at our center between 2006 and 2013. Graft and patient outcomes were compared between transplants with kidneys from old living donors (OLD, 55-65 years) (n = 264) and from young living donors (YLD, <55 years) (n = 745). **Results.** The age was 32.80 ± 9.71 years and 33.91 ± 5.98 years for recipient in YLD and OLD group, respectively. Death-censored graft survival at 1, 3, and 5 years was 98.8%, 97.1%, and 95.8% in patients receiving YLD kidneys, similar to the corresponding values of 97.6%, 95.5% and 95.5% in patients receiving OLD kidneys (P = 0.356). Patient survival at 1, 3, and 5 years after transplantation was also similar for patients receiving YLD kidneys (98.5%, 97.1% ,and 96.7%) and for patients receiving OLD kidneys (99.6%, 99.6%, and 96.8%; P = 0.110). The OLD kidneys were not associated with increased risk of death-censored graft failure (hazard ratio, 2.5; 95% confidence interval, 0.57 to 11.11) and patient death (hazard ratio, 1.67; 95% confidence interval, 0.75 to 3.73). In addition, there is no increased graft loss or patient death for each 10-year increase in donor age. Transplantation with OLD kidneys was not associated with reduced patient or graft outcomes in the short term (≤12 months) or medium term (>1 year). **Conclusions.** Graft and patient outcomes after living-donor kidney transplantation are similar in the short-term and medium-term for donors aged 55 to 65 years and for younger donors. Therefore, the use of OLD kidneys should be encouraged in China.

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Kidney transplantation remains the treatment of choice for patients with end-stage renal disease. Transplantation is associated with approximately 50% lower risk of death than dialysis[1] as well as higher quality of life.[2] However, the numbers of patients on kidney transplant waiting lists still outnumber the transplant procedures performed annually,[3] which has led transplant community to devote many efforts to expand the organ pool. One of the solutions is promoting the using of kidneys from old living donors (OLD) and expanded criteria deceased donors. Data from the United Network for Organ Sharing has indicated the percentage of donors older than 60 years has increased from 19.9% in 1996 to 32.4% in 2004.[4]

Donor age is known to be a primary determinant of death-censored graft survival in recipients receiving kidneys from deceased donors,[5,6] particularly in the long term.[7] However, studies concerning living kidney transplant have not yielded consistent results. Data from the Australia and New Zealand Dialysis and Transplant suggest that transplantation using kidneys from donors older than 60 is associated with greater risk of death-censored graft failure (hazard ratio [HR], 2.00; 95% confidence interval [95%CI], 1.32-3.03) and inferior 5-year graft function (estimated glomerular filtration rate [eGFR] of 45 mL/min vs 56 mL/min), but no increase in 5-year mortality.[8] Data from the Mayo Clinic suggest that death-censored graft survival and patient survival decrease for every 10-year increase in living donor age.[9] On the other hand, Balachandran et al reported similar 5-year patient survival after transplantation of kidneys from donors older than 50 as from younger donors (91.3% vs 95.4%), as well as similar 5-year graft survival (93.7% vs 95.4%). However, eGFR was lower for recipients with kidneys from older donors.[10]

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To help clarify whether living donor age significantly influences kidney transplantation outcomes, we retrospectively analyzed living-donor kidney transplantation at our medical center. We compared outcomes in recipients and grafts for transplants of kidneys from OLD aged 55 to 65 years or from young living donors (YLD) younger than 55 years.

MATERIALS AND METHODS

Study Population and Data Collection

We performed a retrospective single-center review of living donor kidney allografts transplanted between January 2006 and September 2013 at West China Hospital, Sichuan University. The institutional review board approved the study protocol and authorized data collection. Recipient and donor data were extracted from medical records. A total of 1009 patients who received living-donor kidney transplants and were followed up for more than 6 months were included. All donors were older than 18 years and were carefully evaluated before surgery. Most donor kidneys (62.70%) were procured by laparoscopic nephrectomy. As China's policy on living donation has set the upper limit of age to 65 years, recipients were categorized into 2 groups, depending on donor age: OLD for donors 55 to 65 years (n = 264) or YLD for donors younger than 55 years (n = 745). For some analyses, recipients were further subdivided into the following subgroups based on donor age: younger than 35 years, 35 to 45 years, 45 to 55 years, and 55 to 65 years.

The following baseline data were extracted for donors: sex, age, and serum creatinine levels before surgery. The following data were extracted for recipients: age, sex, cause of end-stage renal disease, duration of pretransplantation dialysis, organ transplant history, and human leukocyte antigen mismatch. Transplant-related data included the use of induction antibody therapy, use of calcineurin inhibitors, and posttransplant complications, including delayed graft function (DGF) and infection.

Immunosuppressive Regimen and Infection Prophylaxis

Depending on the pretransplantation evaluation of recipients, induction therapy was administered using rabbit anti-human thymocyte immunoglobulin (1.0-1.5 mg/kg per day for 3-5 days) or anti-CD25 monoclonal antibody (1.0-1.5 mg/kg immediately before surgery and 10-14 days thereafter). Maintenance immunosuppression therapy consisted of a calcineurin inhibitor (cyclosporine A [CsA] or tacrolimus [TAC]) in combination with mycophenolate mofetil and prednisone. The CsA or TAC therapy was initiated on day 2 after transplantation at a fixed dosage of 100 mg CsA or 2 mg TAC, twice per day. Mycophenolate mofetil (2.0 g/day) was administered 1 day before transplantation. Dosage was adjusted based on the measured concentration in the blood; trough levels were 5 to 8 ng/mL for TAC and 75 to 150 ng/mL for CsA, and the area under the curve for mycophenolate mofetil was 30 to 70 mg · h^{-1} · L^{-1}. Methylprednisolone was given intravenously at 7 mg/kg starting on the day of surgery and for the following 3 days; then this drug was replaced with prednisone at 60 mg/day, tapered down by 10 mg/day, and finally maintained at 5 to 10 mg/day. All patients took sulphonamides for 6 months to prevent Pneumocystis pneumonia. Measures to prevent CMV were not routinely performed.

Clinical Outcomes

The primary clinical outcomes of this study were death-censored graft failure, patient death, and eGFR, calculated using the MDRD equation for Chinese and adjusted for body surface area.[11] Outcomes were also analyzed in the short term (≤12 months) and medium term (>12 months).

Other outcomes included DGF, which was defined as the need for dialysis within 7 days after transplantation. Rejection was diagnosed on the basis of an increase in serum creatinine and confirmed when necessary by biopsy; it was treated primarily with bolus doses of methylprednisolone and, if refractory, with antithymocyte globulin. Infection was defined as any infection occurring after transplantation, including wound infection, pulmonary, and urinary tract and skin infection.

Statistical Analyses

Baseline characteristics between donor types were compared using Student *t* test or the χ^2 test, as appropriate. Recipient eGFR and 24-hour urinary protein levels were expressed as mean ± SD and compared between follow-up visits using Student *t* test. Analysis of variance and Kruskal-Wallis tests were used to compare data among several groups. Graft and patient survivals were examined using the Kaplan-Meier method and Cox proportional hazard regression. Results were expressed as HRs with 95%CIs. The following covariates were included in the logistic regression and time-dependent Cox regression models to identify predictors of outcomes: donor gender; recipient characteristics; transplant-related characteristics, including use of induction therapy and calcineurin inhibitors; and post-transplant complications. Data analysis was performed using SPSS 17.0 (IBM, Armonk, New York, USA). *P* less than 0.05 was considered statistically significant.

RESULTS

Recipient and donor characteristics are shown in Table 1. Though there is no difference in serum creatinine in YLD and OLD, older donors demonstrated lower baseline renal function compared with younger donors (85.10 ± 10.86 vs 94.85 ± 24.37; $P = 0.037$). Recipients of OLD kidneys were more likely to receive induction therapy (36.0% vs 28.1%; $P = 0.034$).

Across all recipients in the study, 32 death-censored graft failures and 21 patient deaths occurred during a median follow-up of 32.8 months (34.8 months in YLD and 27.9 months in OLD). Overall graft survival at 1, 3, and 5 years was 98.3%, 96.3%, and 91.2%, respectively, in recipients of YLD kidneys, and 98.1%, 95.9%, and 86.3% in those of OLD kidneys ($P = 0.563$). Death-censored graft survival at 1, 3, and 5 years was similar in recipients of YLD kidneys (98.8%, 97.1%, and 95.8%) and in recipients of OLD kidneys (97.6%, 95.5%, and 95.5%; $P = 0.356$; Figure 1A). Patient survival at 1, 3, and 5 years after transplantation was also similar between the YLD transplants (98.5%, 97.1%, and 96.7%) and OLD transplants (99.6%, 99.6%, and 96.8%; $P = 0.110$; Figure 1B).

Delayed graft function occurred after transplantation in 5 of 264 patients (1.9%) who received OLD kidneys and in

TABLE 1.

Basic characteristics of included donors and recipients

Variable[a]	Donor age <55 y (n = 745)	Donor age 55-65 y (n = 264)	P
Donor characteristics			
Age, y	42.47 ± 7.76	58.50 ± 2.79	<0.001
Male	253 (34)	93 (35.2)	0.382
Height, m	1.60 ± 0.13	1.57 ± 0.19	0.05
Weight, kg	61.03 ± 14.03	59.63 ± 16.40	0.267
Serum creatinine, μmol/L	102.67 ± 22.22	126.56 ± 16.96	0.145
eGFR, mL/min/1.73 m^2	94.85 ± 24.37	85.10 ± 10.86	0.037
Recipient characteristics			
Age, y	32.80 ± 9.71	33.91 ± 5.98	0.081
Male	563 (75.6)	186 (70.5)	0.061
Height, m	1.66 ± 0.07	1.66 ± 0.07	0.501
Weight, kg	58.97 ± 10.03	58.56 ± 9.21	0.562
Cause of end-stage renal disease			
Diabetic nephropathy	26 (3.5)	10 (3.8)	<0.001
Glomerular disease	345 (46.3)	108 (40.9)	
Polycystic kidney disease	29 (3.9)	7 (2.7)	
Vascular	10 (1.3)	4 (1.5)	
Hypertension	99 (13.3)	80 (30.3)	
Unknown	236 (31.7)	55 (20.8)	
PRA, %	3.14 ± 10.24	3.15 ± 10.03	0.328
Previous organ transplantation	9 (1.2)	2 (0.8)	0.419
Preemptive transplantation	90 (12.1)	26 (9.8)	0.195
Time on dialysis, mo.	9.71 ± 11.48	11.35 ± 14.00	0.062
HLA mismatch	3.20 ± 1.10	3.28 ± 0.79	0.285
Induction therapy			
ATG/ATG-F	35 (4.7)	12 (4.5)	0.034
CD-25 antibody	174 (23.4)	83 (31.4)	
Calcineurin inhibitor			
Cyclosporin A	200 (26.8)	55 (20.8)	0.115
Tacrolimus	517 (69.4)	201 (76.1)	
CNI conversion	28 (3.8)	8 (3.0)	

[a] Values are shown as mean ± SD or n (%), unless otherwise noted.

ATG, anti-human thymocyte immunoglobulin; CNI, calcineurin inhibitor; HLA, human leukocyte antigen; PRA, panel reactive antibody.

15 of 745 patients (1.7%) who received YLD kidneys (P = 0.528). All these patients recovered. The rate of acute rejection was also similar between recipients receiving OLD kidneys (32 of 264, 12.1%) and those receiving YLD kidneys (107 of 745, 14.4%; P = 0.212).

Cox regression indicated that donor age older than 55 years was not associated with increased incidence of DGF (HR, 1.15; 95% CI, 0.40-3.32) or acute rejection (AR) (HR, 0.91; 95% CI, 0.60-1.40). We next analyzed donor age greater than 55 years and death-censored graft survival. A multivariate analysis including all of the donor variables related to graft survival is shown in Table 2, model 1. In this model, donor age older than 55 years is not associated with death-censored graft failure (HR, 1.47; 95% CI, 0.67-3.24). Table 2 also displays 3 additional multivariate models, including recipient variables, therapy variables, and posttransplant variables related to death-censored graft failure. All these models (Table 2, models 2, 3, 4) showed that donor age older than 55 years is not related to death-censored graft failure independently. Model 4, which included posttransplant variables, found that AR is associated with increased graft failure (HR, 2.99; 95% CI, 1.41-6.34). Additionally, all these models were also applied to analyze the relationship between donor age greater than 55 years and patient death. Similarly, donor age older than 55 years were not associated with increased patient death (data in, **Table S1, Appendix, SDC,** http://links.lww.com/TP/B105), whereas DGF was found significantly related to patient death (HR, 4.56; 95% CI, 1.05-19.77). Further, donor age older than 55 years were not associated with increased overall graft failure (HR, 1.37; 95% CI, 0.72-2.61), whereas dialysis duration (HR, 1.022; 95% CI, 1.00-1.04), DGF (HR, 4.03; 95% CI, 1.50-10.78) and AR (HR, 2.30; 95% CI, 1.28-4.12) were independent risk factors for overall graft loss.

Although recipients of OLD kidneys consistently showed higher mean serum creatinine levels than recipients of YLD kidneys at every follow-up (Figure 2A), the difference reach significance only at 3, 6, 12, and 30 month. Similarly, the eGFR in recipients of OLD kidneys was significantly lower than that in recipients of YLD kidneys in the first 48 months after transplantation, and no statistical difference was found thereafter (Figure 2B). Both groups showed similar urinary protein excretion throughout follow-up (Figure 2C).

To examine whether increases in donor age affect recipient outcomes, we categorized recipients into subgroups depending on whether their kidneys came from donors younger than 35 years (n = 108), 35 to 45 years (n = 304), 45 to 55 years (n = 333), or 55 to 65 years (n = 264). At 5 years after transplantation, all subgroups showed similar death-censored graft survival (95.8%, 97.8%, 93.8%, and 95.5%; P = 0.141; Figure 3A) and similar patient survival (96.5%, 96.5%, 97% and 96.8%; P = 0.462; Figure 3B). In addition, all recipients showed similar serum creatinine levels at 12 months (109.31, 115.40, 121.86, and 128.83 μmol/L; P = 0.054), 36 months (106.19, 120.40, 131.83 and 127.23 μmol/L; P = 0.173), and 60 months (120.60, 120.83, 145.17, and 147.25 μmol/L; P = 0.521). Patients receiving kidneys from donors younger than 45 years had higher eGFR than those receiving kidneys from donors aged 45 to 55 years, or 55 to 65 years at 12 months (74.35, 70.73, 66.67, and 61.31 mL/min; P < 0.001), 36 months (73.44, 68.28, 61.41, and 59.85 mL/min; P < 0.001), but not at 60 months (65.78, 65.92, 59.1, and 56.58 mL/min; P = 0.311).

Although our data suggest that living donor age does not significantly affect recipient death or graft failure in the short (≤12 months) or medium term (>1 year), we did identify some predictors of these outcomes. Delayed graft function was associated with increased 1-year recipient mortality (HR, 11.11; 95% CI, 1.98-62.28). History of organ transplantation was associated with increased graft failure (HR, 13.03; 95% CI, 1.32-128.64), and late-onset acute graft rejection was associated with increased intermediate graft failure (HR, 4.51; 95% CI, 1.57-12.96). Conversely, a better human leukocyte antigen match was associated with a lower rate of short-term graft failure (HR, 0.48; 95% CI, 0.26-0.87).

DISCUSSION

This retrospective analysis of more than 1000 living-donor kidney transplants at a single large medical center provides strong evidence that patient and graft survival are similar

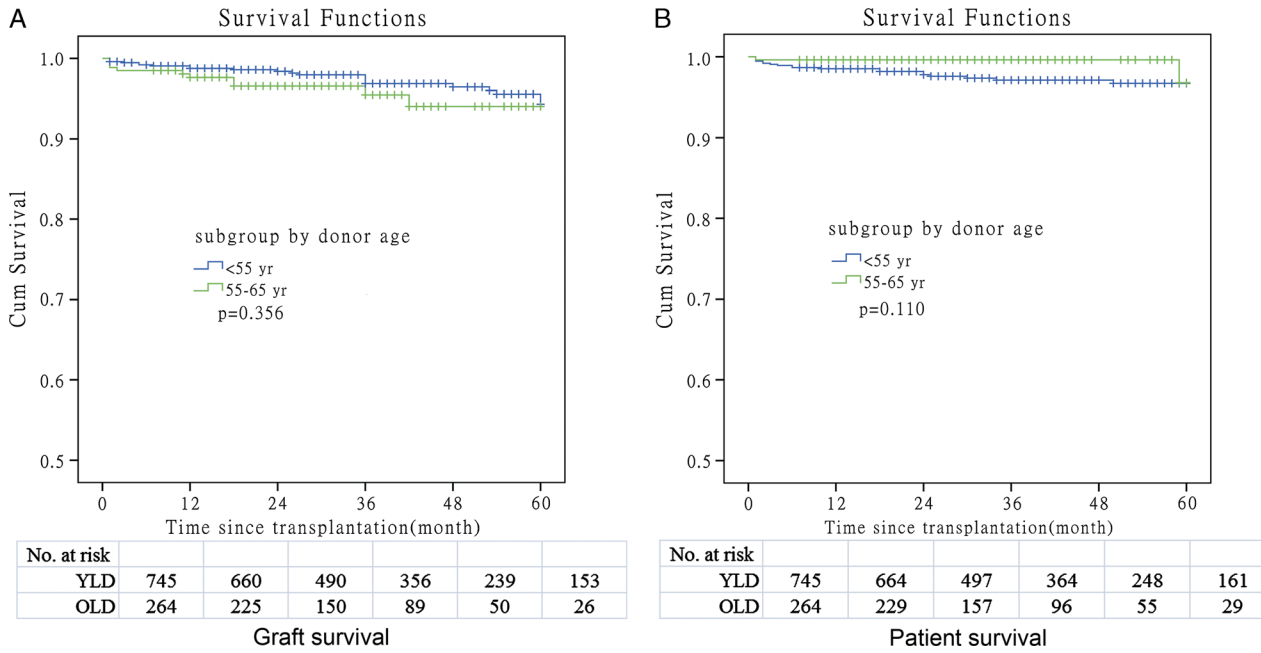


FIGURE 1. Comparison of outcomes after transplant of kidneys from living donors aged 55 to 65 years or from living donors under 55 years. (A) Death-censored graft survival ($P = 0.356$), (B) recipient survival ($P = 0.110$).

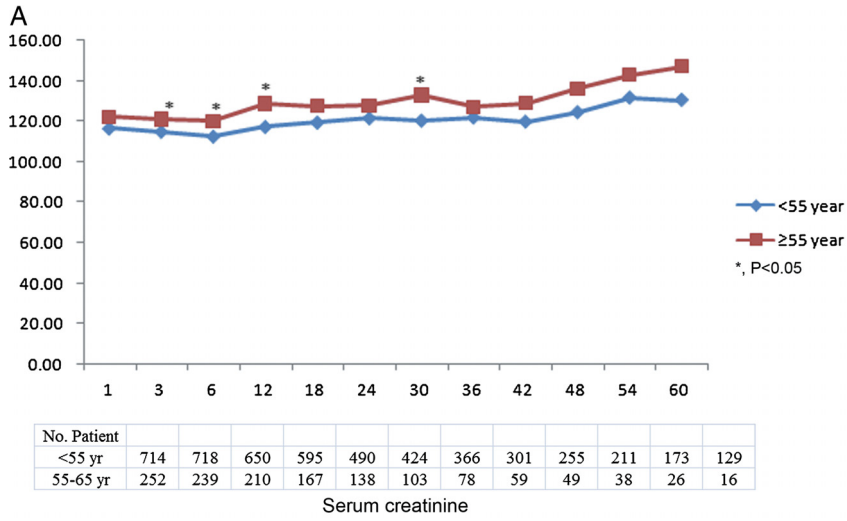
for OLD kidneys as for YLD kidneys. Patient death and death-censored graft failure do not significantly change with each 10-year increase in donor age up to 65 years. Although OLD kidneys showed lower eGFR than YLD kidneys in the short term after transplantation, this difference disappeared after 30 months.

Contrastingly, initial reports on longer-term allograft survival using older donor kidneys noted inferior outcomes compared with younger donor allografts. Retrospective analysis of Australia and New Zealand Dialysis and Transplant data comparing 346 recipients of kidneys from living donors aged 60 years and older with 1855 recipients of kidneys from living donors younger than 60 years showed that death-censored graft survival was, respectively, 90% and 93% at 5 years and 68% and 86% at 10 years. Using kidneys from standard criteria donors with ischemia time less than 12 hours as reference, kidneys from living donors aged 60 years and older had a significantly higher risk of death-censored graft failure (HR, 2.00; 95% CI, 1.32-3.03). In contrast, the risk was similar for kidneys from living donors younger than 60 years and for kidneys from standard criteria donors with ischemia time less than 12 hours (HR, 0.93; 95% CI, 0.68-1.28).[8] Another study using data from the U.S. Renal Data System compared 3053 recipients of OLD (≥55 years) kidneys to 28,208 recipients of YLD (<55 years) kidneys showed that graft survival was, respectively, 85% and 89% at 3 years, and 76% and 82% at 5 years. Compared to reference group of recipients of living donor transplants from donors younger than 55 years, transplant recipients from living donors aged 55 to 59 years (HR,

TABLE 2.

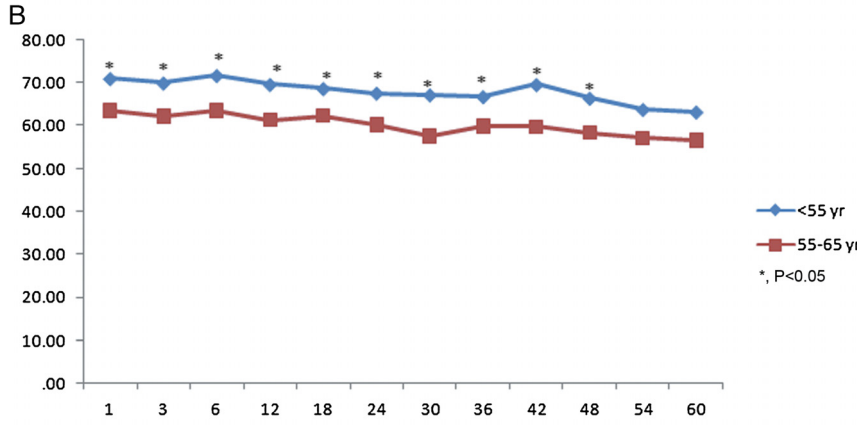
Risk factors for death-censored graft failure

	Death-censored graft failure							
	Model 1: donor variables		Model 2: recipient variables		Model 3: therapy variables		Model 4: posttransplant variables	
Variables	HR	95% CI	HR	95% CI	HR	95% CI	HR	95% CI
Donor age greater than 55 y	1.47	0.67-3.24	1.56	0.70-3.44	1.50	0.68-3.29	1.55	0.71-3.41
Donor sex	0.90	0.43-1.90	—	—	—	—	—	—
Donor eGFR	0.84	0.69-1.03						
HLA	0.87	0.63-1.20	0.83	0.58-1.18	—	—	—	—
Recipient sex	—	—	0.44	0.15-1.26	—	—	—	—
Recipient age	—	—	0.96	0.92-1.01	—	—	—	—
Dialysis time	—	—	1.01	0.98-1.04	—	—	—	—
Previous organ transplantation	—	—	3.44	0.46-25.63	—	—	—	—
Induction therapy	—	—	—	—	0.72	0.29-1.75	—	—
CNI	—	—	—	—	0.69	0.35-1.33	—	—
DGF	—	—	—	—	—	—	2.75	0.64-11.75
AR	—	—	—	—	—	—	3.37*	1.61-7.07
Infection	—	—	—	—	—	—	1.20	0.83-1.74



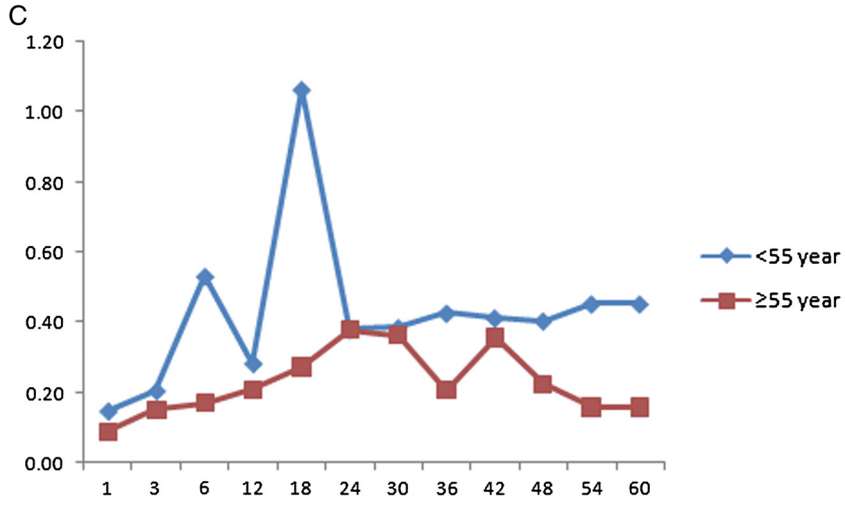
No. Patient												
<55 yr	714	718	650	595	490	424	366	301	255	211	173	129
55-65 yr	252	239	210	167	138	103	78	59	49	38	26	16

Serum creatinine



No. Patient												
<55 yr	714	718	650	595	490	424	366	301	255	211	173	129
55-65 yr	252	239	210	167	138	103	78	59	49	38	26	16

eGFR



No. Patient												
<55 year	499	547	522	485	391	346	295	234	182	161	116	74
≥55 year	171	189	178	152	121	95	71	57	50	37	22	15

24h urine protein

FIGURE 2. Comparison of posttransplantation outcomes in recipients of kidneys from living donors aged 55 to 65 years or from living donors under 55 years. A, Serum creatinine levels, (B) eGFR, and (C) 24-hour urinary protein. *$P < 0.05$ represent differences in mean values between groups at each time point.

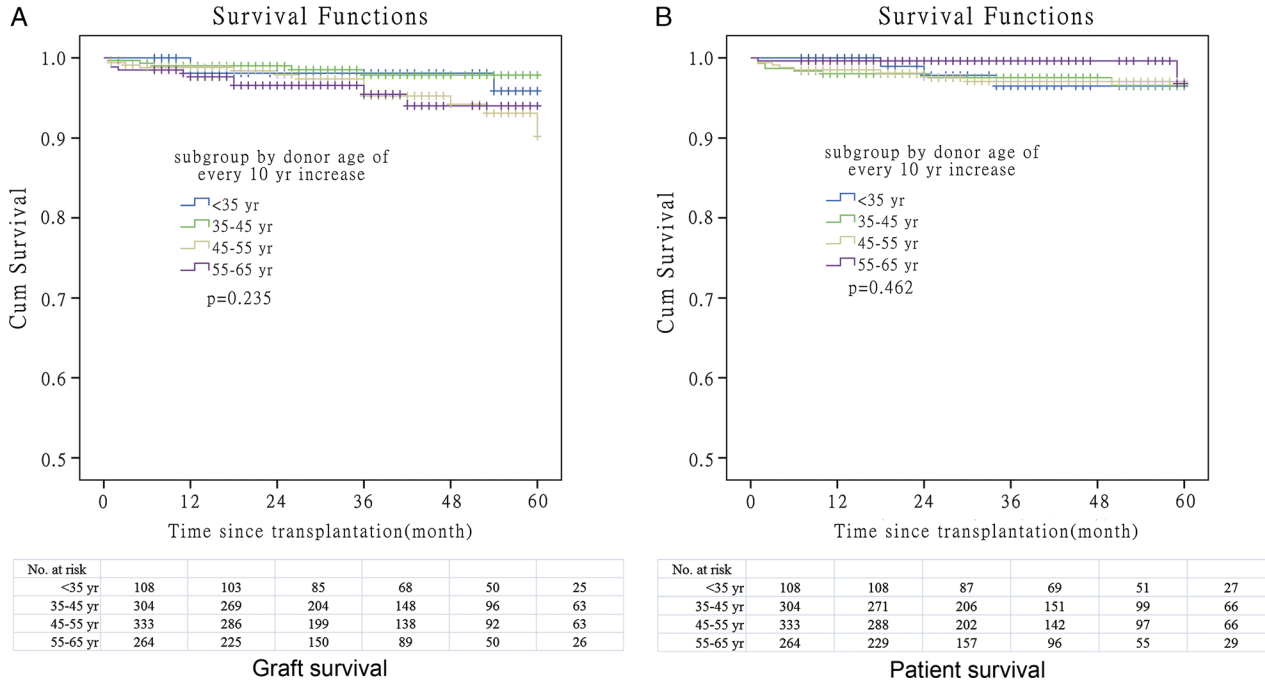


FIGURE 3. Comparison of outcomes in recipients of kidneys from living donors in different age groups (<35, 35-45, 45-55, or 55-65 years). A, Death-censored graft survival ($P = 0.141$), (B) recipient survival ($P = 0.462$).

1.23; 95% CI, 1.10-1.37), 60 to 64 years (HR, 1.29, 95% CI, 1.10-1.51), 65 to 69 years (HR, 1.81; 95% CI, 1.45-2.24), and older than 70 years (HR, 2.32; 95% CI, 1.52-3.53) had a progressively higher risk of graft loss.[12] A systematic review summarizing the results of 31 previous studies also suggested that total graft survival in older living kidney donors (≥60 years) was significantly worse at 5 years compared to younger living donors (<60 years).[13] Several factors may explain the discrepancy between the current data and previous studies. First, living donor selection criteria in our center are quite conservative, which may lead to better outcomes for kidney transplant recipients. This contrasts to practices in the United States, where almost a quarter of living kidney donors have some preexisting, moderate health condition, such as hypertension, eGFR less than 80 mL/min/1.73 m^2, body mass index greater than 30 kg/m^2.[14] Second, our study focused on the most recent era of transplants, those performed from the years 2006 to 2012. Results were consistent with the trend highlighted in a meta-regression of previous studies suggesting a less prominent "period" effect over time,[13] suggesting the evolvement of patient management, such as immunosuppression regimen, may play an important role in the discrepancy of graft survival between kidneys form OLD and YLD.

Our findings are supported in several large-scale studies which had strict donor selection criteria and narrow studying period. A single-center study of more than 462 transplantations (from 2001 to 2008) from Cornell University reported that 1-year, 3-year, and 5-year patient survival was 99.3%, 94.1%, and 91.3%, respectively, in recipients of older donors (>50 years) and 99.7%, 98.7%, and 95.4% in recipients of younger donors (<50 years), respectively ($P > 0.05$). Same data set revealed 1-year, 3-year, and 5-year death-censored graft survival was 99.2%, 95.0%, and 93.7% in older recipients, respectively, and 99.7%, 96.7%, and 95.4% in younger recipients, respectively ($P > 0.05$).[10] Another study involving 1260 living kidney transplants (from 2000 to 2008) from Canada also found that kidneys from older donor (≥60 years) was not associated with increased death-censored graft failure (HR, 0.84; 95% CI, 0.34-2.11).[15] Furthermore, data from the U.S. Organ Procurement and Transplantation Network analyzing 7006 living kidney transplants which did not provide detail on donor selection criteria also showed that 4-year graft survival was similar for kidneys from donors older than 55 years (78%) and for kidneys from donors 55 years or younger (81%), kidney from YLD was not associated with reduced graft failure (risk ratio, 1.00; 95% CI, 0.47-2.13).[4] Together, our results suggested that graft survival in OLD transplantations are satisfactory, justifying the increased use of kidneys from older donors.

One advantage of YLD kidneys in our study was higher eGFR for as many as 48 months after transplantation. This likely reflects the much higher eGFR of YLD kidneys at baseline (94.58 ± 24.37 vs 85.10 ± 10.86 mL/min). Balachandran et al[10] reported significantly higher eGFR for younger kidneys than older kidneys at 6, 12, 24, 36, 48, and 60 months, which again may reflect their higher baseline eGFR (105.3 ± 46.7 vs 82.5 ± 35.12 mL/min). Some researchers argue that kidneys from older donors exhibit a series of physiological changes which are characterized by increased glomerular, vascular and tubular senescence[16] and such morphological changes can result in significant functional changes including a decrease in renal blood flow and GFR, leading to an overall deterioration in renal function. Indeed, Balachandran et al reported recipients of OLD kidneys older than 50 years had greater than 10 mL/min/1.73 m^2 reduction in 5-year recipient GFR compared with recipients of YLD kidneys aged 50 years or younger.[10] However, we did not detect any significant difference in renal function reduction during the follow-up between YLD and OLD groups.

This argues against the concern that OLD kidneys are more prone to rapid loss of function.

Data from deceased kidney transplantation have shown that older donor age is associated with increased risk of DGF,[4,16] and patients with DGF were significantly more likely to die with a functioning graft.[17,18] Similarly, another study found that the risk of DGF increased by 15% (odds ratio, 1.15; 95% CI, 1.11-1.20) for every 10-year increase in living donor age.[19] Data from U.S. Renal Data System found that DGF was associated with 6.55 (95% CI, 4.78-8.97), 3.55 (95% CI, 2.46-5.11), 2.07 (95% CI, 1.53-2.81), and 1.48 (95% CI, 1.26-1.73) fold increased risk of graft loss at 0 to 1, 1 to 3, 3 to 12, and longer than 12 months after transplantation, respectively.[20] To the contrary, our analysis noted that donor age older than 55 years did not increase the incidence of DGF, and DGF is not an independent risk factor for graft loss. Several factors may explain the discrepancy between the current data and previous studies. One is that we strictly control the warm (128 ± 34 seconds) and cold ischemia time (78 ± 28 minutes). Another is that patients at our center generally show a relatively low incidence of DGF (1.79%), which is in line with the incidence reported by Park,[21] but much lower than those reported by Narayanan (8.69%),[21] Patel (4.1%),[22] and Salamzadeh (16.1%).[23] Finally, all of our patients with DGF recovered, so DGF did not lead directly to graft loss. On the other hand, we did find DGF to be associated with increased recipient death, particularly in the first year (HR, 11.392). Because infection is the leading cause of death (66.7%) in our cohort, after examining the incidence of infection, we found that recipients with DGF showed a much higher rate of life-threatening infection in the lung, urinary tract or blood stream than did those without DGF (38.9% vs 16.3%, $P = 0.011$). This is largely due to anti-human thymocyte immunoglobulin use in DGF phase which would increase the infection risk in the following months.[23]

A study in Netherlands reported that living donor age greater than 50 years was associated with increased incidence of AR episodes (risk ratio, 1.53; 95% CI, 1.19-1.98).[24] Those authors proposed that kidneys from older donors are more immunogenic than kidneys from younger ones. We found no correlation between donor age and incidence of acute rejection in our study; in fact, the incidence was lower in recipients of OLD kidneys (7.7% vs 14.3%). Further, we found that AR increased the risk of graft loss 7-fold in our cohort. This is consistent with previous observations that AR episodes are a major determinant of renal allograft survival.[25,26] Our data show that rejection episodes were an independent risk factor for graft failure only after 12 months, but not in the first year. A study in the United States also found that the risk that AR would lead to graft loss was much higher when the rejection occurred at least 1 year later than when it occurred earlier.[27] Hence, our data, along with that from other studies, support the conclusion that late onset of acute rejection compromises graft survival, suggesting the need for more effective immunosuppression approaches.

Our study has some limitations. First, the follow-up period in our study is relatively limited, that the negative impact of kidneys from old donors on patient and graft survival in the long term remained to be investigated. Second, due to the limitation of retrospective study design and lack of national death reporting system, we may not completely identify deaths that occur after transplant in those loss to follow-up; so did the graft outcome. Finally, though we did sophisticated statistical analysis, there are still the odds that our data lack of power to detect differences in outcomes because of a limited number of events that our models could not adjust for a large number of relevant variables.

In conclusion, although OLD kidneys may initially show inferior renal function than YLD kidneys, this difference eventually disappears, and the 2 types of kidney are associated with similar recipient and graft outcomes in the short and medium term. Our results argue for the expansion of older living-donor transplantation, which may help address the current kidney shortage.

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