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ORIGINAL ARTICLE

# Lack of impact of donor age on patient survival for renal transplant recipients ≥60 years

Wai H Lim,[1,2] Gursharan Dogra,[1] Steve J Chadban,[2,3] Scott B Campbell,[2,4] Philip Clayton,[2,3] Solomon Cohney,[2,5] Graeme R Russ[2,6,7] and Stephen P McDonald[2,6,7]

1 Department of Renal Medicine, Sir Charles Gairdner Hospital, Perth, Australia
2 ANZDATA Registry, Adelaide, Australia
3 Renal Unit, Royal Prince Alfred Hospital, Sydney, Australia
4 Renal Unit, Princess Alexandra Hospital, Brisbane, Australia
5 Renal Unit, Royal Melbourne Hospital, Melbourne, Australia
6 Nephrology and Transplantation Services, Royal Adelaide Hospital, Adelaide, Australia
7 Discipline of Medicine, University of Adelaide, Adelaide, Australia

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**Correspondence**
Dr Wai H Lim MBBS, PhD, FRACP, Department of Renal Medicine, Sir Charles Gairdner Hospital, Perth, WA 6009, Australia.
Tel.: (08) 9346 2799; fax: (08) 9346 3942;
e-mail: wai.lim@health.wa.gov.au

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## Summary

There has been an increase in the number of older patients on the transplant waiting list and acceptance of older donor kidneys. Although kidneys from older donors have been associated with poorer graft outcomes, whether there is a differential impact of donor age on outcomes in older recipients remains unclear. The aim of this study was to evaluate the effect of donor age on graft and patient survival in renal transplant (RT) recipients ≥60 years. Using the Australia and New Zealand Dialysis and Transplant Registry, outcomes of 1 037 RT recipients ≥60 years between 1995 and 2009 were analyzed. Donor age groups were categorized into 0–20, >20–40, >40–60, and >60 years. Compared with recipients receiving donor kidneys >60 years, those receiving donor kidneys >20–40 years had lower risk of acute rejection (odds ratio 0.46, 95% CI 0.27, 0.79; $P < 0.01$) and death-censored graft failure (HR 0.37, 95% CI 0.19, 0.72; $P < 0.01$). There was no association between donor age groups and death. With a corresponding growth in the availability of older donor kidneys and the observed lack of association between donor age and patient survival in RT recipients ≥60 years, preferential allocation of older donor kidneys to RT recipients ≥60 years may not disadvantage the life expectancy of these patients.

## Introduction

Renal transplantation is associated with a significant survival advantage over dialysis in patients with end-stage kidney disease (ESKD) across all age groups [1]. With the growth in the number of older ESKD patients being accepted for renal replacement therapy, there is a corresponding increase in the number of older ESKD patients on the deceased donor (DD) transplant wait list. Older donors have been associated with inferior recipient outcomes including reduced renal allograft function and higher risk of graft loss, both of which are independent predictors of patient survival [2–5]. Because older recipients are at a greater risk of death with functioning graft (DFG), it may be appropriate to allocate older donor kidneys to older recipients without compromising their potential survival [6–9]. Allocation algorithms of deceased donor kidneys in most other countries, including Australia, are primarily based upon human leukocyte antigen (HLA)-matching and time on dialysis. With such countries, the impact on patient survival of older renal transplant recipients receiving younger versus older donor kidneys has not been extensively evaluated [5,10]. The Eurotransplant Senior Program (ESP) preferentially

allocate kidneys from donors ≥65 years to recipients ≥65 years and such recipients have achieved superior survival compared with those remaining on the transplant wait list [11–13].

In Australia, the proportion of deceased donors >55 years for kidney transplantation has increased substantially from 26% of overall deceased donors between 2002 and 04 to 36% between 2008 and 10 [14]. The initial allocation of deceased donor kidneys occurs at a national level, involving all potential recipients on the wait list. Around 20% of available deceased donor kidneys are allocated according to the Interstate Exchange Program, whereby the kidneys are shipped to potential recipients who are highly sensitized and with 0–2 HLA-mismatches. Donor issues such as age are not explicitly considered in the allocation algorithm. However, some age-matching still occurs, because a younger healthier potential recipient near the top of the list may decline a marginal kidney, and retain their place on the waiting list until a younger kidney becomes available. The aim of this study was to evaluate the effect of younger versus older donor kidneys on survival and other transplant outcomes in renal transplant recipients ≥60 years.

## Patients and methods

This was a retrospective review of the Australia and New Zealand dialysis and transplant registry (ANZDATA). All ESKD patients who had received a deceased donor kidney transplant in Australia from 1995 to 2009 and who were ≥60 years at time of transplant were included in the study. Follow-up was censored for death and graft loss. The patients receiving multiple organ grafts were excluded. No patients were lost to follow-up.

### Data collection

Recorded baseline data included donors' characteristics such as age (0–20, >20–40, >40–60, and >60 years) and gender; recipients' characteristics including gender, race (categorized as indigenous and nonindigenous), previous grafts, diabetes mellitus, hypertension, coronary artery disease, smoking history (categorized as current, exsmoker, or nonsmoker), peak panel reactive antibody (PRA; 0–25% or >25–50%, or >50% and time on dialysis (categorized into 0–1, >1–3, >3–5, or >5 years on dialysis); and transplant-related characteristics including total ischemic time (categorized into 0–12 h, >12–18 h, or >18 h), induction therapy (either interleukin-2 receptor antibody or T-cell depleting agents) and delayed graft function (defined as requiring dialysis within 72 h of transplantation). Recipients who had received delayed induction therapy after they had experienced delayed graft function were not included as having induction therapy. The number of HLA-mismatch(es) was modeled as a continuous variable in the analysis (i.e., 0–6 HLA-mismatches). The transplant period (categorized into cohorts of 1992–96, 1997–2001, and 2002–07) and transplanting states (Western Australia, South Australia, New South Wales, Queensland, Victoria) were included in the analysis. A separate subanalysis was undertaken that had included recipient age as a covariate (continuous variable) in the multivariate model. In addition, we had also examined different donor age cut-off including donor age <50 years or ≥50 years.

*Clinical outcomes*

Outcomes analyzed included overall graft failure, death-censored graft failure (DCGF), patient death, acute rejection and Modification of Diet in Renal Disease (MDRD)-derived estimated glomerular filtration rate (eGFR; 15) at 1 and 5 years post-transplant. The reporting of acute rejection is voluntary, with the majority being biopsy-proven and coded according to Banff classification.

*Statistics*

Results were expressed as frequency (percentage) for categorical data or as mean and standard deviation (SD) for continuous data. Comparisons of baseline characteristics between donors of different age groups were made by chi-square test for categorical variables and analysis of variance (ANOVA) for normally distributed continuous variable. Survival curves, survival probabilities and estimated median survival times were generated according to the Kaplan–Meier method. Graft and patient survival were evaluated by multivariable Cox-proportional hazards model analysis, whereas acute rejection and eGFR were evaluated by multivariate logistic and linear regression analyses respectively. Statistical evaluation was performed using SSPS V10 statistical software program (SPSS Inc., North Sydney, Australia). A *P*-value of less than 0.05 was considered statistically significant.

## Results

### Baseline characteristics

Of the 1 037 renal transplant recipients ≥60 years, 137 (13.2%) received kidneys from donors aged 0–20 years, 246 (23.7%) from donors >20–40 years, 433 (41.8%) from donors >40–60 years, and 221 (21.3%) from donors >60 years. Baseline characteristics of donors groups are shown in Table. 1. In the study cohort, 69% of renal transplant recipients were aged between 60 to 65 years and 25% were aged between 65 and 70 years. Recipients of younger donor kidneys were more likely to be male, but were less likely to receive induction therapy compared

**Table 1.** Baseline characteristics of older recipients ≥60 years according to donor age groups.

| | Donor age 0–20 years (%) | Donor age >20–40 years (%) | Donor age >40–60 years (%) | Donor age >60 years (%) |
|---|---|---|---|---|
| Donor gender* | | | | |
| Male | 69.8 | 64.2 | 49.4 | 56.6 |
| Recipient hypertension | | | | |
| Yes | 87.8 | 86.4 | 88.9 | 92.0 |
| Recipient gender | | | | |
| Male | 57.6 | 61.0 | 63.3 | 62.6 |
| Recipient diabetes | | | | |
| Yes | 15.1 | 13.4 | 14.1 | 11.9 |
| Recipient race | | | | |
| Indigenous | 6.5 | 4.1 | 2.8 | 5.0 |
| Recipient CAD | | | | |
| Yes | 17.4 | 22.4 | 20.0 | 16.1 |
| Smoking history | | | | |
| Non | 56.2 | 47.5 | 51.7 | 52.3 |
| Exsmoker | 38.7 | 44.6 | 43.4 | 39.3 |
| Current | 5.1 | 7.9 | 5.0 | 8.4 |
| Pretransplant dialysis modality | | | | |
| PD | 23.0 | 28.0 | 26.1 | 24.7 |
| Time on dialysis (y)* | | | | |
| 0–1 | 10.1 | 8.1 | 10.9 | 5.9 |
| >1–3 | 46.8 | 38.2 | 35.3 | 39.3 |
| >3–5 | 16.5 | 28.5 | 20.6 | 19.2 |
| >5 | 26.6 | 25.2 | 33.3 | 35.6 |
| Ischemic time (h) | | | | |
| 0–12 | 34.3 | 33.3 | 35.3 | 29.4 |
| >12–18 | 42.3 | 46.9 | 45.1 | 51.9 |
| >18 | 23.4 | 19.8 | 19.6 | 18.7 |
| HLA-mismatches (mean ± SD) | 2.8 ± 1.1 | 3.0 ± 1.2 | 3.1 ± 1.1 | 3.1 ± 1.0 |
| Peak PRA* | | | | |
| 0–25 | 76.3 | 80.9 | 76.2 | 75.8 |
| >25–50 | 12.2 | 11.0 | 6.2 | 10.0 |
| >50 | 11.5 | 8.1 | 17.6 | 14.2 |
| Prior graft(s) | | | | |
| Yes | 5.0 | 4.1% | 6.7% | 4.1 |
| Induction* | | | | |
| Yes | 34.5 | 47.6 | 46.2 | 58.9 |
| DGF* | | | | |
| Yes | 13.7 | 19.1 | 28.4 | 34.2 |
| Transplant era | | | | |
| 1995–97 | 18.0 | 18.3 | 16.6 | 10.5 |
| 1998–2000 | 19.4 | 16.3 | 17.1 | 16.9 |
| 2001–03 | 19.4 | 17.1 | 18.7 | 13.7 |
| 2004–06 | 23.7 | 22.4 | 20.8 | 22.4 |
| 2007–09 | 19.4 | 26.0 | 26.8 | 36.5 |

*Chi-square or one-way ANOVA $P < 0.05$, data expressed as proportion (%) or mean ± SD.
PRA, panel reactive antibody; CAD, coronary artery disease; y, year(s); h, hour(s).

with those receiving older donor kidneys. Older donor kidneys were more likely to be associated with delayed graft function compared with younger donor kidneys. Of renal transplant recipients with delayed graft function, 61% had received induction therapy (51% had received interleukin-2 receptor antibody and 10% had received T-cell depletive agents). The proportion of renal transplant recipients in each state receiving induction therapy was similar (data not shown). However, ANZDATA registry does not collect information on the duration of induction therapy or the reasons for the use of induction therapy for recipients.

ANZDATA does not collect data on the choice or therapeutic levels of immunosuppression for transplant recipients ≥60 years. However, in renal transplant recipients >60 years, 66% were initiated on cyclosporine (mean ± SD daily dose of 518 ± 184 mg) and 30% were initiated on tacrolimus (mean ± SD daily dose of 11 ± 4 mg). Less than 2% were initiated on sirolimus or everolimus without cyclosporin or tacrolimus. A similar proportion of recipients ≥60 years in each donor age groups was initiated on cyclosporine or tacrolimus (data not shown). Of renal transplant recipients who had experienced delayed graft function, 65% and 30% were initiated on cyclosporine and tacrolimus respectively.

## Association between donor age groups and graft and patient outcomes

*Acute rejection and graft function*

In the adjusted model, compared with recipients of kidneys from donors aged >60 years, those receiving kidneys from donors aged >20–40 years were associated with a significantly lower risk of acute rejection. There was a nonsignificant trend toward lower risk of acute rejection in those receiving kidneys from donors aged 0–20 years (Tables 2 and 3). The presence of delayed graft function, higher PRA levels and greater number of HLA-mismatches were associated with a significantly greater risk of acute rejection.

Compared with recipients of kidneys from donors aged >60 years, those receiving kidneys from donors aged 0–20, >20–40, and >40–60 years were associated with better eGFR at 1 and 5 years in the unadjusted and/or adjusted models. The presence of delayed graft function was associated with poorer eGFR at 1 and 5 years in the adjusted model, but there was no other consistent association between other covariates and eGFR at 1 and 5 years.

*Overall and DCGF*

Compared with recipients of kidneys from donors aged >60 years, those receiving kidneys from donors >20–40 years were associated with a significantly lower risk of overall graft failure and DCGF in unadjusted and/or adjusted models (Tables 2 and 3 and Fig. 1). If acute rejection was included in the multivariate model for DCGF, only recipients of kidneys from donors aged >20–40 years were associated with a significantly lower risk of DCGF (HR 0.39, 95% CI 0.20, 0.74; $P = 0.004$), but not recipients from donors aged 0–20 years (HR 0.54, 95% CI 0.26, 1.12; $P = 0.096$), or >40–60 years (HR 0.72, 95% CI 0.45, 1.14; $P = 0.718$). Causes of graft failure were predominantly chronic allograft nephropathy (CAN, 45.9%),

**Table 2.** Unadjusted model of donor age groups and outcomes in renal transplant recipients ≥60 years.

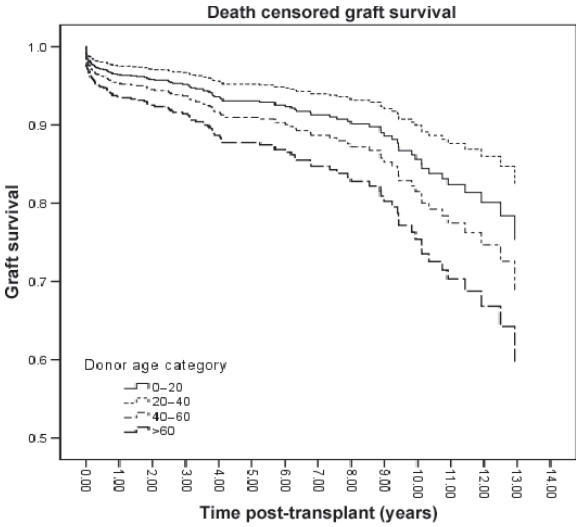
| | Donor age 0–20 years (%) | Donor age >20–40 years (%) | Donor age >40–60 years (%) | Donor age >60 years (%) |
|---|---|---|---|---|
| Graft failure | 33.8 | 32.5 | 37.2 | 37.4 |
| DCGF* | 9.4 | 7.3 | 13.9 | 16.4 |
| Death | 30.2 | 30.1 | 32.1 | 30.6 |
| eGFR 1 year* (mean ± SD) | 59.9 ± 16.4 | 59.9 ± 18.9 | 47.9 ± 15.3 | 38.6 ± 12.9 |
| eGFR 5 years* (mean ± SD) | 62.1 ± 21.9 | 60.0 ± 21.4 | 45.5 ± 16.1 | 35.0 ± 12.2 |

*$P < 0.05$, data expressed as proportion (%) or mean ± SD.
DCGF, death-censored graft failure; eGFR, estimated glomerular filtration rate.

**Table 3.** Adjusted model of donor age groups with graft and patient outcomes in renal transplant recipients ≥60 years.

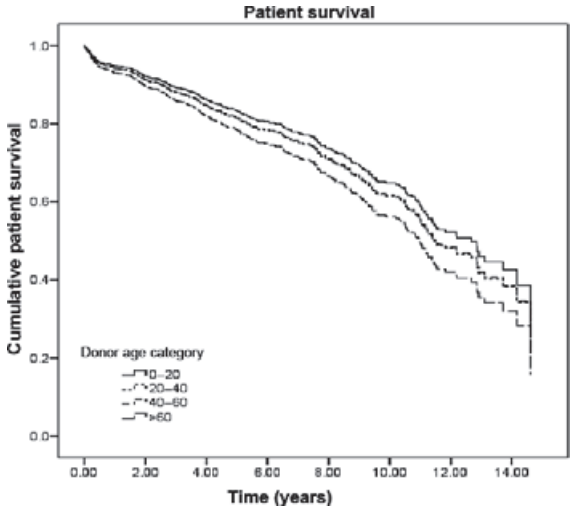
| | Donor age 0–20 years | Donor age >20–40 years | Donor age >40–60 years | Donor age >60 years |
|---|---|---|---|---|
| Graft failure | 0.69 (0.46, 1.04) | 0.67 (0.47, 0.94)* | 0.75 (0.56, 1.01) | 1.00 |
| DCGF | 0.55 (0.27, 1.12) | 0.37 (0.19, 0.72)* | 0.72 (0.45, 1.16) | 1.00 |
| Rejection | 0.64 (0.35, 1.17) | 0.46 (0.27, 0.79)* | 0.70 (0.46, 1.07) | 1.00 |
| Death | 0.75 (0.48, 1.17) | 0.85 (0.58, 1.23) | 0.84 (0.60, 1.16) | 1.00 |
| eGFR 1 year | 7.01 (5.73, 8.30)* | 9.58 (7.81, 11.35)* | 10.02 (7.13, 12.92)* | 0.00 |
| eGFR 5 years | 4.80 (2.20, 7.39)* | 6.59 (3.43, 9.75)* | 5.05 (1.25, 8.85)* | 0.00 |

*$P < 0.05$, data expressed as hazard ratio or as B coefficient with 95% CI.
DCGF, death-censored graft failure; eGFR, estimated glomerular filtration rate.




| Years | Donor 0-20 years | Donor >20-40 years | Donor >40-60 years | Donor >60 years |
|---|---|---|---|---|
| 0 | 139 | 246 | 433 | 219 |
| 1 | 113 | 197 | 332 | 167 |
| 5 | 64 | 115 | 175 | 70 |
| 8 | 36 | 60 | 101 | 32 |

**Figure 1** Kaplan–Meier survival curve of death-censored graft failure (DCGF) with corresponding numerical table of the number at risk at 1, 5, and 8 years post-transplant.




| Years | Donor 0-20 years | Donor >20-40 years | Donor >40-60 years | Donor >60 years |
|---|---|---|---|---|
| 0 | 139 | 246 | 433 | 219 |
| 1 | 119 | 203 | 349 | 177 |
| 5 | 67 | 115 | 192 | 83 |
| 8 | 38 | 61 | 105 | 41 |

**Figure 2** Kaplan–Meier survival curve of patient death with corresponding numerical table of the number at risk at 1, 5, and 8 years post-transplant.

followed by acute rejection (10.2%) and recurrence of glomerulonephritis (3.8%). Of recipients receiving kidneys from donors aged >60 years, 52.4% and 7.1% of graft loss were attributed to CAN and acute rejection respectively, compared with 37.5% and 25.1% respectively in recipients of kidneys from donors aged 0–20 years, 44.0% and 8.0% respectively in recipients of kidneys from donors aged >20–40 years and 44.6% and 9.5% respectively in recipients of kidneys from donors aged >40–60 years. The presence of delayed graft function was associated with a significantly greater risk of overall and DCGF. There was no association between time on dialysis, peak PRA, HLA-mismatches, race, pretransplant modality, comorbidities and induction therapy with overall or DCGF.

If recipient age was included as a covariate in the adjusted model for overall graft failure (adjusted HR for recipient age 1.06, 95% CI 1.03, 1.10; $P = 0.001$), there was still an association between donor age >20–40 and graft failure (donor 0–20 – HR 0.69, 95% CI 0.46, 1.04; donor >20–40 – HR 0.69, 95% CI 0.49, 0.99 [$P = 0.04$]; donor >40–60 – HR 0.78, 95% CI 0.58, 1.05; donor >60 – HR 1.00). If recipient age was included as a covariate in the adjusted model for DCGF (adjusted HR for recipient age 1.05, 95% CI 0.95, 1.15; $P = 0.34$), there was still an association between donor age >20–40 and DCGF (donor 020 – HR 0.74, 95% CI 0.25, 2.14; donor >20–40 – HR 0.30, 95% CI 0.10, 0.95 [$P = 0.04$]; donor >40–60 – HR 0.67, 95% CI 0.31, 1.42; donor >60 – HR 1.00).

*Patient death*

There was no association between donor age groups and the risk of patient death in both unadjusted and adjusted models (Tables 2 and 3 and Fig. 2). In those with failed grafts, there was no association between donor age groups and time from graft loss to death ($P = 0.097$). Donor, recipient and transplant-related characteristics associated with a higher risk of patient death and/or death with functioning graft include diabetes and earlier transplant eras. There was no association between time on dialysis, peak PRA, HLA-mismatches, race, pretransplant modality, induction therapy, and delayed graft function with patient death.

If recipient age was included as a covariate in the adjusted model for death (adjusted HR for recipient age 1.06, 95% CI 1.02, 1.10; $P = 0.002$), there was still no association between donor age groups and death (donor 0–20 – HR 0.75, 95% CI 0.48, 1.17; donor >20–40 – HR 0.88, 95% CI 0.60, 1.28; donor >40–60 – HR 0.87, 95% CI 0.63, 1.21; donor >60 – HR 1.00).

If donor age was stratified into <50 and ≥50 years, there was an association between donor age groups and overall graft failure (donor <50 years – adjusted HR 0.73, 95% CI 0.62, 0.88; 95% CI; $P = 0.008$) and DCGF (donor <50 years – adjusted HR 0.81, 95% CI 0.57, 0.91; $P = 0.010$), but not for patient death (donor <50 years – adjusted HR 0.80, 95% CI 0.62, 1.04; $P = 0.10$).

## Discussion

We have demonstrated that patient survival of renal transplant recipients ≥60 years was not affected by donor age despite a greater risk of premature graft loss in recipients receiving kidneys from older donors. We had considered all renal transplant recipients ≥60 years as a single group because if the matching of donor and recipient age were being contemplated in organ allocation, older recipients using a single age cut-off (e.g., Eurotransplant Senior Program focused on recipients >65 years) would have been considered as a single group. Nevertheless, even if recipient age was adjusted for in the adjusted model, the association between donor age and outcomes was similar.

It is well established that patients with ESKD of all ages benefit from kidney transplantation. Analysis of single center and registry data indicate the risk of mortality post-transplant is significantly less than ESKD patients maintained on dialysis, and this benefit persisted even in older renal transplant recipients of extended criteria donor (ECD) kidneys [16,17]. Previously, we have reported registry data demonstrating that renal transplant recipients ≥55 years had more than a 2.5-fold increase in death with functioning graft compared with recipients <55 years (HR 2.84, 95% CI 1.97, 4.10 for 0–1 year; HR 2.78, 95% CI 2.19, 3.53 for 1–8 years and HR 4.44, 95% CI 3.10, 6.35 for >8 years; all *P*-values <0.01). Furthermore, grafts from donors ≥60 years were associated with a >50% increased risk of death with functioning graft across all age groups [18]. Retrospective analysis of the OPTN database demonstrated that for every 1 year increase in donor age, the risk of death with functioning graft (HR 1.004, $P < 0.001$) was significantly increased [19]. Analysis of the Eurotransplant Senior Program demonstrated that the Eurotransplant Senior Program recipients had significantly lower 1 and 5 year patient survival compared with 'old-to-any' (i.e., recipients of any age receiving a donor kidney of ≥65 years) and 'any-to-old' (i.e., recipients aged between 60–64 years receiving donor kidneys of any age) transplants allocated via Eurotransplant Kidney Allocation System or ETKAS (86% and 60% vs. 88% and 71% vs. 90% and 74% respectively; $P < 0.05$). However, within the EKTAS group, older recipients receiving younger donor kidneys had better patient survival compared with those receiving older donor kidneys [11,17]. In contrast, our study has demonstrated that patient survival among renal transplant recipients ≥60 years receiving younger and older donor kidneys was similar suggesting that donor age may not have the same detrimental effect on older renal transplant recipients than in younger counterparts. The discrepancy in study findings may be partly attributed to the limited use of donor kidneys >75 years (2.5% of overall donor kidneys) in Australia, which has been shown to be associated with poorer patient survival [20]. However, it is somewhat surprising to find no association between time on dialysis and patient death or graft failure and suggest that time on dialysis appears to be more important in younger recipients with longer expected survival compared with older recipients with shorter survival.

According to the Eurotransplant Senior Program, the 1 and 5 year death-censored graft survival in Eurotransplant Senior Program recipients (1 and 5 years 83% and 67% respectively) were inferior compared with 'any-to-old' recipients (1 and 5 years 90% and 81% respectively) [11]. A retrospective single center analysis of a subgroup of the Eurotransplant Senior Program demonstrated that donor kidneys aged ≥75 years transplanted into recipients aged ≥65 years had similar 5 year graft and patient survival as Eurotransplant Senior Program recipients receiving kidneys from donors aged 65–74 years and EKTAS-allocated donor kidneys to recipients aged ≥60 years [21]. Similarly, our study demonstrated that renal transplant recipients ≥60 years receiving kidneys from older donors were at a greater risk of premature graft loss compared with those receiving kidneys from younger donors. Not surprisingly, kidneys from older donors were associated with significantly poorer graft function post-transplant. Older donor kidneys, with reduced functional renal reserve in addition to lower nephron mass and/or numbers may progressively lose renal mass resulting in continuing graft loss over time [22]. There have been multiple studies suggesting that premature graft loss and/or poorer post-transplant graft function were associated with an increased risk of mortality [23,24], but in our study, despite a higher risk of premature graft loss and poorer graft function in renal transplant recipients ≥60 years receiving older donor kidneys compared with younger donor kidneys, this did not translate to an increased risk of death. There was no significant association between DCGF and eGFR at 1 year and patient death in the adjusted model (data not shown) suggesting that these factors may have a lesser impact on the survival of older recipients. The proportion of graft loss attributed to acute rejection/CAN or other causes were similar across all donor age groups and do not explain the differences in graft loss among younger and older donor age groups. However, ANZDATA does not collect information on the management of recipients with CAN or poorer graft functions at 1 year or collect information of biopsy results at different timepoints if available. It may be appropriate to consider performing preimplantation biopsies (to decide whether single or dual kidney should be used) and/or modification of immunosuppression (including reducing CNI or switch from CNI to proliferation signal inhibitors in appropriate recipients) for older donor kidneys.

Furthermore, renal transplant recipients receiving younger donor kidneys appear less immunogenic compared with older kidneys, possibly related to the observation that antigens expressed by injured tissue (i.e., older donor kidneys) may elicit and activate a greater immune response compared with 'normal' tissue (i.e., younger kidneys; 25).

With the recognized detrimental effect of older donor kidneys on graft survival coupled with the shorter life expectancy of older renal transplant recipients, allocation of kidneys based on age-matching would result in a preferential allocation of younger donor kidneys to younger recipients and older donor kidneys to older recipients thereby potentially improving patient survival in younger recipients without affecting the survival in older recipients. Such allocation policy could potentially prevent 'wasted' graft function in allocating younger donor kidneys to older recipients, as the kidneys would continue to function in longer surviving younger recipients. Analysis of the Scientific Registry of Transplant Recipient database of primary deceased donor renal transplants performed between 1990 and 2002 demonstrated that in older recipients aged 60–64 years receiving younger donor grafts, there was an overall average of 2009 graft years lost to death with functioning graft relative to potential graft survival if younger donor grafts were reallocated to younger recipients. The authors calculated that by avoiding allocation of young donor grafts to older recipients, there would be an increased overall graft life by 27 500 graft years, with estimated cost savings in excess of one billion dollars [26]. In our study, the finding of poorer graft survival in older grafts >60 years was not attributed to patient death. In Table. 3, the adjusted hazard ratios for each donor age groups for overall graft failure and DCGF were similar, reaching statistical significance only for donor age >20–40 years compared with donor age >60 years. The clinical relevance of this finding was that patient survival of recipients ≥60 years was not affected by premature graft loss if they had received grafts >60 years compared with younger grafts, indicating that if grafts >60 years were to preferentially be allocated to recipients ≥60 years, this would have no impact on patient survival. The finding of our study may further add to the argument that age-matching allocation should be strongly considered.

The strengths of this study included the very large sample size and inclusiveness. We included all older renal transplant recipients in Australia during the study period, such that a range of centers was included with varying approaches to transplantation. This greatly enhanced the external validity of our findings. These strengths should be balanced against the study's limitations, which included limited depth of data collection. ANZDATA does not collect important information, such as patient compliance, amount of immunosuppression or severity of comorbidities. Even though we had adjusted for a large number of donor, patient and transplant-associated characteristics, the possibility of residual confounding could not be excluded. In common with other Registries, ANZDATA is a voluntary Registry and there is no external audit of data accuracy, including the diagnosis of acute rejection and delayed graft function. Consequently, the possibility of coding/classification bias cannot be excluded. Selection bias resulting from clinicians' and patients' preferences for transplantation (e.g., selection criteria) and immunosuppression type may also occur.

With the continuing increase of older ESKD patients being accepted for renal replacement therapy in Australia, there is likely to be an increase in the number of older patients being accepted onto the deceased donor transplant wait list. With a corresponding growth in the availability of older donor kidneys and the observed lack of association between donor age and patient survival in older renal transplant recipients, preferential allocation of older donor kidneys to older recipients may improve overall functioning graft years without disadvantaging the life expectancy of older recipients.

## Authorship

Wai Lim, Gursharan Dogra: designed research/study, analyzed data and wrote paper. Steve Chadban, Scott Campbell, Solomon Cohney, Philip Clayton, Graeme Russ and Stephen McDonald: wrote paper.

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