Early Graft Loss Following Transplantation From Expanded Criteria Donors

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Background. Expanded criteria donor (ECD) kidneys are associated with higher graft loss rates than standard criteria donor kidneys. We sought to determine factors associated with early graft loss and their discrimination ability for this outcome compared with kidney donor risk index. **Methods.** Data were extracted from the Australia and New Zealand Dialysis and Transplant Registry (ANZDATA) for ECD transplants between 1997 and 2014. The primary outcome was early graft loss (all-cause graft loss within 3 y of transplantation). Death-censored graft loss was substituted as a sensitivity analysis. Era-adjusted odds ratios were calculated by multivariable logistic regression for donor, recipient, and transplant factors available at transplantation. Discrimination was assessed by c-statistic, with 95% confidence intervals (CIs) calculated by bootstrapping. **Results.** Of 2152 ECD kidney transplants, early graft loss occurred in 406 (19%) and was associated with recipient diabetes, smoking, First Nations recipients, and oliguria. Of factors defining ECD (age, elevated terminal creatinine, hypertension, death from cerebrovascular accident), all but mode of death were associated with early graft loss. The multivariable model, including known donor, recipient, and transplant factors, was moderately good at predicting early graft loss (c-statistic 0.65; 95% CI, 0.62-0.68). Recipient factors (c-statistic 0.62; 95% CI, 0.59-0.65) performed equally well compared with donor factors (c-statistic 0.60; 95% CI, 0.57-0.64) or the kidney donor risk index (c-statistic 0.60; 95% CI, 0.56-0.63). **Conclusions.** Early graft loss occurs in approximately one-fifth of ECD kidney transplants. The discriminatory value of commonly used recipient, donor, and transplant factors are approximately comparable and limited.

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INTRODUCTION

The use of expanded criteria donors (ECDs) has been an important part of increasing the donation rate over the past decade, with about one-third of deceased donor kidneys being composed of ECDs, both in Australia and overseas.[1] This reflects an aging recipient and donor pool in whom comorbidities are more common and is also a recognition among the transplant community that despite worse graft survival among recipients of ECD kidneys, there is a survival advantage compared with maintenance dialysis.[2] Kidney allocation systems also consider utility and ECDs remain beneficial from this perspective. By allocating ECD kidneys to older kidney transplant candidates

with a projected shorter life expectancy and conversely, organs from younger donors to younger recipients, fewer organs are discarded, and a maximum benefit realized from each donation.[3,4]

Although long-term outcomes are reasonable and expanding the donor pool has advantages, the risk of death-censored graft loss is increased by about 85% among recipients of ECD compared with standard criteria deceased donor kidneys, and a proportion of ECD recipients will experience early graft loss.[5,6] When early graft loss occurs, there is likely no net benefit to transplantation, given that much of the advantage of kidney transplantation is accrued after the first year posttransplant.[7] Both recipient and donor factors may be important in predicting poor graft outcomes. To inform decision making and kidney allocation processes, risk prediction tools such as the kidney donor risk index (KDRI) can be of benefit. In Australia, a version of the US KDRI is used, although alternate models such as the UK KDRI perform similarly well in this population.[8,9]

Data about the importance of individual components of the KDRI and recipient factors are conflicting, and both donor and recipient factors may impact the translation of risk.[10] In this study, we aimed to determine the performance of the KDRI in predicting early graft loss among recipients of ECD kidneys, determine which individual donor factors predict early graft loss, and evaluate any additional benefit of incorporating recipient and transplant factors.

MATERIALS AND METHODS

Population

Recipients of an ECD kidney between 1997 and 2014, with either graft loss within the first 3 y following transplantation or at least 3 y of follow-up were included. Data were extracted from the Australia and New Zealand Dialysis and Transplant Registry (ANZDATA), described in detail elsewhere.[11] ECDs were defined as donors >60 y; or 50–59 y with 2 of the following: hypertension, cerebrovascular accident (CVA) as a cause of death, or a terminal creatinine of >150 g/dL (132 µmol/L). Multiorgan transplant recipients and those with a history of prior transplantation were excluded. The study was approved by the University of Western Australia Human Research Ethics Committee. The clinical and research activities being reported are consistent with the Principles of the Declaration of Istanbul as outlined in the "Declaration of Istanbul on Organ Trafficking and Transplant Tourism."

Outcomes

The primary outcome was graft loss within 3 y of transplantation, a threshold based on data indicating it takes this long to accrue a survival benefit from ECD transplantation compared with waiting on dialysis for a non-ECD.[7] Death-censored graft loss within 3 y of transplantation was examined as a sensitivity analysis.

Exposures of Interest

The following donor variables were included: age, sex, height, weight, diabetes, hypertension, smoking, terminal creatinine, cerebrovascular accident as mode of death, oliguria (<20 mL/h for 12 h), donation after circulatory death (DCD), and a positive hepatitis C core antibody test (history of hepatitis C infection). The following recipient variables were included: age, sex, diabetes at time of transplantation, obesity (body mass index >30 kg/m² or according to International Obesity Taskforce reference values for recipients <18 y old) at time of transplantation, smoking, ethnicity, and primary disease.[12] The following transplant characteristics were included: en-bloc or dual transplantation (hereafter referred to as dual transplantation), era, ischemic time, delayed graft function (defined as the need for dialysis within 72 h of transplantation), and the total number of HLA mismatches (one field).

The Australian KDRI is based on the US KDRI but without race or hepatitis C because of the different racial composition of the Australian population and separate allocation for organs from donors with active hepatitis C (formula available in the Supplementary material, Australian KDRI calculator, SDC, http://links.lww.com/TXD/A373).[9] KDRI was classified by quintile because the relationship between KDRI and graft survival is known to be nonlinear.[8]

Statistical Analysis

Normally distributed variables were expressed as mean and SD, otherwise median and interquartile range (IQR) were used. Logistic regression was used to compare the odds of graft loss within 3 y of transplantation. These results were presented as odds ratios (ORs) with 95% confidence intervals (CIs) about the estimate. Univariable and era-adjusted analyses were performed and presented for all variables. A multivariable model was then constructed, including those variables defining ECD (age, smoking history, death by CVA, current creatinine) and any variables with a $P \leq 0.05$, by likelihood ratio test in the era-adjusted model. Delayed graft function was excluded from the multivariable model as it lay on the causal pathway for multiple other variables. Variance inflation factors were used to check for colinearity in the final model. Model fit was further assessed graphically by calibration curves. Model accuracy was compared using the c-statistic, deviance, and Akaike information criterion. Bootstrap corrected CIs and optimism corrected values were calculated for the c-statistic for the purpose of internal validation. Analyses were performed using R V.4.0 (R Core Team, Vienna, Austria).

RESULTS

Participant Characteristics

There were 2152 recipients who received ECD kidneys during the study period. The median recipient age was 54 y (IQR, 45–62), the youngest recipient in the cohort was 2 y old and the oldest 78 y old. The median donor age was 63 y (IQR, 60–68) and median KDRI was 1.85 (IQR, 1.64–2.11) (Table 1). Most donors met the ECD criteria due to age alone (≥60 y, 1683 donors, 78%); 777 (46%) and 642 (38%) of these had 1 or 2 additional risk factors defining ECD, respectively. There were 469 (22%) transplants from 50- to 59-y-old donors with 2 or more risk factors defining ECD; 24 donors in this group had all 3 risk factors (5%). Donation occurred after circulatory death in 302 (14.0%) transplants.

Early graft loss was experienced by 406 recipients (19%) at a median of 9 mo following transplantation (IQR, 1–21 mo) (Figures S1 and S2, SDC, http://links.lww.com/TXD/A373: Kaplan–Meier curves overall and by KDRI). Of these, 159 recipients died with a functioning graft (7% of all recipients, 39% of total graft loss). The next most common cause of graft loss was rejection, resulting in 24% (n = 99) of total

TABLE 1.

Donor, recipient, and transplant characteristics

	No early loss (n = 1746)	Early loss (n = 406)	P
Recipient characteristics			
Age (y)	54 (44–62)	55 (45–63)	0.2
Sex (male)	1132 (65%)	268 (66%)	0.7
Diabetes	314 (18%)	108 (27%)	<0.0001
Smoking (current or former)	830 (48%)	221 (45%)	0.01
Obesity	378 (22%)	109 (27%)	0.02
Ethnicity			
Caucasian	1327 (76%)	273 (67%)	
Asian	248 (14%)	50 (12%)	Group
Māori	28 (2%)	16 (4%)	<0.0001
Pacific	40 (2%)	18 (4%)	
Other	34 (2%)	8 (2%)	
ATSI	64 (4%)	41 (10%)	
Primary disease			
Diabetic nephropathy	223 (13%)	80 (20%)	
Hypertension	287 (17%)	38 (9%)	Group
Glomerulonephritis	761 (44%)	160 (39%)	<0.0001
Cystic kidney disease	97 (6%)	27 (7%)	
Other	376 (22%)	101 (25%)	
Donor characteristics			
Age (y)	63 (60–67)	64 (60–69)	<0.01
Sex (male)	908 (52%)	233 (57%)	0.05
Height (cm)	170 (163–176)	170 (163–177)	0.8
Weight (kg)	80 (70–90)	80 (70–86)	0.3
Diabetes	168 (10%)	42 (10%)	0.7
Hypertension	943 (55%)	233 (59%)	0.1
Smoking (current or former)	1052 (61%)	224 (56%)	0.09
Current creatinine >132 µmol/L	193 (11%)	62 (15%)	0.02
Mode of death (CVA)	1371 (80%)	323 (80%)	0.8
DCD	254 (15%)	48 (12%)	0.2
Oliguria (12 h <20 mL/h)	266 (15%)	86 (21%)	<0.01
Hep C (Ab +ve)	3 (0.2%)	4 (1%)	0.03
Transplant characteristics			
En-bloc or dual	57 (3%)	21 (5%)	0.06
Era			
1997–2002	291 (17%)	91 (22%)	
2003–2006	252 (14%)	72 (18%)	Group
2007–2010	375 (22%)	91 (22%)	0.001
2011–2015	828 (47%)	152 (37%)	
Ischemic time (h)	13 (10, 16)	14 (11, 17)	<0.001
Delayed graft function	544 (32%)	214 (53%)	<0.0001
HLA mismatches	4 (2, 5)	4 (2, 5)	0.3

Results presented as median interquartile range and mean (SD) for continuous variables based on distribution, or n (category %) for categorical variables.
Ab, antibody; ATSI, Aboriginal and Torres Strait Islander; CVA, cerebrovascular accident; DCD, donation after circulatory death.

graft loss. There were 107 recipients (5% of all recipients, 26% of total graft loss) whose graft failed within 30 d, suggesting primary nonfunction or an early catastrophic event (n = 78; 74% of these were reported as having delayed graft function). Vascular events, such as renal artery or vein thrombosis, were the most common cause of graft loss among this group (n = 39, 36%), followed by acute tubular necrosis (21, 20%). Graft failure within 30 d was no different for DCD compared with non-DCD transplants (2.6% compared with 5.4%, P = 0.05).

Predictors of Early Graft Loss

Multiple recipient, donor, and transplant factors were associated with early graft loss (Table 2). The addition of adjustment for era did not materially alter any of the univariable estimates of effect.

Recipient diabetes was a strong predictor of graft loss (era-adjusted OR, 1.85; 95% CI, 1.43 to 2.39, P < 0.0001), and consistent with this, diabetic nephropathy as the primary cause of kidney failure was associated with an increased risk of graft loss compared with any other etiology (group P < 0.0001). Recipient obesity predicted an increased risk of graft loss (era-adjusted OR, 1.49; 95% CI, 1.15-1.92; P < 0.01). Recipient ethnicity was a strong predictor (group P < 0.0001) with Māori (era-adjusted OR, 2.82; 95% CI, 1.47-5.24), Pacific people (era-adjusted OR, 2.25; 95% CI, 1.47-5.24), and Aboriginal and Torres Strait Islander (ATSI) people (era-adjusted OR, 3.07; 95% CI, 2.02-4.64) all having over

TABLE 2.

Early graft loss—univariable and era-adjusted analyses

	Univariable, odds ratio (95% CI)	P	Era-adjusted, odds ratio (95% CI)	P
Recipient characteristics				
Age (per 10 y)	1.05 (0.96-1.15)	0.3	1.09 (1.00-1.19)	0.06
Sex (male)	1.05 (0.84-1.33)	0.7	1.05 (0.84-1.33)	0.7
Diabetes	1.65 (1.28-2.12)	<0.001	1.85 (1.43-2.39)	<0.0001
Smoking (current or former)	1.31 (1.06-1.63)	0.01	1.33 (1.07-1.65)	0.01
Obesity	1.33 (1.03-1.70)	0.03	1.49 (1.15-1.92)	<0.01
Ethnicity				
Caucasian	Ref		Ref	
Asian	0.98 (0.70-1.35)	Group	1.03 (0.73-1.42)	Group
Māori	2.78 (1.45-5.14)	<0.0001	2.82 (1.47-5.24)	<0.0001
Pacific	2.19 (1.21-3.82)		2.25 (1.24-3.94)	
Other	1.14 (0.49-2.38)		1.23 (0.52-2.57)	
ATSI	3.11 (2.05-4.69)		3.07 (2.02-4.64)	
Primary disease				
Diabetic nephropathy	Ref		Ref	
Hypertension	0.78 (0.47-1.26)	Group	0.76 (0.46-1.24)	Group
Glomerulonephritis	0.59 (0.43-0.80)	<0.0001	0.51 (0.37-0.70)	<0.0001
Cystic kidney disease	0.37 (0.24-0.56)		0.34 (0.22-0.52)	
Other	0.75 (0.53-1.05)		0.67 (0.48-0.95)	
Donor characteristics				
Age (per 10 y)	1.26 (1.07-1.48)	<0.01	1.30 (1.10-1.53)	<0.01
Sex (male)	1.24 (1.00-1.55)	0.05	1.22 (0.98-1.52)	0.07
Height (per 10 cm)	1.01 (0.91-1.13)	0.8	1.01 (0.91-1.13)	0.9
Weight (per 10 kg)	0.97 (0.90-1.03)	0.3	0.97 (0.91-1.04)	0.5
Diabetes	1.09 (0.75-1.54)	0.7	1.12 (0.77-1.59)	0.5
Hypertension	1.18 (0.94-1.47)	0.1	1.17 (0.94-1.47)	0.2
Smoking (current or former)	0.83 (0.67-1.03)	0.1	0.84 (0.67-1.05)	0.1
Current creatinine >132 μmol/L	1.45 (1.06-1.96)	0.02	1.43 (1.04-1.94)	0.03
Mode of death (CVA)	1.03 (0.79-1.36)	0.83	0.95 (0.73-1.26)	0.7
DCD	0.79 (0.56-1.09)	0.1	0.95 (0.67-1.34)	0.8
Oliguria (12 h <20 mL/h)	1.50 (1.14-1.96)	<0.01	1.39 (1.05-1.82)	0.02
Transplant characteristics				
Dual	1.62 (0.95-2.66)	0.08	1.76 (1.03-2.91)	0.04
Era				
1997–2002	Ref			
2003–2006	0.91 (0.64-1.30)	Group		
2007–2010	0.78 (0.56-1.08)	<0.01		
2011–2015	0.59 (0.44-0.79)			
Ischemic time (per hour)	1.04 (1.02-1.07)	<0.001	1.03 (1.01-1.06)	0.02
Delayed graft function	2.46 (1.98-3.07)	<0.0001	2.53 (2.03-3.16)	<0.0001
HLA mismatches	1.04 (0.98-1.11)	0.2	1.06 (1.00-1.14)	0.06

ATSI, Aboriginal and Torres Strait Islander; CI, confidence interval; CVA, cerebrovascular accident; DCD, donation after circulatory death.

twice the odds of early graft loss compared with Caucasus. There was no difference in the cause of graft failure by ethnicity ($P = 0.6$).

Of the donor factors defining ECD, age (era-adjusted OR, 1.30/10 y of age; 95% CI, 1.10-1.53; $P < 0.01$) and current creatinine >132 μmol/L strongly predicted graft loss (era-adjusted OR, 1.43; 95% CI, 1.04-1.94; $P = 0.03$). Donor hypertension was associated with an increased risk of graft loss (era-adjusted OR, 1.17; 95% CI, 0.94-1.47; $P = 0.2$), which was greater in the multivariable model (multivariable model OR 1.29, 95% CI, 1.01-1.64; $P = 0.04$). Oliguria was associated with a similar risk (era-adjusted OR, 1.39; 95% CI, 1.05-1.82; $P = 0.02$). No other donor factor had a substantial impact on outcomes.

Transplant era was a strong predictor of outcome, with the odds of graft loss being less among more recent recipients (2011–2015 OR, 0.59; 95% CI, 0.44-0.79; group $P < 0.01$). Increasing ischemic time (era-adjusted OR, 1.03/h; 95% CI, 1.01-1.06; $P = 0.02$) was associated with an increased risk, as was delayed graft function (era-adjusted OR, 2.53; 95% CI, 2.03-3.16; $P < 0.0001$).

The estimates of effect were mostly similar between the era-adjusted and multivariable model (Table 3), with the exception of ethnicity (25% and 27% lower in the multivariable compared with the era-adjusted model for Māori, and ATSI people, respectively) and recipient obesity (22% lower in the multivariable compared with the era-adjusted model).

Model Accuracy and Discrimination

Recipient and donor factors were equally good discriminators of graft loss (c-statistic 0.62 [95% CI, 0.59-0.65] compared with 0.60 [95% CI, 0.57-0.64]) (Table 4). However,

TABLE 3.

Early graft loss—multivariable model

	Effect size (95% CI)	*P*
Recipient characteristics		
Age (per 10 y)	1.08 (0.98-1.20)	0.1
Smoking (current or former)	1.22 (0.97-1.55)	0.09
Obesity	1.22 (0.92-1.61)	0.2
Ethnicity		
Caucasian	Ref	
Asian	1.03 (0.70-1.47)	Group
Māori	2.05 (1.00-4.05)	<0.01
Pacific	2.08 (1.09-3.81)	
Other	1.19 (0.47-2.64)	
ATSI	2.31 (1.42-3.70)	
Primary disease		
Diabetic nephropathy	Ref	
Hypertension	0.77 (0.44-1.33)	Group
Glomerulonephritis	0.66 (0.47-0.95)	<0.01
Cystic kidney disease	0.43 (0.27-0.69)	
Other	0.83 (0.57-1.23)	
Donor characteristics		
Age (per 10 y)	1.38 (1.15-1.66)	<0.001
Sex (male)	1.22 (0.96-1.55)	0.1
Hypertension	1.29 (1.01-1.64)	0.04
Current creatinine >132 μmol/L	1.56 (1.09-2.22)	0.02
Mode of death (CVA)	1.00 (0.74-1.37)	0.9
Oliguria (12 h <20 mL/h)	1.35 (1.00-1.82)	0.05
Transplant characteristics		
Dual	1.19 (0.65-2.09)	0.6
Era		
1997–2002	Ref	
2003–2006	0.90 (0.61-1.31)	Group
2007–2010	0.76 (0.53-1.10)	<0.01
2011–2015	0.55 (0.39-0.79)	
Ischemic time (per hour)	1.02 (1.00-1.05)	0.08
HLA mismatches	1.02 (0.94-1.10)	0.7

ATSI, Aboriginal and Torres Strait Islander; CI, confidence interval; CVA, cerebrovascular accident.

even the full multivariable model, including recipient, donor, and transplant factors, was only moderately good at discriminating between cases with and without graft loss (c-statistic 0.65; 95% CI, 0.62-0.68). KDRI was categorized in quintiles because the relationship with graft loss was nonlinear (Figure 1). It was a similarly good predictor of graft loss as the donor model including oliguria (KDRI quintile model c-statistic 0.60; 95% CI, 0.56-0.63). Discrimination for the model including transplant factors only was slightly worse than for recipient or donor factors alone (c-statistic 0.58; 95% CI, 0.55-0.61). Calibration plots were consistent with a linear model fit (Figures S3–S8, SDC, http://links.lww.com/TXD/A373).

Sensitivity Analyses

Increasing recipient age predicted a greater risk of graft loss (era-adjusted OR, 1.09/10 y of age; 95% CI, 1.00-1.19; *P* = 0.06). However, the direction of effect was reversed in sensitivity analyses when graft loss was censored for death (era-adjusted OR, 0.87; 95% CI, 0.79-0.97; *P* < 0.01), indicating that death with a functioning graft was the main driver of this relationship (Table S1, SDC, http://links.lww.com/TXD/A373). Otherwise, there were no important differences between models with death-censored graft loss as the

outcome compared with those presented in the main analysis (all-cause graft loss). There was no interaction between recipient or donor age and KDRI (*P* values for interaction terms in era-adjusted models 0.3 and 0.2, respectively).

DISCUSSION

Among over 2000 recipients of ECD kidneys, 19% of allografts failed within 3 y of transplantation. This represents a substantial proportion among whom there was likely no net benefit to transplantation. Using donor, recipient, and transplant factors available at the time of transplantation, the ability to predict this outcome was limited. We found that recipient factors were as useful as donor factors in discriminating between cases who did and did not have early graft loss.

The ability of any model to predict early graft loss was moderately good at best, with a c-statistic of 0.65 for the multivariable model including donor, recipient, and transplant factors. The performance of KDRI was similar to that obtained for total graft survival among the deceased donor population.[9] In addition to the factors comprising KDRI, oliguria was also a predictor of outcome. However, there was little improvement in model discrimination with the addition of oliguria.

Recipient factors were as important as donor factors. A model including recipient smoking status, obesity, ethnicity, and primary disease accounted for slightly more variability in the outcome, and with similar discrimination, to a model including donor factors only (c-statistic 0.62 compared with 0.60). Recipient diabetes or diabetic nephropathy as the primary cause of kidney failure was a strong predictor, with diabetic kidney disease carrying 3 times the odds of early graft loss compared with the lowest risk group, recipients with cystic kidney disease. This difference was consistent with other populations, persisted after adjustment in the multivariable model, and was similar in sensitivity analyses with death-censored graft loss as the outcome.[13] A similar increase in risk was seen for ATSI recipients, closely followed by Māori recipients. Pacific people also had an increased risk of early graft loss. Some of this difference was due to confounding from other variables in the model, as indicated by the 25% reduction in effect size between the era-adjusted and multivariable models. However, the OR remained above 2.0 for ATSI, Māori, and Pacific recipients in the fully adjusted model, which is consistent with broader disparities in transplant access and outcomes. These have been discussed in detail elsewhere but include a number of modifiable risk factors such as access to culturally appropriate care and systemic barriers that are currently being reviewed by the National Indigenous Kidney Transplantation Taskforce.[14,15] Recipient smoking and obesity were less strong predictors of early graft loss.

Compared with other regions, the use of ECD kidneys in Australia has exceeded 20% of deceased donors since 1996, and currently, 27% of deceased donors are ECDs. The use of ECD kidneys in New Zealand has increased more recently and is now at a similar level.[16] The outcome data reported here, 81% 3-y total graft survival, are consistent with international experience. A systematic review of ECD outcomes for transplants performed during a similar period overseas demonstrated a total 3-y graft survival of 72%.[10] However, in Europe, this was 84% compared with 68% in North America, with the health system in Australia and New Zealand being more analogous to that in Europe. The proportion of graft losses due to death with a functioning allograft was close to

Model accuracy and discrimination

	c-statistic (95% CI)	Optimism corrected c-statistic[a]	Deviance (% difference)	AIC
Full multivariable model	0.65 (0.62-0.68)	0.62	1805	1853
Recipient factors	0.62 (0.59-0.65)	0.60	1837 (2%)	1869
Donor factors	0.60 (0.57-0.64)	0.58	1863 (3%)	1883
KDRI quintiles	0.60 (0.56-0.63)	0.58	1869 (3%)	1885
Transplant factors	0.58 (0.55-0.61)	0.57	1876 (4%)	1890
Donor age	0.58 (0.55-0.61)	0.57	1880 (4%)	1890

Multivariable model and factors from Table 3, all models adjusted for era. Recipient factors—smoking, obesity, ethnicity, primary disease. Donor factors—age, hypertension, current creatinine, mode of death, oliguria. Transplant factors—dual, era, ischemic time.
[a]Optimism corrected by 10-fold cross-validation, 20 repetitions.
AIC, Akaike information criterion; CI, confidence interval (calculated by bootstrap [n = 10 000]); KDRI, kidney donor risk index.
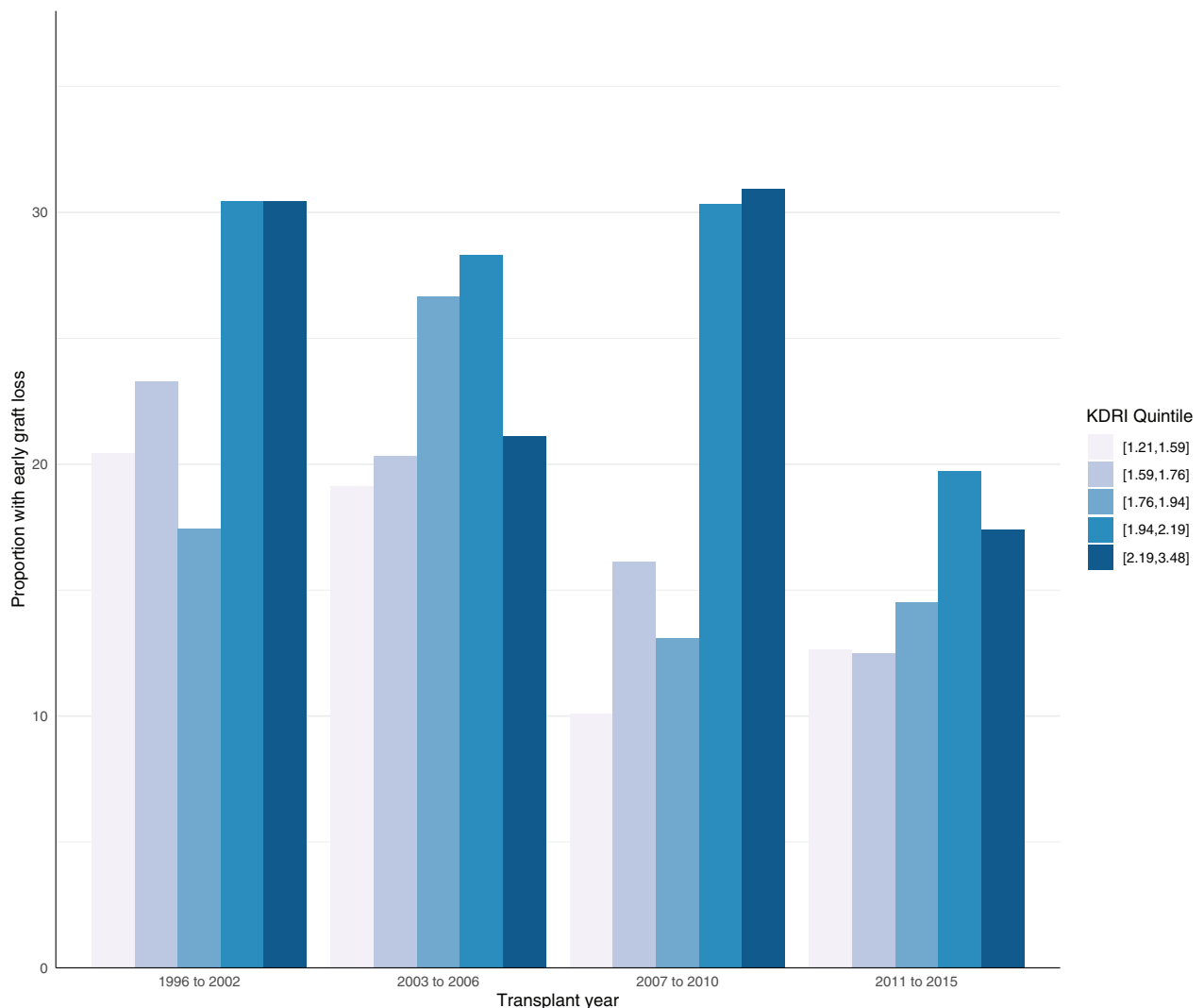
FIGURE 1. Observed probability of early graft loss by era and KDRI. KDRI, kidney donor risk index.

that seen among the overall transplant population, despite the limited period of observation.[16] Graft loss within 30 d was less common than reported among other cohorts (5% compared with 10%), with these very early losses most commonly due to acute tubular necrosis or vascular events.[17] We were unable to validate that ECD kidneys are more sensitive to cold ischemia time than kidneys from non-ECDs. Nevertheless,

this observation in other cohorts has led to interest in the use of machine perfusion technologies targeting ECDs, with improvements in the incidence of delayed graft function but not early graft loss in early data thus far.[18-20]

Era had a large impact on survival, with a 40% lower odds of early graft loss among recipients of ECDs from 2011 to 2015. Although we adjusted for era in all but the

labeled univariable analyses, residual confounding cannot be excluded. The use of registry data from ANZDATA avoided selection bias due to inclusion of nearly all kidney units in Australia and New Zealand. However, limitations in the detail of data collected mean confounding due to unmeasured factors such as adherence was possible.

Our ability to predict early graft loss among recipients of ECD kidneys remains limited. Recipient, donor, and transplant-related factors are all important in determining the likelihood of early graft loss. Undue emphasis should not be placed upon KDRI alone when considering ECD offers. The risk of accepting a given ECD kidney needs to be balanced against expected survival on dialysis, and for many people with kidney failure, ECD kidneys provide an important path to transplantation. Further research is required into causes of early allograft loss, particularly among groups known to be at high risk for this outcome.

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