NEPHROLOGY 2008; **13**, 535–540 doi:10.1111/j.1440-1797.2008.01011.x

Original Article

Pre-emptive renal transplantation from living donors in Australia: Effect on allograft and patient survival

CAROLINE A MILTON,[1] GRAEME R RUSS[2] and STEPHEN P MCDONALD[2]

[1]Department of Renal Medicine, Flinders Medical Centre, and [2]ANZDATA Registry and Department of Nephrology and Transplantation Services, The Queen Elizabeth Hospital, Adelaide, South Australia, Australia

SUMMARY:

Aim: Pre-emptive renal transplantation has become the preferred first-line therapy for patients with end-stage kidney failure. This study examines the outcome of allograft and patient survival in pre-emptive transplantation compared with non-pre-emptive transplantation from living donors in Australia and New Zealand.

Methods: We have performed a retrospective study using the Australian and New Zealand Dialysis and Transplantation Registry. Allograft and patient survival were compared at 1, 5 and 10 years in pre-emptive transplantation and non-pre-emptive transplantation following a living donor transplant.

Results: Allograft survival at 1, 5 and 10 years post pre-emptive transplantation was better than post non-pre-emptive transplantation (multivariate hazard ratio (HR) 0.80 [95% confidence interval 0.64–0.99], $P = 0.036$). Pre-emptive transplantation was associated with a significant patient survival advantage over non-pre-emptive transplantation when analysed from the time of transplantation and adjusted for age and gender (multivariate HR 0.46 [0.27–0.80], $P = 0.006$). Patient survival for pre-emptive transplantation and non-pre-emptive transplantation was 97% [0.95–0.98] and 93% [0.91–0.94] at 5 years and 93% [0.88–0.96] and 84% [0.82–0.87] at 10 years post transplant respectively. There was no difference in the overall rejection rate between pre-emptive transplantation and non-pre-emptive transplantation. Vascular rejection was less common in pre-emptive transplantation (HR 0.70 [0.50–0.98], $P = 0.04$).

Conclusion: Pre-emptive transplantation from a living donor is associated with both better allograft and patient survival compared with transplantation after a period of dialysis. Pre-emptive transplantation should be the preferred modality of renal replacement therapy in patients who have a living donor.

KEY WORDS: **living donor, rejection, renal transplantation.**

Renal transplantation in patients with end-stage kidney failure (ESKF) offers a better survival and quality of life than long-term dialysis.[1,2] Undergoing transplantation without prior dialysis avoids the morbidity, mortality and costs associated with dialysis. In Australia, living donor (LD) transplants continue to increase and now account for 39% of all renal transplants, of which 34% are pre-emptive.[2]

Mange *et al.*, using the United States Renal Data System, has demonstrated both a patient survival and allograft survival advantage in patients having an LD pre-emptive transplant (PET) when compared with those having an LD non-PET.[3] These findings have been reproduced in Europe by the Collaborative Transplant Study and Oxford Transplant Centre[4,5] and several other studies.[6–12]

Controversy exists as to whether PET is associated with a reduced risk of rejection when compared with non-PET. Mange *et al.*[3,12,13] demonstrated an increased risk of rejection with increased duration of dialysis. Other groups in the USA have not been able to demonstrate this.[7]

We analysed data from Australia and New Zealand using the Australian and New Zealand Dialysis and Transplantation Registry (ANZDATA) to determine whether there is an allograft and patient survival advantage in PET compared with non-PET from an LD. The episodes of rejection in the first 6 months post transplant have been reviewed in the PET and non-PET groups for more recent transplants.

Correspondence: Dr Caroline A Milton, Department of Renal Medicine, Flinders Medical Centre, Bedford Drive, Bedford Park, SA 5042, Australia. Email: caroline.milton@fmc.sa.gov.au

Work attributed to: Department of Nephrology and Transplantation Services, The Queen Elizabeth Hospital, 28 Woodville Road, Woodville, SA 5001, Australia.

Accepted for publication 21 May 2008.

METHODS

The ANZDATA registry includes all patients who are residents of Australia or New Zealand and receive chronic renal replacement therapy (RRT). Details of the data collection methods are available elsewhere.[14] This study included all patients in Australia and New Zealand who commenced RRT between April 1991 and December 2005 and underwent a first kidney transplant from an LD in this period. This group were divided into those who received a PET (without a prior period of dialysis) and those whose transplant followed a period of dialysis.

The demographics of the patients in each group were compared using *t*-tests for continuous variables and chi-square tests for categorical variables. Graft survival and patient survival were examined at 1, 5 and 10 years post transplant. Graft survival included deaths with a functioning graft, and patient survival included all reported patient deaths (before and after loss of graft function). Graft function at 6 and 12 months post transplant was assessed with calculated creatinine clearance (from the Cockcroft-Gault formula[15] and compared using two sample *t*-tests. For grafts performed after April 1997 and before June 2005, episodes of rejection in the first 6 months were also reported. The presence of any rejection for these grafts was examined as a dichotomous outcome variable with multiple logistic regression.

In univariate analysis individual variables and their association with graft survival and patient survival were analysed using log-rank tests, with hazard ratios derived from a Cox model. Multivariate Cox regression models for graft and patient survival were created based on the variables assessed in the univariate analysis, with stepwise removal of terms with a *P*-value of <0.2. Cox models of graft and patient outcome had standard errors adjusted for clustering within centre using 'robust' techniques.[16] A *P*-value of 0.05 was taken to indicate statistical significance.

RESULTS

This study included 2603 patients, including 578 recipients of a PET (22%) and 2025 non-PET from an LD.

Patient demographics

The PET patients differed from the non-PET patients in both their baseline characteristics and comorbidities (Table 1). The estimated glomerular filtration rate (eGFR) at the time of commencement of RRT was higher in the PET patients than the non-PET patients. This difference was also reflected in the lower creatinine value at the time of transplantation in the PET group compared with the creatinine at the commencement of dialysis in the non-PET group (Table 1).

The PET patients were younger at both the time of transplantation and commencement of RRT when compared with the non-PET patients. They were less likely to be a current or previous smoker, to be of indigenous racial

Table 1 Demographics of PET and non-PET patients

Variables	Pre-emptive ($n = 578$)	Non-pre-emptive ($n = 2025$)	*P*-value
Age at transplant (years)	35.0 [33.7–36.4]	37.7 [37.0–38.4]	<0.001
Age at commencement of RRT (years)	35.0 [33.7–36.4]	36.1 [35.4–36.8]	0.16
Serum creatinine (μmol/L)	646.8 [628.7–664.8]	906.4 [885.9–927.0]	<0.001
GFR (mL/min) at commencement of RRT	13.1 [12.6–13.6]	9.9 [9.6–10.1]	<0.001
Non-indigenous	97%	93%	<0.001
Indigenous			
Aboriginal/Torres Strait Islander	0%	2%	
Maori/Islander	2%	5%	
Coronary artery disease	3%	7%	<0.001
Peripheral vascular disease	1%	4%	<0.001
Diabetes			
Type 1	3%	4%	
Type 2	2%	5%	0.02
Hypertension	91%	95%	0.000
Chronic lung disease	2%	4%	0.1
Cerebrovascular disease	1%	2%	0.068
Body mass index (kg/m^2)	23.7 [23.4–24.1]	23.9 [23.7–24.2]	0.18
Cigarette smoking			
Current	5%	10%	0.000
Former	22%	24%	
Never	73%	66%	
Late referral	3%	18%	0.000
Donor age (years)	46.4 [45.5–47.3]	45.7 [45.2–46.1]	0.17
Donor sex (female)	57%	56%	0.54
Donor age greater than 50 years	37%	40%	0.31
Unrelated donor (includes spousal)	26%	25%	0.665
Vascular rejection	8.49%	13.12%	0.009

The values are presented as mean [95% confidence interval] where appropriate. GFR, glomerular filtration rate; PET, pre-emptive transplant; RRT, renal replacement therapy.

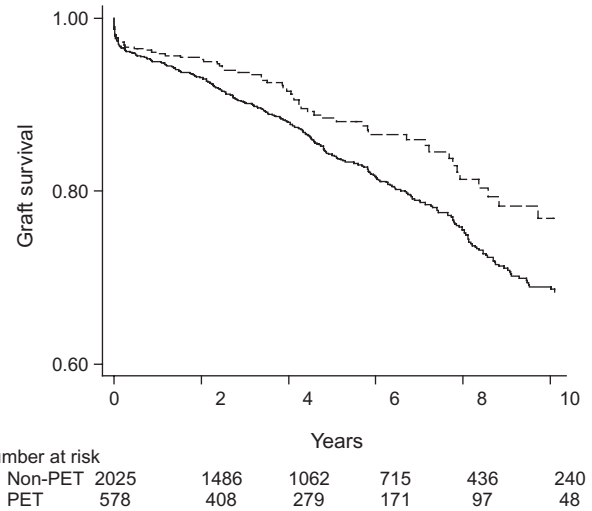

Fig. 1 Allograft survival: Kaplan–Meier graph of allograft survival for LD recipients comparing allograft survival in the (– – –) PET and (——) non-PET groups. LD, living donor; PET, pre-emptive transplant.

origin or to have a late presentation to a nephrologist. They had fewer comorbidities, including coronary artery disease, peripheral vascular disease, hypertension and type 1 diabetes at the time of transplantation (Table 1).

Allograft survival

The PET group had better allograft survival when compared with the non-PET group (Fig. 1, Table 2). This effect remained after adjustment for other factors which predict graft survival (hazard ratio (HR) 0.80 [95% confidence interval 0.64–0.99], $P = 0.04$, Table 3).

There were several other factors identified in our cohort on multivariate analysis as being predictive of allograft failure (Table 3): the presence of peripheral vascular disease, indigenous racial origin, older donor age and higher number of human leucocyte antigen mismatches. Recipients below 25 years of age were more likely to have allograft failure.

To examine the effects of prolonged dialysis, a subgroup analysis of the non-PET group considering only patients who had less than 90 days of dialysis before receiving their transplant was performed ($n = 260$). This cohort was comparable with the PET patients in terms of comorbidities. When PET outcomes were compared with those in this early transplant group, the difference in graft survival was not significant (univariate HR 0.91 [0.60–1.38], $P = 0.67$; multivariate adjusted HR 0.93 [0.67–1.30], $P = 0.68$).

Patient survival

There were 175 deaths in the non-PET group (mortality rate 1.6 [1.4–1.9] per 100 patient-years), but only 17 deaths among the PET group (0.44 [0.24–0.81] per 100 patient-years, $P = 0.006$). There was a significant patient survival advantage in the PET group compared with the non-PET group when analysed from the time of transplantation (HR 0.46 [0.27–0.80], $P = 0.006$) (Fig. 2, Table 4). The 5 year survival in the PET and non-PET groups was 97% and 93% and 10 year survival 93% and 85% respectively (Table 2).

When comparisons of the patient survival among the PET group were made with the subgroup who were transplanted within 90 days of commencing dialysis, there was no difference in the patient survival between the two groups, (univariate HR 0.49 [0.20–1.21], $P = 0.121$; multivariate HR 0.65 [0.29–1.47], $P = 0.30$).

Allograft rejection

There were 1826 grafts performed in the time period when biopsy results for rejection were being collected. There was no difference between the two groups in the rates of biopsy proven rejection in the first 6 months post transplant. In the PET group an episode of rejection occurred at a rate of 34% and in the non-PET group 35%. After adjustment for potential confounders in a multiple logistic regression was performed, there was still no relationship. Vascular rejection was less common in the PET group. However, the number of observations was small with only 37 episodes in the PET group and 191 in the non-PET group. Nevertheless, after adjustment for other covariates an association remained (adjusted HR 0.70 [0.50–0.98], $P = 0.04$). There was no relationship between the duration of dialysis and frequency of vascular rejection.

Allograft function

There was no difference in graft function at 6 and 12 months post transplant between the PET and non-PET groups (mean serum creatinine at 6 months of 131 μmol/L in the PET group *vs* 133 μmol/L in the non-PET group, $P = 0.21$) (Table 2). The corresponding calculated creatinine clearances at 6 months were 62 mL/min in the PET group and 60 mL/min in the non-PET group (Table 2). Similarly, there were no differences in the serum creatinine or calculated creatinine clearance at 12 months (Table 2).

DISCUSSION

A pre-emptive transplant from an LD in Australia and New Zealand was associated with better allograft and patient survival when compared with non-PET LD transplants.

The patient survival advantage seen in PET is clinically important and continues throughout the period of observation. At 5 years post transplant there is a nearly 5% difference in survival between PET and non-PET (97% survival compared with 93% survival) increasing to a 10% difference at 10 years (93% compared with 84% survival).

The cause of the difference in allograft and patient survival between PET and non-PET LD is not clear. Avoidance of dialysis may contribute to the improved outcome in patient survival and fewer episodes of vascular rejection to the improved outcome in allograft survival in PET. Brief

Table 2 Allograft survival, patient survival and serum creatinine post transplant

	Pre-emptive transplant	Non-pre-emptive transplant
Allograft survival, % [95% CI]		
One year post transplant	96 [0.94–0.97]	95 [0.94–0.96]
Five years post transplant	88 [0.85–0.91]	84 [0.82–0.86]
Ten years post transplant	77 [0.7–0.83]	69 [0.66–0.72]
Patient survival, % [95% CI]		
One year post transplant	99 [0.98–0.10]	98 [0.98–0.99]
Five years post transplant	97 [0.95–0.98]	92 [0.91–0.94]
Ten years post transplant	93 [0.88–0.96]	85 [0.82–0.87]
Serum creatinine (μmol/L), mean [95% CI]		
Six months post transplant	131 [127–135]	133 [131–136]
Twelve months post transplant	135 [126–144]	135 [132–138]

CI, confidence interval.

Table 3 Risk factors for graft failure following PET and non-PET†

Variables	Univariate, HR [95% CI]	Multivariate, HR [95% CI]
Pre-emptive transplant	0.71 [0.59–0.86], $P < 0.001$	0.80 [0.64–0.99], $P = 0.036$
HLA mismatches (per mismatch)	1.13 [1.10–1.17], $P < 0.001$	1.14 [1.07–1.21], $P < 0.001$
Indigenous		
Aboriginal/Torres Strait Islander	3.06 [2.13–4.40], $P < 0.001$	4.01 [2.80–5.74], $P < 0.001$
Maori/Islander	1.98 [1.22–3.22], $P = 0.006$	1.61 [1.05–2.49], $P = 0.030$
Coronary artery disease	2.11 [1.46–3.07], $P < 0.001$	1.62 [0.99–2.65], $P = 0.053$
Peripheral vascular disease	3.20 [2.19–4.68], $P < 0.001$	2.39 [1.57–3.66], $P < 0.001$
Diabetes§		
Type 1	1.39 [0.98–1.98], $P = 0.068$	
Type 2	2.27 [1.57–3.27], $P < 0.001$	
Hypertension	0.93 [0.63–1.38], $P = 0.725$	
Chronic airways limitation§	1.21 [0.72–2.03], $P = 0.480$	
Cerebrovascular disease	2.65 [1.39–5.07], $P = 0.003$	1.86 [0.86–4.02], $P = 0.114$
Body mass index§ (per 1 kg/m^2)	1.01 [0.99–1.03], $P = 0.506$	
Current cigarette smoking‡	1.48 [1.10–1.98], $P = 0.009$	1.47 [1.0–2.16], $P = 0.052$
Late referral§	1.31 [0.98–1.75], $P = 0.066$	1.33 [0.97–1.83], $P = 0.073$
Donor age over 50§	1.16 [0.96–1.41], $P = 0.130$	1.01 [1.00–1.02], $P < 0.013$
Living unrelated donor	1.23 [0.96–1.58], $P = 0.106$	

†In addition to the indicated variables, the multivariate model was also adjusted for age category and year of transplantation. ‡Former and never smokers were combined. §Chronic lung disease, body mass index, diabetes, late referral and donor age were sequentially dropped from the multivariate model. CI, confidence interval; HLA, human leucocyte antigen; HR, hazard ratio; PET, pre-emptive transplant.

durations of dialysis were not associated with an increased risk, but prolonged exposure to dialysis (≥90 days) was associated with increased allograft failure and increased risk of patient death post LD transplant. The mediators of this might include more rapid development of comorbidities or alternatively progressive immunologic changes in patients who have ongoing exposure to dialysis. We suspect dialysis exposure increases comorbidities and predicts patient death even after successful transplantation. It is possible the patients on dialysis accumulate increased risk for coronary artery disease and peripheral vascular disease through vascular calcification and ongoing hypertension. Dialysis may increase the risk of patient death and allograft failure through other means not yet understood.

There was no difference between overall rejection rates in the PET and non-PET groups at 6 months. Vascular rejection was less common in the PET group. This may explain the difference in allograft survival in our cohort. It has been previously shown that it is vascular rejection rather than all cause rejection that is associated with graft loss.[17] Mange *et al.* has previously demonstrated an increased risk of rejection with increased duration of dialysis.[3] Given the small number of observations in our dataset this analysis should be repeated in the future when a larger number of observations is available.

The rates of comorbidities that predict patient survival in our cohort were different among the PET and non-PET patients. The non-PET patients had higher rates of coronary artery disease and peripheral vascular disease, both of which increase the risk of patient death in our cohort. These factors were corrected for in the analysis and PET continued to have a better patient survival than non-PET; however,

residual confounding remains a possibility. A subgroup analysis was performed comparing the patient survival among the PET group with a subgroup of the non-PET patients who were transplanted within 90 days of commencing dialysis. These two groups were comparable in terms of comorbidities which predict patient death and there was no difference in patient survival between the PET and group who had short-term dialysis. This analysis supports the theory that ongoing dialysis increases the risk of patient death following an LD transplant.

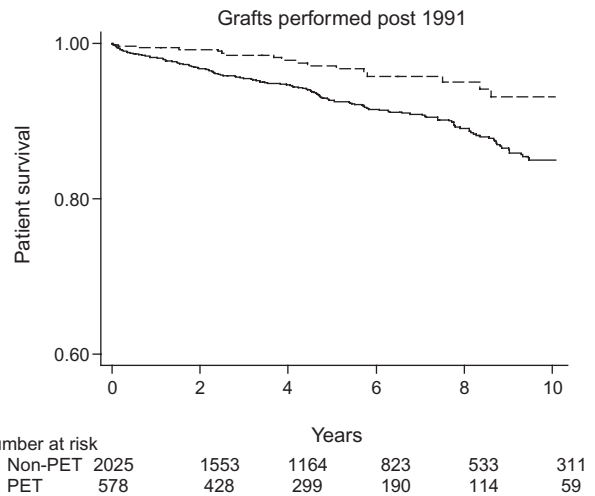

Fig. 2 Patient survival: Kaplan–Meier graph of patient survival for LD recipients (restricted to grafts performed after 1991) by pre-emptive graft. (– – –) PET, (——) non-PET. LD, living donor; PET, pre-emptive transplant.

Residual renal function is important in patient survival in the dialysis population.[18–20] The PET patients had a higher (native kidney) eGFR at the time of transplantation. If this was additive with the allograft function then it could explain the increase in time to renal failure post transplant in the PET patients. However, the mean calculated GFR at 6 and 12 months was the same in both the PET and non-PET groups in our cohort. Ishani *et al*. demonstrated no correlation between pre- and post-transplant GFR and no benefit of a higher GFR pre transplant on allograft survival.[21] Gill *et al*. also showed no difference in six monthly GFR levels in PET compared with non-PET patients.[22] We are not aware of a study that addresses the origin of renal function (native *vs* allograft) post transplant in patients having a PET; however, native residual renal function appears to decrease rapidly post transplant.[21–23] It is unlikely that native residual renal function and hence a difference in eGFR is contributing to the improved allograft and patient survival in our cohort.

The differences in baseline characteristics between the two groups is not unexpected, having been described by other groups.[24] The PET patients are younger, have fewer comorbidities and are less likely to have a late presentation of their renal failure. While there was a difference in comorbidities between the PET and non-PET groups, the overall incidence of each comorbidity assessed was still low in both groups. The only exception to this was hypertension which was high in both groups (Table 1). That indigenous patients were less likely to have a PET was also not unexpected. In Australia, indigenous patients are more likely to have a late presentation of their ESKF, are less likely to have an LD, and

Table 4 Risk factors for patient death following PET and non-PET

Variables	Univariate, HR [95% CI]	Multivariate, HR [95% CI]
Pre-emptive transplant	0.39 [0.24–0.61], $P < 0.001$	0.46 [0.27–0.80], $P = 0.006$
Age	1.04 [1.03–1.05], $P < 0.001$	1.02 [1.00–1.04], $P = 0.042$
Non-Caucasian		
Aboriginal/Torres Strait Islander	2.36 [1.22–4.58], $P = 0.011$	
Maori/Islander	2.35 [1.39–3.98], $P = 0.001$	
HLA mismatches (per mismatch)	1.35 [1.18–1.54], $P < 0.001$	1.29 [1.16–1.42], $P < 0.001$
Body mass index (kg/m^2)	1.04 [1.01–1.07], $P = 0.009$	
Coronary artery disease	3.52 [2.03–6.10], $P < 0.001$	1.95 [1.02–3.71], $P = 0.042$
Peripheral vascular disease	5.35 [3.28–8.73], $P < 0.001$	2.14 [1.19–3.83], $P = 0.011$
Diabetes		
Type 1	2.45 [1.65–3.63], $P < 0.001$	1.61 [0.89–2.90], $P = 0.116$
Type 2	3.37 [2.12–5.35], $P < 0.001$	1.68 [0.95–2.99], $P = 0.076$
Hypertension	0.46 [0.25–0.82], $P = 0.009$	
Chronic airways limitation	2.32 [1.25–4.32], $P = 0.008$	
Cerebrovascular disease	3.49 [2.09–5.84], $P < 0.001$	1.68 [0.81–3.49], $P = 0.165$
Late referral	1.26 [0.88–1.80], $P = 0.208$	1.52 [1.04–2.23], $P = 0.030$
Donor age over 50 years	1.20 [0.94–1.54], $P = 0.149$	
Donor sex (male)	0.97 [0.73–1.29], $P = 0.821$	
Unrelated donor	2.00 [1.40–2.87], $P < 0.001$	

CI, confidence interval; HLA, human leucocyte antigen; HR, hazard ratio; PET, pre-emptive transplant.

once on the transplant list they are less likely to receive a transplant then a non-indigenous patient.[25]

Lead time bias might affect comparisons of graft and patient survival. Ubiquitous to registry data, it is not amenable to adjustment in this form of analysis where entry into a Registry is dependent on commencing RRT. Ishani considered the possibility of lead time bias in his data and was unable to show an effect.[21] Selection bias may also contribute, if patients having a PET have fewer comorbidities that impact on both allograft function and patient survival.

To eliminate the disadvantages of an observational study, a randomized prospective trial (beginning at the same level of renal function to address lead time bias) with patients randomly allocated to PET or non-PET would be required to address allograft and patient survival. This is unlikely to occur as it would be unethical to randomize a patient with an LD to dialysis, particularly given the higher mortality rate during dialysis treatment compared with deceased donor transplantation.[2,26]

Our findings in the Australian and New Zealand data demonstrate a clear allograft and patient survival advantage for patients with ESKF having a PET compared with non-PET. While the mechanisms contributing to the improved outcome are uncertain, there are clear advantages to a patient in avoiding dialysis and having a PET. In addition, PET avoids the morbidity associated with uraemia, dialysis access and long-term dialysis. PET from an LD should be considered the optimal RRT for patients with ESKF.

ACKNOWLEDGEMENTS

We gratefully acknowledge the contributions of the Australian and New Zealand nephrology community who provide information to, and maintain, the ANZDATA Registry database.

REFERENCES

1. Wolfe RA, Ashby VB, Milford EL *et al.* Comparison of mortality in all patients on dialysis, patients on dialysis awaiting transplantation, and recipients of a first cadaveric transplant. *N. Engl. J. Med.* 1999; **341**: 1725–30.
2. Australian and New Zealand Dialysis and Transplantation Registry (ANZDATA). 29th Annual Report, 2006 Report, 2005 Data. [Cited 21 June 2007.] Available from URL: http://www.anzdata.org.au
3. Mange KC, Joffe MM, Feldman HI. Effect of the use or non use of long-term dialysis on the subsequent survival of renal transplants from living donors. *N. Engl. J. Med.* 2001; **344**: 726–31.
4. Roake J, Cahill A, Gray C, Gray D, Morris P. Preemptive cadaveric renal transplantation-clinical outcome. *Transplantation* 1996; **62**: 1411–16.
5. Donelly P, Oman P, Henderson R, Opelz G. Predialysis living donor renal transplantation: Is it still the 'gold standard' for cost, convenience and graft survival. *Transplant. Proc.* 1995; **27**: 1444–6.
6. Cosio F, Alamir A, Yim S *et al.* Patient survival after renal transplantation: I. The impact of dialysis pre-transplant. *Kidney Int.* 1998; **53**: 767–72.
7. Papalois V, Moss A, Gillingham K, Sutherland D, Matas A, Humar A. Pre-emptive transplants for patients with renal failure: An argument against waiting until dialysis. *Transplantation* 2000; **70**: 625–31.
8. Meier-Kriesche H, Kaplan B. Waiting time on dialysis as the strongest modifiable risk factor for renal transplant outcomes. *Transplantation* 2002; **74**: 1377–81.
9. Asdersakis A, Augustine T, Dyer P *et al.* Pre-emptive kidney transplantation: The attractive alternative. *Nephrol. Dial. Transplant* 1998; **13**: 1799–1803.
10. Kasiske B, Snyder J, Matas A, Ellison M, Gill J, Kausz A. Preemptive kidney transplantation: The advantage and the advantaged. *J. Am. Soc. Nephrol.* 2002; **13**: 1358–64.
11. Offner G, Hoyer PF, Meyer B, Pichlmayr R, Brodehl J. Pre-emptive renal transplantation in children and adolescents 1993. *Transpl. Int.* 1993; **6**: 125–8.
12. Mange K, Weir M. Preemptive renal transplantation: Why not? *Am. J. Transplant* 2003; **3**: 1336–40.
13. Mange K, Joffe M, Feldmen H. Dialysis prior to living donor kidney transplantation and rates of acute rejection. *Nephrol. Dial. Transplant* 2003; **18**: 172–7.
14. Excell L, McDonald SP. *2004 Australia and New Zealand Dialysis and Transplant Registry Report*. Adelaide: ANZDATA Registry, 2004.
15. Cockcroft DW, Gault MH. Prediction of creatinine clearance from serum creatinine. *Nephron* 1976; **16**: 31–41.
16. Williams RL. A note on robust variance estimation for cluster-correlated data. *Biometrics* 2000; **56**: 645–6.
17. McDonald S, Russ G, Campbell S, Chadban S. Kidney transplant rejection in Australia and New Zealand: Relationships between rejection and graft outcome. *Am. J. Transplant* 2007; **7**: 1201–8.
18. Shemin D, Bostrom AG, Laliberty P, Dworkin LD. Residual renal function and mortality risk in hemodialysis patients. *Am. J. Kidney Dis* 2001; **38**: 85–90.
19. Wang AY, Lai KN. The importance of residual renal function in dialysis patients. *Kidney Int.* 2006; **69**: 1726–32.
20. Bargman JM, Golper TA. The importance of residual renal function for patients on dialysis. *Nephrol. Dial. Transplant* 2005; **20**: 671–773.
21. Ishani A, Ibrahim H, Gilbertson D, Collins A. The impact of residual renal function on graft and patient survival rates in recipients of preemptive renal transplants. *Am. J. Kidney Dis.* 2003; **42**: 1275–82.
22. Gill J, Tonelli M, Johnson N, Pereira B. Why do preemptive kidney transplant recipients have an allograft survival advantage? *Transplantation* 2004; **78**: 873–9.
23. Van Buren D, Burke J, Lewis R. Renal function in patients receiving long-term cyclosporine therapy. *J. Am. Soc. Nephrol.* 1994; **4**: S17–S22.
24. Weng FL, Mange KC. A comparison of persons who present for preemptive and non preemptive kidney transplantation. *Am. J. Kidney Dis.* 2003; **42**: 1050–57.
25. McDonald S. Indigenous transplant outcomes in Australia: What the ANZDATA Registry tells us. *Nephrology* 2004; **9**: S138–S143.
26. McDonald SP, Russ GR. Survival of recipients of cadaveric kidney transplants compared to dialysis treatment in Australia and New Zealand, 1991–2000. *Nephrol. Dial. Transplant* 2002; **17**: 2212–19.