ORIGINAL ARTICLE

Weekend effect on early allograft outcome after kidney transplantation- a multi-centre cohort study

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SUMMARY

Weekend surgery may be associated with a higher risk of early complications, but the effect of the timing of kidney transplant surgery on early allograft outcome remains uncertain. The aim of this study is to evaluate whether the association between weekend transplant surgery and allograft failure was modified by prevalent vascular disease. Using data from the Australia and New Zealand Dialysis and Transplant registry, we examined the association between weekend status and 90-day and 1-year allograft failure in deceased donor transplant recipients between 1994–2012. Two-way interaction between vascular disease and weekend status was examined. Of 6622 recipients, 1868 (28.2%) received transplants during weekends. Compared with weekday transplants, weekend transplants were associated with an adjusted hazard ratio (HR) for 90-day and 1-year allograft failure of 0.99 (0.78–1.25; $P = 0.917$) and 0.93 (0.76–1.13, $P = 0.468$), respectively. There was a significant interaction between prevalent vascular disease and weekend status for 90-day allograft failure ($P_{interaction} = 0.008$) but not at 1-year, such that patients with vascular disease were more likely to experience 90-day allograft failure if transplanted on weekend (versus weekdays), particularly failures secondary to vascular complications. Timing of transplantation does not impact on allograft outcome, although those with vascular disease may benefit from more intensive post-transplant follow-up for potential vascular complications.

Transplant International 2019; 32: 387–398

Key words
allograft loss, kidney transplantation, registry, vascular disease, weekend

Received: 8 May 2018; Revision requested: 20 June 2018; Accepted: 8 November 2018; Published online: 6 December 2018

Introduction

Limited availability of resources over the weekend in many hospitals, leading to substantial reduction in both routine services and staffing levels has been linked with poorer health outcomes. Previous epidemiological studies have consistently demonstrated an independent relationship between weekend medical and surgical hospital

doi:10.1111/tri.13377

admissions and adverse health outcomes. Patients presenting with acute medical emergencies including acute coronary events or strokes during weekends have higher rates of mortality compared to similar presentations during weekdays [1–3]. Similar adverse associations have also been observed for patients undergoing both elective and emergency surgical procedures suggesting the likely contribution of limited services and resources to poorer outcomes following surgical procedures undertaken during weekends [4,5].

The nature of deceased donor organ transplantation is often unpredictable, and frequently involves undertaking transplant surgery during weekends when there is reduced availability of routine health services. With increasing evidence showing a direct association between cold ischaemic time and adverse long-term graft and patient outcomes [6], surgeons and transplantation services are often placed under increasing pressure to expedite transplant surgery if donor organs were to become available, even over the weekend. In contrast with the observed phenomena of the adverse impact of weekend hospitalizations, short-term outcomes of kidney or liver transplants have not been shown to be affected by the timing of transplant surgery [7–9], although a recent single-centre study suggests that surgical complications were greater for weekend compared with weekday transplants [10]. With the findings that patients with prevalent coronary artery disease (CAD) and/or peripheral vascular disease (PVD) have higher risk of postoperative complications and poorer prognosis following vascular surgery [11,12], we therefore hypothesized that a similar finding of poorer short-term allograft outcome may be evident following kidney transplantation of patients with prevalent vascular disease, particularly during weekends where a less experienced or familiar multi-disciplinary transplant team may be operative and hospital staffing may be reduced. The aim of this study is to examine whether the association between kidney transplants performed on the weekends compared with weekdays for early allograft failure is modified by the presence of prevalent vascular disease and/or other vascular risk factors (such as diabetes and smoking history), particularly for early allograft failure attributed to vascular-related complications.

Materials and methods

Study population

Using data from the Australia and New Zealand Dialysis and Transplant (ANZDATA) registry, all primary deceased donor kidney transplant recipients in Australia and New Zealand between 1994 and 2012 were included in the analyses. Recipients of multiple organ allografts and live-donor kidney transplants were excluded. Recipients were categorized into two groups according to the day they had received their kidney transplants: weekdays (Monday to Friday) or weekends (Saturday and Sunday).

Data collection

Recorded baseline characteristics included recipient age, gender, race, body mass index (BMI), waiting time pre-transplant (in years), prevalent vascular disease (i.e. presence of CAD, cerebrovascular disease or PVD), vascular risk factors at time of transplant (diabetes and smoking history) and cause of end-stage kidney disease (ESKD); donor age and method of donor death [donation after brain-death (DBD) or donation after circulatory death (DCD)]; immunological characteristics included peak percentage panel reactive antibody (%PRA) and number of human leukocyte antigen (HLA)-mismatches at the ABDR loci; transplant-related factors such as total ischaemic time (in hours), use of induction therapy (including both interleukin-2 receptor antibody and T cell depleting antibody), transplant era and types of initial immunosuppressive agents [categorized as calcineurin-inhibitor (CNI; none, cyclosporin or tacrolimus), antimetabolite (none, azathioprine or mycophenolate) and prednisolone]. Transplant era was categorized into six groups for analysis (i.e. 1994–1997, 1998–2001, 2002–2005, 2006–2009, 2010–2012).

Clinical outcomes

The primary clinical outcome of this study was short-term overall allograft failure (i.e. 7, 30 and 90 days post-transplantation). Secondary outcomes include allograft failure at 90 days attributed to vascular complications (defined as failures secondary to renal artery or renal vein thrombosis, renal artery stenosis, haemorrhage and cortical necrosis post-transplant not related to rejection), allograft failure at 1 and 5 years post-transplantation, presence of delayed graft function (defined as requiring dialysis within the first week post-transplant) and acute rejection within 6 months of transplant. Causes of allograft failures were compared between weekday and weekend transplants.

Statistical analyses

Data were expressed as number (proportion), mean ± standard deviation (SD) or median [interquartile range (IQR)] where appropriate, with comparisons

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between groups examined by chi-square test, analysis of variance (ANOVA) or Kolmogorov–Smirnov test, respectively. The associations between weekdays vs. weekend transplants, allograft failure and acute rejection at 6 months were examined using the adjusted Cox proportional hazard regression analysis. The association between weekend status and delayed graft function was examined using an adjusted logistic regression analysis. Covariates associated with each clinical outcome with *P*-values of < 0.10 in the unadjusted analyses were included in the multivariable-adjusted analyses, although donor and recipient age, prevalent vascular disease, diabetes, total ischaemic time and waiting time were included in the adjusted models given their biological relationships with outcomes. In addition, shared frailty Cox regression models, accounting for the potential intra-cluster correlation within transplant states and country were undertaken for analysis involving allograft failure. Results were expressed as hazard ratio (HR) or odds ratio (OR) with 95% confidence interval (95% CI). Potential interactions between time of transplants and prevalent vascular disease or vascular risk factors of diabetes and smoking history were examined using two-way interaction term in the multivariate model, with *P*-value (for interaction) of < 0.01 indicating the presence of significant interaction.

Competing risk regression analyses were conducted for allograft failure at 90 days attributed to vascular complications using the method described by Fine and Gray [13]. The stratified proportional sub-distribution HRs (SHR) were calculated to estimate the exposure and covariate effects on the cumulative incidence function, adjusted for the competing risk of nonvascular causes of allograft failure. Covariates included in the competing risk models were identical to the Cox regression models.

Sensitivity analyses examining the associations between extended weekend status (i.e. defined as Friday, Saturday and Sunday) and total comorbid score (i.e. defined as the total number of comorbid conditions of CAD, PVD, cerebrovascular disease, diabetes and smoking history) with allograft failure were undertaken. All analyses were undertaken using SPSS V10 statistical software program (SPSS Inc., North Sydney, NSW, Australia) and STATA (version 11 StataCorp LP, College Station, TX, USA).

Results

Study population

There were 6622 recipients included in this study, of which 4754 (71.8%) and 1868 (28.2%) received kidney transplants during weekdays and weekends, respectively. Baseline characteristics and clinical outcomes of the study population according to day of transplants are shown in Table 1. Of these recipients, 371 (5.6%) and 540 (8.2%) experienced allograft failure at 90 days and 1 year, respectively. The proportion of recipients who had experienced allograft failure at 7 days (3.4% vs. 3.4%; $P = 0.989$), 90 days (5.6% vs. 5.6%; $P = 0.938$) and 1 year (8.3% vs. 7.8%; $P = 0.465$) was similar between those transplanted on weekdays compared to weekends. Donor, recipient and transplant-related characteristics were similar across weekday and weekend transplants. The proportion of recipients with prevalent vascular disease was similar in those transplanted on weekdays and weekends (15% vs. 15%; $P = 0.774$), with CAD being the most prevalent site-specific vascular disease. Less than 10% were DCD transplants and total ischaemic time was significantly shorter in weekend transplants (median 13 h vs. 14 h, $P = 0.009$) compared with weekday transplants.

Timing of transplant and risk of early allograft failure

Compared with weekday transplants, weekend transplants were associated with unadjusted and adjusted HRs for 90-day allograft failure of 1.03 (0.63, 1.67; $P = 0.906$) and 0.99 (0.78, 1.25; $P = 0.917$), respectively. The adjusted HRs for allograft failure at 7 days and 30 days were 1.01 (0.74, 1.37; $P = 0.946$) and 0.99 (0.76, 1.30; $P = 0.969$), respectively, for weekend transplants compared with weekday transplants. Covariates associated with 90-day allograft failures are shown in Table 2. In the shared frailty models, the estimates of early allograft failures for weekend transplants were similar, with adjusted HR for allograft failure at 7 days, 30 days and 90 days of 0.92 (0.64, 1.35; $P = 0.691$), 0.93 (0.68, 1.28; $P = 0.661$) and 0.94 (0.72, 1.23; $P = 0.670$), respectively, compared with weekday transplants. Kaplan–Meier curves for 90-day allograft failure stratified by weekend status are shown in Fig. 1a.

Timing of transplant and 1 and 5-year risk of allograft failure

Compared with weekday transplants, there were no associations between weekend transplants with 1-year [adjusted HR 0.93 (0.76, 1.13), $P = 0.468$] or 5-year allograft failure [adjusted HR 0.90 (0.79, 1.03), $P = 0.126$]. Covariates associated with 1-year allograft

Table 1. Baseline characteristic of weekday and weekend deceased donor kidney transplants between 1994–2012 (n = 6622).

	Weekday (n = 4754)	Weekend (n = 1868)	P-value
Demographics			
Age (years, mean ± SD)	47.3 ± 14.0	47.2 ± 13.8	0.669
Male (n, %)	2960 (62.3)	1159 (62.0)	0.869
Race (n, %)			
Caucasian	3733 (78.5)	1460 (78.2)	0.940
Indigenous	462 (9.7)	183 (9.8)	
Others	559 (11.8)	225 (12.0)	
Coronary artery disease (n, %)	478 (10.1)	194 (10.4)	0.688
Peripheral vascular disease (n, %)	286 (6.0)	100 (5.4)	0.300
Cerebrovascular disease (n, %)	149 (3.1)	63 (3.4)	0.620
Any prevalent vascular disease* (n, %)			
None	4042 (85.0)	1583 (84.7)	0.842
At least 1 site	712 (15.0)	285 (15.3)	
Body mass index (kg/m^2, n, %)			
0–20	606 (13.0)	212 (11.6)	0.454
>20–25	1735 (37.2)	688 (37.7)	
>25–30	1482 (31.8)	580 (31.8)	
>30	843 (18.0)	346 (18.9)	
Waiting time (years, mean ± SD)	3.5 ± 2.6	3.4 ± 2.6	0.615
Diabetes (n, %)	655 (13.8)	258 (13.8)	0.971
Smoker (n, %)			
Nonsmoker	2564 (54.3)	1002 (54.2)	0.986
Former smoker	1521 (32.2)	595 (32.2)	
Current smoker	636 (13.5)	252 (13.6)	
Cause of ESKD (n, %)			
Glomerulonephritis	2041 (42.9)	827 (44.3)	0.898
Diabetes	486 (10.2)	190 (10.2)	
Cystic	733 (15.4)	280 (15.0)	
Vascular	230 (4.8)	87 (4.7)	
Analgesic nephropathy	69 (1.5)	22 (1.2)	
Others	1195 (25.2)	462 (24.7)	
Donor characteristics			
Age (years, mean ± SD)	42.1 ± 17.5	42.9 ± 17.6	0.063
DCD (n, %)	378 (8.0)	145 (7.8)	0.798
Immunology/Transplant			
HLA-ABDR mismatches (n, %)			
0	193 (4.1)	71 (3.8)	0.887
1–2	1674 (35.3)	661 (35.4)	
3–6	2877 (60.6)	1133 (60.8)	
Peak PRA >50% (n, %)	506 (10.6)	196 (10.5)	0.246
Ischaemic time (hours)			
Mean ± SD	14.2 ± 5.0	13.7 ± 4.5	<0.001
Median (IQR)	14.0 (6.0)	13.0 (6.0)	0.009
Categories	220 (4.8)	82 (4.5)	0.003
0–6	1566 (33.9)	699 (38.2)	
7–12	2021 (43.7)	774 (42.4)	
13–18	818 (17.6)	273 (14.9)	
>18			
Induction (n, %)	2240 (47.1)	876 (46.9)	0.870
Transplant era (n, %)			
1994–1997	931 (19.6)	370 (19.8)	0.315
1998–2001	900 (18.9)	341 (18.3)	

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Table 1. Continued.

	Weekday (n = 4754)	Weekend (n = 1868)	P-value
2002–2005	903 (19.0)	396 (21.2)	
2006–2009	962 (20.2)	367 (19.6)	
2010–2012	1058 (22.3)	394 (21.1)	
Initial immunosuppression (n, %)			
Prednisolone	4542 (95.5)	1791 (95.9)	0.545
CNI			
None	170 (3.6)	53 (2.8)	0.299
Cyclosporin	2867 (60.3)	1145 (61.3)	
Tacrolimus	1717 (36.1)	670 (35.9)	
Anti-metabolite			
None	328 (6.9)	119 (6.4)	0.704
MMF/myfortic	3559 (74.9)	1400 (74.9)	
Azathioprine	867 (18.2)	349 (18.7)	

ESKD, end-stage kidney disease; HLA, human leukocyte antigen; PRA, panel reactive antibody; CNI, calcineurin-inhibitor, MMF, mycophenolate mofetil; DCD, donation after circulatory death.

Data expressed as number (proportion) or as mean ± SD or as median [interquartile range (IQR)].

*Includes any of coronary artery disease, cerebrovascular disease or peripheral vascular disease.

Table 2. Association between timing of transplantation (weekdays versus weekend), 90-day and 1-year allograft failures.

	90-day allograft failure Adjusted HR (95% CI; P-value)	1-year allograft failure Adjusted HR (95% CI; P-value)
Day of transplant		
Weekdays	1.00	1.00
Weekends	0.99 (0.78, 1.25; $P = 0.917$)	0.93 (0.76, 1.13; $P = 0.468$)
Prevalent vascular disease	1.25 (0.94, 1.67; $P = 0.123$)	1.40 (1.11, 1.76; $P = 0.004$)
Donor age (per 10-year increase)	1.25 (1.17, 1.34; $P < 0.001$)	1.21 (1.15, 1.28; $P < 0.001$)
Waiting time (per year increase)	1.05 (1.01, 1.10; $P = 0.010$)	1.04 (1.00, 1.07; $P = 0.045$)
Donation after circulatory death	0.64 (0.41, 1.03; $P = 0.065$)	0.74 (0.51, 1.07; $P = 0.109$)
Total ischaemic time (per hour increase)	1.05 (1.02, 1.07; $P < 0.001$)	1.04 (1.02, 1.06; $P < 0.001$)
Recipient age (per 10-year increase)	1.04 (0.95, 1.14; $P = 0.420$)	1.05 (0.98, 1.14; $P = 0.181$)
Diabetes	1.06 (0.78, 1.45; $P = 0.705$)	1.05 (0.81, 1.35; $P = 0.709$)
Ethnicity		
Caucasian	1.00	1.00
Asian/others	1.26 (0.90, 1.76; $P = 0.173$)	1.27 (0.96, 1.67; $P = 0.092$)
Indigenous	1.32 (0.94, 1.86; $P = 0.107$)	1.63 (1.25, 2.14; $P \leq 0.001$)
Smoking history		
Nonsmoker	1.00	1.00
Former smoker	1.20 (0.94, 1.53; $P = 0.134$)	1.14 (0.93, 1.40; $P = 0.199$)
Current smoker	1.33 (0.97, 1.81; $P = 0.072$)	1.39 (1.08, 1.78; $P = 0.010$)
Body mass index (kg/m^2)		
<20	1.20 (0.83, 1.73; $P = 0.336$)	1.20 (0.89, 1.60; $P = 0.229$)
20–24.9	1.00	1.00
25–29.9	1.04 (0.79, 1.37; $P = 0.773$)	0.96 (0.77, 1.20; $P = 0.716$)
≥30	1.60 (1.19, 2.14; $P = 0.002$)	1.29 (1.01, 1.65; $P = 0.043$)
HLA-mismatches	1.04 (0.97, 1.11; $P = 0.283$)	1.05 (0.99, 1.11; $P = 0.079$)

HLA, human leukocyte antigen.

Data are presented as adjusted hazard ratio (HR) with 95% CI and P-values.

failures are shown in Table 2. In the shared frailty models, the adjusted HR of 1- and 5-year allograft failure for weekend transplants were 0.89 (0.72, 1.11; $P = 0.309$) and 0.88 (0.77, 1.02; $P = 0.083$), respectively, compared with weekday transplants.

Timing of transplant, delayed graft function and acute rejection at 6 months

Compared with weekday transplants, there was no association between weekend transplants with delayed graft function (adjusted OR 0.99, 0.86, 1.13, $P = 0.890$) or acute rejection at 6 months (adjusted HR 0.93, 0.82, 1.06, $P = 0.269$).

Interaction between timing of transplant and prevalent vascular disease for early allograft failure

Prevalent vascular disease modified the associations between timing of transplant with 7-day (*P*-value for interaction 0.035), 30-day (*P*-value for interaction 0.007) and 90-day allograft failure (*P*-value for interaction 0.008); but not for allograft failures at 1 and 5 years. Given these interactions, separate models were constructed for patients with ($n = 997$; 15.1% of overall cohort) and without ($n = 5625$) prevalent vascular disease. In recipients with prevalent vascular disease, transplants that had occurred on the weekend were more likely to fail compared with transplants that had occurred on the weekday (Fig. 2). There was no association between weekend status and early allograft failure for recipients without prevalent vascular disease (Fig. 2). The estimates of the frailty models for recipients with prevalent vascular disease who have received transplants on the weekends were similar [7 days: adjusted HR 2.06 (1.03, 4.12, $P = 0.041$); 30 days: adjusted HR 2.11 (1.19, 3.72, $P = 0.010$); 90 days: adjusted HR 1.80 (1.11, 2.91, $P = 0.017$)]. There were no interactions between timing of transplants with diabetes or smoking history for allograft failure.

Causes of allograft failure

Figure 3 shows the causes of allograft failure post-transplant according to the timing of transplantation. Almost 50% of the allograft failures occurring within 7 days post-transplant on the weekend were attributed to vascular complications, compared with 17% for weekday transplants. The majority of the allograft failures attributed to vascular complications for weekend transplants

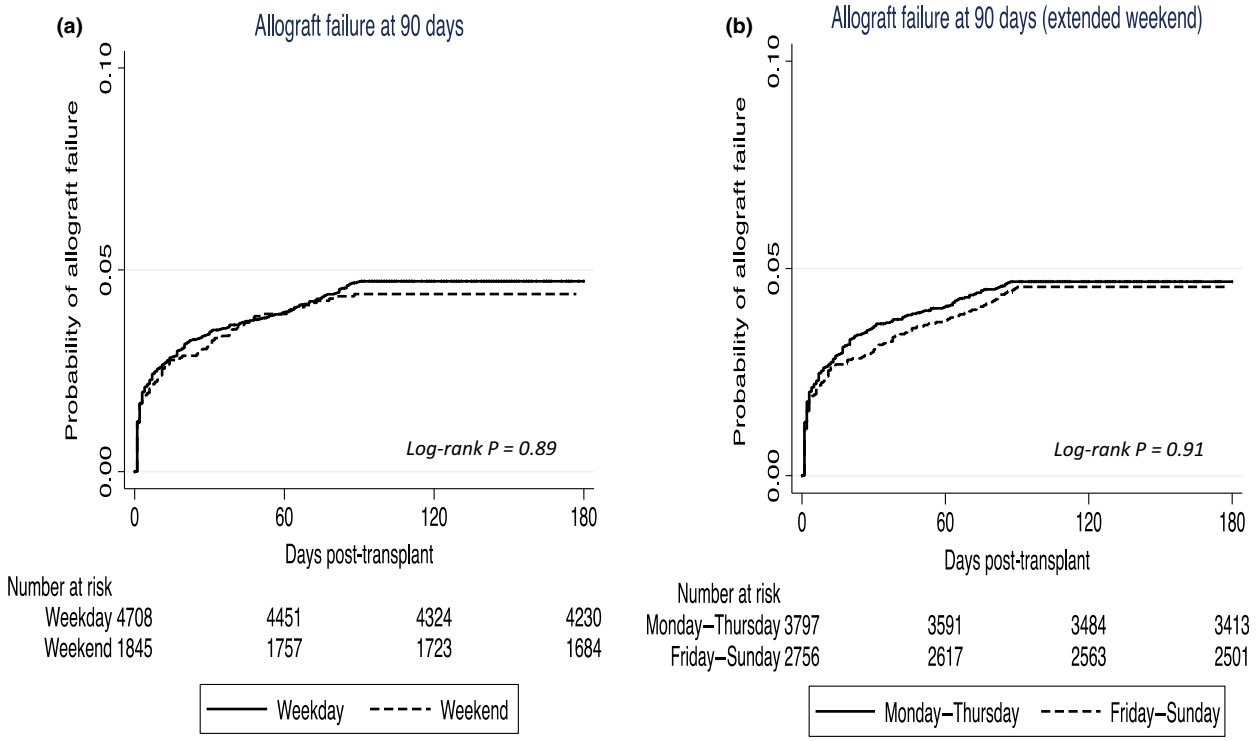

Figure 1 Adjusted Kaplan–Meier failure curves with number at risk tables for 90-day allograft failure, stratified by weekend status (a: weekday – Monday to Friday, weekend – Saturday and Sunday) and extended weekend status (b: weekday – Monday to Thursday, extended weekend – Friday to Sunday). Log-rank *P*-values are shown.

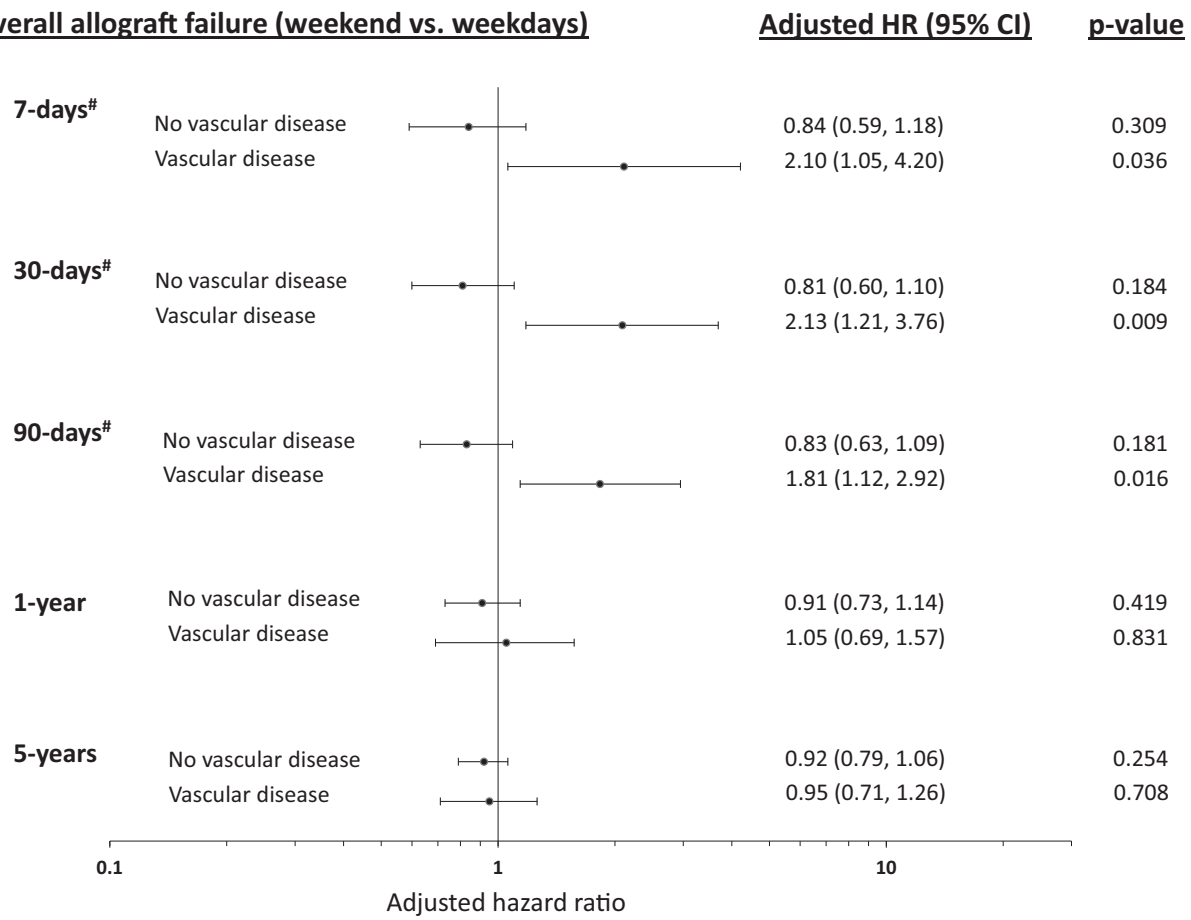

Figure 2 Forest plots showing the adjusted hazard ratio (HR) with 95% confidence intervals (95% CI) and corresponding *P*-values of weekend (versus weekday transplants) for allograft failure at 7, 30, 90 days, 1 and 5 years postkidney transplant, stratified by the presence of prevalent vascular disease in the recipients. #denote significant interactions between prevalent vascular disease and weekend status for allograft failures.

occurred within the first 7 days post-transplant ($n = 30$), with only two further allograft failures from vascular complications occurring between 7 and 90 days post-transplant.

Table 3 shows the causes of overall allograft failure at 90 days according to the timing of transplant surgery for the study cohort, and separately in those with and without prevalent vascular disease. In recipients with prevalent vascular disease, 3.2% of weekend transplants lost their allografts at 90-days from vascular complications, compared with 0.6% of weekday transplants.

Competing risk model for vascular-related allograft failure at 90 days

In the competing risk analysis, compared with weekday transplants, the adjusted SHR for 90-day allograft failure attributed to vascular complications for weekend transplants was 1.21 (0.78, 1.88; $P = 0.404$), accounting for the competing risk of nonvascular causes of allograft failure. When stratified by prevalent vascular disease, the adjusted SHR for vascular-related 90-day allograft failure was 4.59 (1.18, 17.79; $P = 0.028$) for those with prevalent vascular disease; and was 0.98 (0.60, 1.61; $P = 0.951$) for those without prevalent vascular disease. Figure 4 shows the adjusted cumulative incidence curves for 90-day allograft failure attributed to vascular-related complications, stratified by weekend status of the study cohort (Fig. 4a) and restricted to those with prevalent vascular disease (Fig. 4b).

Sensitivity analyses: extended weekend status and total comorbid score

Of 6622 kidney transplants, 2788 (42.1%) were undertaken between Friday and Sunday. Compared with weekday transplants, extended weekend transplants

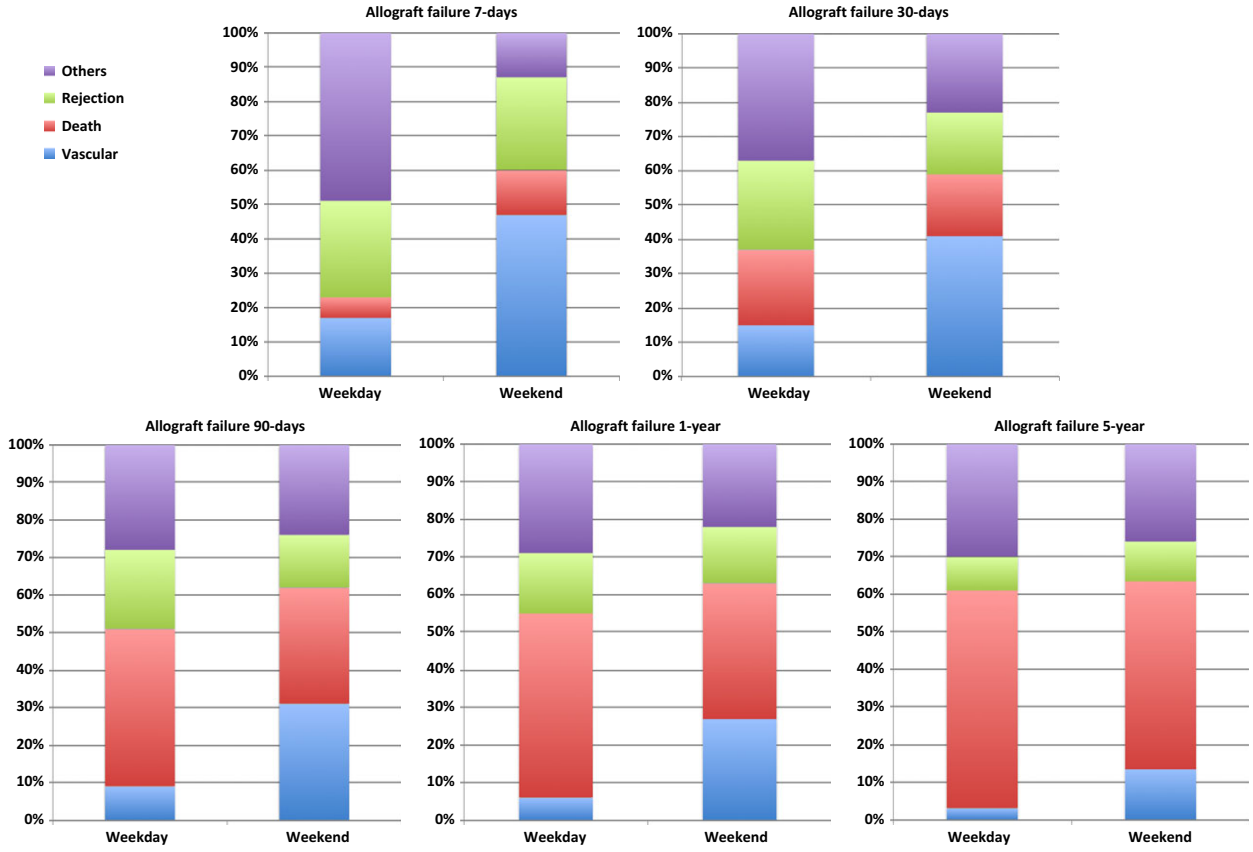

Figure 3 Bar graphs showing the proportion of allograft failures at 7, 30, 90 days, 1 and 5-years postkidney transplant by weekend status attributed to vascular causes, rejection, death with a functioning graft and other causes.

were associated with adjusted HR for 90-day allograft failure of 1.02 (0.83, 1.26; $P = 0.836$) (Fig. 1b). There was an interaction between extended weekend status and prevalent vascular disease (P-value for interaction 0.009) such that in those with prevalent vascular disease, the adjusted HR of extended weekend transplants for 90-day allograft failure was 1.83 (1.13, 2.94; $P = 0.013$); whereas for those without prevalent vascular disease, the adjusted HR was 0.88 (0.69, 1.12; $P = 0.302$), compared with weekday transplants. Similar estimates and interactions (with prevalent vascular disease) were observed for other time points as the main models.

If a total comorbid score was included in the main model, there was no association or interaction between comorbid score and timing of transplant for allograft failures at any time points.

Discussion

In this large registry study of over 6000 deceased donor kidney transplant recipients spanning over two decades, we have found no association between the timing of kidney transplants with short- and medium-term allograft outcomes. Early allograft failures attributed to vascular complications were more common in weekend transplants compared with weekday transplants, with the majority of the failures from vascular complications occurring within the first 7 days post-transplant. Recipients with prevalent vascular disease may have a higher risk of early allograft failure attributed to vascular complications if transplants occurred on the weekends. However, given the small number of events and wide confidence intervals of the estimates, these findings may have led to erroneous inference and therefore it must be emphasized that the findings of the possible association and interaction effects between the timing of transplantation and prevalent vascular disease for early allograft failure remain uncertain and must be interpreted with caution.

Several population cohort studies that have evaluated the association between day of transplant surgery and clinical outcomes have not consistently demonstrated an adverse impact of weekend compared with weekday transplantation. In an analysis of data extracted from the United Network of Organ Sharing (UNOS) registry of almost 140,000 deceased donor kidney transplant recipients, there

Table 3. Causes of 90-day allograft failure after kidney transplantation of the study cohort, stratified by those with or without prevalent vascular disease and have received kidney transplants on weekdays versus weekends.

All recipients (P = 0.62)*	Weekdays (n = 4754)	Weekends (n = 1868)
Death with functioning graft (n, %)	55 (1.16)	19 (1.02)
Cardiac arrest (n)	6	2
Cardiac failure (n)	2	0
Myocardial ischaemia (n)	8	4
Cerebrovascular accident (n)	5	0
Pulmonary embolism (n)	3	1
Infection (n)	22	6
Rejection (n, %)	43 (0.90)	16 (0.86)
Renal artery thrombosis (n, %)	21 (0.44)	10 (0.54)
Renal vein thrombosis (n, %)	38 (0.80)	22 (1.18)
Renal artery stenosis (n, %)	3 (0.06)	0 (0.00)
Infections (n, %)	7 (0.15)	4 (0.21)
Haemorrhage (n, %)	10 (0.21)	8 (0.43)
Cortical necrosis post-transplant† (n, %)	12 (0.25)	6 (0.32)
HUS (n, %)	4 (0.08)	0 (0.00)
Glomerulonephritis (n, %)	3 (0.06)	2 (0.11)
Recipients without prevalent vascular disease (P = 0.72)*	**Weekdays (n = 4042)**	**Weekends (n = 1583)**
Death with functioning graft (n, %)	37 (0.92)	10 (0.63)
Cardiac arrest (n)	5	1
Cardiac failure (n)	1	0
Myocardial ischaemia (n)	3	2
Cerebrovascular accident (n)	4	0
Pulmonary embolism (n)	1	1
Infection (n)	13	2
Rejection (n, %)	35 (0.87)	12 (0.76)
Renal artery thrombosis (n, %)	20 (0.49)	6 (0.38)
Renal vein thrombosis (n, %)	35 (0.87)	20 (1.26)
Renal artery stenosis (n, %)	3 (0.07)	0 (0.00)
Infections (n, %)	6 (0.15)	1 (0.06)
Haemorrhage (n, %)	13 (0.27)	7 (0.37)
Cortical necrosis post-transplant† (n, %)	12 (0.30)	5 (0.32)
HUS (n, %)	3 (0.07)	0 (0.00)
Glomerulonephritis (n, %)	2 (0.05)	2 (0.13)
Recipients with prevalent vascular disease (P = 0.35)*	**Weekdays (n = 712)**	**Weekends (n = 285)**
Death with functioning graft (n, %)	18 (2.53)	9 (3.16)
Cardiac arrest (n)	1	1
Cardiac failure (n)	0	0
Myocardial ischaemia (n)	5	2
Cerebrovascular accident (n)	1	0
Pulmonary embolism (n)	2	0
Infection (n)	9	4
Rejection (n, %)	9 (1.26)	4 (1.40)
Renal artery thrombosis (n, %)	1 (0.14)	4 (1.40)
Renal vein thrombosis (n, %)	3 (0.42)	2 (0.70)
Renal artery stenosis (n, %)	0 (0.00)	0 (0.00)
Infections (n, %)	1 (0.14)	3 (1.05)
Haemorrhage (n, %)	0 (0.00)	2 (0.70)
Cortical necrosis post-transplant† (n, %)	0 (0.00)	1 (0.35)
HUS (n, %)	1 (0.14)	0 (0.00)
Glomerulonephritis (n, %)	1 (0.12)	0 (0.00)

HUS, haemolytic uraemic syndrome.

*The corresponding P-values represent the chi-square test comparing the causes of allograft failure between weekday and weekend transplants for the study cohort and when stratified by kidney transplant recipients with and without prevalent vascular disease.

†Cortical necrosis not attributed to rejection.

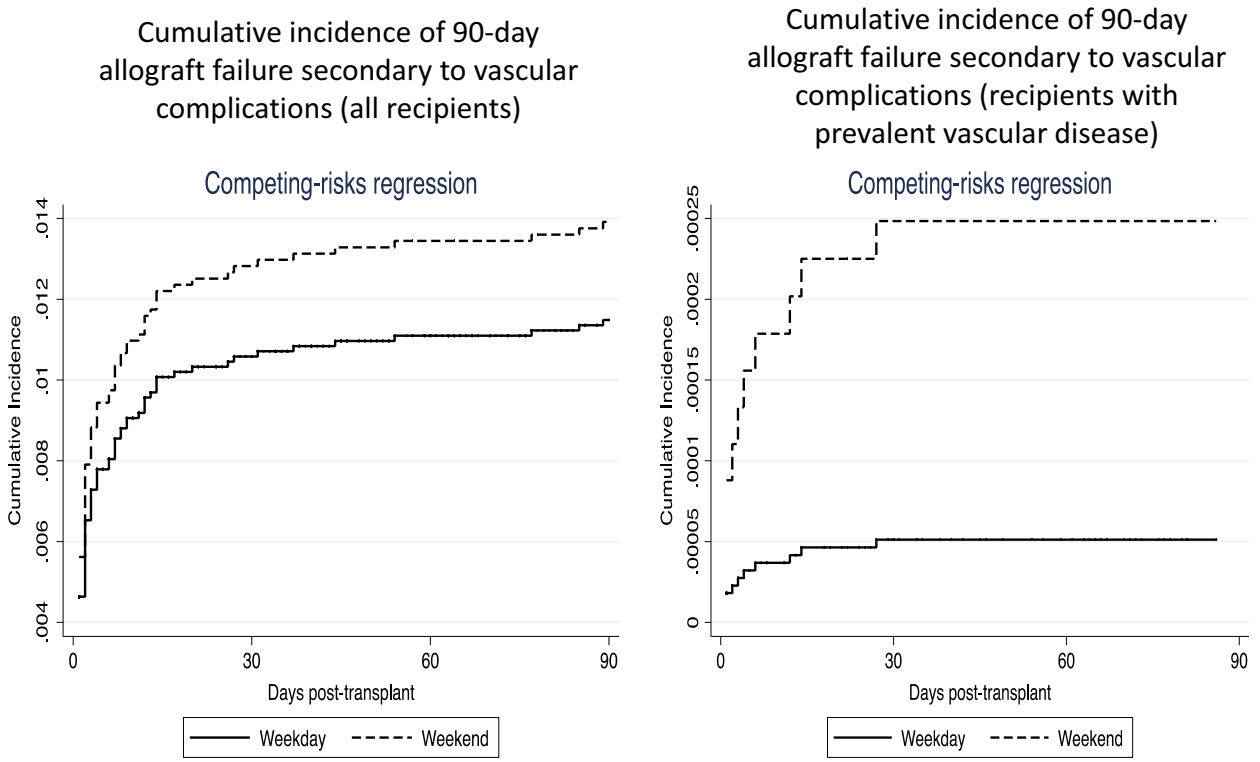

Figure 4 Adjusted cumulative incidence curves of 90-day allograft failure secondary to vascular complications, stratified by weekend versus weekday kidney transplants, adjusted for the competing risk of other nonvascular causes of 90-day allograft failures, donor age, recipient age, ethnicity, era, diabetes and smoking history. (a) shows the cumulative incidence of the study cohort (n = 6622), and (b) shows the cumulative incidence restricted to recipients with prevalent vascular disease (n = 997).

were no associations between weekend transplant status and short (1 month or 1 year) and long-term allograft or patient survival. Median length of hospital stay was 1 day less for weekend transplants compared with weekday transplants (6 vs. 7 days, $P = 0.008$). The results remained unchanged even if each day of the week was examined separately [7]. Another cohort study involving 12 902 deceased donor kidney transplant recipients from 19 transplant centres across England have corroborated similar findings and have shown that weekend kidney transplants were not associated with an increased risk of short-term allograft outcomes compared with weekday transplants, including the risk of rejection, re-hospitalizations and development of delayed graft function [9]. In contrast, a single centre study of 580 deceased donor kidney transplants showed that surgical complications occurred more often on weekends compared with weekdays (37% vs. 28%), although these early adverse events did not translate to a difference in short or long-term allograft and patient survivals [10]. Similarly, in other nonkidney solid organ transplantation including liver transplantation, there was no association between timing of transplantation and allograft outcome [8]. Our study has corroborated the findings from these studies and showed a lack of association between the timing of transplants and adverse early allograft outcomes, including delayed graft function and acute rejection. There was a suggestion that surgical/technical difficulties manifesting as early allograft failure from vascular complications may be more prevalent in weekend transplants, especially among recipients with prevalent vascular disease. However, given the lack of consistent association and interaction between a vascular comorbid score (derived from the presence of prevalent vascular disease and vascular risk factors) and the timing of transplantation for early allograft failure, a more in-depth assessment of the nature of these early allograft failures from vascular complications (e.g. to ascertain whether these failures were directly attributed to the presence of vascular disease and whether these failures were related to transplantation occurring on weekends as opposed to weekdays) is required but is beyond the scope of data capture within the ANZDATA registry.

In direct contrast with medical or surgical emergencies whereby weekend admissions were consistently associated with poorer outcomes, the lack of association between timing of surgery and short-term

allograft or patient outcomes following kidney transplantation may reflect differences in patient characteristics and/or severity of acute illnesses between those presenting for transplantation (i.e. more clinically stable) compared with those being admitted with acute illnesses [1–3]. With the observation that recipients with prevalent vascular disease may experience higher rates of vascular complications post-transplant on the weekend, it is possible that this effect may be a reflection of 'susceptible' higher-risk patients rather than a manifestation of a reduction in resources resulting from the timing of transplantation. Despite the possibility of random error, our study suggests that clinicians will need to be vigilant in the immediate post-transplant care, with the availability of the most experienced transplant team members and have prompt access to vascular imaging services, especially in those transplants with complex vasculatures/anastomoses involving patients with substantial vascular disease burden.

There are several limitations that are inherent in registry studies. There may be unmeasured residual confounders such as the surgical approach/complications (e.g. duration of anastomotic time, complexities of recipient surgery, surgical expertise), timing of organ procurement and transplant surgery (e.g. working hours versus night-time), duration of hospitalization, readmissions to hospital and other postoperative complications (including interventions to treat these complications), which are not collected by ANZDATA registry but may have modified the association between day of transplant surgery and early allograft failure. Selection bias may still exist because there may be systematic differences in the management of kidney transplant recipients between transplanting centres and clinicians.

In conclusion, our analysis showed that the timing of transplant surgery had no impact on allograft outcome up to 5 years post-transplant. Recipients with prevalent vascular disease may experience a higher technical rate of early allograft failure if transplanted on the weekend, suggesting that more intensive peri-operative care with frequent and repeated imaging of the allograft vasculature should be considered in the early post-transplant period.

Authorship

WL and GW: designed the study and/or analysed the data; all authors contributed to writing of the paper.

Funding

The authors have declared no funding.

Conflict of interest

The authors declare no conflicts of interest.

Acknowledgements

The authors acknowledge the substantial contributions of the entire Australian and New Zealand nephrology community (physicians, surgeons, database managers, nurses, renal operators and patients) that provide information to, and maintain, the ANZDATA database. The data reported here have been supplied by ANZDATA. The interpretation and reporting of these data are the responsibility of the authors and in no way should be seen as official policy or interpretation of ANZDATA. Wai H Lim is supported by a Clinical Research Fellowship from the Raine Foundation (University of Western Australia and Health Department of Western Australia) and Jacquot Career Development Fellowship (Royal Australasian College of Physicians); and Germaine Wong is supported by National Health and Medical Research Council Career Development Fellowship.

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