Original Article

Int J Organ Transplant Med 2024;15(4):172-182
https://doi.org/10.66224/ijotm.2024.15.1186

Comparison of Glomerular Filtration Rate in Transplanted Kidneys between Living and Deceased Donors after 12 Months of Transplantation

Hossein Saffari[1], Hamid Tavakoli[2], Mohammad Javad Soleimani[1], Ehsan Zolfi[1], Bahareh Marghoob[3], Nasrollah Abian[1]*

[1]Department of Urology, Hasheminejad Kidney Center, School of Medicine, Iran University of Medical Sciences, Tehran, Iran
[2]Respiratory Evaluation Sciences Program, Collaboration for Outcomes Research and Evaluation, Faculty of Pharmaceutical Sciences, University of British Columbia, Vancouver, Canada
[3]Division of Nephrology, Department of Internal Medicine, Hasheminejad Kidney Center, School of Medicine, Iran University of Medical Sciences, Tehran, Iran

ABSTRACT

Background: Kidney transplantation (KT) is the treatment of choice for end-stage renal disease (ESRD) supplied from living donors or deceased ones.

Objective: This study aims to assess trends in renal function, as measured by glomerular filtration rate (GFR), in living and deceased donor groups within 1-year post-transplant surgery.

Methods: We included ESRD patients admitted to the Hasheminejad Kidney Center in Iran from 2001 to 2014. GFR was the primary outcome of interest.

Results: Among a total of 442 recipients, 382 individuals were included in the GFR study population. Over three-quarters of the study sample (n= 291; 76.4%) received a transplant from a living donor. The average baseline GFR (SD) among patients with deceased and living donors was 55.5 (26.75) and 63.8 (22.45), respectively. The interaction of time and donor type was used to evaluate the trend of GFR per 6 months, and it was 1.37 (mL/min) higher in the living donor group (95% CI= −0.88-3.62 and p= 0.234). Out of 415 recipients with recorded rejection status, 142 (34.2%) had acute rejection, more often in deceased-donor than living-donor recipients (42.9% vs 31.5%, p= 0.039). However, in multivariable analysis, donor type was not independently associated with rejection (OR= 0.76, 95% CI= 0.45–1.27; p= 0.29), while lower baseline GFR and delayed graft function were associated with higher odds.

Conclusion: The annual decrease in GFR was identical across the study groups, although the absolute GFR level was higher in patients with living donors.

KEYWORDS: Kidney transplantation; Glomerular filtration rate; Deceased donor; Living donor; Rejection rate

INTRODUCTION

Among urologic diseases, end-stage renal disease (ESRD) has the highest mortality rate (around 20% mortality rate even with dialysis) [1]. The prevalence of ESRD is increasing worldwide, and just in the United States, 360 per one million people undergo renal replacement therapy (RRT) [2]. Transplantation is the treatment of choice for ESRD, and compared with maintenance therapies such as dialysis, it significantly decreases morbidity and mortality [3]. Given the excellent outcomes of RRT and shortage of living donors (LD), the use of deceased donors (DD) is strongly encouraged [4]. A cost-effectiveness analysis that evaluated the economic effects and patients' quality of life also supports DD transplantation [5]. By the end of 2006, 21,251 patients underwent RRT in Iran, 1,066 of whom were from DD [6]. There is general

*Correspondence: Nasrollah Abian, MD
Department of Urology, Hasheminejad Kidney Center, School of Medicine, Iran University of Medical Sciences, Tehran, Iran
ORCID: 0000-0002-2506-4321
E-mail: Naabian@gmail.com

agreement that the survival of patients who receive a kidney from LD is longer than that of patients who receive an organ from DD; however, some studies have shown that this difference may be explained by disease severity and baseline characteristics of individuals, rather than donor type [7].

Renal function within the first year of surgery is one of the best indicators of long-term graft survival [8, 9]. The objectives of this study are to evaluate outcomes of LD versus DD transplantation in patients with ESRD. The primary objective is to evaluate GFR between donor type, and the secondary objective is to evaluate the likelihood of kidney rejection as one of the most unpleasant outcomes of RRT.

MATERIALS AND METHODS

We conducted a historical cohort study of patients with a history of kidney transplantation at Hasheminejad Kidney Center (Tehran, Iran) from 2001 to 2014. The outcome variables were measured at baseline (GFR at discharge after transplantation) and at 1, 6, and 12 months after transplantation. Since GFR in the first year post-RRT predicts graft survival, we conducted the study 1 year after transplantation surgery.

The data were collected from patient documents and through telephone. All LDs were unrelated to recipients. All recipients were negative for panel reactive antibodies. Individuals who were not reachable by phone were excluded. Kidney transplantations were performed by three skilled transplantation surgeons throughout the study period. We compared the effects of time on renal function and the likelihood of rejection between two study groups during the first year after transplantation.

We defined two related analytic populations for the analyses. The primary GFR study population consisted of all transplant recipients with available baseline and at least one post-transplant GFR measurement; patients with missing GFR values were excluded from this cohort. For the analysis of acute rejection, we used a second study population that included all recipients with recorded rejection status and excluded only those with missing rejection information, regardless of whether GFR measurements were missing.

Study Exposure

The exposure of interest in this study was the source of transplant (living or deceased donors). There were multiple retrieval units in Tehran to collect deceased kidneys. All kidneys were transplanted immediately after receiving them (prepared within 3 hours of retrieval) to mitigate the likelihood of cold ischemia.

For recipients of LDs, we assessed underlying comorbidities, immunological evaluations, and kidney artery assessment with computed tomography (CT) angiography; only 4 cases required angiography.

Donors with multiple renal arteries and recipients with a body mass index (BMI) greater than 30 were excluded from the study. For left nephrectomy, we used the transperitoneal method (open transperitoneal donor nephrectomy) with a midline incision; and for right nephrectomy, we used a right flank incision. The immunosuppression protocol was as follows: on the day before surgery, Anti-thymocyte globulin (ATG) was started to induce immunosuppression, which was continued for 3 days afterward.

On the surgery day, a methylprednisolone pulse was started (500mg on the first day and 250mg on the second and third days), which was continued for 3 days, followed by oral prednisolone 50mg daily; the prednisolone is tapered every 3 days to reach 5mg per day. The combination of mycophenolate and cyclosporine is used to maintain immune suppression; the former is started on the day before surgery, while the latter is mostly administered on postoperative day 2, depending on the function of the transplanted kidney.

Table 1: Characteristics of the study population for primary outcome (change in glomerular filtration rate) by donor type: living donor vs. deceased donor.

Characteristics	Deceased Donor (N= 91)	Living Donor (N= 291)	Total (N= 382)	P-value	Std Diff
Continuous Variables, Mean (SD)					
Age (Year)	41.5 (12.81)	40.5 (13.49)	40.8 (13.32)	0.557	0.08
BMI (kg/m^2)	24.7 (2.03)	24.5 (2.47)	24.5 (2.38)	0.530	0.10
Categorical Variables, n (%)					
Sex					
Female	34 (37.4%)	102 (35.1%)	136 (35.6%)	0.688	0.05
Male	57 (62.6%)	189 (64.9%)	246 (64.4%)		-0.05
Nephrectomy	3 (3.3%)	1 (0.3%)	4 (1.0%)	0.043	0.23
Reoperation	5 (5.5%)	12 (4.1%)	17 (4.5%)	0.562	0.07
Diabetes	17 (18.7%)	50 (17.2%)	67 (17.5%)	0.750	0.04
DGF	14 (15.4%)	23 (7.9%)	37 (9.7%)	0.036	0.24

Abbreviations: BMI= Body Mass Index; DGF= Delayed Graft Function; Std Diff= Standard Difference
P-values for continuous variables were calculated using independent-samples t-tests.
P-values for categorical variables were calculated using chi-square tests.
Fisher's exact test was used when expected cell counts were <5.

Study Outcome

GFR was the primary outcome of interest. GFR is a powerful indicator for estimating long-term transplant recipient patient survival. To calculate the GFR, we used creatinine clearance based on the CKD-EPI formula. To ensure that excluding subjects with missing GFR does not bias our results, we compared subjects with missing GFR to those included in the final analysis.

Graft rejection was defined as the presence of acute T cell-mediated rejection (TCMR) or acute antibody-mediated rejection (ABMR), confirmed by percutaneous biopsy according to Banff criteria. This biopsy was performed if renal function or urinary output declined and other etiologies (such as infection, vascular complications, or urinary obstruction) were ruled out. Acute TCMR was considered positive if pathologic assessment reported interstitial inflammation (>25% of nonsclerotic cortical parenchyma and at least moderate infiltration {i2 or i3}) with moderate to severe tubulitis, intimal arteritis, or transmural arteritis, in which case, high doses of steroids or ATG were administered. On the other hand, acute ABMR was defined as the presence of histologic injury (i.e., microvascular injury, arteritis, thrombotic microangiopathy, or tubular injury), antibody interaction with the vascular endothelium, and serologic evidence of donor-specific antibodies; in this scenario, Intravenous immunoglobulin and plasmapheresis were administered.

Study Confounders

The model was adjusted for baseline (preoperative) GFR and for potential confounding variables that were extracted from patient charts or obtained via telephone interviews (i.e., age, sex, BMI at the time of transplantation, and a history of diabetes mellitus). Variables that indicate kidney disease severity were also included as confounders: history of nephrectomy, reoperation, previous transplantation, and history of delayed graft function (DGF, defined as a patient needing dialysis within the first week after RRT [11]).

Ethical Considerations

The current study was approved by the Clinical Research Ethics Board of Iran University of Medical Sciences (1398.1235). At admission to the hospital, patients had signed consent forms approved by Iran University of Medical Sciences to use their medical documents for research purposes.

Table 2: Characteristics of individuals excluded due to missing GFR compared with the overall study population.

Characteristics	Study Population Group (N= 382)	Excluded due to Missing GFR (N= 60)	P-value [1]	Std Diff
Age (Year)	40.8 (13.32)	41.2 (13.22)	0.836	-0.03
BMI (kg/m^2)	24.5 (2.38)	24.8 (2.16)	0.474	-0.15
Sex	136 (35.6%)	24 (40.0%)	0.510	-0.09
Nephrectomy [2]	4 (1.0%)	8 (13.3%)	0.000	-0.49
Reoperation	17 (4.5%)	14 (23.3%)	0.000	-0.56
Diabetes	67 (17.5%)	17 (28.3%)	0.002	-0.26
DGF	37 (9.7%)	11 (18.3%)	0.002	-0.25

Abbreviations: BMI= Body Mass Index; DGF= Delayed Graft Function
[1] P-values for continuous variables were calculated using independent-samples t-tests. P-values for categorical variables were calculated using chi-square tests
[2] The P-value for Nephrectomy was calculated using Fisher's exact test. P-values for categorical variables were calculated using the chi-square test.

Statistical Analysis

SAS Enterprise Guide (Version 6.1, Cary, NC, USA) was used for all analyses. Generalized linear models (GLMs) with generalized estimating equations (GEEs) were used to account for the clustered nature of the data (three observations per patient). All aforementioned exposures of interest and confounders were included as independent variables in the model. GFR with a normal distribution was the dependent variable. As our study investigates associations (not predictions), we used multiple imputation (MI) to handle missing values, except for the missing outcome variable (GFR). From the final GEE model, we also obtained model-based marginal means of GFR at 1, 6, and 12 months by donor type. These marginal means were averaged over the covariate distribution and then combined across imputed datasets using Rubin's rules. The units of time in this study were ordinal variables. To evaluate the effect of time on GFR, we determined the interaction between time and donor type, along with the effects of all other covariates [12]. The equation for the GLM model is as follows:

$$GFR = time + Age + Sex + DonorType + Baseline\ GFR + BMI + Nephrectomy + ReOperation + DiabetesHistory + DGF + time * Age + time * Sex + time * DonorType + time * Baseline\ GFR + time * BMI + time * Nephrectomy + time * ReOperation + time * DiabetesHistory + time * DGF$$

As described in the statistical model, we used a repeated-measures approach based on a general estimating equation rather than the maximum likelihood method. The time variable in this approach was ordinal: for the first measurement after RRT in month 1, the time value was 0; for the second measurement at month 6, the time value was 1; and for the third measurement at 12 months, the time value was 2. Because the spacing between these visits is not perfectly equal, we included the log of the time interval between visits as an offset in the GEE model; thus, we adjusted for unequal follow-up times while keeping the trend over time correctly estimated.

To address potential overfitting in GEE model selection, Quasi-likelihood under the Independence Model Criterion (QIC) was extracted from the GENMOD output for each imputed dataset. The QIC values were then averaged across imputations and also compared within each imputation. Reduced models were preferred only when they showed a lower average QIC and consistent improvement across imputations.

In a sensitivity analysis, we addressed missing kidney function measurements at 1, 6, and 12 months using multiple imputation. All 442 transplanted patients were included in this analysis. Missing follow-up values were imputed from donor type, baseline kidney function, demographic and clinical variables, and

Table 3: Association between donor type and change in GFR after adjustment for potential confounders.

Parameters	GFR change (mL/min)	95% CI lower, upper	P-value
Main Effects of Donor Type and Covariates on GFR			
Donor (reference=deceased)*	-0.66	-3.56, 2.25	0.658
Time (6-months)**	35.74	17.92, 53.57	<0.0001
Age at baseline (Year)	-0.00	-0.10, 0.10	0.986
Sex (reference=female)	-4.65	-7.60, -1.70	0.002
GFR at baseline (mL/min)	0.80	0.74, 0.87	<0.0001
BMI (kg/m^2)	-0.49	-1.03, 0.05	0.075
Nephrectomy	-10.94	-25.15, 3.28	0.132
Reoperation	2.54	-4.36, 9.43	0.471
Diabetes Mellitus	-2.68	-5.97, 0.60	0.110
DGF	-3.40	-7.83, 1.03	0.132
Interaction of Time-point with the Covariates			
Time*Donor (reference=deceased)*	1.37	-0.88, 3.62	0.233
Time*Age at baseline	-0.08	-0.15, -0.00	0.037
Time*Sex (reference=female)	-2.05	-4.34, 0.23	0.079
Time*GFR at baseline	-0.17	-0.22, -0.12	<0.0001
Time*BMI	-0.62	-1.04, -0.21	0.003
Time*Nephrectomy	0.69	-10.31, 11.68	0.903
Time*Reoperation	-5.59	-10.82, -0.36	0.036
Time*Diabetes Mellitus	1.22	-1.30, 3.74	0.342
Time*DGF	-2.17	-5.49, 1.15	0.200

Abbreviations: GFR= Glomerular Filtration Rate; BMI= Body Mass Index; DGF= Delayed Graft Function.
*With each additional 6-month interval after RTT, recipients of living-donor kidneys have, on average, 1.37 mL/min higher GFR than recipients of deceased-donor kidneys; this difference is not statistically significant.
**Unit of time is six months. Coefficients are interactions of time and covariates.
To check whether removing interaction terms improved the model, we compared QIC values from the full and reduced models across all imputations. We calculated diff. = (QIC reduced) – (QIC full), where a positive value means the reduced model fits worse. The average difference was 0.15, and all differences were greater than zero. This shows that the reduced model had a higher (worse) QIC in every imputation. Because of this, removing interactions did not improve the model, and we kept all interaction terms in the final GEE model.

visit time. The same GEE model as in the main analysis was then applied to each imputed dataset, and the estimates were combined using standard multiple-imputation rules.

To evaluate the robustness of our findings to the choice of time coding, we also refitted the GEE model in a sensitivity analysis in which time was coded as 1, 2, and 3 for months 1, 6, and 12, respectively; these results are summarized in Appendix I.

For the secondary objective, we calculated the rejection rate using a GLM with a binomial distribution and a logit link. This model generated the odds ratio (OR) for rejection within

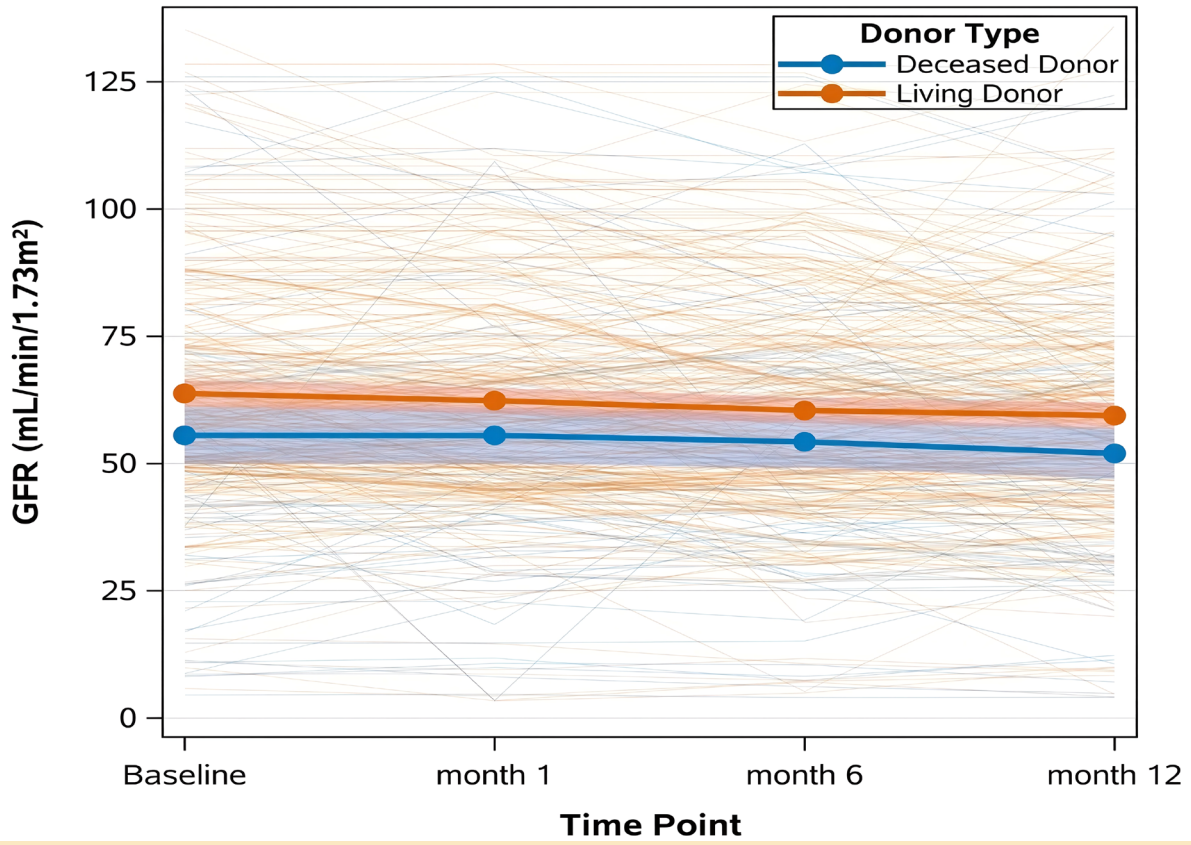

Figure 1: GFR trajectories by donor type: living donor versus deceased donor. Solid lines represent mean GFR for living- and deceased-donor recipients at baseline, 1 month, 6 months, and 12 months after transplantation, with 95% confidence bands. Faint lines represent longitudinal GFR measurements from all subjects included in the study (n = 382). GFR= glomerular filtration rate

1 year after RRT in the living donor group compared with the deceased donor group (the deceased donor group was assigned as the reference group).

For transparency, we provide an illustrative design matrix for the longitudinal GEE model in Appendix II. This matrix shows, for a single subject, how time in 6-month units, donor type, and the time-by-donor and time-by-covariate interaction terms were coded across the repeated GFR measurements.

RESULTS

A total of 442 patients were recruited, and after excluding those with missing post-transplant GFRs, 382 were included in the study. The mean age was 40.8 years (SD= 13.2), and 246 (64.4%) were male. None of the patients received a transplant from their relatives. More than three-quarters of patients, 291 (76.4%), received a transplant from a living donor. The average GFR at baseline was significantly higher in the LD group compared to the DD group (63.8, SD: 22.45 vs 55.5, SD: 26.75; p= 0.003). Table 1 presents baseline patient characteristics and covariate distributions, along with crude statistical differences between the deceased and living donor groups.

Living-donor recipients had higher baseline CKD-EPI GFR than deceased-donor recipients (63.8 vs 55.5 mL/min/1.73 m^2; p= 0.004; standardized difference= −0.34).

Subjects with missing GFR were compared to those included in the final analysis. As shown in Table 2, both groups were similar in Age, Sex, and BMI. As shown in Table 2, patients excluded from the main GEE analysis because of missing follow-up kidney function differed somewhat from those included. To assess the

Table 4: Pooled marginal means of GFR over time by donor type.

Donor Type	Time-Point	Mean GFR	95% CI lower, upper
Deceased-donor	Month 1	60.93	58.15, 63.72
Deceased-donor	month 6	58.95	56.32, 61.57
Deceased-donor	month 12	55.79	52.69, 58.88
Living-donor	Month 1	60.64	59.56, 61.71
Living-donor	month 6	58.94	57.40, 60.48
Living-donor	month 12	58.22	56.41, 60.03

Marginal means from the GEE model were combined across imputations using Rubin's Rules (Rubin, 1987). Total variance incorporated within- and between-imputation components, and degrees of freedom were computed using the Barnard-Rubin small-sample adjustment (Barnard & Rubin, 1999).

impact of these exclusions, we repeated the analysis after using multiple imputation and including all 442 patients. The estimates from this imputed-data GEE (Appendix III) were very similar to those from the complete-case analysis: the direction and statistical significance of the donor effect and the donor-by-time interaction were unchanged, and the changes in coefficient sizes were small.

To evaluate the trend in GFR across the two groups, we used a generalized estimating equation model that included time, donor type, and their interaction, as well as age, sex, baseline GFR, BMI, nephrectomy, reoperation, diabetes mellitus, and delayed graft function as covariates (Table 3). Time was coded in six-month intervals, so the time coefficient represents the expected change in GFR per six months of follow-up. Overall, GFR declined over time in both donor groups. After adjustment for all covariates, we did not find strong evidence that the rate of GFR change differed between living- and deceased-donor recipients: the estimated difference in six-month change between living and deceased donor groups was 1.37 mL/min/1.73 m² (95% CI= −0.88 to 3.62; p= 0.234). Statistically significant interactions between time and age, baseline GFR, BMI, and reoperation were observed, indicating that these factors modified the pattern of GFR change over time, whereas the time interactions with donor type, sex, diabetes, nephrectomy, and delayed graft function were not statistically significant. Fig. 1 illustrates the GFR trajectories in the two donor groups.

After extracting QIC in GEE model selection from the GENMOD output for each imputed dataset, averaging QIC values across imputations, and comparing them within each imputation, we found that removing interaction terms did not improve the model fit. Therefore, we retained all interactions in the final model.

Model-based marginal means from the GEE model provide a complementary view of GFR trajectories by donor type (Table 4). Among deceased-donor recipients, mean GFR decreased from 60.9 mL/min/1.73 m² (95% CI= 58.2 to 63.7) at 1 month to 55.8 mL/min/1.73 m² (95% CI= 52.7 to 58.9) at 12 months, whereas among living-donor recipients it decreased from 60.6 mL/min/1.73 m² (95% CI= 59.6 to 61.7) to 58.2 mL/min/1.73 m² (95% CI= 56.4 to 60.0) over the same period. These marginal means were pooled across imputed datasets using Rubin's rules, ensuring that both within- and between-imputation variability were reflected in the confidence intervals.

As shown in Table 2, patients excluded from the main GEE analysis because of missing follow-up GFR differed somewhat from those included in a few variables. To assess the impact of these exclusions, we repeated the analysis after using multiple imputation and including all 442 patients. The estimates from this

Table 5: Characteristics of the rejection study population by donor type: living donor vs deceased donor.

Characteristics	Deceased Donor (N= 98)	Living Donor (N= 317)	Total (N= 415)	P-value	Std Diff
Continuous Variables, Mean (SD)					
Age (Year)	41.2 (12.93)	41.0 (13.41)	41.1 (13.28)	0.899	0.02
BMI (kg/m^2)	24.8 (2.09)	24.6 (2.42)	24.6 (2.35)	0.395	0.10
Categorical Variables, n (%)					
Sex					
Female	39 (39.8%)	109 (34.4%)	148 (35.7%)	0.328	0.11
Male	59 (60.2%)	208 (65.6%)	267 (64.3%)		-0.11
Nephrectomy	6 (6.1%)	6 (1.9%)	12 (2.9%)	0.038	0.22
Reoperation	10 (10.2%)	21 (6.6%)	31 (7.5%)	0.239	0.13
Diabetes	22 (22.4%)	61 (19.2%)	83 (20.0%)	0.526	0.08
DGF	17 (17.3%)	30 (9.5%)	47 (11.3%)	0.035	0.23

Abbreviations: BMI= Body Mass Index; DGF= Delayed Graft Function; Std Diff= Standard Difference
P-values for continuous variables were calculated using independent-samples t-tests.
P-values for categorical variables were calculated using chi-square tests.
Fisher's exact test was used when expected cell counts were <5.

imputed-data GEE (Appendix III) were very similar to those from the complete-case analysis: the direction and statistical significance of the donor effect and the donor-by-time interaction were unchanged, and the changes in coefficient sizes were small.

A sensitivity analysis using an alternative time coding (month 1= 1, month 6= 2, and month 12= 3) yielded donor-by-time and covariate interaction estimates that were very similar to those of the main model, supporting the robustness of our conclusions regarding GFR trajectories.

In the rejection study population (n= 415), Table 5 and Table 6 demonstrate the distribution of demographic and baseline indicators within living and deceased donors.

Acute rejection occurred in 142 recipients (34.2%) (Table 6). These estimates are based on all patients with recorded rejection status, regardless of whether GFR measurements were missing. Deceased-donor recipients had a higher crude proportion of rejection than living-donor recipients (42.9% [42 of 98] vs 31.5% [100 of 317]; p= 0.039; standardized difference 0.24). Baseline characteristics were generally similar between donor groups in this population, although nephrectomy and delayed graft function were more common among deceased-donor recipients. In the multivariable logistic regression model fitted in the rejection study population (Table 7), living-donor transplantation was not independently associated with rejection within one year (odds ratio= 0.76, 95% CI= 0.45 to 1.27; p= 0.290), whereas lower baseline GFR (odds ratio per 1 mL/min/1.73 m^2 increase 0.97, 95% CI= 0.96 to 0.99; p< 0.0001) and delayed graft function (odds ratio= 2.60, 95% CI= 1.23 to 5.51; p= 0.013) were significantly associated with higher odds of rejection.

DISCUSSION

Kidney transplantation is the preferred treatment of choice for ESRD, but because of the scarcity of LDs, waiting lists are increasing worldwide. RRT from DDs is a recommended alternative. However, in Iran, LDs are scarce and cost significantly more than those from DDs [6]. Thus, more Iranians are receiving kidneys from DDs, resulting in increased waiting times and more severe disease. In the current study, we evaluated differences in GRF among Iranian patients receiving organs from living and deceased donors. Our results

Table 6: Characteristics of the outcomes in rejection study population by donor type: living donor vs deceased donor.

Characteristics	Deceased Donor (N= 98)	Living Donor (N= 317)	Total (N= 415)	P-value	Std Diff
CKD/EPI at Baseline (mL/min/1.73 m2)	54.4 (27.84)	61.0 (23.09)	59.5 (24.42)	0.021	-0.26
Rejection	42 (42.9%)	100 (31.5%)	142 (34.2%)	0.039	0.24

Abbreviations: CKD/EPI= Chronic Kidney Disease Epidemiology Collaboration; Std Diff= Standard Difference
P-values for continuous variables were calculated using independent-samples t-tests.
P-values for categorical variables were calculated using chi-square tests.

indicate that baseline GFR largely explained the difference in GFR between donor groups. Specifically, although the GFR at both time points (6- and 12-month post-transplant) was significantly lower in the DD group, the decline in GFR was similar in both groups. The difference in baseline GFR may be explained by the longer wait times for DD organs in Iran.

Our data also showed that recipients of DDs had a better response within one month after the procedure. This finding can be explained by the severity of disease and decreasing GFR in this group. Nevertheless, after the first month, the GFR slightly decreased, and the trend was similar to that of the live donor group. Although the trend in both groups was negative, and the DD group had significantly lower GFRs, there was no significant difference in the slope of GFR reduction, and the downward trend was almost identical between groups. Lee *et al.* [15] reported 275 and 179 cases of living and deceased kidney transplantations, respectively, from 1995 to 2008. They measured creatinine levels at 5- and 10- years post-transplant surgery. No difference was observed between the two groups. Wigger *et al.* [16] studied patients for 16 years and measured GFR at 5-year intervals. They reported that the GFR decreased from 88 mL/min to 68 mL/min.

In the present study, all living donors were unrelated. In a recent study, it was shown that in relative donors-recipients, the level of GFR remained higher than in non-relative cases of living donors [17].

In our study, the likelihood of rejection was similar in both groups. These findings are consistent with those of Nemati *et al.* [4], who reported that the likelihood of rejection was similar in LDs and DDs in the first year after transplantation. In contrast, Campbell *et al.* [18] reported that LD recipients had a much higher rate of, and more severe, rejection than deceased donor recipients, which was inconsistent with our findings.

Major strengths of this study include its relatively large sample size, consistent surgical method, and long study period, which helped us identify the effects of exposure on kidney transplant survival. As one of the limitations of our study, we were unable to identify the socio-economic status of the patients and the exact time patients underwent dialysis, both of which can affect kidney survival after transplantation. Some other potential confounders, such as cold ischemic time, human leukocyte antigen mismatch, the Kidney Donor Profile Index (KDPI), and donor estimated GFR, were unavailable for many patients, which may have affected kidney survival after transplantation.

In conclusion, given the scarcity of LDs, DDs are a reasonable substitute. Although some experts have raised concerns about kidney survival, we showed that the decline in kidney function in the DD group was equal to that in the LD group, and that the rejection rate in the first year of transplantation was similar in both groups. Future research on the survival of these two types of transplant recipients should include a longer follow-up period to evaluate whether patient survival differs

Table 7: Association between donor type and change in GFR after adjustment for potential confounders.

Parameters	Odds Ratio of Rejection	95% CI lower, upper	P-value
Age at baseline (Year)	0.99	0.97, 1.01	0.235
Sex (reference= female)	0.68	0.40, 1.16	0.156
Donor (reference=deceased)*	0.76	0.45, 1.27	0.295
GFR at baseline (mL/min/1.73 m^2)	0.97	0.96, 0.99	<0.0001
BMI (kg/m2)	1.04	0.95, 1.15	0.380
Nephrectomy	0.55	0.08, 3.66	0.538
Reoperation	1.61	0.55, 4.73	0.387
Diabetes Mellitus	1.41	0.81, 2.45	0.220
DGF	2.60	1.23, 5.51	0.013

Abbreviations: GFR= Glomerular Filtration Rate; BMI= Body Mass Index; DGF= Delayed Graft Function
*Donor type (living vs. deceased) was not independently associated with rejection within one year after transplantation (odds ratio= 0.76, 95% CI= 0.45–1.27; p= 0.290).

after adjusting for potential confounders. In addition, cost-effectiveness analyses can provide important information on the long-term performance of these two procedures from a population-based perspective.

FINANCIAL SUPPORT: None.

CONFLICTS OF INTEREST: None declared.

REFERENCES

1. Chertow GM, Fan D, McCulloch CE, Hsu C. Chronic kidney disease and the risks of death, cardiovascular events, and hospitalization. *N Engl J Med* 2004;**351**:1296–305.
2. Schnuelle P, Lorenz D, Trede M, Van Der Woude FJ. Impact of renal cadaveric transplantation on survival in end-stage renal failure: evidence for reduced mortality risk compared with hemodialysis during long-term follow-up. *J Am Soc Nephrol* 1998;**9**:2135–41.
3. Abecassis M, Bartlett ST, Collins AJ, *et al*. Kidney transplantation as primary therapy for end-stage renal disease: a National Kidney Foundation/Kidney Disease Outcomes Quality Initiative (NKF/KDOQITM) conference. *Clin J Am Soc Nephrol* 2008;**3**:471–80.
4. Nemati E, Einollahi B, Lesan Pezeshki M, *et al*. Does kidney transplantation with deceased or living donor affect graft survival? *Nephro-Urol Mon* 2014;**6**:e12182.
5. YaghoubiFard S, Goudarzi R, Etminan A, *et al*. Costeffectiveness analysis of dialysis and kidney transplant in patients with renal impairment using disability adjusted life years in Iran. *Med J Islam Repub Iran* 2016;**30**:390.
6. Ghods AJ, Mahdavi M. Organ transplantation in Iran. *Saudi J Kidney Dis Transpl* 2007;**18**:648-55.
7. Guirado L, Vela E, Clèries M, *et al*. [Why renal transplant from living donors gives better results than cadaver renal transplant?]. *Nefrol Publ Of Soc Esp Nefrol* 2008;**28**:159–67.
8. Hariharan S, McBride MA, Cherikh WS, *et al*. Post-transplant renal function in the first year predicts long-term kidney transplant survival. *Kidney Int* 2002;**62**:311–8.
9. Salvadori M, Rosati A, Bock A, *et al*. Estimated one-year glomerular filtration rate is the best predictor of long-term graft function following renal transplant. *Transplantation* 2006;**81**:202–6.
10. Cockcroft DW, Gault MH. Prediction of creatinine clearance from serum creatinine. *Nephron* 1976;**16**:31–41.
11. Mallon DH, Summers DM, Bradley JA, Pettigrew GJ. Defining delayed graft function after renal transplantation: simplest is best. *Transplantation* 2013;**96**:885–9.
12. Zafari Z, Sin DD, Postma DS, *et al*. Individualized prediction of lung-function decline in chronic obstructive pulmonary disease. *CMAJ Can Med Assoc J* 2016;**188**:1004–11.
13. Goldfarb DA. Re: Cost-Effectiveness of Hepatitis C-Positive Donor Kidney Transplantation for Hepatitis C-Negative Recipients with Concomitant Direct-Acting Antiviral Therapy. *J Urol* 2019;**201**:431.
14. Kamalkiran M, Ravikiran V, Shashidhar C, *et al*. Kidney Transplantation from a Hepatitis C Virus-

positive Donor to a Hepatitis C Virus-negative Recipient. *Indian J Nephrol* 2018;**28**:488–9.

15. Lee S, Kim J, Shin M, *et al*. Comparison of outcomes of living and deceased donor kidney grafts surviving longer than 5 years in Korea. *Transplant Proc* 2010;**42**:775–7.
16. Wigger M, Drückler E, Muscheites J, Stolpe HJ. Course of glomerular filtration rate after renal transplantation and the influence of hypertension. *Clin Nephrol* 2001;**56**:S30-34.
17. Simforoosh N, Basiri A, Tabibi A, *et al*. Living Unrelated Versus Related Kidney Transplantation: A 25-Year Experience with 3716 Cases. *Urol J* 2016;**13**:2546–51.
18. Campbell SB, Hothersall E, Preston J, *et al*. Frequency and severity of acute rejection in live- versus cadaveric-donor renal transplants. *Transplantation* 2003;**76**:1452–7.