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Mortality and Graft Loss Attributable to Readmission following Kidney Transplantation: Immediate and Long-Term Risk

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Abstract

Background—Following kidney transplantation, early readmission is independently associated with graft loss and mortality. The mechanism of this association is poorly understood. Understanding the timeline of risk, ie, during the readmission hospitalization versus time periods postreadmission, will provide additional insights.

Methods—We used national registry data to study 56,076 adult Medicare-primary first-time kidney transplant recipients from December 1999–October 2011. Piecewise Cox proportional hazard models were used to estimate the association between graft loss, mortality, and readmission for two time periods: readmission hospitalization and postreadmission.

Results—During the readmission hospitalization, graft loss was substantially higher (deceased donor (DDKT) without delayed graft function (DGF) hazard ratio: 24.6^{34.4}_{7.9}, $p < 0.001$; with DGF: 10.8^{15.2}_{21.4}, $p < 0.001$; live donor (LDKT): 18.1^{36.7}_{74.2}, $p < 0.001$) and mortality was substantially higher (DDKT without DGF: 14.1^{20.8}_{30.7}, $p < 0.001$; with DGF: 9.0^{31.2}_{8.0}, $p < 0.001$; LDKT: 9.0^{18.2}_{41.3}, $p < 0.001$). Immediately following readmission discharge, graft loss (DDKT without DGF: 2.08^{2.40}_{2.77}, $p < 0.001$; with DGF: 1.83^{2.14}_{2.51}, $p < 0.001$; LDKT: 2.00^{2.50}_{3.13}, $p < 0.001$) and mortality (DDKT without DGF: 2.16^{2.43}_{2.73}, $p < 0.001$; with DGF: 1.83^{2.16}_{2.88}, $p < 0.001$; LDKT: 1.90^{2.34}_{2.88}, $p < 0.001$) remained elevated, but much less so. Following

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DISCLOSURE

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readmission, the hazard of graft loss remained, but decreased 19% per year for DDKT recipients (time varying coefficient $0.78^{0.81}_{0.85}$, $p<0.001$) and 14% per year for LDKT recipients ($0.79^{0.86}_{0.93}$, $p<0.001$). The hazard of mortality remained, but decreased 14% per year for DDKT recipients ($0.83^{0.86}_{0.89}$, $p<0.001$) and 9% per year for LDKT recipients ($0.85^{0.91}_{0.98}$, $p<0.001$).

Conclusions—In conclusion, readmission is most strongly associated with graft loss and mortality during the readmission hospitalization, but also portends a lasting, albeit attenuated, risk postreadmission.

INTRODUCTION

Over 30% of kidney transplant (KT) recipients experience early hospital readmission (EHR), or re-hospitalization within 30 days of discharge following KT (1). To appropriately manage these recipients, it is vital to understand the immediate and long-term ramifications of EHR. Early hospital readmission increases the risk of subsequent hospitalization within the first year following KT. In addition, EHR is associated with inferior graft and patient survival. Deceased donor KT recipients who experience EHR are 1.43 times more likely to lose their graft and 1.50 times more likely to die compared to recipients who do not experience EHR. The same is true among live donor KT recipients who experience EHR; with a 1.54 fold increase in graft loss and a 1.45 fold increase in mortality (2).

Existing estimates of the association between graft loss, mortality, and EHR, may be misleading. These numbers suggest that upon readmission to the hospital, a recipient's risk for graft loss increases by approximately 50% and their risk remains elevated indefinitely after the readmission is over. In other words, the risk of graft loss and death for recipients who are acutely ill and readmitted to the hospital is considered the same as the risk for recipients who experienced EHR in the past, survived that readmission, and are currently months or years postreadmission. Prior work in transplantation, and other fields, assumes that the risk associated with EHR is constant over time without considering the possibility that it may vary with time (2, 3–11). In particular, the association between EHR and adverse transplant outcomes may be substantially different for KT recipients that are in the hospital experiencing EHR and those that have previously experienced EHR. Furthermore, it is unknown whether recipients who previously experienced EHR carry an increased risk of adverse outcomes for the remainder of their life or if that risk attenuates over time. Assuming a constant association may underestimate the risk attributable to the readmission hospitalization and it may give an inaccurate estimate of the durability of that risk for recipients surviving postreadmission.

The objective of this study was to quantify the association between EHR and survival during two distinct time periods: the EHR hospitalization and postEHR. A second objective of the study was to determine whether the association between EHR and survival is constant during post-EHR follow-up.

MATERIALS AND METHODS

Study Population

The study population included 56,076 adult first-time KT recipients from December 1, 1999 through October 31, 2011 who had Medicare Part A and B as their primary insurance for at least 60 days before and 60 days following the date of transplant. Recipient, donor, and transplant characteristics were obtained from Organ Procurement Transplantation Network data. This study was reviewed by the institutional review board at Johns Hopkins School of Medicine and determined to qualify for an exemption under 45 CFR 46.101(b) as study participants cannot be identified directly or through linked identifiers.

Exposure and Outcome Ascertainment

EHR hospitalization was captured using United States Renal Data System (USRDS) claims data. As specified in our previously published models of EHR following KT, EHR was defined as any hospitalization to an acute care facility within 30 days of discharge after initial KT hospitalization (1, 2). KT recipients who died prior to initial discharge following KT were excluded ($n=1,743$). KT recipients who had graft loss prior to discharge, but did not die, were also excluded from the analysis ($n=1,489$) because readmission in a recipient with a functioning graft at the time of discharge is mechanistically different than readmission of a recipient who has already lost their graft.

Association Between EHR and Survival

Cox proportional hazard models were used to estimate the hazard of death-censored graft loss and mortality associated with EHR. Separate models were used for deceased donor kidney transplant (DDKT) and live donor kidney transplant (LDKT). Each model was adjusted for recipient, donor, and transplant characteristics based on the Scientific Registry of Transplant Recipients risk adjustment models (12). Models for DDKT were adjusted for age, sex, African American race, body mass index (BMI), preemptive transplant, cause of end stage renal disease (ESRD), peak panel reactive antibody, hepatitis C status, time on dialysis, human leukocyte antigen (HLA) mismatch, pulsatile perfusion, cold ischemic time, donor/recipient weight ratio, donor race, terminal creatinine, donor hypertension, donor diabetes, extended criteria donor, donation after cardiac death, regional/national sharing. Models for DDKT were also stratified based on occurrence of delayed graft function (DGF). Models for LDKT were adjusted for age sex, African American race, BMI, preemptive transplant, cause of ESRD, peak panel reactive antibody, hepatitis C status, time on dialysis, HLA mismatch, recipient/donor weight ratio, donor race. Recipients were censored at 5 years of follow-up, time of re-transplant, or administratively at end-of-study. We used a clustered sandwich estimator for standard errors to account for possible center-level correlation. The proportional hazard assumption for each model was confirmed visually using log-log plots and Schoenfeld residuals.

We estimated the hazard of death-censored graft loss and mortality for two distinct time periods: from EHR admission date to EHR discharge or death/graft loss (EHR hospitalization) and from EHR discharge date to death/graft loss or censorship (postEHR). To avoid immortal person-time bias among KT recipients with EHR (requiring patient and

graft survival up to the point of readmission) we used a standard method of late entries in which the recipients with EHR only contributed to the exposed risk set starting at the time of admission for the EHR hospitalization. Based on exploratory data analysis and prior hypotheses, the attributable hazard during the EHR hospitalization was treated as constant and we used a time-varying coefficient to estimate attributable hazard during the post-EHR time period. In other words, the estimate for “EHR hospitalization” represents the hazard averaged over the entire hospitalization while the “post-EHR” hazard represents the hazard at the time of EHR discharge and that hazard can vary based on the amount of time since EHR discharge.

Reason for Readmission and Cause of Death

Reason for readmission was explored for recipients experiencing death/graft loss during the readmission hospitalization using Diagnosis-Related Group (DRG) codes. Cause of death, based on OPTN data, was explored for 4 distinct recipient groups: recipients experiencing EHR and dying on the day of admission, recipients experiencing EHR and dying during the readmission hospitalization after at least 1 day of hospitalization, recipients that previously experienced readmission that died within 30 days following readmission discharge, and recipients that previously experienced EHR that died greater than 30 days following readmission discharge. Unfortunately, OPTN and USRDS data on cause of graft loss was missing for almost the entire study population; therefore we were unable to include this in our analysis.

Statistical Analysis

Confidence intervals are reported as per the method of Louis and Zeger, as previously described (13, 14). All analyses were performed using STATA 14.0/MP for Linux (Stata Corp LP, College Station, TX, USA).

RESULTS

Early Hospital Readmission

Of 56,076 KT recipients, 17,739 experienced EHR (31.6%) (Table 1). The median time from transplant discharge to EHR was 8 days (IQR 4–15). Among recipients who experienced EHR, the length of stay for the EHR hospitalization ranged from 1 to 217 days with a median length of stay of 4 days (IQR 2–7 days).

Crude Death-censored Graft Loss and Mortality

Crude death-censored graft loss within 30 days of transplant discharge was 1.5% for recipients who experienced EHR and 0.2% for recipients without EHR ($p<0.001$). Crude mortality within 30 days of transplant discharge was 0.8% for recipients who experienced EHR and 0.2% for recipients without EHR ($p<0.001$). Crude death-censored graft loss within 1 year of transplant discharge was 7.2% for recipients who experienced EHR and 2.4% for recipients without EHR ($p<0.001$). Crude mortality within 1 year of transplant discharge was 7.3% for recipients who experienced EHR and 2.5% for recipients without EHR ($p<0.001$).

Association Between EHR and Survival During the EHR Hospitalization Time Period

During the EHR hospitalization, 1.2% (n=218) of recipients lost their graft. Median time from EHR admission to death-censored graft loss was 4 days (IQR 1–14), with 48 (22.0%) recipients losing their graft on the same day as EHR admission. Among recipients losing their graft during the EHR hospitalization, the 3 most common reasons for readmission included: kidney/urinary tract disorder (n= 111, 50.9%), unspecified surgical procedure (n=11, 5.0%), and infection (n=8, 3.7%). During the EHR hospitalization, 0.9% (n=158) of recipients died. Median time from EHR admission to death was 12 days (IQR 3–29), with 11 (7.0%) recipients dying on the same day as EHR admission. Among recipients dying during the EHR hospitalization, the 3 most common reasons for readmission included: kidney/urinary tract disorder (n=31, 19.6%), infection (n=21, 13.3%), and respiratory disorder (n=18, 11.4%).

In an adjusted model of DDKT recipients without DGF, during the EHR hospitalization, recipients who experienced EHR were 34.4-times more likely to lose their graft compared to recipients without EHR (aHR_{24.6}34.4_{47.9}, $p<0.001$)(Table 2). Among DDKT recipients with DGF, during the EHR hospitalization, recipients who experienced EHR were 15.2-times more likely to lose their graft compared to recipients without EHR (aHR_{10.8}15.2_{21.4}, $p<0.001$)(Table 2). LDKT recipients who experienced EHR were 36.7-times more likely to lose their graft compared to recipients without EHR (aHR_{18.1}36.7_{74.2}, $p<0.001$). In an adjusted model of DDKT recipients without DGF, during the EHR hospitalization, recipients who experienced EHR were 20.8-times more likely to die compared to recipients without EHR (aHR_{14.1}20.8_{30.7}, $p<0.001$). Among DDKT recipients with DGF, during the EHR hospitalization, recipients who experienced EHR were 12.8-times more likely to die compared to recipients without EHR (aHR_{9.03}12.8_{18.0}, $p<0.001$)(Table 2). LDKT recipients who experienced EHR were 18.2-times more likely to die compared to recipients without EHR (aHR_{9.00}18.2_{41.3}, $p<0.001$).

For recipients experiencing EHR and dying on the day of admission, the cause of death was missing for 9.1%. The 3 most common causes of death were cardiac events (45.5%), infection (27.2%), and cerebrovascular event or graft failure (9.1% each) (Table 3). For recipients experiencing EHR and dying during the readmission hospitalization after at least 1 day of hospitalization, the cause of death was missing for 19.0%. The 3 most common causes of death were infection (34.7%), cardiac event (26.5%), and respiratory failure (7.5%) (Table 3).

Association Between EHR and Survival During the Post-EHR Time Period

During the post-EHR time period, 33.6% (n=5845) of recipients lost their graft, with a median time from EHR discharge to death-censored graft loss of 687 days (IQR 238–1212) and 355 (6.1%) recipients losing their graft within 30 days of EHR discharge. During the post-EHR time period, 22.5% (n=3953) of recipients died, with a median time from EHR discharge to death of 766 days (IQR 277–1265) and 158 (3.9%) recipients dying within 30 days of EHR discharge.

In an adjusted model of DDKT recipients without DGF, during the post-EHR time period, recipients who previously experienced EHR were 2.40-times more likely to lose their graft compared to recipients without EHR (aHR $_{2.08}2.40_{2.77}$, $p<0.001$) (Table 2). Among DDKT recipients with DGF, during the post-EHR time period, recipients who previously experienced EHR were 2.14-times more likely to lose their graft compared to recipients without EHR (aHR $_{1.83}2.14_{2.51}$, $p<0.001$) (Table 2). LDKT recipients who previously experienced EHR were 2.50-times more likely to lose their graft compared to recipients without EHR (aHR $_{2.00}2.50_{3.13}$, $p<0.001$). In an adjusted model of DDKT recipients without DGF, during the post-EHR time period, recipients who previously experienced EHR were 2.43-times more likely to die compared to recipients without EHR (aHR $_{2.16}2.43_{2.73}$, $p<0.001$) (Table 2). Among DDKT recipients with DGF, during the post-EHR time period, recipients who previously experienced EHR were 2.16-times more likely to die compared to recipients without EHR (aHR $_{1.83}2.16_{2.54}$, $p<0.001$) (Table 2). LDKT recipients who previously experienced EHR were at a 2.34-times more likely to die compared to recipients without EHR (aHR $_{1.90}2.34_{2.88}$, $p<0.001$).

During the post-EHR time period, the hazard of graft loss for recipients who previously experienced EHR decreased linearly over time by 19% per year for DDKT recipients (time varying coefficient (tvc) $_{0.78}0.81_{0.85}$, $p<0.001$) (Figure 1A) and 14% per year for LDKT recipients (tvc $_{0.79}0.86_{0.93}$, $p<0.001$) (Figure 1B). During the post-EHR time period, the hazard of death for recipients who previously experienced EHR decreased linearly over time by 14% per year for DDKT recipients (tvc $_{0.83}0.86_{0.89}$, $p<0.001$) (Figure 2A) and by 9% per year for LDKT recipients (tvc $_{0.85}0.91_{0.98}$, $p=0.009$) (Figure 2B).

For recipients that previously experienced readmission that died within 30 days following readmission discharge, the cause of death was missing for 25.9%. The 3 most common causes of death were cardiac event (32.9%), infection (20.9%), and cerebrovascular event or respiratory failure (5.1% each) (Table 3). For recipients that previously experienced EHR that died greater than 30 days following readmission discharge, the cause of death was missing for 51.2%. The 3 most common causes of death were cardiac event (15.7%), infection (13.5%), and malignancy (6.1%) (Table 3).

DISCUSSION

In this national study of 56,076 first-time KT recipients, we found that the association between EHR and adverse transplant outcomes is dynamic. The majority of death-censored graft loss and mortality attributable to EHR occurred during the EHR hospitalization. During the EHR hospitalization, graft loss was between 34.4-times higher among DDKT recipients without DGF, 15.2-times higher for DDKT recipients with DGF, and 36.7-times higher among LDKT recipients. Similarly, mortality was 20.8-times higher among DDKT recipients without DGF, 12.8-times higher among DDKT recipients with DGF, and 18.2-times higher among LDKT recipients. Immediately following readmission discharge, graft loss and mortality remained elevated, but much less so. Graft loss was between 2.40-times higher among DDKT recipients without DGF, 2.14-times higher among DDKT recipients with DGF, and 2.50-times higher among LDKT recipients. Similarly, mortality was between 2.43-times higher among DDKT recipients without DGF, 2.16-times higher among DDKT

recipients with DGF, and 2.34-times higher among LDKT recipients. The hazard of death-censored graft loss and mortality continued to decrease with long-term post-EHR follow-up. During the readmission hospitalization and immediately post-EHR the majority of deaths were due to cardiac events and infection (72.7% among recipients experiencing EHR that died on the day of admission; 61.2% among recipients experiencing EHR that died later during the readmission hospitalization; 53.8% among recipients that previously experienced EHR and died within 30 days of readmission discharge).

Current understanding of the association between EHR and mortality averages the risk attributable to EHR over the entire follow-up period. This approach may underestimate the risk during readmission hospitalization and may over-estimate the risk post-readmission. In our previous work on EHR following KT, we found that EHR was associated with 1.50-times higher mortality over 5 years of follow-up (2). Our new approach demonstrates that the risk attributable to EHR is highest during the EHR hospitalization and declines over time. Outside the field of transplantation, readmission is a well-understood risk factor for mortality following surgery. Following various surgical procedures, including pancreatectomy, coronary artery bypass grafting, orthopedic repairs, colectomy, esophagectomy, and lung cancer resection, EHR is associated with a 2.3 to 6.6-fold increase in the risk of mortality (2, 3, 4, 8–11, 15). Interestingly, studies with longer follow-up have a lower estimated risk ratio, indicating the effect may be a partial artifact of study design and follow-up time.

Our study is not the first to use time-varying exposure methods to change the understanding of a biological process (16–19). Previous work by our group used similar methods to show that in pediatric KT recipients and liver transplant recipients the hazard of graft loss varies over time and is highest during late adolescence and early adulthood (16, 17). Beyond the field of transplantation, several studies have used these methods. Bolard et al used piecewise Cox proportional hazard models to show that the hazard of mortality by cancer stage varied with time post diagnosis (18). Similarly, Platt et al used extended Cox proportional hazard models with time-varying covariates to better characterize predictors of fetal and infant mortality over the timeline of gestation (19). Our study is novel in treating EHR as a time-varying risk factor for adverse post-KT outcomes and to our knowledge is the first study to use these methods in the context of studying readmission.

Our findings may have practical implications for management of KT recipients experiencing EHR. In our previously published work on readmission following kidney transplantation we showed that 36% of readmission were due to kidney/urinary tract procedures and 12% were due to infection (1). In the current study, we found that among the subgroup of recipients that lost their graft or died during the readmission hospitalization issues with the kidney/urinary tract was the most common reason for readmission, however cardiac events and infection were the most common reasons for death. These findings suggest that although recipients may be readmitted due to issues with allograft function, death results from another pathologic process. Interventions to decrease the risk of infection and optimize cardiac function may mitigate the acute risk associated with EHR.

Following EHR discharge, the risk of graft loss and mortality is attenuated but does not disappear completely and infection and cardiac events remain important causes of death among previously readmitted recipients in the first 30 days post-EHR. Clinicians need to remain mindful of the increased risk associated with readmission and common causes of death during the readmission hospitalization. Conversely, several years post-EHR, the remaining risk is minimal and recipients that make it to this point are unlikely to require specialized care.

Our study had several notable limitations. To ascertain readmission we had to limit our study population to with Medicare as their primary insurer. Medicare primary KT-recipients may be systematically different than KT recipients with alternative insurance providers. However, Medicare is the leading primary insurer for approximately half of all KT recipients, making our study population an important sub-set of the general KT population. In addition, since all individuals with end-stage renal disease (ESRD) requiring dialysis are Medicare eligible, regardless of age or disability, our inferences should be minimally affected. A further limitation of our study is that we cannot determine whether recipients that lost their graft during readmission were readmitted because they were already losing their graft or they lost their graft as a result of readmission. In addition, we do not have granular detail about the cause of graft loss, which would help differentiate between recipients that are readmitted because they are doing poorly and recipients that are readmitted and then develop a poor outcome. Similarly, death during readmission could represent failure to rescue or death due to the readmission itself. Even though we cannot directly delineate the casual pathway between EHR and adverse outcomes, our study is the first to isolate the EHR hospitalization time period as a source of substantial risk. An additional limitation is that many other factors have been shown to contribute to posttransplant outcomes, which were not explored in this study including health-related quality of life, socioeconomic status, and community-risk (20–22).

In conclusion, EHR remains a frequent and noteworthy occurrence post-KT. Recipients experiencing EHR should be managed with great care, as they are more susceptible to adverse outcomes both during the EHR hospitalization and for an extended period post-EHR.

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ABBREVIATIONS

AHR Adjusted Hazard Ratio

BMI	Body Mass Index
DDKT	Deceased Donor kidney transplant
DGF	Delayed Graft Function
ESRD	End Stage Renal Disease
EHR	Early Hospital Readmission
HLA	Human Leukocyte Antigen
KT	Kidney Transplant
LDKT	Live Donor Kidney Transplant
TVC	Time Varying Coefficient
USRDS	United States Renal Data System

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Figure 1. Hazard ratio of postreadmission death censored death-censored graft loss over time, comparing readmitted to nonreadmitted (REF) (A) deceased donor (DDKT) and (B) live donor (LDKT) kidney transplant recipients.

Figure 2. Hazard ratio of postreadmission mortality over time, comparing readmitted to nonreadmitted (REF) (A) deceased donor (DDKT) and (B) live donor (LDKT) kidney transplant recipients.

Table 1

Study population characteristics, by early hospital readmission, n=56,076.

	No Early Hospital Readmissions n=38,337	Early Hospital Readmissions n= 17,739	p-value
Median age, IQR (years)	53, 41–62	55, 44–63	< 0.001
Female (%)	38.9	39.3	0.3
African American race (%)	30.7	35.9	< 0.001
Recipient BMI, kg/m ² (%)			< 0.001
Underweight (<18.5)	2.2	2.1	
Normal (18.5–25)	32.5	29.9	
Overweight (25–30)	34.6	33.5	
Obese (>30)	30.8	34.4	
Hepatitis C positive (%)	4.9	6.6	<0.001
Cause of ESRD (%)			<0.001
Congenital	29.1	35.5	
Diabetes	26.3	25.1	
Glomerulonephritis	23.2	20	
Hypertension	7.3	5.9	
Unknown	13.9	13.4	
Median dialysis vintage, IQR (years)	3.3, 1.8–5.0	3.6, 2.0–5.4	<0.001
Median peak PRA, IQR	1, 0–16	2, 0–19	<0.001
Donor race			<0.001
Caucasian	66.9	67.5	
African American	14	16	
Other	19.1	16.5	
Donor recipient weight ratio	0.97, 0.77–1.2	0.95, 0.7–1.2	<0.001
Donor hypertension (%)	19.6	23.7	<0.001
Donor diabetes (%)	4.6	5.6	<0.001
Median donor creatinine, IQR (mg/dL)	1.0, 0.7–1.3	1.0, 0.7–1.3	0.003
Live donor (%)	24.2	21.1	<0.001
ECD donor (%)	13.5	17.6	<0.001
DCD donor (%)	6.9	8	<0.001
Pre-emptive kidney transplant (%)	2.6	2.6	0.9
HLA mismatch (%)			<0.001

	No Early Hospital Readmissions n= 38,337	Early Hospital Readmissions n= 17,739	p-value
0	7.9	6.3	
1	3.4	2.9	
2	7.9	6.7	
3	16.7	16.1	
4	22.9	22.9	
5	26.9	28.9	
6	14.2	16.2	
Regional/national share (%)	43.5	41.6	<0.001
Median cold ischemia time	15, 7.5–21.5	15.5, 8.5–22	<0.001
Pulsatile perfusion (%)	8.2	9	0.001

Table 2

Hazard of death-censored graft loss and mortality during early hospital readmission hospitalization (readmission hospitalization) and following early hospital readmission discharge (post-readmission).

	Readmission Hospitalization Graft Loss	Readmission Hospitalization Mortality	Post-Readmission Graft Loss	Post-Readmission Mortality
Deceased Donor Recipients without Delayed Graft Function ¹	24.634.447.9	14.120.830.7	2.082.402.77	2.162.432.73
Deceased Donor Recipients with Delayed Graft Function ¹	10.815.221.4	9.0312.818.0	1.832.142.51	1.832.162.73
Living Donor Recipients ²	18.136.774.2	9.0018.241.3	2.002.503.13	1.902.342.88

All p-values < 0.001

¹ Models adjusted for age, sex, African American race, body mass index, pre-emptive transplant, cause of end stage renal disease, peak panel reactive antibody, hepatitis C status, time on dialysis, human leukocyte antigen mismatch, pulsatile perfusion, cold ischemic time, donor/recipient weight ratio, donor race, terminal creatinine, donor hypertension, donor diabetes, extended criteria donor, donation after cardiac death, regional/national sharing.

² Models adjusted for age sex, African American race, body mass index, pre-emptive transplant, cause of end stage renal disease, peak panel reactive antibody, hepatitis C status, time on dialysis, human leukocyte antigen mismatch, recipient/donor weight ratio, donor race.

Table 3

Cause of death relevant to the early hospital readmission hospitalization for four recipient groups: recipients experiencing readmission and dying on the day of admission, recipients experiencing readmission and dying during the readmission hospitalization after at least 1 day of hospitalization, recipients that previously experienced readmission that died within 30 days following readmission discharge, and recipients that previously experienced readmission that died greater than 30 days following readmission discharge.

Cause of death	Death on admission n= 11	Death during readmission hospitalization n= 147	Death within 30 days following readmission discharge n= 158	Death beyond 30 days following readmission discharge n= 3795
Cardiac (%)	45.5	26.5	32.9	15.7
Infection (%)	27.2	34.7	20.9	13.5
Cerebrovascular (%)	9.1	4.1	5.1	3.7
Graft failure (%)	9.1	0.2	1.3	1.5
Bleeding (%)	-	4.8	2.5	1.3
Respiratory (%)	-	7.5	5.1	-
Endocrine (%)	-	1.4	-	-
Multi-system (%)	-	-	3.8	-
Malignancy (%)	-	-	-	6.1
Suicide (%)	-	-	0.6	0.3
Unknown (%)	9.1	19.0	25.9	51.2